Structure Plan – Maddington Kenwick Strategic Employment Area

Precinct 1

April 2019

This structure plan is prepared under the provisions of the City of Gosnells Local Planning Scheme No. 6

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION:

[DATE]

Signed for and on behalf of the Western Australian Planning Commission

……………………………………….

AN OFFICER OF THE Commission duly authorised by the Commission pursuant to section 16 of the *Planning and Development Act 2005* for that purpose, in the presence of:

………………………………………. Witness

………………………………………. Date

……………………… Date of Expiry

Table of amendments

Amendment No.	Summary of the Amendment	Amendment type	Date by WAPC

EXECUTIVE SUMMARY

The City of Gosnells has prepared a Structure Plan (SP) for Precinct 1 of the Maddington Kenwick Strategic Employment Area (MKSEA).

The SP area is located approximately 15 km south-east of the Perth CBD and comprises approximately 121 hectares (ha) of land bound by Bickley Road, Victoria Road, and Tonkin Highway, within the suburbs of Maddington and Kenwick.

The purpose of the SP is to address the planning requirements intended to guide the future industrial subdivision and development of the SP area in accordance with the *Planning and Development (Local Planning Schemes) Regulations 2015.*

Structure Plan Summary Table

Item	Data	Section number referenced within report
Total area covered by the Structure Plan	121 ha	Part 2: 1.2.2
Developable area – General Industry zone	91.386 ha	
Developable area – Composite Residential/Light Industry zone	11.013 ha	
Area of Local Open Space/Drainage (includes natural area and biodiversity assets)	9.445 ha	
Estimated lot yield – General Industry zone	91 lots (10,000m^2)	Part 2: 3.1
Lot yield - Composite Residential/Light Industry zone	13 lots	Part 2: 3.1
Area of natural areas and biodiversity assets (including development buffers)	Threatened Ecological Community (TEC) – 4.208 ha Conservation Category Wetland (CCW) (also comprising a TEC, and Priority Flora Species) – 2.222 ha	Part 2: 2.1.3

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PART 1 - IMPLEMENTATION

1. Structure Plan Area

This Structure Plan (SP) shall apply to the following lots:

Street Address	Lot on Plan	Lot Area (m^2)	Owner
113 Victoria Road	Lot 15 on Deposited Plan 29539	20222	J A Ardizzone
19 Victoria Road	Lot 5 on Diagram 19583	4047	S Baraiolo
67 Victoria Road	Lot 20 on Diagram 31600	20222	Biagioni Nominees Pty Ltd & Delga Nominees Pty Ltd
307 Kenwick Road	Lot 1 on Diagram 13222	20117	Broadwest Corporation Pty Ltd
11 Victoria Road	Lot 3 on Diagram 19583	4047	G E Brown
55 Victoria Road	Lot 14 on Diagram 27972	20216	J L & J Colwill
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3 Victoria Road	Lot 8 on Diagram 19583	4795	Webley Holdings Pty Ltd
95 Victoria Road	Lot 407 on Plan 31347	20212	White Eagle Corporation Pty Ltd

Figure 1 - Structure Plan Area – Lots.

The SP shall apply to the land contained within the inner edge of the line denoting the Structure Plan boundary on the Structure Plan map (Figure 1).

2. Structure Plan Content

This SP comprises:

- Implementation (Part 1)
- Explanatory and Technical Appendices (Part 2)

3. Operation

This SP shall come into operation at the time of approval by the Western Australian Planning Commission pursuant to Schedule 2, Part 4, Clause 22 of the *Planning and Development (Local Planning Schemes) Regulations 2015.*

This SP is to be read in conjunction with any associated Development Contribution Plan (DCP) and Development Contribution Plan Report (DCPR) pursuant to the Scheme.

4. Staging

The staging of development will be driven by private developers through the lodgement of subdivision and development applications. A DCP and associated DCPR are to be prepared to fund the shared provision of Common Infrastructure Works (CIWs) and Public Open Space (POS) to support development of the area for industry. The likely priority order of CIWs and staging will be considered through the establishment of the DCPR.

5. Subdivision and Development Requirements

The SP Map (Figure 2) designates land use, zones and reserves applicable within the subject area. The SP is given effect pursuant to Schedule 2, Part 4, Clause 27 of the *Planning and Development (Local Planning Schemes) Regulations 2015.*

5.1 Zoning and Land Use

The zoning and land use permissibility within the SP area is to be guided by the Scheme. Due regard shall be given to the following requirements in the assessment of subdivision and development applications for land within the SP.

5.1.2 General Industry and Composite Residential/Light Industry

The SP area is proposed to be zoned ‘General Industry’ and ‘Composite Residential/Light Industry’. Land use permissibility is to be guided by the Scheme in relation to that zone.

5.2 Conditions of Subdivision and Development

Conditions are to be applied to subdivision and development approvals to ensure the successful implementation of the SP. The following conditions are to be applied as a minimum. Additional conditions may be required based on the assessment of individual applications and range of site specific issues which may arise through the subdivision and development assessment/approvals process.

5.2.1 Public Open Space/Conservation Areas

The Local Government shall impose a condition requiring land designated as Public Open Space/Conservation on the adopted SP to be given up by the landowner/applicant free of cost and vested in the City.

5.2.2 Management of Wetlands and Conservation Areas

The Local Government shall impose a condition requiring the landowner/applicant to the prepare and implement an Interim Wetland and Conservation Management Plan (requiring revegetation, rehabilitation and management) for land designated as Public Open Space/Conservation on the SP, in accordance with the Environmental Assessment and Management Strategy – Maddington Kenwick Strategic Employment Area Precinct 1.

5.2.3 Fauna Relocation

The Local Government shall impose a condition requiring the landowner/applicant to prepare and implement a Fauna Relocation and Management Plan (or similar) prior to any ground disturbing works involving the removal of existing vegetation and associated fauna species.

5.2.4 Urban Water Management

The Local Government shall impose a condition requiring the landowner/applicant to prepare and implement an Urban Water Management Plan to support each stage of subdivision.

5.2.5 Drainage Basins

The Local Government shall impose a condition requiring land designated as Nominal Drainage Basin on the SP to be given up free of cost and vested in the City.

5.2.6 Acid Sulphate Soils

5.2.6.1 The Local Government shall impose a condition requiring the landowner/applicant to undertake detailed investigations to confirm the presence of actual Acid Sulphate Soils (ASS) and/or potential Acid Sulphate Soils (PASS) where excavation exceeds a depth of 2m.

5.2.6.2 The Local Government shall impose a condition requiring the landowner/applicant to prepare and implement an Acid Sulphate Soil and Dewatering Management Plan (ASSDMP). Should the presence of ASS and/or PASS be detected.

5.2.7 Traffic and Access

5.2.7.1 The Local Government shall impose a condition requiring satisfactory arrangements being made by the landowner/applicant for the upgrading and/or construction of subdivisional roads (including intersection treatments and footpaths) which abut the subject land.

5.2.7.2 The Local Government shall impose a condition requiring land for subdivisional roads (including intersections and road widening) to be given up by the landowner/applicant and transferred to the Crown free of cost.

5.2.7.3 The Local Government shall impose a condition restricting direct access by industrial vehicles to/from Composite Residential/Light Industry zoned lots onto Bickley Road. Access for industrial vehicles is only permitted from the rear of these lots via the new subdivisional road.

5.2.7.4 The Local Government shall impose a condition requiring the imposition of a Notification on Title advising prospective purchasers of restricted direct access by industrial vehicles to/from Composite Residential/Light Industry zoned lots onto Bickley Road. Access for industrial vehicles is only permitted from the rear of these lots via the new subdivisional road.

5.2.7.5 The Local Government shall impose a condition requiring the imposition of a covenant restricting direct access by industrial vehicles to/from Composite Residential/Light Industry zoned lots onto Bickley Road. Access for industrial vehicles is only permitted from the rear of these lots via the new subdivisional road.

5.2.8 Water Supply

The Local Government shall impose a condition requiring arrangements being made with the Water Corporation to provide a suitable water supply to service the subject land.

5.2.9 Wastewater Disposal

The Local Government shall impose a condition requiring satisfactory arrangements being made with the Water Corporation for the provision of sewerage infrastructure to service the subject land.

5.2.10 Electricity Supply

The Local Government shall impose a condition requiring arrangements being made to the satisfaction of the Western Australian Planning Commission and to the specification of Western Power for the provision of the electricity supply to service the subject land.

5.2.11 Drainage

The Local Government shall impose a condition requiring the landowner/applicant to fill and/or drain the subject land including ensuring that stormwater is contained onsite, or appropriately treated and connected to the local drainage system.

5.2.12 Development Contribution

The Local Government shall impose a condition requiring arrangements being made with the City for the landowner/applicant to contribute to the cost of providing common infrastructure as established through Amendment No. 170.

5.2.13 Bushfire Management Plans

The Local Government shall impose a condition requiring the landowner/applicant to prepare and implement a Bushfire Management Plan in accordance with State Planning Policy 3.7 – Planning in Bushfire Prone Areas and the Guidelines for Planning in Bushfire Prone Areas.

5.3 Infrastructure Requirements

The development and subdivision of land within the SP area will require developers to make a financial contribution towards infrastructure, servicing upgrades and land for public purposes identified as Common Infrastructure Works (CIWs).

These CIW items are likely to include the upgrading/construction of specific subdivisional roads to an industrial standard and the provision of drainage, sewer, power, street lighting, telecommunications, water reticulation infrastructure, and reimbursement for land to accommodate specific roads, drainage and environmental buffers.

The engineering design and costing of CIWs is to be undertaken by the City. Infrastructure and servicing upgrades will generally be the responsibility of the developers. The reimbursement for the cost of upgrades identified as common will made available via an approved amendment and adopted DCPR for the SP area.

5.4 Local Development Plans

A Local Development Plan (LDP) is required to be prepared for ‘Composite Residential/Light Industry’ zoned lots as shown on the SP with an LDP boundary designation. The LDP is required to address the following matters:

- Vehicle access from Bickley Road will be limited to domestic traffic in association with the residential dwelling.
- Industrial vehicle access is only permitted to the rear of these lots from the new subdivisional road. Industrial vehicle access is not permitted from Bickley Road.
- Supplemental provisions to address the presentation of residential dwellings and landscaping along Bickley Road to facilitate a high quality streetscape.
- Supplemental provisions to address built form and presentation/screening/fencing of industrial buildings along Bickley Road.

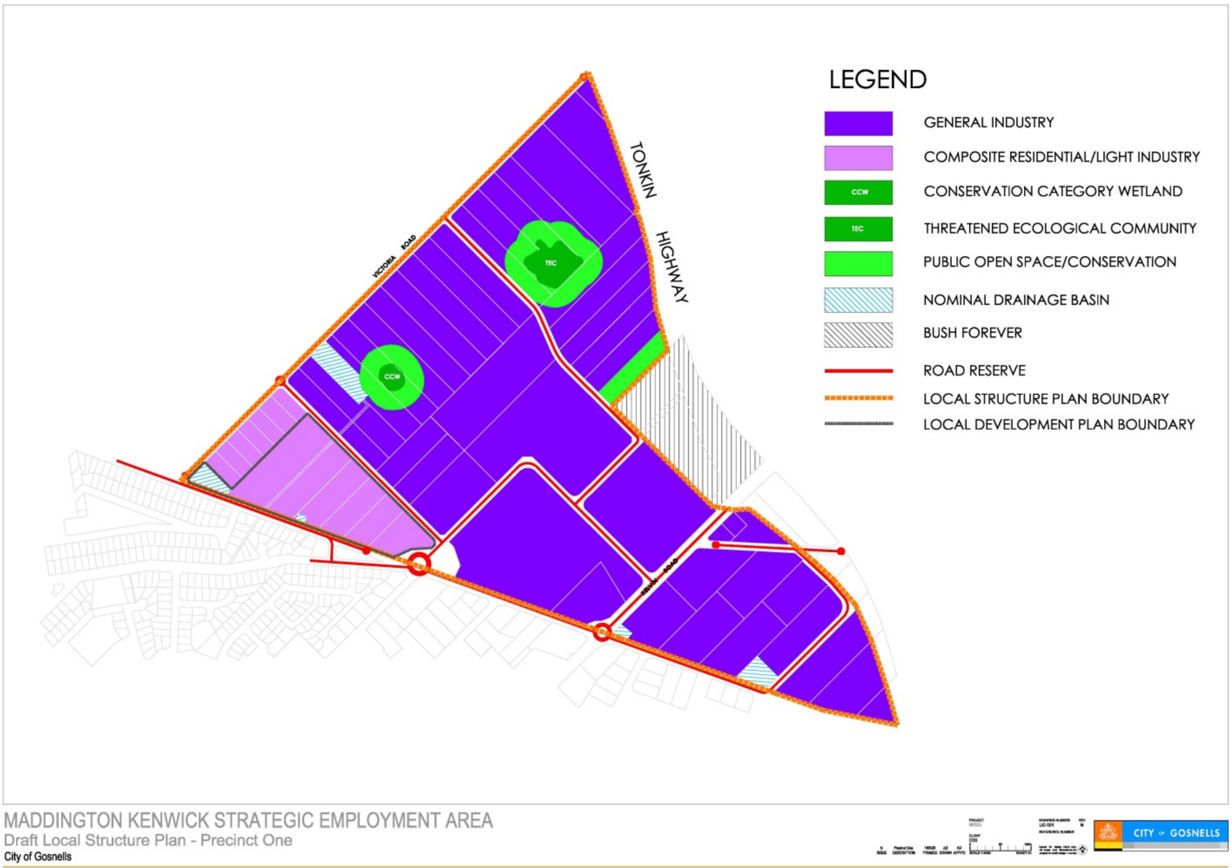

Figure 2 - MKSEA Precinct 1 Structure Plan Map.

PART 2 - EXPLANATORY SECTION

1. Planning Background

1.1 Introduction and Purpose

The City of Gosnells (CoG) has prepared a Structure Plan (SP) for Precinct 1 of the Maddington Kenwick Strategic Employment Area (MKSEA). The purpose of the SP is to provide a planning framework to guide the future land use, subdivision and development of the area.

The main objectives of the plan are to:

- rationalise private and public land uses having regard for buffer areas associated with environmentally sensitive areas;
- ensure adequate land is reserved for drainage purposes;
- ensure the orderly and proper subdivision of all lots within the SP area;
- ensure the road configuration considers the existing regional road networks;
- ensure the internal road layout applies a modified grid pattern road system consistent with *Development Control Policy 4.1 – Industrial Subdivision*;
- increase the level of employment self-sufficiency and self-containment within the locality;
- provide public open space (POS) to act as a buffer for the protection and conservation of wetlands and associated flora and fauna.

The preparation of this SP is supported by the following technical information:

Appendix A	MKSEA Precinct 1 Structure Plan Map
Appendix B	Environmental Assessment and Management Strategy
Appendix C	Priority Flora and Plant Communities Map
Appendix D	Vegetation Condition Map
Appendix E	Conservation Significant Flora and Vegetation Map
Appendix F	Wetland Features Map
Appendix G	Structure Plan Response to Environmental Considerations Map
Appendix H	Bush Forever, Environmentally Sensitive Areas and Regional Ecological Linkages Map
Appendix I	Environmental Geology Map
Appendix J	Acid Sulphate Soils Investigation Report
Appendix K	Local Water Management Strategy
Appendix L	Bushfire Management Plan
Appendix M	Cultural Heritage Assessment Report
Appendix N	Transport Impact Assessment

1.2 Land Description

1.2.1 Location

The subject site is located within the suburbs of Kenwick and Maddington and situated within the locality of the City of Gosnells. It is bound by Bickley Road to the south, Tonkin Highway to the east, Victoria Road to the west and is located approximately 15km south-east of the Perth CBD.

Refer to figure 3 – Location Plan

Refer to figure 4 – Regional Context Plan

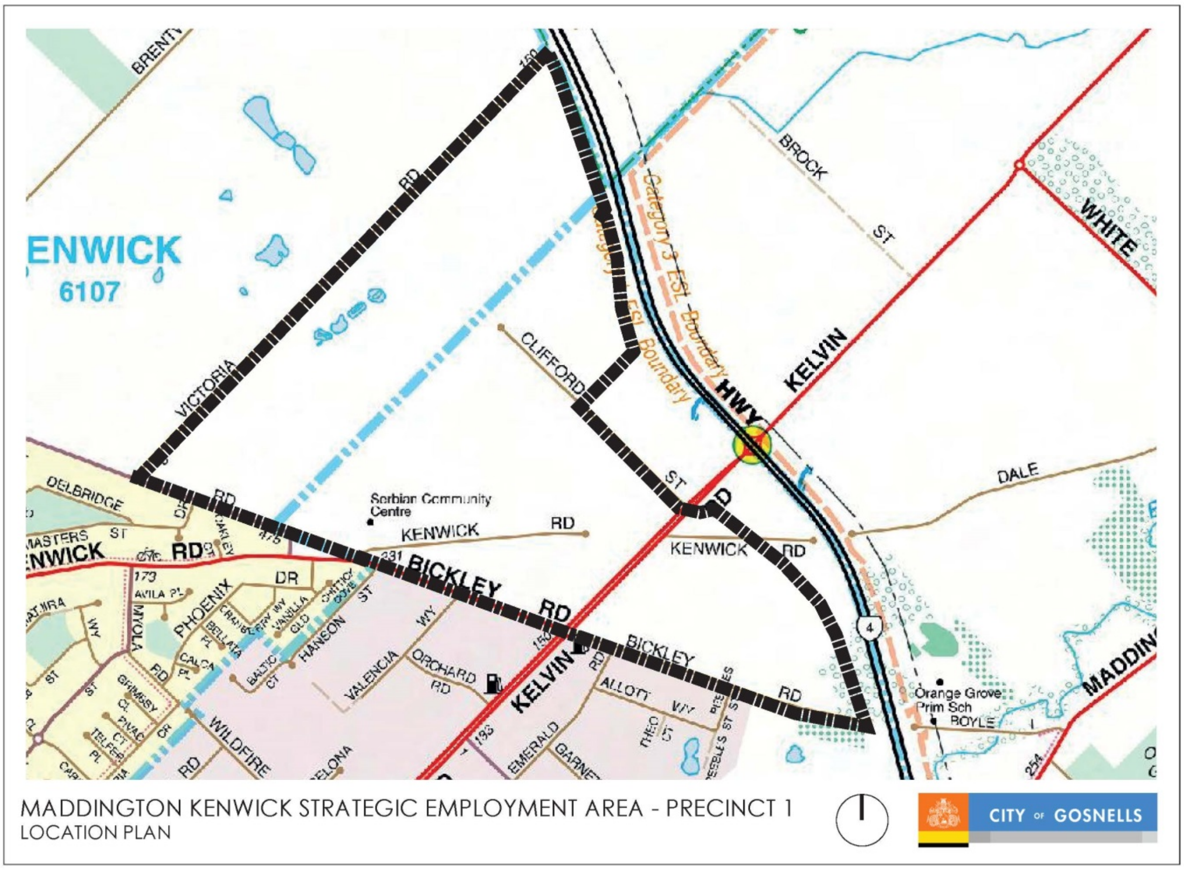

Figure 3 - Location Plan

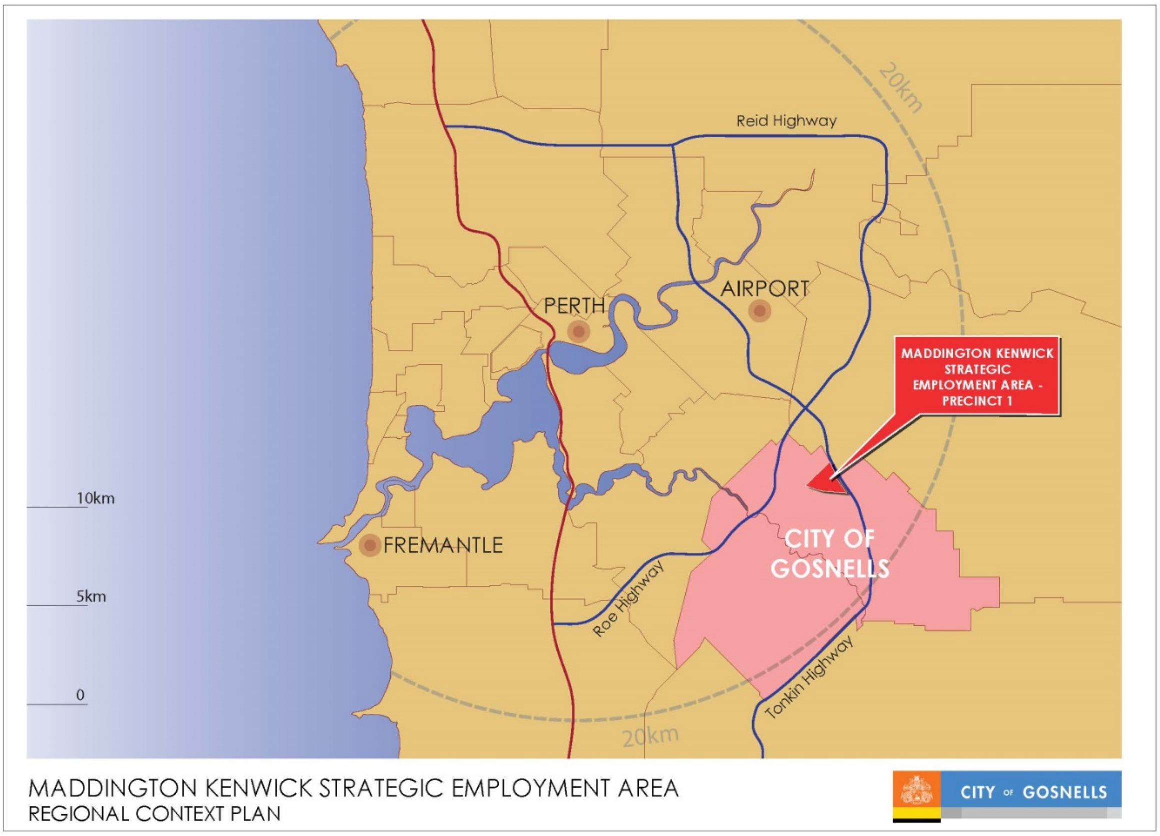

Figure 4 - Regional Context Plan

1.2.2 Area and Land Use

The subject site encompasses approximately 121ha of land and comprises 53 lots in multiple ownership. Substantial development in the form of large industrial warehouses has occurred within the central part of the subject site (Lot 800 Clifford Street), along with extensive land clearing. Several other landholders operate transport depots and storage yards under temporary approvals. The remainder of the lots accommodate traditional rural lifestyle uses associated with the former rural zone

Refer to Figure 5 – Aerial Photograph

Figure 5 - Aerial Photograph

1.2.3 Legal Description and Ownership

Street Address	Lot on Plan	Lot Area (m^2)	Owner
113 Victoria Road	Lot 15 on Deposited Plan 29539	20222	J A Ardizzone
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Figure 6 - Lots – Legal Description and Ownership

1.3 Planning Framework

1.3.1 Zoning and Reservations

The subject site is zoned 'Industrial' under the Metropolitan Region Scheme (MRS). This zoning is appropriate to support the subdivision and development of an Industrial Precinct.

Refer to Figure 7 – Metropolitan Region Scheme Zoning

The subject site is zoned 'Business Development' under the CoG Town Planning Scheme No. 6 (Scheme). This zoning is appropriate for the purpose of implementing a SP to coordinate subdivision and development and use of the land due to fragmented land ownership, and other matters that may impact on the orderly and proper planning of the area, such as inadequate servicing infrastructure.

Refer to Figure 8 – Town Planning Scheme No.6 Zoning

1.3.2 Maddington Kenwick Strategic Employment Area – Indicative Local Structure Plan

In order to inform the preparation of a District Water Management Strategy and for the purpose of providing context to the future preparation of local structure plans, the CoG prepared an indicative local structure plan for the MKSEA.

Refer to Figure 9 – MKSEA Indicative Local Structure Plan (2015)

1.3.3 Planning Strategies

1.3.3.1 Perth and Peel@3.5million

Perth and Peel@3.5million is a long-term integrated strategy for effective land development and provision of infrastructure, to accommodate Perth's overall future population growth scenario of 3.5 million over the next 30 years. The sub-regional frameworks set out in the strategy align with and build upon with the principles detailed in *Directions 2031 and Beyond*. They are recognised under the State Planning Framework (*State Planning Policy No.1*) and are required to be taken into account when preparing and reviewing strategies, policies and plans.

1.3.3.3 Economic and Employment Lands Strategy: non-heavy industrial – Perth metropolitan and Peel region

The Economic and Employment Lands Strategy: non-heavy industrial (EELS) (the Strategy) is a state government initiative which provides the strategic planning framework for industrial land use planning over the next 20 years and beyond. The strategy's aim is to facilitate the recuperation of the industrial land bank to a sustainable level, whereby the land shortage of industrial land encountered in the mid 2000s will not re-occur. The strategy is relevant to the subject site as it identifies the MKSEA as a potential industrial area. It should be noted that the EELS is simply a guide for broad level land use. The suitability of the MKSEA Precinct 1 to support an Industrial zoning was investigated through concept planning, technical assessments, and the preparation of a draft SP. As such, the designation of the Industrial zone through the SP is consistent with the EELS.

Refer to Figure 10 - Economic and Employment Lands Strategy: non-heavy industrial – Perth metropolitan and Peel regions

2. Site Conditions and Constraints

2.1 Biodiversity and Natural Assets

The *Environmental Assessment and Management Strategy MKSEA – Precinct 1* (EAMS) (Emerge Associates 2019) was prepared on behalf of the CoG for the land area subject to the SP. The EAMS incorporates a range of site specific investigations and assessments into the environmental attributes and values present, and informs the SP response with regards to the protection and enhancement of conservation worthy assets.

The key factors addressed within the EAMS include:

- Vegetation
- Wetlands
- Vegetation and Wetland Management
- Fauna
- Fauna Management

A copy of the EAMS is contained in Appendix B.

2.1.1 Vegetation

Native plant communities found within the subject site account for approximately 3.63% of the land area. Historical clearing and land use activities have left the overall remaining flora and vegetation values within the site in a degraded condition, resulting in more than 96% of the vegetation value within the Precinct 1 area to be considered as 'completely degraded'. Of the non 'completely degraded' native vegetation found to occur, there are twelve native plant communities considered to be in a 'degraded', 'good', and 'very good' condition category.

Two occurrences of Commonwealth and State listed Threatened Ecological Communities (TEC) exist within the subject site, comprising: 1.22 ha of '*banksia woodlands of Swan Coastal Plain*'; and 0.35 ha of '*Corymbia calophylla – Kingia australis woodlands on heavy soils of the Swan Coastal Plain*'. One priority flora species, *Lepyrodia curvescens,* also exists within the subject site.

On a regional scale, the majority of Precinct 1 occurs within the Swan Coastal Plain. The subregion is characterised as comprising *of Banksia* low woodland on leached sands and *Melaleuca* swamps where ill-drained; and woodland of *Eucalyptus gomphocephala* (tuart)*, E. Marginata* (jarrah) *and Corymbia calophylla* (marri) on less leached soils. The subregion is recognised as a biodiversity hotspot and contains a broad variety of endemic flora and vegetation.

Refer to Appendix C - Priority Flora and Plant Communities Map

Refer to Appendix D - Vegetation Condition Map

Refer to Appendix E - Conservation Significant Flora and Vegetation Map

2.1.2 Wetlands

13 wetlands were identified to exist within the subject site. These comprise of one Resource Enhancement Wetland (REW) situated toward the north-western corner of the subject site, and 12 Multiple Use Wetlands (MUW) found mainly within the western part of the subject site between Victoria Road, Bickley Road and Kelvin Road.

The *Flora, Vegetation and Wetland Assessment* (Emerge 2018) (Contained in Appendix C of the EAMS) includes an assessment of wetlands, and identifies the REW mapped within Precinct 1 to contain values potentially representative of Conservation Category Wetland (CCW), and recommends the wetland be reclassified to a CCW management category.

There are other very small areas (<0.01 ha) of CCW (associated with the adjoining Bush Forever Site 53) and REW occurring within or in close proximity to the subject site.

Refer to Appendix F - Wetland Features Map

2.1.3 Vegetation and Wetland Management

The consideration of natural environmental areas within Precinct 1 has been significant to the overall design of the draft SP, resulting in the proposed retention and enhancement of conservation worthy environmental assets.

Flora and vegetation values confirmed to exist within Precinct 1 include two areas of TEC, and one priority flora species, as described in section 2.1.1. These areas of conservation worthy flora and vegetation are proposed to be retained and surrounded by a 50 m buffer and zoned Public Open Space/Conservation to ensure the establishment of Biodiversity Asset (Nature) Public Open Space.

The SP contains one candidate CCW being the listed REW mentioned in section 2.1.2. It has been recommended that this wetland be upgraded to a CCW management category and the boundary modified due to its current condition, and that it also includes a TEC. Another CCW associated with Bush Forever Site 53 occurs on the eastern boundary of (though not within) the subject site. Due to the significant environmental values associated with the CCW's, the SP proposes a 50 m buffer for each of these assets and a zoning of Public Open Space/Conservation to ensure the establishment of Biodiversity Asset (Nature) Public Open Space. The buffer separation requirements for the CCW's have been determined through a wetland buffer study (Contained in part 4.4.2 of the EAMS).

The Multiple Use Wetland's (MUW) identified to exist within Precinct 1 contain few significant wetland attributes and have not required a spatial response with regards to buffer protection. Development of these wetlands is considered suitable if hydrological considerations are addressed as per the *Local Water Management Strategy MKSEA – Precinct* 1 (LWMS) (Emerge 2019) (Appendix K).

The approach to facilitate the establishment of these areas designated for Public Open Space/Conservation, and the broader requirements for the protection and management of the conservation worthy vegetation and wetlands contained within these areas are detailed in the *Wetlands and Conservation Area Management Strategy* (WCAMS) (contained in part 5 of the EAMS). The broad objectives of the WCAMS include:

- Separation of wetlands and conservation areas from the adjacent land use(s) that may threaten its desired values, via either a spatial separation or use of physical barriers.
- Protection and preservation of the existing conservation values.
- Preventing proposed activities that may lead to degradation of the conservation area.
- Restoring the ecological integrity of degraded areas through revegetation.
- Management and maintenance of ecological values.
- The transfer of land designated as POS/Conservation into public ownership, and reservation to 'Local Open Space' under the CoG Town Planning Scheme.

In accordance with the objectives of the WCAMS, The SP requires land areas designated as POS/Conservation to be given up free of cost by the affected landowner/applicant and vested in the City. Due to the fragmented ownership associated with the land areas required for this designation, development is expected to occur in a staggered approach, with the portions of land required likely to be ceded at different times.

The WCAMS establishes both short and long-term plans of action for a consistent approach to the management of wetlands and conservation areas within the SP area. Short-term plans of action will require the landowner/applicant (as a condition of subdivision and development) to prepare and implement an interim Wetland and Conservation Area Management Plan (WCAMP). Such a plan shall address the CoG Council Policy 6.2.2 *Rehabilitation and Revegetation of Natural Areas*, and associated guidelines.

A future comprehensive long-term WCAMP will ultimately be prepared and implemented by the CoG when a sufficient portion (nominally 65%) of the land area required for POS/Conservation is ceded. Such a plan will build upon, and be informed by existing interim management plans.

A copy of the WCAMS can be found in part 5 of the EAMS (Appendix B).

Refer to Appendix G – Structure Plan Response to Environmental Considerations Map
Refer to Appendix B - Environmental Assessment and Management Strategy

2.1.4 Bush Forever Sites

Bush Forever Site 53 is situated between Clifford Street and Tonkin Highway, adjacent to the subject site and not within the SP boundary. Site 53 is known to support TECs listed as endangered (SCP20b) and vulnerable (SCP3b) under the *Environmental and Biodiversity Conservation Act (EPBC Act).* One flora species listed as vulnerable, being *Conospersum undulatum*, is also present in Bush Forever Site 53.

A CCW has also been found to occur within the Bush Forever Site. As outlined in section 2.1.3, a 50 m buffer has been proposed (within the subject site) to ensure the protection of this wetland.

2.1.5 Ecological Linkages

One mapped ecological linkage (No. 43) passes through the site in an east-west direction. This connects to other linkages to the east and north-west of the site. A very small part of one of these connected ecological linkages (No.44) passes through the south-eastern corner of the site, it is however not considered to contribute to or provide any significant ecological linkage functionality due to the vegetation within Precinct 1 being highly fragmented.

Refer to Appendix H - Bush Forever, Environmentally Sensitive Areas and Regional Ecological Linkages

2.1.6 Fauna

Historical clearing of remnant vegetation associated with rural land uses has compromised the overall fauna values within Precinct 1. There are however large pockets of remnant vegetation representing the highest values with regards to general fauna habitat, though recent fauna assessment has observed these areas to be disturbed beyond their natural characteristics as they are lacking in significant native groundcover/shrubs and microhabitats.

A recently undertaken field survey identified a total of 27 native fauna species and two introduced fauna species within Precinct 1. The majority of these were observed to be common widespread bird species.

2.1.7 Fauna Species of Conservation Significance

A range of conservation significant fauna species are known to occur within the overall MKSEA area and the broader region surrounding Precinct 1. These include three species of threatened black cockatoo, specifically the Carnaby's black cockatoo, forest red-tailed black cockatoo, and Baudin's black cockatoo.

Habitat mapping on a regional scale by the Department of Planning has indicated that Precinct 1 contains flora habitats potentially supportive of foraging of black cockatoos, and that a number of roosting and breeding areas are in proximity to the precinct, occurring to the east of the site within the Darling Range. The most recent records with regards to the occurrence of black cockatoo roosting sites have been obtained through annual community surveys as a part of the *Great Cocky Count* (GCC).

The latest GCC, undertaken in 2017, indicates that Precinct 1 does not contain any confirmed Black Cockatoo roosting sites. There are however confirmed roosting sites for Black Cockatoos in proximity to the subject site, approximately 2 km to the north-west within Precinct 3 of the MKSEA, and approximately 2km to the north-east within the suburb of Wattle Grove.

As a result of the extensive clearing and the degraded nature of environmental values within Precinct 1, potential fauna habitats are limited to areas of intact native vegetation. These patches are known to contain flora species which potentially provide foraging habitats for the abovementioned species of black cockatoo. The SP proposes to retain the majority of these areas of native vegetation and their associated fauna species by way of incorporation into areas of proposed Biodiversity Asset (Nature) POS. Other areas of vegetation existing outside of proposed POS are to be considered on a lot-by-lot basis, due to the fragmented land ownership within the precinct.

In line with the WAPC's *Model Subdivision Conditions Schedule*, developers will be required to prepare and implement a Fauna Relocation and Management Plan (or similar) prior to any ground disturbing works which may impact upon fauna species or associated habitat. Such a plan will deal with the ongoing management of the fauna habitat. The three species of black cockatoo, namely *Calyptorhynchus latirostris* (Carnaby's black cockatoo), *Calyptorhynchus banksia naso* (forest red-tailed black cockatoo), and *Calyptorhynchus baudinii* (Baudin's black cockatoo) are protected under the EPBC Act, therefore the potential clearing of any associated habitat as a result of any proposed development will need to be considered in the context of a referral in accordance with the EPBC Act.

A copy of the Fauna Assessment Report can be found in Appendix D of the EAMS.

Refer to Appendix B - Environmental Assessment and Management Strategy

2.2 Landform and Soils

2.2.1 Landforms, Topography and Soils

The subject site is situated on the eastern side of the Swan Coastal Plain, being the geomorphic unit much of the Perth Metropolitan region is characterised by. The site has been identified to fall broadly within both the Guildford association and the Forrestfield association however more recent finer scale mapping has placed the majority of the subject site within the Pinjarra Plain, with a small portion (the north-eastern side) within the Piedmont Zone. The elevation of the site ranges from 12 m Australian Height Datum (AHD) on the south-west corner to 28 AHD on the north-east corner.

The soils underlying the subject site generally comprise of topsoil (sand) or areas of fill to depths ranging from 0.1 m to 0.45 m, overlying sand, clayey, silty or gravelly materials. The specific environmental geology group soil types found within the subject site comprise of 'Sandy Clay' (C_s), 'Sand' (S_8), 'Sand' (S_{10}) and 'Sand' (S_{12}).

A recent investigation was undertaken with regard to the threat of acid sulphate soils (ASS) within the subject site. It was determined through this process that soil types associated with S_8 or S_{10} environmental geology groups were not considered to be true indicators of potential acid sulphate soils (PASS) or actual acid sulphate soils (AASS). Overall, the risk for ASS to occur within Precinct 1 is relatively low based on both regional and site specific ASS risk mapping.

Future investigations may prompt the requirement for an Acid Sulphate Soil and Dewatering Management Plan.

Refer to Appendix I - Environmental Geology Map
Refer to Appendix J - Acid Sulphate Soils Investigation

2.2.2 Site Contamination

The *Contaminated Sites Database* (DWER 2018) does not list any classified contaminated sites within the planning area. There is however two classified contaminated sites situated within 200m from the southern boundary (near Bickley Road). These sites are not anticipated to have any impact within the SP area as they are located within an existing industrial precinct and are hydrologically downstream from the area.

2.3 Groundwater and Surface Water

2.3.1 Groundwater Hydrology

The historical regional minimum groundwater levels underlying Precinct 1, as shown from data taken from the Perth Groundwater Atlas, range from 9 m AHD in the western corner to 16 m AHD in the eastern corner. The depth to groundwater of the subject site ranges from approximately 3 m to 15 m below ground level, with the area along Bickley Road being a lower depth to regional ground water, and the area along Tonkin Highway and below elevated earth mounds being higher.

A number of groundwater monitoring investigations have been completed across the subject site with the most recent being undertaken in 2017 by Emerge Associates. The maximum groundwater level (MGL) across Precinct 1, as determined through the outcomes of groundwater monitoring investigations, ranges from 13 m AHD near the western side to 21 m AHD near the Tonkin Highway, with depth to this perched MGL ranging from 0.9 m to

4.5 m below ground level. Further discussion regarding the characteristics of groundwater underlying Precinct 1 can be found in Appendix K – Local Water Management Strategy MKSEA - Precinct 1 (LWMS) (Emerge 2019).

Precinct 1 contains no existing natural waterways. Investigations have indicated that stormwater runoff within the subject site ultimately drains into Bickley Brook, by way of overland flow, unlined open drains and pipes towards Victoria Road and Bickley Road.

Refer to Appendix K - Local Water Management Strategy

2.4 Bushfire Hazard

The SP is required to adhere to the *Guidelines for Planning in Bushfire Prone Areas* and *State Planning Policy 3.7: Planning in Bushfire Prone Area.* A Bushfire Management Plan (BMP) for Precinct 1 has been prepared by Urbaqua in accordance with the abovementioned guidelines and methodology.

The BMP identifies the extent of bushfire hazard associated with the future development of Precinct 1 and sets out a series of risk management strategies to reduce the occurrence of, and minimise the impact of bushfires in bushfire prone areas, thereby reducing the threat to life, property and the environment.

Bushfire hazard within and in close proximity to the subject site ranges from low to extreme, however the fire risk is associated with the areas of threatened vegetation. These areas of vegetation are to be protected by 50 m buffers and zoned for POS/Conservation, and will thus be incapable of supporting development. A 6 m firebreak associated with each of these areas of vegetation will be maintained by the City subject to the POS/Conservation areas being given up and vested with the City. Further separation will be achieved by asset protection zones (APZ) on the individual lots. The APZs will ensure that the radiant heat impact from any potential fire on any future development will not exceed 29kW/m^2 (BAL-29).

The construction of residential dwellings within the Composite Zone is to meet the requirements of *AS3959 Construction of buildings in Bushfire Prone Areas*.

The BMP is required to be implemented by the developer at the subdivision and development stage, with subsequent BMP's and/or Bushfire Attack Level (BAL) assessments required to be completed to support future development proposals. Developers must have regard for the section 6 – *Responsibilities for Implementation and Management of the Bushfire Measures* on pages 24 - 25 of the BMP to achieve a suitable and effective bushfire management outcome.

Refer to Appendix L - Bushfire Management Plan

2.5 Heritage

2.5.1 Aboriginal Heritage

An Aboriginal Cultural Heritage Impact Assessment was undertaken for the SP area on 22 October 2018 as a part of an overall heritage assessment for the land area pertaining to precincts 1, 2 & 3B of the MKSEA. The CoG engaged heritage consultants Australian Cultural Heritage Management (ACHM) to undertake the assessment. An ACHM Archaeologist was joined on site by Whadjuk Noongar Representatives, and CoG staff.

The primary aim of the investigation was to re-examine the six previously identified Aboriginal Heritage sites that were known to exist within the broader MKSEA area. Of these previously registered Aboriginal heritage sites within the overall MKSEA, none were known to exist within Precinct 1.

In considering the historical development and clearing of the land associated with the SP area, the investigation into the existence of heritage sites was concentrated to areas of remnant vegetation associated with mapped areas of conservation flora and wetlands (areas described in section 2.1.3) due to the greater potential for discovery of in-situ cultural material in an original depositional context within such areas. The heritage team surveyed two separate lots associated with these areas of conservation value, and as a result, no Aboriginal heritage sites were identified to exist.

Whilst no previous heritage sites were known to exist within the Precinct 1 area prior to the investigation, and subsequently no new sites identified, prospective subdividers/developers within the SP area are to have regard for the requirements of the *Aboriginal Heritage Act 1972* (AHA) by exercising due diligence in trying to ascertain whether or not any proposed activity on a specified area may impact (damage or destroy) an Aboriginal site. This advice accords with part 1.15 (Offences relating to Aboriginal Sites) of the *Cultural Heritage Due Diligence Guidelines* (DAA 2013), where:

'Under section 17 of the AHA, a person who excavates, destroys, damages, conceals or in any way alters any Aboriginal site commits an offence, unless he or she acts with the authorisation of the Registrar of Aboriginal Sites (Registrar) under section 16 or the consent of the Minister of Aboriginal Affairs (Minister) under section 18.'

With regard to the broader MKSEA planning area, the scheme amendment process for the rezoning of both Precincts 2 and 3B is currently subject to a formal Environmental Review (ER), as required by s.48C(1) (a) of the Environmental Protection Act 1986 (EP Act).

Works required to be undertaken as a part of the ER in relation to addressing 'Social Surroundings' as a key environmental factor within Precincts 2 and 3B of the MKSEA, include the following tasks:

- *'Characterise the heritage and cultural values within and adjacent to the amendments areas to identify sites of significance and their relevance within a wider regional context.*
- *Conduct appropriate Aboriginal heritage surveys to identify Aboriginal sites, values and/or cultural associations.*
- *Conduct appropriate consultation to identify concerns in regard to environmental impacts as they affect heritage and cultural matters.*
- *Provide a description and figure(s) of the heritage and cultural values and proposed impacts within and adjacent to the amendments areas (including the Greater Brixton Street Wetlands).*
- *Assess the impacts on heritage sites, values and/or cultural associations, associated with the future development including those arising from changes to the environment which may impact on cultural and heritage significance (including the Greater Brixton Street Wetlands).*
- *Predict the residual impacts on heritage sites, values and/or cultural associations, for direct, indirect and cumulative impacts after consideration of the mitigation hierarchy.*
- *Outline the mitigation and management measures to ensure impacts to heritage site, values and / or cultural association (direct or indirect) are minimised, and not greater than predicted.'*

Following completion of the above tasks, this information is to be compiled within an ER document and advertised for public comment, including referral to the South West Aboriginal Land and Sea Council (who act on behalf of the Whadjuk Working Party) for comment and input into the heritage aspects of Precincts 2 and 3B.

Refer to Figure 11 – MKSEA Precinct Plan

Refer to Appendix M – Cultural Heritage Assessment Report

2.6 Context and other Land Use Constraints and Opportunities

2.6.1 Local Context

The subject site is well situated for industrial development, being in close proximity to existing industrial development (Davison industrial area) and an existing integrated regional, district and local road network. The Tonkin Highway adjacent to the subject site can be easily accessed and can provide further connections to Roe Highway, Reid Highway, Great Eastern Highway and Leach Highway.

2.6.2 Recreational Opportunities

A variety of recreational opportunities exist within the general vicinity of the subject site. District Open Space (Mills Park) is located approximately 3 km west of the area, and there are a number of neighbourhood parks situated within the exiting residential area to the south west. The location of the site relative to Tonkin Highway provides connection to recreational opportunities approximate to both the Maddington and Gosnells Town Centres.

Refer to figure 12 - Local Context Plan

2.6.3 Existing Land Uses

Existing land uses within the subject site reflect a transition from traditional rural type uses to industrial development. The central part of the area has been subject to recent development in the form of large industrial warehouses. There is also a mixture of transport depots and storage yards currently operating under temporary approvals. The remainder of lots within the subject area accommodate traditional rural uses associated with the former General Rural zone.

The land to the north and north-west is currently zoned General Rural and generally supports rural type development and various non-traditional rural type uses. The land area immediately to the east separated by the Tonkin Highway and within the suburb of Orange Grove generally supports traditional rural lifestyle uses along with a mixture of businesses. The land uses to the south and south-west comprise of existing industrial (Davison industrial area) and residential housing respectively.

2.7 Design Philosophy

The design formulation relating to the SP is based on the need to facilitate opportunities for industrial development with a suitable interface between the future industrial uses within the subject site and the abutting residential development and existing industrial uses to the west and the south. The SP proposes a zoning of 'General Industry' for the majority of the land area, with the portion of land to the west of the site to be zoned 'Composite Residential/Light Industry' in order to provide an appropriate interface between the existing residential lots south of Bickley Road and future General Industry.

The proposed internal movement system contemplates the existing road network associated with recent industrial developments on site and allows for fluidity of movement through the subject site. Proposed internal roads within the SP also consider the areas of conservation and associated buffers as the road interface to these areas allow for practical access for the purposes of management and maintenance. The location of proposed roads has taken into account the existing cadastre in order to support the development intentions of individual landowners. Consideration has been made to ensure that impacts relating to the loss of developable land are at a minimum and shared equitably amongst affected landowners by proposing roads along existing lot boundaries.

2.7.1 Composite Residential/Light Industry

Development of lots zoned 'Composite Residential/Light Industry' will be guided by a LDP. The LDP will ensure the development of these lots is coordinated in a manner that appropriately addresses the interface with the existing Kenwick residential area along Bickley Road. The required design and built form objectives of the LDP include:

- Limiting vehicle access from Bickley Road to domestic traffic only in association with the residential dwelling.

- Restricting industrial/heavy vehicle access to the rear of Bickley Road lots via the new subdivisional road. Industrial vehicle access will not be permitted from Bickley Road.

- Supplemental provisions to address the presentation of residential dwellings and landscaping along Bickley Road to facilitate a high quality streetscape.

- Supplemental provisions to address built form and presentation/screening/fencing of industrial buildings along Bickley Road

In relation to industrial vehicle access, a requirement of the LDP will be for landowners/developers to facilitate the provision of a new subdivisional road prior to the use of these lots for industrial purposes. This will require a coordinated approach from landowners to undertake the necessary administrative tasks to excise land for the road reserve and to construct the road. Temporary industrial vehicle access from Bickley Road is not supported in the absence of the new subdivisional road being provided, on the basis that unacceptable impacts are likely to be imposed on the Kenwick residential area along Bickley Road, as result of industrial traffic.

Refer to Appendix A - MKSEA Precinct 1 Structure Plan Map.

2.8 Public Open Space/Conservation

The SP proposes a zoning of Public Open Space/Conservation for areas of identified conservation worthy vegetation and wetlands and associated buffers. The proposed Public Open Space/Conservation zoning will facilitate the establishment of Biodiversity Asset (Nature) Public Open Space (POS). The zoning has been applied in order to ensure a protective zoning for the conservation worthy natural areas, in lieu of an existing 'Conservation' zone or similar, and does not facilitate a typical form of recreational (active or passive) POS.

No general requirement currently exists for recreational POS to be provided within industrial areas. It is however necessary to ensure adequate facilities of both active and passive recreation are provided for employees during work hours. As outlined in section 2.7.2, a variety of recreational opportunities exist within the vicinity of the subject site to cater for the needs of employees and visitors frequenting the area.

The SP requires that land designated Public Open Space/Conservation is to be given up by the landowner/applicant free of cost and vested in the CoG. These designated areas will ultimately be owned and managed by the CoG (in accordance with the WCAMS, as outlined in section 2.1.3) and reserved for Local Open Space under the CoG Town Planning Scheme.

2.9 Movement Network

2.9.1 Road Networks

The road network within and surrounding the SP area comprises of:

- Tonkin Highway (*Primary Distributor*)
- Bickley Road (*District Distributor B* and *Local Distributor*)
- Victoria Road (*Access Road*)
- Kelvin Road (*Distributor A*)
- Clifford Street (*Access Road*)
- Kenwick Road (*Access Road*)

These road networks will provide convenient visitor access to the subject site from other regional areas.

2.9.2 Pedestrian/Cycle Network

There is limited pedestrian and cycling infrastructure within the subject site. The adjacent cycle network is currently being reviewed by the WA Department of Transport.

It is proposed that all local road roads will include 2m wide paths, to be constructed on one side of every street. Pedestrian and cycling crossing at intersections will be provided via kerb ramps, and pedestrian refuge will be provided where medians or roundabout splitter islands exist. There is a 3.5m shared path proposed for the western side of Kelvin Road, consistent with the Department of Transport's strategic cycle network for the Perth metropolitan area.

Refer to Figure 13 - Infrastructure Plan – Roads and Footpaths

2.9.3 Public Transport

The subject site is well serviced by existing public transport routes and stops within and surrounding the SP area. The Public Transport Authority (PTA) has advised there are no current plans to change the existing bus route network in the vicinity of the SP area.

Refer to Figure 14 – Local Context Plan – Public Transport

2.9.4 Transport Planning

A Transport Impact Assessment (TIA) has been prepared to support the SP for the MKSEA Precinct 1. This report aims to assess the operations of the proposed development internally and its connections to the adjacent road network with a focus on the traffic operations, access arrangements and road reservations widths. The road network will be designed to accommodate class 4 restricted access vehicles (RAV 4). The SP identifies changes to the existing road network as follows:

- Kenwick Road (between Bickley Road and Kelvin Road) has been realigned and is now connected to Kelvin Road as a left-in, left-out only intersection;
- Kenwick Road and Bickley Road intersection has recently been realigned and modified to a roundabout
- Kenwick Road (east of Kelvin Road) will be closed on both ends and a new road constructed that will connect this section of Kenwick Road to Bickley Road.
- Bickley Road (between Belmont Road and the Bickley/Hanson roundabout) will be terminated at both ends by a cul-de-sac. This road will be upgraded to a residential standard and will not be suitable for industrial vehicles.
- Victoria Road will be terminated at the Bickley Road intersection by a cul-de-sac.

Refer to Appendix N – Transport Impact Assessment

2.10 Water Management

2.10.1 District Water Management Strategy

A District Water Management Strategy (DWMS) (Report on MKSEA Precinct 1 District Water Management Strategy (GHD 2010) was prepared to support the Metropolitan Region Scheme (MRS) rezoning of the MKSEA Precinct 1 from Rural to Industrial.

The objective of the DWMS is to provide key design and management strategies with regards to water usage, water conservation and efficiency, water quantity management, and water quality management within the subject site. The critical aim of the DWMS is to ensure that both water quantity (discharge volume and peak flow) and water quality associated with land use changes resulting from industrial development are maintained to pre-development levels. The Local Water Management Strategy (LWMS) prepared for MKSEA Precinct 1 provides a more comprehensive level of detail regarding water management within the subject site, and addresses issues previously outstanding within the DWMS.

2.10.2 Local Water Management Strategy

A Local Water Management Strategy (LWMS) has been prepared to support the SP for the MKSEA Precinct 1. The LWMS provides the appropriate framework for delivering best practice integrated water cycle management. It is also intended to provide overall guidance for the preparation of future Urban Water Management Plans required through the subdivision and development process. The LWMS has been developed in accordance with the objectives and principles outlined in the overarching DWMS and Better Urban Water Management Guidelines (WAPC 2008). The design objectives and principles of the LWMS also take into account and accommodate the spatial area of the LWMS for the central portion of the MKSEA Precinct 1 which was prepared in accordance with the subdivision and development recently undertaken by a private developer.

The integrated water cycle management approach proposed in the LWMS was informed by a range of investigations into the existing environment (both regional and site specific), including various previous investigations undertaken by government agencies, previous technical studies and investigations into the MKSEA commissioned by the CoG, and recent investigations undertaken by Emerge Associates.

The design objectives of the LWMS propose to deliver best practice outcomes via water sensitive urban design (WSUD). These include a series of detailed management approaches with regards to water consumption, wastewater management, stormwater quantity and quality management, groundwater level and quality management, and wetland management.

The general approach to water consumption and wastewater management is to utilise both groundwater and reticulated scheme water. The subject site operates within the Water Corporation integrated water supply system and therefore will be supplied by scheme water. Water efficiency measures will be encouraged to reduce water requirements.

Stormwater management proposes to treat runoff from small rainfall events as close to source as possible within lots and road reserves to mimic the existing hydrological regime. Detention structures are also required within some post-development catchments to maintain pre-development peak flow rates.

Groundwater management focuses on the maintenance of Maximum Groundwater Level (MGL) by specifying where the invert of treatment and detention structures can be located. These locations should generally follow existing drain inverts so that shallow perched groundwater conditions (which potentially feed the wetland) are not altered. For the majority of Precinct 1, existing soil profiles will provide sufficient depth of sand to facilitate building and pavement construction. Finished flood levels of habitable buildings will need to be protected from groundwater through the use of sand fill.

Non-structural measures (e.g. education) have been proposed to ensure both stormwater and groundwater quality outcomes are met.

In summary, the recommended approach to water management proposed by the LWMS includes:

- Maintain flow regime to the wetland and sensitive environment within the subject site so that the hydrology providing for these areas is maintained.
- Avoid changes to existing groundwater controls so that groundwater conditions are maintained.
- Avoid the need for significant imported fill that could potentially alter catchment hydrology.

- Treatment of road reserve runoff via extended detention/infiltration in swales.
- Lots retain small event runoff (i.e first 15 mm of rainfall) onsite and detain some runoff up to the major event onsite.
- Conveyance of minor and major event runoff from lots and road reserves will be achieved via swales and overland flow within road reserves.
- Minor and major event flows will be detained within swales and detention areas to ensure pre-development peak flows discharging from the MKSEA are maintained.

As a condition of subdivision, developers within the precinct will be required to prepare an Urban Water Management Plan (UWMP). Each UWMP will provide information on the implementation of the LWMS through detailed civil design.

A copy of the LWMS can be found in Appendix K.

Refer to Appendix K – Local Water Management Strategy

2.11 Development Contributions

The City of Gosnells will initiate Amendment No. 170 to establish a Development Contribution Plan (DCP) and Development Contribution Plan Report (DCPR) for Precinct 1 of the MKSEA. The DCP will provide a mechanism by which development contributions can be collected for common infrastructure items and land required for public purposes necessary to support the development of the area.

3. Conclusion

The City of Gosnells has prepared a Structure Plan for Precinct 1 of the Maddington Kenwick Strategic Employment Area (MKSEA) in order to facilitate the future land use, subdivision and development of the land area bound by Bickley Road, Victoria Road and the Tonkin Highway, within the suburbs of Maddington and Kenwick. The SP and supporting report demonstrates how the proposal accords with State and Local Government provisions and represents the orderly and proper planning for the area, including optimising the subdivision and development potential for the site whilst providing protection and conservation of wetlands and associated flora and fauna, and ensuring the provision of passive public open space.

The key objectives of the proposal are to:

- rationalise private and public land uses having regard for buffer areas associated with environmentally sensitive areas;
- ensure adequate land is reserved for drainage purposes;
- ensure the orderly and proper subdivision of all lots within the SP area whilst optimising the development potential of the subject site;
- ensure the road configuration considers the existing regional road networks;
- ensure the internal road layout applies a modified grid pattern road system following *Development Control Policy 4.1 – Industrial Subdivision;*
- increase the level of employment self-sufficiency and self-containment within the locality;
- provide public open space (POS) to act as a buffer for the protection and conservation of wetlands and associated flora and fauna.

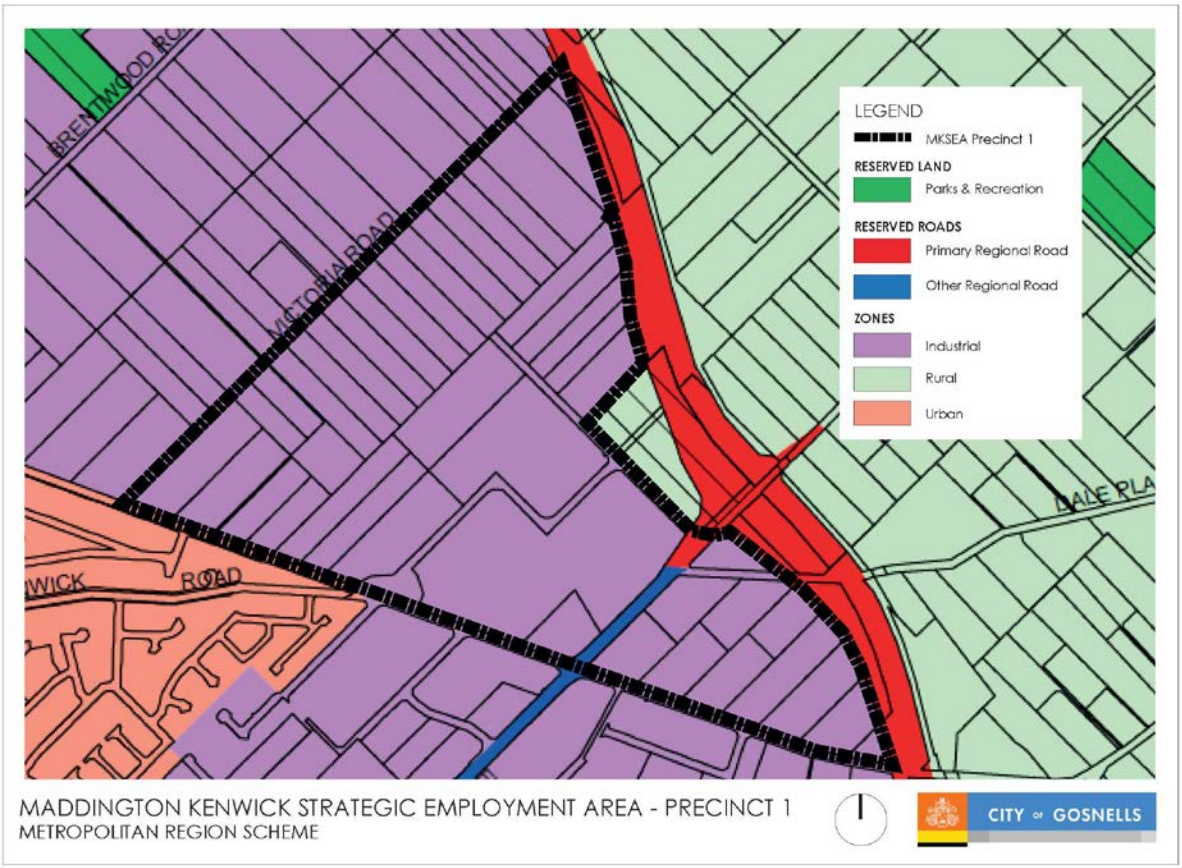


Figure 7 – Metropolitan Region Scheme

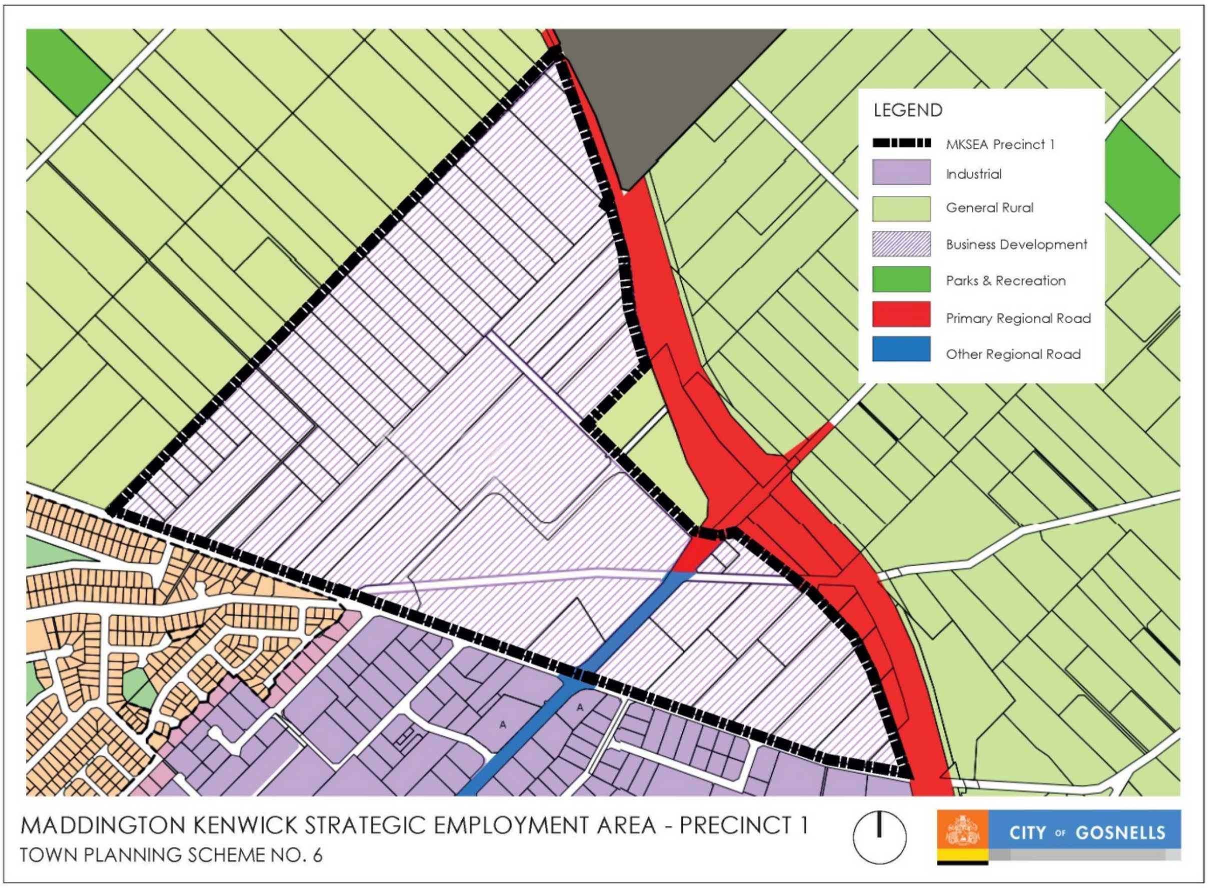


Figure 8 – Town Planning Scheme No. 6

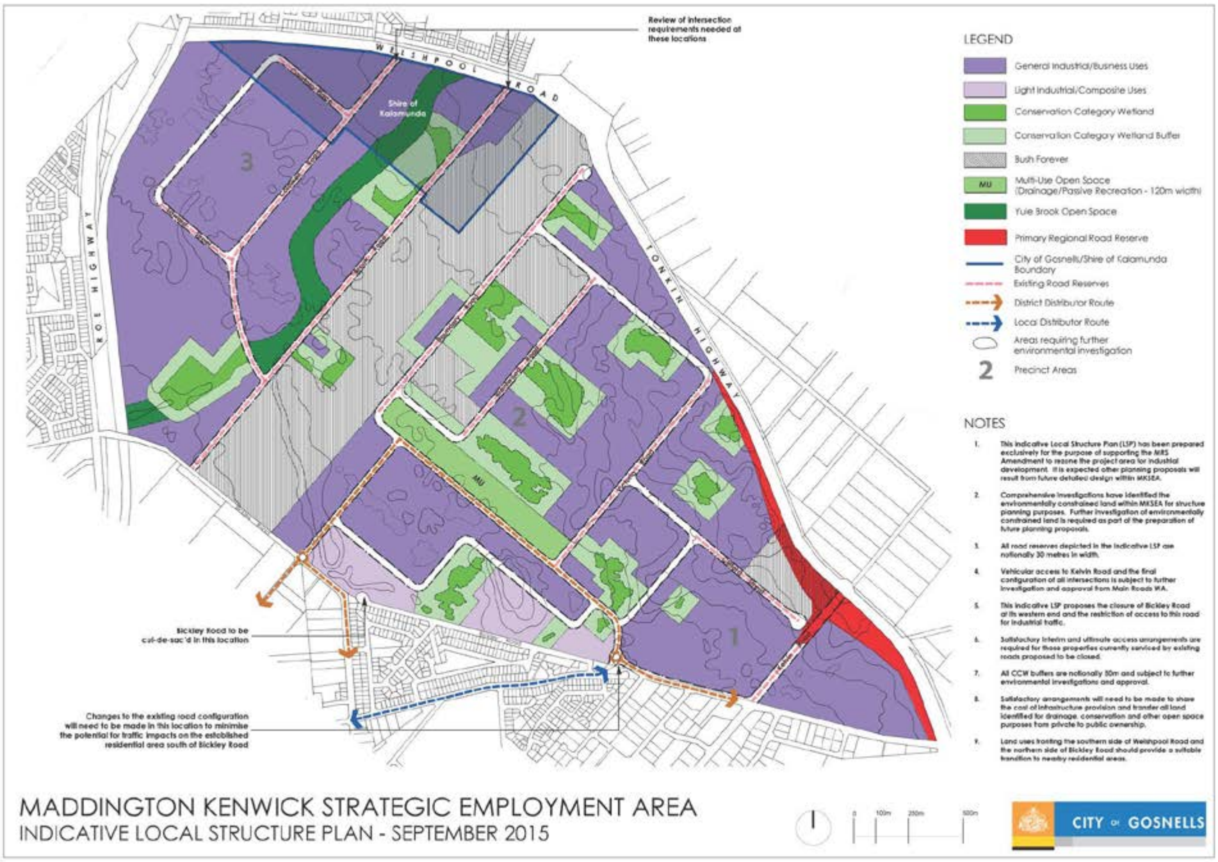
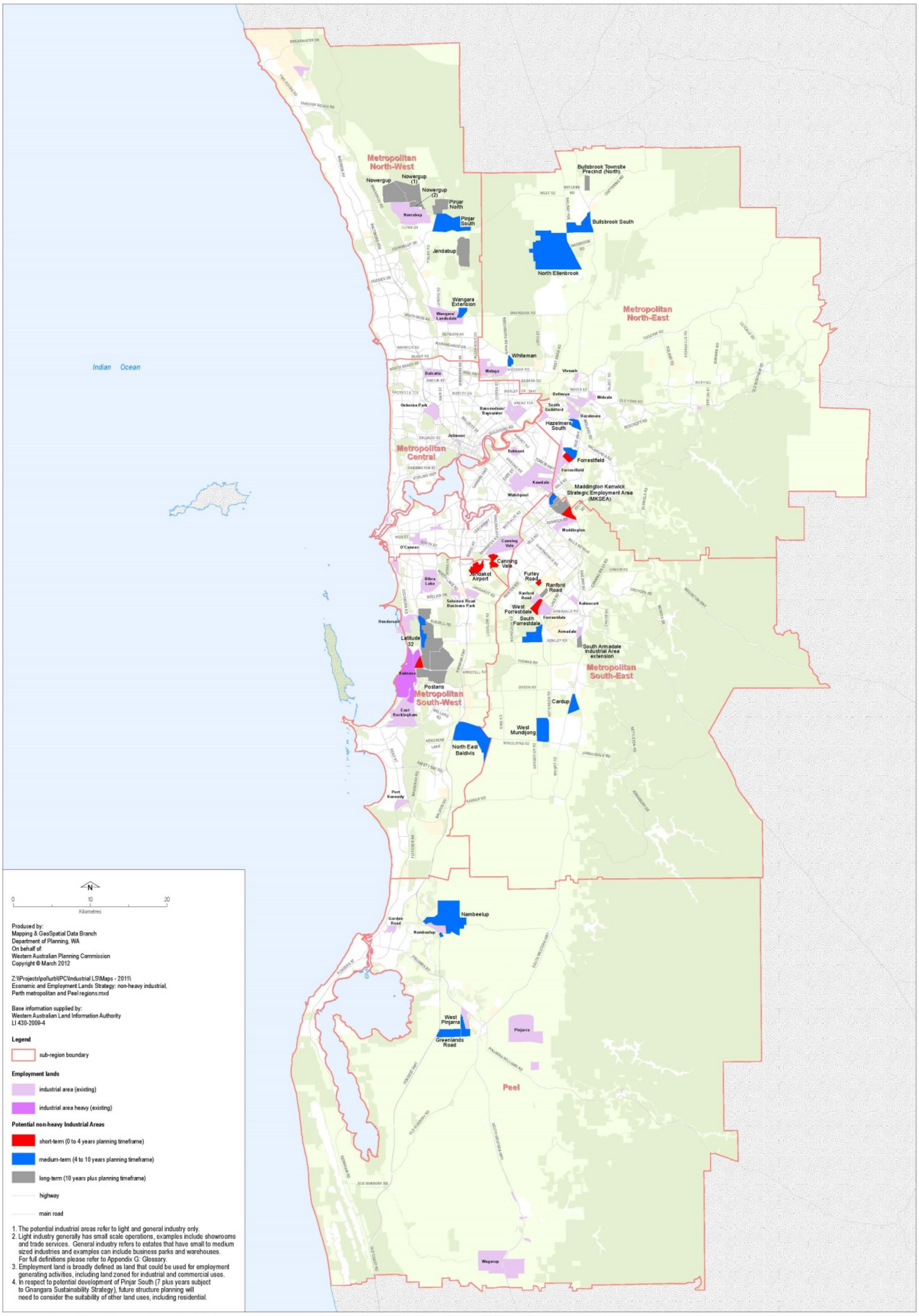


Figure 9 – MKSEA Indicative Local Structure Plan (2015)



Economic and Employment Lands Strategy: non-heavy industrial, Perth metropolitan and Peel regions

Figure 10 – Economic and Employment Lands Strategy

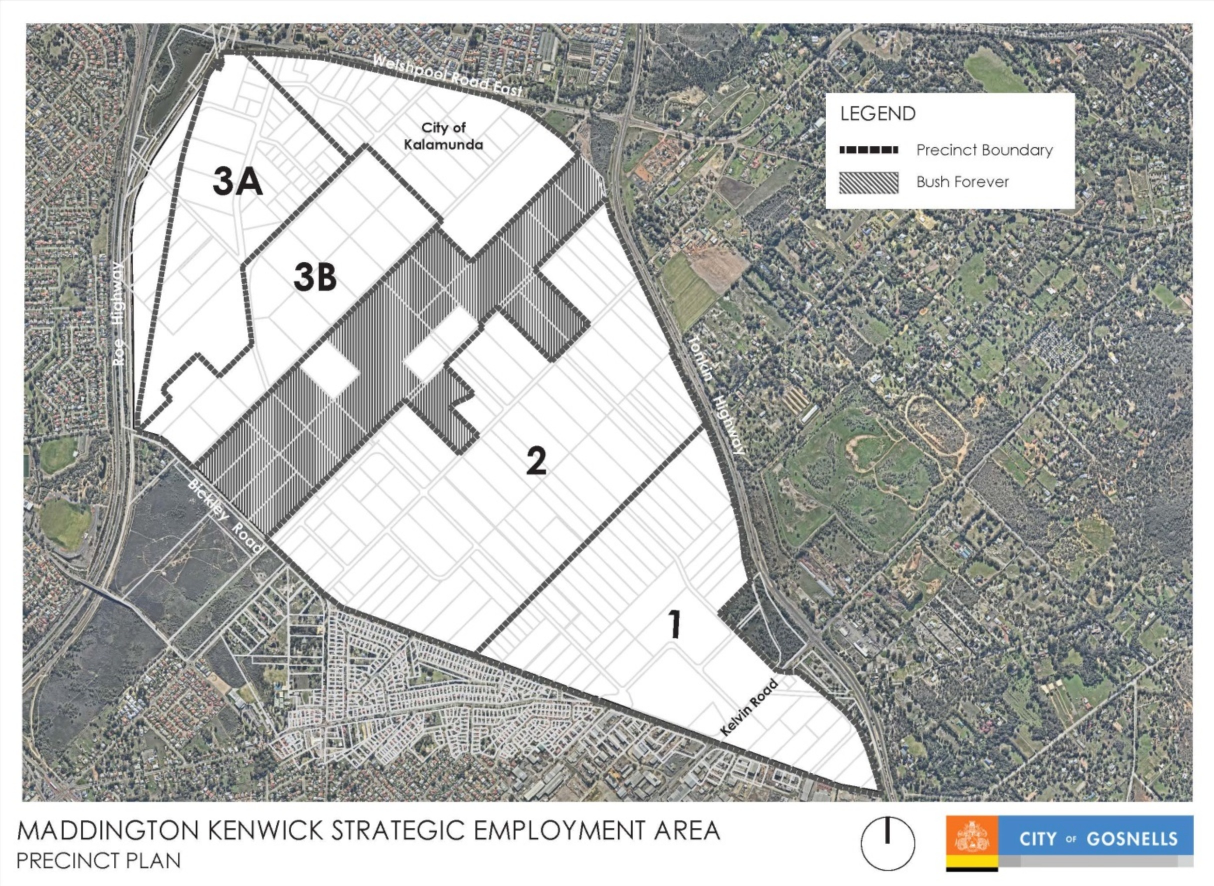


Figure 11 – MKSEA Precinct Plan

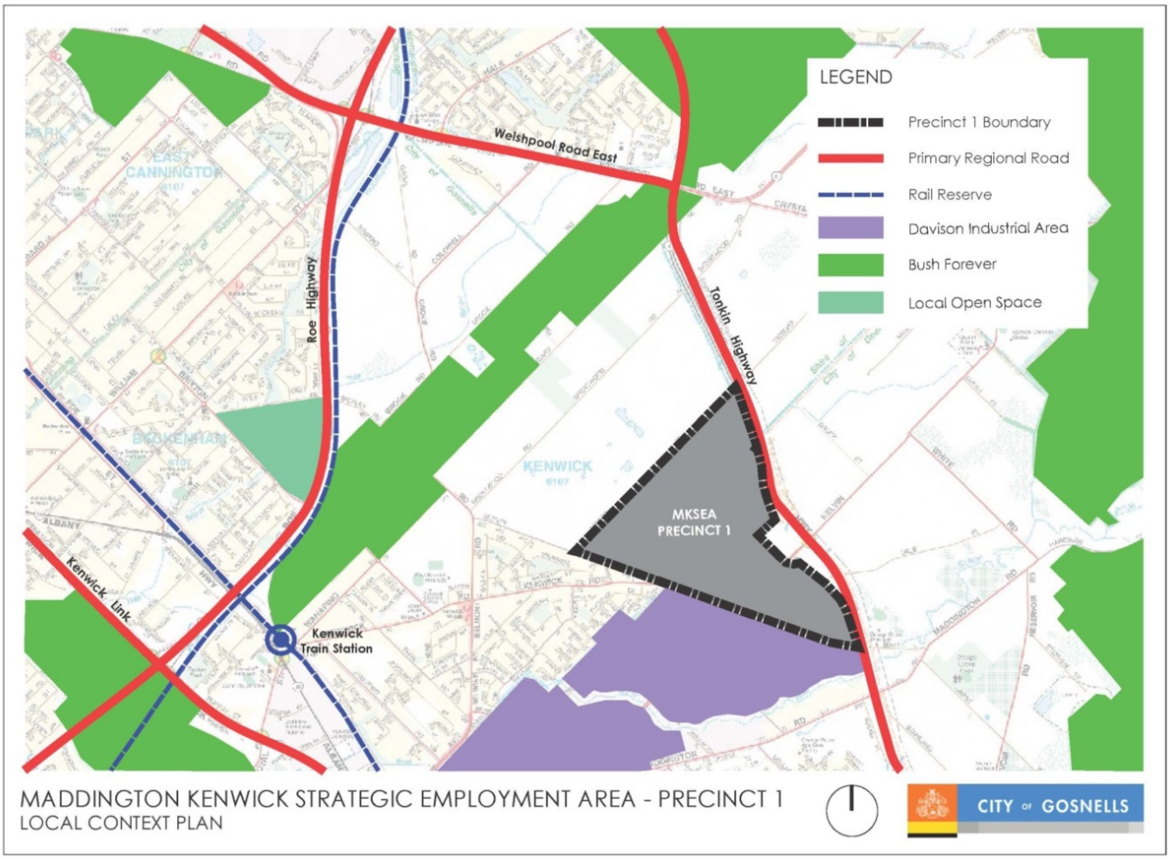


Figure 12 – Local Context Plan

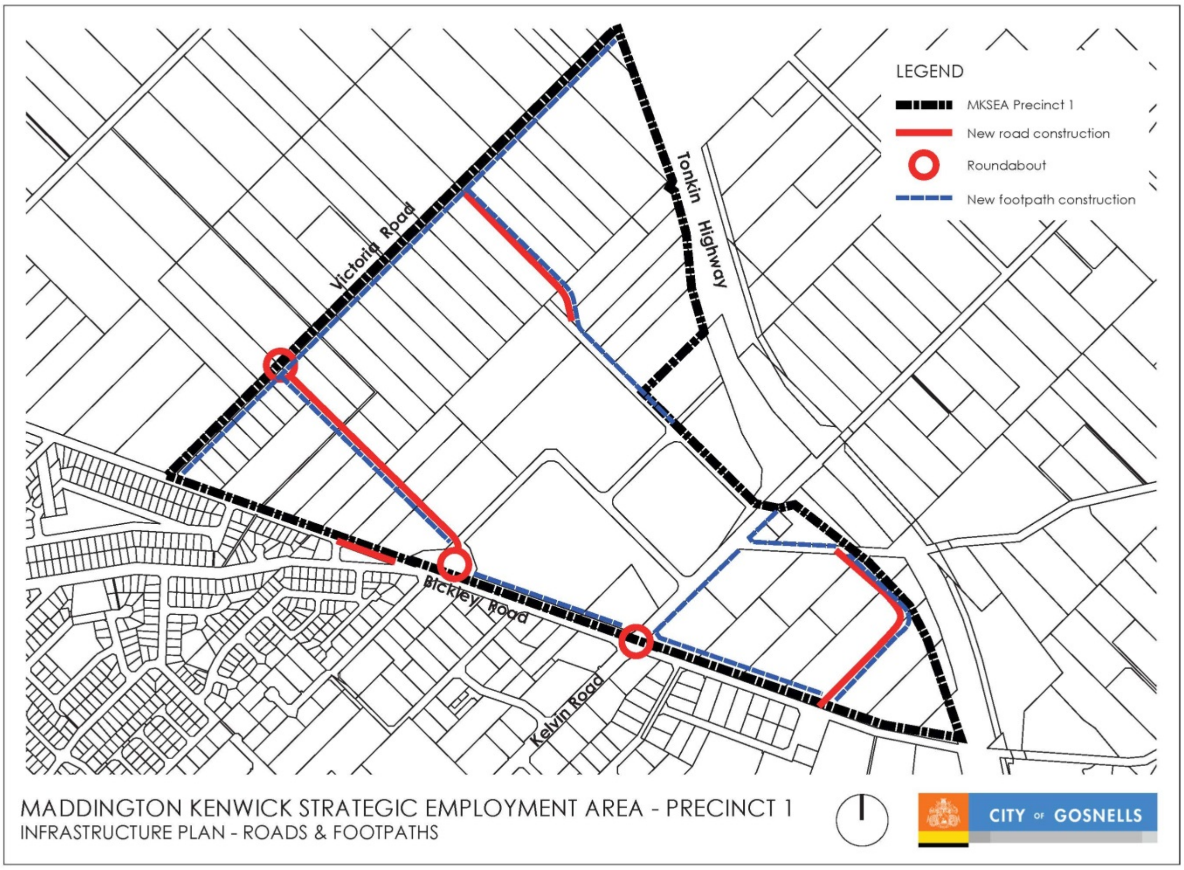


Figure 13 – Infrastructure Plan – Roads and Footpaths

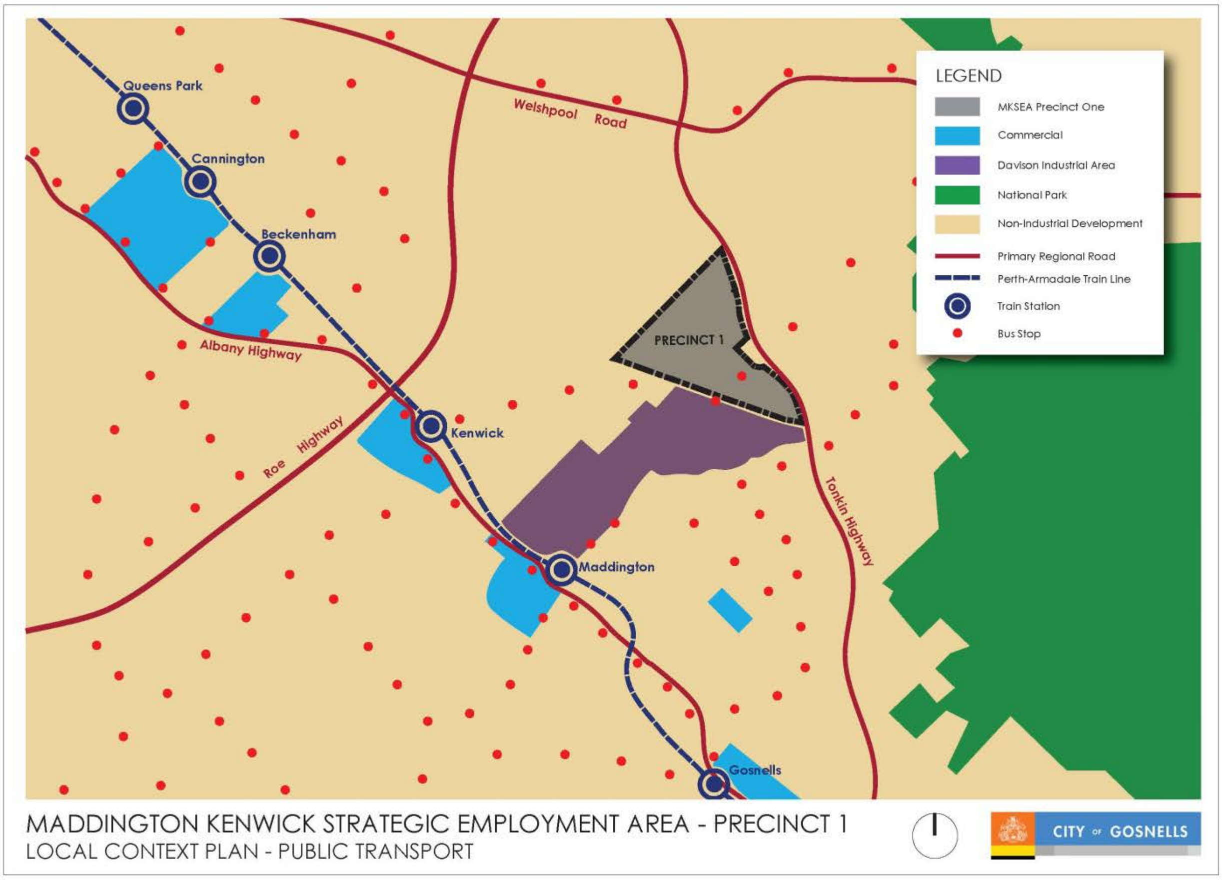


Figure 14 – Local Context Plan – Public Transport

References

Legislation

Aboriginal Heritage Act 1972

Biodiversity Conservation Act 2016

Bush Fires Act 1954

Contaminated Sites Act 2003

Environmental Protection Act 1986

Environment Protection and Biodiversity Conservation Act 1999

Environmental Protection (Clearing of Native Vegetation) Regulations 2004

Planning and Development (Local Planning Scheme) Regulations 2015

Wildlife Conservation Act 1950

General References

Australian Cultural Heritage Management 2018, *Final Report for the Aboriginal Heritage Impact Assessment of the City of Gosnells MKSEA Planning Scheme Oct 2018. Whadjak Noongar Heritage Site Investigation and Survey*

Cardno 2019, *MKSEA Precinct 1 Structure Plan Transport Impact Assessment. MKSEA Traffic Study*

City of Gosnells (CoG) 2014, *Natural Areas: Rehabilitation and revegetation guidelines*

City of Gosnells (CoG) 2014*, Public Open Space Strategy*

City of Gosnells (CoG) 2017*, Council Policy 6.2.2: Rehabilitation and revegetation of natural areas*

Department of Aboriginal Affairs (DAA) 2013*, Aboriginal Heritage Due Diligence Guidelines (Version 3.0)*

Emerge Associates 2018, *Acid Sulfate Soil Investigation Maddington Kenwick Strategic Employment Area Precincts 1, 2 and 3B*

Emerge Associates 2019, *Environmental Assessment and Management Strategy – Maddington Kenwick Strategic Employment Area Precinct*

Emerge Associates 2019, *Flora, Vegetation and Wetland Assessment - Maddington Kenwick Strategic Employment Area Precinct 1*

Emerge Associates 2019, *Local Water Management Strategy Maddington Kenwick Strategic Employment Area - Precinct 1*

Urbaqua 2019, *Bushfire Management Plan, Maddington Kenwick Strategic Employment Area – Precinct 1*

Western Australian Planning Commission (WAPC) 2008*, Better Urban Water Management, Perth*

Western Australian Planning Commission (WAPC) 2012*, Economic and Employment Lands Strategy: non-heavy industrial Perth metropolitan and Peel regions*

Western Australian Planning Commission (WAPC) 2015, *Planning and Development (Local Planning Schemes) Regulations 2015 Structure Plan Framework*

Western Australian Planning Commission (WAPC) 2017*, Model Subdivision Conditions Schedule*

State Planning Commission (SPC) 1988, *Development control policy 4.1 – Industrial subdivision*

Western Australian Planning Commission and Department of Planning (WAPC and DoP) 2015*, State Planning Policy 3.7 Planning in Bushfire Prone Areas*

Western Australian Planning Commission and Department of Planning, Lands and Heritage (WAPC and DPLH) 2018*, Perth and Peel@3.5 Million*

4. Technical Appendices

Appendix A MKSEA Precinct 1 Structure Plan Map

MADDINGTON KENWICK STRATEGIC EMPLOYMENT AREA

Draft Local Structure Plan - Precinct One

City of Gosnells

ISSUE	DESCRIPTION	YYMMDD	DRAWN	APPV'D
N	Precinct One	190329	AD	AD

PROJECT MKSEA
CLIENT COG
SCALE 1:4000 SHEET A1
DRAWING NUMBER UD 001 REV N

CITY OF GOSNELLS

Appendix B Environmental Assessment and Management Strategy

emerge
ASSOCIATES
Integrated Science & Design

Environmental Assessment and Management Strategy

Maddington Kenwick Strategic Employment Area

Precinct 1

Project No: EP17-010(09)

Prepared for City of Gosnells
April 2019

Document Control

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Doc no.:	EP17-010(09)--029				
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	Updated to reflect changes to draft Local Structure Plan and the enactment of the Biodiversity Conservation Act 2016. Final report submitted to client.				
1E	April 2019	Sean Moylan	SCM	Ashley Bird	ALB
	Updated to reflect changes to draft Local Structure Plan. Final report submitted to client.				

Executive Summary

This *Environmental Assessment and Management Strategy* (EAMS) has been prepared on behalf of the City of Gosnells (CoG) for Precinct 1 of the Maddington Kenwick Strategic Employment Area (MKSEA). The CoG has prepared the draft Maddington Kenwick Strategic Employment Area Local Structure Plan (LSP), presented in **Appendix A**, which outlines the proposed industrial development of Precinct 1, in addition to the broader MKSEA region.

This EAMS has been prepared to address the requirements of the Western Australian Planning Commission's (WAPC) *Structure Plan Framework* (WAPC 2015) to support the preparation and implementation of the draft LSP. This report provides a synthesis of information from a range of sources regarding the environmental features, attributes and values of Precinct 1.

A range of site-specific environmental investigations have been completed to date, the results of which are discussed in this EAMS, including:

- *Flora, Vegetation and Wetland Assessment* (Emerge Associates 2019a) (**Appendix C**)
- *Fauna Assessment* (Harewood 2018) (**Appendix D**)
- *Local Water Management Strategy* (Emerge Associates 2019b)
- *Acid Sulfate Soil Investigation* (Emerge Associates 2018)
- *Geotechnical Investigation Report* (JDSi 2018)

The site comprises a total area of approximately 121 ha and is comprises in excess of 50 separate land parcels of various ownership. The majority of Precinct 1 is zoned 'Industrial' under the Metropolitan Region Scheme (MRS) and 'Business Development' under the CoG Town Planning Scheme (TPS) No. 6, with remaining areas associated with existing roads reserved for either 'Primary Regional Roads' or 'Other Regional Roads' under the MRS.

The relevant environmental attributes and values of Precinct 1 are summarised as follows:

- The majority of Precinct 1 has been historically cleared to allow for agricultural activities.
- Topography across Precinct 1 is relatively uniform, with elevation ranging between 12 and 28 m Australian Height Datum (m AHD).
- Overall, flora and vegetation values within Precinct 1 have been subject to historical degradation, resulting in over 96% of vegetation within Precinct 1 identified as being in 'completely degraded' condition on the Keighery (1994) vegetation condition scale.
- Twelve native plant communities were identified within Precinct 1, with vegetation condition within these communities ranging from 'degraded' to 'very good'.
- Two Threatened Ecological Communities (TECs) were identified within Precinct 1. These are SCP3a *'Corymbia calophylla – Kingia australis* woodlands on heavy soils of the Swan Coastal Plain' and SCP20a 'Banksia woodlands of the Swan Coastal Plain (*Banksia attenuata* woodlands over species rich dense shrublands'.
- One priority flora species, *Lepyrodia curvescens* (P2) was identified as possibly occurring within Precinct 1.
- Vegetation within the two TECs represent the most significant fauna habitat values within Precinct 1, with the majority of the habitat values significantly reduced due to historical clearing.

- Three species of conservation significance were positively identified as utilising Precinct 1, forest red-tailed black cockatoo, Carnaby's black cockatoo and Baudin's black cockatoo.
- Twelve multiple use wetlands (MUW) and one resource enhancement wetland (REW) were identified as occurring within Precinct 1. A portion of the REW was identified as containing values that support its reclassification to a conservation category wetland (CCW).
- No Registered Aboriginal Heritage Sites or Other Heritage Places are mapped within Precinct 1.
- The site is classified as having a moderate to low risk of acid sulfate soils (ASS) occurring within 3 m of the natural soil surface.
- There are no existing land uses in proximity to Precinct 1 which are incompatible with its proposed industrial land use.

The draft LSP has responded to the environmental values and attributes of Precinct 1, with the proposed spatial responses and future management discussed in **Section 4**, and summarised in **Table ES1**.

Table ES1: Environmental attributes and values present within Precinct 1 and the draft Local Structure Plan response

Environmental attributes and values present within Precinct 1	Structure Plan Response
Flora and vegetation: Priority flora	The draft LSP provides for the future retention of a possibly occurring priority flora species, through the incorporation of its likely location within the proposed conservation category wetland boundary and the provision of buffers around these areas.
Flora and vegetation: Threatened ecological communities	The draft LSP provides for the future retention of threatened ecological communities, through their incorporation within the proposed conservation category wetland boundary (SCP3a), and conservation area (SCP20a), and the provision of buffers around these areas.
Fauna	The draft LSP provides for the future retention of vegetation that provides significant fauna habitat, through its incorporation within the proposed conservation category wetland boundary and the provision of buffers around these areas.
Wetlands	The draft LSP provides for the future retention of the conservation category wetlands and the provision of buffers around them.
Hydrology	The draft LSP provides for the conveyance of minor and major event runoff from lots and road reserves through the provision of appropriately sized roads to accommodate swales. In addition, the provision of drainage basins will ensure pre-development peak flows discharging from the MKSEA are maintained through the detention of major and minor event flows. The implementation of Precinct 1's Local Water Management Strategy will ensure groundwater continues to perch on a seasonal basis, so maintaining the existing wetlands.

This EAMS also outlines the environmental framework to be implemented across Precinct 1 as part of future subdivision and development phases of the industrial process, including:

- Preparation and implementation of Interim and Final Wetland and Conservation Area Management Plans for each public open space area identified in the draft LSP. Each plan will outline the management requirements for the wetland and conservation area and its associated environmental values.

- Preparation and implementation of a Fauna Relocation and Management Plan (or similar) prior to any ground disturbing works which may impacts upon fauna species or associated habitat.
- Preparation of an Urban Water Management Plan to support each stage of subdivision.
- Consideration of potential requirement for a clearing permit.
- The potential requirement for an Acid Sulfate Soil and Dewatering Management Plan (ASSDMP) based on future investigations, if required.

Overall, the environmental attributes and values of Precinct 1 can be accommodated within the draft LSP design or can be managed appropriately through the future subdivision and development phases in line with the relevant state and local government legislation, policies and guidelines.

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Appendix D

Fauna Assessment (Harewood 2018)

Appendix E

City of Gosnells: Specifications for Conservation Area Fencing

List of Abbreviations

Table A1: Abbreviations – General terms

General terms	
AASS	Actual Acid Sulfate Soil
AHD	Australian Height Datum
ASS	Acid Sulfate Soil
ASSDMP	Acid Sulfate Soil and Dewatering Management Plan
CCW	Conservation Category Wetland
DBH	Diameter at Breast Height
DWMS	District Water Management Strategy
EAMS	Environmental Assessment and Management Strategy
ESA	Environmentally Sensitive Area
IBRA	Interim Biogeographic Regionalisation of Australia
LWMS	Local Water Management Strategy
MNES	Matters of National Environmental Significance
MUW	Multiple Use Wetland
PASS	Potential Acid Sulfate Soil
PEC	Priority Ecological Community
PDWSA	Public Drinking Water Source Area
REW	Resource Enhancement Wetland
TEC	Threatened Ecological Community
WCAMP	Wetland and Conservation Area Management Plan
UWMP	Urban Water Management Plan

Table A2: Abbreviations – Legislation and policies

Legislation and policies	
BC Act	*Biodiversity Conservation Act 2016*
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
LPP	*Local Planning Policy*

Table A3: Abbreviations – Organisations

Organisations	
CoG	City of Gosnells
DBCA	Department of Biodiversity Conservation and Attractions
DoEE	Department of Environment and Energy
DoW	Department of Water (now known as Department of Water and Environmental Regulation)
DPAW	Department of Parks and Wildlife (now known as Department of Biodiversity Conservation and Attractions)
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority
WAPC	Western Australian Planning Commission

Table A4: Abbreviations – Planning and building terms

Planning and building terms	
LSP	Local Structure Plan
MKSEA	Maddington Kenwick Strategic Employment Area
MRS	Metropolitan Region Scheme
TPS	Town Planning Scheme

1 Introduction

1.1 Background

The City of Gosnells (CoG) has prepared a draft Local Structure Plan (LSP) to guide the future industrial development of the Maddington Kenwick Strategic Employment Area (MKSEA), which is provided in **Appendix A**. The MKSEA is divided into a number of planning precincts, as shown in **Figure 1**, of which Precinct 1 is the subject of this report.

Precinct 1 of the MKSEA, is approximately 121 hectares (ha) in size and is situated approximately 15 km south-east of Perth, within the CoG, see **Figure 1**. Precinct 1 is generally bound by Bickley Road, Victoria Road and Tonkin Highway, and comprises a number of separate land parcels in various ownerships. Precinct 1 does not include Bush Forever Site 53 'Clifford Street Bushland', which is situated adjacent to its north-eastern boundary.

The majority of Precinct 1 is zoned 'Industrial' under the Metropolitan Region Scheme (MRS) and 'Business Development' under the CoG Town Planning Scheme (TPS) No. 6, with remaining areas, associated with existing roads, reserved for either 'Primary Regional Roads' or 'Other Regional Roads' under the MRS, as shown in **Plate 1**. The majority of Precinct 1 has been historically cleared to support a range of rural land uses, and more recently parts of it have been developed to support light industrial land uses.

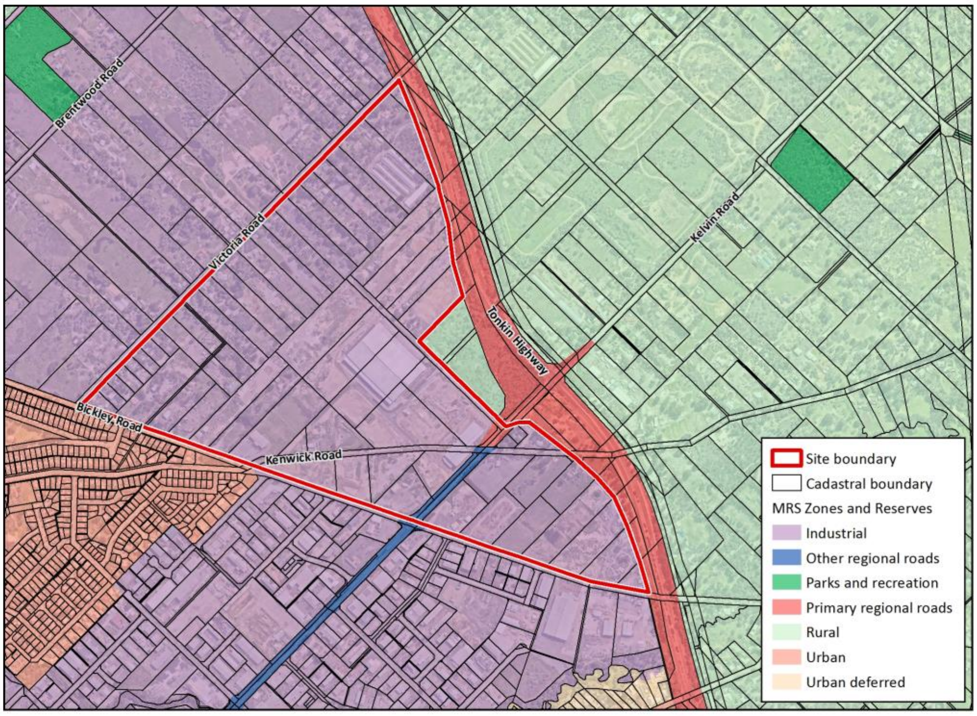

Plate 1: MRS zones and reserves surrounding Precinct 1 (DPLH 2018)

1.2 Purpose of this report

The draft LSP has been prepared by the CoG to support and guide future industrial development within Precinct 1. Following the approval of the draft LSP, industrial development will likely be delivered through subdivision approvals and/or development applications, in accordance with its layout.

The purpose of this Environmental Assessment and Management Strategy (EAMS) is to support the preparation and lodgement of the LSP documentation. The EAMS is the principal supporting environmental document for the LSP process, providing a synthesis of information regarding the environmental values and attributes of Precinct 1. It is consistent with the Western Australian Planning Commission's (WAPC) *Structure Plan Framework* (WAPC 2015) and it:

- identifies and assesses the existing environmental values and attributes of Precinct 1 (**Section 2**)
- discusses the land use planning context and the proposed LSP (**Section 3**)
- discusses how the draft LSP design responds to the existing environment and outlines the proposed future environmental management strategy (**Section 4**)
- describes how the environmental management strategy will be implemented (**Section 5**)
- summaries the draft LSP's response to the existing environmental values and attributes of Precinct 1 (**Section 6**).

1.3 Assessment scope

To inform the EAMS, Emerge Associates was engaged by the CoG to undertake a range of environmental investigations and assessments across Precinct 1, and prepare various environmental management strategies, as outlined in **Table 1**.

The EAMS has incorporated the outcomes of these investigations, assessments and strategies, to provide an overarching environmental assessment of Precinct 1. It documents the existing environmental attributes and values and ensures that significant ones can be accommodated within the LSP, and at future stages of development.

Table 1: Environmental investigations, assessments and strategies undertaken/prepared

Component	Purpose	Relevant EAMS section/s
Level 1 terrestrial vertebrate and avian fauna assessment	To assess and document the existing terrestrial vertebrate and avian fauna habitat values and known species occurrences within Precinct 1. This assessment builds on the outcomes of previously completed fauna investigations, where these are applicable to Precinct 1.	**Section 2.2.2**. The *Fauna Assessment* (Harewood 2018) report is provided in **Appendix D**.
Detailed vegetation and targeted flora assessment	To assess and document the existing flora and vegetation values within Precinct 1, including the assessment of wetland boundaries and management categorisations. This assessment builds on the outcomes of previously completed flora, vegetation and wetland investigations, where these are applicable to Precinct 1.	**Section 2.2.1** *Flora, Vegetation and Wetland Assessment* (Emerge Associates 2019a) report is provided in **Appendix C**.
Wetland Buffer Study	To determine appropriate wetland buffer distances and provide guidance on appropriate land uses for buffer zones to inform the LSP.	**Section 4.4.2**
Wetland and Conservation Area Management Strategy	To provide guidance on the management strategy for proposed areas of public open Space that will contain conservation category wetlands and conservation areas. This strategic-level management framework will inform future Wetland and Conservation Area Management Plans.	**Section 5.1**
Rare Flora Management Strategy	To provide guidance on the management requirements for occurrences of Rare Flora. Given the location of Rare Flora occurrences within wetland and conservation areas, this is to be addressed as part of the Wetland and Conservation Area Management Strategy.	**Section 5.1**
Threatened Ecological Community Management Strategy	To provide guidance on the management requirements for occurrences of Threatened Ecological Communities. Given the location of Threatened Ecological Community occurrences within wetland and conservation areas, this is to be addressed as part of the Wetland and Conservation Area Management Strategy.	**Section 5.1**

In addition to this EAMS, the following documents, specific to Precinct 1, have been prepared or commissioned to support the LSP:

- *Local Water Management Strategy* (Emerge Associates 2019b)
- *Acid Sulfate Soil Investigation* (Emerge Associates 2018)
- *Flora, Vegetation and Wetland Assessment* (Emerge Associates 2019a)
- *Geotechnical Investigation Report* (JDSi 2018)

The CoG has also previously commissioned a range of environmental studies and investigations across the broader MKSEA. These have supported the strategic land use planning process completed to date and aided the understanding of the environmental attributes and values of the area. The reports associated with these studies and investigations include:

- *MKSEA Environmental Review: Flora, Vegetation, Fauna and Wetlands* (Cardno BSD 2005)
- *MKSEA Engineering Feasibility Study* (GHD 2005)
- *MKSEA Preliminary Transport Study* (Cardno BSD 2006)
- *MKSEA Surface Water and Groundwater Investigation and Monitoring Program* (Aquaterra 2008)
- *Preliminary Investigation of Aboriginal Heritage – City of Gosnells MKSEA* (ACHM 2009)
- *Report on MKSEA Precinct 1 District Water Management Strategy* (GHD 2010)
- *The Flora, Vegetation and Wetlands of the MKSEA* (Tauss and Weston 2010)
- *Black Cockatoo Survey - MKSEA* (360 Environmental 2012)
- *MKSEA Surface Water and Groundwater Monitoring and Investigation Report* (Endemic 2012)
- *District Water Management Strategy MKSEA Precincts 2 and 3* (TME 2014)
- *MKSEA Bushfire Hazard Assessment* (Eco Logical 2014)

2 Existing Environment

The outcomes of previously completed investigations, in addition to further site-specific targeted investigations undertaken by Emerge Associates, have informed the identification and assessment of the existing environmental attributes and values within Precinct 1 and are discussed in further detail below.

2.1 Landform and soils

2.1.1 Topography

Precinct 1 slopes generally to the west, with its elevation ranging from approximately 12 m Australian Height Datum (AHD) in the south-west to 28 m AHD in the north-east (DoW 2008), see **Figure 2**.

2.1.2 Landform, soils and geology

Regional soil association mapping indicates that the majority of Precinct 1 occurs within the Guildford soil association, with the south-eastern corner encompassing the Forrestfield soil association (Churchward and McArthur 1980). Based on regional landform mapping of the Swan Coastal Plain (Gozzard 2011), the majority of Precinct 1 is located within the Pinjarra Plain, with the north-eastern portion in the Piedmont Zone (also called the Ridge Hill Shelf). The Pinjarra Plain lies between the Bassendean Dunes and the Piedmont Zone and comprises a relatively flat landscape of fertile heavy alluvial soils. The Pinjarra Plain is dominated by channels which, when combined with the flatness of the plain and underlying soil characteristics, results in the formation of small seasonal swamps (Seddon 2004).

The Geological Survey of Western Australia, as documented in *Perth Metropolitan Region 1:50,000 Environmental Geology Series Armadale Part Sheets 2033 I & 2133 IV* (Jordan 1986), indicates that Precinct 1 is underlain by the Guildford Formation, and is comprised of 'Sandy Clay' (C_S), 'Sand' (S_8), 'Sand' (S_{10}) and 'Sand' (S_{12}). The general description of these soil units is provided in **Table 2** and their extent is shown in **Figure 3**.

Table 2: Environmental geology of Precinct 1

MAP UNIT	DESCRIPTION
(C_S)	Silty in part, pale grey-brown, medium to coarse, poorly sorted, sub-angular to rounded, frequent heavy minerals, rare feldspar, of alluvial origin.
(S_8)	White to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin.
(S_{10})	White to pale grey at surface, yellow at depth, fine to medium-grained, moderately well sorted, subangular to subrounded quartz, of eolian origin, over other units.
(S_{12})	Dark yellowish orange, medium to coarse, sub-angular to sub-rounded quartz with heavy minerals

Onsite geotechnical investigations across Precinct 1 were undertaken by Douglas Partners in January 2014 and more recently by JDSi in September 2017 (as part of a wider sampling program across other parts of the MKSEA), the sampling locations are shown in **Figure 3**.

The results of Precinct 1 specific geotechnical investigations are generally consistent with regional geological mapping (Douglas Partners 2015; JDSi 2018), indicating that soils underlying Precinct 1 are generally comprised of topsoil (sand) or fill to depths ranging from 0.1 m to 0.45 m, overlying sand, clayey, silty or gravelly materials. The depth of sand overlying less permeable material within Precinct 1 ranged from 0.3 m to over 2 m (JDSi 2018).

Further detail regarding the geotechnical characteristics of Precinct 1, in addition to the complete *Geotechnical Investigation Report* (JDSi 2018), is provided in the *Local Water Management Strategy* (Emerge Associates 2019b).

2.1.3 Acid sulfate soils

Acid sulfate soils (ASS) is the name commonly given to naturally occurring soils and sediment containing iron sulphide (iron pyrite) materials. In their natural state, ASS are generally present in waterlogged anoxic conditions and do not present any risk to the environment. ASS can present issues when oxidised, producing sulphuric acid, which can impart a range of impacts on the surrounding environment, infrastructure and human health.

The Department of Water and Environment Regulation (DWER) provides broad-scale mapping indicating areas of potential ASS risk (DWER 2018). The DWER mapping indicates that Precinct 1 is classified as having a moderate to low risk of ASS occurring within 3 m of the natural soil surface.

A site specific *Acid Sulfate Soil Investigation* (Emerge Associates 2018) was undertaken across the broader MKSEA in September 2017. The investigation determined that the soil types associated with the S_8 or S_{10} environmental geology groups did not present any true indicators of potential acid sulphate soils (PASS) or actual acid sulphate soils (AASS); and that the soil types associated with the C_S environmental geology group presented slight indicators of PASS at limited locations across the MKSEA.

Overall, the risk of ASS occurrence within Precinct 1 is considered to be relatively low based on regional ASS risk mapping (DWER 2018) and the outcomes of site-specific ASS investigations (Emerge Associates 2018). Further information with regard to ASS and their potential occurrence within Precinct 1 is provided in the *Acid Sulfate Soil Investigation* (Emerge Associates 2018).

2.2 Biodiversity and natural area assets

2.2.1 Flora and vegetation

2.2.1.1 Regional context

Native vegetation is described and mapped at different scales in order to illustrate patterns in its distribution. At a continental scale the *Interim Biogeographic Regionalisation of Australia* (IBRA) divides the Swan Coastal Plain into two floristic subregions (Environment Australia 2000).

Precinct 1 is contained within the Perth subregion of the Swan Coastal Plain, which is characterised as mainly containing *Banksia* low woodland on leached sands with *Melaleuca* swamps where ill-drained; and woodland of *Eucalyptus gomphocephala* (tuart), *E. marginata* (jarrah) and *Corymbia calophylla* (marri) on less leached soils (Beard 1990).

At a regional scale, vegetation complex mapping undertaken by Heddle *et al.* (1980) indicates the majority of Precinct 1 occurs within the Guildford Complex, whilst the eastern portion is mapped within the Forrestfield Complex. The descriptions of each complex are detailed in **Table 3**. In 2013, there was 5.87% of the pre-European extent of the Guildford Complex remaining on the Swan Coastal Plain and 11.9% of the Forrestfield Complex (LBP 2013).

Table 3: Regional vegetation complex descriptions (Heddle et al. 1980)

Complex	Description
Guildford	A mixture of open forest to tall open forest of *Corymbia calophylla - Eucalyptus wandoo - Eucalyptus marginata* and woodland of *Eucalyptus wandoo* (with rare occurrences of *Eucalyptus lane-poolei*). Minor components include *Eucalyptus rudis - Melaleuca rhaphiophylla.*
Forrestfield	Vegetation ranges from open forest *of Corymbia calophylla - Eucalyptus wandoo, Eucalyptus marginata* to open forest of *Eucalyptus marginata - Corymbia calophylla, Allocasuarina fraseriana - Banksia* spp. Fringing woodland of *Eucalyptus rudis* in the gullies that dissect this landform.

2.2.1.2 Site-specific surveys and investigations

A number of detailed flora and vegetation surveys have been previously undertaken across the MKSEA, which have incorporated Precinct 1, including:

- *MKSEA Environmental Review: Flora, Vegetation, Fauna and Wetlands* (Cardno BSD 2005)
- *The Flora, Vegetation and Wetlands of the MKSEA* (Tauss and Weston 2010).

In spring 2017 a detailed sampling of vegetation, a targeted flora survey, and a wetland assessment was undertaken across Precinct 1. This assessment builds on the results of previously completed flora, vegetation and wetland assessments across Precinct 1 and is documented in the *Flora Vegetation and Wetland Assessment* (Emerge Associates 2019a). This assessment represents the most up to date and complete record of flora, vegetation and wetland values within Precinct 1 and its outcomes are discussed in detail below. A copy of the assessment report is provided in **Appendix C**.

2.2.1.3 Plant communities

Based on the findings from the *Flora Vegetation and Wetland Assessment* (Emerge Associates 2019a) twelve native plant communities were identified as occurring within Precinct 1. However, the majority of Precinct 1 was observed to be characterised by heavily disturbed areas comprising non-native grasses with occasional native shrubs and trees and planted vegetation, which was not identified as comprising a native plant community.

The description and total extent of each identified plant community within Precinct 1 are provided in **Table 4** and representative photographs of communities are provided in **Plate 2 to 11**. The extent of each plant community within Precinct 1 is shown in **Figure 4**.

Table 4: Plant communities identified within Precinct 1

Community	Description	Area (ha)
AlHa	Low shrubland *Acacia lasiocarpa* and *Hypocalymma angustifolium* over non-native grassland **Eragrostis curvula* over mixed forbland (previously referred to as RS1 (Tauss and Weston 2010)).	0.16
AfDb	Scattered *Allocasuarina fraseriana* over open occasional *Xanthorrhoea preissii* over forbland *Dasypogon bromeliifolius* and non-native grasses	0.03
AfEtBm	*Allocasuarina fraseriana – Eucalyptus todtiana – Banksia menziesii* low woodland over species rich low shrubs (previously referred to as T10 (Tauss and Weston 2010)).	1.19
AfSlDf	Occasional *Allocasuarina fraseriana* over open shrubland *Hibbertia hypericoides* over low shrubland *Stirlingia latifolia* over closed forbland *Desmocladus flexuosus*	0.05
BAf	Open forest *Banksia attenuata* and *Allocasuarina fraseriana* over occasional *Kingia australis* over closed non-native grassland	0.83
Cc	Low open forest *Corymbia calophylla* over (assumed) limited understorey NB: previously referred to as T1 (Tauss and Weston 2010).	0.99
CcHa	Open forest *Corymbia calophylla* over open shrubland *Hypocalymma angustifolium* over non-native grassland	0.41
CcXpMt	Low open forest *Corymbia calophylla* over open shrubland *Xanthorrhoea preissii* and *Hypocalymma angustifolium* over open forbland *Mesomelaena tetragona*	0.35
***EEt**	Forest **Eucalyptus camaldulensis*, *Eucalyptus rudis* and *Eucalyptus todiana* over grassland **Ehrharta calycina*	0.08
EtBmSl	Woodland *Eucalyptus todtiana*, planted *Eucalyptus sp. and *Banksia menziesii* over shrubland *Hibbertia hypericoides* and *Stirlingia latifolia* over forbland *Lomandra sericea*	0.03
Mp	Low open forest *Melaleuca preissiana* over non-native closed grassland	0.19
MrVjLc	Low forest *Melaleuca rhaphiophylla* over scattered *Viminaria juncea* over low open shrubland *Acacia pulchella* and *Hypocalymma angustifolium* over scattered *Leptocarpus canus*	0.09
Non-native vegetation	Heavily disturbed areas comprising non-native grasses with occasional native shrubs and trees and planted vegetation	116.69

* introduced species

*Plate 2: Plant community **AfDb***

*Plate 3: Plant community **AfSlDf***

*Plate 4: Plant community **BAf***

*Plate 5: Plant community **CcHa***

*Plate 6: Plant community **CcXpMt***

*Plate 7: Plant community ***EEt***

*Plate 8: Plant community **EtBmSl***

*Plate 9: Plant community **Mp***

*Plate 10: Plant community **MrVjLc***

Plate 11: Non-native vegetation

2.2.1.4 Vegetation condition

Vegetation condition was assessed by (Emerge Associates 2019a) using methods from Keighery (1994) for the majority of Precinct 1, the descriptions of which are detailed in **Appendix B**. For vegetation containing *Banksia* species, the condition scale provided in the approved conservation advice for the 'Banksia Woodlands of the Swan Coastal Plain' ecological community from the Department of Environment and Energy (DoEE)(2016) was used in addition to the Keighery scale. Descriptions of each of the vegetation condition categories are detailed further in the *Flora, Vegetation and Wetland Assessment* (Emerge Associates 2019a) (**Appendix C**) .

The majority of Precinct 1 (approximately 96%) has been subject to historical disturbance and was determined to be in 'completely degraded' condition, dominated by non-native vegetation. Areas of native vegetation within the remainder of Precinct 1 ranges in condition between 'degraded', 'good' and 'very good', with vegetation in 'degraded' condition dominated by non-native species, due to factors including clearing and fire. Vegetation condition within Precinct 1 is shown in **Figure 5** and detailed in **Table 5**.

Table 5: Extent of vegetation condition categories within Precinct 1

Condition category	Size (ha)
Pristine	0.00
Excellent	0.00
Very Good	0.98
Good	0.07
Degraded	3.27
Degraded – completely degraded	0.08
Completely Degraded	116.69

2.2.1.5 Threatened Ecological Communities

Generally, ecological communities can be described as vegetation communities that are assemblages of species that occur together in a particular type of habitat. An ecological community's structure, composition and distribution are determined by a range of environmental factors. 'Threatened ecological communities' (TECs) are ecological communities that are recognised as rare or under threat and therefore warrant special protection.

Selected TECs are afforded statutory protection at a Commonwealth level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). TECs listed under the EPBC Act are categorised as either 'critically endangered', 'endangered' or 'vulnerable'. Any action likely to have a significant impact on a TEC listed under the EPBC Act requires approval from the Commonwealth Minister for the Environment.

At the state level, the recently proclaimed *Biodiversity Conservation Act 2016* (BC Act) provides for direct statutory acknowledgement and protection for TECs. However, although the BC Act's regulations have enacted the provisions relating to TECs, at time of writing, no TECs have been formally listed under the BC Act. Therefore, TECs contained on a list endorsed by the Minister for the Environment are considered through state approval processes, such as the environmental impact assessment process pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* pursuant to Part V of the EP Act.

It is expected that those TECs to be listed under the BC Act will be consistent with those currently on the list endorsed by the Minster for the Environment.

Where an ecological community is under consideration for listing as a TEC, but it does not yet meet survey criteria or has not been adequately defined, or it is rare but not currently threatened, it is identified as a 'priority ecological community' (PEC). PECs are also considered through the above state environmental approvals process.

Appendix B provides detailed descriptions as to the definitions and categories of TECs.

As part of the *Flora Vegetation and Wetland Assessment* (Emerge Associates 2019a), a desktop study was undertaken to review previous surveys conducted within Precinct 1 and DBCA records of previously recorded TECs and PECs. In the context of this information, site-specific flora and vegetation investigations further refined existing TEC and PEC mapping. Based on the outcomes of these desktop and site-specific investigations, two TECs were identified as occurring within Precinct 1, as listed below in **Table 6** and shown in **Figure 6**.

Table 6: TECs identified within Precinct 1

Plant community	TEC code	TEC name	Level of significance		Area (ha)	Vegetation condition
			State	EPBC Act		
CcXpMt	SCP3a	*Corymbia calophylla – Kingia australis* woodlands on heavy soils of the Swan Coastal Plain	Critically Endangered	Endangered	0.35	Very good,
AfEtBm AFDb	SCP20a	Banksia woodlands of the Swan Coastal Plain (*Banksia attenuata* woodlands over species rich dense shrublands)	Endangered	Endangered	1.22	Very good, Degraded

Further information regarding the occurrence of TECs within Precinct 1 is detailed within the *Flora Vegetation and Wetland Assessment* (Emerge Associates 2019a), provided in **Appendix C**.

2.2.1.6 Significant flora

Certain flora species that are considered to be rare or under threat warrant special protection under state and/or federal legislation. At a federal level, flora species may be listed as 'threatened' pursuant to the EPBC Act and any action likely to have a significant impact on a listed threatened species requires approval from the Commonwealth Minister for the Environment.

At a state level, plant species could formerly be classed as threatened flora (TF) under the WC Act. The recently proclaimed BC Act has replaced the WC Act and provides increased statutory protection for these TF. Species which were potentially rare or threatened, or meet the criteria for near threatened, or had recently been removed from the threatened species list were classed as 'priority' flora (PF) species.. **Appendix B** provides detailed descriptions as to the definitions and categories of threatened and priority flora currently utilised by DBCA.

As part of the *Flora Vegetation and Wetland Assessment* (Emerge Associates 2019a), a desktop study was undertaken to review previous surveys conducted within Precinct 1 and DBCA records of previously recorded Threatened Flora and Priority Flora. In the context of this information, site-specific flora and vegetation investigations included additional searches for Threatened Flora and Priority Flora identified as being likely to occur within Precinct 1. Based on the outcomes of these desktop and site-specific investigations, one priority flora species, *Lepyrodia curvescens* (P2), is identified as possibly occurring within Precinct 1, the location of which is shown in **Figure 6**.

The occurrence of *Lepyrodia curvescens* was identified by Tauss and Weston (2010), and whilst it was not recorded by Emerge Associates during their 2017 fieldwork, suitable habitat was identified as occurring within Precinct 1, and it is considered possible that the species can occur within Precinct 1 (Emerge Associates 2019a).

No other occurrences of threatened or priority flora were identified within Precinct 1. Further information regarding the occurrence of threatened or priority flora species within Precinct 1 is provided within the *Flora Vegetation and Wetland Assessment* (Emerge Associates 2019a), provided in **Appendix C**.

2.2.2 Terrestrial fauna

2.2.2.1 Regional context

Precinct 1 is located in the eastern margin of the Swan Coastal Plain, which is typically characterised by areas largely cleared of remnant vegetation to facilitate rural land uses. Notwithstanding, the region does contain some large areas of remnant vegetation, in addition to other environmental features such as roadside mature trees, waterways and wetlands, all of which provide fauna habitat values.

A range of conservation significant fauna species are known to occur within the broader region encompassing Precinct 1. This includes three species of threatened black cockatoo, namely Carnaby's black cockatoo (CBC), forest red-tailed black cockatoo (FRTBC) and Baudin's black cockatoo (BBC).

Regional scale habitat mapping published by the Department of Planning (2011) which maps likely CBC habitat used for feeding, night roosts and breeding areas across the Swan Coastal Plain indicates that Precinct 1 contains areas of potential black cockatoo foraging habitat and is located in proximity to a number of roosting and breeding areas, the majority of which are located in the Darling Range to the east of Precinct 1.

Records of black cockatoo roosting sites across south-west Western Australia are maintained by Birdlife Australia, which are based on annual community surveys as part of the *Great Cocky Count* (GCC). Based on the most recently published 2018 GCC report, Precinct 1 does not contain any confirming black cockatoo roosting sites. However, confirmed roosting sites for FRTBCs in proximity to Precinct 1 include:

- two approximately 2 km north-west of Precinct 1, within Precinct 3 of the MKSEA
- one approximately 2 km north-east of Precinct 1, within Wattle Grove, adjacent to the Darling Escarpment.

No other confirmed black cockatoo roost sites have been recorded as part of the GCC within 6 km of Precinct 1.

2.2.2.2 Site specific surveys and investigations

A number of site-specific fauna investigations have been undertaken across the MKSEA to date, including:

- *MKSEA Environmental Review: Flora, Vegetation, Fauna and Wetlands* (Cardno BSD 2005)
- *Black Cockatoo Survey - MKSEA* (360 Environmental 2012).
- *Fauna Assessment MKSEA Precinct 1* (Harewood 2018).

A level 1 fauna assessment (Harewood 2018) of Precinct 1 was completed across 2017 and early 2018. This assessment builds on the results of previously completed fauna assessments across Precinct 1 and included:

- Desktop investigations to compile a list of vertebrate fauna potentially occurring within Precinct 1, involving searches of State and Commonwealth fauna databases, a review of existing publications relevant to the area and a review of previous fauna surveys undertaken in the region.
- Daytime reconnaissance field surveys on 23 October 2017, 14 November 2017 and 19 February 2018, in order to identify and assess fauna habitat values within Precinct 1 and record any opportunistic observations of fauna species.

A copy of the fauna assessment report is provided in **Appendix D** and the results of the assessment have been summarised below.

2.2.2.3 Fauna assessment

A total of 27 native fauna species were observed within Precinct 1 (or positively identified through foraging evidence, scats, tracks, skeletons or calls) during the reconnaissance field survey (as listed in **Appendix D**). Two introduced species (excluding domestic livestock) were also confirmed as being present. The majority of the recorded fauna species are common, widespread bird species.

Based on the findings of the fauna assessment, it was concluded that the overall fauna habitat values within Precinct 1 have been compromised to varying degrees as a result of extensive historical vegetation clearing and degradation of remnant patches (Harewood 2018). Larger areas of remnant vegetation within Precinct 1 represent the highest general fauna habitat value when compared to the widespread areas of parkland cleared vegetation. However, most of these areas are disturbed from their natural state and lack significant native groundcover/shrubs and microhabitats such as hollow logs.

In consideration of the observed site characteristics, the overall fauna biodiversity of Precinct 1 is well below pre-disturbance levels (Harewood 2018). Due to historical clearing and degradation of native vegetation, the majority of Precinct 1 is likely to be only utilised by generally common and widespread fauna species with non-specific requirements (Harewood 2018).

2.2.2.4 Species of conservation significance

Certain fauna species that are considered to be rare or under threat warrant special protection under state and/or federal legislation. At a federal level, fauna species may be listed as 'threatened' pursuant to the EPBC Act and any action likely to have a significant impact on a listed threatened species requires approval from the Commonwealth Minister for the Environment.

At a state level, fauna species could formerly be classed as 'threatened' under the WC Act. The recently proclaimed BC Act has replaced the WC Act and provides statutory acknowledgement and increased protection for threatened fauna. The BC Act introduces new provisions for the protection of threatened fauna habitat. The DBCA also maintains a list of priority fauna species which, while not considered threatened under the BC Act and therefore not protected directly, involve some concern over their long-term survival. **Appendix B** provides detailed descriptions as to the definitions and categories of threatened and priority fauna species.

Based on the results of the fauna assessment (Harewood 2018), three fauna species of conservation significance were positively identified as utilising Precinct 1 for some purpose, including:

- *Calyptorhynchus latirostris* (Carnaby's black cockatoo)
  Foraging evidence of the species was found within Precinct 1 (chewed pine cones). In addition, areas of native vegetation containing marri, coastal blackbutt and banksia trees represents foraging habitat for the species. Where larger endemic trees (DBH > 500 mm) occur within Precinct 1, these trees represent potential breeding habitat based on the EPBC Act referral guidelines for the species (DSEWPaC 2012).
- *Calyptorhynchus banksii naso* (forest red-tailed black cockatoo)
  Foraging evidence of the species was found within Precinct 1 (chewed marri fruits). In addition, areas of native vegetation containing marri, coastal blackbutt and sheoak trees represents

foraging habitat for the species. Where larger endemic trees (DBH > 500 mm) occur within Precinct 1, these trees represent potential breeding habitat based on the EPBC Act referral guidelines for the species (DSEWPaC 2012).

- *Calyptorhynchus baudinii* (Baudin's black cockatoo)
  Foraging evidence of the species was found within Precinct 1 (chewed marri fruits). In addition, areas of native vegetation containing marri and banksia trees represents foraging habitat for the species. Where larger endemic trees (DBH > 500 mm) occur within Precinct 1, these trees represent potential breeding habitat based on the EPBC Act referral guidelines for the species (DSEWPaC 2012).

Evidence observed within Precinct 1 indicates that all three black cockatoo species have utilised vegetation within Precinct 1 for foraging purposes. However, the extent of quality foraging habitat within Precinct 1 is relatively small compared to similar habitat available for black cockatoos across the broader region. Whilst larger endemic trees (DBH > 500 mm) occurring within Precinct 1 are identified as potential habitat trees due to their size, no actual roosting or breeding was identified within Precinct 1 during the assessment (Harewood 2018).

In addition to the above, the following species are considered to possibly utilise Precinct 1 for some purpose at times, based on their known range and available habitat types within Precinct 1:

- *Falco peregrinus* (peregrine falcon)
  This species may potentially utilise some sections of Precinct 1 as part of a much larger home range. However, no evidence of nesting within Precinct 1 was observed, and it is considered very unlikely the species would breed onsite (Harewood 2018).
- *Isoodon fusciventer* (quenda)
  This species is known to persist in paddocks with dense grasses and areas of nearby remnant vegetation, and as such may potentially occur within portions Precinct 1. However, no evidence of this species was observed during the Precinct 1 specific assessment (Harewood 2018).

2.2.3 Bush Forever

The Government of Western Australia's Bush Forever policy is a strategic plan for conserving regionally significant bushland within the Swan Coastal Plain portion of the Perth Metropolitan Region. The objective of Bush Forever is to protect comprehensive representations of all original ecological communities by targeting a minimum of 10% of each vegetation complex for protection (Government of WA 2000a). The Bush Forever policy is only applicable within the boundary of the Metropolitan Region Scheme (MRS).

No Bush Forever sites are located within Precinct 1. However, Bush Forever Site 53 'Clifford Street Bushland' (BF 53) is located adjacent to the north-eastern boundary of Precinct 1, as shown in **Figure 7**.

A conservation category wetland (UFI# 15115) is mapped as occurring within BF 53. The original site description for BF 53 (Government of WA 2000b) identified known occurrences of two TECs within BF 53, namely SCP 3b (*Corymbia calophylla - Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain) and SCP 20b (*Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain), in addition to one threatened flora species, *Conospermum undulatum*. Given BF 53 is located outside of Precinct 1, this area including CCW UFI# 15115 was not surveyed as part of the *Flora Vegetation and Wetland Assessment* (Emerge Associates 2019a).

2.2.4 Ecological linkages

Ecological or biodiversity linkages are described as areas of native vegetation which provide a corridor or linkage (typically linear) between patches of vegetation to allow movement of flora and fauna and their genetic material through the landscape, helping to maintain metapopulations. Ecological linkages are often continuous or near-continuous as the more fractured a linkage is, the less ease flora and fauna have in moving within the corridor (Alan Tingay and Associates 1998).

The Perth Biodiversity Project, supported by the Western Australia Local Government Association (WALGA), has identified and mapped regional ecological linkages within the Perth Metropolitan Region (PBP 2007).

One regional ecological linkage is mapped by over Precinct 1 as shown in **Figure 7**. Based on the outcomes of site-specific fauna assessment conducted by Harewood (2018), Precinct 1 is not considered to contribute to or provide any significant ecological linkage functionality, given the highly fragmented nature of vegetation across Precinct 1.

2.2.5 Environmentally sensitive areas

Within Western Australia, the clearing of native vegetation can only be undertaken once a Clearing Permit has been attained under Part V of the EP Act, or if the clearing activity is in accordance with a valid exemption, including:

- Exemptions listed in Schedule 6 of EP Act. These include, but are not limited to:
  - Clearing undertaken in accordance with a subdivision approval
  - Clearing that is required under other laws (for example, Local Governments may require landholders to establish and maintain firebreaks under the *Bush Fires Act 1954*).
- Exemptions listed in the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* (the Regulations). These are associated with low impact land management practices and include, but are not limited to:
  - Clearing to allow for the construction of fence-lines
  - Clearing for vehicular and walking tracks
  - Burning to reduce fire hazards
  - The collection of firewood.

'Environmentally sensitive areas' (ESAs) are prescribed under the Regulations to protect native vegetation values in proximity to significant threatened flora, ecological communities, wetlands or ecosystems. Within ESAs, exemptions listed in the Regulations do not apply and a Clearing Permit is required to undertake such clearing activities. The relevance of ESAs is limited to this specific context.

One ESA is located across the majority of Precinct 1, centred on Bush Forever Site 53, which sits adjacent to the eastern boundary. This is likely to be associated with the CCW located within Bush Forever Site 53. In addition to the large ESA, a very small ESA occurs on the northern border of Precinct 1, which is likely to be associated with a previously recorded location of a threatened flora species. The locations of these ESAs are shown in **Figure 7**.

2.3 Hydrology

2.3.1 Groundwater

Data from the *Perth Groundwater Atlas* shows that historical regional minimum groundwater levels below Precinct 1 range from 9 m AHD in the western corner to 16 m AHD in the eastern corner (DWER 2018). Based on this data, depth to groundwater ranges from approximately 3 m to 15 m below ground level. Generally, depth to regional groundwater is lower along Bickley Road and higher along Tonkin Highway and below elevated earth mounds.

A number of groundwater monitoring investigations have been previously completed across Precinct 1 by various proponents, as documented in the following reports:

- *Report on MKSEA Precinct 1 District Water Management Strategy* (GHD 2010)
- *MKSEA Surface Water and Groundwater Monitoring and Investigation Report* (Endemic 2012)
- *Local Water Management Strategy for MKSEA Area 1* (McDowell Affleck 2016)
- Clifford St, Maddington - Precinct 1 MKSEA: Information supporting the preparation of a LWMS (D Newsome [Strategen] 2016, pers. comm., 8 April)

In addition to the above, Emerge Associates completed six months of groundwater level monitoring at accessible and existing groundwater bores located across MKSEA during 2017, as documented in the *Local Water Management Strategy* (Emerge Associates 2019b).

Based on the outcomes of groundwater monitoring investigations, maximum groundwater level (MGL) across Precinct 1 ranges between 13 m AHD near the western boundary and 21 m AHD near Tonkin Highway, with depth to this perched MGL ranging from 0.9 m to 4.5 m below ground level. In addition, groundwater quality beneath Precinct 1 is typical of sites historically utilised for grazing and rural agriculture and nutrient concentrations generally exceed relevant surface water quality guideline values (Emerge Associates 2019b).

The characteristics of groundwater underlying Precinct 1 are discussed further in the *Local Water Management Strategy* (Emerge Associates 2019b).

2.3.2 Surface water

There are no existing natural waterways within Precinct 1. However, Bickley Brook is located approximately 200 m south of Precinct 1.

Existing culverts beneath Tonkin Highway allow runoff from upstream catchments to flow through Bush Forever Site 53 and into Precinct 1 (J Miller [Main Roads Western Australia] 2017, pers. comm., 19 May). Stormwater runoff within Precinct 1 is conveyed via a combination of overland flow, unlined open drains and pipes towards Victoria Road or Bickley Road, ultimately draining into Bickley Brook (GHD 2010).

2.3.3 Wetlands

Wetlands are areas which are permanently, seasonally or intermittently waterlogged or inundated with water. Naturally occurring wetland features are common across the Swan Coastal Plain and can contain fresh or salty water, which may be flowing or still. DBCA classifies wetland types based on their inundation characteristics and physical structure, details descriptions of which are provided in **Appendix B**.

In order to provide an indication of the relative condition and conservation value of mapped geomorphic wetlands on the Swan Coastal Plain, each wetland has been evaluated and assigned one of three management categories, either conservation category wetland (CCW), resource enhancement wetland (REW) or multiple use wetland (MUW). Detailed description of each wetland management category can be found in **Appendix B**.

DBCA maintains the *Geomorphic Wetlands of Swan Coastal Plain* spatial dataset, which specifies the classifications and management categories of all wetland features across the Swan Coastal Plain. The significance of each wetland is based on hydrological, biological and human use features, which are the key components for the classification of the management categories (Semeniuk 1995).
13 wetlands are identified as occurring within Precinct 1, 12 MUWs and one REW (DBCA 2018), as detailed in **Table 7** and shown in **Figure 8**. In addition, multiple other wetlands occur to the south and north-west of Precinct 1, including a CCW associated with Bush Forever Site 53.

Table 7: Geomorphic wetlands present within Precinct 1 (DBCA 2018)

Unique feature identifier (UFI)	Wetland type	Management Category
8048	Palusplain	Multiple Use
8049	Palusplain	Multiple Use
8051	Sumpland	Multiple Use
8052	Palusplain	Multiple Use
8053	Sumpland	Multiple Use
8054	Sumpland	Multiple Use
8055	Dampland	Multiple Use

Table 7: Geomorphic wetlands present within Precinct 1 (DBCA 2018) continued

Unique feature identifier (UFI)	Wetland type	Management Category
8056	Palusplain	Multiple Use
13369	Palusplain	Multiple Use
15007	Sumpland	Multiple Use
15116	Palusplain	Multiple Use
15768	Palusplain	Multiple Use
8050	Sumpland	Resource Enhancement

The *Flora, Vegetation and Wetland Assessment* (Emerge Associates 2019a) includes an assessment of wetlands, which identified that the REW mapped within Precinct 1 (UFI#8050) contains values that are potentially representative of a CCW, and recommends that a portion of this wetland be reclassified to a CCW management category.

The Plant community **CcXpMt** within the existing mapped boundary of UFI#8050 is in 'very good' condition. This plant communities represent a TEC listed under the EPBC Act, as confirmed by DBCA, SCP3a. In addition, previous surveys of the **CcXpMt** community recorded the presence of Priority 2 flora species *Lepyrodia curvescens* (Tauss and Weston 2010) within UFI#8050. Due to the hydrology of the wetland, it was identified by Emerge Associates that the geomorphic evaluation is representative of a palusplain wetland.

As a result of the *Flora, Vegetation and Wetland Assessment* (Emerge Associates 2019a), Emerge Associates has recommended that the portion of the wetland feature that supports the TEC represents a conservation category wetland. Therefore, this portion of **CcXpMt** vegetation is recommended to be excised from the existing resource enhancement wetland (REW) and reclassified as a conservation category wetland (CCW) and that the geomorphic evaluation is changed from sumpland to palusplain due to the landform.

The proposed revised boundary of REW UFI#8050 and the proposed CCW boundary are shown in **Figure 9**, and further information provided in the *Flora, Vegetation and Wetland Assessment* (Emerge Associates 2019a) (**Appendix C**).

2.4 Heritage

2.4.1 Indigenous heritage

The *Aboriginal Heritage Inquiry System* (AHIS) is maintained pursuant to Section 38 of the *Aboriginal Heritage Act 1972* (AH Act) by the Department of Planning, Lands and Heritage (DPLH), containing information on Registered Aboriginal Heritages Sites and Other Heritage Places throughout Western Australia.

In accordance with the *Aboriginal Heritage Due Diligence Guidelines* (DAA 2013), a search of the AHIS online database (DPLH 2018) was undertaken to support preparation of the draft LSP, which did not identify any Aboriginal heritage sites as being mapped by DPLH within Precinct 1.

The closest Aboriginal heritage site is located approximately 250 m north of Precinct 1, where 'Artefacts / Scatter' sites are registered.

2.4.2 Non-indigenous heritage

In order to determine the actual or potential presence of sites or features of non-indigenous heritage significance within Precinct 1, a review of readily available information at a federal, state and local government level was undertaken to determine if any of the following occur within Precinct 1:

- World Heritage Sites
- National Heritage Places
- Commonwealth Heritage Places
- Sites listed in the State Register of Heritage Places
- Sites listed in the City of Gosnells Heritage Register.

A review of the above registers did not identify any heritage features as being mapped within Precinct 1.

2.5 Other land use considerations

2.5.1 Historic and existing land uses

A review of historical aerial imagery for Precinct 1 between 1953 to present (Landgate 2018) was completed to understand temporal changes in land use. The majority of Precinct 1 was historically cleared prior to 1953, which appears to have occurred for agricultural purposes. Revegetation of some portions of Precinct 1 appeared to occur after 1985, associated with natural regeneration and rural-residential land uses, with minimal clearing of vegetation occurring after this time.

Since 2012, development has occurred within the southern and central portions of Precinct 1, associated with light industrial land uses.

2.5.2 Potential site contamination

A desktop study of the potential presence of historical contamination within Precinct 1 was conducted. The State Government, through the DWER, has the overall responsibility for developing, administering and enforcing the *Contaminated Sites Act 2003* and its associated procedures. Part of this responsibility includes maintenance of the *Contaminated Sites Database* which holds information on known, previously or potentially contaminated sites within Western Australia.

The *Contaminated Sites Database* holds information on known contaminated sites that have been classified by the DWER as:

- Contaminated – remediation required
- Contaminated – restricted use
- Remediated for restricted use.

A search of the *Contaminated Sites Database* indicated none of the land parcels incorporating Precinct 1 are recorded on the database. However, two sites located approximately 100 m to the south of Precinct 1 are identified on the database, with one site identified as 'remediated for restricted use' and one as 'contaminated – restricted use'.

2.5.3 Surrounding land uses

The broader MKSEA region extends to the north-west of Precinct 1, as shown in **Figure 1** and currently supports a mix of rural-residential and light industrial land uses. A combination of urban and light industrial lands occur to the south of Precinct 1. Bush Forever Site 53 abuts a portion of the eastern boundary, with the remainder of the eastern boundary comprised of Tonkin Highway, which is identified under the MRS as a 'primary regional road'. Land to the east of Tonkin Highway supports rural land uses.

None of the identified land uses surrounding Precinct 1 would preclude it from being suitable for the proposed industrial development.

3 The Proposal

3.1 Historical planning context

3.1.1 Regional planning framework

The State Government has identified the MKSEA (and therefore Precinct 1) for future industrial development through the strategic land use planning framework, as documented in various planning strategies such as the *Economic and Employment Lands Strategy: non-heavy industrial* (WAPC 2012), the *Perth and Peel@3.5 Million* (WAPC and DPLH 2018a) and the associated *South Metropolitan Peel Sub-regional Planning Framework* (WAPC and DPLH 2018b).

In order to facilitate the proposed future industrial development process within Precinct 1, MRS Amendment 1211/41 was initiated and subsequently gazetted in September 2012, which resulted in Precinct 1 being rezoned from 'Rural' to 'Industrial' under the MRS.

The WAPC referred the proposed scheme amendment to the Environmental Protection Authority (EPA) to determine whether environmental assessment under Part IV of the *Environmental Protection Act 1986* (EP Act) was required. The EPA advised the WAPC that the proposed scheme amendment did not require formal assessment and identified the main environmental issues relating to the proposed amendment as follows:

- Stormwater management, specifically the management of drainage to ensure untreated runoff does not impact on adjacent CCWs.
- Wetlands, specifically the close proximity of CCWs and that all reasonable measures should be taken to minimise impacts upon CCWs and their buffers.
- Bush Forever, specifically the adjacent location of Bush Forever Site 53.
- The potential risk of ASS occurrence based on regional ASS risk mapping published by DWER.

In their consideration of the MRS Amendment, the WAPC noted that all of the environmental considerations raised by the EPA can be appropriately managed and addressed through the standard structure planning process. These environmental considerations have been considered during the preparation of the draft LSP and the associated future environmental management strategy, as discussed in **Section 4**.

3.1.2 Local planning framework

The CoG has coordinated the initial phases of the planning and development process across the MKSEA, undertaking a range of preliminary studies and investigations to demonstrate the feasibility of the proposed industrial development.

Following MRS 1211/41, in 2012, the CoG TPS No. 6 Amendment 126 was passed to rezone all land parcels within Precinct 1 from 'general rural' to 'business development', to enable future industrial development of Precinct 1 consistent with the overarching regional planning framework.

TPS No. 6 Amendment 126 was referred to the EPA under s48A of the EP Act, who advised the CoG that the proposed scheme amendment did not require formal assessment. The EPA provided advice identifying the main environmental issues relating to the proposed amendment as follows:

- Bush Forever, specifically the adjacent location of Bush Forever Site 53.
- The future management of CCWs (within Bush Forever Site 53), and advice on measures that should be taken to minimise impacts upon CCWs and their buffers.

Based on the outcomes of preliminary environmental investigations, the CoG prepared an indicative LSP in August 2014 to provide a conceptual spatial framework to inform the preparation of a District Water Management Strategy and to provide a basis for the ultimate preparation of a Local Planning Strategy for the MKSEA, to be informed over time by more detailed study of the area.

3.2 Local Structure Plan

The CoG has prepared a LSP for the MKSEA, as provided in **Appendix A**. This document is specific to the application of the draft LSP to Precinct 1. The LSP identifies the following land uses within Precinct 1:

- Industrial zones.
- Composite zones.
- Drainage basins.
- Public open space / conservation areas.
- Buffers around conservation category wetland and threatened ecological communities.
- An integrated local road network.

Specific LSP spatial considerations to respond to identified environmental values include:

- Retention of all identified significant environmental values within public open space areas, including identified occurrences of TECs, the single occurrence of priority flora, and the associated wetland feature (determined to be representative of a CCW).
- Provision of buffers around the wetland feature determined to be representative of a CCW (Emerge Associates 2019a).

Areas of public open space (POS) will meet the ‘Biodiversity Asset (Nature)’ park classification detailed in the CoG Public Open Space Strategy (CoG 2014b). This classification encompasses Bush Forever sites and conservation category wetlands, and envisages that the POS may include: boardwalks, fencing, walk trails, interpretative signage and additional native plantings. Such POS will be reserved under the local planning scheme for conservation purposes as a ‘local reserve’.

These spatial design responses are discussed in detail in **Section 4**.

3.3 Consultation

The planning of the broader MKSEA region has been a long-term process that has involved finding an outcome that satisfies significant environmental, heritage and economic issues that exist within the MKSEA region. In addition to the environmental values within Precinct 1 and broader MKSEA, lots within Precinct 1 are owned by numerous different land holders, requiring extensive consultation to ensure that all landowners were able to have input on the process. Consultation with landowners has occurred through the planning process since 2006, with input from the CoG, the EPA and DBCA (and preceding government environmental departments).

Advice was provided from the EPA regarding the MRS Amendment (MRS 1211/41) and the CoG Town Planning Scheme No. 6 Amendment 126, with both scheme amendments not requiring any further assessment. Prior to the EPA determination, both amendments were advertised for public comment, as part of the environmental impact assessment process.

Consultation with the CoG is ongoing to inform the preparation of a finalised LSP, and has involved consultation with other government agencies throughout the process.

Consultation and investigations have influenced the preparation of the draft LSP, and consultation will continue as part of future subdivision and development within Precinct 1.

3.4 Future planning approvals process

Subject to approval and endorsement of the draft LSP by the CoG and the WAPC, industrial development of Precinct 1 will most likely be progressed either through subdivision, amalgamation or development approvals (collectively referred to as 'future planning stages').

The key environmental values and attributes that require further consideration have been outlined in **Section 4** of this report and include:

- Flora and vegetation, including TECs and conservation significant flora
- Fauna
- Bush Forever
- Groundwater and stormwater
- Wetlands
- Acid sulfate soils.

Future planning and development should also take into consideration the various environment-related local planning policies prepared by the CoG. A summary of these policies and their relevance to Precinct 1 is provided in **Table 8** below.

In addition, the WAPC generally imposes conditions on subdivision applications (which incorporate both subdivisions and amalgamations) to ensure development considers all the appropriate management measures. These conditions are usually determined in accordance with WAPC's *Model Subdivision Conditions Schedule 2017* and include those relating to environmental considerations.

Where subdivision or amalgamation of Precinct 1 is not applicable, development approval(s) will be sought to progress industrial development in accordance with the proposed LSP. The local government is generally responsible for the imposition of conditions on development approvals and these include those relating to environmental considerations.

Table 8: Summary of relevant CoG Local Planning Policies

Local planning policy (LPP)	Summary of policy	Relevant to site (Y/N)	Summary of considerations
LPP 4.7 Planning and Development of Public Open Space and Streetscapes	The policy has been developed to establish standards for the provision and development of new areas of public open space (POS) and streetscapes.	Y	Given Precinct 1 is proposed to be developed for industrial land uses, POS has not been considered as a specific requirement at this stage. As part of future detailed subdivision planning POS and streetscapes will be incorporated, in particular regarding a buffer to the CCW within Precinct 1.
LPP 5.6 MKSEA Precinct 1	The policy has been developed to provide guidance for the assessment and determination of applications for planning approval within Precinct 1 of the MKSEA. LPP 5.6 guides landowners to ensure that future development does not compromise the value or wellbeing of any environmental feature.	Y	The LSP suitably responds to the environmental values within Precinct 1 through: • Provision of a buffer around the proposed CCW in the south-west of Precinct 1, and the associated TEC. • Accommodation of a TEC occurrence (SCP20a) located in the northern portion of Precinct 1 to protect the environmental values associated with the TEC. • Provision of a buffer (where existing roads don't occur) surrounding the CCW within Bush Forever Site 53.

4 Environmental Assessment and Management Strategies

This section outlines the spatial response of the draft LSP to the environmental attributes and values associated with Precinct 1 and the future environmental management considerations that will be required as part of future planning stages. Only those environmental values and attributes that require specific consideration based on their presence within Precinct 1, and/or applicable legislation and policy requirements are assessed.

It should be noted that in addition to environmental management considerations implemented through the statutory planning process (generally pursuant to Part IV of the EP Act), the establishment and ongoing operation of certain industrial uses within Precinct 1 may also be regulated under Part V of the EP Act. This involves the management and regulation of "prescribed premises" which are certain industrial land uses identified in the *Environmental Protection Regulations 1987.* The EP Act requires DWER to assess, monitor, audit and manage the impacts that industry may have on the surrounding environment. These operational approvals associated with Part V of the EP Act will be dealt with by future landowners and operators following the statutory planning and development process.

4.1 Flora and vegetation

4.1.1 Management objectives

In the context of environmental impact assessments, the EPA's objective for flora and vegetation is '*to protect flora and vegetation so that biological diversity and ecological integrity are maintained'.* Where a proposal may potentially impact upon flora and vegetation values, the following mitigation hierarchy should be applied to minimise potential impacts:

1. **Avoid** impacts
2. **Minimise** impacts
3. **Offset** impacts

4.1.2 Draft LSP response

The retention of natural environmental values within Precinct 1 was an important design consideration throughout the draft LSP design process, and as a result the draft LSP provides for the retention of significant environmental features within Precinct 1. As outlined in **Section 2**, the majority of Precinct 1 does not support significant flora and vegetation values. The remaining significant flora and vegetation values within Precinct 1 include two TECs, SCP3aand SCP20a, in addition to the possible occurrence of one priority flora species, *Lepyrodia curvescens* (P2).

All significant flora and vegetation values within the draft LSP have been proposed for future retention within areas of POS. The areas of POS will accommodate 50 m buffers around the boundaries of the TECs, in accordance with the approved conservation advice for the 'Shrublands and Woodlands of the eastern Swan Coastal Plain' ecological community (DoEE 2017), and they will be managed in accordance with the Wetlands and Conservation Area Management Strategy detailed in **Section 5.1**.

4.2 Fauna

4.2.1 Management objectives

In the context of environmental impact assessment, the EPA's objective for terrestrial fauna is *'to protect fauna so that biological diversity and ecological integrity are maintained'.* The application of the mitigation hierarchy should be applied to avoid or minimise impacts to terrestrial fauna where possible.

The EPBC Act also provides protection for listed 'threatened' species, including black cockatoos, which are known to make use of habitat within Precinct 1. Any proposed action which is considered likely to result in a 'significant' impact upon these species, identified by the DoEE as Matters of National Environmental Significance (MNES), should be referred to the Commonwealth Department of Environment and Energy.

4.2.2 Draft LSP response

Due to the cleared and degraded nature of vegetation within Precinct 1 there are limited fauna habitat values associated with it, with the areas of highest value associated with patches of intact native vegetation. These patches are known to contain flora species which provide foraging resources for black cockatoo species.

The draft LSP provides for the future retention of the majority of intact remnant vegetation and associated fauna habitat, through its incorporation within areas of public open space (POS). The retention of individual trees or stands of vegetation outside of proposed POS areas will be considered on a lot-by-lot basis, due to the fragmented ownership of land within Precinct 1. The vegetation to be retained cannot be specifically identified at the LSP level of planning, and will be determined at detailed subdivision and/or development application stages of planning. Typically, retention of vegetation can be achieved when vegetation occurs on the boundary of lots, within existing road reserves, at locations where fill is not required or where development will not occur.

4.2.3 Future management requirements

It is anticipated that, in line with the WAPC's *Model Subdivision Conditions Schedule's* environmental conditions, there will be a requirement for a Fauna Relocation and Management Plan (or similar) to be prepared and implemented prior to any on-ground works being undertaken which may impact upon or involve the clearing of potential or known fauna habitat. The ongoing management of fauna habitat will be dealt with in accordance with the plan.

The three species of black cockatoo that use Precinct 1 are protected under the EPBC Act. Therefore, development proponents will need to consider the clearing of associated habitat in the context of a referral in accordance with the EPBC Act.

4.3 Hydrology

4.3.1 Management objectives

The *State Water Strategy for Western Australia* (Government of WA 2003) and *Better Urban Water Management* (WAPC 2008) endorse the promotion of integrated water cycle management and application of water sensitive urban design (WSUD) principles to provide improvements in the management of stormwater, and to increase the efficient use of other existing water supplies. Of particular relevance to the wetland habitat within Precinct 1 is the *Better Urban Water Management* criteria for ecological protection, which requires development to maintain or restore desirable environmental flows and/or hydrological cycles.

4.3.2 Draft LSP response

A Local Water Management Strategy (LWMS) has been prepared by Emerge Associates (Emerge Associates 2019b) to support the draft LSP, in accordance with the requirements of state and local planning policies. The LWMS provides a framework for the future delivery of a best practice approach to integrated water cycle management utilising WSUD principles. The LWMS includes detailed management approaches for groundwater, stormwater, potable water consumption and flood mitigation, which together meet the ecological protection criteria.

The principal elements of the LWMS are summarised below:

- The efficient use of water resources will be promoted through lot scale water conservation measures and the use of waterwise gardening principles across Precinct 1.
- General building wastewater will be serviced be reticulated sewer and any industrial process wastewater will be treated appropriately within the lot.
- Lots will treat and infiltrate the small rainfall event and detain runoff up to the major rainfall event within the lot.
- The small rainfall event on road reserves will be treated and infiltrated as close to source as possible.
- Major rainfall event runoff from road reserves will be detained to maintain pre-development peak flow rates.
- Sand fill and/or subsoil drains may be utilised by lot owners to meet appropriate clearances to groundwater but are not mandated across Precinct 1.
- Infiltration of the small rainfall event across Precinct 1 ensures groundwater continues to perch on a seasonal basis, which maintains the existing wetland.

4.3.3 Future management requirements

It is anticipated that environmental condition D2 of the WAPC's *Model Subdivision Conditions Schedule* 2017 will be attached to all subdivision approvals, requiring the preparation of an Urban Water Management Plan (UWMP). Each UWMP will provide information on the implementation of the LWMS through detailed civil design. Further information on UWMP requirements is provided in the LWMS (Emerge Associates 2019b).

4.4 Wetlands

4.4.1 Overview

The Precinct 1 draft LSP area contains one candidate conservation category wetland (CCW) and is directly adjacent to the CCW contained within Bush Forever Site 53. Due to the significant environmental values associated with CCWs they need to be protected by buffers from adjoining land uses. As detailed in **Section 4.4.2**, a wetland buffer study was prepared to determine the appropriate LSP response to the CCWs.

The multi use wetlands (MUW) contained within the Precinct 1 draft LSP area and the portion of the resource enhancement wetland (REW) (UFI 8050) that does not contain the TEC, contain few wetland attributes and are suitable for development if hydrological considerations are addressed in accordance with the draft LSP's Local Water Management Strategy. Therefore, the presence of MUWs and the residual REW within Precinct 1 do not require a specific spatial response within the draft LSP and were not considered in the buffer study.

4.4.2 Wetland buffer study

4.4.2.1 Scope of study

This study considers how the draft LSP should respond to the buffering requirements of the wetland areas to be retained:

- The conservation category wetland associated with Bush Forever Site 53.
- The proposed conservation category wetland located to the south-east of Victoria Road and north-east of Bickley Road (part of UFI 8050).

The CoG requires that the guidance documents listed below inform this study, and passages from these documents have been used verbatim where appropriate:

- Environmental Guidance for Planning and Development, Guidance Statement No.33, EPA, 2008.
- Guideline for the Determination of Wetland Buffer Requirements [Draft] for public comment, WAPC, December 2005.

When considering the form and size of any buffers, the study has adopted the definition provided in the WAPC guideline:

'Buffer' Separation of a wetland from adjacent land use through either spatial separation or the use of physical barriers to reduce the threats to desired values and attributes and ensure wetland activities do not have undue impact on the land use.

4.4.2.2 What is the separation requirement?

Context

The MKSEA project aims to enable the expansion of the Maddington industrial area in a manner that protects and where possible enhances the unique environmental characteristics of the area and the amenity of the nearby established communities. To achieve this aim consideration needs to be given to the overall balance of social, environmental and economic aspects associated with the various parameters that may affect the future of a wetland. This could result in alternative separation arrangements to those recommended in the guidance referred to **Section 4.4.2.1**.

Purpose

The EPA's guidance states that "the buffer adjoining a wetland helps to maintain the ecological processes and functions associated with the wetland and aims to protect the wetland from potential adverse impacts. A buffer can also help to protect the community from potential nuisance insects, for example, midges. To maintain wetland values, it is important to determine, protect and manage an adequate buffer." The guidance recommends a minimum 50 m buffer distance, but also that a site-specific buffer requirement may be determined.

The WAPC guidance further defines the role that separation can provide for the protection of wetlands:

- protection from direct disturbance or other change/impact to the wetland function areas
- can provide indirect support for wetland function areas through hydrological and terrestrial processes
- vegetation interception and use of nutrients in surface and subsurface flow
- can suppress water tables locally and reduce salinisation of surface soils
- role highly dependent on hydrogeology and catchment characteristics
- can add to as well as maintain aesthetics of wetland function area
- protection from direct disturbance or other change/impact to the wetland function area
- maybe a focus for passive recreation
- protection of wetland features and function integral to recreation values.
- protection from direct disturbance or other change/impact to the wetland function area.

Form of separation

Separation can involve two general forms: a physical barrier (fence, wall, road), or a spatial, along-the-ground separation distance or area. These forms are not mutually exclusive, and in some cases, a combination can provide a solution. Key considerations in defining separation needs are the attributes of the wetland and the threats associated with the surrounding land uses.

Physical barriers

The WAPC guidance states that in some circumstances, physical barriers may provide an alternative to large separation distances or areas, e.g. the use of a fence to keep domestic animals from nearby residences out of the wetland or use of a path to help prevent the spread of weed seed.

Separation requirement

The separation requirement effectively is the envelope of the separation distance and management required to deal with all separation issues, e.g. habitat protection, edge effects, light spill, fire management, water quality management, specific to each proposed or existing adjacent land use.

Activities compatible with the surrounding land use and the management objective of the wetland may be permitted in all or part of the separation area, e.g. passive recreation.

The extent of the separation area around a particular wetland should be based on an assessment of:

- the wetland's values
- the activities, land uses or development near the wetland (existing and proposed)
- the threats posed by the adjacent activities, land uses or development.

The WAPC guidance states that the achievement of the management objective for a wetland may require more than the separation distance proposed or may be achieved with less. Variation from the guideline's suggested distances needs to be considered on the merits of each case.

4.4.2.3 Determining the separation requirement

The WAPC guidelines, although never formally adopted, provide the most readily available framework on which to base any determination of wetland separation requirement. For this study the following steps have been taken:

1. Establish the management objective for the wetlands.
2. Establish the threats to the wetlands.
3. Based on steps 1 and 2, establish an achievable separation requirement that is compatible with the aim of the MKSEA project, see **Section 4.4.2.2.**

Step 1: Management objectives

Both of the wetlands included in the scope of this study meet the definition of a conservation category wetland (CCW). The WAPC guidance recommends the separation requirement for CCWs should aim to achieve this objective:

- to preserve wetland (natural) attributes and functions

In direct response to this objective, the MKSEA Precinct 1 draft LSP proposes the retention of these CCWs in their entirety for their environmental values and does not propose any development within the boundaries of either.

Step 2: Threats

The WAPC guidance recommends separation distances and management measures on the basis of potential threats. Separation measures are required to mitigate only those threats that are present. For example, if there is no potential for loss of vegetation (habitat modification), there is no need for a separation requirement to manage this impact. Similarly, if the only threat identified is the potential for alteration to the water regime, no separation distance is required.

The guidance also states that there are many anthropogenic threats to wetlands; however, separation or provision of a buffer may not manage all of them. Threats that can be mitigated by buffering are detailed in **Table 9**.

Table 9: Threats to CCWs within and adjacent to Precinct 1

Threat		Impact to CCWs
Issue	**Risk**	
Alteration to the water regime	Removal of vegetation	None, as no development will take place within the CCWs.
	Development of impervious surfaces	Potentially, as industrial development immediately abutting the wetlands could realistically be expected to include hardstand. Can be managed by an appropriate buffer.
	Groundwater pumping	Not applicable.
	Increases in water level	None, as the LWMS for Precinct 1 will ensure that the existing water regime that influences the CCWs will remain unaltered.
Habitat modification	Clearing	None as no clearing will take place within the CCWs.
	Fire	Potentially - can be managed through the use of firebreaks.
	Grazing	Not applicable as grazing will be excluded.
	Invasion of exotic species	Potentially – can be managed by an appropriate buffer.
	Invasion of exotic fauna	Potentially – can be managed by an appropriate buffer and fencing.
Inappropriate recreational use	Active pursuits, e.g. motocross, mountain biking	Potentially – can be managed by exclusion of these uses and the use of fencing.
	Passive pursuits, e.g. bird watching, picnicking	Potentially – can be managed by an appropriate buffer and control of access.
Diminished water quality	Nutrients enrichment	Potentially, as runoff from industrial development abutting the wetlands could transport nutrients, suspended solids organic and toxic compounds - can be managed by an appropriate buffer.
	Suspended solids and sedimentation	
	Organic and toxic compounds	
	Salinity	
	Acidification	

Step 3: Establish the separation requirement

This study considers the full breadth of the WAPC guidance to establish feasible CCW separation requirements to address the threats identified in **Table 9**. However, the study also recognises the constraints posed by existing development and infrastructure within Precinct 1, and the controls that can be provided by using physical barriers in conjunction with spatial buffers. Where a spatial buffer is appropriate, the study has sought to adopt a separation distance of between 100 m, as referenced in the WAPC guidance, and 50 m, which is the EPA's minimum separation distance recommendation. Detailed guidance that is provided for consideration by the WAPC is reproduced as part of **Table 10**.

Table 10 details the proposed separation requirements for the CCWs within and adjacent to Precinct 1. Where required, areas of POS will be established within Precinct 1 to encompass the CCW excised from UFI# 8050 and to accommodate the separation requirement for the CCW within Bush Forever site 53. As the Bush Forever site contains a Threaten Ecological Community (SCP20b), the draft LSP has responded, where possible, by providing a 50 m buffer from its boundary in accordance with the approved conservation advice for the 'Shrublands and Woodlands of the eastern Swan Coastal Plain' ecological community (DoEE 2017).

Table 10: Conservation category wetlands: Precinct 1 separation requirements

Threat	WAPC's detailed guidance	Separation requirements	
		CCW excised from UFI# 8050	CCW associated with Bush Forever Site 53 (BF53)
Alteration to the water regime	• Regulation of groundwater abstraction as catchment management measure.	• ***Regulation of groundwater abstraction: No specific separation required*** - alteration to water regime adequately managed by the LWMS.	• ***Regulation of groundwater abstraction: No specific separation required*** • - alteration to water regime adequately managed by the LWMS.
Habitat modification	• 100 m weed infestation • Up to 100 m for bird habitat dependent on extent of use. • 6-50 m firebreak. • Fence for controlling exotic fauna access. • ≥ 100 m to minimise edge effects.	• ***Weed infestation: 50 m buffer with active management*** - within the industrial context of Precinct 1 weeds can be managed through buffer separation, and active management. Application of 100 m of separation is not recommended. Additional separation does not ensure improved weed management outcomes but does increase the area over which weed management must be undertaken. • ***Bird habitat: no specific separation required*** – the CCW is not known to be used by significant populations of water or migratory birds for which separation may be important.	• ***Weed infestation:*** ○ ***50 m buffer along the north-western boundary of BF53*** ○ ***The existing road with fencing on south-western boundary.*** - within the industrial context of Precinct 1 weeds can be managed through a combination of area and barrier separation, as provided by the road, and active management. Application of 100 m of separation is not recommended. Additional separation does not ensure improved weed management outcomes but does increase the area over which weed management must be undertaken. • ***Bird habitat: no specific separation required*** – the CCW is not known to be used by significant populations of water or migratory birds for which separation may be important.

Table 10: Conservation category wetlands: Precinct 1 separation requirements (continued)

Threat	WAPC's detailed guidance	Separation requirements	
		CCW excised from UFI# 8050	CCW associated with Bush Forever Site 53 (BF53)
Continued from above.	Continued from above.	• ***Firebreak: install a 6 m firebreak[1] around the external perimeter of the POS*** – the firebreak will be installed and maintained to the City of Gosnell's specification and will not cross into the CCW's boundary. • ***Exotic fauna: install fencing*** – fencing with gated access along the POS' boundary. • ***Edge effects[2]: managed by the measures set out above*** – the EPA's guidance states that measures to manage potential edge effects include, fencing and gates and weed management.	• ***Firebreak:*** ○ install a 6 m firebreak[1] at the external edge of the 50 m buffer. ○ the existing road together with the cleared verge will provide a firebreak along the south-western boundary of BF53 ○ the firebreak will be installed and maintained to the City of Gosnell's specification and will not cross into the CCW's boundary. • ***Exotic fauna: install fencing*** – fencing along the road, fencing will be installed around the external boundaries of the buffer. • ***Edge effects[2]: managed by the measures set out above.*** – the EPA's guidance states that measures to manage potential edge effects include, fencing and gates and weed management.
Inappropriate recreational use	• ≥ 50 m to improve aesthetics. • ≥ 50 m for barrier. • Fence, paths for controlling access.	• ***Aesthetics: landscaping treatments*** – revegetation within the buffer. • ***Barrier: path separation*** - where possible paths will be at least 50 m from the boundary of the CCW but may meander into the buffer. • **Controlling access: Install fencing and gates** – to restrict access to authorised motorised vehicles.	• ***Aesthetics and barrier: a revegetated 50 m buffer*** - along the north-western boundary of BF 53 to improve the aesthetics. • ***Controlling access: fencing*** - In addition to the fencing along the road, fencing will be installed around the external boundaries of the buffer.

[1] Firebreak specifications to be consistent with the City of Gosnells *Annual Fire Hazard Reduction Notice* (as published) or in accordance with an approved Bushfire Management Plan.

[2] Edge effects—The deterioration of the health of natural areas near the interface with developed or cleared areas. The edges of natural areas are prone to weed infestation, pests and diseases, exposure to the weather, altered drainage and watertable regimes, trampling and other impacts. *Environmental Guidance for Planning and Development, Guidance Statement No.33*, EPA, 2008.

Table 10: Conservation category wetlands: Precinct 1 separation requirements (continued)

Threat	WAPC's detailed guidance	Separation requirements	
		CCW excised from UFI# 8050	CCW associated with Bush Forever Site 53 (BF53)
Diminished water quality	• Drainage inflows eliminated or managed. • Where a proposal may affect wetland water quality, particularly through un-channelised flow, detailed site specific work should be undertaken to determine the specific separation measures required, including management measures.	• ***Drainage inflow (including unchannelised): no specific separation required*** - the implementation of the LWMS removes the threat of impacts on water quality. - the 50 m buffer provides addition protection from industrial land use and likely hardstand runoff.	• ***Drainage inflow (including unchannelised): no specific separation required*** - Located upstream of Precinct 1. - the buffer provides addition protection from industrial land use and likely hardstand runoff.

4.4.2.4 Buffer study summary

To enable the conservation objective for conservation category wetlands (CCW) and the aims of the MKSEA project to be achieved, this Wetland Buffer Study has developed separation requirements that consist of physical barriers and distance. The Precinct 1 draft LSP will encompass the proposed separation areas within public open space to provide the necessary protection to the CCWs and facilitate passive recreation. The physical buffer requirements identified in this study are summarised in **Table 11**.

Table 11: Wetland buffer requirements

Precinct 1 LSP Wetland area or buffer	Physical buffer requirements
CCW excised from UFI 8050	• No development within the boundary of the wetland. • A 50 m separation area from the boundary of the wetland. • Fencing around the boundary of the associated POS, with pedestrian access and a gate for emergency and maintenance vehicle access. • A 6 m firebreak around the external perimeter of the associated POS.
Buffer to the CCW associated with Bush Forever Site 53	• A 50 m separation area from the north-western boundary of Bush Forever Site 53. • The existing road, with cleared verge, along the south-western boundary Bush Forever Site 53. • Fencing along along the boundary between the road and Bush Forever Site 53 and the separation area. Fencing along the north-western and north-eastern boundaries of the separation area • A 6 m firebreak along the separation area's external boundary.

These buffer requirements have informed the Wetland and Conservation Area Management Strategy set out in **Section 5.1**.

4.5 Environmentally Sensitive Areas

4.5.1 Management objectives

Within ESAs, exemptions under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* do not apply (such as clearing for the construction of fence-lines, the reduction of fire hazards and the collection of firewood) and a Clearing Permit may be required prior to the clearing of any vegetation.

Notwithstanding, exemptions under Schedule 6 of the EP Act still apply in ESAs, including any clearing in accordance with a subdivision or development approval under the *Planning and Development Act 2005.*

4.5.2 Draft LSP response

The extension of a declared ESA across the majority of Precinct 1 does not require a specific spatial consideration within the draft LSP.

4.5.3 Future management requirements

The portion of the ESA mapped as occurring within Precinct 1 is predominately cleared and is characterised by a small number of scattered planted trees over introduced grasses, which do not represent significant environmental values.

It is likely that vegetation within the portion of Precinct 1 declared an ESA will require clearing as part of future industrial development. If this occurs, the clearing must be taken in accordance with either:

- An approved Clearing Permit under Part V of the EP Act; or
- A valid exemption under Schedule 6 of the EP Act, including in accordance with a subdivision or development approval under the *Planning and Development Act 2005*.

The future industrial development of Precinct 1 will be undertaken in accordance with subdivision or development approval(s), which are valid exemptions for clearing within an ESA, as detailed above.

5 Implementation Framework

5.1 Wetland and Conservation Area Management Strategy

5.1.1 Purpose

The purpose of this strategy is to define a consistent approach to the short and long-term management of the wetlands and conservation areas within the Precinct 1 draft LSP. The strategy applies to:

- The conservation category wetland and Threatened Ecological Community (TEC) buffers associated with Bush Forever Site 53.
- The proposed conservation category wetland located to the south-east of Victoria Road and north-east of Bickley Road (excised from UFI 8050).
- The proposed Banksia Woodland conservation area located to the north-east of Clifford Street and south-east of Victoria Road.
- The 50m buffers to be placed around the proposed conservation category wetland and the Banksia Woodland TEC.
- The Biodiversity Asset (Nature) POS that will encompass these areas, in accordance with the CoG Public Open Space Strategy (CoG 2014b). These POS areas will ultimately be reserved for 'Local Open Space' under the CoG Town Planning Scheme (TPS) No.6, and will be brought into public ownership and management.

Where future subdivision or development applications contain any of the above assets (either partly or wholly), it is anticipated that, in line with the WAPC's *Model Subdivision Conditions Schedule*, a condition of approval would likely require proponents to prepare a Wetland and Conservation Area Management Plan for these assets, consistent with this strategy. For the sake of brevity, this term is applied to the proposed conservation area encompassing the *Banksia* Woodland, even though it does not contain a designated wetland.

5.1.2 Policy and guidance

The policy and guidance documents that have informed this strategy are listed below, and passages from these documents have been used verbatim where appropriate:

- *Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community*, Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s 266B), 2016
- *Wetlands Conservation Policy for Western Australia*, Government of Western Australia, 1997
- *Guidelines checklist for preparing a wetland management plan*, Department of Environment and Conservation, 2008
- *Environmental Guidance for Planning and Development*, Guidance Statement No.33, EPA, 2008.
- *Environmental Factor Guideline Flora and Vegetation*, EPA, 2016
- *Environmental Factor Guideline Inland Waters Environmental Quality*, EPA, 2016

- *Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans*, EPA, 2017.
- *Policy Statement: Rehabilitation and Revegetation of Natural Areas,* Policy No. CP 6.2.2, City of Gosnells, 2017.

5.1.3 Management framework

Drawing from guidance provided by the then Department of Environment and Conservation (2008) and the EPA (2017), this strategy has adopted the management framework illustrated in **Plate 12**.

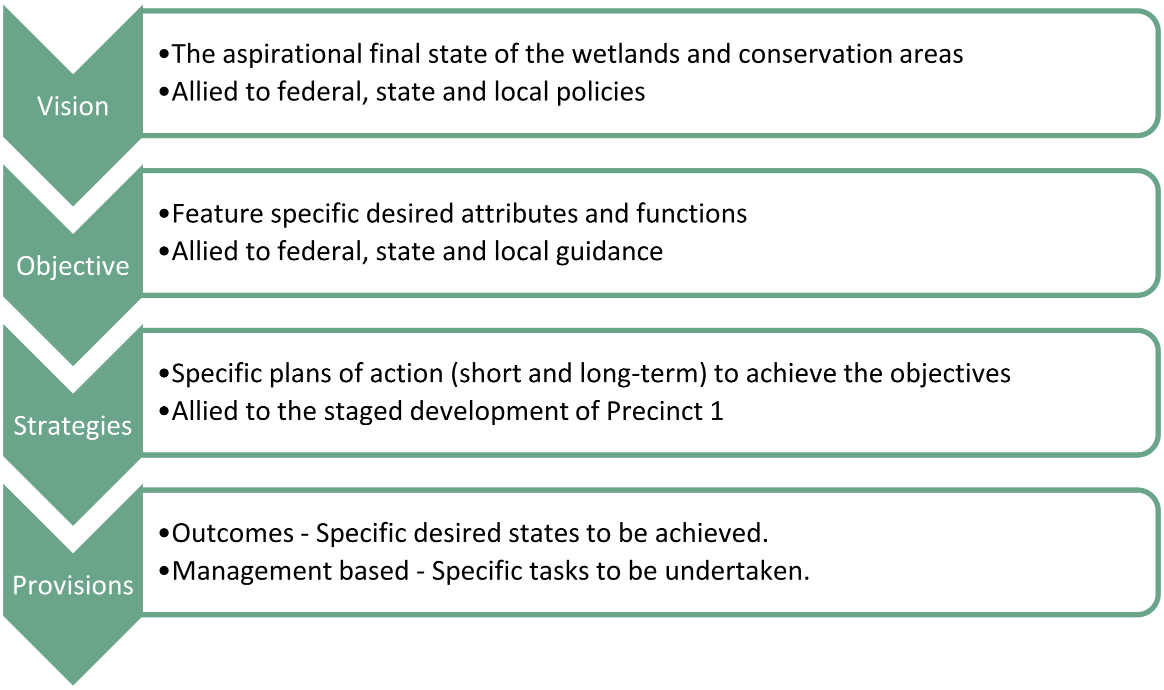

Plate 12: Management framework

This strategy focuses on the above fours steps, the subsequent Wetland and Conservation Area Management Plans (WCAMPs) will define the items listed in **Table 12**.

Table 12: Management framework items to be addressed in WCAMPs

Item	WCAMP Content
Outcome provisions	Site-specific trigger thresholds and criteria
Management based provisions	Site-specific management actions and targets
Triggered Action Response Plan (TARP)	Actions that are triggered if the plan's provisions are not being achieved.
Monitoring	A monitoring regime appropriate to a plan's provisions
Reporting	A reporting regime, including an annual report and noncompliance reporting to the CoG.
Adaptive management and review	How the plan will adapt to changing or unforeseen circumstances, and triggers for formally reviewing the plan
Stakeholder consultation	Details of stakeholders consulted during the preparation of the plan, their issues and the plan's response

5.1.4 Vision

The aspirational final state of the wetlands and conservation areas

The proposed vision for the wetlands and conservations areas within Precinct 1 is:

Wetlands and Conservation Areas protected, enhanced and managed to conserve and improve their unique environmental, ecological and amenity characteristics, with increased community awareness and appreciation of their value.

The following policy and guidance statements have informed the vision:

- Wetlands Conservation Policy for Western Australia 1997 that committed the government to the following principals:
    1. To prevent the further loss or degradation of valuable wetlands and wetland types, and promote wetland conservation, creation and restoration.
    2. To include viable representatives of all major wetland types and key wildlife habitats and associated flora and fauna within a Statewide network of appropriately located and managed conservation reserves which ensure the continued survival of species, ecosystems and ecological functions.
    3. To maintain, in viable wild populations, the species and genetic diversity of wetland-dependent flora and fauna.
    4. To maintain the abundance of waterbird populations, particularly migratory species.
    5. To greatly increase community awareness and appreciation of the many values of wetlands, and the importance of sound management of the wetlands and their catchments in the maintenance of those values.

- The EPA's objectives for flora and vegetation and inland waters environmental quality:
    - "To protect flora and vegetation so that biological diversity and ecological integrity are maintained."
    - "To maintain the quality of groundwater and surface water so that environmental values are protected."

5.1.5 Objectives

Feature specific desired attributes and functions

Precinct 1 contains a proposed conservation category wetland (CCW), an area of Banksia Woodland and the buffers for the CCW and TEC within Bush Forever Site 53. Based on the feature specific desired attributes and functions of these areas, the objectives listed in **Table 13** have been identified.

Table 13: Wetland and conservation area management objectives

Wetland or conservation area	Objective
Proposed conservation category wetlands and buffers	• Separate the wetland from the adjacent land use(s) that might threaten its desired values, through either spatial separation or the use of physical barriers, consistent with the Wetland Buffer Study (**Section 4.4.2**). • Preserve and protect the existing conservation values of the wetlands. • Prevent any activity that may lead to further loss or degradation. • Restore ecological integrity and function through revegetation of degraded areas. • Manage and maintain ecological values. • Transfer the public open space containing the wetlands and buffers into public ownership and reserve this land for 'Local Open Space' under the City of Gosnells' TPS no. 6.
Conservation Area containing Banksia Woodland TEC and its buffer.	• Protect the ecological community to prevent further loss of extent and degradation. • Restore the ecological community within its original range by the active abatement of threats, re-vegetation and other conservation initiatives. • Restore ecological integrity and function through revegetation of degraded areas. • Manage and maintain ecological values. • Transfer the public open space containing the Banksia Woodland into public ownership and reserve this land for 'Local Open Space' under the City of Gosnells' TPS no. 6.
Bush Forever Site 53 buffers	• Separate the wetland and TEC from the adjacent land use(s) that might threaten their desired values, through either spatial separation or the use of physical barriers. • Retain all remnant vegetation in the buffer • Restore ecological integrity and function through revegetation of degraded areas. • Manage and maintain ecological values. • Transfer the public open space containing the buffer area into public ownership and reserve this land for 'Local Open Space' under the City of Gosnells' TPS no. 6.

5.1.6 Strategies

Specific plans of action (short and long-term) to achieve the objectives.

While the CoG is progressing the necessary approvals for the adoption of the draft LSP across Precinct 1, future planning requirements, e.g. subdivisions and development applications will be the responsibility of landowners or groups of landowners.

The land required to form the Biodiversity Asset (Nature) public open space (POS) proposed in the draft LSP spans a number of adjacent cadastral lots held in private ownership. This land will only be transferred into public ownership when a landowner initiates and implements an approved subdivision or development application. Therefore, it is highly unlikely that the land necessary to form POS will come into public ownership in an orderly fashion.

In response to this, the strategies put in place to achieve the stated objectives must allow for a series of interim phases before the entirety of the proposed POS can be ceded into local reserves and managed as single entities. The adoption of short-term and longer-term plans of action are therefore proposed, with the following temporal boundaries:

Short-term – applies before the entirety of a proposed area of POS is ceded into public ownership and is vested to a Management Authority, anticipated to be the CoG. During this period, it is likely that there will be a mosaic of different land uses and ownership within these areas, and the plans of action will need to reflect the constraints that this places on achieving the areas' objectives.

Long-term – applies once the entirety of a proposed area of POS is ceded into public ownership and is vested to a Management Authority, anticipated to be the CoG. At this point, the plans of action can focus on managing the area as a single entity towards its objectives.

5.1.6.1 Short-term plans of action

The developer of each property that contains any of the POS areas identified in **Section 5.1.1** will be required by planning approval condition(s) to prepare and implement an Interim Wetland and Conservation Area Management Plan. The plan should address the CoG Council Policy 6.2.2 (CoG 2017) and associated guidelines (CoG 2014a).

5.1.6.2 Long-term plans of action

As development and consequent ceding of POS areas proceeds, a sufficient proportion of the POS area will eventually fall under the CoG management. When the accumulated area of POS, nominally 65%, triggers the need, the city will prepare long-term management plan(s) for the subject areas. Management planning will be informed by prior and ongoing monitoring and will build on Interim Wetland and Conservation Area Management Plans.

For any areas of POS ceded into public ownership, the CoG will continue to implement the Interim Wetland and Conservation Area Management Plans until such time as the 65% trigger is met.

The above guidance will be applied by the CoG but may be varied according to site-specific circumstances.

5.1.7 Provisions

The Interim Wetland and Conservation Area Management Plans that will be prepared by individual developers in the short-term and the CoG in the long-term, are as a minimum required to address the provisions listed in **Table 14**, where relevant; together with the items listed in **Table 12**. Also listed in **Table 14** are potential related issues and items to be addressed.

Table 14: Wetland and Conservation Area Management Plan provisions

Provision	Potential issues and items to address
Vegetation management, revegetation and rehabilitation	• Mapping of asset and buffer to inform weed management and revegetation planning. • Two-year revegetation program for buffer and environmental asset to be approved and satisfactory arrangements made for implementation. • Protection/enhancement of other compatible values (recreational, scientific, educational, aesthetic, cultural, heritage and commercial), and resolution of any potential conflicts between different objectives/ uses. • Repair of degraded areas. • Detailed revegetation plan including source and types of seed (addressing provenance), plants, mulch, soil, and other materials, propagation methods, fertilisation and irrigation if appropriate, topsoil management, mulching and soil stabilisation (minimising disease risk), planting schedule, planting density, seedling maintenance. • Revegetation monitoring to inform reporting and subsequent in-fill planting program(s), and to demonstrate achievement measured against agreed success criteria.
Weed management	• Weed control/eradication outlining chemical, biological and manual methods of removal and weeding schedule.
Fire management	• The location of firebreaks, consultation with relevant authorities, access for firefighters, education of the local community. • Firebreaks to comprise, 6 m compacted crushed limestone fire access track on the periphery of the buffer POS, inside the fence line. 3.6m gate(s) to provided, as required.
Dieback management	• Disease control standards, e.g. cleaning of equipment, regular surveys for the presence of dieback, response plans.
Midges and mosquitoes management	• Monitor to determine if there is an amenity impact, and control if necessary, e.g. apply larvicide.
Water quality	• Compatibility with the stormwater management measures detailed in the LSP's Local Water Management Strategy. • Groundwater and surface water monitoring and reporting measures will be detailed in future UWMP(s) and should be incorporated into the Wetland and Conservation Area Management Plans.
Fencing	• Temporary fencing to protect the POS from encroachment during construction works; permanent fencing along the peripheral boundary of the POS. Fencing to the city's Specification for Conservation Area Fencing (March 2018), attached as **Appendix E**. Allowance to be made for fire access gates, as required, and pedestrian access.
Maintenance and community access	• Interim and ultimate access strategy. • Consider walking trails, seating, signage, educational facilities (for example, interpretive signage), entry points, vehicular access for maintenance and emergency vehicles.

5.1.8 Strategy summary

This strategy has established the vision and conservation objectives for the areas of Biodiversity Assets (Nature) public open space (POS) within the MKSEA Precinct 1 Local Structure Plan area. The strategy recognises that areas of POS are unlikely to be established in an orderly fashion, due to the mix of landownerships and the reliance on individual developers to make land within the areas available through the planning process. In response to this, the strategy sets out short and long-term plans of action, with the aim of preventing the further degradation of an area before all the land required for an area of POS is assembled and vested to a Management Authority.

The strategy proposes that the short-term action plans will require a series of Interim Wetland and Conservation Area Management Plans (WCAMP), with the Management Authority ultimately preparing a comprehensive 'long-term' WCAMP for an area. It is not possible to put any timeframes against the preparation of these WCAMPs, as it is likely to be the private sector that will initiate the necessary planning processes.

5.2 Other environmental values

A summary of the draft LSP's responses to the environmental values and attributes not addressed directly in the Wetland and Conservation Area Strategy is provided in **Table 15**. The table also outlines the proposed future management required as part of the subdivision and development process.

Table 15: Environmental management framework implementation table

Attribute	LSP phase	Subdivision phase	Development phase
Fauna	The draft LSP design allows for the future retention of the majority of intact remnant vegetation and associated fauna habitat within Precinct 1, through the provision of open space areas.	A Fauna Relocation Management Plan (or similar) will be prepared where a proposal requires the removal of existing vegetation and associated fauna habitat.	Implementation of Fauna Relocation Management Plan.
Hydrology	A Local Water Management Strategy (LWMS) has been prepared to support the draft LSP.	An *Urban Water Management Plan* (UWMP) will be prepared and implemented at the subdivision stage based on the principles outlined in the LWMS.	Implementation of UWMP. Lot-specific industrial wastewater and onsite effluent management to be detailed.

6 Conclusion

The CoG has prepared the Precinct 1 draft LSP which outlines the proposed industrial development of the area. This EAMS has been prepared to support the draft LSP.

The draft LSP has responded to the environmental values and attributes of Precinct 1, with the proposed spatial responses and future management outlined in **Section 4**, which include:

- Retention of all identified significant environmental values within public open space areas, including identified occurrences of SCP 3a and SCP 20a TECs, the single occurrence of priority flora, and the associated wetland feature (determined to be representative of a CCW).
- Provision of a 50 m buffer around the wetland feature determined to be representative of a CCW.
- Provision of a 50 m buffer surrounding the identified Banksia Woodland TEC.

This EAMS also outlines the environmental management framework to be implemented across Precinct 1 as part of future subdivision and development phases, including:

- Preparation and implementation of Interim and Final Wetland and Conservation Area Management Plans for each open space area identified in the draft LSP. Each plan will outline the management requirements for the wetland and conservation area and its associated environmental values.
- Preparation and implementation of a Fauna Relocation and Management Plan (or similar) prior to any ground disturbing works which may impacts upon fauna species or associated habitat.
- Preparation of an Urban Water Management Plan to support each stage of subdivision.
- Consideration of potential requirement for a clearing permit.
- The potential requirement for an Acid Sulfate Soil and Dewatering Management Plan (ASSDMP) based on future investigations, if required.

Overall, the environmental attributes and values of Precinct 1 can be accommodated within the draft LSP design or can be managed appropriately through the future subdivision and development phases in line with the relevant state and local government legislation, policies and guidelines.

7 References

7.1 Legislation

Aboriginal Heritage Act 1972

Biodiversity Conservation Act 2016

Bush Fires Act 1954

Contaminated Sites Act 2003

Environmental Protection Act 1986

Environment Protection and Biodiversity Conservation Act 1999

Environmental Protection (Clearing of Native Vegetation) Regulations 2004

Wildlife Conservation Act 1950

7.2 General references

360 Environmental 2012, Black Cockatoo Survey – Maddington Kenwick Strategic Employment Area.

Australian Cultural Heritage Management (ACHM) 2009, Preliminary Investigation of Aboriginal Heritage - City of Gosnells Maddington Kenwick Strategic Employment Area (MKSEA).

Alan Tingay and Associates 1998, A Strategic Plan for Perth's Greenways - Final Report.

Aquaterra 2008, MKSEA Surface Water and Groundwater Investigation and Monitoring Program.

Beard, J. S. 1990, Plant Life of Western Australia, Kangaroo Press Pty Ltd., Kenthurst, N.S.W.

Cardno BSD 2005, Maddington-Kenwick Strategic Industrial Area - Environmental Review: Flora, Vegetation, Fauna and Wetlands.

Cardno BSD 2006, Maddington Kenwick Strategic Employment Area - Preliminary Transport Study.

Churchward, H. M. and McArthur, W. M. 1980, 'Landforms and Soils of the Darling System, Western Australia', in Department of Conservation and Environment (ed.), Atlas of Natural Resources Darling System Western Australia, Department of Conservation and Environment.

City of Gosnells (CoG) 2014a, Natual Areas: Rehabilitation and revegetation guidelines.

City of Gosnells (CoG) 2014b, Public Open Space Strategy.

City of Gosnells (CoG) 2017, Council Policy 6.2.2: Rehabilitation and revegetation of natural areas.

Department of Aboriginal Affairs (DAA) 2013, Aboriginal Heritage Due Diligence Guidelines (Version 3.0), Department of Aboriginal Affairs, Perth.

Department of the Environment and Energy (DoEE) 2016, Banksia Woodlands of the Swan Coastal Plain in Community and Species Profile and Threats Database, Canberra.

Deparment of Environment and Energy (DoEE) 2017, Approved Conservation Advice for Shrublands and Woodlands of the eastern Swan Coastal Plain, Canberra.

Douglas Partners 2015, Report on Geotechnical Investigation - Proposed Warehouse Development Lots 252 to 256 Clifford Street, Maddington, WA, Revision 1.

Department of Water (DoW) 2008, LiDAR Elevation Dataset, Swan Coastal Plain, Perth.

Department of Sustainability Environment Water Populations and Communities (DSEWPaC) 2012, EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered) Calyptorhynchus latirostris, Baudin's cockatoo (vulnerable) Calyptorhynchus baudinii and Forest red-tailed black cockatoo (vulnerable) Calyptorhynchus banksii naso, Commonwealth of Australia, Canberra.

Eco Logical 2014, Maddington Kenwick Strategic Employment Area Bushfire Hazard Assessment.

Emerge Associates 2018, Acid Sulfate Soil Investigation Maddington Kenwick Strategic Employment Area Precincts 1, 2 and 3B.

Emerge Associates 2019a, Flora, Vegetation and Wetland Assessment - Maddington Kenwick Strategic Employement Area Precinct 1, EP17-010(02)--004 Revision B.

Emerge Associates 2019b, Local Water Management Strategy Maddington Kenwick Strategic Employment Area - Precinct 1, EP17-010(11)--014D ASC, Revision D.

Environment Australia 2000, Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1 - Summary Report, Department of Environment and Heritage.

GHD 2005, Maddington Kenwick Strategic Employment Area Engineering Feasibility Study.

Government of WA 2000a, Bush Forever - Volume 1: Policies, principles and processes, Perth.

Government of WA 2000b, Bush Forever, Volume 2: Bush Forever Site Descriptions, Perth.

Government of WA 2003, A State Water Strategy for Western Australia, Perth.

Gozzard, J. R. 2011, Sea to scarp [electronic resource]: geology, landscape and land use planning in the southern Swan Coastal Plain, Geological Survey of Western Australia.

Harewood, G. 2018, Fauna Assessment (Level 1) Maddington Kenwick Strategic Employment Area Precinct 1.

Heddle, E. M., Loneragan, O. W. and Havel, J. J. 1980, 'Vegetation Complexes of the Darling System Western Australia', in Department of Conservation and Environment (ed.), Atlas of Natural Resources Darling System Western Australia, Perth.

Jordan, J. E. 1986, Armadale Part Sheets 2033 I and 2133 IV, Geological Survey of Western Australia, Department on Minerals and Energy, Perth.

Keighery, B. 1994, Bushland Plant Survey: A guide to plant community survey for the community, Wildflower Society of WA (Inc), Nedlands.

Local Biodiversity Project (LBP) 2013, 2013 Native Vegetation extent by Vegetation complexes on the Swan Coastal Plain south of Moore River, Western Australian Local Government Association, Perth.

Perth Biodiversity Project (PBP) 2007, Perth Biodiversity Project - Mapping and Information Instalment 2, Western Australian Local Government Association, Perth.

Seddon, G. 2004, A Sense of Place: a response to an environment, the Swan Coastal Plain Western Australia, Blooming Books, Melbourne.

Tauss, C. and Weston, A. S. 2010, The flora, vegetation and wetlands of the Maddington-Kenwick Strategic Emplyment Area.

TME Town Planning Management Engineering (TME) 2014, District Water Management Strategy - Maddington Kenwick Strategic Employment Area Precincts 2 and 3.

Western Australian Planning Commission (WAPC) 2008, Better Urban Water Management, Perth.

W. A. P. Commission (WAPC) 2015, Structure Plan Framework, Planning and Development (Local Planning Schemes) Regulations 2015.

L. a. H. Western Australian Planning Commission and Department of Planning (WAPC and DPLH) 2018a, Perth and Peel@3.5 Million, Western Australian Planning Commisson, Perth.

L. a. H. Western Australian Planning Commission and Department of Planning (WAPC and DPLH) 2018b, South Metropolitan Peel Sub-regional Planning Framework, Western Australian Planning Commission, Perth.

7.3 Online references

CSIRO 2014, The State of the Climate Report for 2014, viewed March 2018, <http://www.csiro.au/en/Research/OandA/Areas/Assessing-our-climate/State-of-the-Climate/2014-SoC-Report>.

Department of Aboriginal Affairs (DAA) 2018, *Aboriginal Heritage Enquiry System*, viewed March 2018, <http://maps.dia.wa.gov.au/AHIS2/>.

Department of the Environment and Energy (DoEE) 2016, *EPBC Act Protected Matters Report*, generated from the EPBC Act Protected Matters Database, report generated 14 October 2016¸ <https://www.environment.gov.au/epbc/protected-matters-search-tool>.

Department of Parks and Wildlife (DPaW) 2013, *A visual guide to the Interim Biogeographic Regionalisation for Australia (IBRA) in WA*, viewed 14 October 2016, <http://florabase.dec.wa.gov.au/help/ibra/#map>.

Department of Parks and Wildlife (DPaW) 2015a, *Threatened Priority Flora Database*, viewed 14 October 2016, <http:// https://www2.landgate.wa.gov.au/bmvf/app/waatlas/>.

Department of Water (DoW) 2001, *Perth Groundwater Atlas (groundwater contours)*, viewed March 2018, <http://atlases.water.wa.gov.au/idelve/gwa/>.

Department of Water (DoW) 2018, *Perth Groundwater Atlas (Public Drinking Water Source Areas data layer)*, viewed March 2018, <http://atlases.water.wa.gov.au/idelve/gwa/>.

Department of Water and Environmental Regulation (DWER) 2016a, *Acid Sulfate Soil – Swan Coastal Plain Database*, viewed 13 October 2016, <http:// https://www2.landgate.wa.gov.au/bmvf/app/waatlas/>.

Department of Water and Environmental Regulation (DWER) 2016b, *Contaminated Sites Database*, viewed March 2018, <https://secure.dec.wa.gov.au/idelve/css/>.

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Figures

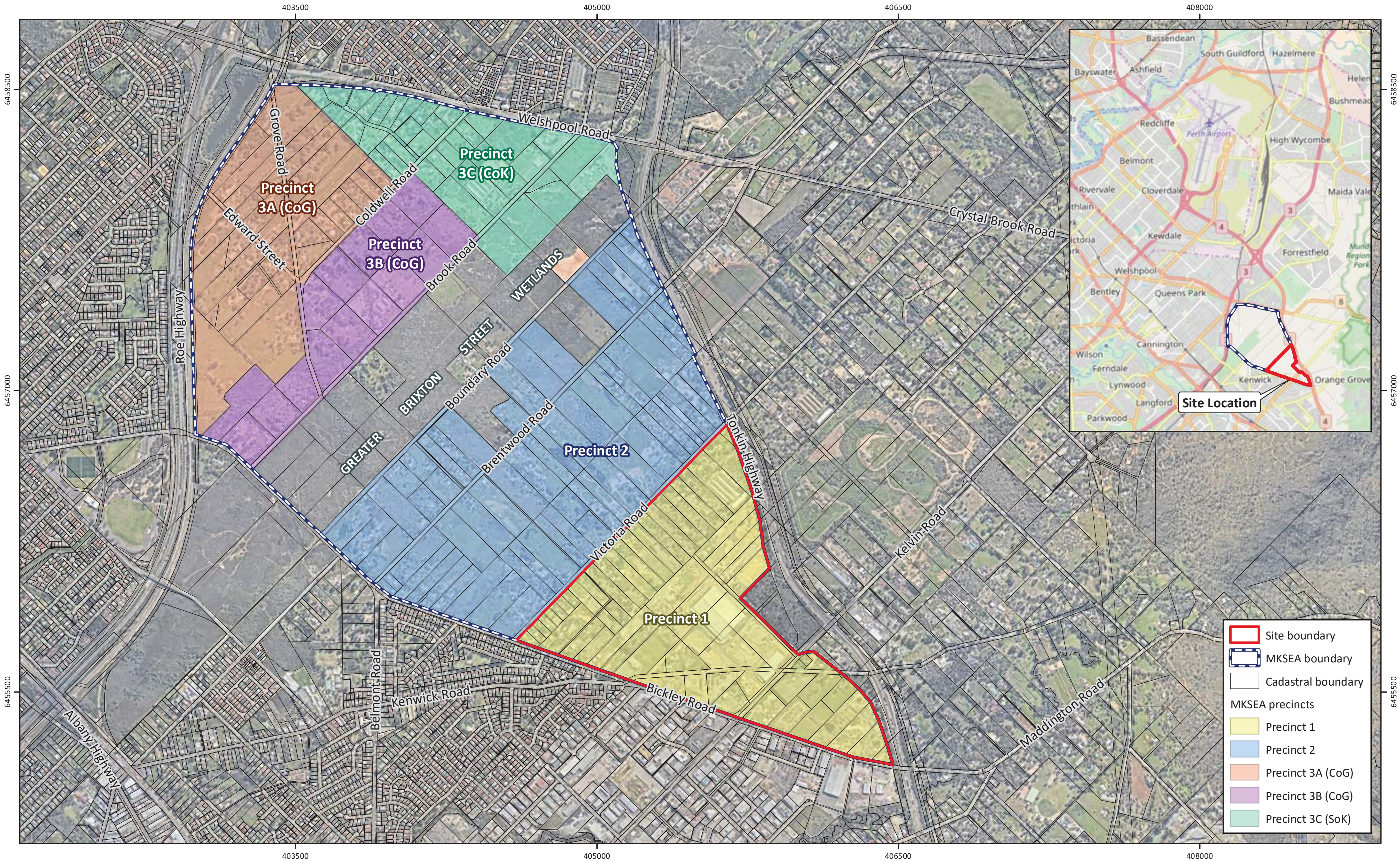

Figure 1: Site Locality

Project:	Environmental Assessment and Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number: EP17-010(09)--F52a
Drawn: SCM
Date: 15/08/2018
Checked: ALB
Approved: ALB
Date: 15/08/2018

emerge ASSOCIATES

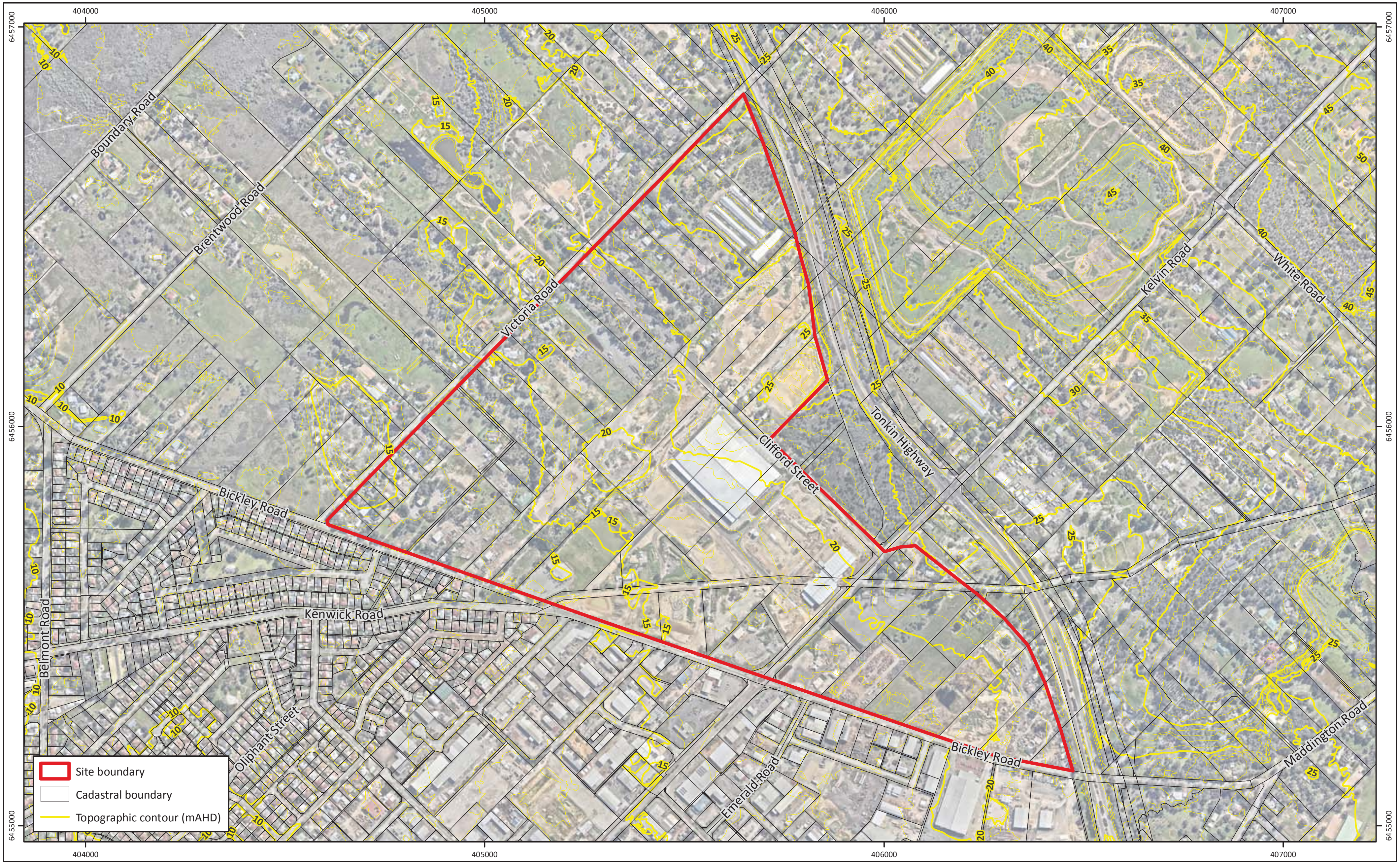

Figure 2: **Topographic Contours**

Project:	Environmental Assessment and Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number:
EP17-010(09)--F53

Drawn:	KNM
Date:	20/03/2018
Checked:	ADB
Approved:	ALB
Date:	04/04/2018

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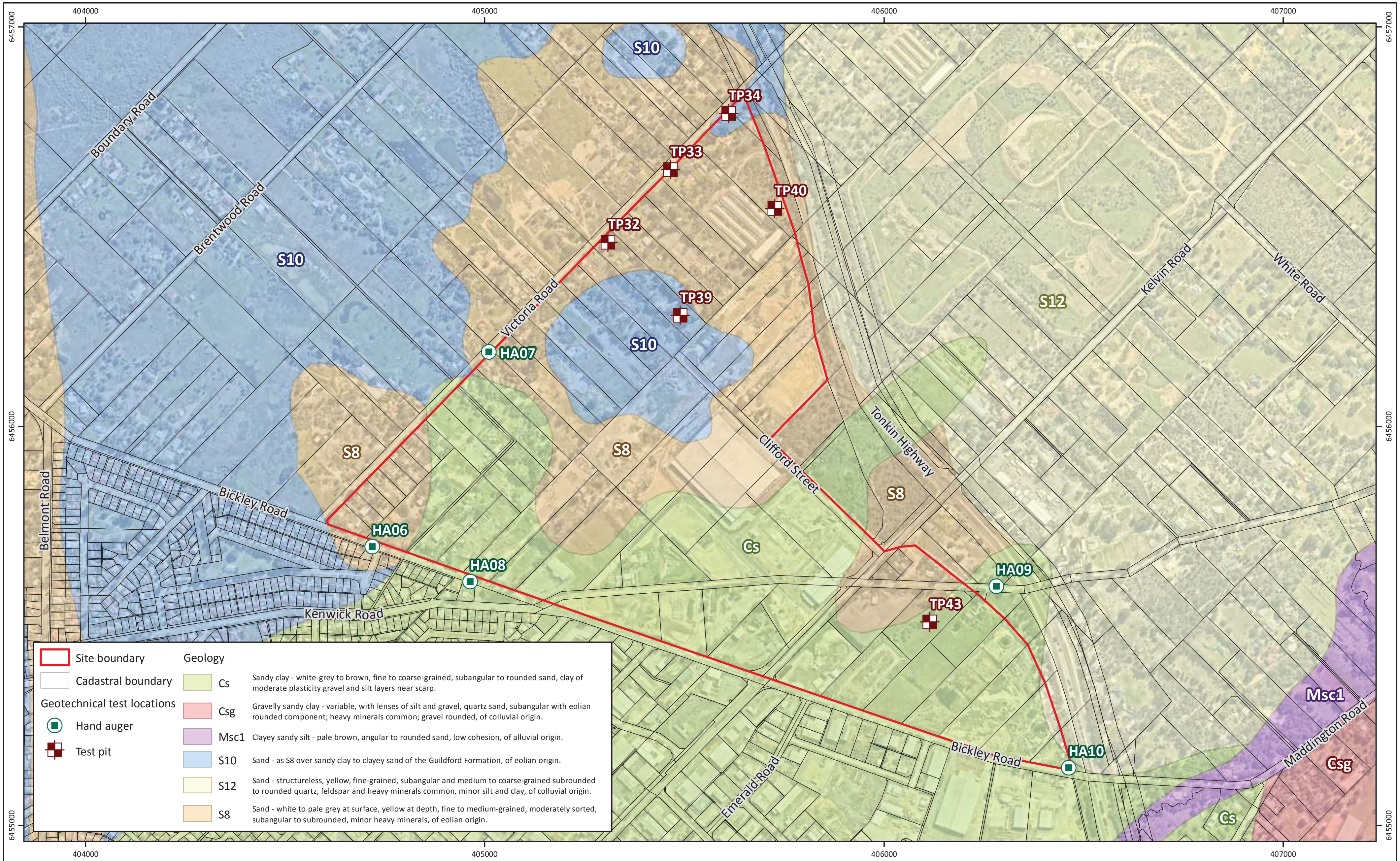
Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES



Site boundary	Geology		
Cadastral boundary		Cs	Sandy clay - white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp.
Geotechnical test locations		Csg	Gravelly sandy clay - variable, with lenses of silt and gravel, quartz sand, subangular with eolian rounded component; heavy minerals common; gravel rounded, of colluvial origin.
Hand auger		Msc1	Clayey sandy silt - pale brown, angular to rounded sand, low cohesion, of alluvial origin.
Test pit		S10	Sand - as S8 over sandy clay to clayey sand of the Guildford Formation, of eolian origin.
		S12	Sand - structureless, yellow, fine-grained, subangular and medium to coarse-grained subrounded to rounded quartz, feldspar and heavy minerals common, minor silt and clay, of colluvial origin.
		S8	Sand - white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin.

Figure 3: Environmental Geology

Project: Environmental Assessment and Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(09)--F54
Drawn: KNM
Date: 20/03/2018
Checked: ADB
Approved: ALB
Date: 04/04/2018

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

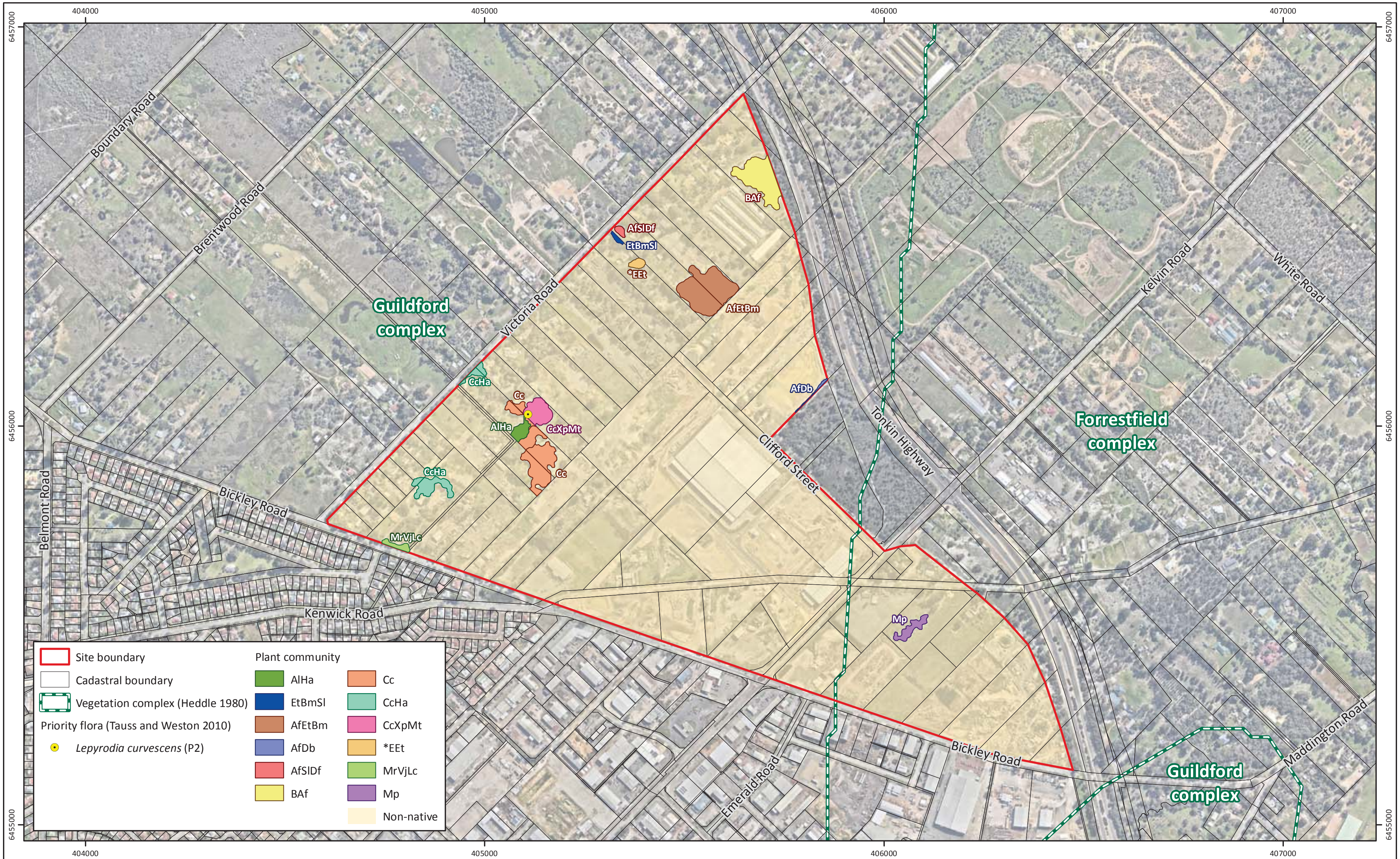

Figure 4: **Priority Flora and Plant Communities**

Project:	Environmental Assessment and Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number:
EP17-010(09)--F55a

Drawn:	KNM
Date:	10/01/2019
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Approved:	ALB
Date:	11/01/2019

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GDA 1994 MGA Zone 50

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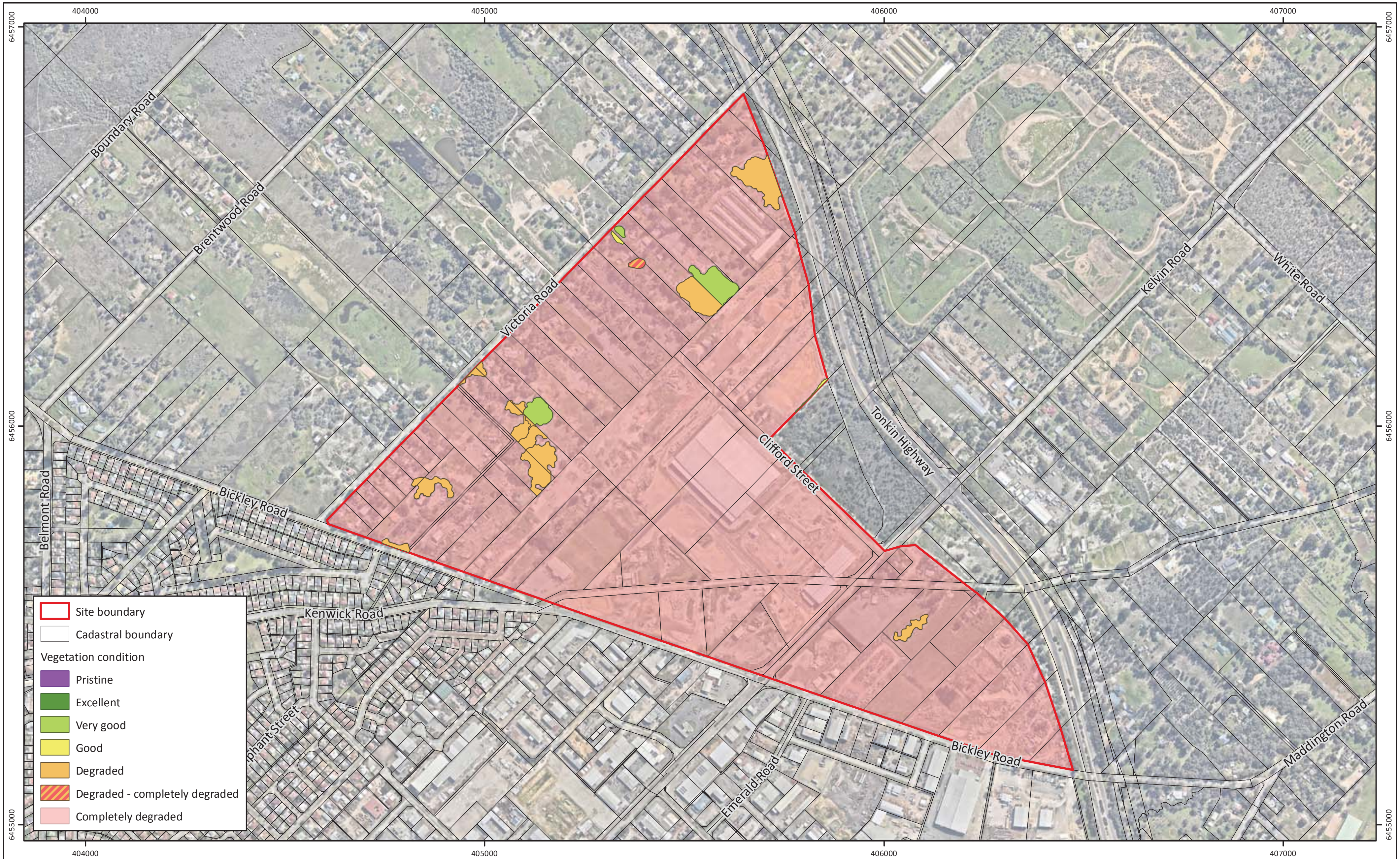

Figure 5: **Vegetation Condition**

Project: Environmental Assessment and Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(09)--F56a
Drawn: KNM
Date: 10/01/2019
Checked: ALB
Approved: ALB
Date: 11/01/2019

Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

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Figure 6: Conservation Significant Flora and Vegetation

Project: Environmental Assessment and Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number: EP17-010(09)--F57a
Drawn: KNM
Date: 10/01/2019
Checked: ALB
Approved: ALB
Date: 11/01/2019

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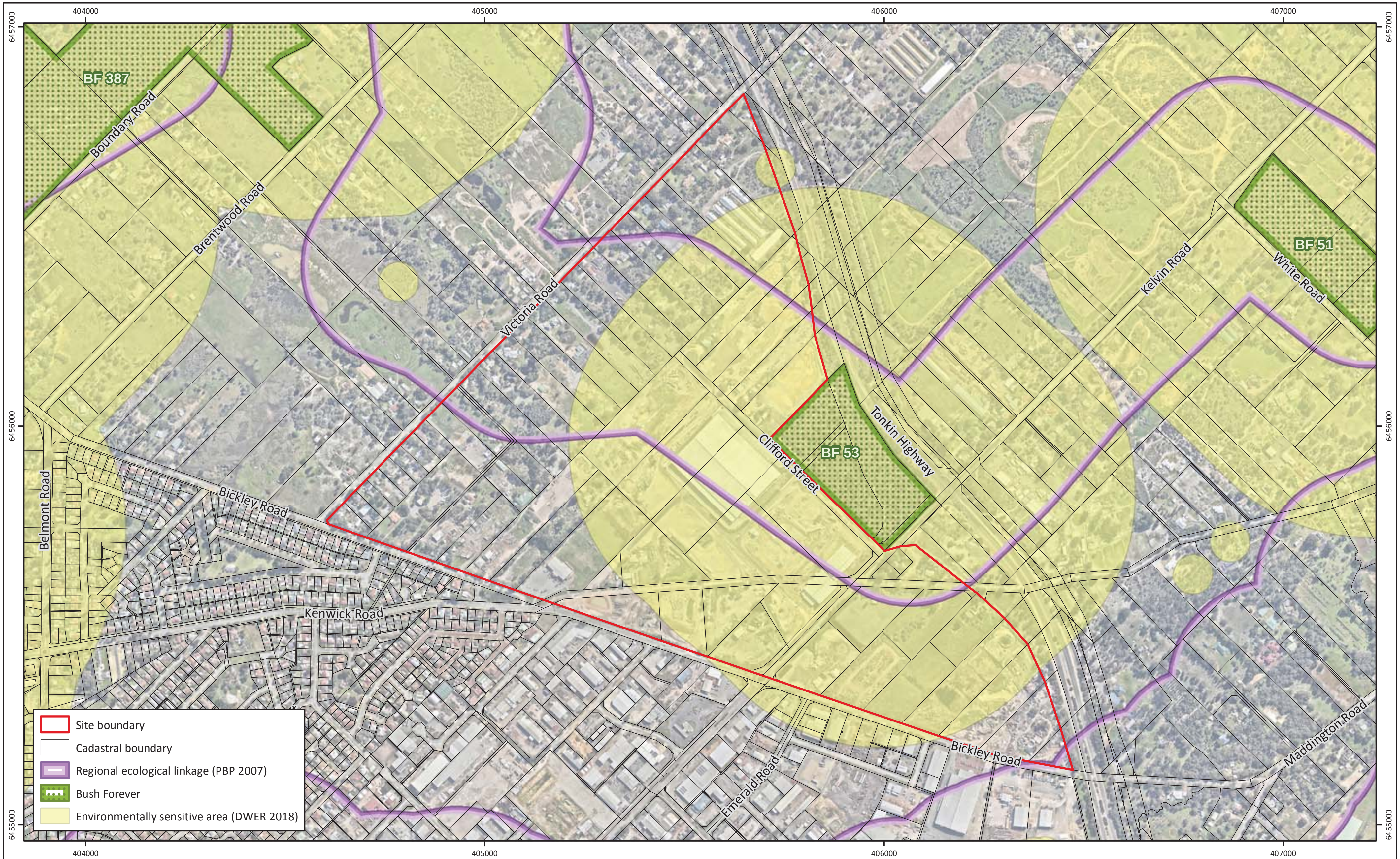

Figure 7: **Bush Forever, Environmentally Sensitive Areas and Regional Ecological Linkages**

Project: Environmental Assessment and Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(09)--F58

Drawn: KNM
Date: 20/03/2018
Checked: ADB
Approved: ALB
Date: 04/04/2018

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Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

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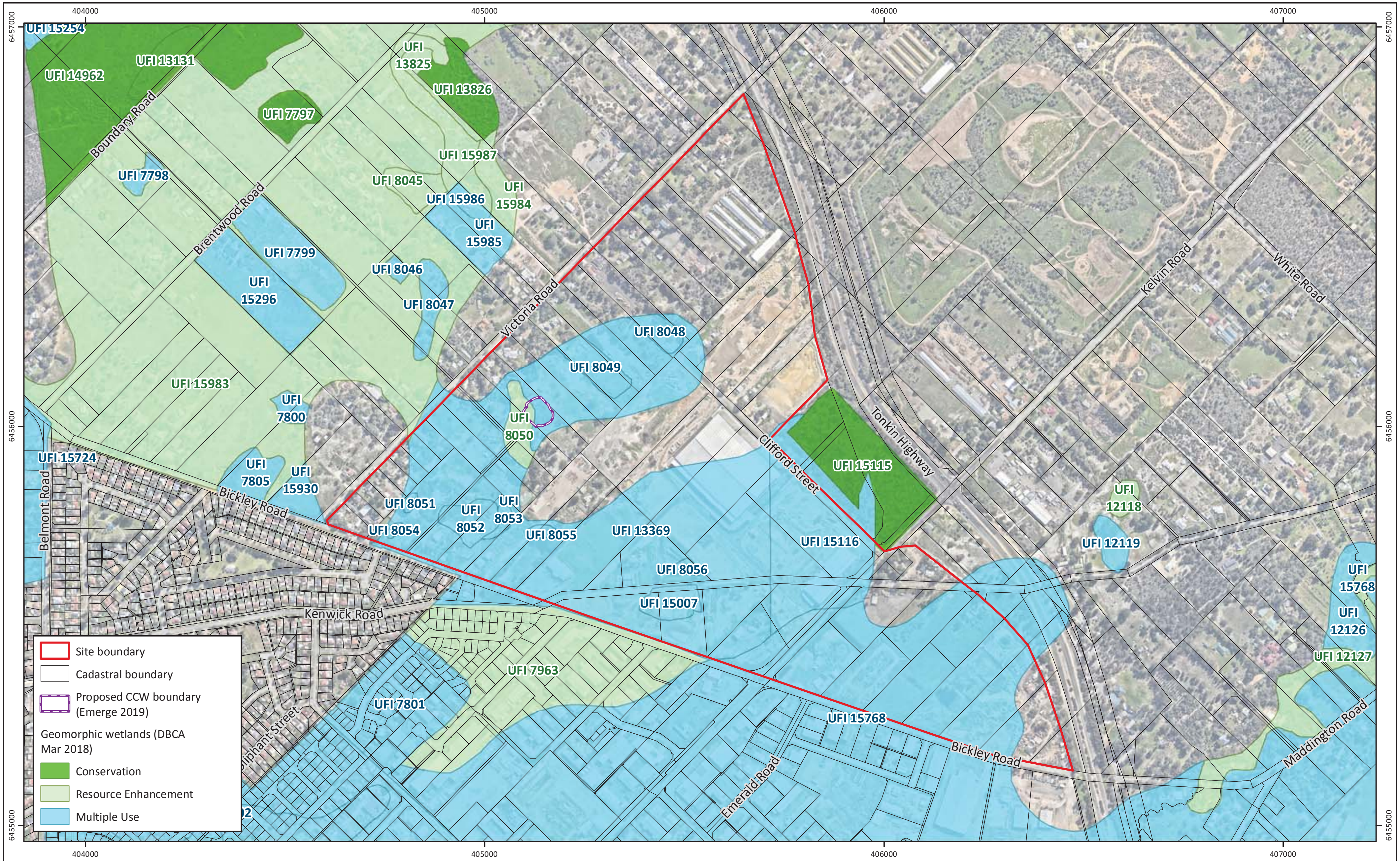

Figure 8: Wetland Features

Project: Environmental Assessment and Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number: EP17-010(09)--F59b
Drawn: KNM
Date: 10/01/2019
Checked: ALB
Approved: ALB
Date: 11/01/2019

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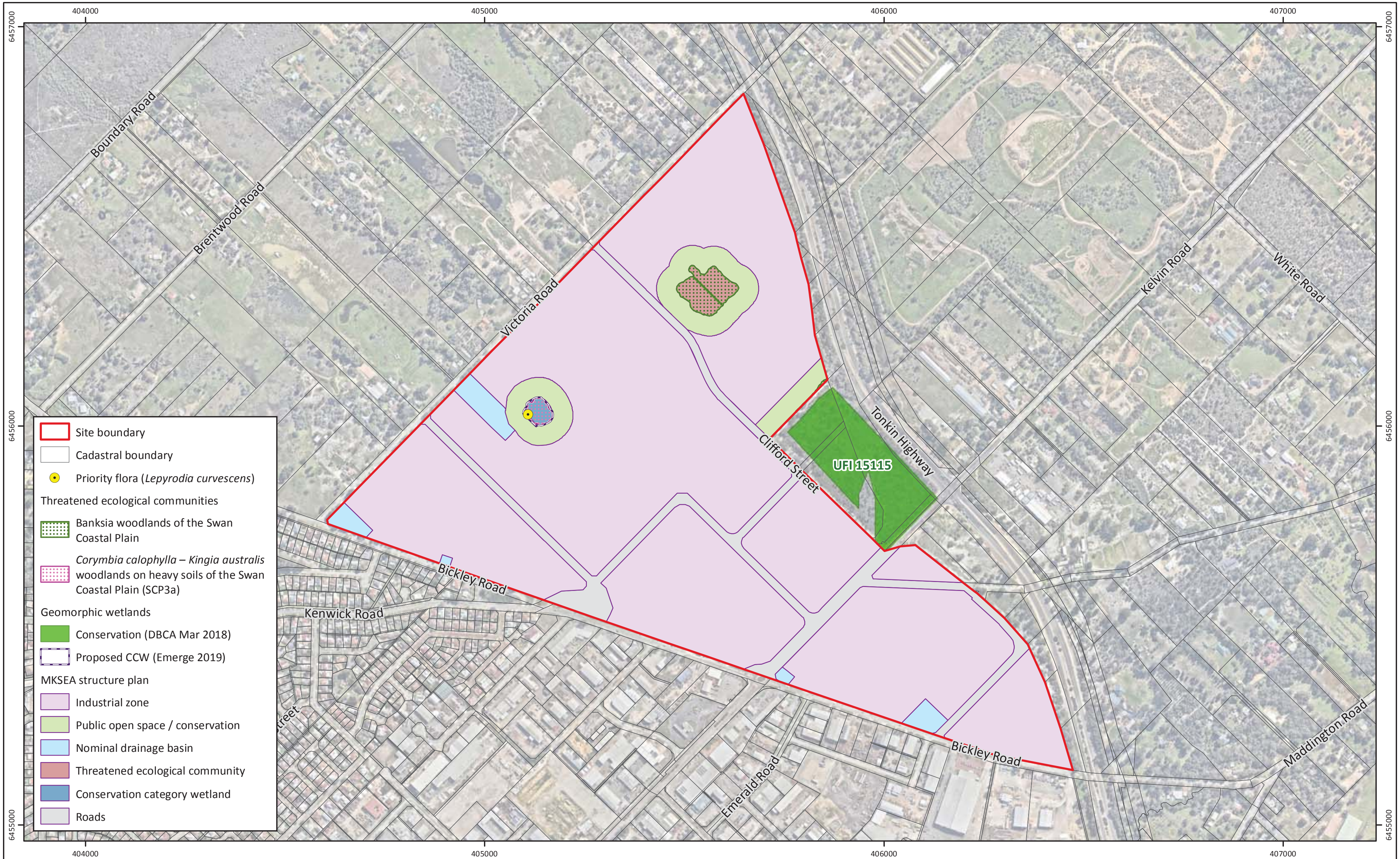

Figure 9: **Structure Plan Response to Environmental Considerations**

Project:	Environmental Assessment and Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number:
EP17-010(09)--F61f
Drawn: KNM
Date: 15/04/2019
Checked: ALB
Approved: ALB
Date: 15/04/2019

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Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

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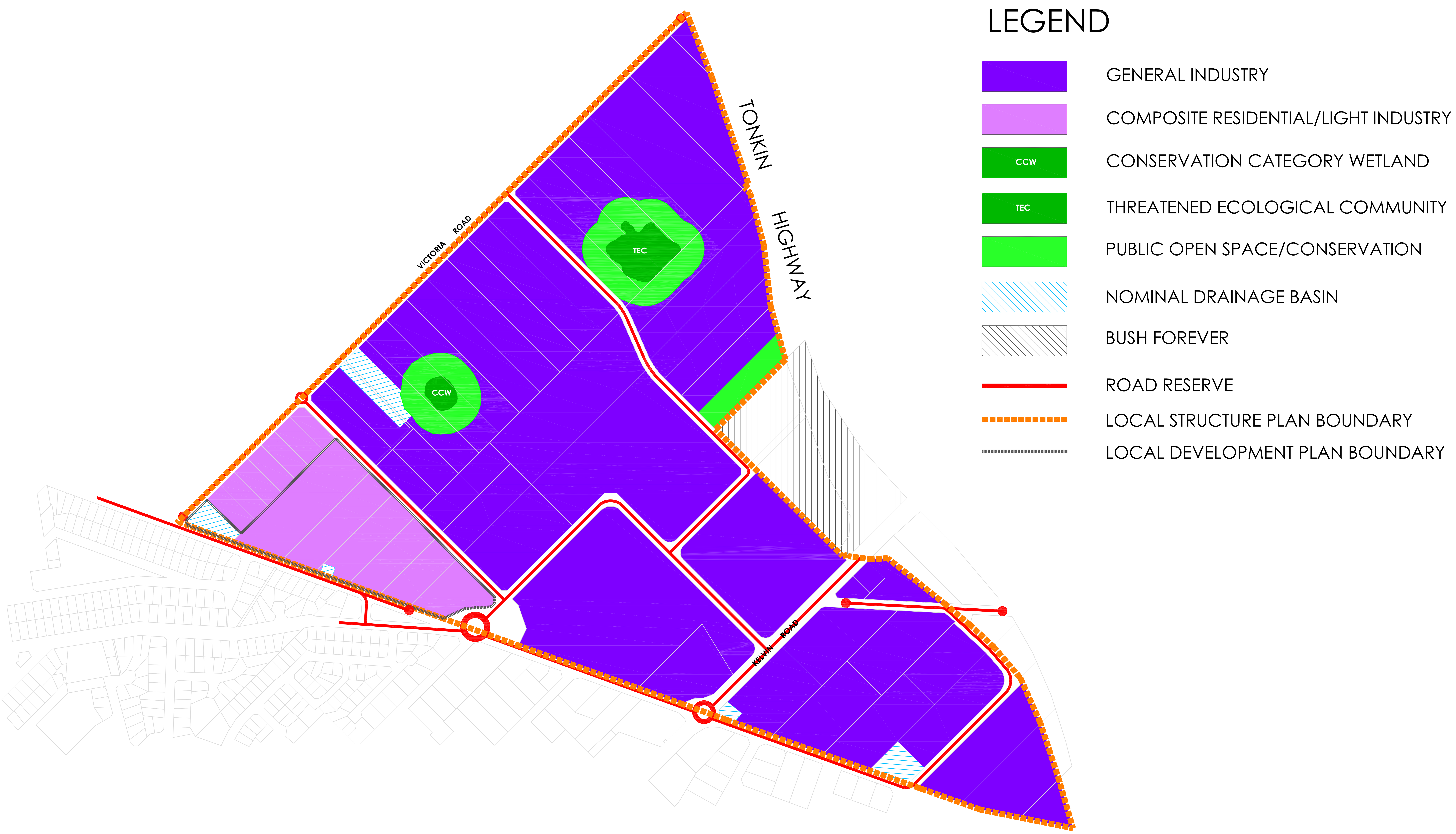
Appendix A

Draft Local Structure Plan (City of Gosnells 2019)



MADDINGTON KENWICK STRATEGIC EMPLOYMENT AREA

Draft Local Structure Plan - Precinct One

City of Gosnells

ISSUE	DESCRIPTION	YYMMDD	DRAWN	APPV'D
N	Precinct One	190329	AD	AD

PROJECT MKSEA

CLIENT COG

SCALE 1:4000 — 0 — 80 — 160m — SHEET A1

DRAWING NUMBER UD 001

REV N

REFERENCE NUMBER

Issued for design intent only. All areas and dimensions are subject to detail design + survey.

CITY OF GOSNELLS

Appendix B

Definitions and Criteria

Definitions and Criteria

The tables below provide definitions and criteria for the various categories of Threatened and Priority Flora, Threatened Ecological Communities, Priority Ecological Communities, vegetation condition ratings, DBCA Threatened Fauna, DBCA Priority Fauna, and geomorphic wetlands.

Table 1: Definitions of conservation significant flora species pursuant to the EPBC Act and BC Act and on DBCA's Priority Flora List (DBCA 2018)

CONSERVATION CODE	CATEGORY
EX†	Threatened Flora – Presumed Extinct Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently and have been gazetted as such.
T^†	Threatened Flora – Extant Taxa which are declared to be likely to become extinct or is rare, or otherwise in need of special protection.
CR^	Threatened Flora – Critically Endangered Taxa which are considered to be facing an extremely high risk of extinction in the wild.
EN^	Threatened Flora – Endangered Taxa which are considered to be facing a very high risk of extinction in the wild.
EX†	Threatened Flora – Presumed Extinct Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently and have been gazetted as such.
P1□	Priority One – Poorly Known Taxa Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat e.g. road verges, urban areas, farmland, active mineral leases etc., or the plants are under threat, e.g. from disease, grazing by feral animals etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora' but are in urgent need of further survey.
P2□	Priority Two – Poorly Known Taxa Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey.
P3□	Priority Three – Poorly Known Taxa Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but needs further survey.
P4□	Priority Four – Rare Taxa Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

^pursuant to the EPBC Act, †pursuant to the BC Act, □on DBCA's Priority Flora List

Table 2: Categories of Threatened Ecological Communities (English and Blyth 1997)

CONSERVATION CATEGORY	DESCRIPTION
PD	**Presumably Totally Destroyed** An ecological community that has been adequately searched for but for which no representative occurrences have been located.
CE	**Critically Endangered** An ecological community that has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
E	**Endangered** An ecological community that has been adequately surveyed and is not critically endangered but is facing a very high risk of total destruction in the near future.
V	**Vulnerable** An ecological community that has been adequately surveyed and is not critically endangered or endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

Table 3: Categories of Priority Ecological Communities (DEC 2010)

PRIORITY CATEGORIES	DESCRIPTION
Priority 1	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority 2	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority 3	Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (i) communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (ii) Communities made up of large, and/or widespread occurrences that may or not be represented in the reserve system but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
Priority 4	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened or that have been recently removed from the threatened list. These communities require regular monitoring.
Priority 5	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Table 4: Vegetation Condition Scale (Keighery 1994)

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds and non-aggressive species.
Very Good	Vegetation structure altered obvious signs of disturbance. Disturbance to vegetation structure covers repeated fire, aggressive weeds, dieback, logging, grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. Disturbance to vegetation structure covers frequent fires, aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. Disturbance to vegetation structure includes frequent fires, presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas often described as “parkland cleared” with the flora comprising weed or crop species with isolated native trees or shrubs.

Table 5: DBCA Priority Fauna Categories

CATEGORY	CODE	DESCRIPTION
Priority 1	P1	Taxa with few, poorly known populations on threatened lands
Priority 2	P2	Taxa with few, poorly known populations on conservation lands
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands
Priority 4	P4	Taxa in need of monitoring (Not currently threatened or in need of special protection but could be if present circumstances change)
Priority 5	P5	Taxa in need of monitoring (Not considered threatened but are subject to specific conservation program, the cessation of which would result in the species becoming threatened within five years)

Table 6: Categories of DBCA Threatened Fauna

CATEGORY	CODE	DESCRIPTION
Schedule 1	S1	Fauna which is rare or likely to become extinct
Schedule 2	S2	Fauna which is presumed extinct
Schedule 3	S3	Birds which are subject to an international agreement between the governments of Australia and other countries relating to the protection of migratory birds and birds in danger of extinction
Schedule 4	S4	Fauna that is otherwise in need of special protection

Table 7: DBCA Priority Fauna Categories

CATEGORY	CODE	DESCRIPTION
Priority 1	P1	Taxa with few, poorly known populations on threatened lands
Priority 2	P2	Taxa with few, poorly known populations on conservation lands
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands
Priority 4	P4	Taxa in need of monitoring (Not currently threatened or in need of special protection but could be if present circumstances change)
Priority 5	P5	Taxa in need of monitoring (Not considered threatened but are subject to specific conservation program, the cessation of which would result in the species becoming threatened within five years)

Table 8: Wetland classifications used by DBCA (adapted from Hill et al. 1996)

	Basin	flat	channel	slope	highland
Permanently inundated	Lake	-	River	-	-
Seasonally inundated	Sumpland	Floodplain	Creek	-	-
Intermittent inundation	Playa	Barlkarra	Wadi	-	-
Seasonally waterlogged	Dampland	Palusplain	Trough	Paluslope	Palusmont

Table 9: Geomorphic Wetlands of the Swan Coastal Plain management categories (Hill et al. 1996)

Management category	General Description	management objectives
Conservation (CCW)	Wetlands which support a high level of attributes and functions.	Highest priority wetlands. Objective is to preserve and protect the existing conservation values of the wetlands through various mechanisms including: • Reservation in national parks, crown reserves and State owned land • Protection under Environmental Protection Policies • Wetland covenanting by landowners No development or clearing is considered appropriate. These are the most valuable wetlands and any activity that may lead to further loss or degradation is inappropriate.
Resource Enhancement (REW)	Wetlands which may be partially modified but still support substantial ecological attributes and functions.	Priority wetlands. Ultimate objective is to manage, restore and protect towards improving their conservation value. These wetlands have the potential to be restored to Conservation category. This can be achieved by restoring wetland function, structure and biodiversity. Protection is recommended through a number of mechanisms such as crown reserves, state or local government owned land, environmental protection policies and sustainable management on private properties.
Multiple Use (MUW)	Wetlands with few remaining important attributes but still provide important hydrological functions	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare.

Appendix C

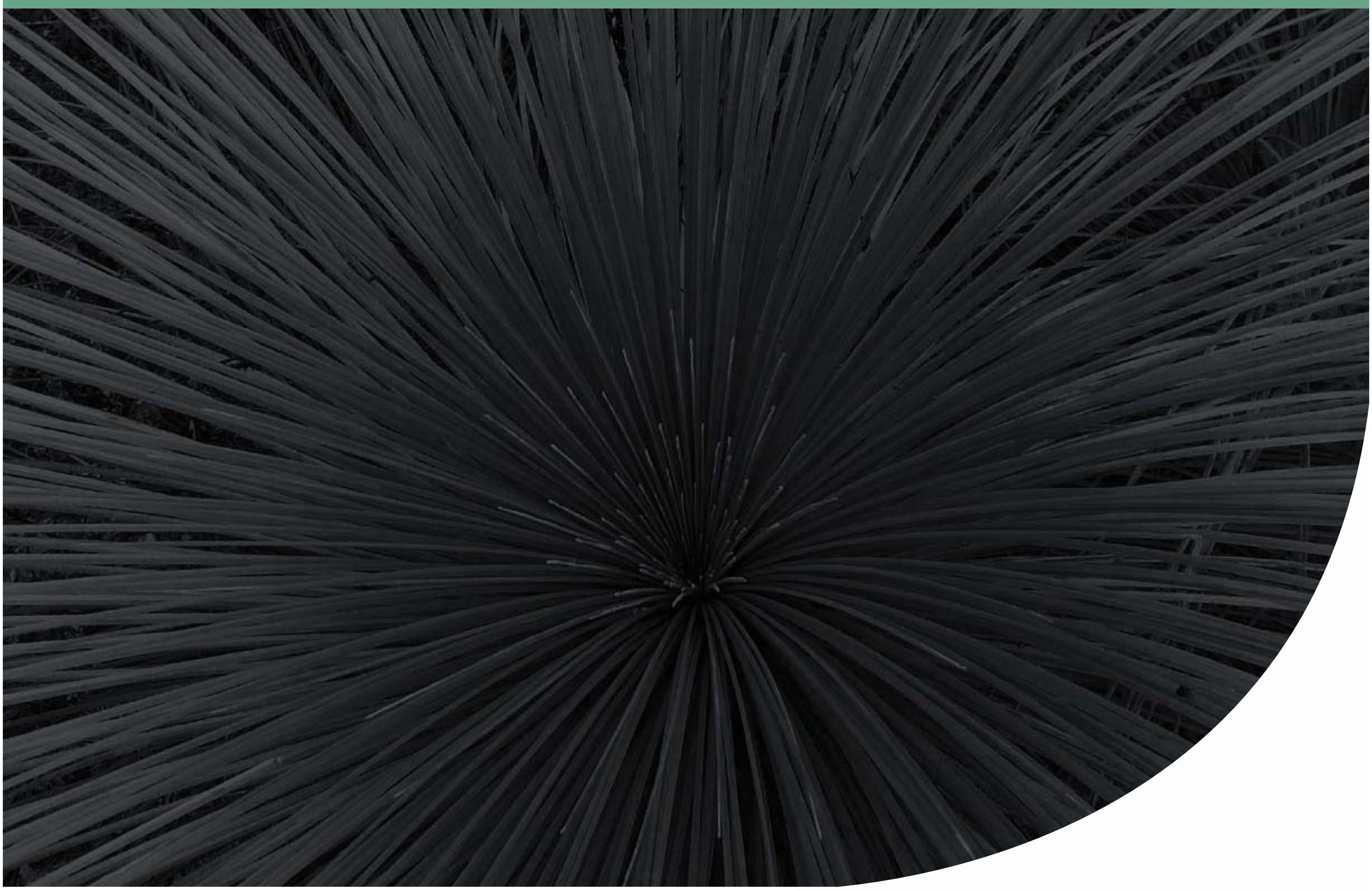
Flora, Vegetation and Wetland Assessment Report (Emerge Associates 2019)

Flora, Vegetation and Wetland Assessment

Maddington Kenwick Strategic Employment Area - Precinct 1

Project No: EP17-010(02)

Prepared for City of Gosnells
January 2019



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Executive Summary

The City of Gosnells engaged Emerge Associates (Emerge) to undertake a detailed flora, vegetation and wetland assessment within the Maddington Kenwick Strategic Employment Area (MKSEA). This report presents outcomes of the flora, vegetation and wetland assessment within Precinct 1 of the MKSEA. Precinct 1 is approximately 121 hectares (ha) in size and comprises multiple privately owned lots bound by Bickley Road, Tonkin Highway and Victoria Road, in the localities of Maddington and Kenwick (referred to herein as ‘the site’).

Two botanists from Emerge Associates undertook multiple surveys within the site during May, July, August and September 2017. During the surveys an assessment was made on the type, condition and values of vegetation across the site, as well as targeted searches for ‘threatened’ and ‘priority’ flora and assessment of the geomorphic and management categories of wetland features in the site.

Access to vegetation for surveys was limited by private landownership. A total of 14 lots within the site within which native vegetation was known or suspected to be present were identified as requiring survey. Multiple attempts were made to contact the landowners of these lots to request access to conduct flora and vegetation surveys. Permission was obtained to access seven lots, access was denied by the landowner to five lots and no response was received from the landowner, or no contact details were available, for two lots. Information from a previous flora and vegetation assessment that spanned Precinct 1 (Tauss and Weston 2010) and the Department of Biodiversity and Conservation and Attractions (DBCA) databases (threatened and priority flora and communities) was used to supplement the surveys, particularly for inaccessible lots.

Outcomes of the survey include:

- Non-native vegetation is present across 116.69 ha (96.4%) of the site.
- Remnant native vegetation is present across 4.40 ha (3.6%) of the site in fragmented patches.
- A total of 53 native and 16 non-native (weed) species were recorded in the site.
- No threatened or priority flora species were recorded in the site.
- One priority flora species, *Lepyrodia curvescens* (P2), has potential to occur in the site. This species was previously recorded by Tauss and Weston (2010) at one location within the site.
- No other threatened or other priority flora species are considered likely to occur in the site.
- The native vegetation within the site was classified into twelve native plant communities that are present in ‘very good’, ‘good’, ‘degraded’ and ‘degraded – completely degraded’ condition.
- The site supports occurrences of two Commonwealth and State listed TECs comprising:
    - 1.22 ha of the EPBC Act listed TEC ‘banksia woodlands of the Swan Coastal Plain’ which is also a State listed TEC and a State listed PEC.
    - 0.35 ha of the EPBC Act listed TEC ‘*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain’ which is also a State listed TEC.
- The portion of UFI 8050 and UFI 804913369 that represents a TEC should be excised and a new palusplain conservation category wetland (CCW) feature created that encompasses this vegetation.
- The following values present in the site would be considered locally and/or regionally significant:
    - Patches of remnant native vegetation due to their location on the eastern side of the Swan Coastal Plain, where vegetation is generally poorly reserved.

- Native and planted trees that may provide foraging, breeding and/or roosting habitat for threatened black cockatoos.
- Shrubland vegetation that may provide habitat for conservation significant ground dwelling fauna species such as quenda (P4).

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Abbreviation Tables

Table A1: Abbreviations – General terms

General terms	
CCW	Conservation category wetland
ESA	Environmentally sensitive area
FCT	Floristic community type
IBRA	Interim Biogeographic Regionalisation of Australia
MUW	Multiple use wetland
NVIS	National Vegetation Inventory System (ESCAVI 2003)
P1	Priority 1
P2	Priority 2
P3	Priority 3
P4	Priority 4
P5	Priority 5
PEC	Priority ecological community
REW	Resource enhancement wetland
T	Threatened
TEC	Threatened ecological community
UFI	Unique feature identifier

Table A2: Abbreviations – units of measurement

Units of measurement	
cm	Centimetre
ha	Hectare
m	Metre
m^2	Square metre
mAHD	Metres in relation to the Australian Height Datum
mm	Millimetre

Table A3: Abbreviations – Organisations

Organisations	
CoG	City of Gosnells
DBCA	Department of Biodiversity, Conservation and Attractions
DoW	Department of Water (now DWER)
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority
WALGA	Western Australia Local Government Association

Table A4: Abbreviations –Legislation

Legislation	
BAM Act	*Biosecurity and Agriculture Management Act 2007*
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
BC Act	*Biodiversity Conservation Act 2016*

Table A5: Abbreviations – Planning terms

Planning terms	
TPS	Town planning scheme
MKSEA	Maddington Kenwick Strategic Employment Area
MRS	Metropolitan region scheme

1 Introduction

1.1 Project background

The Maddington Kenwick Strategic Employment Area (MKSEA), in the City of Gosnells (CoG) and the Shire of Kalamunda, has been identified for future industrial development since 1990. The MSKEA is divided into three planning precincts. This report covers Precinct 1 (herein referred to as the site), which is entirely located within the CoG and is zoned industrial under the *Metropolitan Region Scheme* (MRS) and business development under the City's Town Planning Scheme 6.

The site is located approximately 15 kilometres (km) south-east of Perth and extends over approximately 121 hectares (ha). The site is comprised of multiple freehold lots bound by Victoria Road to the west, Tonkin Highway to the north and Bickley Road to the south. Tonkin Highway and Bickley Road intersect at the south-eastern corner of the site. Bush Forever Site 53 lies within the above boundaries but is excluded from the site. The location and extent of the site is shown in **Figure 1.**

1.2 Purpose and scope of work

Emerge Associates (Emerge) were engaged by the CoG to provide environmental consultancy services to support the preparation of a structure plan for the site. The purpose of this assessment is to provide sufficient information on the flora, vegetation and wetland values within the site to inform this process.

The scope of work was specifically to undertake a reconnaissance and a detailed flora and vegetation survey, a targeted flora survey and wetland survey/assessment. The flora and vegetation surveys were completed in accordance with the Environmental Protection Authority's (EPA) *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016). Wetland assessments were undertaken using the Department of Biodiversity, Conservation and Attractions' (DBCA) *A Methodology for the evaluation of wetlands on the Swan Coastal Plain, Western Australia* (DBCA 2017c)

As part of this scope of work, the following tasks were undertaken:

- Desktop review of relevant background information pertaining to the site and surrounds, including database searches for threatened and priority flora species and ecological communities.
- Compilation of a comprehensive list of flora species recorded as part of the field survey.
- Mapping of plant communities and vegetation condition.
- Identification of conservation significant flora and vegetation.
- Identification of wetlands and recommended changes to classification.
- Documentation of the desktop assessment, survey methodology and results into a report.

2 Background

2.1 Environmental context

2.1.1 Climate

Climate has a strong influence on the types of vegetation that grow in a region and the life cycles of the flora present. It is therefore critical for a flora and vegetation survey to respond appropriately to climatic conditions to ensure that surveys are conducted during times when flora species are easiest to detect and identify.

The south west of Western Australia experiences a Mediterranean climate of hot dry summers and cool wet winters. In Mediterranean type climates some flora species will typically spend part of their life-cycle as either underground storage organs or as seed. This is an adaptation to unfavourable environmental conditions such as excessive heat and drought that occur over the summer period. These species, known as 'geophytes' or 'annuals', tend to re-emerge during winter when favourable conditions return and are most visible during spring, which is the flowering period for a majority of plant species. Therefore, spring is the optimal time to complete flora and vegetation surveys in the south west of WA.

An average of 820.3 millimetres (mm) of rainfall is recorded annually from the Gosnells City weather station, which is the closest weather station approximately 2.5 km from the site. The majority of this rainfall is received between the months of May and August. Mean maximum temperatures from this station range from 18.7^{o}C in July to 33.0^{o}C in February, while mean minimum temperatures range from 8.7^{o}C in July to 18.8^{o}C in February (BoM 2017).

A total of 576.5 mm of rain was recorded from May to October 2017 (BOM 2017) indicating sufficient seasonal rainfall occurred at the site to promote the growth of flora species prior to this survey. An annual total of 730.7 mm was recorded for 2017; 89% of the annual average for Gosnells City weather station.

2.1.2 Geomorphology and soils

Landform and soils influence vegetation types at regional and local scales. The site occurs on the eastern side of the Swan Coastal Plain, which is the geomorphic unit that characterises much of the Perth metropolitan region.

The Swan Coastal Plain is approximately 500 km long and 20 to 30 km wide and is roughly bound by the Indian Ocean to the west and the Darling Scarp to the east. Broadly the Swan Coastal Plain consists of two sedimentary belts of different origin. Its eastern side has formed from the deposition of alluvial material washed down from the Darling Scarp, while its western side is comprised of three dune systems that run roughly parallel to the Indian Ocean coastline (Seddon 2004).

Examination of broad scale mapping places the majority of the site within the Guilford association excepting the south-eastern corner which is within the Forrestfield association (Churchward and McArthur 1980). Finer scale mapping by Gozzard (2011) places the majority of the site on the Pinjarra Plain with a very small portion on the north-eastern side of the site in the Piedmont Zone (also called the Ridge Hill Shelf). The Pinjarra Plain lies between the Bassendean Dunes and the Piedmont Zone and comprises a relatively flat landscape of fertile heavy alluvial soils (Beard 1990). Numerous channels are present and, when combined with the flatness of the plain, result in the formation of small seasonal swamps (Seddon 2004).

The Piedmont Zone is a narrow band (1.5-3.5 km wide) between the Darling Scarp to the east and the Pinjarra Plain to the west. This zone consists of alluvial fans deposited by streams and remnants of marine terraces (Beard 1990).

Geotechnical investigations undertaken in the site in 2017 indicate the pattern of *in situ* soils is consistent with regional mapping (Emerge Associates 2018b, c). Soils underlying the site comprise sand or fill, overlying an impervious layer of clayey, silty or gravelly materials. The depth to this impervious layer ranges from approximately 0.0-0.1 m in the southern and south-eastern portion of the site to approximately 1.9-2.1 m in the north-eastern portion of the site. Additional a low rise occurs in the central portion of the site where depth to the impervious layer of approximately 2.9-3.1 m was recorded.

2.1.3 Topography

The elevation of the site ranges from 12 m in relation to the Australian Height Datum (mAHD) on the south-western corner of the site to 28 mAHD on the north-eastern corner of the site (DoW 2008) (**Figure 2**).

2.1.4 Hydrology

Examination of the Department of Water's (DOW) hydrography dataset shows eight earth damns in the site (DWER 2018). No other hydrography features are mapped within the site.

Hydrology within the site is strongly influenced by the impervious layer present below the sandy upper soil profile, as described in **Section 2.1.2**. The depth of sand in the upper soil profile is sufficient to allow small rainfall events to infiltrate at the source across most of the site (Emerge Associates 2018a). During larger rainfall events the presence of the impervious clay layer is likely to result in soil saturation and inundation. Seasonal waterlogging and surface ponding therefore has potential to occur after high rainfall, in particular during winter and early spring and in the south-western portion of the site where depth to the impervious layer is shallowest.

2.1.5 Wetlands

Wetlands include "areas of seasonally, intermittently or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh and saline, e.g. waterlogged soils, ponds, billabongs, lakes, swamps, tidal flats, estuaries, rivers and their tributaries" (Wetlands Advisory Committee 1977). Wetlands can further be recognised by the presence of vegetation associated with waterlogging or the presence of hydric soils such as peat, peaty sand or carbonate mud (Hill *et al*. 1996).

Wetlands of national or international significance may be afforded special protection under Commonwealth or international agreements. The following lists of important wetlands were checked as part of this assessment:

- Ramsar List of Wetlands of International Importance (DBCA 2017d)

- A Directory of Important Wetlands in Australia (DBCA 2018a).

No Ramsar or listed 'important wetlands' are located within the site. Brixton Street Swamps, listed as an 'important wetland', is located approximately 380 m north-west of the western site boundary.

On the Swan Coastal Plain DBCA (2017c) have used the geomorphic wetland classification system developed by Semeniuk (1987) and Semeniuk and Semeniuk (1995) to classify wetlands based on the landform shape and water permanence (hydro-period) as outlined in **Table 1**. DBCA maintains the *Geomorphic Wetlands of the Swan Coastal Plain* dataset (DBCA 2018b), which further categorises geomorphic wetland features into specific management categories to guide land use and conservation. The management categories of wetlands are determined based on hydrological, biological and human use features as outlined in **Table 2**. Further information regarding the process for assigning management categories in the *Geomorphic Wetlands of the Swan Coastal Plain* dataset is provided in **Appendix A**.

Table 1: Wetland types defined in the Geomorphic Wetlands of the Swan Coastal Plain (DBCA 2017c)

Inundation level	Geomorphology				
	Basin	Channel	Flat	Slope	Highland
Permanently inundation	Lake	River	-	-	-
Seasonally inundation	Sumpland	Creek	Floodplain	-	-
Intermittent inundation	Playa	Wadi	Barlkarra	-	-
Seasonally waterlogged	Dampland	Trough	Palusplain	Paluslope	Palusmont

Table 2: Management categories defined in the Geomorphic Wetlands of the Swan Coastal Plain (DBCA 2017c)

Management category	Description of wetland	Management objectives
Conservation (CCW)	Support high levels of attributes	Preserve wetland attributes and functions through reservation in national parks, crown reserves and state owned land. Protection provided under environmental protection policies.
Resource enhancement (REW)	Modified or degraded but still supporting substantial attributes and functions	Restore wetland through maintenance and enhancement of wetland functions and attributes. Protection via crown reserves, state or local government owned land, environmental protection policies and sustainable management on private lots.
Multiple use (MUW)	Few important wetland attributes and functions but still provide important hydrological functions	Use, development and management considered in the context of water, town and environmental planning through land care.

Each classified wetland listed in the Geomorphic Wetland of the Swan Coastal Plain dataset is given a 'unique feature identifier' (UFI). This dynamic dataset is continually updated with site-specific wetland surveys providing new and relevant information. Note that as this dataset was drafted at a regional scale the boundaries of mapped wetland features are often inconsistent with physical wetland boundaries.

A review of DBCA's *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicated that one 'conservation', 12 'multiple use' and two 'resource enhancement' category wetland features (or parts of features) occur within the site. The details of the mapped wetland features in the site are provided in **Table 3** and their locations are shown in **Figure 3**. Note that only very small areas of the CCW UFI 15115 and the REW UFI 15983 occur in the site (<0.01 ha). The intersection of such small portions of these wetland features is not relevant to planning for the site and as such these features are not discussed in the remainder of this report.

Wetlands in the site form part of a larger connected wetland system that extends to the north and south of the site.

Table 3: Geomorphic wetlands located in the site

UFI number	Wetland Type	Conservation Status	Area within site (ha)
8048	Palusplain	Multiple Use	0.70
8049	Palusplain	Multiple Use	1.32
8051	Sumpland	Multiple Use	0.13
8052	Palusplain	Multiple Use	1.19
8053	Sumpland	Multiple Use	0.25
8054	Sumpland	Multiple Use	0.11
8055	Dampland	Multiple Use	0.21
8056	Palusplain	Multiple Use	0.24
13369 (part)	Palusplain	Multiple Use	39.44
15007 (part)	Sumpland	Multiple Use	1.07
15115	Palusplain	Conservation	0.01^
15116 (part)	Palusplain	Multiple Use	7.93
15768 (part)	Palusplain	Multiple Use	17.95
8050	Sumpland	Resource Enhancement	1.17
15983	Palusplain	Resource Enhancement	0.01^

^=the portion of these wetlands located within the site is very small and considered to be negligible.

DBCA is also the custodian of the *Consanguineous Suites* dataset (DBCA 2017a). The concept of consanguineous suites was developed by Semeniuk (1988) and refers to the natural grouping of wetlands. Consanguineous suites have been identified using criteria based on wetland classification, geometry, stratigraphy, inferred origin and hydrology. A total of 62 consanguineous suites are recognised on the Swan Coastal Plain. Visible differences are present between wetlands of the same type in different consanguineous suites. The regional significance of a wetland can be determined by examining the proportion of the original extent of the wetland type in that consanguineous suite that remains and supports a high level of value, attributes and functions.

The south-eastern portion of the site is located within the Keysbrook consanguineous suite and the remainder of the site is within the Mungala consanguineous suite. Within the Keysbrook consanguineous suite 110,831.1 ha remains of which 5.4% (dampland), 1.3% (palusplain) and 9.1% (sumpland) of this is mapped as CCW. Within the Mungala consanguineous suite a total of

25,978.6 ha remains and 11.6% (dampland), 4.1% (palusplain) and 29.3% (sumpland) of this is mapped as CCW.

2.1.6 Regional vegetation

Native vegetation is described and mapped at different scales in order to illustrate patterns in its distribution. At a continental scale the *Interim Biogeographic Regionalisation of Australia* (IBRA) divides the Swan Coastal Plain into two floristic subregions (Environment Australia 2000). The site is contained within the 'SWA02' or Perth subregion, which is characterised as mainly containing *Banksia* low woodland on leached sands with *Melaleuca* swamps where ill-drained; and woodland of *Eucalyptus gomphocephala* (tuart), *E. marginata* (jarrah) and *Corymbia calophylla* (marri) on less leached soils (Beard 1990). This subregion is recognised as a biodiversity hotspot and contains a wide variety of endemic flora and vegetation types.

Variations in native vegetation within the site can be further classified based on regional vegetation associations. Beard *et al.* (2013) mapping shows the site as comprising vegetation association 'Pinjarra 968'. This association is described as '*Eucalyptus marginata* (jarrah), *Corymbia calophylla* (marri) and *E. wandoo* (wandoo) woodland'(Beard *et al.* 2013). 'Pinjarra 968' association has 6.64% of its pre-European extent remaining on the Swan Coastal Plain with 1.17% protected for conservation purposes (Government of Western Australia 2015). A small area of 'Pinjarra 3' vegetation association occurs in the south-eastern portion of the site. This association is described as mainly jarrah and marri forest' (Beard *et al.* 2013). 'Pinjarra 3' association has 11.58% of its pre-European extent remaining on the Swan Coastal Plain with 1.53% protected for conservation purposes (Government of Western Australia 2015).

Heddle *et al.* (1980) mapped the majority of the site as comprising the Guildford complex and the eastern portion of the site as comprising the Forrestfield complex. The Guildford complex is described as 'open forest to tall open forest of *Corymbia calophylla - Eucalyptus wandoo - Eucalyptus marginata* and woodland of *Eucalyptus wandoo* (with rare occurrences of *Eucalyptus lane-poolei*) (and) minor components include *Eucalyptus rudis - Melaleuca rhaphiophylla*'. The Forrestfield complex is described as 'open forest of *Corymbia calophylla - Eucalyptus wandoo*, *Eucalyptus marginata* to open forest of *Eucalyptus marginata - Corymbia calophylla, Allocasuarina fraseriana - Banksia* spp. (with) fringing woodland of *Eucalyptus rudis* in the gullies'. The Guildford complex was determined to have 5.87% remaining in 2013 (PBP 2013), of which 0.27% is under formal protection, and the Forrestfield complex was determined to have 11.90% remaining in 2013 (PBP 2013), of which 1.16% is under formal protection.

Studies have indicated that the loss of biodiversity caused by habitat fragmentation is significantly greater once a habitat type falls below 30% of its original extent (Miles 2001). However, this is a purely biodiversity protection orientated objective. On the Swan Coastal Plain, which is considered a 'constrained area', the EPA has previously applied an objective of retaining 10% of each vegetation complex (EPA 2006). The conserved areas of the 'Pinjarra 968' and 'Pinjarra 3' associations and the Guildford and Forrestfield complexes fall below this retention objective.

2.1.7 Historic land use

Review of historical images available from 1953 onwards (WALIA 2017), shows that large areas of the site were cleared of native vegetation around 1965, with continual clearing until 2017. It is likely that vegetation was originally cleared for grazing and/or cropping uses and later for rural residential uses.

2.2 Significant flora and vegetation

2.2.1 Threatened and priority flora

Certain flora species that are considered to be rare or under threat warrant special protection under Commonwealth and/or State legislation. At a Commonwealth level, flora species may be listed as 'threatened' pursuant to Schedule 1 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Any action likely to have a significant impact on a species listed under the EPBC Act requires approval from the Commonwealth Minister for the Environment and Energy.

In Western Australia flora species may also be classed as 'threatened' under the Biodiversity *Conservation Act 2016* (BC Act). Threatened flora species are listed under sections 19(1) and 26(2) of the BC Act. It is an offence to 'take' or disturb threatened flora without Ministerial approval. Threatened flora species listed under the EPBC Act and/or BC Act are assigned a conservation status according to their national extent.

Flora species that do not currently meet the criteria for listing as threatened but are potentially rare or threatened may be added to the DBCA's *Priority Flora List*. These species are classified into 'priority' levels based on threat. Whilst priority species are not under direct statutory protection, they are considered during State approval processes. Further information on threatened and priority species and their categories is provided in **Appendix A**.

A search was conducted for threatened and priority flora within a five km radius of the site using the *Protected Matters Search Tool* (DoEE 2017d), *NatureMap* (DPaW 2017) and DBCA's threatened and priority flora database (reference no. 30-0317FL). Thirty five threatened and 74 priority flora species were identified as potentially occurring in the wider local area as listed in **Table 4.**

Of the flora species potentially occurring in the local area, those with habitat preferences of seasonally wet areas such as clay pans and wetlands or woodlands were deemed to have potential to occur in the site. This is because previous surveys have shown that the vegetation previously recorded in the site is of the above types and landforms.

On this basis 23 threatened and 40 priority flora species were identified as having the potential to occur within the site (shaded green in **Table 4**). Of these, DBCA records exist within the site for seven species:

- *Banksia mimica* (endangered under the EPBC Act)
- *Conospermum undulatum* (vulnerable under the EPBC Act)
- *Grevillea thelemanniana* (critically endangered under the EPBC Act)
- *Byblis gigantea* (P3)
- *Isopogon drummondii* (P3)
- *Centrolepis caespitosa* (P4)

- *Drosera occidentalis* subsp. *occidentalis* (P4).

Some of these records are more than 50 years old and pre-date the extensive vegetation clearing that has occurred within the site as described in **Section 2.1.7**.

In addition to DBCA records, three other priority flora species have been recorded in the site during previous surveys (see **Section 2.4**). *Lepyrodia curvescens* (P2) and *Verticordia lindleyi* subsp*. lindleyi* (P4) were previously recorded by Tauss and Weston (2010). *Acacia lasiocarpa* var. *bracteolata* long peduncle variant (G.J. Keighery 5026) (P1) was recorded in the site during an earlier survey (Cardno BSD 2005) but was not recorded during surveys in 2010 (Tauss and Weston 2010), leaving its status in the site unconfirmed.

Table 4: Significant flora species known or likely to occur within five km of the site

Species	Level of significance		LS	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Scholtzia sp. Bickley (W.H. Loaring s.n. PERTH 06165184)	T	X	P	Unknown.	Sep	Possible
Calectasia cyanea	T	CR	P	Heathland on white sand or laterite gravel over laterite.	Jun-Oct	Unlikely
Grevillea thelemanniana	T	CR	P	Seasonal clay/sand based depressions.	Sep-Nov	**DBCA record in site**
Ptilotus pyramidatus	T	CR	A/ P	Clay sand in seasonally inundated floodplains.	early Oct	Possible
Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	P	Low woodland on grey, clayey sand with lateritic pebbles (Pinjarra Plain) near winter wet flats.	Sep - Nov	Possible
Thelymitra dedmaniarum	T	CR	G	Red brown sandy loam with dolerite and granite outcrops.	Oct-Nov	Unlikely
Andersonia gracilis	T	E	PG	Seasonally damp, black sandy clay flats near or on the margins of swamps.	Sep - Nov	Possible
Banksia mimica	T	E	P	Flat to gentle slopes, on grey and white sand.	Dec-Jan	**DBCA record in site**
Caladenia huegelii	T	E	PG	Well-drained, deep sandy soils in lush undergrowth in a variety of moisture levels.	Sep-early Nov	Possible
Calytrix breviseta subsp. *breviseta*	T	E	P	Seasonally wet sandy-clay soil on swampy flats.	Oct-Nov	Possible
Darwinia apiculata	T	E	P	Lateritic soils.	Oct	Unlikely
Diuris purdiei	T	E	PG	Sand to sandy clay soils in areas subject to winter inundation.	Sep-Oct	Possible
Drakaea elastica	T	E	PG	Bare patches of sand within otherwise dense vegetation in low-lying areas alongside winter-wet swamps.	Jul-Oct	Possible
Eremophila glabra subsp. *chlorella*	T	E	P	Sandy clay. Winter-wet depressions.	Jul-Nov	Possible
Eucalyptus x balanites	T	E		Light coloured sandy soils over laterite. In gently sloping heathland or open mallee woodland.	Oct - Feb	Unlikely
Goodenia arthrotricha	T	E	P	Gravel, granite rocks.	Oct-Nov	Unlikely
Grevillea curviloba subsp. *curviloba*	T	E	P	Winter wet, deep peaty grey sands over limestone at depth.	Sep-Oct	Unlikely
Lasiopetalum pterocarpum	T	E	P	Riparian community with species such as Flooded Gum, Marri and Swamp Peppermint.	Aug-Nov	Possible
Lepidosperma rostratum	T	E	P	Peaty sand and clay amongst low heath, in winter-wet swamps.	May-Aug	Possible
Macarthuria keigheryi	T	E	P	Grey/white sands in low-lying winter wet areas.	Sep-Dec/Feb-Mar	Possible
Synaphea stenoloba	T	E	P	Swampy loam in depressions that are occasionally inundated.	Aug-Oct	Possible
Thelymitra stellata	T	E	PG	Sandy loam, clay or gravel over laterite or gravel.	Sep-Nov	Unlikely

Table 4: Significant flora species known or likely to occur within five km of the site (continued)

Species	Level of significance		LS	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Trithuria occidentalis	T	E	A	Partly submerged on the edge of shallow winter-wet clay pans in very open shrubland.	Oct-Nov	Possible
Acacia anomala	T	V	P	Shallow sand, loam, clay over gravel.	Aug-Sep	Unlikely
Acacia aphylla	T	V	P	Laterite and granite outcrops on hillsides.	Aug-Oct	Unlikely
Anthocercis gracilis	T	V	P	Steep granite slopes along the Darling Scarp in shallow, humus-rich sandy or loamy soils.	Sep-Oct	Unlikely
Chamelaucium sp. Gingin (N.G. Marchant 6)	T	V	P	White yellow sand in low woodland.	Sep-Dec	Unlikely
Conospermum undulatum	T	V	P	Sand and sandy clay soils, on flat or gently sloping sites between the Swan and Canning Rivers.	May-Oct	**DBCA record in site**
Diuris drummondii	T	V	PG	In low-lying depressions in peaty and sandy clay swamps.	Nov-Jan	Possible
Diuris micrantha	T	V	PG	Dark grey-black sandy clay-loam in winter wet depressions or swamps. Often in shallow standing water.	Aug-Oct	Possible
Drakaea micrantha	T	V	PG	Open sandy patches often adjacent to winter-wet swamps.	Sep-Oct	Possible
Eleocharis keigheryi	T	V	P	Clay or sandy loam in freshwater creeks and transient waterbodies such as seasonally wet clay pans.	Aug-Dec	Possible
Tetraria australiensis	T	V	P	Sand over clay, winter wet depressions and drainage lines.	Nov-Dec	Possible
Austrostipa bronwenae	T	-	P	Sand, clay, in winter wet areas.	Sep-Oct	Possible
Schoenus pennisetis	T	-	A	Grey or peaty sand and sandy clay in swamps and winter wet depressions.	Aug-Sep	Possible
Acacia lasiocarpa var. *bracteolata* long peduncle variant (G.J. Keighery 5026)	P1	-	P	Grey or black sand over clay in winter wet areas.	May-Aug	**Previously recorded**
Haloragis scoparia	P1	-	P	Clay in winter-wet areas.	May	Possible
Hydrocotyle striata	P1	-	A	Sand and clay in springs and creek lines.	Nov	Possible
Ptilotus sericostachyus subsp. *roseus*	P1	-	P	Unknown.	Sep-Dec	Possible
Schoenus sp. Beaufort (G.J. Keighery 6291)	P1	-	A	Mud in winter-wet clay pans.	Sep-Oct	Possible
Senecio gilbertii	P1	-	P	Peaty sand in swamps and on slopes.	Sep-Nov	Possible
Boronia humifusa	P1	-	P	Gravelly clay loam over laterite.	Jun or Sep	Unlikely
Calandrinia sp. Piawaning (A.C. Beauglehole 12257)	P1	-	A	Brown/grey sandy loam or clay in seasonally wet areas.	Oct	Possible
Hemigenia rigida	P1	-		Sand, lateritic gravel on hill slopes and granite outcrops.	Aug-Dec/Jan	Unlikely
Thelymitra magnifica	P1	-	PG	Gravelly soil on stony ridges.	Sep-Oct	Unlikely
Comesperma griffinii	P2	-	A/P	Yellow or grey sand on plains.	Oct	Possible
Comesperma rhadinocar-pum	P2	-	P	Sandy soils.	Oct-Nov	Possible
Haloragis aculeolata	P2	-	P	Black sand or clay over limestone in winter-wet areas.	Sep or Dec	Unlikely

Table 4: Significant flora species known or likely to occur within five km of the site (continued)

Species	Level of significance		LS	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Isotropis cuneifolia subsp. *glabra*	P2	-	P	Sand, clay loam in winter-wet flats.	Sep	Possible
Johnsonia pubescens subsp. *cygnorum*	P2	-	P	Grey white yellow sands on flats and seasonally wet areas.	Sep	Possible
Lepyrodia curvescens	P2	-	P	Sand and laterite in seasonally inundated swampland.	Sep-Nov	**Previously recorded**
Melaleuca viminalis	P2	-	P	Sand, clay in creek lines and wetlands.	Oct-Dec	Possible
Schoenus loliaceus	P2	-	A	Sandy soils in winter-wet depressions.	Aug-Nov	Possible
Stenanthemum sublineare	P2	-	P	White sand on coastal plains.	Oct-Dec	Possible
Andersonia sp. Blepharifolia (F. & J. Hort 1919)	P2	-	P	Sandy clay with lateritic gravel.	Sep-Nov	Unlikely
Thysanotus sp. Badgingarra (E.A. Griffin 2511)	P2	-	P	Grey sand with lateritic gravel.	December	Unlikely
Acacia benthamii	P3	-	P	White, grey ands, sandy clay in winter wet flats and swamps	Oct-Nov	Possible
Acacia horridula	P3	-	P	Gravelly soils over granite, sand, rocky hillsides.	May-Aug	Unlikely
Allocasuarina grevilleoides	P3	-	P	Sand over laterite, gravel.	Sep-Nov	Unlikely
Angianthus micropodioides	P3	-	A	Saline sandy soils on edge of rivers, depressions and clay pans.	Nov-Dec /Jan-Feb	Possible
Asteridea gracilis	P3	-	A	Sand, clay, gravelly soils.	Sep-Dec	Possible
Babingtonia urbana	P3	-	P	Grey sand, lateritic gravel.	Jan-Mar	Possible
Banksia kippistiana var. *paenepeccata*	P3	-	P	Lateritic gravelly soils.	Oct-Nov	Unlikely
Banksia pteridifolia subsp. *vernalis*	P3	-	P	White/grey sand over laterite.	Sep-Oct	Unlikely
Beaufortia purpurea	P3	-	P	Lateritic or granitic soils on rocky slopes.	Oct-Feb	Unlikely
Byblis gigantea	P3	-	P	Sandy-peat swamps. Seasonally wet areas.	Sep-Jan	**DBCA record in site**
Carex tereticaulis	P3	-	P	Black peaty sand.	Sep-Oct	Possible
Chamaescilla gibsonii	P3	-	P	Clay to sandy clay in winter-wet flats, shallow water-filled clay pans.	Sep	Possible
Cyathochaeta teretifolia	P3	-	P	Grey sand, sandy clay in swamps and creek edges.	Oct-Jan	Possible
Eryngium pinnatifidum subsp. Palustre (G.J. Keighery 13459)	P3	-	P	Grey brown sand or clay in winter wet flats.	Sep-Nov	Possible
Eryngium sp. Subdecumbens (G.J. Keighery 5390)	P3	-	A	Clay in seasonal wetlands.	Sep-Nov	Possible
Haemodorum loratum	P3	-	P	Grey or yellow sand, gravel.	Nov	Possible
Isopogon drummondii	P3	-	P	Yellow-grey sand.	Feb-Jun	**DBCA record in site**
Lasiopetalum glutinosum subsp. *glutinosum*	P3	-	P	Brown clay loam on slopes	Sep-Dec	Possible

Table 4: Significant flora species known or likely to occur within five km of the site (continued)

Species	Level of significance		LS	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Styphelia filifolia	P3	-	P	Littered grey to brown sand in winter-wet sites, plains and swamps.	Mar-May	Possible
Meionectes tenuifolia	P3	-	P	Clay loam in seasonally wet areas.	Oct-Dec	Possible
Myriophyllum echinatum	P3	-	A	Clay in winter-wet flats.	Nov	Possible
Platysace ramosissima	P3	-		Sandy soils.	Oct-Nov	Possible
Schoenus capillifolius	P3	-	A	Brown mud in clay pans	Oct-Nov	Possible
Schoenus sp. Waroona (G.J. Keighery 12235)	P3	-	A	Clay or sandy clay in winter wet flats.	Oct-Nov	Possible
Schoenus benthamii	P3	-	P	White, grey ands, sandy clay in winter wet flats and swamps	Oct-Nov	Possible
Stylidium aceratum	P3	-	A	Sandy soils in swamp heathland.	Oct-Nov	Possible
Stylidium periscelianthum	P3	-	P	Loamy clay, moist soils, on wet flats and low granitic hills.	Sep-Oct	Possible
Halgania corymbosa	P3	-	P	Gravelly soils, soils over granite.	Aug-Nov	Unlikely
Pithocarpa corymbulosa	P3	-	P	Gravelly or sandy loam, amongst granite outcrops.	Jan-Apr	Unlikely
Stackhousia sp. Red-blotched corolla (A. Markey 911)	P3	-	P	Granitic soils on slopes.	Sep-Nov	Unlikely
Thysanotus anceps	P3	-	P	White or grey sand, lateritic gravel, laterite.	Oct-Dec	Unlikely
Acacia oncinophylla subsp. *patulifolia*	P4	-	P	Granitic soils, occasionally on laterite.	Aug-Dec	Unlikely
Aponogeton hexatepalus	P4	-	P	Mud. Freshwater: ponds, rivers, claypans.	Jul-Oct	Possible
Boronia tenuis	P4	-	P	Laterite, stony soils, granite.	Aug-Nov	Unlikely
Calothamnus accedens	P4	-	P	Sandy soils over laterite.	Sep-Jan	Unlikely
Calothamnus graniticus subsp. *leptophyllus*	P4	-	P	Clay over granite, lateritic soils. Hillsides.	Jun-Aug	Unlikely
Centrolepis caespitosa	P4	-	A	White sand, clay on salt flats and wet areas.	Oct-Dec	**DBCA record in site**
Conostylis pauciflora subsp. *euryrhipis*	P4	-	P	White, grey, yellow sand on coastal consolidated dunes.	Aug-Oct	Unlikely
Cyanicula ixioides subsp. *ixioides*	P4	-	PG	Laterite, gravel.	Aug-Oct	Unlikely
Dodonaea hackettiana	P4	-	P	Sand, outcropping limestone.	Jul-Oct	Unlikely
Drosera occidentalis subsp. *occidentalis*	P4	-	P	Sandy & clayey soils in swamps & wet depressions.	Nov-Dec	**DBCA record in site**
Hibbertia montana	P4	-	P	Loam over granite, lateritic soils, with granite rocks, lateritic ridges.	Jul-Oct	Unlikely
Hydrocotyle lemnoides	P4	-	A	Floating in swamps.	Aug-Oct	Possible
Lasiopetalum bracteatum	P4	-	P	Sandy clay, clay, lateritic gravel along drainage lines, creeks, gullies, granite outcrops.	Aug-Nov	Unlikely
Ornduffia submersa	P4	-		Sand, clay, loam in winter wet areas.	Aug-Nov	Possible
Pimelea rara	P4	-	P	Lateritic soils.	Dec-Jan	Unlikely
Schoenus natans	P4	-	A	Aquatic, in winter-wet depressions.	Oct	Possible

Table 4: Significant flora species known or likely to occur within five km of the site (continued)

Species	Level of significance		LS	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Senecio leucoglossus	P4	-	A	Gravelly lateritic or granitic soils on outcrops or slopes.	Aug-Dec	Unlikely
Stylidium longitubum	P4	-	A	Sandy clay, clay. Seasonal wetlands.	Oct-Dec	Possible
Stylidium striatum	P4	-	P	Brown clay over laterite on hill slopes.	Oct-Nov	Unlikely
Tripterococcus sp. Brachylobus (A.S. George 14234)	P4	-	P	Winter-wet areas on grey sand.	Oct-Feb	Possible
Verticordia lindleyi subsp. *lindleyi*	P4	-	P	Sand and sandy clay in winter wet areas.	May or Nov-Jan	**Previously recorded**

Note: LS=life strategy, T=threatened, CR=critically endangered, E=endangered, V=vulnerable, P1=Priority 1, P2=Priority 2, P3=Priority 3, P4=Priority 4, P=perennial, PG=perennial geophyte, A=annual. Species considered to be potentially present or previously recorded within the site are shaded green.

2.2.2 Threatened and priority ecological communities

An ecological community is a naturally occurring group of native plants, animals and other organisms that are interacting in a unique habitat. An ecological community's structure, composition and distribution are determined by environmental factors such as soil type, position in the landscape, altitude, climate and water availability (DoEE 2017e). 'Threatened ecological communities' (TECs) are ecological communities that are recognised as rare or under threat and therefore warrant special protection.

Selected TECs are afforded statutory protection at a Commonwealth level under section 181 of the EPBC Act. Any action likely to have a significant impact on a community listed under the EPBC Act requires approval from the Commonwealth Minister for the Environment and Energy. TECs are also listed within Western Australia but are currently are not afforded direct statutory protection at a State level. Nonetheless their significance is acknowledged through other State environmental approval processes such as 'environmental impact assessment' pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*.

A plant community that is under consideration for listing as a TEC in Western Australia, but does not yet meet survey criteria or has not been adequately defined, may be listed as a 'priority ecological community' (PEC). Listing as a PEC is similarly considered during State approval processes. Further information on categories of TECs and PECs is provided in **Appendix A**.

Known locations of TECs and PECs within 10 km of the site were searched for using the publicly available *Weed and native flora dataset* (Keighery *et al.* 2012), *Protected Matters Search Tool* (DoEE 2017d) and DBCA's threatened and priority ecological communities' database (reference no. 21-0317EC). These search results, combined with previous surveys undertaken in the site (Tauss and Weston 2010), indicate that 13 TECs or PECs have previously been recorded or have potential to occur within the site (shaded green in **Table 5**). This includes two locations which DBCA have visited and confirmed the presence of a TEC (see **Section 2.4.3**).

Table 5: TECs and PECs known to occur within 10 km of the site

Code	Community name	TEC/ PEC	Level of significance		Likelihood of occurrence
			State	EPBC Act	
SCP8	Herb rich shrublands in clay pans	TEC	Vulnerable	Critically endangered (Clay pans of the Swan Coastal Plain)	**Previously recorded**
SCP10a	Shrublands on dry clay flats	TEC	Endangered	Critically endangered (Clay pans of the Swan Coastal Plain)	**Previously recorded**
SCP7	Herb rich saline shrublands in clay pans	TEC	Vulnerable	Critically endangered (Clay pans of the Swan Coastal Plain)	Possible
SCP3a	*Corymbia calophylla – Kingia australis* woodlands on heavy soils of the Swan Coastal Plain	TEC	Critically endangered	Endangered	**Confirmed within the site**
SCP20c	Shrublands and woodlands of the eastern side of the Swan Coastal Plain	TEC	Critically endangered	Endangered	Possible
SCP3c	*Eucalyptus calophylla - Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain	TEC	Critically endangered	Endangered	Possible
SCP20a	*Banksia attenuata* woodlands over species rich dense shrublands	TEC	Endangered	Endangered (Banksia woodlands of the Swan Coastal Plan)	**Confirmed within the site (DBCA 2017b)**
MUCHEA LIMESTONE	Shrublands and woodlands on Muchea Limestone	TEC	Endangered	Endangered	Possible
-	Banksia dominated woodlands of the Swan Coastal Plain IBRA Region	TEC/ PEC	Priority 3	Endangered (Banksia woodlands of the Swan Coastal Plan)	Likely
SCP20b	*Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain	TEC	Endangered	Endangered (Banksia woodlands of the Swan Coastal Plan)	Possible
SCP23a	Central *Banksia attenuata – B. menziesii* woodlands	TEC	-	Endangered (Banksia woodlands of the Swan Coastal Plan)	**Previously recorded**
SCP21c	Low lying *Banksia attenuata* woodlands or shrublands	PEC/ TEC	Priority 3	Endangered (Banksia woodlands of the Swan Coastal Plan)	Possible
Coastal saltmarsh	Subtropical and Temperate Coastal Saltmarsh	PEC/ TEC	Priority 3	Vulnerable	Unlikely
SCP2	Southern wet shrublands of the Swan Coastal Plain	TEC	Endangered	-	Possible
SCP3b	*Corymbia calophylla - Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain	TEC	Vulnerable	-	**Previously recorded**

Table 5: TECs and PECs known to occur within 10 km of the site (continued)

Code	Community name	TEC/ PEC	Level of significance		Likelihood of occurrence
Central granite shrublands (Com 5, Markey)	Central Northern Darling Scarp Granite Shrubland Community	PEC	Priority 4	-	Unlikely

Note: Communities known or considered to be potentially present within the site are shaded green.

Six of these communities have been previously been recorded in the site (Cardno BSD 2005; Tauss and Weston 2010; DBCA 2017b):

- SCP3a: *Corymbia calophylla – Kingia australis* woodlands on heavy soils of the Swan Coastal Plain (critically endangered in WA, endangered under the EPBC Act)
- SCP3b: *Corymbia calophylla - Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain (vulnerable in WA)
- SCP8: Herb rich shrublands in clay pans (vulnerable in WA, critically endangered under the EPBC Act)
- SCP10a: Shrublands on dry clay flats (endangered in WA, critically endangered under the EPBC Act)
- SCP20a: *Banksia attenuata* woodlands over species rich dense shrublands (endangered in WA and under the EPBC Act).
- SCP23a: Central *Banksia attenuata – B. menziesii* woodlands (endangered under the EPBC Act)

Note that SCP20a and SCP23a are listed as TECs in WA and are also likely to represent the 'banksia dominated woodlands of the Swan Coastal Plain IBRA region' PEC (P3). These communities also have potential to represent the Commonwealth listed TEC 'banksia woodlands of the Swan Coastal Plan' (the banksia woodland TEC), dependent on meeting diagnostic characteristics and thresholds.

Of the six above TECs, DBCA have confirmed the presence of one occurrence of SCP3a TEC and one occurrence of SCP20a TEC within the site (as detailed in **Section 2.4.3**).

Eight additional communities are considered to have potential to occur in the site based on geomorphology, soils and regional vegetation patterns:

- SCP2: Southern wet shrublands of the Swan Coastal Plain (endangered in WA)
- SCP3c: *Eucalyptus calophylla - Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain (critically endangered in WA, endangered under the EPBC Act)
- SCP7: Herb rich saline shrublands in clay pans (vulnerable in WA, critically endangered under the EPBC Act)
- SCP20b: *Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain (endangered in WA and under the EPBC Act)
- SCP20c: Shrublands and woodlands of the eastern side of the Swan Coastal Plain (critically endangered in WA, endangered under the EPBC Act)
- SCP21c: Low lying *Banksia attenuata* woodlands or shrublands (Priority 3 in WA, endangered under the EPBC Act)

- Banksia dominated woodlands of the Swan Coastal Plain IBRA Region (Priority 3 in WA, endangered under the EPBC Act)
- Shrublands and woodlands on Muchea Limestone (endangered in WA and under the EPBC Act).

2.2.3 Local and regional significance

Flora species and ecological communities may be significant for a number of reasons irrespective of whether they have special protection under policy or legislation. Three reasons that vegetation within the site may be significant are listed below:

- The vegetation includes flora species listed as 'significant flora of the foothills and Pinjarra Plain in the Perth metropolitan region' (Government of WA 2000b).
- The vegetation is connected to Bush Forever Site 53 (Clifford Street Bushland) which comprises high quality remnant vegetation as detailed in **Section 2.3.1**.
- The vegetation includes potential habitat for threatened or priority fauna species including, in particular, three species of black cockatoo listed under the EPBC Act and the BC Act: Baudin's black cockatoo (endangered), Carnaby's black cockatoo (endangered) and forest red-tailed black cockatoo (vulnerable).

2.2.4 Weeds

The term 'weed' can refer to any plant that requires some form of action to reduce its effect on the economy, the environment, human health and amenity. Many non-native flora species and some native species are considered to be weeds.

A particularly invasive or detrimental weed species may be listed as a 'declared pest' pursuant to the Western Australia's *Biosecurity and Agriculture Management Act 2007* (BAM Act), indicating that it warrants special management to limit its spread. Further information on categories of declared pests is provided in **Appendix A.**

Due to historical disturbance and grazing a wide variety of weed species are expected to be present in the site. In addition, planted native and non-native species are expected to be present in the site.

2.3 Land use planning considerations

A range of legislation, regulations and polices are relevant to the evaluation of vegetation in Western Australia. Key considerations applicable to the site are described below and also shown in **Figure 4**.

2.3.1 Bush Forever

The Government of Western Australia's *Bush Forever* policy is a strategic plan for conserving regionally significant bushland within the Swan Coastal Plain portion of the Perth Metropolitan Region. The objective of *Bush Forever* is to protect comprehensive representations of all original ecological communities by targeting a minimum of 10% of each vegetation complex for protection (Government of WA 2000a). *Bush Forever* sites are representative of regional ecosystems and habitat and have a key role in the conservation of Perth's biodiversity.

Bush Forever Site 53 (Clifford Street Bushland) lies directly adjacent to the north-east of the site. This *Bush Forever* site is known to support TECs listed as endangered (SCP20b) and vulnerable (SCP3b) under the EPBC Act. One flora species listed as vulnerable under the EPBC Act, *Conospermum undulatum*, is also present in Bush Forever Site 53 (Government of WA 2000b).

Bush Forever Site 387 (Greater Brixton Street Wetlands) is located approximately 700 m north-west of the site. This *Bush Forever* site is known to support TECs listed as endangered (SCP3a) and critically endangered (SCP07, SCP08 and SCP10a) under the EPBC Act, as well as multiple threatened and priority flora species (Government of WA 2000b). Greater Brixton Street Wetlands is the most species-rich *Bush Forever* site on the Swan Coastal Plain, with at least 518 native flora taxa recorded; a third of that recorded for the whole Swan Coastal Plain (Government of WA 2000b).

The locations of *Bush Forever* sites surrounding the site are shown in **Figure 4**.

2.3.2 Environmentally sensitive areas

'Environmentally sensitive areas' (ESAs) are prescribed under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* and have been identified to protect native vegetation values of areas surrounding significant, threatened or scheduled flora, vegetation communities or ecosystems. Within an ESA none of the exemptions under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* apply. However, exemptions under Schedule 6 of the EP Act still apply, including any clearing in accordance with a subdivision approval under the *Planning and Development Act 2005* (a recognised exemption under the Schedule 6 of the EP Act).

One ESA (No. 3734) is located across the majority of the site, centered on Bush Forever Site 53.

ESA (No. 3459) is located approximately 500 m north-east of the site, centered on Bush Forever Site 51. A large ESA (No. 3499) is located 2 km north-west of the site, centered on Bush Forever Site 387. Three smaller ESAs (Nos. 3444, 3443 and 3441) are located to the north-east and south of the site. The locations of these ESAs are shown in **Figure 4**.

2.3.3 Ecological linkages

Ecological linkages are linear landscape elements that allow the movement of fauna, flora and genetic material between areas of remnant habitat. The movement of fauna and the exchange of genetic material between vegetation remnants improve the viability of those remnants by allowing greater access to breeding partners and food sources, refuge from disturbances such as fire and maintenance of genetic diversity of plant communities and populations. Ecological linkages are ideally continuous or near-continuous as the more fractured a linkage is, the less ease flora and fauna have in moving within the corridor (Alan Tingay and Associates 1998).

The Perth Biodiversity Project, supported by the Western Australia Local Government Association (WALGA), have identified and mapped regional ecological linkages within the Perth Metropolitan Region (WALGA and PBP 2004). In order to extend this study outside of the Perth Metropolitan Region, the South West Biodiversity Project was established, resulting in the identification and mapping of the South West regional ecological linkages (Molloy *et al.* 2009).

One mapped ecological linkage (No. 43) passes through the site in an east-west direction. This connects to other linkages to the east and north-west of the site. A very small part of one of these connected ecological linkages (No. 44) passes through the south-eastern corner of the site. The locations of ecological linkages within and near the site are shown in **Figure 4**.

2.4 Previous surveys

2.4.1 Cardno BSD (2005)

A flora, vegetation, fauna and wetland assessment of a wider region including the site was undertaken in October 2004 (Cardno BSD 2005). The following flora and vegetation values were recorded in the site during the Cardno BSD (2005) survey:

- *Conospermum undulatum* (T)
- *Isopogon drummondii* (P3)
- *Acacia lasiocarpa* var. *bracteolata* long peduncle variant (P1)
- Vegetation representing three TECs (SCP 3a, 8 and 20a)
- Vegetation in 'completely degraded' to 'excellent' condition using the Government of WA (2000a) scale
- One wetland recommended to be changed from REW to CCW management category (UFI 8050).

2.4.2 Tauss and Weston (2010)

A flora, vegetation and wetland assessment of the entire MKSEA area including the site was undertaken in 2010 (Tauss and Weston 2010). The following flora and vegetation values were recorded in the site during the Tauss and Weston (2010) survey:

- *Conospermum undulatum* (T)
- *Verticordia lindleyi subsp. lindleyi* (P4)
- *Lepyrodia curvescens* (P2)
- Vegetation representing five TECs (SCP 3a, 8, 10a, 20a and 23a)
- The presence of *Isopogon drummondii* (P3) recorded by Cardno BSD (2005) was not confirmed due to lack of access to Lot 25 Victoria Road, where the species had been previously recorded.
- The presence of *Acacia lasiocarpa* var. *bracteolata* long peduncle variant (P1) recorded by Cardno BSD (2005) was also not confirmed. *Acacia lasiocarpa* var. *lasiocarpa* sens. strict. was recorded in the same area as the Cardno BSD (2005) record. Tauss and Weston (2010) suggest that the previous record may have been misidentified.
- Vegetation in 'degraded' to 'very good' condition using the Government of WA (2000a) scale.

2.4.3 DBCA

DBCA advised in 2017 that they had visited Lots 14 and 15 Victoria Road and Lot 252 Clifford Street to verify TEC mapping (Val English 2017, pers. comms., 6 April). Lot 14 Victoria Road and Lot 252 Clifford Street were each confirmed to support a patch of vegetation representing SCP3a TEC and Lot 15 Victoria Road was confirmed to support a patch of vegetation representing SCP20a TEC. Examination of recent aerial imagery indicated that the vegetation within Lot 252 Clifford Street has since been cleared and therefore no longer supports a TEC.

Subsequently DBCA reviewed additional data and undertook additional surveys in 2018 and provided advice relating to TECs in the site:

- Lot 14 Victoria Road still supports a patch of the SCP3a TEC (Val English 2018, correspondence dated 30 August).
- Lot 13 Victoria Road does not support SCP3a TEC and SCP8 TEC (which are mapped as occurring in this lot within the DBCA database) due to the vegetation being too degraded (Val English 2018, correspondence dated 23 November). DBCA have advised that they will be removing these TEC occurrences from their database.
- Lot 73 Victoria Road does not support TEC 3a (which is mapped as occurring in this lot within the DBCA database) due to the vegetation being too degraded (Val English 2018, correspondence dated 23 November).

Subsequently DBCA have advised that they will be removing the TEC occurrences within Lots 13 and 73 Victoria Road from their database.

3 Methods

3.1 Rationale

A total of 14 lots within the site within which native vegetation was known or suspected to be present were identified as requiring survey. Multiple attempts were made to contact the landowners of these lots to request access to conduct flora and vegetation surveys.

Surveys were completed in all lots for which permission to access was obtained. Reconnaissance surveys were undertaken in autumn 2017 to identify areas of native vegetation and wetlands and to complete an initial assessment as to whether further surveys were required in spring. Detailed sampling of vegetation and targeted flora surveys were then undertaken in spring 2017 as required.

Where permission to access a lot was not forthcoming or verifiable, an assessment of flora and vegetation values was made from the lot boundary; and/or using information adapted from previous surveys (Cardno BSD 2005; Tauss and Weston 2010) and DBCA (DBCA 2017e, b, f).

3.2 Reconnaissance surveys

Reconnaissance surveys were undertaken by Emerge botanists on 30 May and 3 July. Selected areas of vegetation were assessed to determine whether native vegetation was present and if further surveys were required in spring. During the assessment, the site was traversed by vehicle and on foot and general notes on the composition and condition of vegetation was recorded, as well as digital photographs. For some of the lots for which access was not permitted surveys were conducted from road sides or from adjacent lots that could be accessed. A hand-held GPS receiver was used to record a track log during these surveys.

3.3 Spring surveys

Two botanists from Emerge undertook the spring surveys of the site on 31 August 2017 and 15 September 2017. These surveys included detailed sampling of selected vegetation, targeted flora surveys and wetland assessments. Areas of native vegetation were traversed on foot and the composition and condition of vegetation was recorded.

Survey and sampling procedures are outlined in **Section 3.3.1** for vegetation and **Section 3.3.2** for targeted surveys and **Section 3.3.4** for assessment of wetland features.

3.3.1 Flora and vegetation sampling

Detailed sampling of vegetation was undertaken using non-permanent quadrats, completed over a 10 x 10 m area using physical markers and a measuring tape. A total of nine quadrats were surveyed and the position of each was recorded with a hand-held GPS unit, as shown on **Figure 6.**

The data recorded within each quadrat included:

- site details (site name, site number, observers, date, location)

- environmental information (slope, aspect, bare-ground, rock outcropping soil type and colour class, litter layer, topographical position, time since last fire event)
- biological information (vegetation structure, foliage projective cover of each of the three main strata (upper, mid and ground),vegetation condition, degree of disturbance, species present).

Additional plant taxa not observed within quadrats were recorded opportunistically as the botanists traversed the site. Photographs were taken throughout the field visit to show particular site conditions. All plant specimens collected during the field survey were dried, pressed and then named in accordance with requirements of the Western Australian Herbarium. Identification of specimens occurred through comparison with named material and through the use of taxonomic keys. Flora species not native to Western Australia are denoted by an asterisk '*' in text and raw data.

Vegetation condition was assigned at each quadrat and changes in vegetation condition were also noted and mapped across the site. The condition of the majority of the vegetation was assessed using methods from Keighery (1994), as shown in **Table 6**. For vegetation containing *Banksia* spp., the condition scale provided in the conservation advice for the 'banksia woodlands of the Swan Coastal Plain TEC' (DoEE 2016), as shown in **Table 6,** was applied.

Table 6: Vegetation condition scale applied during the field assessment

Condition category	Definition (Keighery 1994)	Measure (DoEE 2016)†	
		Typical native vegetation composition	Typical weed cover
Pristine	Pristine or nearly so, no obvious signs of disturbance.	Native plant species diversity fully retained or almost so	Zero or close to
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.	High native plant species diversity	Less than 10%
Very good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing	Moderate native plant species diversity	5-20%
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.	Low native plant species diversity	5-50%
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.	Very low native plant species diversity	20-70%
Completely degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.	Very low to no native species diversity	Greater than 70%

†= for assessing banksia woodland vegetation against the TEC condition thresholds.

3.3.2 Threatened and priority flora

Areas of suitable habitat for threatened and priority flora species with potential to occur in the site were identified and searched. In addition, vegetation supporting previous records of threatened and/or priority flora (from DBCA search results and/or Tauss and Weston (2010)) was surveyed again to confirm the presence of the species and number of individuals.

Searches were conducted within the flowering season for the majority of species. Multiple surveys were undertaken of some patches of vegetation to ensure the full suite of potential species and variation in flowering time was accounted for. The location of each threatened or priority individual (or population boundary where more appropriate) was recorded with a hand-held GPS receiver.

3.3.3 Threatened and priority ecological communities

The locations of TECs and/or PECs within the site according to the DBCA database (DBCA 2017e, b) and previous surveys (Tauss and Weston 2010) were reviewed using recent aerial photography and, where possible, site visits. Advice from DBCA on particular TEC occurrences within the site was also reviewed (see **Section 2.4.3**).

Areas of native vegetation potentially representing a TEC were assessed against key diagnostic characteristics and, if available, size and/or vegetation condition thresholds provided in the following documents:

- *Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community (TSSC 2016)*
- *Approved Conservation Advice for Corymbia calophylla - Kingia australis woodlands on heavy soils of the Swan Coastal Plain* (DoEE 2017a)
- *Approved Conservation Advice for Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain (DoEE 2017b)*
- *Interim Recovery Plan 2012-2017 for Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain (Swan Coastal Plain community type 20b – Gibson et al. 1994)* (DEC 2012).
- *Approved Conservation Advice for Shrublands and Woodlands of the eastern Swan Coastal Plain (DoEE 2017c).*

3.3.4 Wetland assessment

Recent aerial photographs of the 12 wetland features in the *Geomorphic Wetlands of the Swan Coastal Plain* dataset within the site were examined to provide an indication of flora and vegetation values and disturbance. All wetland features in the site were surveyed during the reconnaissance survey to determine whether the currently assigned geomorphic type and management category were appropriate. This included the following:

- An assessment of geomorphology and inundation levels to define the most suitable geomorphic classification.
- An assessment of ‘significant’ features such as presence of a TEC or threatened flora to define the applicable management category (including ‘significant’ features adjacent to existing wetland features).

In addition to the attributes recorded in sample points, and dependent on access, additional information was recorded to support the reclassification of a wetland. Additional information included:

- colour photographs of the wetland in all directions (taken during the optimal time)
- a recent aerial photograph with the current and proposed wetland mapping and the vegetation units present
- the vegetation condition of the wetland as per the Keighery (1994) scale.

3.4 Mapping and data analysis

3.4.1 Plant community identification and description

The boundaries of native plant communities were determined through examining recent aerial photography and the previous boundaries of plant communities from Tauss and Weston (2010). Where native vegetation was located within lots that were not accessible plant community label, description, vegetation condition and associated data was adopted from the previous Tauss and Weston (2010) survey.

Where native vegetation was located within accessible lots plant communities were identified based on flora species composition, structure and landform. Statistical analysis was not required to separate communities due to the small size and discrete arrangement of vegetation remnants. Plant communities were described according to the dominant species present using the structural formation descriptions of the *National Vegetation Inventory System* (NVIS) (ESCAVI 2003). The identified plant communities were then mapped on aerial photography (1:15,000) from the sample points and boundaries were interpreted from aerial photography. The vegetation condition of each plant community was mapped on aerial photography (1:13,000) based on data recorded during the field survey.

3.4.2 Floristic community type assignment

Where vegetation was not accessible the 'floristic community type' (FCT) from the Gibson *et al.* (1994) dataset previously assigned by Tauss and Weston (2010) and/or the DBCA TEC/PEC search results (DBCA 2017e) was adopted. Similarly, the FCT assigned to vegetation in accessible lots in the DBCA TEC/PEC search results (DBCA 2017e) was adopted.

The remaining vegetation in assessable lots was considered too small and/or degraded to assign an FCT. This is because the number of species recorded in these patches would not have been sufficient to provide an accurate comparison against a comprehensive regional dataset such as that of Gibson *et al.* (1994). Furthermore, these patches did not currently represent an intact FCT.

3.4.3 Species accumulation curve

A species accumulation curve was plotted from sample data by generating a trendline (log) in Microsoft Excel. The trendline was forecast to locate the asymptote of the curve (the point at which the curve flattens), which provides an indication of amount of sampling that would be required before it can be assumed few species remain undetected. Minimum species richness was also estimate using Primer-6 (Clarke and Gorley 2006). The Jacknife1 non-parametric estimator is reported, as it is known to perform well in comparison to simulated and real data sets and is recommended for small sample sizes (Gotelli and Colwell 2011). Comparison between actual and estimated species accumulation assists in evaluating the adequacy of sampling effort.

3.4.4 Proposed wetlands

The boundaries of wetlands proposed to be reclassified were mapped on aerial photography (1:12,500). The proposed wetland boundaries were based on the mapped plant community boundaries but were smoothed so as to be more consistent with the scale that other features in the *Geomorphic Wetlands of the Swan Coastal Plain* dataset are drawn. The current associated wetland feature was overlaid on the proposed boundary/ies and the management category, as determined during the wetland assessment (DBCA 2017c), was displayed.

3.5 Survey limitations

It is important to note the specific constraints imposed on surveys and the degree to which these may have limited survey outcomes. An evaluation of the survey methodology against standard constraints outlined in the EPA document *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016) is provided in **Table 7**.

Table 7: Evaluation of survey methodology against standard constraints outlined in EPA Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment

Constraint	Degree of limitation	Details
Availability of contextual information	No limitation	The broad scale contextual information described in **Section 2** is adequate to place the site and vegetation in context.
	No limitation	It is well understood that vegetation on the eastern side of the Swan Coastal Plain is poorly reserved. Therefore, any native vegetation remaining on the eastern Swan Coastal Plain has a high potential to comprise TEC/s. Sufficient information regarding flora and vegetation values, as well as DBCA mapped FCTs and TECs (including some that have been confirmed) was available. This information was used to characterize vegetation that was not accessible during the surveys.
Experience level of personnel	No limitation	This flora and vegetation assessment was undertaken by two qualified botanists with seven and nine years of botanical experience in Western Australia. Identification of specimens was undertaken by the two above botanists as well as specialist taxonomist Udani Sirisena who has over 12 years' botanical experience in Western Australia. Technical review was undertaken by a senior environmental consultant with 15 years' experience in environmental science in Western Australia.
Suitability of timing / temporal coverage	No limitation	The reconnaissance survey was conducted in May and July and the detailed survey was conducted in late August and September, thus within the main (early) flowering season. Above average rainfall was recorded in July and August 2017, preceding the spring surveys. This was followed by below average rain in September 2017, indicating that seasonal drying and warming associated with spring had commenced between August and September. It is likely that many plant species would have been in flower and/or visible at the time of survey. In addition, many species known to occur in the site are perennial species which would be visible throughout the year. The degraded nature of much of the site limits the potential habitat for native geophytic plants such as orchids. The survey timing was considered adequate to allow the detection of species for which seasonal timing is critical. The only exception to this is *Lepyrodia curvescens*, which was not surveyed for during its flowering period. Although not recorded a confirmed collection of *L. curvescens* was made in the site during a previous survey (Tauss and Weston 2010) indicates that this species may have been present.

Table 7: Evaluation of survey methodology against standard constraints outlined in EPA Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (continued)

Constraint	Degree of limitation	Details
Suitability of timing / temporal coverage	No limitation	Comprehensive flora and vegetation assessments can require multiple visits, at different times of year, and over a period of a number of years, to enable detection of all species present. The site was visited multiple times with the first reconnaissance trip in May, followed by surveys in July, August and September 2017. The late August and September surveys were conducted to ensure the suite of species only visible or flowering during spring were recorded. Additional surveys later in spring 2017 of accessible lots were not deemed to be required due to lack of suitable habitat for threatened and/or priority flora (except that already known to occur in the site). Therefore, this survey is considered to meet the requirements of a detailed survey following the guidelines provided by the EPA (2016).
Spatial coverage / sampling intensity	Minor limitation	Four lots supporting native vegetation values that would have been advantageous to survey were unable to be surveyed due to lack of access. For these lots, landowners either denied access or were not contactable (e.g. no contact details and/or no residents in the lot). However, the previous survey data (Tauss and Weston 2010) and/or vegetation information from DBCA was used for these lots. Given the level of information available for vegetation in these lots, and that TECS have been mapped, and in some cases confirmed by DBCA, the lack of access is not considered a significant limitation. The remaining lots that were not accessible were able to be viewed from other locations so it could not be confirmed that they did not support intact native vegetation. Site coverage was comprehensive for lots that were accessible (track logged).
	No limitation	Species richness within site is estimated at 109 species (Jacknife1) (refer species accumulation curve and estimates shown in **Plate 11**) and a total of 69 species were recorded in the site. This indicates that approximately 63% of the Jacknife1 estimate was recorded. The remaining estimated native species are likely located in patches of native vegetation located within inaccessible lots. Therefore, considering the degraded nature of the site, particularly within accessible lots, the survey effort is considered sufficient to prepare a species inventory for these lots
Influence of disturbance	No limitation	For the majority of the site time since fire is greater than 60 years as interpreted from aerial imagery and therefore short lived species more common after fire may not have been visible. One small previous fire was observed within the site in Lot 25 Victoria Road. This fire was estimated to have occurred within the past one or two years. The trees in this vegetation had blackened trunks but were primarily still alive and contained a living canopy. The understorey supported some scattered native species but was strongly dominated by non-native grasses. This vegetation appeared to have been subject to long term disturbances prior to the fire event. Subsequently the fire is not considered a limitation to the assessment of this vegetation.
	No limitation	Historical ground disturbance was evident in parts of the site and subsequently native vegetation is either altered from its original state or limited to isolated patches. The disturbance history of the site was considered when undertaking field sampling.
Adequacy of resources	No limitation	All resources required to perform the survey were available.

4 Results

4.1 General site conditions

The land within the site is primarily used for residential purposes. However, land used for basic raw material storage and stock keeping were also observed within the site. Many lots have been completely cleared of native vegetation and comprise hardstand used for storage. Other non-residential land uses include a community centre, an industrial warehouse is located in the central portion of the site and a poultry farm is located in the northern corner of the site.

The site has a flat to gently undulating topography. Soils generally consist of sand, sandy clay and sand over clay. Landform and soil patterns are modified from their original state as many lots have been levelled, some have dams and evidence of imported fill was frequently recorded.

Native vegetation cover in the site is low and exists as fragmented patches. Most of the patches of native vegetation occur in the north-western portion of the site, within lots along Victoria Road. The remainder of the site supports two small areas of native vegetation and scattered native and planted trees over non-native grasses.

Evidence of a fire was recorded in the north-eastern portion of the site. This fire was estimated to have occurred within the last two years and many trees had blackened trunks but were still alive. Impacts to native species from the fire were deemed to be low, as the understorey vegetation was dominated by non-native species.

4.2 Survey access

Permission was obtained to access seven of the privately owned lots in the site that contained or potentially contained native vegetation. For the remaining seven lots that contained or potentially contained native vegetation, access was denied by the landowner for five lots and no response was received from the landowner, or no contact details were available, for two lots.

To supplement the current survey, information was incorporated from a previous flora and vegetation assessment that spanned Precinct 1 (Tauss and Weston 2010), information from DBCA databases (DBCA 2017e, f) and correspondence from DBCA (refer Section 2.4.3). This combination of information was sufficient to characterise all native vegetation in the site.

The access status of lots in the site is shown in **Figure 5**.

4.3 Flora

A total of 53 native and 16 non-native (weed) species were recorded within the site during the field survey, representing 23 families and 49 genera. The species list was focused on native taxa and is not a comprehensive list of non-native (including planted) taxa in the site. The dominant families containing native taxa were Myrtaceae (eight native taxa and five weed taxa) and Fabaceae (seven native taxa and two weed taxa). The most common genus was *Eucalyptus* with five taxa. A complete species list is provided in **Appendix B** and sampled data in **Appendix C**.

4.3.1 Threatened and priority flora

No threatened or priority flora species were recorded in the site during the surveys in 2017.

One priority flora species, *Lepyrodia curvescens* (P2), was previously recorded in Lot 14 Victoria Road (Tauss and Weston 2010). During the current survey this lot was visited during May 2017 and no individuals of this species were recorded. However, as the lot was not surveyed in the peak flowering period, and suitable habitat occurs, this species is considered to have potential to occur in Lot 14 Victoria Road. The previously recorded location of this species (Tauss and Weston 2010) is shown in **Figure 6**.

Other historical records of threatened and priority flora species occur in the site but are considered unlikely to be current. Some of these records are located within inaccessible lots which, through examination of aerial imagery, have been subject to intensive vegetation clearing and are unlikely to be current. Other records within accessible lots were not recorded during the surveys in 2017 and are considered unlikely to occur in the site.

4.3.2 Locally and regionally significant flora

One flora species identified as significant (Government of WA 2000b), *Cyathochaeta equitans*, was recorded in the site. This species is listed as significant because the Pinjarra Plain region is considered to be at the limit of its known geographical range and also due to 'significant populations'. This species was recorded in R2.

Drosera macrantha subsp. *macrantha* was recorded in the site in R1 and R2. *D. macrantha* (Swan Coastal Plain form) is listed as 'significant' due to its endemicity to the Swan Coastal Plain. However, this form is not listed as current on Florabase and *D. macrantha* has been split into multiple subspecies, of which none are endemic to the Swan Coastal Plain. Therefore, although *D. macrantha* was recorded in the site, it is not considered to be regionally significant.

4.3.3 Declared pests

No flora species listed as declared pests pursuant to the BAM Act were recorded in the site.

4.4 Vegetation

4.4.1 Plant communities

Twelve native plant communities were identified within the site, including three plant communities identified previously by Tauss and Weston (2010) within lots that were not accessible during the current survey. The two communities previously identified are assumed to be current and have been included to display the entire suite of native vegetation present in the site. The remainder of the site supports hardstand or a plant community dominated by various non-native species.

Plant community **CcXpMt** is the most intact native plant community in the site. One patch of **CcXpMt** occurs in the western portion of the site and extends over 0.35 ha. This community comprised an intact native canopy and understorey, with minimal non-native species.

Plant community **Cc** is similar to **CcXpMt** but occurs in lots that were not accessible during the survey. Multiple patches of **Cc** were identified through comparison of the Tauss and Weston (2010) data and recent aerial imagery and the community extends over 0.99 ha. This community is assumed to have lower native understorey species and diversity based on DBCA indicating that occurrences of this community were too degraded to be included in the DBCA TEC database during a site visit in 2018 (refer to **Section 2.4.3**).

Plant community **BAf** extends over 0.83 ha and is located in the northern portion of the site. Evidence of a recent (within the past two years) fire was present but the majority of the canopy trees were living. The understorey contained low native species diversity and cover and native species recorded were primarily within one small area of the community.

Plant community **AfSlDf** occurs as a very small (0.05 ha) circular patch with moderate species diversity in the shrub layer. The canopy layer is very sparse and consists of one species only (*Allocasuarina fraseriana*). Access was not permitted to this community and survey was conducted from the adjacent property. Plant community **EtBmHh** occurs as an adjacent very small (0.03 ha) linear patch and is separated from **AfSlDf** by a firebreak. This community contains a combination of native, non-native and planted species, particularly in the canopy layer.

Plant communities **AlHa** (0.16 ha) and **AfEtBm** (1.19 ha) were not accessible during the current survey and were adapted from the previous survey (Tauss and Weston 2010). The boundaries of these communities were identified from aerial photography and their descriptions follow the previous survey.

The other eight plant communities exist as small patches of vegetation ranging from 0.03-0.41 ha.

The remainder of the site (116.69 ha) contains non-native vegetation, bare soil or hardstand, with occasional scattered native trees and shrubs. A description and the area of each plant community is provided in **Table 8** and representative photographs of each are provided in **Plate 1** to **Plate 10**. The location of each plant community is shown on **Figure 6.**

Table 8: Plant communities identified within the site

Plant community	Description	Area (ha)
AlH	Low shrubland *Acacia lasiocarpa* and *Hypocalymma angustifolium* over non-native grassland **Eragrostis curvula* over mixed forbland NB: previously referred to as RS1 (Tauss and Weston 2010).	0.16
AfDb	Scattered *Allocasuarina fraseriana* over open occasional *Xanthorrhoea preissii* over forbland *Dasypogon bromeliifolius* and non-native grasses (**Plate 1**).	0.03
AfEtBm	*Allocasuarina fraseriana – Eucalyptus todtiana – Banksia menziesii* low woodland over species rich low shrubs NB: previously referred to as T10 (Tauss and Weston 2010).	1.19
AfSlDf	Occasional *Allocasuarina fraseriana* over open shrubland *Hibbertia hypericoides* over low shrubland *Stirlingia latifolia* over closed forbland *Desmocladus flexuosus* (**Plate 2**).	0.05
BAf	Open forest *Banksia attenuata* and *Allocasuarina fraseriana* over occasional *Kingia australis* over closed non-native grassland (**Plate 3**).	0.83

Table 8: Plant communities identified within the site (continued)

Plant community	Description	Area (ha)
Cc	Low open forest *Corymbia calophylla* over (assumed) limited understorey NB: previously referred to as T1 (Tauss and Weston 2010).	0.99
CcHa	Open forest *Corymbia calophylla* over open shrubland *Hypocalymma angustifolium* over non-native grassland (**Plate 4**).	0.41
CcXpMt	Low open forest *Corymbia calophylla* over open shrubland *Xanthorrhoea preissii* and *Hypocalymma angustifolium* over open forbland *Mesomelaena tetragona* (**Plate 5**).	0.35
***EEt**	Forest **Eucalyptus camaldulensis*, *Eucalyptus rudis* and *Eucalyptus todiana* over grassland **Ehrharta calycina* (**Plate 6**).	0.08
EtBmSl	Woodland *Eucalyptus todtiana*, planted *Eucalyptus sp. and *Banksia menziesii* over shrubland *Hibbertia hypericoides* and *Stirlingia latifolia* over forbland *Lomandra sericea* (**Plate 7**).	0.03
Mp	Low open forest *Melaleuca preissiana* over non-native closed grassland (**Plate 8**).	0.19
MrVjLc	Low forest *Melaleuca rhaphiophylla* over scattered *Viminaria juncea* over low open shrubland *Acacia pulchella* and *Hypocalymma angustifolium* over scattered *Leptocarpus canus* (**Plate 9**).	0.09
Non-native vegetation/ hardstand	Heavily disturbed areas comprising non-native grasses with occasional native shrubs and trees and planted vegetation; or hardstand; or bare ground (**Plate 10**).	116.69

*Plate 1: Plant community **AfDb** in 'good' condition*

*Plate 2: Plant community **AfSlDf** in 'very good' condition*

*Plate 3: Plant community **BAf** in 'degraded' condition*

*Plate 4: Plant community **CcHa** in 'degraded' condition*

*Plate 5: Plant community **CcXpMt** in 'very good' condition*

Plate 6: Plant community ****EEt*** *in 'degraded - completely degraded' condition*

Plate 7: Plant community ***EtBmSl*** *in 'good' condition*

*Plate 8: Plant community **Mp** in 'degraded' condition*

*Plate 9: Plant community **MrVjLc** in 'degraded' condition*

Plate 10: Non-native vegetation in 'completely degraded' condition

4.4.2 Vegetation condition

The majority (96%) of the site is in 'completely degraded' condition and is dominated by non-native vegetation. This vegetation consists of planted trees and shrubs, native scattered trees and shrubs over non-native grasses such as **Ehrharta calycina* and **Eragrostis curvula*. Areas of bare soil and hardstand were also mapped as being in 'completely degraded' condition.

Plant community **CcXpMt** was mapped as being in 'very good' condition due to an intact vegetation structure with very low cover and diversity of non-native species. During the field survey the land owner detailed manual weed control that has been undertaken in this community for multiple years.

Plant community **EtBmHh** was mapped as being in 'good' condition due to an altered structure. The canopy layer is sparse and includes planted non-native trees such as **Acacia longifolia* and **Callistemon* sp. occurring among scattered native trees. The understorey is also sparse and contains non-native grasses.

Adjacent to **EtBmHh**, plant community **AfSlDf** has a relatively intact shrub layer and was mapped as being in 'very good' condition. The canopy layer has been removed and only scattered *Allocasuarina fraseriana* trees are present, as well as some non-native grass and bulbous species.

Plant community **BAf** was mapped as being in 'degraded' condition. This vegetation had been subject to a fire within the past two years and the understorey was dominated by a dense layer of non-native grasses with low cover of native species. The lack of native understorey diversity and cover was considered to be unlikely solely due to the fire.

Plant community **AfDb** was mapped as being in 'good' condition. This vegetation comprises a narrow band bordered by a fence line and a large bare area of sand that was recently cleared. The native species diversity was low and some grassy weeds were present. The native canopy layer was sparse and altered from its original state.

Other small patches of scattered vegetation in the site were mapped as being in 'degraded' and 'degraded – completely degraded' condition due to the dominance of non-native species with scattered occasional native trees and shrubs.

Plant community **AfEtBm** was not accessible during the current survey and therefore the vegetation condition was mapped as per the previously assigned condition of 'very good' and 'degraded' (Tauss and Weston 2010). Plant communities **AlHa** and **Cc** were mapped as being in 'degraded' condition based on advice from DBCA (see **Section 2.4.3**).

The extent of vegetation by condition category is detailed in **Table 9** and shown on **Figure 7**.

Table 9: Size of vegetation condition categories within the site

Condition category	Size (ha)
Pristine	0
Excellent	0
Very Good	0.98
Good	0.07
Degraded	3.27
Degraded - completely degraded	0.08
Completely degraded	116.69

4.4.3 Floristic community type assignment

DBCA have previously conducted visits of lots in the site to confirm FCTs and/or TECs (Val English 2017, pers. comms., 6 April; Val English 2018, correspondence dated 4 September and 23 November).

Plant community **AfEtBm** was determined by DBCA to represent FCT 20a '*Banksia attenuata* woodlands over species rich dense shrublands'. Plant community **CcXpMt** was determined by DBCA to represent FCT 3a '*Corymbia calophylla – Kingia australis* woodlands on heavy soils'. No further FCT analysis was conducted for these plant communities. A summary of FCTs present in the site is provided in **Table 10**.

The remaining plant communities in the site were considered too degraded and/or small in size to assign to a FCT.

Table 10: Plant community and likely FCT represented within the site for each sample point

Plant community	Sample unit/source	Floristic community type (FCT)	Reservation and conservation status (Gibson *et al.* 1994)
CcXpMt	• R4 • Tauss and Weston (2010) • DBCA	FCT 3a: *Corymbia calophylla – Kingia australis* woodlands on heavy soils	Unreserved Vulnerable
AfEtBm	• Tauss and Weston (2010) • DBCA	FCT 20a: *Banksia attenuata* woodlands over species rich dense shrublands	Unreserved Endangered

4.4.4 Threatened and priority ecological communities

Two TECs were recorded within the site as detailed below.

A total of 1.22 ha of the EPBC Act listed banksia woodland TEC is located within the site associated with plant communities **AfEtBm** and **AfDb**. Whether a patch of vegetation is considered to represent the banksia woodland TEC depends on a number of diagnostic criteria including geographic location, soils, landform, structure, composition, condition and patch size (DoEE 2016). This vegetation also represents FCT 20a '*Banksia attenuata* woodland over species rich dense shrublands' which is listed as an 'endangered' TEC in WA under the BC Act. Plant communities **AfEtBm** and **AfDb** would also represent the PEC 'banksia dominated woodlands of the Swan Coastal Plain IBRA region' which is listed as P3 in WA.

Plant community **AfEtBm** extends over 1.19 ha, comprising 0.58 ha of vegetation in 'very good' condition and 0.61 ha of vegetation in 'degraded' condition. According to the banksia woodland TEC guidelines (DoEE 2016), to qualify as the TEC vegetation in 'very good' condition must be greater than 1 ha in size and vegetation in 'degraded' condition is not considered to comprise the TEC. When considered together, the two parts of this vegetation would not meet the condition and patch size thresholds to be considered a patch. However, DBCA have confirmed vegetation at the same location as a patch of banksia woodland TEC (DBCA 2017b). So as to align results with the current DBCA mapping the entirety of **AfEtBm** (1.19 ha) is identified as a patch of the EPBC Act listed banksia woodland TEC.

Plant community **AfDb** meets the minimum condition threshold of 'good' for the banksia woodland TEC, but, at 0.03 ha in size, does not meet the minimum size threshold of 2 ha (DoEE 2016). However, the **AfDb** vegetation is contiguous with banksia woodland vegetation in Bush Forever Site 53, which is mapped as FCT 20a and banksia woodland TEC in the DBCA database (DBCA 2017e). Therefore, the **AfDb** vegetation would be viewed as part of the same patch and therefore part of a larger occurrence of the banksia woodland TEC.

The banksia woodland TEC is synonymous with the 'banksia dominated woodlands of the Swan Coastal Plain IBRA region' PEC (P3) and therefore the **AfDb** vegetation also represents this PEC.

A patch of vegetation in approximately the same location as plant community **CcXpMt** has been confirmed by DBCA as representing the '*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain' TEC (refer **Section 2.4.3**). This community is in 'very good' condition and extends over 0.35 ha. No minimum condition or patch size thresholds apply to the '*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain' TEC. The soil, landform and flora species present in **CcXpMt** match the TEC description and it is therefore considered a 0.35 ha patch of EPBC Act listed '*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain' TEC.

Plant community **CcXpMt** represents FCT 3a '*Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain', which is listed as an 'endangered' TEC in WA under the BC Act.

Multiple TEC occurrences that are mapped by DBCA in the site were reviewed during field surveys and determined to no longer be current. This includes occurrences of SCP8 and SCP3a in the north-western and south-western portions of the site. The TECs present within the site are summarised in **Table 11** and shown in **Figure 8**.

No other TECs or PECs were recorded within the site.

Table 11: TECs recorded within the site

TEC code	TEC name	Level of significance		Location	Area (ha)
		State	EPBC Act		
SCP20a	Banksia woodlands of the Swan Coastal Plain (*Banksia attenuata* woodlands over species rich dense shrublands)	Endangered	Endangered	15 Victoria Road[#]	1.22
				50 Victoria Road[#]	
SCP3a	*Corymbia calophylla – Kingia australis* woodlands on heavy soils of the Swan Coastal Plain	Critically Endangered	Endangered	14 Victoria Road	0.35

Note: [#]=access not available so DBCA record deemed to be current.

4.4.5 Locally and regionally significant vegetation

The eastern side of the Swan Coastal Plain has been subject to extensive historic vegetation clearing and native vegetation from the eastern side of the Swan Coastal Plain is poorly reserved. As such, any remnant native vegetation in the site is likely to be considered regionally significant.

Native vegetation in the site may support fauna species of conservation significance. In particular, trees in the site have the potential to provide foraging, roosting and nesting habitat for three species of threatened black cockatoos. These trees include the following:

- large mature eucalypt trees (diameter at breast height larger than 500 mm) that may provide nesting habitat
- native trees such as *Corymbia calophylla* (marri) and non-native trees such as *Melia azedarach* (cape lilac) that may provide foraging habitat
- groups of native and/or planted eucalypt trees that may provide roosting habitat.

Native and non-native shrubland vegetation in the site may provide habitat for conservation significant ground dwelling fauna, such as quenda (P4).

4.4.6 Species richness and sampling adequacy

A total of 69 species were recorded in the site. A species accumulation curve derived from sample data is presented in **Plate 11**. After nine samples the curve is still increasing and has not reached its asymptote. This indicates that a proportion of species likely remain undetected by sampling.

Species richness was estimated in Primer-6 to be 109 (Jacknife1). Based on the trend of the species accumulation curve approximately 20 to 30 samples would be required to capture that many species. Therefore, the 69 species recorded in the site indicates that approximately 63% of the estimated 109 species in the site were recorded. Given the small size and degraded condition of the majority of vegetation visited in the survey, and that non-native species which are included in the estimate were not a focus of the survey, 69 species is considered to be adequate to prepare a representative species inventory of native species within accessible lots.

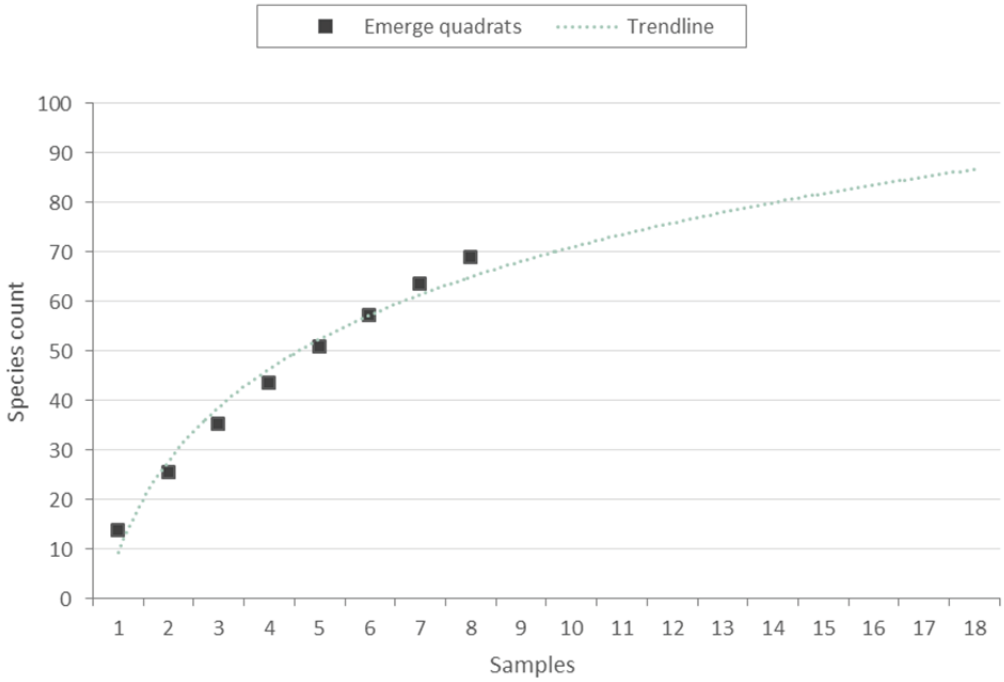

Plate 11: Species accumulation curve derived from sample data (y =26.795ln(x) + 9.3159, R^2 = 0.9734)

4.5 Wetlands

Of the 13 mapped wetland features in the site, 11 aligned with their current geomorphic classification and management category, and no changes are recommended. The accuracy of the boundaries of these 11 features were not assessed and it is likely that, due to the broad scale mapping of the *Geomorphic Wetlands of the Swan Coastal Plain dataset*, some features extend further than their associated on-ground values.

Portions of two wetland features within Lot 14 Victoria Road, REW UFI No. 8050 and MUW UFI No. 13369, were identified as supporting values that were potentially indicative of a CCW and were surveyed using the methodology outlined in **Section 3.3.4**. A summary of the changes recommended to portions of UFI 8050 and UFI 13369 is shown in **Table 12** and detailed information about the wetland is provided in **Section 4.5.1**.

Table 12: Summary of proposed changes to geomorphic wetlands in the site

UFI	2017 survey access	Geomorphic classification		Management category		Boundary changes	Reasoning
		Current (DBCA 2018b)	Recommendation	Current (DBCA 2018b)	Recommendation		
8050	Part (Lot 14 Victoria Rd only)	Sumpland	Palusplain	REW	CCW (part)	Yes	TEC
13369	Part (Lot 14 and 51 Victoria Rd, 10 and 237 Bickley Road only)	Palusplain	Palusplain	MUW	CCW (part)	Yes	TEC

Note: CCW=conservation category wetland, MUW=multiple use wetland, TEC=threatened ecological community.

4.5.1 UFI 8050/13369 (portions within Lot 14 Victoria Road)

The currently mapped wetland features UFI 8050 and UFI 13369 occur in the south-western portion of the site as shown in **Figure 9**. During the current survey only lots 14 and 51 Victoria Road and lots 10 and 237 Bickley Road associated with these wetland features were accessible for survey. Information regarding vegetation within some adjacent lots that was also relevant to these wetland features was subsequently provided by DBCA (refer **Section 2.4.3**).

UFI 8050 is classified as a sumpland wetland indicating it is within a basin landform that is seasonally inundated. However, the portion of the feature within Lot 14 Victoria Road occurs within a flat (palusplain) landform rather than a basin. Topographic contours indicate that the feature is within a gently undulating landscape (12-15 mAHD). The previous survey recorded presence of surface waterlogging within the wetland feature during spring, with a shallow perched water table at approximately 0.4 m (Tauss and Weston 2010). The seasonal water table was estimated to be at approximately 1.8 m depth (Tauss and Weston 2010). UFI 13369 is currently classified as palusplain.

The UFI 8050 feature encompasses the north-western portions of plant communities **AlHa, Cc** and **CcXpMt**, as well as non-native vegetation. Plant community **CcXpMt** within Lot 14 Victoria Road was confirmed as representing the '*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain' TEC by DBCA (refer **Section 2.4.3**). The portion of UFI 13369 within Lot 14 Victoria Road that contains plant community **CcXpMt** was similarly confirmed by DBCA to represent this TEC (refer **Section 2.4.3**). DBCA determined that plant communities **AlHa** and **Cc** within adjacent lots 13 and 73 Victoria are too degraded to be identified as a TEC.

Evaluation of the portions of UFI 8050 and UFI 13369 within Lot 14 Victoria Road that contain a TEC indicated that these areas represent a CCW. Where plant communities **Cc** and **AlHa** occur in adjacent lots they support values that are consistent with the current resource enhancement management category assigned to UFI 8050. Where non-native vegetation occurs values are consistent with the current multiple use management category assigned to UFI 13369.

It is recommended that the portions of wetland features UFI 8050 and UFI 13369 within Lot 14 Victoria Road that contain a TEC are made into a new palusplain wetland feature with a conservation management category. This new CCW feature extends over 0.37 ha.

Representative photographs of the vegetation present within UFI 8050, taken from Lot 14 Victoria Road, are provided in **Plate 12** and **Plate 13**. The boundaries proposed for the new CCW feature are shown in **Figure 9**. The completed DBCA evaluation for this feature is presented in **Appendix D**.

*Plate 12: Plant community **CcXpMt** within REW UFI 8050 looking east, showing intact native woodland vegetation.*

*Plate 13: Edge of plant community **CcXpMt** within REW UFI 8050 looking south towards plant community **AlHa**.*

5 Discussion

The site has been subject to significant historical disturbance and is dominated by non-native vegetation. Further clearing of native vegetation has occurred recently, as indicated by the absence of some areas of native vegetation previously recorded in the site by Tauss and Weston (2010). Remnant native vegetation within the site is fragmented and varies in quality. Some areas of native vegetation have higher conservation value as they represent TECs (further discussed in **Section 5.2** below). However, the areas of native vegetation are relatively small and are disconnected from larger areas of native vegetation that occur nearby to the site in *Bush Forever* sites 53 and 387.

Access to all areas of native vegetation was not possible during the current survey due to limitations of private landownership. The lack of access was not ideal. However, it was not considered a significant limitation as information regarding native vegetation in lots not accessible was available from Tauss and Weston (2010) and/or DBCA (DBCA 2017b, e, f) including correspondence (detailed in **Section 2.4.3**).

Where areas of native vegetation were inaccessible or unable to be viewed from other locations, information from other sources was adopted (Tauss and Weston 2010; DBCA 2017b, e, f). Although information from these sources is outdated (e.g. the Tauss and Weston (2010) data was collected from 2007-2009), it was considered to provide a fair account of the values of inaccessible areas of native vegetation. On occasions when previously surveyed areas could be visited, the values of vegetation were found to be generally consistent with the condition and composition that had previously been described. Furthermore, some TEC information obtained from DBCA (DBCA 2017b and correspondence outlined in **Section 2.4.3**) has been confirmed during site visits by DBCA representatives, meaning classification of these areas is complete.

5.1 Threatened and priority flora

The DBCA threatened and priority flora database search results indicated that threatened and priority flora had previously been recorded within the site (DBCA 2017f). From a combination of examination of aerial photography and/or field surveys it was determined that all of the DBCA flora records were located within lots that no longer support native vegetation or the native vegetation had been disturbed. In addition, none of the threatened and priority flora that were previously recorded were identified elsewhere during field surveys. Therefore, the DBCA flora records in the site are deemed to no longer be current.

The two priority flora species recorded in the site by Tauss and Weston (2010) were not identified in the DBCA threatened and priority flora database. The single Tauss and Weston (2010) record of *Verticordia lindleyi* subsp. *lindleyi* (P4) was determined to no longer be current due to vegetation clearing in the intervening period. The status of the other priority flora species recorded in the site by Tauss and Weston (2010), *Lepyrodia curvescens* (P2), was unable to be confirmed in the current survey.

L. curvescens is a perennial dioecious rhizomatous rush measuring 25-40 cm high and occurs in seasonally inundated swamps and flowers between September and November (DBCA 2018c). Tauss and Weston (2010) previously recorded this species in Lot 14 Victoria Road, where remnant native vegetation and suitable seasonally inundated habitat is present. Lot 14 Victoria Road was accessible during the current survey and was visited in May 2017. Being a perennial, if *L. curvescens* was present it would potentially have been visible at this time. But it would not have been flowering making detection more difficult. Therefore, although *L. curvescens* was not recorded, the presence or absence of this species could not be confirmed and it is considered to have potential to occur in the site.

No other threatened or priority flora species were recorded during the survey. If other threatened or priority flora species are present they would likely be located within the few better condition patches of vegetation in the site. Access to search for threatened or priority flora species in these patches was limited during the current survey. However, previous assessments by Tauss and Weston (2010) did not record any other threatened or priority flora species in these patches of vegetation. Consequently, it is considered unlikely that other threatened or priority flora species occur in the site.

5.2 Threatened and priority ecological communities

All the TEC occurrences identified in the site are already identified within the DBCA threatened and priority ecological community database. The vegetation condition and boundaries of these known TEC occurrences were refined during the current survey, through site surveys or through reviewing previously recorded information against current aerial photography.

The 'banksia woodlands of the Swan Coastal Plain' TEC (banksia woodland TEC) occurs at two locations within the site. The larger occurrence (**AfEtBm**) extends over 1.19 ha across two adjacent lots on Victoria Road, of which neither were accessible during the current survey. One lot (Lot 15) was previously visited by DBCA who confirmed the presence of the TEC in 'very good' condition. The vegetation within the other lot (Lot 50) was previously determined to be banksia woodland in 'degraded' condition in 2007 (Tauss and Weston 2010).

When viewed as a combined patch the **AfEtBm** vegetation does not meet the minimum thresholds for vegetation condition and size (DoEE 2016). Nonetheless, as DBCA had confirmed the vegetation as being banksia woodland TEC (DBCA 2017e), this classification was adopted. It is assumed that DBCA may have determined the vegetation in Lot 50 Victoria Road to be in better condition than reported by Tauss and Weston (2010) or that 'very good' was an appropriate condition for the entire patch. The second occurrence of banksia woodland TEC (**AfDb** within Lot 107 Clifford St) was viewed from the adjacent *Bush Forever* site. This occurrence is very small (0.03 ha in size) and only qualifies as the banksia woodland TEC due to contiguity with the adjacent larger patch of banksia woodland that occurs outside of the site in Bush Forever Site 53.

These occurrences are relatively small remnants of banksia woodland. However, floristic community type is considered in the assessment of the values of banksia woodland TEC and being representative of FCT 20a on the eastern Swan Coastal Plain, these patches may be considered to have relatively higher conservation significance.

The '*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain' TEC, has been confirmed by DBCA in 2018 as occurring within Lot 14 Victoria Rd (Val English 2018, correspondence dated 30 August). One patch of the **CcXpMt** vegetation within this lot was determined to represent the TEC. The adjacent **Cc** vegetation within Lots 13 and 73 Victoria Road was initially determined to also represent the TEC (Tauss and Weston 2010). Subsequently, DBCA visited these lots and determined that the **Cc** vegetation was too degraded to be included in the DBCA TEC database (Val English 2018, correspondence dated 23 November). The conservation advice for '*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain' TEC states that no thresholds for size and/or condition apply to this TEC due to its very restricted distribution (DoEE 2017a). It is unclear what basis DBCA determined the **Cc** vegetation to be too degraded to represent the TEC, but as Lots 13 and 73 were not accessible to Emerge personnel, it is assumed that the **Cc** vegetation supported an extremely limited suite of species associated with FCT 3a.

The 'clay pans of the Swan Coastal Plain' TEC (claypan TEC) was previously determined to occur within Lot 13 Victoria Road (Tauss and Weston 2010). Following a site visit DBCA indicated that the vegetation in this lot, plant community **AlHa**, was also too degraded to be included in the DBCA TEC database (Val English 2018, correspondence dated 23 November). Conservation advice for the clay pan TEC defines a minimum threshold of 'good' condition for a patch of this TEC. The **AlHa** vegetation is assumed to be in 'degraded' condition and therefore does not represent the claypan TEC.

5.3 Wetlands

Confirming the classification of most of the wetlands features in the site was straightforward. The mapped MUW features have values that align with the MUW description as containing 'few remaining important attributes and functions' (DBCA 2017c).

The portions of wetland features UFI 8050 and UFI 13369 recommended for reclassification support values that are inconsistent with their current geomorphic and/or management categories. The recommendation to change the geomorphic classification of the portion of UFI 8050 from sumpland to a palusplain is administrative. However, changing the management category of these areas to CCW will have implications for their future management. A main reason for changing the management category of the portions of UFI 8050 and UFI 13369 is the presence of TEC vegetation. A new feature encompassing the TEC vegetation is recommended to be created.

Inconsistencies between wetland boundaries and associated vegetation are not unusual due to the regional scale that the *Geomorphic Wetlands of the Swan Coastal Plain* dataset was drafted. The proposed boundary of the new CCW feature (shown in **Figure 9**) were smoothed to be consistent with the scale of mapping in the *Geomorphic Wetlands of the Swan Coastal Plain* dataset. Consequently, where features are drawn within lots, they extend beyond the mapped plant community boundaries, which were drawn at finer scale. Where features abut lot boundaries they were drawn to match lot boundaries to ensure that features are not identified in lots where they do not physically occur.

Note that the DBCA procedure for requesting a change to wetland management category or boundary requires that colour photographs are supplied from four compass points surrounding a wetland feature. It was not possible to capture four photos during the current survey as adjacent lots were not accessible.

5.4 Local and regional significance

The woodland and wetland communities on the eastern side of the Swan Coastal Plain (i.e. on the Pinjarra Plain) are typified by high numbers of endemic, threatened and priority taxa (Government of WA 2000b). *Cyathochaeta equitans* was recorded within the site and is one of these species. It is considered to be a 'significant' flora species of the Pinjarra Plain and associated foothills in the Perth metropolitan region' (Government of WA 2000b).

The vegetation on the eastern side of the Swan Coastal Plain is fragmented and generally poorly reserved (DEC 2002). As such, much of the remaining remnant vegetation in this area has the potential to represent one of several TECs as outlined in **Section 5.2**. The vegetation in the site representing the '*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain' TEC may in particular be considered regionally significant. This TEC has a restricted distribution and extent and the remaining patches are under threat (DoEE 2017a).

The site is located near the Greater Brixton Street Wetlands (Bush Forever Site 387) which are renowned for containing a high diversity of flora and unique combination of ecological communities. Many of the taxa and ecological communities recorded within the site also occur within the Greater Brixton Street Wetlands. A biodiversity linkage is mapped between the site and the Greater Brixton Street Wetlands. However, as vegetation within the site is highly modified and fragmented, there is no vegetated corridor connecting the site and the Greater Brixton Street Wetlands. The vegetation in the site is therefore unlikely to be considered significant based on its proximity to the Greater Brixton Street Wetlands alone.

The value of the vegetation within the site to species of black cockatoo is likely to be limited to foraging, although potential roosting and breeding habitat trees may occur (Harewood 2018).

6 Conclusions

The site has been subject to significant historical and ongoing disturbance.

No threatened or priority flora species were recorded during the 2017 surveys in the site. One priority species, *Lepyrodia curvescens* (P2), is considered likely to occur in the site based on a previous record (Tauss and Weston 2010). No other threatened or other priority flora species are considered likely to occur within the site.

Native vegetation extends over 4.40 ha (3.63%) of the site and comprises 12 plant communities in ‘degraded’, ‘good’ and ‘very good’ condition. The remaining 116.69 ha of the site supports non-native vegetation in ‘completely degraded’ condition or hardstand.

The site supports occurrences of three Commonwealth and State listed TECs comprising:

- 1.22 ha of ‘banksia woodlands of the Swan Coastal Plain’[1]
- 0.35 ha of ‘*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain’[2]

The portion of **CcXpMt** vegetation within UFI 8050 and UFI 13369 that represents a TEC should be excised and a new wetland feature created that encompasses this vegetation. The geomorphic classification of this new feature should be palusplain and the management category should be conservation (CCW).

The following values present in the site would be considered locally and/or regionally significant:

- Patches of remnant native vegetation due to their location on the eastern side of the Swan Coastal Plain, where vegetation is generally poorly reserved.
- Native and planted trees that may provide foraging, breeding and/or roosting habitat for threatened black cockatoos.
- Shrubland vegetation that may provide habitat for conservation significant ground dwelling fauna species such as quenda (P4).

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[1] State listed TEC ‘*Banksia attenuata* woodlands over species rich dense shrublands’ and State listed PEC ‘Banksia dominated woodlands of the Swan Coastal Plain IBRA region’.
[2] State listed TEC ‘*Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain’.

7 References

7.1 General references

Alan Tingay and Associates 1998, *A Strategic Plan for Perth's Greenways - Final Report*.

Beard, J. S. 1990, *Plant Life of Western Australia*, Kangaroo Press Pty Ltd., Kenthurst, N.S.W.

Beard, J. S., Beeston, G. R., Harvey, J. M., Hopkins, A. J. M. and Shepherd, D. P. 2013, *The vegetation of Western Australia at the 1:3,000,000 scale. Explanatory memoir. Second edition.*, Conservation Science Western Australia, 9: 1-152.

Cardno BSD 2005, *Maddington-Kenwick Strategic Industrial Area - Environmental Review: Flora, Vegetation, Fauna and Wetlands*.

Churchward, H. M. and McArthur, W. M. 1980, *'Landforms and Soils of the Darling System, Western Australia'*, in Department of Conservation and Environment (ed.), *Atlas of Natural Resources Darling System Western Australia*, Department of Conservation and Environment.

Clarke, K. R. and Gorley, R. N. 2006, *PRIMER v6: User Manual/Tutorial*, PRIMER-E, Plymouth.

Department of Biodiversity, Conservation and Attractions (DBCA) 2017a, *Consanguineous Wetlands Suites (DBCA-020)*.

Department of Biodiversity, Conservation and Attractions (DBCA) 2017b, *Map of theatened ecological community records including sites confirmed by DBCA*, pers. comm. Val English Kensington.

Department of Biodiversity, Conservation and Attractions (DBCA) 2017c, *A methodology for the evaluation of wetlands on the Swan Coastal Plain*, draft prepared by the Wetlands Section of the Department of Biodiversity, Conservation and Attractions and the Urban Water Branch of the Department of Water and Environmental Regulation, Perth.

Department of Biodiversity, Conservation and Attractions (DBCA) 2017d, *Ramsar Sites (DBCA-010)*.

Department of Biodiversity Conservation and Attractions (DBCA) 2017e, *Threatened and Priority Ecological Community Database Search Results Ref. 21-0317EC*, Species and Communities Branch, Perth.

Department of Biodiversity Conservation and Attractions (DBCA) 2017f, *Threatened and Priority Flora Database Search Results Ref. 30-0317FL*, Species and Communities Branch, Perth.

Department of Biodiversity, Conservation and Attractions (DBCA) 2018a, *Directory of Important Wetlands in Australia - Western Australia (DBCA-045)*.

Department of Biodiversity, Conservation and Attractions (DBCA) 2018b, *Geomorphic Wetlands, Swan Coastal Plain (DBCA-019)*.

Department of Environment and Conservation (DEC) 2002, *A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions in 2002*, Perth.

Department of Conservation (DEC) 2012, *Interim Recovery Plan 2012-2017 for Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain (Swan Coastal Plain community type 20b – Gibson et al. 1994). Interim Recovery Plan No. 328.*, Perth.

Department of the Environment and Energy (DoEE) 2016, *Banksia Woodlands of the Swan Coastal Plain in Community and Species Profile and Threats Database*, Canberra.

Department of Environment and Energy (DoEE) 2017a, *Approved Conservation Advice for Corymbia calophylla - Kingia australis woodlands on heavy soils of the Swan Coastal Plain*, Delegate of the Minister (for Environmenta and Energy).

Department of Environment and Energy (DoEE) 2017b, *Approved Conservation Advice for Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain*, Delegate of the Minister (for Environmenta and Energy).

Deparment of Environment and Energy (DoEE) 2017c, *Approved Conservation Advice for Shrublands and Woodlands of the eastern Swan Coastal Plain*, Canberra.

Department of Water (DoW) 2008, *LiDAR Elevation Dataset, Swan Coastal Plain*, Perth.

Department of Parks and Wildlife (DPaW) 2016, *A methodology for the evaluation of wetlands on the Swan Coastal Plain*, Wetlands Section , Department of Parks and Wildlife and Urban Water Branch, Department of Water, Perth.

Department of Water and Environmental Regulation (DWER) 2018, *Hydrography Linear (Heirarchy) (DWER-031)*, Perth.

Emerge Associates 2018a, *Local Water Management Strategy Maddington Kenwick Strategic Employment Area - Precinct 1*.

Emerge Associates 2018b, *Local Water Management Strategy Maddington Kenwick Strategic Employment Area - Precinct 2*.

Emerge Associates 2018c, *Local Water Management Strategy Maddington Kenwick Strategic Employment Area - Precinct 3B*.

Environment Australia 2000, *Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1 - Summary Report*, Department of Environment and Heritage.

Environmental Protection Authority (EPA) 2006, *Guidance Statement No. 10. Level of Assessment for Proposals Affecting Natural Areas Within the System 6 Region and Swan Coastal Plain Portion of the System 1 Region*, Perth.

Environmental Protection Authority (EPA) 2016, *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment*, Perth.

ESCAVI 2003, *Australian Vegetation Attribute Manual: National Vegetation Information System, Version 6.0*, Department of the Environment and Heritage, Canberra.

Gibson, N., Keighery, B., Keighery, G., Burbidge, A. and Lyons, M. 1994, *A Floristic survey of the southern Swan Coastal Plain*, Department of Conservation and Land Management and the Conservation Council of Western Australia, Perth.

Gotelli, N. J. and Colwell, R. K. 2011, *Estimating species richness*, Oxford University Press, Oxford.

Government of WA 2000a, *Bush Forever - Volume 1: Policies, principles and processes*, Perth.

Government of WA 2000b, *Bush Forever, Volume 2: Bush Forever Site Descriptions*, Perth.

Government of Western Australia 2015, *2015 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of May 2016*, Department of Parks and Wildlife, Perth.

Gozzard, J. R. 2011, *Sea to scarp [electronic resource]: geology, landscape and land use planning in the southern Swan Coastal Plain*, Geological Survey of Western Australia.

Harewood, G. 2018, *Fauna Assessment (Level 1) Maddington Kenwick Strategic Employment Area Precinct 1*.

Heddle, E. M., Loneragan, O. W. and Havel, J. J. 1980, *'Vegetation Complexes of the Darling System Western Australia'*, in Department of Conservation and Environment (ed.), *Atlas of Natural Resources Darling System Western Australia*, Perth.

Hill, A. L., Semeniuk, C. A., Semeniuk, V. and Del Marco, A. 1996, *Wetlands of the Swan Coastal Plain: Volume 2A - Wetland Mapping, Classification and Evaluation*, Water and Rivers Commission and the Department of Environmental Protection, Perth.

Keighery, B. 1994, *Bushland Plant Survey: A guide to plant community survey for the community*, Wildflower Society of WA (Inc), Nedlands.

Keighery, B. J., Keighery, G. J., Longman, V. M. and Clarke, K. A. 2012, *Weed and Native Flora Data for the Swan Coastal Plain*, Departments of Environmental Protection and Conservation and Land Management, Western Australia.

Miles, C. 2001, *NSW Murray Catchment Biodiversity Action Plan*, Nature Conservation Working Group Inc, Albury, New South Wales.

Molloy, S., Wood, J., Hall, S., Wallrodt, S. and Whisson, G. 2009, *South West Regional Ecological Linkages Technical Report*, Western Australian Local Government Association and Department of Environment and Conservation, Perth.

Perth Biodiversity Project (PBP) 2013, *2013 Native Vegetation extent by Vegetation complexes on the Swan Coastal Plain south of Moore River* Western Australian Local Government Association, Perth.

Seddon, G. 2004, *A Sense of Place: a response to an environment, the Swan Coastal Plain Western Australia*, Blooming Books, Melbourne.

Semeniuk, C. A. 1987, *Wetlands of the Darling System - a geomorphic approach to habitat classification*, Journal of the Royal Society of Western Australia, 69: 95-112.

Semeniuk, C. A. 1988, *Consanguineous wetlands and their distribution in the Darling System, Southwestern Australia*, Journal of the Royal Society of Western Australia, 70(3): 69-87.

Semeniuk, C. A. and Semeniuk, V. 1995, *A Geomorphic Approach to Global Classification for Inland Wetlands*, Vegetatio, 118(1/2): 103-124.

Tauss, C. and Weston, A. S. 2010, *The flora, vegetation and wetlands of the Maddington-Kenwick Strategic Emplyment Area*.

Threatened Species Scientific Committee (TSSC) 2016, *Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community*.

Western Australian Local Government Association and Perth Biodiversity Project (WALGA and PBP) 2004, *Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region*, Perth.

Wetlands Advisory Committee (Report of the Wetlands Advisory Committee to the Environmental Protection Authority), 1977, *The status of reserves in System Six*, Environmental Protection Authority, Perth.

7.2 Online references

Bureau of Meteorology (BoM) 2017, *Climate Averages,* viewed 28th February 2017, <http://www.bom.gov.au/climate/data/>.

Department of Biodiversity, Conservation and Attractions (DBCA) 2018c, *Florabase*, viewed 06th February 2018, < https://florabase.dpaw.wa.gov.au>.

Department of the Environment (DoEE) 2017d, *Protected Matters Search Tool*, viewed 28th February 2017 <https://www.environment.gov.au/epbc/protected-matters-search-tool>.

Department of the Environment (DoEE) 2017e, *Threatened Ecological Communities*, viewed 4th April 2017 <http://www.environment.gov.au/biodiversity/threatened /communities/about>.

Department of Parks and Wildlife (DPaW) 2017, *NatureMap,* viewed 28th February 2017 < https://naturemap.dpaw.wa.gov.au/>.

West Australian Land Information Authority (WALIA) 2017, *Landgate Map Viewer*, viewed 3rd April 2017, <http://landgate.wa.gov.au>.

Figures

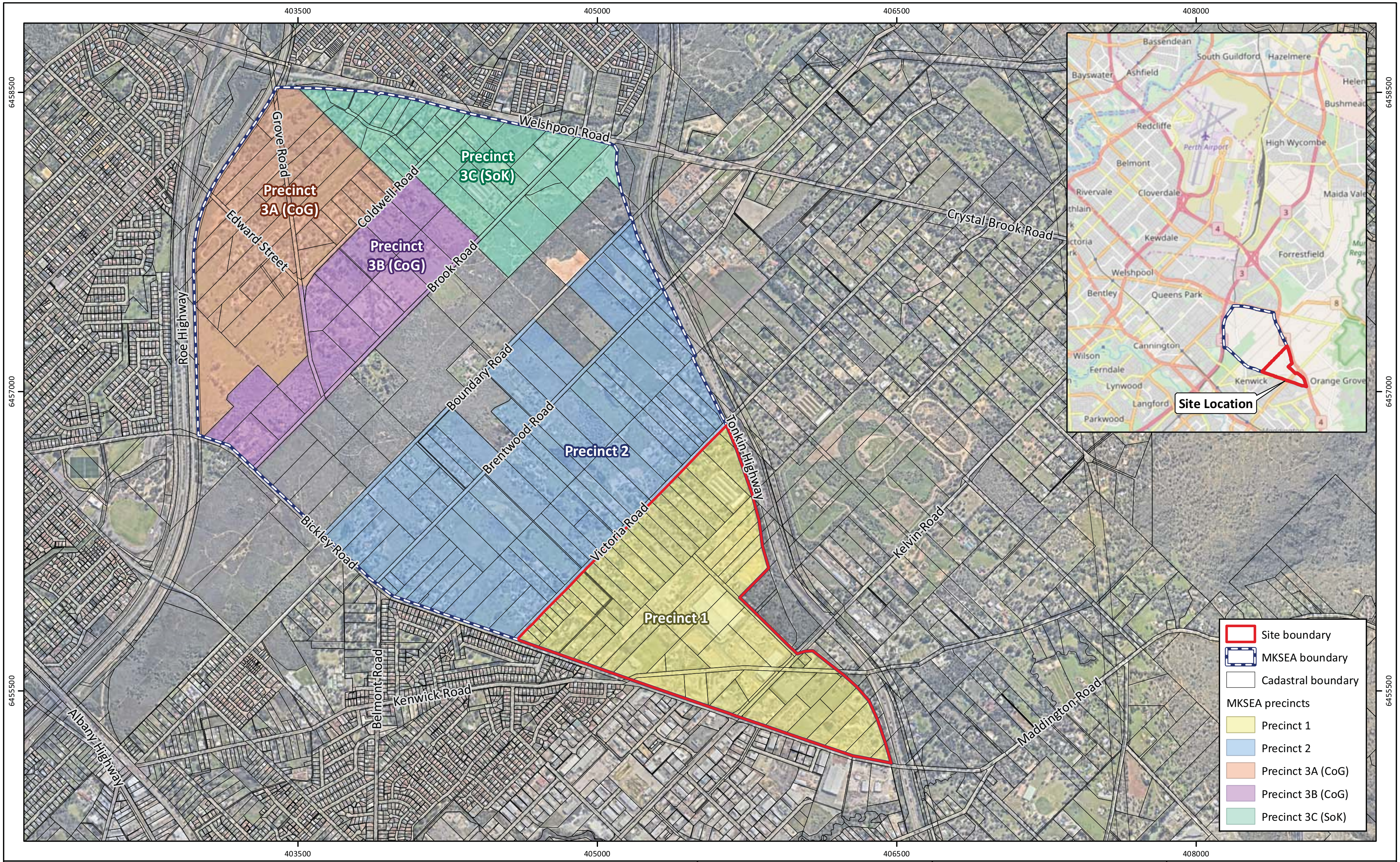

Figure 1: **Site Locality**

Project:	Flora, Vegetation and Wetland Assessment Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number:
EP17-010(02)--F32a

Drawn:	RAO
Date:	18/06/2018
Checked:	TAA
Approved:	TAA
Date:	18/06/2018

Scale: 1:25,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

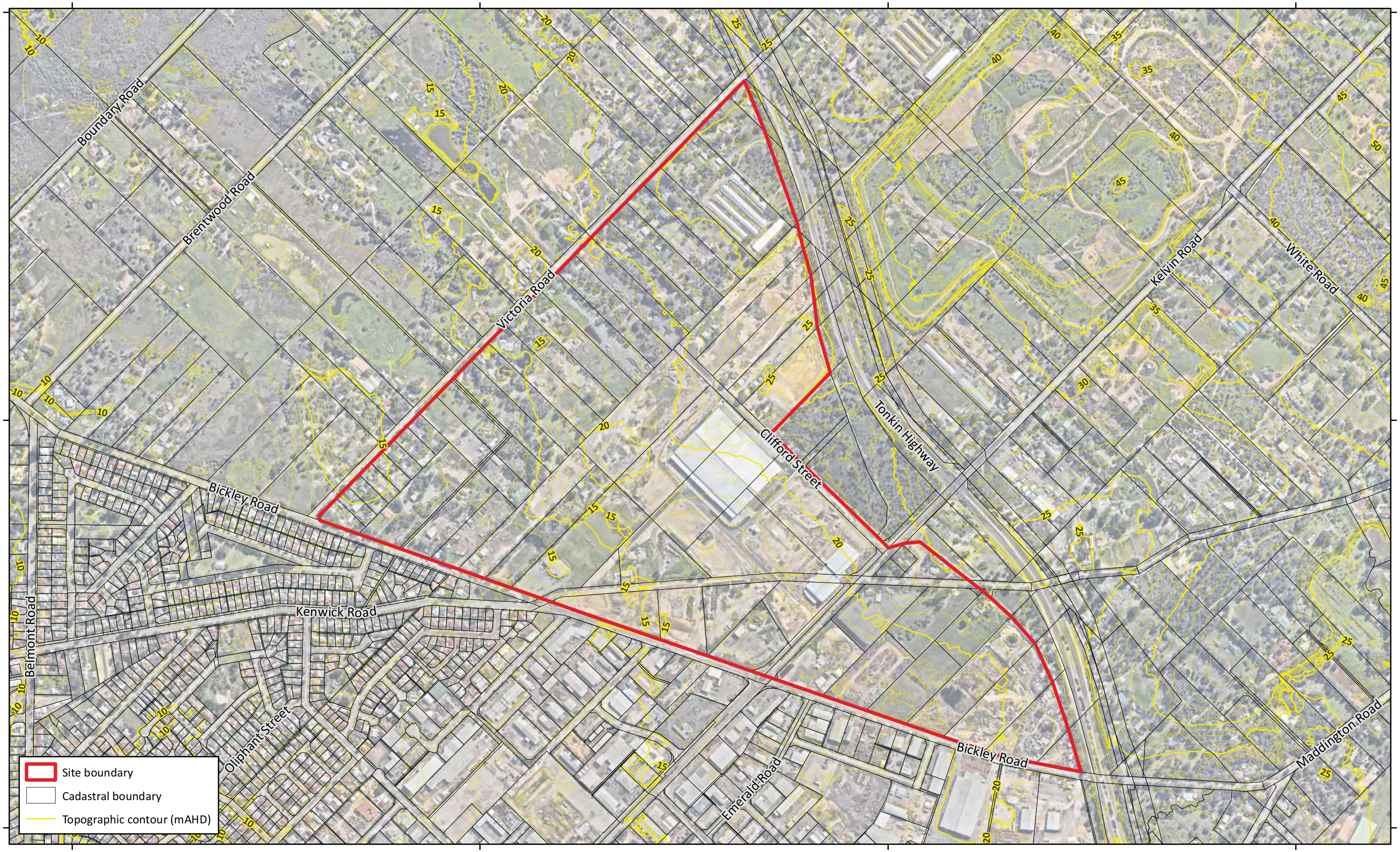

Figure 2: Topographic Contours

Project: Flora, Vegetation and Wetland Assessment
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number: EP17-010(02)--F33a
Drawn: RAO
Date: 18/06/2018
Checked: TAA
Approved: TAA
Date: 18/06/2018

N

0 200 400
Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

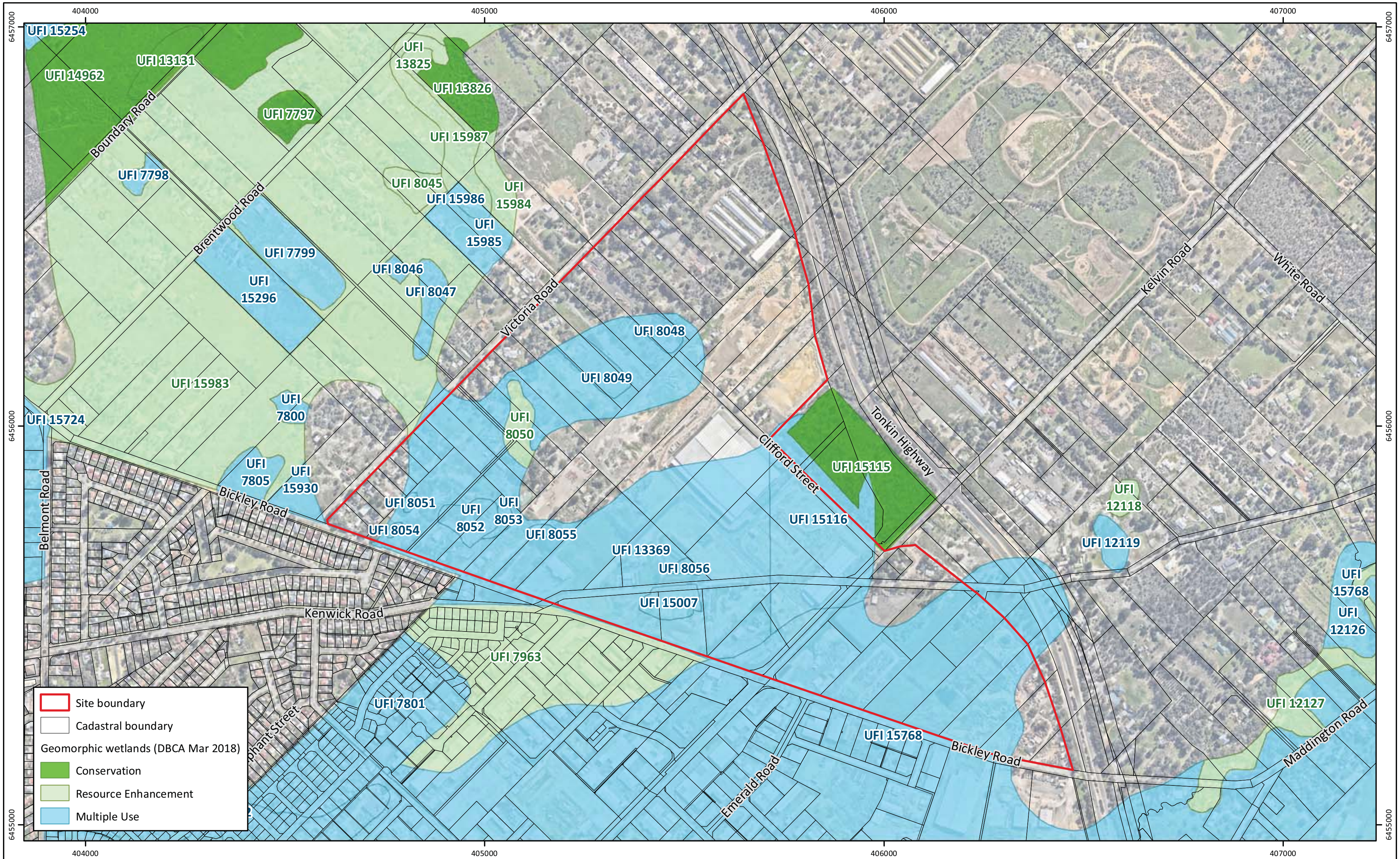

Figure 3: **Wetland Features**

Project: Flora, Vegetation and Wetland Assessment
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(02)--F34a

Drawn:	RAO
Date:	18/06/2018
Checked:	TAA
Approved:	TAA
Date:	18/06/2018

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Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

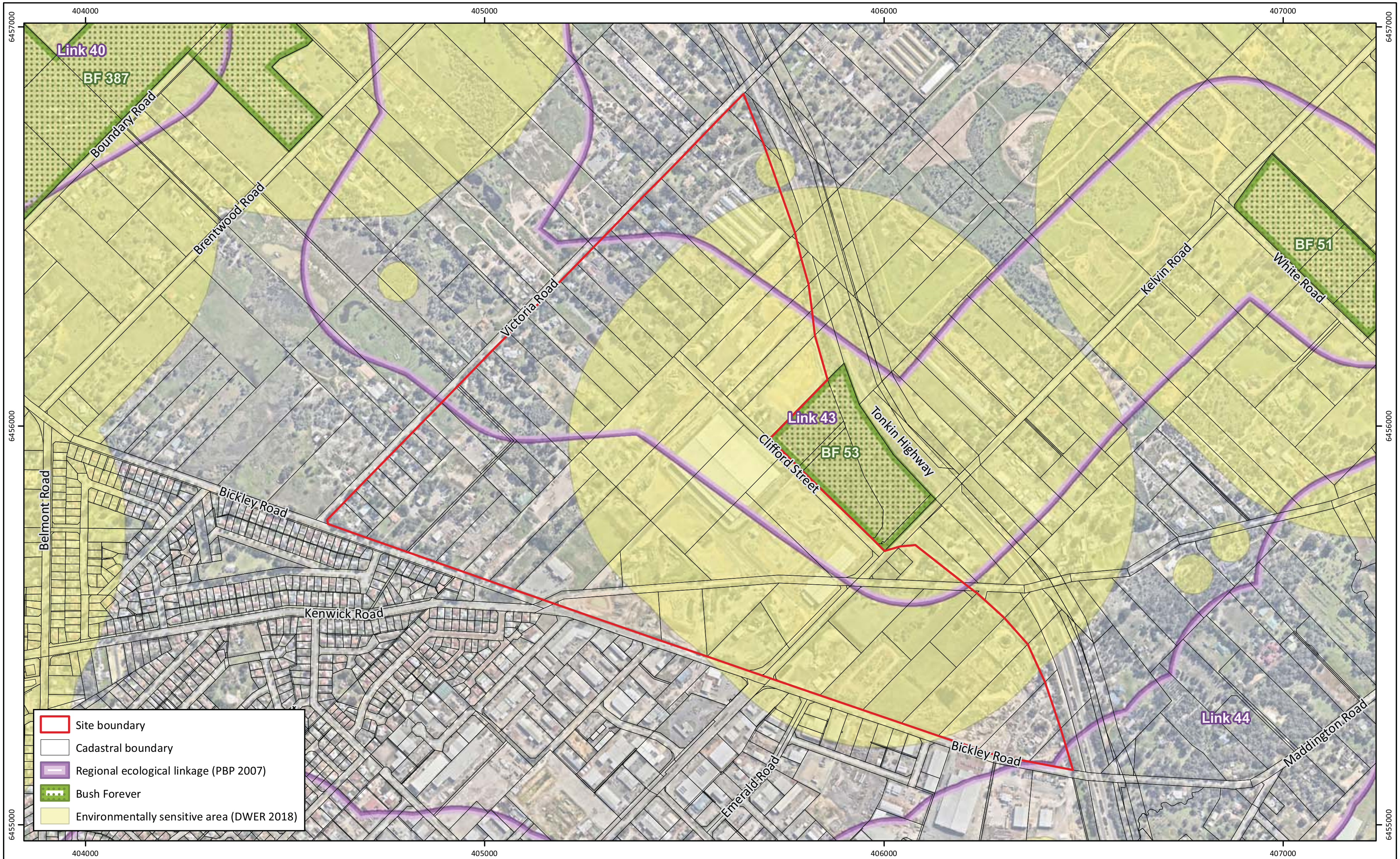

Figure 4: **Environmental Features**

Project: Flora, Vegetation and Wetland Assessment
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(02)--F35a
Drawn: RAO
Date: 18/06/2018
Checked: TAA
Approved: TAA
Date: 18/06/2018

Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

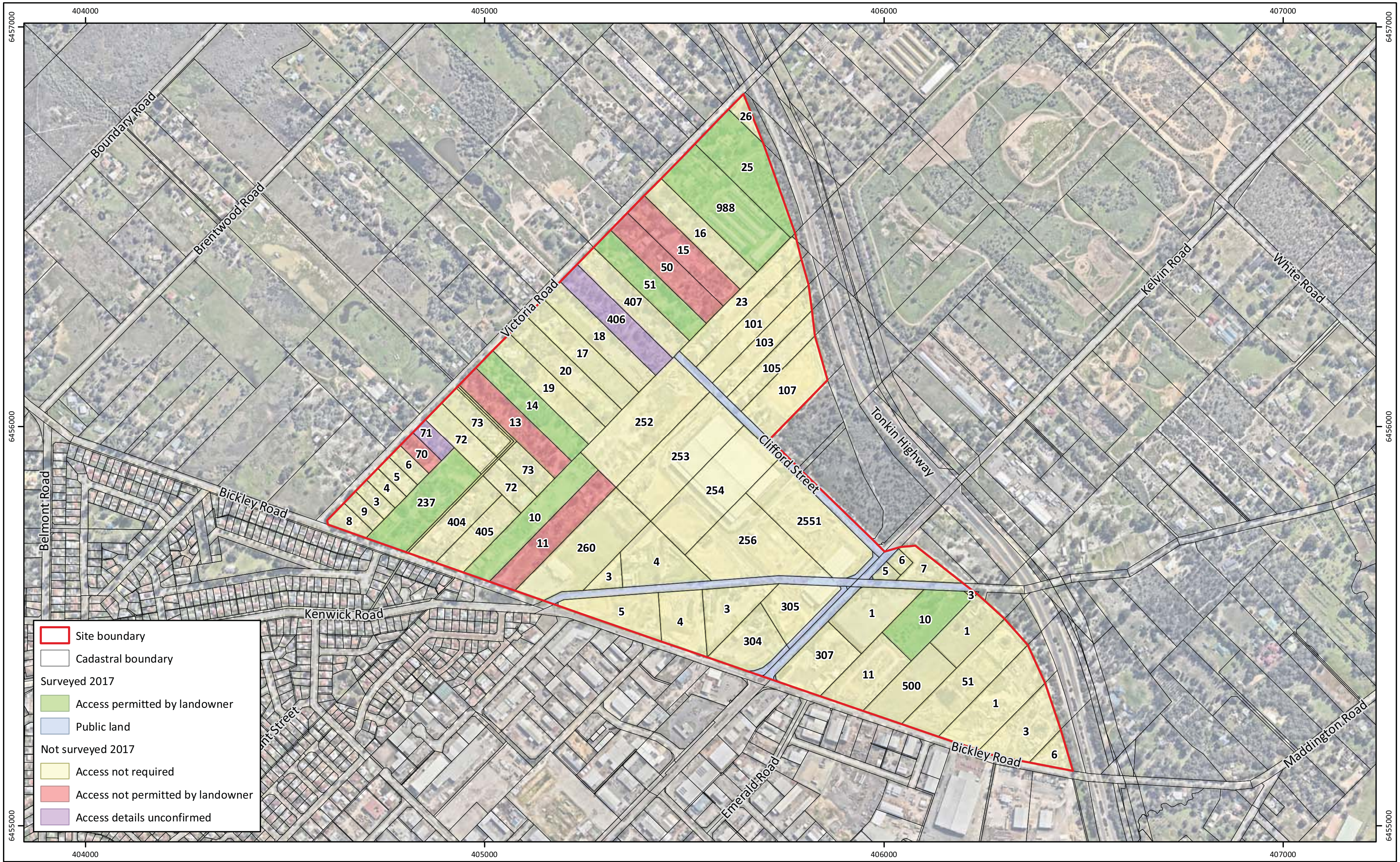

Figure 5: **Site Access**

Project: Flora, Vegetation and Wetland Assessment
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(02)--F36a
Drawn: RAO
Date: 18/06/2018
Checked: TAA
Approved: TAA
Date: 18/06/2018

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

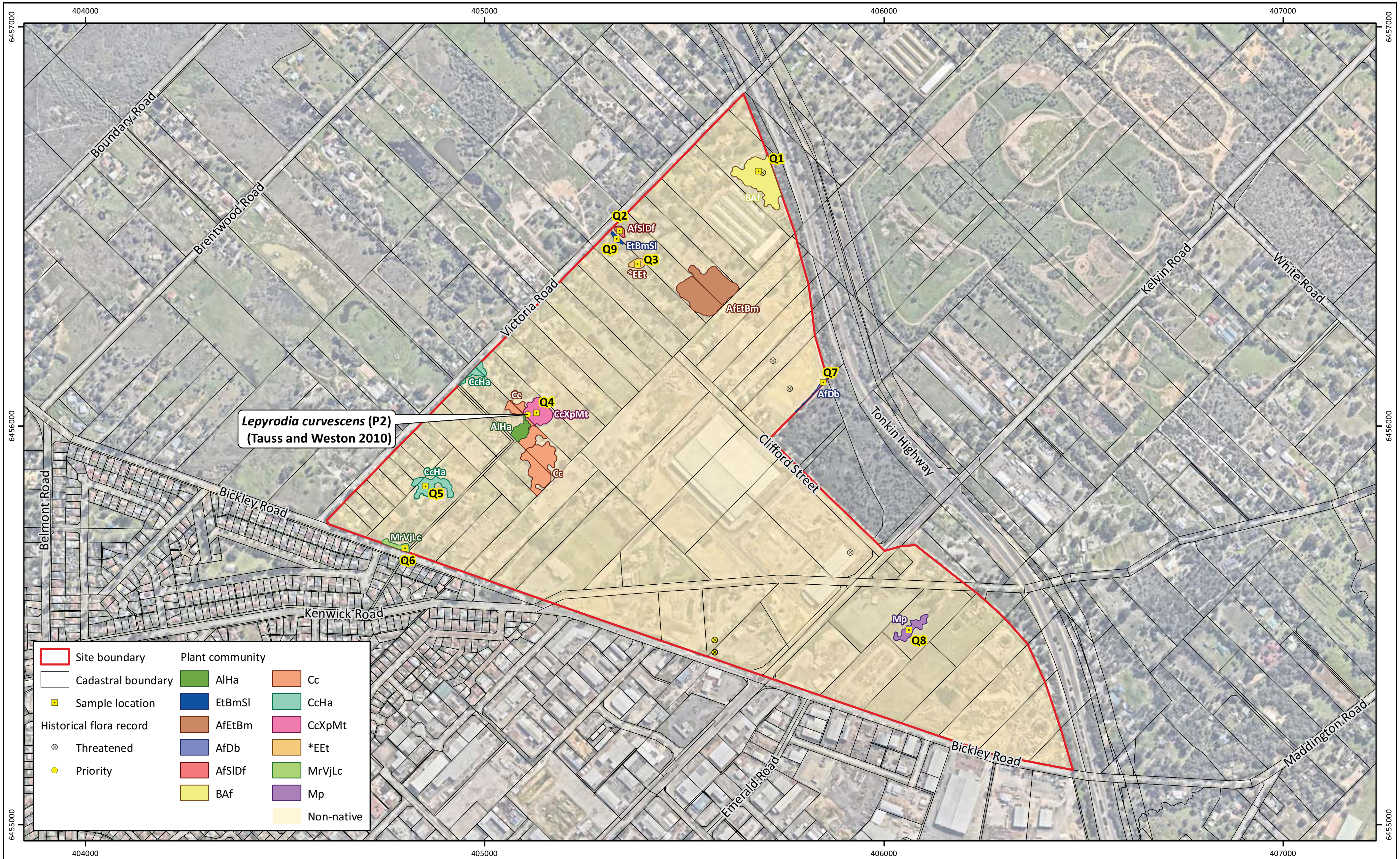

Figure 6: Survey Locations, Priority Flora and Plant Communities

Project: Flora, Vegetation and Wetland Assessment
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(02)--F37b
Drawn: RAO
Date: 09/01/2019
Checked: TAA
Approved: TAA
Date: 11/01/2019

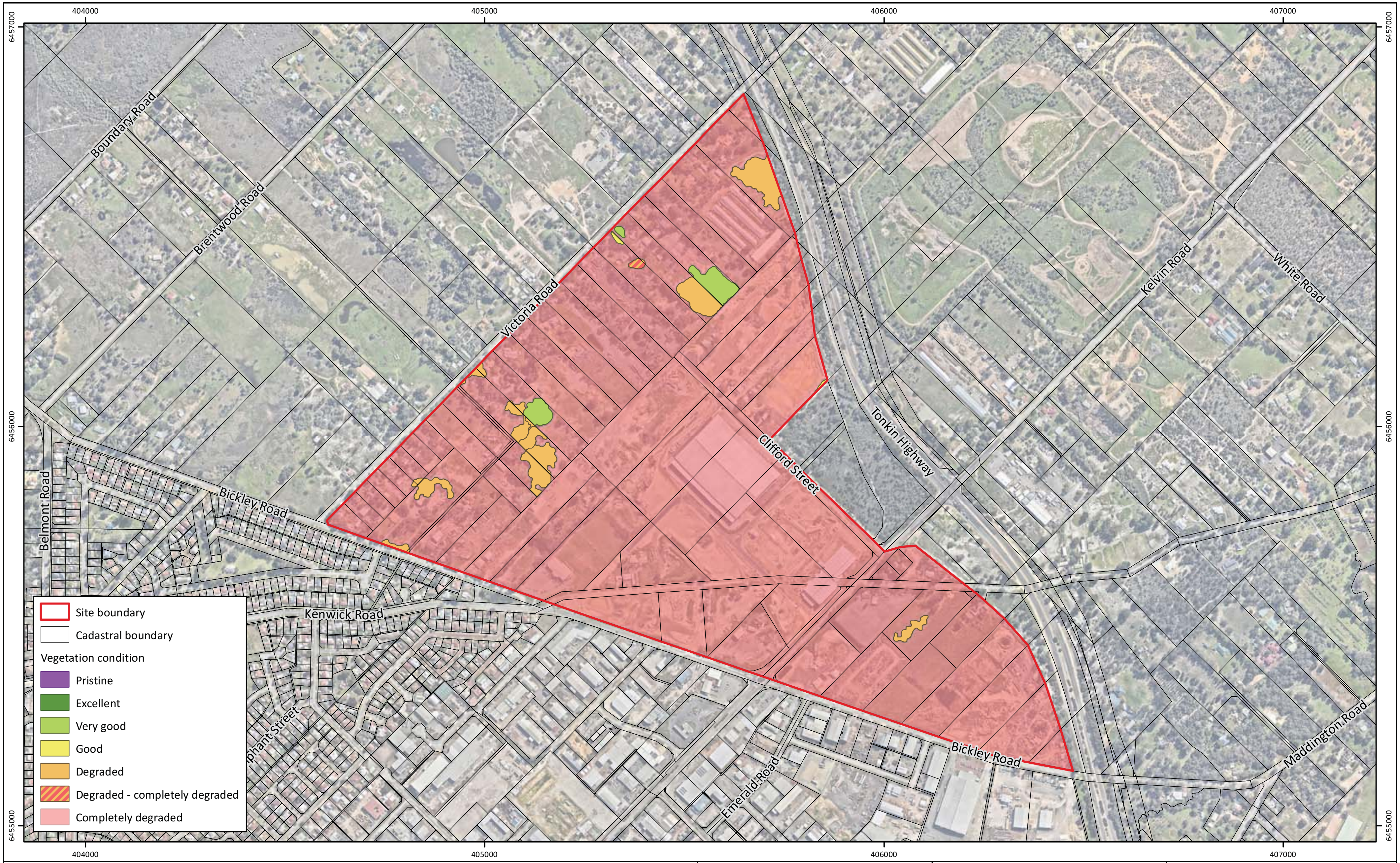

Figure 7: Vegetation Condition

Project: Flora, Vegetation and Wetland Assessment
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(02)--F38b
Drawn: RAO
Date: 09/01/2019
Checked: TAA
Approved: TAA
Date: 11/01/2019

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Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

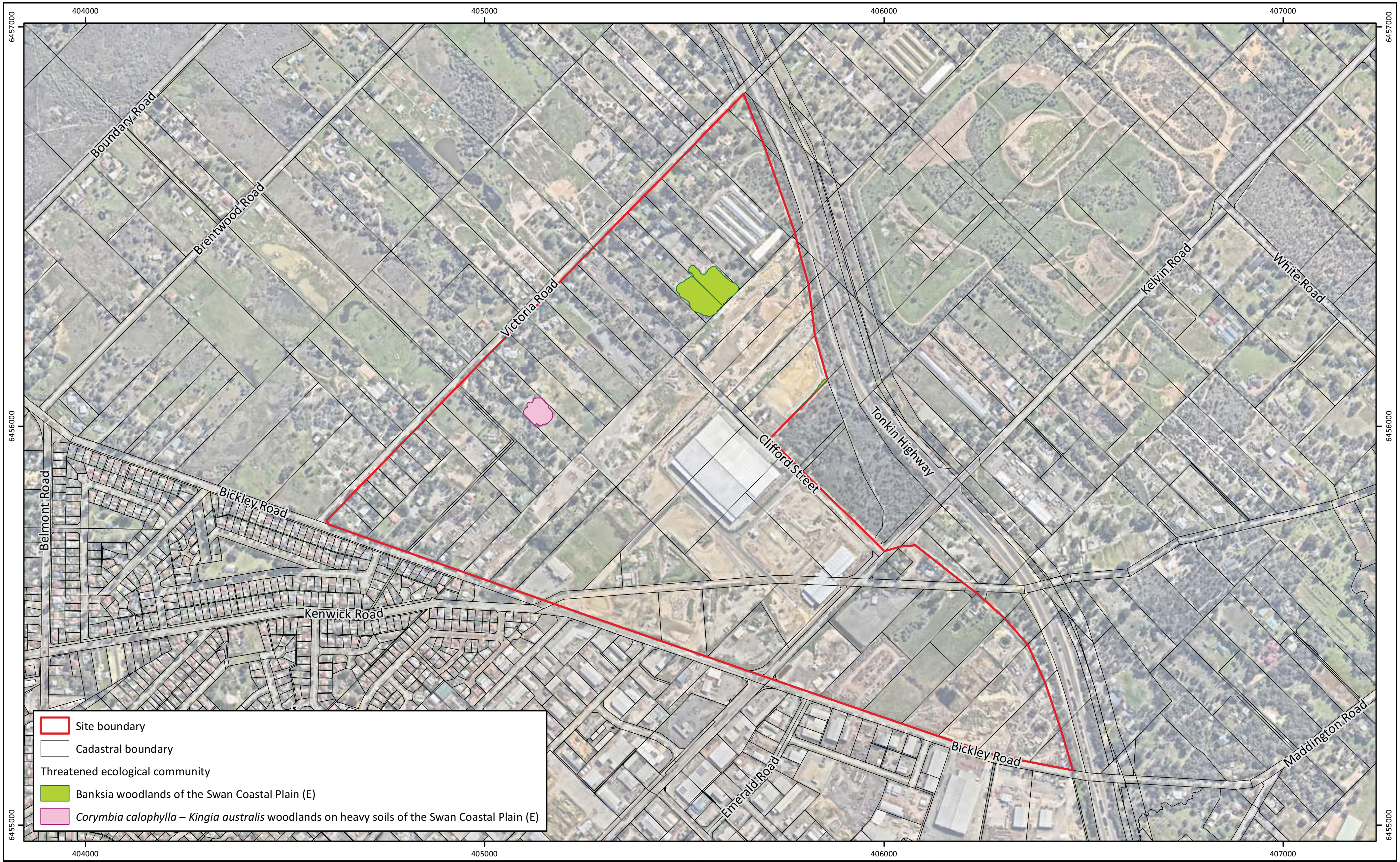

Figure 8: Threatened Ecological Communities

Project:	Flora, Vegetation and Wetland Assessment Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number:
EP17-010(02)--F39b
Drawn: RAO
Date: 09/01/2019
Checked: TAA
Approved: TAA
Date: 11/01/2019

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Metres
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GDA 1994 MGA Zone 50

emerge ASSOCIATES

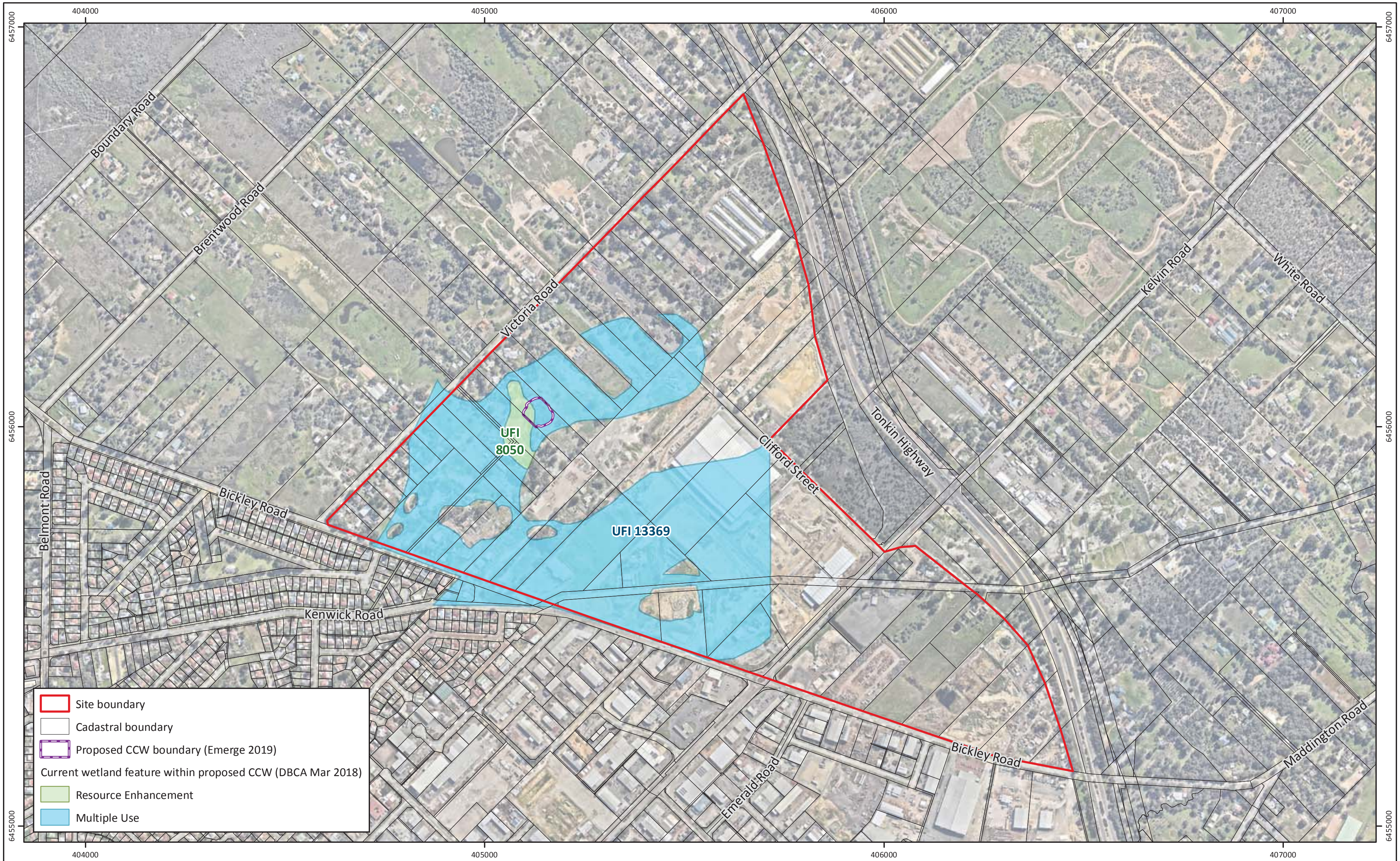

Figure 9: **Recommended Wetland Reclassification - UFI 8050 and UFI 13369**

Project: Flora, Vegetation and Wetland Assessment
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number: EP17-010(02)--F40b
Drawn: RAO
Date: 09/01/2019
Checked: TAA
Approved: TAA
Date: 11/01/2019

N

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Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix A

Additional Background Information

Conservation Significant Flora and Vegetation

Threatened and priority flora

Flora species considered rare or under threat warrant special protection under Commonwealth and/or State legislation. At the Commonwealth level, flora species can be listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Flora species considered 'threatened' pursuant to Schedule 1 of the EPBC Act are assigned categories according to their conservation status, as outlined in **Table 1**.

In Western Australia, plant taxa may be classed as 'threatened' under the *Biodiversity Conservation Act 2016* (BC Act) which is enforced by Department of Biodiversity Conservation and Attractions (DBCA). Threatened flora species are listed under sections 19(1) and 26(2) of the BC Act. It is an offence to 'take' or disturb threatened flora without Ministerial approval. Section 5(1)1 of the Act defines to take as including "… to gather, pluck, cut, pull up, destroy, dig up, remove, harvest or damage flora by any means" or to cause or permit the same to be done. The definition of threatened flora under the BC Act is provided in **Table 1**.

Section 43 of the BC Act requires that an occurrence of a threatened species or threatened ecological community is reported to DBCA where the occurrence has been identified as part of field work completed:

- as part of an assessment under Part IV of the *Environmental Protection Act 1986*; or
- in relation to an application for a clearing permit under the *Environmental Protection Act 1986* section 51E(1)(d).

Penalties apply to individuals and organisations that fail to provide accurate reports of threatened species or communities.

The *Biodiversity Conservation Regulations 2018* (BC Regulations 2018) came into effect on January 1 2019. The BC Regulations include provisions for licencing, charges, penalties and other provisions associated with the BC Act.

Flora species that may be threatened or near threatened but lack sufficient information to be listed under the BC Act may be added to the DBCA's *Priority Flora List* (DBCA 2018c). Priority flora species are considered during State approval processes. Priority flora categories and definitions are listed in **Table 1**.

Table 1: Definitions of conservation significant flora species pursuant to the EPBC Act and BC Act and on DBCA's Priority Flora List (DBCA 2018c)

Conservation code	Description
EX[†]	Threatened Flora – Presumed Extinct Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.
T^[†]	Threatened Flora – Extant Taxa which are declared to be likely to become extinct or is rare, or otherwise in need of special protection.
CR^	Threatened Flora – Critically Endangered Taxa which are considered to be facing an extremely high risk of extinction in the wild.
EN^	Threatened Flora – Endangered Taxa which are considered to be facing a very high risk of extinction in the wild.
VU^	Threatened Flora – Vulnerable Taxa which are considered to be facing a high risk of extinction in the wild.
P1[□]	Priority One – Poorly Known Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat e.g. road verges, urban areas, farmland, active mineral leases etc., or the plants are under threat, e.g. from disease, grazing by feral animals etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P2[□]	Priority Two – Poorly Known Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey.
P3[□]	Priority Three – Poorly Known Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but needs further survey.
P4[□]	Priority Four – Rare Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

^pursuant to the EPBC Act, †pursuant to the BC Act, [□]on DBCA's *Priority Flora List*

Threatened and priority ecological communities

'Threatened ecological communities' (TECs) are recognised as ecological communities that are rare or under threat and therefore warrant special protection. Selected TECs are afforded statutory protection at a Commonwealth level under section 181 of the EPBC Act. TECs nominated for listing under the EPBC Act are considered by the Threatened Species Scientific Committee and a final decision is made by the Commonwealth Minister for the Environment and Energy. Once listed under the EPBC Act, communities are categorised as either 'critically endangered', 'endangered' or 'vulnerable' as defined in **Table 2**. Any action likely to have a significant impact on a community listed under the EPBC Act requires approval from the Minister for the Environment and Energy.

Within Western Australia TECs are determined by the Western Australian Threatened Ecological Communities Scientific Advisory Committee (WATECSAC) and endorsed by the State Minister for the Environment. The WATECSAC is an independent group comprised of representatives from organisations including tertiary institutions, the Western Australian Museum and DBCA. The TECs endorsed by the State Minister are published by DBCA (DBCA 2018b).

TECs are assigned to one of the categories outlined in **Table 2** according to their status (in relation to the level of threat). TECs are afforded direct statutory protection at a State level under the BC Act and BC Regulations. Their significance is also acknowledged through other state environmental approval processes such as 'environmental impact assessment' pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*.

Table 2: Categories of threatened ecological communities (English and Blyth 1997; DEC 2009).

Conservation code	Description
PD	Presumably Totally Destroyed An ecological community that has been adequately searched for but for which no representative occurrences have been located.
CE	Critically Endangered An ecological community that has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
E	Endangered An ecological community that has been adequately surveyed and is not critically endangered but is facing a very high risk of total destruction in the near future.
V	Vulnerable An ecological community that has been adequately surveyed and is not critically endangered or endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

An ecological community that is under consideration for listing as a TEC, but does not yet meet survey criteria or has not been adequately defined may be listed as a 'priority ecological community' (PEC). PECs are categorised as priority category 1, 2 or 3 as described in **Table 3**. Ecological communities that are adequately known and are rare but not threatened, or meet criteria for 'near threatened', or that have been recently removed from the threatened list, are placed in 'priority 4'. These ecological communities require regular monitoring. Conservation dependent ecological communities are placed in 'priority 5' (DEC 2009). Listed PECs are published by DBCA (DBCA 2017b).

Table 3: Categories of priority ecological communities (DEC 2009).

Priority code	Description
P1	Priority One Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
P2	Priority Two Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
P3	Priority Three Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (i) communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (ii) communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
P4	Priority Four Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened or that have been recently removed from the threatened list. These communities require regular monitoring.
P5	Priority Five Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Weeds

A number of legislative and policy documents exist in relation to weed management at state and national levels. The *Biosecurity and Agriculture Management Act 2007* (BAM Act) is the principle legislation guiding weed management in Western Australia and lists declared pest species. At a national level, the Australian government has compiled a list of 32 Weeds of National Significance (WoNS) (DoEE 2018), of which many are also listed under the BAM Act.

Declared Pests

Part 2.3.23 of the BAM Act requires a person must not; "*a) keep, breed or cultivate the declared pest; b) keep, breed or cultivate an animal, plant or other thing that is infected or infested with the declared pest; c) release into the environment the declared pest, or an animal, plant or other thing that is infected or infested with the declared pest; or d) intentionally infect or infest, or expose to infection or infestation, a plant, animal or other thing with a declared pest*".

Under the BAM Act, all declared pests are assigned a legal status, as described in **Table 4**. Species assigned to the 'declared pest, prohibited - s12' category are placed in one of three control categories, as described in

Table 5.

The *Biosecurity and Agriculture Management Regulations 2013* specify keeping categories for species assigned to the 'declared pest - s22(2)' category, which relate to the purposes of which species can be kept, as well as the entities that can keep them. The categories are described in

Table *6*.

The Western Australian Organism List (WAOL) provides the status of organisms which have been categorised under the BAM Act (DAFWA 2016).

Table 4: Legal status of declared pest species listed under the BAM Act (DAFWA 2016).

Category	Description
Declared Pest Prohibited - s12	May only be imported and kept subject to permits. Permit conditions applicable to some species may only be appropriate or available to research organisations or similarly secure institutions.
Declared Pest s22(2)	Must satisfy any applicable import requirements when imported, and may be subject to an import permit if they are potential carriers of high-risk organisms. They may also be subject to control and keeping requirements once within Western Australia

Table 5: Control categories of declared pest species listed under the BAM Act (DAFWA 2016).

Category	Description
C1	Exclusion Not established in Western Australia and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.
C2	Eradication Present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.
C3	Management Established in Western Australia but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

Table 6: Keeping categories of declared pest species listed under the BAM Act (DAFWA 2016).

Category	Description
Prohibited	Can only be kept under a permit for public display and education purposes, and/or genuine scientific research, by entities approved by the state authority.
Exempt	No permit or conditions are required for keeping.
Restricted	Organisms which, relative to other species, have a low risk of becoming a problem for the environment, primary industry or public safety and can be kept under a permit by private individuals.

Wetland Habitat

Geomorphic wetland types

On the Swan Coastal Plain DBCA (2017a) have used the geomorphic wetland classification system developed by Semeniuk (1987) and Semeniuk and Semeniuk (1995) to classify wetlands based on the landform shape and water permanence (hydro-period) as outlined in **Table 7**.

Table 7: Geomorphic Wetlands of the Swan Coastal Plain classification categories (DBCA 2017a)

Level of inundation	Geomorphology			
	Basin	Flat	Channel	Slope
Permanently inundated	Lake	-	River	-
Seasonally inundated	Sumpland	Floodplain	Creek	-
Seasonally waterlogged	Dampland	Palusplain	-	Paluslope

Wetland management categories

DBCA maintains the *Geomorphic Wetland of the Swan Coastal Plain* dataset (DBCA 2018a), which also categorises individual wetlands into specific management categories as described in **Table 8**.

Table 8: Geomorphic Wetlands of the Swan Coastal Plain classification categories (DBCA 2017a)

Management category	Description of wetland	Management objectives
Conservation (CCW)	Support high levels of attributes	Preserve wetland attributes and functions through reservation in national parks, crown reserves and state owned land. Protection provided under environmental protection policies.
Resource enhancement (REW)	Partly modified but still supporting substantial functions and attributes	Restore wetland through maintenance and enhancement of wetland functions and attributes. Protection via crown reserves, state or local government owned land, environmental protection policies and sustainable management on private properties.
Multiple use (MUW)	Few wetland attributes but still provide important hydrological functions	Use, development and management considered in the context of water, town and environmental planning through land care.

The management categories of wetland features are determined based on hydrological, biological and human use features. The DBCA document *A methodology for the evaluation of specific wetland types on the Swan Coastal Plain, Western Australia* (DBCA 2017a) details the methodology by which wetlands on the Swan Coastal Plain are assigned management categories based on a two tiered evaluation system, with preliminary and secondary evaluation stages. The preliminary evaluation aims to identify any features of conservation significance that would immediately place the wetland within the CCW management category. Examples of these significant features include presence on significant wetland lists, presence of TECs or PECs (Priority 1 and 2), presence of threatened flora and over 90% of vegetation in good or better condition based on the Keighery (1994) scale. If such environmental values are identified the wetland would be categorised as CCW without further evaluation.

Should the preliminary evaluation indicate that no such features occur, the secondary evaluation and site assessment are then applied. In the secondary evaluation, an appropriate management category is determined through the assessment of a range of environmental attributes, functions and values.

Wetland reclassification

DBCA have a protocol for proposing changes to the wetland boundaries and management categories of the existing geomorphic wetland dataset (DEC 2007). The procedure involves a wetland desktop evaluation and site assessment which culminates in a recommended management category. Relevant information should be obtained in the optimal season for vegetation condition and water levels, which is usually spring (DEC 2007). In the case of larger wetlands that have undergone a degree of disturbance, a separate management category may be assigned to parts of the wetland in order to reflect the current values.

References

General references

Department of Biodiversity, Conservation and Attractions (DBCA) 2017a, *A methodology for the evaluation of wetlands on the Swan Coastal Plain*, draft prepared by the Wetlands Section of the Department of Biodiversity, Conservation and Attractions and the Urban Water Branch of the Department of Water and Environmental Regulation, Perth.

Department of Biodiversity Conservation and Attractions (DBCA) 2017b, *Priority Ecological Communities for Western Australia Version 27*.

Department of Biodiversity, Conservation and Attractions (DBCA) 2018a, *Geomorphic Wetlands, Swan Coastal Plain (DBCA-019)*.

Department of Biodiversity, Conservation and Attractions (DBCA) 2018b, *List of Threatened Ecological Communities endorsed by the Western Australian Minister for Environment*, Perth.

Department of Biodiversity, Conservation and Attractions (DBCA) 2018c, *Threatened and Priority Flora List 16 January 2018*, Perth.

Department of Environment and Conservation (DEC) 2007, *Protocol for proposing modifications to the Geomorphic Wetlands Swan Coastal Plain dataset*, Perth.

Department of Environment and Conservation (DEC) 2009, *Definitions, Categories and Criteria for Threatened and Priority Ecological Communities*, Perth.

English, V. and Blyth, J. 1997, *Identifying and Conserving Threatened Ecological Communities in the South West Botanical Province*, ANCA National Reserves System Cooperative Program, Project Number N702, Perth.

Keighery, B. 1994, *Bushland Plant Survey: A guide to plant community survey for the community*, Wildflower Society of WA (Inc), Nedlands.

Semeniuk, C. A. 1987, *Wetlands of the Darling System - a geomorphic approach to habitat classification*, Journal of the Royal Society of Western Australia, 69: 95-112.

Semeniuk, C. A. and Semeniuk, V. 1995, *A Geomorphic Approach to Global Classification for Inland Wetlands*, Vegetatio, 118(1/2): 103-124.

Online references

Department of Agriculture and Food (DAFWA) 2018, *The Western Australian Organism List* (WAOL), <https://www.agric.wa.gov.au/bam/western-australian-organism-list-waol>.

Department of Environment and Energy (DoEE) 2018, Weeds of National Significance, <http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html>.

Appendix B

Species List

Flora Species List - MKSEA Precinct 1

Note: * denotes introduced weed species

Family		Species
Amaranthaceae		
		Lyginia barbata
Asparagaceae		
		Lomandra hermaphrodita
		Lomandra sericea
Asteraceae		
	*	*Arctotheca calendula*
Casuarinaceae		
		Allocasuarina fraseriana
		Allocasuarina humilis
Colchicaceae		
		Burchardia congesta
Cyperaceae		
		Cyathochaeta avenacea
		Cyathochaeta equitans
		Lepidosperma squamatum
		Mesomelaena pseudostygia
		Mesomelaena tetragona
		Tetraria octandra
Dasypogonaceae		
		Dasypogon bromeliifolius
		Kingia australis
Dilleniaceae		
		Hibbertia huegelii
		Hibbertia hypericoides
Droseraceae		
		Drosera macrantha subsp. *macrantha*
		Drosera pallida
		Drosera stolonifera
Fabaceae		
	*	*Acacia longifolia*
		Acacia pulchella
		Bossiaea eriocarpa
	*	*Chamaecytisus palmensis*
		Gastrolobium capitatum
		Hovea trisperma
		Jacksonia floribunda
		Jacksonia furcellata
		Viminaria juncea

Flora Species List - MKSEA Precinct 1

Note: * denotes introduced weed species

Family		Species
Goodeniaceae		
		Dampiera linearis
Haemodoraceae		
		Conostylis setigera subsp. *setigera*
Iridaceae		
		Iridaceae sp.
	*	*Watsonia meriana* var. *bulbillifera*
Loranthaceae		
		Nuytsia floribunda
Myrtaceae		
	*	*Callistemon* sp.
		Corymbia calophylla
	*	*Eucalyptus botryoides*
	*	*Eucalyptus camaldulensis*
		Eucalyptus rudis
	*	*Eucalyptus* sp.
		Eucalyptus todtiana
		Hypocalymma angustifolium
		Eremaea pauciflora subsp. *pauciflora*
	*	*Leptospermum laevigatum*
		Melaleuca preissiana
		Melaleuca rhaphiophylla
		Melaleuca seriata
Oxalidaceae		
	*	*Oxalis glabra*
	*	*Oxalis pes-caprae*
Pinaceae		
	*	*Pinus* sp.
Poaceae		
		Austrostipa sp.
	*	*Cenchrus clandestinus*
	*	*Ehrharta calycina*
	*	*Ehrharta longiflora*
	*	*Eragrostis curvula*
Proteaceae		
		Adenanthos cygnorum
		Banksia attenuata
		Banksia dallanneyi var. *dallanneyi*
		Banksia menziesii

Flora Species List - MKSEA Precinct 1

Note: * denotes introduced weed species

Family	Species
	Stirlingia latifolia
Restionaceae	
	Alexgeorgea nitens
	Chordifex sinuosus
	Desmocladus fasciculatus
	Desmocladus flexuosus
	Hypolaena exsulca
	Leptocarpus canus
Rutaceae	
	Philotheca spicata
Violaceae	
	Hybanthus calycinus
Xanthorrhoeaceae	
	Xanthorrhoea preissii

Appendix C

Sample Data

Site Details			EP17-010 MKSEA
Address	Lot 25 Victoria Road	Photo No.	57
Date	31/08/2017	Photo direction	east
Author	RAO/SKP	Geographic datum and zone	GDA94 50
Sampling unit	Quadrat	Easting	405686
Sample number	Q1	Northing	6456638

Geographic and Habitat Data			
Aspect	-	Hydrology	dry
Slope	negligible	Adjacent Vegetation	cleared/road reserve
Topographic position	gentle rise	Vegetation Condition	degraded
Altitude (m)	-	Time since fire	<2 yrs
Bare ground %	<5%	Disturbance	high
Soil type/texture	sand	Rock type	N/A
Soil colour	grey white	Rock %	0
Microclimate	-	Litter type and %	leaves, sticks, 5%

Vegetation Description

Open forest *Banksia attenuata* and *Allocasuarina fraseriana* over occasional *Kingia australis* over closed non-native grassland

Native Strata	Height (m)	Total % Cover
Canopy	10	25
Mid	2	5
Ground	0.4	<1

Q1 Flora List

	Species
	Adenanthos cygnorum
	Alexgeorgea nitens
	Allocasuarina fraseriana
*	*Arctotheca calendula*
	Banksia attenuata
	Burchardia congesta
*	*Chamaecytisus palmensis*
	Conostylis setigera subsp. *setigera*

Q1 Flora List	
	Corymbia calophylla
	Dasypogon bromeliifolius
	Desmocladus fasciculatus
	Desmocladus flexuosus
	Drosera macrantha subsp. *macrantha*
	Drosera stolonifera
*	*Ehrharta calycina*
*	*Ehrharta longiflora*
	Eremaea pauciflora subsp. *pauciflora*
	Eucalyptus todtiana
	Hibbertia hypericoides
	Hybanthus calycinus
	Kingia australis
	Lepidosperma squamatum
	Lomandra hermaphrodita
	Mesomelaena pseudostygia
	Stirlingia latifolia
	Tetraria octandra
NB: * denotes non-native species	

Site Details			
Locality	Lot 51 Victoria Rd	Photo No.	197
Date	15/09/2017	Photo direction	S
Author	RAO	Geographic datum and zone	GDA94 50
Sampling unit	Quadrat	Easting	405330
Sample number	Q2	Northing	6456469

Geographic and Habitat Data			
Aspect	flat	Hydrology	dry
Slope	flat	Adjacent Vegetation	similar/non-native
Topographic position	-	Vegetation Condition	G
Altitude (m)	-	Time since fire	no evidence
Bare ground %	25	Disturbance	moderate-low
Soil type/texture	sand	Rock type	N/A
Soil colour	grey-white	Rock %	0
Microclimate	-	Litter type and %	leaves, sticks, 30%

Vegetation Description

Woodland *Eucalyptus todtiana* , planted **Eucalyptus* sp. and *Banksia menziesii* over shrubland *Hibbertia hypericoides* over forbland and *Lomandra sericea* .

Native Strata	Height (m)	Total % Cover
Canopy	15	15
Mid	0.5	20
Ground	0.3	10

Q2 Flora List

	Species
*	*Acacia longifolia*
	Banksia dallanneyi var. dallanneyi
	Banksia menziesii
	Bossiaea eriocarpa
*	*Callistemon sp.*
	Chordifex sinuosus
	Conostylis setigera subsp. setigera
	Cyathochaeta equitans

Q2 Flora List	
	Dasypogon bromeliifolius
	Drosera macrantha subsp. *macrantha*
	Drosera pallida
*	*Eragrostis curvula*
*	*Eucalyptus sp.*
	Eucalyptus todtiana
	Gastrolobium capitatum
	Hibbertia hypericoides
	Hovea trisperma
	Hypolaena exsulca
	Jacksonia floribunda
	Jacksonia furcellata
	Lomandra sericea
	Lyginia barbata
	Melaleuca seriata
	Mesomelaena pseudostygia
	Nuytsia floribunda
*	*Oxalis pes-caprae*
	Tetraria octandra
	Xanthorrhoea preissii
NB: * denotes non-native species	

Site Details			
Locality	Lot 51 Victoria Rd	Photo No.	160
Date	15/09/2017	Photo direction	E
Author	RAO	Geographic datum and zone	GDA94 50
Sampling unit	Quadrat	Easting	405383
Sample number	Q3	Northing	6456407

Geographic and Habitat Data			
Aspect	flat	Hydrology	dry
Slope	flat	Adjacent Vegetation	similar/non-native
Topographic position	-	Vegetation Condition	D-CD
Altitude (m)	-	Time since fire	no evidence
Bare ground %	40	Disturbance	high
Soil type/texture	sand	Rock type	N/A
Soil colour	grey	Rock %	0
Microclimate	-	Litter type and %	leaves, sticks, bark, 50%

Vegetation Description

Forest **Eucalyptus camaldulensis, Eucalyptus rudis* and *Eucalyptus todiana* over grassland **Ehrharta calycina*

Native Strata	Height (m)	Total % Cover
Canopy	15	40
Mid	1	1
Ground	0.2	<1

Q3 Flora List

	Species
*	*Ehrharta calycina*
	Eragrostis curvula
*	*Eucalyptus botryoides*
*	*Eucalyptus camaldulensis*
	Eucalyptus rudis
	Eucalyptus todtiana
	Iridaceae sp.
*	*Leptospermum laevigatum*

	Melaleuca preissiana
	Xanthorrhoea preissii
NB: * denotes non-native species	

Site Details			
Locality	Lot 14 Victoria Rd	Photo No.	7309
Date	30/05/2017	Photo direction	E
Author	RAO	Geographic datum and zone	GDA94 50
Sampling unit	Quadrat	Easting	405129
Sample number	Q4	Northing	6456034

Geographic and Habitat Data			
Aspect	flat	Hydrology	dry
Slope	flat	Adjacent Vegetation	similar/non-native
Topographic position	-	Vegetation Condition	very good
Altitude (m)	-	Time since fire	no evidence
Bare ground %	<1	Disturbance	low
Soil type/texture	sand	Rock type	N/A
Soil colour	grey	Rock %	0
Microclimate	-	Litter type and %	leaves, 90%

Vegetation Description

Low open forest *Corymbia calophylla* over open shrubland *Xanthorrhoea preissii* and *Hypocalymma angustifolium* over open forbland *Mesomelaena tetragona*

Native Strata	Height (m)	Total % Cover
Canopy	10	60
Mid	1	25
Ground	0.3	15

Q4 Flora List

	Species
*	*Acacia longifolia*
	Austrostipa sp.
	Banksia dallanneyi var. *dallanneyi*
	Corymbia calophylla
	Cyathochaeta avenacea
	Dasypogon bromeliifolius
	Ehrharta calycina
	Hibbertia hypericoides

Q4 Flora List	
	Hypocalymma angustifolium
	Kingia australis
	Mesomelaena tetragona
	Tetraria octandra
	Xanthorrhoea preissii
NB: * denotes non-native species	

Site Details			
Locality	Lot 237 Bickley Rd	Photo No.	11
Date	3/07/2017	Photo direction	
Author	SKP	Geographic datum and zone	GDA94 50
Sampling unit	Quadrat	Easting	404852
Sample number	Q5	Northing	6455849

Geographic and Habitat Data			
Aspect	-	Hydrology	dry
Slope	flat	Adjacent Vegetation	non-native
Topographic position	-	Vegetation Condition	D
Altitude (m)	-	Time since fire	no evidence
Bare ground %	10	Disturbance	high
Soil type/texture	sand/clay	Rock type	N/A
Soil colour	brown	Rock %	0
Microclimate	-	Litter type and %	leaves, sticks, 30%

Vegetation Description

Open forest *Corymbia calophylla* over open shrubland *Hypocalymma angustifolium* over non-native grassland

Native Strata	Height (m)	Total % Cover
Canopy	10	25
Mid	0.5	1
Ground	N/A	0

Q5 Flora List

	Species
*	*Cenchrus clandestinus*
	Corymbia calophylla
*	*Eragrostis curvula*
	Hypocalymma angustifolium
*	*Oxalis pes-caprae*
*	*Pinus* sp.

NB: * denotes non-native species

Site Details			
Locality	Lot 237 Bickley Rd	Photo No.	12
Date	3/07/2017	Photo direction	
Author	SKP	Geographic datum and zone	GDA94 50
Sampling unit	Quadrat	Easting	404801
Sample number	Q6	Northing	6455693

Geographic and Habitat Data			
Aspect	-	Hydrology	
Slope	flat	Adjacent Vegetation	non-native grassland
Topographic position	-	Vegetation Condition	D
Altitude (m)	-	Time since fire	no evidence
Bare ground %	20	Disturbance	high
Soil type/texture	sand/clay	Rock type	N/A
Soil colour	brown	Rock %	0
Microclimate	-	Litter type and %	leaves, sticks, 30%

Vegetation Description

Low forest *Melaleuca rhaphiophylla* over scattered *Viminaria juncea* over low open shrubland *Acacia pulchella* and *Hypocalymma angustifolium* over scattered *Leptocarpus canus*

Native Strata	Height (m)	Total % Cover
Canopy	5	30
Mid	1	15
Ground	0.3	5

Q6 Flora List

	Species
	Acacia pulchella
*	*Eragrostis curvula*
*	*Eucalyptus sp.*
	Hypocalymma angustifolium
	Leptocarpus canus
	Melaleuca rhaphiophylla
*	*Oxalis glabra*

*	*Oxalis pes-caprae*
	Viminaria juncea
*	*Watsonia meriana* var. *bulbillifera*
NB: * denotes non-native species	

Site Details			
Locality	Lot 107 Clifford St	Photo No.	81
Date	15/09/2017	Photo direction	NE
Author	RAO	Geographic datum and zone	GDA94 50
Sampling unit	Quadrat (linear)	Easting	405848
Sample number	Q7	Northing	6456109

Geographic and Habitat Data			
Aspect	flat	Hydrology	dry
Slope	negligible	Adjacent Vegetation	similar/cleared
Topographic position	slight crest	Vegetation Condition	D
Altitude (m)	-	Time since fire	no evidence
Bare ground %	50	Disturbance	high
Soil type/texture	sand	Rock type	N/A
Soil colour	grey-white	Rock %	0
Microclimate	-	Litter type and %	leaves, sticks, 20%

Vegetation Description

Scattered *Allocasuarina fraseriana* over open occasional *Xanthorrhoea preissii* over forbland *Dasypogon bromeliifolius* and non-native grasses.

Native Strata	Height (m)	Total % Cover
Canopy	8	15
Mid	1	1
Ground	0.4	30

Q7 Flora List	
	Species
	Adenanthos cygnorum
	Allocasuarina fraseriana
	Burchardia congesta
	Dampiera linearis
	Dasypogon bromeliifolius
*	*Ehrharta calycina*
	Gastrolobium capitatum
	Hibbertia huegelii
	Mesomelaena pseudostygia

Q7 Flora List	
	Xanthorrhoea preissii
NB: * denotes non-native species	

Site Details			
Locality	Lot 10 Kenwick Rd	Photo No.	15
Date	3/07/2017	Photo direction	
Author	SKP	Geographic datum and zone	GDA94 50
Sampling unit	Quadrat	Easting	406062
Sample number	Q8	Northing	6455489

Geographic and Habitat Data			
Aspect	-	Hydrology	
Slope	flat	Adjacent Vegetation	non-native
Topographic position	low	Vegetation Condition	D
Altitude (m)	-	Time since fire	no evidence
Bare ground %	5	Disturbance	high
Soil type/texture	sandy clay	Rock type	N/A
Soil colour	brown	Rock %	0
Microclimate	-	Litter type and %	leaves, sticks, 30%

Vegetation Description

Low open forest *Melaleuca preissiana* over non-native closed grassland

Native Strata	Height (m)	Total % Cover
Canopy	6	80
Mid	N/A	0
Ground	N/A	0

Q8 Flora List

	Species
	Melaleuca preissiana
*	*Ehrharta calycina*
*	*Ehrharta longiflora*
*	*Eragrostis curvula*

NB: * denotes non-native species

Site Details			
Locality	Lot 50 Victoria Rd	Photo No.	195
Date	15/09/2017	Photo direction	E
Author	RAO	Geographic datum and zone	GDA94 50
Sampling unit	Quadrat	Easting	405337
Sample number	Q9	Northing	6456490

Geographic and Habitat Data			
Aspect	flat	Hydrology	dry
Slope	flat	Adjacent Vegetation	similar/non-native
Topographic position	-	Vegetation Condition	VG
Altitude (m)	-	Time since fire	no evidence
Bare ground %	5	Disturbance	moderate-low
Soil type/texture	sand	Rock type	N/A
Soil colour	grey-white	Rock %	0
Microclimate	-	Litter type and %	leaves, sticks, 20%

Vegetation Description

Occasional *Allocasuarina fraseriana* over open shrubland *Hibbertia hypericoides* over low shrubland *Stirlingia latifolia* over closed forbland *Desmocladus flexuosus*

Native Strata	Height (m)	Total % Cover
Canopy	8	20
Mid	0.4	10
Ground	0.2	50

Q9 Flora List

	Species
	Allocasuarina fraseriana
	Allocasuarina humilis
	Burchardia congesta
	Dasypogon bromeliifolius
	Desmocladus flexuosus
*	*Ehrharta calycina*
*	*Eragrostis curvula*
	Hibbertia hypericoides
	Philotheca spicata

Q9 Flora List	
	Stirlingia latifolia
*	*Watsonia meriana var. bulbillifera*
	Xanthorrhoea preissii
Note that no access was permitted and this releve was sampled from an adjacent property	
NB: * denotes non-native species	

Appendix D

Wetland Reclassification Documentation

PRELIMINARY EVALUATION CRITERIA

REW UFI No. 8050 (excluding TEC vegetation)

No	Criteria	Y/N	Evaluation Comments 7/01/2019 RAO
1	The wetland is currently recognised as internationally or nationally significant for its natural values. Lists/registers include:		
	The Ramsar Convention on Wetlands	N	
	State government endorsed candidate sites for the Ramsar Convention on Wetlands	N	
	Directory of Important Wetlands in Australia	N	
	National Heritage List	N	
	Or equivalent.	N	
2	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and is identified as significant for its natural values under one or more of the following:		
	Conservation Reserves for Western Australia Systems 1, 2, 3, 5	N	
	Conservation Reserves for Western Australia, The Darling System – System 6	N	
	A Systematic Overview of Environmental Values of the Wetlands, Rivers and Estuaries of the Busselton – Walpole Region	N	
	The Environmental Significance of Wetlands in the Perth to Bunbury Region	N	
	Bush Forever, Swan Bioplan or equivalent.	N	
3	The wetland supports a breeding, roosting, or refuge site or a critical feeding site for populations of fauna listed by the Australian Government (for example, Environment Protection and Biodiversity Conservation Act 1999, migratory bird agreements such as JAMBA, CAMBA and RoKAMBA) or the State (for example, Threatened and Specially Protected Fauna listed under the Wildlife Conservation Act 1950).	N	
4	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and supports one or more of the following:		
	An occurrence of a Threatened Ecological Community	N	
	A confirmed occurrence of a Priority 1 or Priority 2 Ecological Community	N	
	A confirmed occurrence of a Declared Rare (Threatened) flora species.	N	
5	Equal to or greater than 90% of the wetland supports vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B.	N	From 2017 field survey and Tauss and Weston (2010)
6	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and is known to support internationally, nationally or state-wide scientific values including geoheritage and geoconservation.	N	
	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and meets one of the following:		
	≤10% of wetlands of the same type are assigned Conservation management category within the Swan Coastal Plain (by area)	N	Using palusplain instead of sumpland

PRELIMINARY EVALUATION CRITERIA

REW UFI No. 8050 (excluding TEC vegetation)

No	Criteria	Y/N
7	≤10% of all wetlands in the same consanguineous suite are assigned Conservation management category (by area)	N
	≤10% of wetlands of the same type in its consanguineous suite are assigned Conservation management category (by area)	N
	best representative of its type within its consanguineous suite domain.	N

Evaluation Comments

7/01/2019

RAO

Using palusplain instead of sumpland

Note: If a wetland does not satisfy any of the above preliminary evaluation criteria or, does satisfy the preliminary evaluation criteria but is not considered to be commensurate with the values of a Conservation management category wetland then a secondary evaluation including a full site assessment is required. Refer to Step 3 and 4 of the evaluation procedure which indicates the process for conducting a secondary evaluation.

Resu	**Secondary evaluation required**

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SECONDARY EVALUATION CRITERIA

REW UFI No. 8050 (excluding TEC vegetation)

Attributes/ functions/ values	General criteria	Number	Criteria	Y/N	Score
Geomorphology	Representativeness	1	≤20% of wetlands of the same type are assigned Conservation on the Swan Coastal Plain by area.	y	**H**
		2	≤20% of wetlands in the same consanguineous suite are assigned Conservation by area.	y	**H**
		3	≤20% of wetlands of the same type in the same consanguineous suite are assigned Conservation by area.	y	**H**
		4	The wetland is outstanding in some geomorphic aspect, for example size, origin, height relative to sea level, depth, age.	n	
	Naturalness	5	Alteration to the wetland's geomorphology by % area:		
			< 25% altered (=H)	n	
			25-75% altered (=I)	y	**I**
			> 75% altered. (=L)	n	
	Scarcity	6	The wetland exhibits unusual geomorphology or unusual internal geomorphic features compared to other wetlands of the same type in the consanguineous suite.	n	
		7	The wetland is the best example of its type in its consanguineous suite.	n	
Wetland processes	Representativeness	8	The wetland is an important component of the natural hydrological cycle providing natural functions (e.g. flood protection and recharge/discharge).	n	
			The wetland's vegetation, geomorphology, hydrology or sediments are modified; however, the wetland is still a component of the hydrological cycle providing natural and artificial functions (e.g. flood remediation, recharge/discharge and hydrological storage).	y	**I**
			The wetland's vegetation, geomorphology, hydrology or sediments are modified to the extent that the wetlands hydrological functions are artificial such as storage, or the wetland has been disconnected from the natural hydrological cycle and no longer provides natural attributes and functions.	n	
		9	The wetland supports a representative process (e.g. wetland process typical of the wetland's hydrological setting, sediment accretionary process typical of the wetland's geomorphic setting or hydrochemical process typical of the wetland's geological setting).	n	

SECONDARY EVALUATION CRITERIA

REW UFI No. 8050 (excluding TEC vegetation)

Attributes/ functions/ values	General criteria	Number	Criteria	Y/N	Score
	Naturalness	10	The wetland is not subject to altered wetland processes or, is subject to altered wetland processes and the wetland's natural attributes and functions are maintained.	n	
			The wetland is subject to altered wetland processes and the wetland's natural attributes and functions have been changed; however, they have the potential to be rehabilitated.	y	**I**
			The wetland is subject to altered wetland processes to the extent that the wetland no longer supports natural attributes and functions.	n	
	Scarcity	11	The wetland exhibits unusual processes (e.g. hydrological, sedimentological, chemical, biological) compared to other wetlands of the same type in the consanguineous suite.	n	
Linkages	Representative-ness	12	The wetland is a hydrological link in a larger or more complex and intact system.	n	
	Naturalness	13	The wetland is part of a continuous ecological linkage or wildlife corridor, or a regionally significant ecological linkage or wildlife corridor connecting bushland or wetland areas.	n	
			The wetland is part of a fragmented ecological linkage or wildlife corridor.	n	
			The wetland is disturbed and isolated, surrounded by either a built or highly disturbed environment with no nearby native vegetation or waterways to support an intact or fragmented ecological linkage or wildlife corridor.	y	**L**
	Scarcity	14	The wetland has unusual hydrological, hydrochemical or ecological linkages with adjacent wetland or bushland.	n	
	Representative-ness	15	The wetland is isolated from other undisturbed wetlands or bushland and as a result, maintains important ecological or genetic fauna or flora diversity within its consanguineous suite domain.	n	
		16	The wetland contains evidence of surface water that is vital to maintaining regionally significant populations of native aquatic or terrestrial flora or fauna.	n	
		17	The wetland provides a nursery for native fauna populations, or maintains fauna populations at a vulnerable stage of their life cycle.	n	

SECONDARY EVALUATION CRITERIA

REW UFI No. 8050 (excluding TEC vegetation)

Attributes/ functions/ values	General criteria	Number	Criteria	Y/N	Score
Habitats	Naturalness	18	The wetland supports habitats that are unaltered or the wetland has been altered and its natural habitats are maintained.	n	
			The wetland supports habitats that are altered; however, the habitats are still identifiable and have the potential to be rehabilitated.	y	**I**
			The wetland is altered and as a result is no longer supporting natural habitats which can be rehabilitated.	n	
	Scarcity	19	The wetland supports habitats that are unusual compared to other wetlands of the same type on the Swan Coastal Plain.	n	
Flora	Representativ e-ness	20	The wetland's current diversity of native flora is similar to what would be expected in an unaltered state.	n	
			The wetland supports a reduced diversity of native flora due to human induced disturbances.	n	
			The wetland supports a significantly reduced diversity of native flora species due to human induced disturbances.	y	**L**
		21	The wetland is identified in a vegetation complex (Heddle et al. 1980) which is represented by:		
			≤30% of the pre-European extent	y	**H**
			30-50% of the pre-European extent.	n	
	Naturalness	22	Using the vegetation condition scale outlined in Appendix B, the wetland's vegetation condition by area is:		
			≥ 75% Good, Very Good, Excellent or Pristine	n	
			25-75% Good, Very Good, Excellent or Pristine	n	
			< 25% Good, Very Good, Excellent or Pristine.	y	**L**
		23	The wetland or ≥ 50% of the wetland boundary is surrounded by land dominated by remnant native vegetation.		
			The wetland or 10-50% of the wetland boundary is surrounded by land dominated by remnant native vegetation.	y	**I**
			The wetland or < 10% of the wetland boundary is surrounded by land dominated by remnant native vegetation.	n	
		24	The wetland supports an occurrence of Declared Rare, Priority 1, Priority 2, Priority 3 or Priority 4 flora, or an occurrence of 3 or more significant flora taxa.	n	

SECONDARY EVALUATION CRITERIA

REW UFI No. 8050 (excluding TEC vegetation)

Attributes/ functions/ values	General criteria	Number	Criteria	Y/N	Score
	Scarcity	25	The wetland is likely to support Declared Rare, Priority 1, Priority 2, Priority 3 or Priority 4 flora; however, the occurrence cannot be located or its habitat has been altered and is no longer in a natural state.	n	
		26	The wetland supports an occurrence of a Threatened Ecological Community, Priority 1 or Priority 2 ecological community.	n	
		27	The wetland supports an occurrence of a Priority 3 or Priority 4 ecological community.	n	
Fauna	Representativ e-ness	28	The wetland is an ecological refuge for regionally significant fauna species or fauna assemblages.	n	
			The wetland has the potential to be an ecological refuge but is disturbed and its attributes and functions require rehabilitation.	n	
		29	The wetland supports a permanent or seasonal feeding, breeding, roosting or watering site for regionally significant native fauna.	n	
			The wetland supports a permanent or seasonal feeding, breeding, roosting or watering site for regional or local fauna but only in association with other surrounding natural areas.	n	
	Naturalness	30	The wetland's current diversity of native fauna is similar to what would be expected in an unaltered state, or the wetland supports diverse fauna compared to other wetlands of the same type.	n	
			The wetland supports a reduced diversity of fauna compared to other wetlands of the same type.	y	**I**
		31	The wetland supports limited attributes and functions for fauna populations due to human induced disturbances.	y	**L**
	Scarcity	32	The wetland is likely to support a breeding, roosting, refuge or feeding site for populations of fauna listed by the Commonwealth (e.g. EPBC Act 1999, JAMBA, CAMBA, RoKAMBA Agreements) or the State (e.g. Threatened or Specially Protected Fauna listed under the Wildlife Conservation Act 1950).	n	
		33	The wetland supports a breeding, roosting, refuge or feeding site for Priority 1, Priority 2, Priority 3 or Priority 4 fauna.	n	

SECONDARY EVALUATION CRITERIA

REW UFI No. 8050 (excluding TEC vegetation)

Attributes/ functions/ values	General criteria	Number	Criteria	Y/N	Score
		34	The wetland supports an occurrence of a Threatened Ecological Community, Priority 1 or Priority 2 ecological community.	n	
		35	The wetland supports an occurrence of a Priority 3 or Priority 4 ecological community or a breeding, roosting, refuge or feeding site for significant fauna.	n	
Cultural	Representative-ness	36	The wetland or its immediate surrounds is identified for its natural values on a national or State heritage list or the wetland supports other known regional heritage values.	n	
		37	The wetland or its immediate surrounds is identified for its natural values on a municipal heritage list or the wetland supports other known local heritage values.	n	
		38	The wetland or its immediate surrounds is identified on a national, State or local list or register for its Aboriginal cultural value (e.g. Department of Aboriginal Affairs register).	n	
		39	The wetland is important to the local community either nationally or state wide for its natural values.	n	
		40	The wetland is or has the potential to be a site for public or private based recreation.	n	
		41	The wetland is likely to support heritage, cultural or social values; however, the value cannot be confirmed or the value has been disturbed and are no longer as important or significant.	n	
			The wetland did support heritage, cultural or social values; however, these have been significantly disturbed and are no longer important or the values have been removed.	n	
Scientific and educational	Representative-ness	42	The wetland supports known important teaching or research characteristics and for this reason is an existing or potential education or research site. Note, the wetland must still support the relevant teaching or research characteristics.	n	
			The wetland has the potential to be used as a study or research site.	n	
		43	The wetland supports known scientific, geoheritage or geoconservation values.	n	

SECONDARY EVALUATION CRITERIA

REW UFI No. 8050 (excluding TEC vegetation)

Attributes/ functions/ values	General criteria	Number	Criteria	Y/N	Score
		44	The wetland did support scientific or educational values; however, these have been significantly disturbed and are no longer as important or the values have been removed.	n	

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SECONDARY EVALUATION TALLY

REW UFI No. 8050 (excluding TEC vegetation)

Attributes / functions / values	Scores		
	High	Intermediate	Low
Geomorphology	3	1	0
Wetland processes	0	2	0
Linkages	0	0	1
Habitats	0	1	0
Flora	1	1	2
Fauna	0	1	1
Cultural	0	0	0
Scientific and educational	0	0	0
Total score	**4**	**6**	**4**
Defining attributes/functions/values	Geomorphology		

Applicable management category	**Rehabilitation potential**

DBCA 2017 A methodology for the evaluation of wetlands on the Swan Coastal Plain, WA

PRELIMINARY EVALUATION CRITERIA
REW UFI No. 8050 (only TEC lot)

Evaluation Comments
8/01/2019

No	Criteria	Y/N	RAO
1	The wetland is currently recognised as internationally or nationally significant for its natural values. Lists/registers include:		
	The Ramsar Convention on Wetlands	N	
	State government endorsed candidate sites for the Ramsar Convention on Wetlands	N	
	Directory of Important Wetlands in Australia	N	
	National Heritage List	N	
	Or equivalent.	N	
2	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and is identified as significant for its natural values under one or more of the following:		
	Conservation Reserves for Western Australia Systems 1, 2, 3, 5	N	
	Conservation Reserves for Western Australia, The Darling System – System 6	N	
	A Systematic Overview of Environmental Values of the Wetlands, Rivers and Estuaries of the Busselton – Walpole Region	N	
	The Environmental Significance of Wetlands in the Perth to Bunbury Region	N	
	Bush Forever, Swan Bioplan or equivalent.	N	
3	The wetland supports a breeding, roosting, or refuge site or a critical feeding site for populations of fauna listed by the Australian Government (for example, Environment Protection and Biodiversity Conservation Act 1999, migratory bird agreements such as JAMBA, CAMBA and RoKAMBA) or the State (for example, Threatened and Specially Protected Fauna listed under the Wildlife Conservation Act 1950).	N	
4	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and supports one or more of the following:		
	An occurrence of a Threatened Ecological Community	Y	‘Corymbia calophylla - Kingia australis woodlands on heavy soils of the Swan Coastal Plain’
	A confirmed occurrence of a Priority 1 or Priority 2 Ecological Community	N	
	A confirmed occurrence of a Declared Rare (Threatened) flora species.	N	
5	Equal to or greater than 90% of the wetland supports vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B.	Y	Majority in 'very good' condition
6	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and is known to support internationally, nationally or state-wide scientific values including geoheritage and geoconservation.	N	
	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and meets one of the following:		

PRELIMINARY EVALUATION CRITERIA
REW UFI No. 8050 (only TEC lot)

Evaluation Comments
8/01/2019
RAO

No	Criteria	Y/N	Comments
7	≤10% of wetlands of the same type are assigned Conservation management category within the Swan Coastal Plain (by area)	Y	Using palusplain instead of sumpland
	≤10% of all wetlands in the same consanguineous suite are assigned Conservation management category (by area)	N	
	≤10% of wetlands of the same type in its consanguineous suite are assigned Conservation management category (by area)	Y	Using palusplain instead of sumpland
	best representative of its type within its consanguineous suite domain.	N	

Note: If a wetland does not satisfy any of the above preliminary evaluation criteria or, does satisfy the preliminary evaluation criteria but is not considered to be commensurate with the values of a Conservation management category wetland then a secondary evaluation including a full site assessment is required. Refer to Step 3 and 4 of the evaluation procedure which indicates the process for conducting a secondary evaluation.

Result	Conservation category wetland

DBCA *2017 A methodology for the evaluation of wetlands on the Swan Coastal Plain, WA*

Appendix D

Fauna Assessment (Harewood 2018)

Fauna Assessment

(Level 1)

Maddington Kenwick Strategic Employment Area

Precinct 1

City of Gosnells

MARCH 2018

Version 2

On behalf of:
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Acronyms/Abbreviations:

ALA: Atlas of Living Australia www.ala.org.au

BA: Birdlife Australia (Formerly RAOU, Birds Australia).

BC Bill: *Biodiversity Conservation Bill (2015)*. WA Government.

°C: Degrees Celsius.

CALM: Department of Conservation and Land Management (now DBCA), WA Government.

CAMBA: China Australia Migratory Bird Agreement 1998.

CBD: Central Business District.

DBCA: Department of Biodiversity, Conservation and Attractions (formerly DPaW, DEC, CALM, DoE), WA Government

DBH: Diametre at Breast Height – tree measurement.

DEC: Department of Environment and Conservation (now DBCA), WA Government.

DEH: Department of Environment and Heritage (now DotEE), Australian Government.

DEP: Department of Environment Protection (now DER), WA Government.

DER: Department of Environment Regulation (now DWER), WA Government.

DEWHA: Department of the Environment, Water, Heritage and the Arts (now DotEE), Australian Government

DMP: Department of Mines and Petroleum (formerly DoIR), WA Government.

DoE: Department of Environment (now DER/DBCA), WA Government.

DoP: Department of Planning, WA Government.

DotE: Department of the Environment (now DotEE), Australian Government.

DotEE: Department of the Environment and Energy (formerly SEWPaC, DWEHA, DEH & DotE), Australian Government.

DoIR: Department of Industry and Resources (now DMP), WA Government.

DoW: Department of Water (now DWER), WA Government.

DPaW: Department of Parks and Wildlife (now DBCA), WA Government.

DWER: Department of Water and Environmental Regulation (formed by the amalgamation of OEPA, DoW and DER), WA Government.

EP Act: *Environmental Protection Act 1986*, WA Government.

EPA: Environmental Protection Authority, WA Government.

EPBC Act: *Environment Protection and Biodiversity Conservation Act 1999,* Australian Government.

ha: Hectare (10,000 square metres).

IBRA: Interim Biogeographic Regionalisation for Australia.

IUCN: International Union for the Conservation of Nature and Natural Resources – commonly known as the World Conservation Union.

JAMBA: Japan Australia Migratory Bird Agreement 1981.

km: Kilometre.

m: Metre.

mm: Millimetre.

P: Priority - DBCA fauna conservation ranking.

POS: Public Open Space.

ROKAMBA: Republic of Korea-Australia Migratory Bird Agreement 2007.

S: Schedule - Western Australian *Wildlife Conservation Act (1950)* Threatened Fauna Category.

SEWPaC: Department of Sustainability, Environment, Water, Population and Communities (now DotEE), Australian Government.

SRE: Short Range Endemic.

SSC: Species Survival Commission, International.

WA: Western Australia.

WAM: Western Australian Museum, WA Government.

WAPC: Western Australian Planning Commission, WA Government.

WC Act: *Wildlife Conservation Act 1950*, WA Government.

WRP: Western Ringtail Possum.

SUMMARY

This report details the results of a fauna assessment of various freehold allotments within Precinct 1 of the Maddington Kenwick Strategic Employment Area (MKSEA) located in the City of Gosnells (subject site). The subject site covers approximately 121 ha most of which is cleared or parkland cleared though some areas of remnant native vegetation remain (total area about 4.4 ha) (Figures 1 & 2).

It is understood that outline development plans are being prepared to support future development across Precinct 1. A range of investigations, including this fauna survey, have been undertaken in order to fully understand the suite of environmental values across the area.

The scope of works was to conduct a level 1 fauna survey as defined by the Environmental Protection Authority (EPA 2016). The assessment has included a literature review ("desktop study") and several daytime reconnaissance surveys.

Overall fauna habitat values at the subject site have been severely compromised by the removal of most of the original native vegetation and the degradation of remnant patches. Most areas lack any natural attributes and are now only utilised by generally common and widespread fauna species with non-specific requirements which allow them to persist in disturbed/highly disturbed habitats. As a consequence the fauna diversity of the subject site is well below levels present prior to historical disturbances having occurred.

The individual remnant native trees and groves of trees, while limited in extent support the primary fauna habitat value within the site although these areas vary in quality, with most areas being degraded and lacking significant native groundcover/shrubs and microhabitats such as hollow logs.

Opportunistic fauna observations are listed in Appendix B. A total of 27 native fauna species were observed (or positively identified from foraging evidence, scats, tracks, skeletons or calls) within the subject site during the day time surveys. Excluding domestic livestock, two introduced species were also confirmed as being present. Most of the fauna species recorded are common, widespread bird species.

Evidence of all three threatened black cockatoo species was observed (Baudin's Black Cockatoo and the forest red-tailed black cockatoo - foraging evidence (chewed marri fruits) and Carnaby's black-cockatoo – foraging evidence (chewed pine cones). No evidence of any migratory or DBCA priority species was found.

With respect to native vertebrate fauna, 10 mammals (includes eight bat species), 87 bird, 15 reptile and eight frog species have previously been recorded in the general area, some of which have the potential to occur in or utilise sections of the subject site at times, a conclusion largely based on the presence of apparently suitable habitat.

Of the 120 native animals that are listed as potentially occurring in the area, four are considered to be endangered/vulnerable or in need of special protection under State and/or Commonwealth legislation, these being the three species of black cockatoo and the peregrine falcon. In addition, the Priority 4 quenda may occur, though habitat for this species appears largely marginal in quality.

With respect to vertebrate fauna in general, no significant impacts are anticipated as a consequence of development at the site. In cases where some impact is anticipated, the degree of the impact is only expected to be low and relates to the loss of small areas of habitat. As most species are common and widespread no overall change in their conservation status is anticipated, despite a possible localised reduction in habitat extent.

Based on available information it is considered at this stage very unlikely that impacts on black cockatoos (or any other *EPBC Act* listed threatened or migratory species) which may occur as a result of development at any scale within the subject site will result in a "significant impact" as defined by the Commonwealth DotEE (DotE 2013).

1. INTRODUCTION

This report details the results of a fauna assessment of various freehold allotments within Precinct 1 of the Maddington Kenwick Strategic Employment Area (MKSEA) located in the City of Gosnells (subject site). The subject site is situated about 12 kilometres south east of the Perth central business district in south west Western Australia and is centred at approximately 32.029578°S and 116.000168°E (Figure 1).

The subject site covers approximately 121 ha most of which is cleared or parkland cleared though some areas of remnant native vegetation remain (total area about 4.4 ha) (Figure 2).

2. DEVELOPMENT PROPOSAL

It is understood that outline development plans are being prepared to support future development across Precinct 1. A range of investigations, including this fauna survey, have been undertaken in order to fully understand the suite of environmental values across the area. The findings of this fauna survey and other investigations will be used to inform and support the development, with the primary aim of minimising potential environmental impacts as much as reasonable and practicable.

It is also anticipated that the information presented will be used by regulatory authorities to assess the potential impact of the proposal on fauna and fauna habitats as part of finalising the outline development plan and for future subdivision development approval processes.

3. SCOPE OF WORKS

The scope of works was to conduct a level 1 fauna survey as defined by the EPA (EPA 2016).

The fauna assessment has therefore included:

1. Level 1 Fauna Survey;
2. Report summarising methods, results and discussion on likely constraints on development within the subject site.

This survey report has been prepared for use in the EPA's EIA process (if required) and is considered suitable for this purpose.

4. METHODS

4.1 POTENTIAL FAUNA INVENTORY – LITERATURE REVIEW

4.1.1 Database Searches

Searches of the following databases were undertaken to aid in the compilation of a list of conservation significant fauna potentially occurring within the subject site:

- DBCA's NatureMap Database Search (combined data from DBCA, ALA, WAM, BA and consultant's reports) (DBCA 2018b); and

- Protected Matters Search Tool (DotEE 2018).

It should be noted that lists produced during the abovementioned database searches contain observations/inferred distributions from a broader area than the subject site and therefore may include species that would only ever occur as vagrants due to a lack of suitable habitat or the presence of only marginal habitat within the subject site itself. The databases also often included or are based on very old records and in some cases the species in question have become locally or regionally extinct.

Information from these sources should therefore be taken as indicative only and local knowledge and information also needs to be taken into consideration when determining what actual species may be present within the specific area being investigated.

4.1.2 Previous Fauna Surveys in the Area

Fauna surveys, assessments and reviews have been undertaken in nearby areas in the past, though not all are publically available and could not be referenced. The most significant of those available have been used as the primary reference material for compiling the potential fauna assemblage for the general area.

Those reports referred to included, but were not limited to:

- 360 Environmental (2012). Black Cockatoo Survey – Maddington Kenwick Strategic Employment Area. Unpublished report for the City of Gosnells.

- ATA (1994). A Report of a Fauna Survey of Perth Airport. Report 93/78. Unpublished report for the Federal Airports Corporation.

- ATA Environmental (2006). Vertebrate Fauna Assessment Brookdale Redevelopment Area. Unpublished report for the Armadale Redevelopment Authority.

- Bancroft, W., Moore, A., & Bamford, M. (2017). Black-cockatoo values of the Maddington Kenwick Strategic Employment Area (MKSEA) Precinct 3A (Kenwick/Wattle Grove). Unpublished report for Emerge Associates.

- Dell, J. (pers.comm) (1994). Results of Western Australia Museum Surveys, December 1986 to April 1990.
- ENV Australia (2005). Southern River Precinct 3 - Environmental Review. Unpublished report for the City of Gosnells.
- Harewood, G. (2009). Fauna Assessment (Level 1) – Mills Park - Beckenham. Unpublished report for Cardno (WA) Pty Ltd.
- Harewood, G. (2014). Fauna Assessment - Hazelmere Precinct 9A. Unpublished report for Emerge Associates.
- Harewood, G. (2016). Fauna Assessment - Maddington Kenwick Strategic Employment Area – Precinct 3 - City of Gosnells. Unpublished report for Emerge Associates.
- Harvey, M. S., Dell, J. How, R. A., & Waldock, J. M. (1987). Ground Fauna of Bushland Remnants on the Ridge Hill Shelf and Pinjarra Plain Landforms, Perth. Report to the Australian Heritage Commission. NEP Grant N95/49. 56 pp.
- How, R.A (1995). Objection Assessment of Fauna Values for Perth Airport. Unpublished report for the Australian Heritage Commission.
- How, R.A, Harvey, M.S., Dell J., & Waldock, J.M. (1996). Ground Fauna of Urban Bushland Remnants in Perth. Report to the Australian Heritage Commission. NEP Grant N93/04. 103 pp.
- Turpin, J. and Bamford, M. (2009). Keane Road Strategic Link Armadale, Fauna Assessment. Unpublished report for EnviroWorks Consulting.

As with the databases searches some reports refer to species that would not occur in the subject site due to a lack of suitable habitat (extent and/or quality) and this fact was taken into consideration when compiling the potential fauna species list. It should also be noted that the NatureMap database is likely to include some records from previous fauna surveys in the area including some of those listed above.

4.1.3 Existing Publications

The following represent the main publications used to identify and refine the potential fauna species list for the subject site:

- Anstis, M. (2013). Tadpoles and Frogs of Australia. New Holland Publishers, Sydney.
- Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). The New Atlas of Australian Birds. Royal Australasian Ornithologists Union, Victoria.

- Bush, B., Maryan, B., Browne-Cooper, R. & Robinson, D. (2007). Reptiles and Frogs in the Bush: Southwestern Australia. UWA Press, Nedlands.
- Bush, B., Maryan, B., Browne-Cooper, R. & Robinson, D. (2010). Field Guide to Reptiles and Frogs of the Perth Region. UWA Press, Nedlands.
- Churchill, S. (2008). Australian Bats. Second Edition, Allen & Unwin.
- Cogger, H.G. (2014). Reptiles and Amphibians of Australia. 7th Edition. CSIRO Publishing.
- Johnstone, R.E. and Storr, G.M. (1998). Handbook of Western Australian Birds: Volume 1 – Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth Western Australia.
- Johnstone, R.E. and Storr, G.M. (2004). Handbook of Western Australian Birds: Volume 2 – Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth Western Australia.
- Menkhorst, P. and Knight, F. (2011). A Field Guide to the Mammals of Australia. Oxford University Press, Melbourne.
- Morgan, D.L., Beatty, S.J., Klunzinger, M.W, Allen, M.G. and Burnham, Q.E (2011). Field Guide to the Freshwater Fishes, Crayfishes and Mussels of South Western Australia. Published by SERCUL.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (1983). Lizards of Western Australia II: Dragons and Monitors. WA Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (1990). Lizards of Western Australia III: Geckos and Pygopods. WA Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (1999). Lizards of Western Australia I: Skinks. Revised Edition, WA Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (2002). Snakes of Western Australia. Revised Edition, WA Museum, Perth.
- Tyler M.J. & Doughty P. (2009). Field Guide to Frogs of Western Australia, Fourth Edition, WA Museum, Perth.
- Van Dyck, S., Gynther, I. & Baker, A. Eds (2013). Field Companion to The Mammals of Australia. Queensland Museum.
- Wilson, S. and Swan, G. (2017). A Complete Guide to Reptiles of Australia. Reed, New Holland, Sydney.

- Woinarski, J., Burbidge, A. & Harrison, P. (2014). The Action Plan for Australian Mammals 2012. CSIRO Publishing.

4.1.4 Fauna of Conservation Significance

The conservation significance of fauna species has been assessed using data from the following sources:

- *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). Administered by the Australian Government Department of the Environment and Energy (DotEE);
- *Wildlife Conservation Act 1950* (*WC Act*). Administered by the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) (Govt. of WA 2018);
- Red List produced by the Species Survival Commission (SSC) of the World Conservation Union (also known as the IUCN Red List - the acronym derived from its former name of the International Union for Conservation of Nature and Natural Resources). The Red List has no legislative power in Australia but is used as a framework for State and Commonwealth categories and criteria; and the
- DBCA Priority Fauna list. A non-statutory list maintained by the DBCA for management purposes (DBCA 2018b).

The *EPBC Act* also requires the compilation of a list of migratory species that are recognised under international treaties including the:

- Japan Australia Migratory Bird Agreement 1981 (JAMBA);
- China Australia Migratory Bird Agreement 1998 (CAMBA);
- Republic of Korea-Australia Migratory Bird Agreement 2007 (ROKAMBA); and
- Bonn Convention 1979 (The Convention on the Conservation of Migratory Species of Wild Animals).

(Note - Species listed under JAMBA are generally also classified as migratory under Schedule 5 of the *WC Act*.)

All migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as matters of national environmental significance (NES) under the *EPBC Act*.

The conservation status of all vertebrate fauna species listed as occurring or possibly occurring in the vicinity of the subject site has been assessed using the most recent lists published in accordance with the above-mentioned instruments and is indicated as such in the fauna listings of this report. A full listing of conservation codes is provided in Appendix A.

A number of other species not listed in official lists can also be considered of local or regional conservation significance. These include species that have a restricted range, those that occur in breeding colonies and those at the limit of their range.

While not classified as rare, threatened or vulnerable under any State or Commonwealth legislation, a number of birds have been listed as species of significance on the Swan Coastal portion of the Perth Metropolitan Region (Bush Forever - Government of Western Australia 1998 and 2000). The bird species are often referred to as "Bush Forever Decreaser Species".

The three categories used for birds within the Bush Forever documents are:

- Habitat specialists with reduced distribution on the Swan Coastal Plain (code Bh)
- Wide ranging Species with reduced populations on the Swan Coastal Plain. (code Bp)
- Extinct in the Perth region (code Be)

The presence of Bush Forever species should be taken into some consideration when determining the fauna values of an area. Bush Forever decreaser species are indicated as such within the species list held in Appendix B.

4.1.5 Invertebrate Fauna of Conservation Significance

It can be difficult to identify significant invertebrate species (e.g. short range endemics (SREs) as there are uncertainties in determining the range-restrictions of many species due to lack of surveys, lack of taxonomic resolutions within target taxa and problems in identifying certain life stages. Where invertebrates are collected during surveys, a high percentage are likely to be unknown, or for known species there can be limited knowledge or information on their distribution (Harvey 2002).

For this project, the assessment for conservation significant invertebrates has been limited to those listed by the DBCA and *EPBC Act* database searches (which rely on distribution records and known habitat preferences). No assessment of the potential for SREs to be present has been made.

4.1.6 Likelihood of Occurrence – Vertebrate Fauna of Conservation Significance

Fauna of conservation significance identified during the literature review as previously being recorded in the general area were assessed and ranked for their likelihood of occurrence within the subject site itself. The rankings and criteria used were:

- Would Not Occur: There is no suitable habitat for the species in the subject site and/or there is no documented record of the species in the general area since records have been kept and/or the species is generally accepted as being locally/regionally extinct (supported by a lack of recent records).
  - Locally Extinct: Populations no longer occur within a small part of the species natural range, in this case within 10 or 20km of the subject site. Populations do however persist outside of this area.
  - Regionally Extinct: Populations no longer occur in a large part of the species natural range, in this case within the Perth section of the Swan Coastal Plain and nearby Darling Range. Populations do however persist outside of this area.
- Unlikely to Occur: The subject site is outside of the currently documented distribution for the species in question, or no suitable habitat (type, quality and extent) was identified as being present during the field assessment. Individuals of some species may occur occasionally as vagrants/transients especially if suitable habitat is located nearby but the subject site itself would not support a population or part population of the species.
- Possibly Occurs: The subject site is within the known distribution of the species in question and habitat of at least marginal quality was identified as being present during the field assessment, supported in some cases by recent records being documented in literature from within or near the subject site. In some cases, while a species may be classified as possibly being present at times, habitat may be marginal (e.g. poor quality, fragmented, limited in extent) and therefore the frequency of occurrence and/or population levels may be low.
- Known to Occur: The species in question was positively identified as being present (for sedentary species) or as using the subject site as habitat for some other purpose (for non-sedentary/mobile species) during the field survey. This information may have been obtained by direct observation of individuals or by way of secondary evidence (e.g. foraging debris, tracks and scats). In some cases, while a species may be classified as known to occur, habitat may be marginal (e.g. poor quality, fragmented, limited in extent) and therefore the frequency of occurrence and/or population levels may be low.

4.1.7 Taxonomy and Nomenclature

Taxonomy and nomenclature for fauna species used in this report is generally taken from the DBCA's WA Fauna Census Database which is assumed to follow Aplin and Smith (2001) for amphibians and reptiles and Johnstone (2001) for birds. Jackson and Groves (2015) has been used for mammals.

Common names are taken from the Western Australia Museum (WAM) recognised primary common name listings when specified, though where common names are not provided they have been acquired from other publications. Sources include Cogger (2014), Wilson and Swan (2013), Van Dyck & Strahan (2013), Christidis and Boles (2008), Bush *et al.* (2010), Bush *et al.* (2007), Tyler *et al*. (2000), and Glauret (1961). Not all common names are generally accepted.

4.2 SITE SURVEYS

A daytime reconnaissance survey of the subject site was carried out by Greg Harewood (B.Sc. Zoology) on the 23 October 2017, the 14 November 2017 and the 19 February 2018. It should be noted that access to many lots was restricted and therefore direct observations where limited in these areas.

4.2.1 Fauna Habitat Assessment

The vegetation communities identified during the botanical survey of the site carried out by Emerge Associates (Emerge Associates 2018) have been used as the basis for a classification of areas into broad fauna habitat types. This information has been supplemented with observations made during the fauna assessment.

The main aim of the habitat assessment was to determine if it was likely that any species of conservation significance would be utilising the areas that may be impacted on as a consequence of development at the subject site. The habitat information obtained was also used to aid in finalising the overall potential fauna list.

As part of the literature review, available information on the habitat requirements of the species of conservation significance listed as possibly occurring in the area was researched. During the field survey the habitats within the subject site were assessed and specific elements identified, if present, to determine the likelihood of listed threatened species utilising the area and its significance to them.

4.2.2 Opportunistic Fauna Observations

Opportunistic observations of fauna species were made during the field survey. Methods involved traversing a series of transects across the subject site during the day while searching microhabitats such as logs, rocks, leaf litter and observations of bird species with binoculars. Secondary evidence of a species presence such as tracks, scats, skeletal remains, foraging evidence or calls were also noted if observed/heard.

5. SURVEY CONSTRAINTS

No seasonal sampling has been carried out as part of this fauna assessment. The conclusions presented are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the subject site at the time of the field assessments. It should also be recognised that site conditions can change with time.

Some fauna species are reported as potentially occurring within the subject site based on there being suitable habitat (quality and extent) within the subject site or immediately adjacent. With respect to opportunistic observations, the possibility exists that certain species may not have been detected during field investigations due to:

- seasonal inactivity during the field survey;
- species present within micro habitats not surveyed;
- cryptic species able to avoid detection; and
- transient wide-ranging species not present during the survey period.

Lack of observational data on some species should therefore not necessarily be taken as an indication that a species is absent from the subject site.

The habitat requirements and ecology of many of the species known to occur in the wider area are often not well understood or documented. It can therefore be difficult to exclude species from the potential list based on a lack of a specific habitat or microhabitat within the subject site. As a consequence of this limitation the potential fauna list produced is most likely an overestimation of those species that actually utilise the subject site for some purpose. Some species may be present in the general area but may only use the subject site itself on rare occasions or as vagrants/transients.

In recognition of survey limitations, a precautionary approach has been adopted for this assessment. Any fauna species that would possibly occur within the subject site (or immediately adjacent), as identified through ecological databases, publications, discussions with local experts/residents and the habitat knowledge of the Author, has been assumed to potentially occur in the subject site.

As previously indicated access to many lots was restricted and therefore direct observations where limited in these areas.

6. RESULTS

6.1 POTENTIAL FAUNA INVENTORY – LITERATURE REVIEW

A list of fauna species considered most likely to occur in the subject site has been compiled from information obtained during the desktop study and is presented in Appendix B. This listing was refined after information gathered during the site reconnaissance survey was assessed. The results of some previous fauna surveys carried out in the general area are summarised in this species listing as are the DBCA NatureMap database search results. The raw database search results from NatureMap (DBCA 2018b) and the Protected Matters Search Tool (DotEE 2018) are contained within Appendix C.

The list of potential fauna takes into consideration that firstly the species in question is not known to be locally extinct and secondly that suitable habitat for each species, as identified during the habitat assessment, is present within the subject site. Compiling an accurate fauna list has limitations (see Section 5 above) and therefore, as discussed the listing is likely to be an overestimation of the fauna species actually present within the subject site at any one time.

6.2 SITE SURVEYS

6.2.1 Fauna Habitat Assessment

The subject site is situated on the eastern margin of the Swan Coastal Plain at the foot of the Darling Scarp in an area that has largely been cleared of vegetation, primarily for livestock grazing. Remnant native vegetation onsite is now represented mainly by areas of tree species in various densities and combinations including marri, sheoak, *banksia* and *melaleuca* over native understorey or introduced grasslands. The balance of the site is either totally cleared or parkland cleared with scattered trees, mostly planted non-endemic eucalyptus species, some pine trees, with a small number of endemics (e.g. marri).

Topography of the subject site is almost flat with a gradual rise from about 10 mAHD in the west to about 26 mAHD in the east. Soils within the subject site range from thin, light grey Bassendean Sands to white grey to brown sandy clays of the Guildford Formation.

The subject site contains a small number of manmade dams and ornamental lakes but no other wetland habitats of significance.

Descriptions and examples images of the main fauna habitats/dominant vegetation present within the subject site are provided in Table 1. The location and extent of the identified habitat elements is shown in Figure 3 (courtesy Emerge 2018).

Table 1: Main Fauna Habitats within the Subject Site

Code	Fauna Habitat Description	Example Image
AfDb	Scattered *Allocasuarina fraseriana* over open occasional *Xanthorrhoea preissii* over forbland *Dasypogon bromeliifolius* and non-native grasses. Total Area = ~0.03 ha (~0.03%)	
AfSlDf	Occasional *Allocasuarina fraseriana* over open shrubland *Hibbertia hypericoides* over low shrubland *Stirlingia latifolia* over closed forbland *Desmocladus flexuosus*. Total Area = ~0.05 ha (~0.04%)	
BAf	Open forest *Banksia attenuata* and *Allocasuarina fraseriana* over occasional *Kingia australis* over closed non-native grassland. Total Area = ~0.83 ha (~0.68%)	
CcHa	Open forest *Corymbia calophylla* over open shrubland *Hypocalymma angustifolium* over non-native grassland. Total Area = ~0.41 ha (~0.34%)	

Code	Fauna Habitat Description	Example Image
CcXpMt	Low open forest *Corymbia calophylla* over open shrubland *Xanthorrhoea preissii* and *Hypocalymma angustifolium* over open forbland *Mesomelaena tetragona*. Total Area = ~1.34 ha (~1.11%)	
*EEt	Forest **Eucalyptus camaldulensis*, *Eucalyptus rudis* and *Eucalyptus todiana* over grassland **Ehrharta calycina*. Total Area = ~0.08 ha (~0.07%)	
EtBmHh	Woodland *Eucalyptus todtiana*, planted **Eucalyptus* sp. and *Banksia menziesii* over shrubland *Hibbertia hypericoides* over forbland *Lomandra sericea.* Total Area = ~0.04 ha (~0.03%)	
Mp	Low open forest *Melaleuca preissiana* over non-native closed grassland. Total Area = ~0.19 ha (~0.16%)	

Code	Fauna Habitat Description	Example Image
MrVjLc	Low forest *Melaleuca rhaphiophylla* over scattered *Viminaria juncea* over low open shrubland *Acacia pulchella* and *Hypocalymma angustifolium* over scattered *Leptocarpus canus*. Total Area = ~0.09 ha (~0.07%)	
RS1#	*Leptocarpus canus – Chaetanthus aristatus* mid-dense, species-rich rushes, sedges and open herbs and patchy *Viminaria juncea* tall open shrubs. Total Area = ~0.16 ha (~0.13%)	No Image Avialble
T10#	*Allocasuarina fraseriana – Eucalyptus todtiana – Banksia menziesii* low woodland over species rich low shrubs. Total Area = ~1.19 ha (~0.98%)	No Image Avialble
Non-native vegetation	Heavily disturbed areas comprising non-native grasses with occasional native shrubs and trees and planted vegetation. Total Area = ~116.69 ha (~96.37%)	

Overall fauna habitat values at the subject site have been severely compromised by the removal of most of the original native vegetation and the degradation of remnant patches. Most areas lack any natural attributes and are now only utilised by generally common and widespread fauna species with non-specific requirements which allow them to persist in disturbed/highly disturbed habitats. As a consequence, the fauna diversity of the subject site is well below levels present prior to historical disturbances having occurred.

The individual remnant native trees and groves of trees, while limited in extent support the primary fauna habitat value although these areas vary in quality, with most areas being degraded and lacking significant native groundcover/shrubs and microhabitats such as hollow logs.

6.2.2 Opportunistic Fauna Observations

Opportunistic fauna observations are listed in Appendix B. A total of 27 native fauna species were observed (or positively identified from foraging evidence, scats, tracks, skeletons or calls) within the subject site during the day time surveys. Excluding domestic livestock, two introduced species were also confirmed as being present. Most of the fauna species recorded are common, widespread bird species.

Evidence of all three threatened black cockatoo species was observed (Baudin's Black Cockatoo and the forest red-tailed black cockatoo - foraging evidence (chewed marri fruits) and Carnaby's black-cockatoo – foraging evidence (chewed pine cones). No evidence of any migratory or DBCA priority species was found.

6.3 FAUNA INVENTORY – SUMMARY

6.3.1 Vertebrate Fauna

Table 2 summarises the number of vertebrate fauna species potentially occurring within or utilising at times the subject site, based on results from the desktop study and observations made during the field assessment. A complete list of vertebrate fauna possibly inhabiting or frequenting the subject site is located in Appendix B.

Table 2: Summary of Potential Vertebrate Fauna Species (as listed in Appendix B)

Group	Total number of potential species	Potential number of specially protected species	Potential number of migratory species	Potential number of priority species	Number of species recorded during field survey
Amphibians	8	0	0	0	0
Reptiles	15	0	0	0	0
Birds	93^{6}	4	0	0	29^{2}
Non-Volant Mammals	8^{6}	0	0	1	0
Volant Mammals (Bats)	8	0	0	0	0
Total	**132^{12}**	**4**	**0**	**1**	**29^{2}**

Superscript = number of introduced species included in total.

Not all species listed as potentially occurring within the subject site in existing databases and publications (i.e. *EPBC Act* Threatened Fauna and Migratory species lists, DBCA's NatureMap database, various reports and publications) are shown in the expected listing in Appendix B. Some species have been excluded from this list based largely on the lack of suitable habitat within the subject site and in the general area or known local extinction, even if suitable habitat is present.

Despite the omission of some species it should be noted that the list provided is still very likely an over estimation of the fauna species utilising the subject site (either on a regular or infrequent basis) as a result of the precautionary approach adopted for the assessment. At any one time only a subset of the listed potential species are likely to be present within the bounds of the subject site.

As most of the subject site is cleared the majority represents unsuitable habitat for many of the potential species listed. Most, if present, would be confined to the small areas of remnant native bushland and even in these areas only a subset of the species listed are likely to be present at any one time.

6.3.2 Vertebrate Fauna of Conservation Significance

A review of the *EPBC Act* threatened fauna list, DBCA's Threatened Fauna Database and Priority List, unpublished reports and scientific publications identified a number of specially protected, priority or migratory vertebrate fauna species as potentially occurring in the general vicinity of the subject site. Of these species, most that have no potential whatsoever to utilise the subject site for any purpose have been omitted from the potential list (Appendix B), principally due to lack of suitable habitat (including extent and/or quality) or known local extinction.

In summary, three vertebrate fauna species of conservation significance were positively identified as utilising the subject site for some purpose during the survey period, these being:

- *Calyptorhynchus latirostris* Carnaby`s Black-Cockatoo – S2 (*WC Act*), Endangered (*EPBC Act*)
  Some foraging evidence attributed to this species was found during field survey (chewed pine cones). The small areas of remnant native vegetation containing marri, coastal blackbutt and banksia trees (in addition to some scattered individual trees) within the subject site represents foraging habitat for this species. Larger native endemic trees (≥50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

- *Calyptorhynchus banksii naso* Forest Red-tailed Black-Cockatoo – S3 (*WC Act*), Vulnerable (*EPBC Act*)
  Some foraging evidence attributed to this species was found during field survey (chewed marri fruits). The small areas of remnant native vegetation containing marri, coastal blackbutt and sheoak trees (in addition to some scattered individual trees) within the subject site represents foraging habitat for this species. Larger native endemic trees (≥50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

- *Calyptorhynchus baudinii* Baudin`s Black-Cockatoo – S3 *(WC Act),* Endangered (*EPBC Act*)
  Some foraging evidence attributed to this species was found during field survey (chewed marri fruits). The small areas of remnant native vegetation containing marri and banksia trees (in addition to some scattered individual trees) within the subject site represents foraging habitat for this species. Larger native endemic trees (≥50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

Based on the habitats present and current documented distributions it is considered possible that several additional species of conservation significance may use the subject site for some purpose at times, though, as no evidence of any using the subject site at the time of the field survey was found, the status of some in the area remains uncertain.

These species are:

- *Falco peregrinus* Peregrine Falcon – S7 (*WC Act*)
  This species potentially utilises some sections of the subject site as part of a much larger home range. No evidence of nesting was observed and the probability of this species breeding within the subject site can be considered to be very low.

- *Isoodon fusciventer* Quenda – P4 (DBCA Priority Species)
  No evidence of the quenda was observed but it is known to persist in paddocks with dense grasses and small remnants in nearby areas so may occur in the subject site. Most of the subject site is however unsuitable for this species to use as habitat.

Habitat for some of these species on-site, while considered possibly suitable, may be marginal in extent/quality and species listed may only visit the area for short periods, or as rare/uncommon vagrants/transients.

As previously indicated a number of other species of conservation significance, while possibly present in the wider area (e.g. forested areas of the nearby Darling Range), are not listed as potential species due to known localised extinction (and no subsequent recruitment from adjoining areas), lack of suitable habitat and/or the presence of feral predators. Details on conservation significant species and reasons for the omission of some from the potential listing are provided in Appendix D and Table 3.

Twenty six bird species that potentially frequent or occur in the subject site are noted as Bush Forever Decreaser Species in the Perth Metropolitan Region (six were sighted/identified as having used the within the subject site during the survey). Decreaser species are a significant issue in biodiversity conservation in the Perth section of the Swan Coastal Plain as there have been marked reductions in range and population levels of many sedentary bird species as a consequence of disturbance and land clearing (Dell & Hyder-Griffiths 2002).

6.3.3 Invertebrate Fauna of Conservation Significance

Five invertebrate species of conservation significance appeared in the DBCA or *EPBC Act* database searches (DBCA 2018b, DotEE 2018), these being an unnamed cricket (*Kawaniphila pachomai*), two unnamed bees (*Leioproctus bilobatus* & *Leioproctus douglasiellus*), the short-tongued bee (*Neopasiphae simplicior*) and Carter's freshwater mussel (*Westralunio carteri*).

None of these species are considered likely to persist within the subject site due to a total absence of suitable habitat, local extinction and/or because the area is outside of their currently documented range. Additional information on each species can be found in Appendix D.

7. FAUNA VALUES

7.1 CONSERVATION SIGNIFICANCE OF THE SUBJECT SITE

The conservation significance of the subject site has been determined by applying site specific criteria such as:

- Fauna species and/or habitat present within the subject site that is poorly represented in the general vicinity;
- Fauna habitat within the subject site supporting species of conservation or other significance; and
- Fauna habitat within the subject site in better condition than other similar locations in the general vicinity.

The majority of the subject site is cleared and as a consequence the diversity of fauna species has been significantly reduced from its original natural levels. Habitat degradation as a result of partial clearing, altered fire regimes and the presence of introduced predators is also likely to have had a significant effect on species diversity in the remnants that remain. Because of these factors most of the site has very little conservation significance to fauna in general. This is to a certain extent supported by the fact that none of the vegetation remaining on site was selected for inclusion in bush forever while some nearby remnants were (Government of Western Australia 2000a).

The site does have some value principally as foraging habitat for black cockatoos but the extent of this vegetation, relative to that present in nearby reserved/national park areas, is relatively small. Some of the larger remnants are also likely to provide habitat for of native fauna species of conservation significance (e.g. quenda) in a largely cleared landscape and the retention and ongoing management of this areas should be considered during development planning, though there very small size and degree of fragmentation limits there long term viability.

7.2 VALUE OF THE SUBJECT SITE AS AN ECOLOGICAL LINKAGE/WILDLIFE CORRIDOR

Wildlife or ecological corridors are considered to provide avenues for the movement of individuals and populations of both flora and fauna. An ecological corridor is defined as ‘habitat that permits the movement of organisms between ecological isolates’ and linkage with adjacent bushland areas is therefore a natural attribute of high priority in the assessment of any sites significance. These corridors can be important for the survival of species as they provide access to feeding and breeding locations as well as access to other populations and therefore to a wider gene pool (Newmark 1993).

Within Bush Forever Volume 1 (Figure 6 - Government of Western Australia 2000a) conceptual “greenway” corridors are shown. The subject site is not shown as forming part of recognised greenway corridor. The remnant native vegetation present very fragmented and does not constitute a fauna corridor or ecological linkage of any significance.

8. POTENTIAL IMPACTS AND DEVELOPMENT CONSIDERATIONS

8.1 POTENTIAL IMPACTS OF DEVELOPMENT

In general the most significant impacts to fauna of any development include:

- Loss of vegetation/fauna habitat that may be used for foraging, breeding, roosting, or dispersal (includes loss of hollow bearing trees);
- Fragmentation of vegetation/fauna habitat which may restrict the movement of some fauna species;
- Modifications to surface hydrology, siltation of creek lines;
- Changes to fire regimes;
- Pollution (e.g. oil spills);
- Noise/light/dust;
- Spread of plant pathogens (e.g. dieback) and weeds;
- Potential increase in the number of predatory introduced species (e.g. cats);

- Death or injury of fauna during clearing and construction; and
- An increase in fauna road kills subsequent to development.

The exact extent of development within the subject site is not known at this stage. However, assuming that the area is developed for light industrial purposes in accordance the City of Gosnell's LSP it is expected that the majority of the remnant vegetation would be removed. Based on this assumption possible impacts on specific species of conservation significance previously recorded in the general area is provided in the table below. Additional information on those species listed is provided in Appendix D.

Table 3: Likelihood of Occurrence and Possible Impacts – Fauna Species of Conservation Significance **(continues on following pages).**

Common Name	Genus & Species	Conservation Status (See Appendix A for codes)	Habitat Present	Likelihood of Occurrence	Maximum Possible Impacts
Unnamed Cricket	*Kawaniphila pachomai*	P1	No	Would Not Occur.	No impact.
Unnamed Bee	*Leioproctus bilobatus*	P2	No	Would Not Occur.	No impact.
Short-tongued Bee	*Neopasiphae simplicior*	S2, CR	No	Would Not Occur.	No impact.
Unnamed Bee	*Leioproctus douglasiellus*	S2, VU	No	Would Not Occur.	No impact.
Carter's Freshwater Mussel	*Westralunio carteri*	S3, VU	No	Would Not Occur.	No impact.
Perth Lined Lerista	*Lerista lineata*	P3	No	Would Not Occur.	No impact.
Darling Range Heath Ctenotus	*Ctenotus delli*	P4	No	Would Not Occur.	No impact.
Coastal Plains Skink	*Ctenotus ora*	P3	No	Would Not Occur.	No impact.
Black-striped Snake	*Neelaps calonotos*	P3	No	Would Not Occur.	No impact.
Southern Death Adder	*Acanthophis antarcticus*	P3	No	Would Not Occur.	No impact.
Malleefowl	*Leipoa ocellata*	S3, VU	No	Would Not Occur. - species locally extinct.	No Impact.
Australasian Bittern	*Botaurus poiciloptilus*	S2, EN	No	Would Not Occur.	No impact.
Glossy Ibis	*Plegadis falcinellus*	S5, Mig	No	Would Not Occur.	No impact.
Painted Snipe	*Rostratula benghalensis*	S2, Mig, EN	No	Would Not Occur.	No impact.
Migratory Shorebirds/Wetland Species	Various	S5, Mig, Various	No	Would Not Occur.	No impact.
Blue-billed Duck	*Oxyura australis*	P4	No	Would Not Occur.	No impact.
Osprey	*Pandion haliaetus*	S5, Mig	No	Would Not Occur.	No impact.

Common Name	Genus & Species	Conservation Status (See Appendix A for codes)	Habitat Present	Likelihood of Occurrence	Maximum Possible Impacts
Peregrine Falcon	*Falco peregrinus*	S7	Yes	Possible but only rarely.	Loss/modification of very small areas of degraded habitat. Significant impact not likely.
Fork-tailed Swift	*Apus pacificus*	S5, Mig	Yes	Unlikely to Occur, Flyover only on very rare occasions.	No impact.
Grey Wagtail	*Motacilla cinerea*	S5, Mig	No	Would Not Occur.	No impact.
Carnaby`s Black Cockatoo	*Calyptorhynchus latirostris*	S2, EN	Yes	Known to Occur	Loss/modification of small areas of habitat. Significant impact not likely.
Baudin`s Black Cockatoo	*Calyptorhynchus baudinii*	S3, EN	Yes	Known to Occur.	Loss/modification of small areas of habitat. Significant impact not likely.
Forest Red-tailed Black Cockatoo	*Calyptorhynchus banksii naso*	S3, VU	Yes	Known to Occur.	Loss/modification of small areas of habitat. Significant impact not likely.
Chuditch	*Dasyurus geoffroii*	S3, VU	No	Would Not Occur.	No impact.
South-western Brush-tailed Phascogale	*Phascogale tapoatafa wambenger*	S3	No	Unlikely to Occur.	No impact.
Quenda	*Isoodon fusciventer*	P4	Yes	Possibly Occurs.	Loss/modification of small areas of habitat. Significant impact not likely.
Numbat	*Myrmecobius fasciatus*	S3, VU	No	Would Not Occur - species locally extinct.	No Impact.
Western Ringtail Possum	*Pseudocheirus occidentalis*	S2, VU	No	Would Not Occur - species locally extinct.	No Impact.
Woylie	*Bettongia penicillata ogibyi*	S1, EN	No	Would Not Occur - species locally extinct.	No Impact.
Quokka	*Setonix brachyurus*	S3, VU		Would Not Occur - species locally extinct.	
Western Brush Wallaby	*Macropus irma*	P4	No	Would Not Occur.	No impact.
Water Rat	*Hydromys chrysogaster*	P4	No	Would Not Occur	No impact.

8.2 CONSIDERATIONS FOR PLANNING AND DEVELOPMENT

With respect to vertebrate fauna in general, no significant impacts are anticipated as a consequence of development at the site. In cases where some impact is anticipated, the degree of the impact is only expected to be low and relates to the loss of small areas of habitat. As most species are common and widespread no overall change in their conservation status is anticipated, despite a possible localised reduction in habitat extent. There are substantial areas of similar habitat in nearby areas including some nature reserves/regional parks and most if, not all species likely to utilise the subject site will persist in these locations despite any future development.

The assessment does indicate that any considerations required during ongoing development planning would be limited to the presence of habitat used or potentially used by some threatened fauna species in particular those listed under the *EPBC Act*, namely the three species of black cockatoo. The proposed development area is however made up of numerous individual lots with different landowners potentially undertaking “actions” as separate entities, and therefore possible “impacts” in each lot are likely to be assessed individually by the proponents. The overall extent of native vegetation is also very small (~4.4 ha).

With this in mind it is considered highly unlikely that impacts on black cockatoos that may occur as a result of development at any scale within each individual landholding would be considered a “significant impact” as defined by the Commonwealth DotEE (DotE 2013).

While the retention of areas of vegetation potentially utilised by black cockatoos should be considered during the planning process, based on the assessment above it is not likely to represent a constraint to development in any one lot.

This conclusion is primarily based on the fact that most of the individual lots are totally cleared or almost totally cleared of natural vegetation and therefore don’t contain significant areas of potential cockatoo habitat. Where some habitat is present it is limited in extent and patchy in distribution. Also, given the presence of significant areas of better quality habitat to the east (Darling Range forests) black cockatoos are considered far more likely to frequent these areas than to be specifically attracted to vegetation within the subject site itself.

The subject site is also not located in a documented cockatoo breeding area, and while some trees present may qualify as “potential breeding habitat” using DotEE criteria (Commonwealth of Australia 2012) the probability of any one tree actually developing hollows that would then be used by black cockatoos for breeding can be considered to be extremely low. The area is also unlikely to be considered of specific importance for the recovery of black cockatoos in the long term. For example the population growth of the Carnaby’s black-cockatoo is primarily limited by factors associated with breeding, and consequently priority areas for the recovery of the species are currently focused on known breeding sites (Cale 2003).

9. CONCLUSION

The fauna assessment within the subject site was undertaken for the purposes of categorising the fauna assemblages and identifying fauna habitats present. A targeted assessment of black cockatoo habitat within the area was also carried out.

With respect to native vertebrate fauna, 10 mammals (includes eight bat species), 87 bird, 15 reptile and eight frog species have previously been recorded in the general area, some of which have the potential to occur in or utilise sections of the subject site at times, a conclusion largely based on the presence of apparently suitable habitat.

Of the 120 native animals that are listed as potentially occurring in the area, four are considered to be endangered/vulnerable or in need of special protection under State and/or Commonwealth legislation, these being the three species of black cockatoo and the peregrine falcon. In addition, the Priority 4 quenda may occur, though habitat for this species appears largely marginal in quality.

With respect to vertebrate fauna in general, no significant impacts are anticipated as a consequence of development at the site. In cases where some impact is anticipated, the degree of the impact is only expected to be low and relates to the loss of small areas of habitat. As most species are common and widespread no overall change in their conservation status is anticipated, despite a possible localised reduction in habitat extent.

Based on available information it is considered at this stage very unlikely that impacts on black cockatoos (or any other *EPBC Act* listed threatened or migratory species) which may occur as a result of development at any scale within the subject site will result in a “significant impact” as defined by the Commonwealth DotEE (DotE 2013).

10. REFERENCE

360 Environmental (2012). Black Cockatoo Survey – Maddington Kenwick Strategic Employment Area. Unpublished report for the City of Gosnells.

Allen, G.R., Midgley, S.H., Allen, M. (2003). Freshwater Fishes of Australia. Western Australian Museum, Perth, Western Australia.

Anstis, M. (2013). Tadpoles and Frogs of Australia. New Holland Publishers, Sydney.

Aplin, K.P. and Smith, L.A. (2001). Checklist of the frogs and reptiles of Western Australia, Records of the Western Australian Museum Supplement No. 63, 51-74.

ATA (1994). A Report of a Fauna Survey of Perth Airport. Report 93/78. Unpublished report for the Federal Airports Corporation.

ATA Environmental (2006). Vertebrate Fauna Assessment Brookdale Redevelopment Area. Unpublished report for the Armadale Redevelopment Authority.

Bancroft, W., Moore, A., & Bamford, M. (2017). Black-cockatoo values of the Maddington Kenwick Strategic Employment Area (MKSEA) Precinct 3A (Kenwick/Wattle Grove). Unpublished report for Emerge Associates.

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). The New Atlas of Australian Birds. Royal Australasian Ornithologists Union, Victoria.

Bush, B., Maryan, B., Browne-Cooper, R. & Robinson, D. (2007). Reptiles and Frogs in the Bush: Southwestern Australia. UWA Press, Nedlands.

Bush, B., Maryan, B., Browne-Cooper, R. & Robinson, D. (2010). Reptiles and Frogs of the Perth Region. UWA Press, Nedlands.

Cale, B. (2003). Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan 2002-2012. CALM, Wanneroo.

Christidis, L. and Boles, W.E. (2008). Systematics and Taxonomy of Australian Birds. CSIRO Publishing, Melbourne.

Cogger, H.G. (2014). Reptiles and Amphibians of Australia. 7th Edition. CSIRO Publishing.

Commonwealth of Australia (2012). *EPBC Act* Referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered) *Calyptorhynchus latirostris*, Baudin's cockatoo (vulnerable) *Calyptorhynchus baudinii*, Forest red-tailed black cockatoo (vulnerable) *Calyptorhynchus banksii naso*.

Dell, J. (pers.comm) (1994). Results of Western Australia Museum Surveys, December 1986 to April 1990.

Dell, J. (2000). A draft summary assessment of the fauna values of the Kemerton Bushland. Unpublished report for the Conservation Branch, Policy Division, Department of Environmental Protection.

Department of Biodiversity, Conservation and Attractions (DBCA) (2018a). Threatened and Priority Fauna Rankings. 15 February 2018.

Department of Biodiversity, Conservation and Attractions (DBCA) (2018b). NatureMap Database search. "By Circle" - 116° 00' 02" E, 32° 01' 46" S (plus 10km buffer), accessed 25/02/2018.

Department of Conservation and Land Management (CALM) (2005). Fauna Note No. 05/2005 Carnaby's Cockatoo, Written by Tamra Chapman, Belinda Cale and Marion Massam. CALM, Wanneroo.

Department of Environment and Conservation (DEC) (2007a). Karrak-watch: A summary of information about the Forest red-tailed black cockatoo, http://www.dec.wa.gov.au/our-environment/science-and-research/animal-conservation-research/2384-karrak-watch-the-forest-red-tailed-black-cockatoo.html

Department of Environment and Conservation (DEC) (2007b). Forest Black Cockatoo (Baudin's Cockatoo - *Calyptorhynchus baudinii*) and Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) Recovery Plan. DEC.

Department of Environment and Conservation (DEC) (2012a). Chuditch (*Dasyurus geoffroii*) Recovery Plan. Wildlife Management Program No. 54. Department of Environment and Conservation, Perth, Western Australia.

Department of Environment and Conservation (DEC) (2012b). Carnaby's cockatoo (*Calyptorhynchus latirostris*) Recovery Plan. Department of Environment and Conservation, Perth, Western Australia.

Department of the Environment (DotE) (2013). Matters of National Environmental Significance. Significant Impact Guidelines 1.1, *EPBC Act 1999*.

Department of the Environment and Energy (DotE) (2018). *EPBC Act* Protected Matters Report: Point Search -32.0295 116.00048 (0km Buffer) Available from: http://www.environment.gov.au. Accessed 25/02/2018.

Emerge Associates (Emerge) (2018). Maddington Kenwick Strategic Employment Area Precinct 1 - Flora and Vegetation Survey. Unpublished report for City of Gosnells.

ENV Australia (2005). Southern River Precinct 3 - Environmental Review. Unpublished report for the City of Gosnells.

EPA (2016). Technical Guidance – Terrestrial Vertebrate Fauna Surveys (replaces EPA (2004). Guidance for the Assessment of Environmental Factors No 56: Terrestrial Surveys for Environmental Impact Assessment, but not yet updated).

Glauret, L. (1961). A Handbook of the Lizards of Western Australia. Handbook 6, Western Australian Naturalists Club, Perth.

Government of Western Australia (1998). Perth Bushplan

Government of Western Australia (2000a). Bush Forever Volume 1. Policies, Principles and Processes. Department of Environmental Protection Perth, Western Australia.

Government of Western Australia (2000b). Bush Forever Volume 2. Directory of Bush Forever Sites. Department of Environmental Protection Perth, Western Australia.

Government of Western Australia (2018). Wildlife Conservation Act 1950. Wildlife Conservation (Specially Protected Fauna) Notice 2017. Government Gazette, WA. 16 January 2018.

Harewood, G. (2009). Fauna Assessment (Level 1) – Mills Park - Beckenham. Unpublished report for Cardno (WA) Pty Ltd.

Harewood, G. (2014). Fauna Assessment - Hazelmere Precinct 9A. Unpublished report for Emerge Associates.

Harewood, G. (2016). Fauna Assessment - Maddington Kenwick Strategic Employment Area – Precinct 3 - City of Gosnells. Unpublished report for Emerge Associates.

Harvey, M.S., Dell, J. How R.A.., & Waldock, J.M. (1997). Ground Fauna of Bushland Remnants on the Ridge Hill Shelf and Pinjarra Plain Landforms, Perth. Report to the Australian Heritage Commission. NEP Grant N95/49. 56 pp.

Harvey, M. S. (2002). Short-range endemism among the Australian fauna: some examples from non-marine environments. Invertebrate Systematics 16: 555-570.

Harvey, M.S., Dell, J. How, R.A.., & Waldock, J.M. (1987). Ground Fauna of Bushland Remnants on the Ridge Hill Shelf and Pinjarra Plain Landforms, Perth. Report to the Australian Heritage Commission. NEP Grant N95/49. 56 pp.

Heddle, E.M., Loneragan, O.W. and Havel, J.J. (1980). Vegetation of the Darling System, In: Atlas of Natural Resources, Darling System, Western Australia Department of Conservation and Environment, Perth, Western Australia.

Higgins, P. J. (Ed.) (1999). Handbook of Australian, New Zealand and Antarctic Birds. Volume 4: Parrots to Dollarbird. Oxford University Press, Melbourne, Australia.

How, R.A (1995). Objection Assessment of Fauna Values for Perth Airport. Unpublished report for the Australian Heritage Commission.

How, R.A, Harvey, M.S., Dell J., & Waldock, J.M. (1996). Ground Fauna of Urban Bushland Remnants in Perth. Report to the Australian Heritage Commission. NEP Grant N93/04. 103 pp.

How, R., Cooper, N. K. and Bannister, J. L. (2001). Checklist of the mammals of Western Australia, Records of the Western Australian Museum Supplement No. 63, 91-98.

Jackson, S. & Groves, C. (2015). Taxonomy of Australian mammals. CSIRO Publishing.

Johnstone, R.E. (2001). Checklist of the birds of Western Australia, Records of the Western Australian Museum Supplement No. 63, 75-90.

Johnstone, R. E. (2008). Assessment of Potential Impact to Carnaby's Cockatoo and Baudin's Cockatoo for Southern Seawater Desalination Plant Binningup to Harvey. Prepared for URS Australia Pty Ltd.

Johnstone, R. E. & Kirkby, T. (2008). Distribution, status, social organisation, movements and conservation of Baudin's Cockatoo (*Calyptorhynchus baudinii*) in South-west Western Australia. Records of the WA Museum 25: 107-118 (2008).

Johnstone, R. E. & Kirkby, T. (2011). Carnaby's Cockatoo (*Calyptorhynchus latirostris*), Baudin's Cockatoo (*Calyptorhynchus baudinii*) and the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) on the Swan Coastal Plain (Lancelin–Dunsborough), Western Australia. Studies on distribution, status, breeding, food, movements and historical changes. Report for the Department of Planning, Western Australia.

Johnstone R.E. & C, Kirkby, T. & Biota Environmental Sciences Pty Ltd (2006). Perth – Bunbury Highway (Kwinana Freeway Extension and Peel Deviation). Targeted Threatened Fauna Survey. Unpublished report for Main Roads Western Australia.

Johnstone, R.E. and Storr, G.M. (1998). Handbook of Western Australian Birds: Volume 1 – Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth Western Australia.

Johnstone, R. E. and Storr, G.M. (2004). Handbook of Western Australian Birds: Volume 2 – Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth Western Australia.

Johnstone, R.E. & C (2004). Review of Baudin's Cockatoo and Forest Red-Tailed Black Cockatoo in South Western Australia with Special Reference to Collie Area – In Bluewater's Power Station PER May 2004 – Appendix C.

Menkhorst, P. and Knight, F. (2011). A Field Guide to the Mammals of Australia. Oxford University Press, Melbourne.

Morcombe, M. (2004). Field Guide to Australian Birds. Steve Parish Publishing, Archerfield, Queensland.

Morgan, D.L., Beatty, S.J., Klunzinger, M.W, Allen, M.G. and Burnham, Q.E (2011). Field Guide to the Freshwater Fishes, Crayfishes and Mussels of South Western Australia. Published by SERCUL.

Nevill, S (ed) (2005). Guide to the Wildlife of the Perth Region. Simon Nevill Publications, Perth.

Newmark, W.D. (1993). The Role and Design of Wildlife Corridors with Examples from Tanzania., Ambio 22, 500-504.

Pizzey, G & Knight, F. (2012). The field guide to the birds of Australia. 9th Edition. Harper Collins, Sydney.

Saunders, D. A. (1974). Breeding biology of the Short-billed form of the White-tailed Black Cockatoo *Calyptorhynchus baudinii latirostris* (Carnaby). Emu 74: 292-293.

Saunders, D. A. (1979a). The availability of tree hollows for use as nest sites by White-tailed Black Cockatoos. Australian Wildlife Research 6: 205-216.

Saunders, D. A. (1979b). Distribution and taxonomy of the White-tailed and Yellow-tailed Black-Cockatoos *Calyptorhynchus* spp. Emu 79.

Saunders, D. (1980). Food and Movements of the Short-billed Form of the White-tailed Black Cockatoo. Aust. Wildl. Res. 7(1980) pp. 257-269.

Saunders, D. A. (1986). Breeding season, nestling success and nestling growth in Carnaby's Black-Cockatoo, *Calyptorhynchus funereus latirostris*, over 16 years at Coomallo Creek, and a method for assessing the viability of populations in other areas. Australian Wildlife Research 13: 261-273.

Saunders, D. A., Smith, G. T. and Rowley, I. (1982). The availability and dimensions of tree hollows that provide nest sites for cockatoos (Psittaciformes) in Western Australia. Australian Wildlife Research 9: 541-556.

Simpson, K. and Day, N. (2010). Field Guide to the Birds of Australia. Penguin Books, Ringwood.

Sorena M. and T. Soderquist (1995). Western Quoll *Dasyurus geoffroyi*. pp 62-64 in Strahan R. (ed). (1995). The Mammals of Australia. Australian Museum / Reed Books.

Soderquist T. (1995). Brush-tailed Phascogale *Phascogale tapoatafa*. pp 104-106 in Strahan R. (ed). (1995). The Mammals of Australia. Australian Museum / Reed Books.

Storr, G.M., Smith, L.A. and Johnstone R.E. (1983). Lizards of Western Australia II: Dragons and Monitors. WA Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone R.E. (1990). Lizards of Western Australia III: Geckos and Pygopods. WA Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone R.E. (1999). Lizards of Western Australia I: Skinks. Revised Edition, WA Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone R.E. (2002). Snakes of Western Australia. Revised Edition, WA Museum, Perth.

Tyler M.J., Smith L.A. and Johnstone R.E. (2000). Frogs of Western Australia, Revised Edition, WA Museum, Perth.

Turpin, J. and Bamford, M. (2009). Keane Road Strategic Link Armadale, Fauna Assessment. Unpublished report for EnviroWorks Consulting.

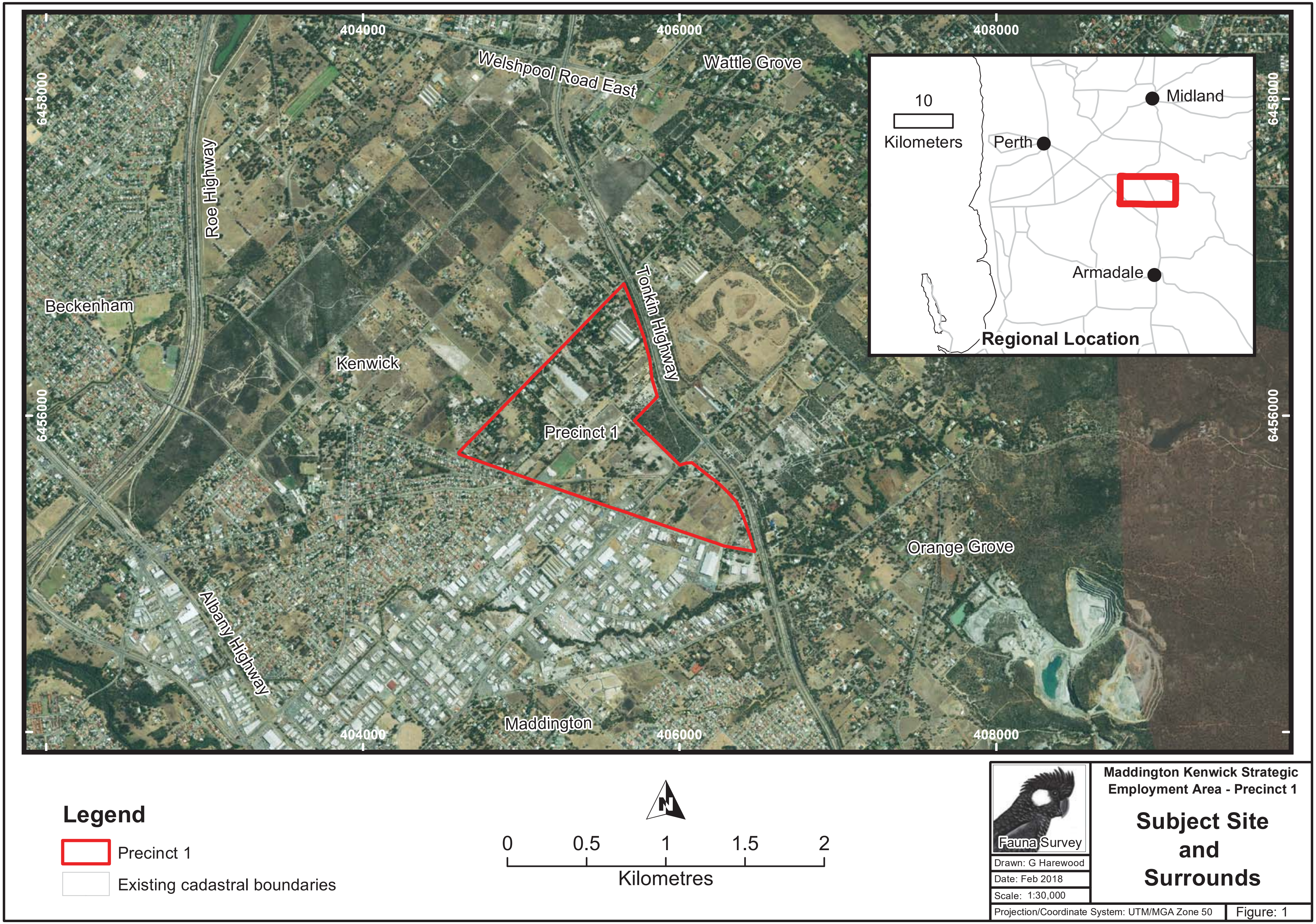
Van Dyck, S., Gynther, I. & Baker, A. Eds (2013). Field Companion to The Mammals of Australia. Queensland Museum.

Van Dyck, S. & Strahan, R. Eds (2008). The Mammals of Australia. Third edition Queensland Museum.

Wilson, S. and Swan, G. (2013). A Complete Guide to Reptiles of Australia. Reed, New Holland, Sydney.

Woinarski, J., Burbidge, A. & Harrison, P. (2014). The Action Plan for Australian Mammals 2012. CSIRO Publishing.

FIGURES



Maddington Kenwick Strategic Employment Area - Precinct 1

Subject Site and Surrounds

Drawn: G Harewood

Date: Feb 2018

Scale: 1:30,000

Projection/Coordinate System: UTM/MGA Zone 50

Figure: 1

Legend

Precinct 1 Boundary

N

0 100 200 300 400 500

Metres

Fauna Survey

Drawn: G Harewood

Date: Feb 2018

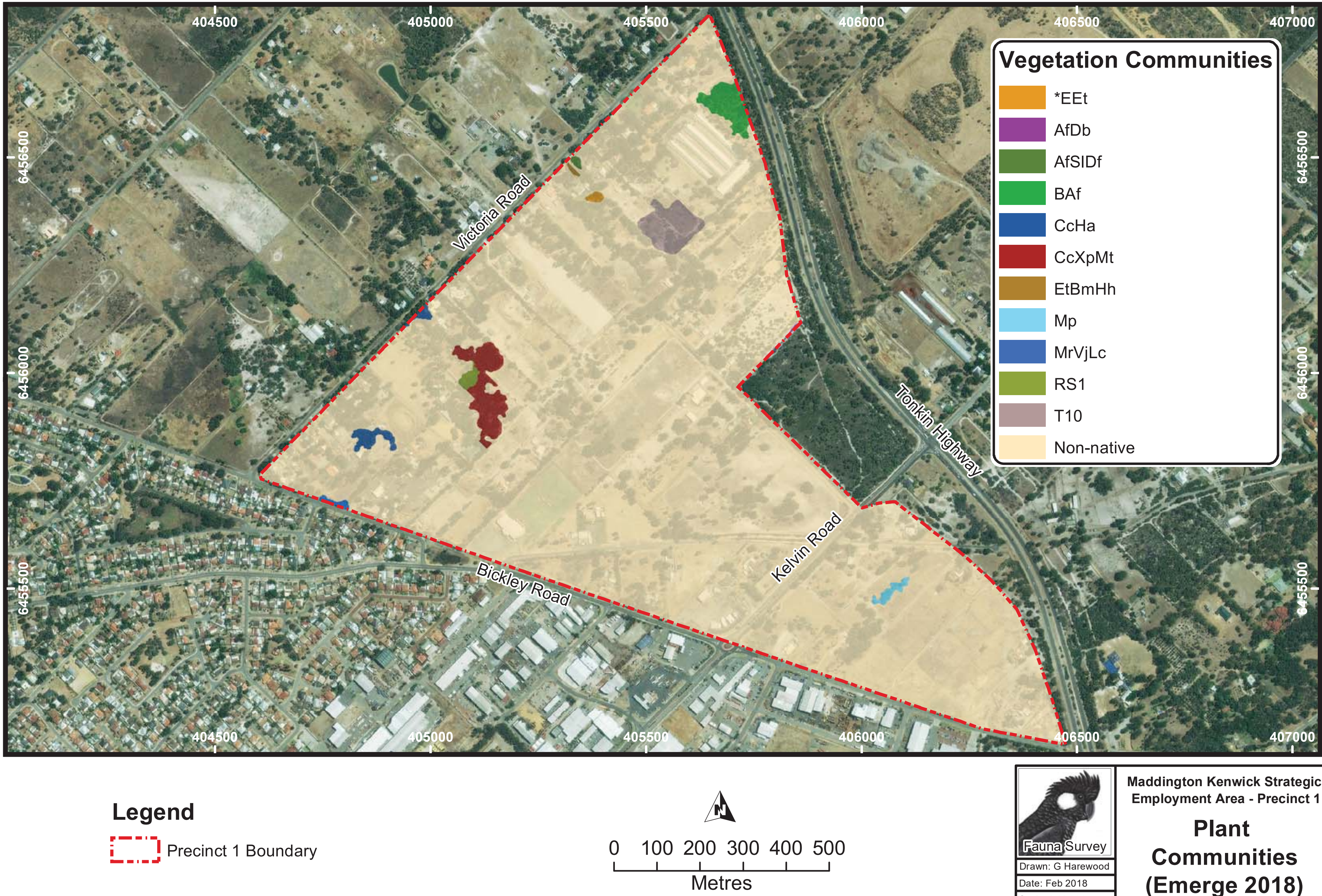
Scale: 1:11,000

Projection/Coordinate System: UTM/MGA Zone 50

Maddington Kenwick Strategic Employment Area - Precinct 1

Subject Site Air Photo

Figure: 2



Maddington Kenwick Strategic Employment Area - Precinct 1

Plant Communities (Emerge 2018)

Drawn: G Harewood

Date: Feb 2018

Scale: 1:11,000

Projection/Coordinate System: UTM/MGA Zone 50

Figure: 3

APPENDIX A

CONSERVATION CATEGORIES

EPBC Act (1999) Threatened Fauna Categories

Threatened fauna may be listed under Section 178 of the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) in any one of the following categories:

Category	Code	Description
Extinct	E	There is no reasonable doubt that the last member of the species has died.
*Extinct in the wild	EW	A species (a) is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
*Critically Endangered	CE	A species is facing an extremely high risk of extinction in the wild in the immediate future.
*Endangered	EN	A species: (a) is not critically endangered; and (b) is facing a very high risk of extinction in the wild in the near future.
*Vulnerable	VU	A species (a) is not critically endangered or endangered; and (b) is facing a high risk of extinction in the wild in the medium-term future.
Conservation Dependent	CD	A species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered
*Migratory	Migratory	(a) all migratory species that are: (i) native species; and (ii) from time to time included in the appendices to the Bonn Convention; and (b) all migratory species from time to time included in annexes established under JAMBA, CAMBA and ROKAMBA; and (c) all native species from time to time identified in a list established under, or an instrument made under, an international agreement approved by the Minister.
Marine	Ma	Species in the list established under s248 of the *EPBC Act*

Note: Only species in those categories marked with an asterix are matters of national environmental significance (NES) under the *EPBC Act*.

Wildlife Conservation (Specially Protected Fauna) Notice 2017 Categories

Published as Specially Protected under the *Wildlife Conservation Act 1950*, and listed under Schedules 1 to 7 of the Wildlife Conservation (Specially Protected Fauna) Notice.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

Category	Code	Description
Schedule 1 Critically Endangered species	CR	Threatened species considered to be facing an extremely high risk of extinction in the wild.
Schedule 2 Endangered species	EN	Threatened species considered to be facing a very high risk of extinction in the wild.
Schedule 3 Vulnerable species	VU	Threatened species considered to be facing a high risk of extinction in the wild.
Schedule 4 Presumed extinct species	EX	Species which have been adequately searched for and there is no reasonable doubt that the last individual has died.
Schedule 5 Migratory birds protected under an international agreement	IA	Birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and the Bonn Convention, relating to the protection of migratory birds.
Schedule 6 Fauna that is of special conservation need as conservation dependent fauna	CD	Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened.
Schedule 7 Other specially protected fauna.	OS	Fauna otherwise in need of special protection to ensure their conservation.

Western Australian DBCA Priority Fauna Categories

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

Category	Code	Description
Priority 1 Poorly Known Species.	P1	Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
Priority 2 Poorly Known Species.	P2	Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
Priority 3 Poorly Known Species.	P3	Species that are known from several locations and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
Priority 4 Rare, Near Threatened and other species in need of monitoring.	P4	(a) Rare: Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened: Species that are considered to have been adequately surveyed and that are close to qualifying for Vulnerable, but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

*Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

***IUCN Red List* Threatened Species Categories**

The *IUCN Red List of Threatened Species*™ is a checklist of taxa that have undergone an extinction risk assessment using the *IUCN Red List Categories and Criteria*.

Categories are summarized below.

Category	**Code**	**Description**
Extinct	EX	Taxa for which there is no reasonable doubt that the last individual has died.
Extinct in the Wild	EW	Taxa which is known only to survive in cultivation, in captivity or and as a naturalised population well outside its past range and it has not been recorded in known or expected habitat despite exhaustive survey over a time frame appropriate to its life cycle and form.
Critically Endangered	CR	Taxa facing an extremely high risk of extinction in the wild.
Endangered	EN	Taxa facing a very high risk of extinction in the wild.
Vulnerable	VU	Taxa facing a high risk of extinction in the wild.
Near Threatened	NT	Taxa which has been evaluated but does not qualify for CR, EN or VU now but is close to qualifying or likely to qualify in the near future.
Least Concern	LC	Taxa which has been evaluated but does not qualify for CR, EN, VU, or NT but is likely to qualify for NT in the near future.
Data Deficient	DD	Taxa for which there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status.
Not Evaluated	NE	Taxa which has not been evaluated.

A full list of categories and their meanings are available at:

http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria

APPENDIX B

FAUNA OBSERVED OR POTENTIALLY IN SUBJECT SITE

Fauna Observed or Potentially in Subject Site

MKSEA Precinct 1

Approximate centroid = 32.029497°S 116.000484°E

Compiled by Greg Harewood - February 2018
Recorded (Sighted/Heard/Signs/Captured) = X

A = Harewood, G. (2018). Fauna Assessment (Lecvel 1) Maddington Kenwick Strategic Employment Area Precinct 1. Unpublished report for Emerge Associates.
B = Harewood, G. (2016). Fauna Assessment Maddington Kenwick Strategic Employment Area Precinct 3. Unpublished report for Emerge Associates.
C = Turpin, J. and Bamford, M. (2009). Keane Road Strategic Link Armadale, Fauna Assessment. Unpublished report for the EnviroWorks Consulting.
D = ATA Environmental (2006). Vertebrate Fauna Assessment Brookdale Redevelopment Area. Unpublished report for the Armadale Redevelopment Authority.
E = ENV Australia (2005). Southern River Precinct 3 - Environmental Review. Unpublished report for the City of Gosnells.
F = ATA (1994). A Report of a Fauna Survey of Perth Airport. Report 93/78. Unpublished report for the Federal Airports Corporation.
How, R.A (1995). Objection Assessment of Fauna Values for Perth Airport. Unpublished report for the Australian Heritage Commission.
Dell, J. (pers.comm) (1994). Results of Western Australia Museum Surveys, December 1986 to April 1990.
Robson and Chester (1989). Report on the Aquatic Fauna of Munday Swamp as an Indicator of Environnmental Quality. Murdoch University.
Storey, A.W. et al (1993). Wetlands on the Swan Coastal Plain Volume 7. Waterbird Usage of Wetlands of the Swan Coastal Plain. EPA and Water Aurthority of WA.
G = DBCA (2018). NatureMap Database search. “By Circle” 116° 00' 02" E, 32° 01' 46" S – Subject Site (plus 10 km buffer). 25 February 2018.

Class / **Family** / *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Amphibia									
Myobatrachidae Ground or Burrowing Frogs									
Crinia georgiana	Quacking Frog	LC				X			X
Crinia glauerti	Clicking Frog	LC				X	X	X	X
Crinia insignifera	Squelching Froglet	LC			X	X	X	X	X
Geocrinia leai	Ticking Frog	LC							X
Heleioporus eyrei	Moaning Frog	LC				X	X	X	X
Limnodynastes dorsalis	Western Banjo Frog	LC			X	X	X	X	X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Hylidae Tree or Water-Holding Frogs									
Litoria adelaidensis	Slender Tree Frog	LC			X	X	X	X	X
Litoria moorei	Motorbike Frog	LC				X	X		X
Reptilia									
Gekkonidae Geckoes									
Christinus marmoratus	Marbled Gecko					X			X
Pygopodidae Legless Lizards									
Aprasia repens	Sandplain Worm Lizard					X			X
Lialis burtonis	Burton’s Legless Lizard					X	X	X	X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class Family *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Scincidae Skinks									
Acritoscincus trilineatum	Southwestern Cool Skink					X	X	X	
Cryptoblepharus buchananii	Fence Skink					X	X	X	X
Ctenotus fallens	West Coast Ctenotus							X	X
Egernia kingii	King's Skink								X
Hemiergis quadrilineata	Two-toed Mulch Skink							X	X
Lerista elegans	West Coast Four-toed Lerista					X	X	X	X
Menetia greyii	Dwarf Skink					X	X	X	X
Morethia lineoocellata	West Coast Pale-flecked Morethia					X			X
Morethia obscura	Shrubland Pale-flecked Morethia					X			X
Tiliqua rugosa	Bobtail				X	X	X	X	X
Elapidae Elapid Snakes									
Notechis scutatus	Tiger Snake					X	X		X
Pseudonaja affinis	Dugite					X	X	X	X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Aves									
Phasianidae Quails, Pheasants									
Coturnix pectoralis	Stubble Quail	LC					X		X
Coturnix ypsilophora	Brown Quail	LC				X			X
Anatidae Geese, Swans, Ducks									
Anas gracilis	Grey Teal	LC	X			X	X	X	X
Anas platyrhynchos	Mallard	Introduced					X		X
Anas superciliosa	Pacific Black Duck	LC	X	X	X	X	X	X	X
Chenonetta jubata	Australian Wood Duck	LC	X	X	X	X	X	X	X
Tadorna tadornoides	Australian Shelduck	LC		X	X	X	X	X	X
Ardeidae Herons, Egrets, Bitterns									
Ardea alba	Great Egret	CA JA						X	
Ardea ibis	Cattle Egret	CA JA							X
Ardea novaehollandiae	White-faced Heron	LC	X			X	X	X	X
Ardea pacifica	White-necked Heron	LC				X	X		X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Threskiornithidae Iibises, Spoonbills									
Threskiornis molucca	Australian White Ibis	LC	X	X		X	X	X	
Threskiornis spinicollis	Straw-necked Ibis	LC	X	X	X		X	X	X
Accipitridae Kites, Goshawks, Eagles, Harriers									
Accipiter cirrocephalus	Collared Sparrowhawk	Bp LC						X	X
Accipiter fasciatus	Brown Goshawk	Bp LC	X				X	X	X
Aquila audax	Wedge-tailed Eagle	Bp LC					X	X	X
Aquila morphnoides	Little Eagle	Bp LC						X	
Circus approximans	Swamp Harrier	LC							X
Circus assimilis	Spotted Harrier	LC							X
Elanus caeruleus	Black-shouldered Kite	LC	X				X	X	X
Haliastur sphenurus	Whistling Kite	Bp LC				X			X
Hamirostra isura	Square-tailed Kite	Bp LC							X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class Family *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Falconidae Falcons									
Falco berigora	Brown Falcon	Bp LC		X		X		X	X
Falco cenchroides	Australian Kestrel	LC			X	X	X	X	X
Falco longipennis	Australian Hobby	LC							X
Falco peregrinus	Peregrine Falcon	S7 Bp LC							X
Columbidae Pigeons, Doves									
Columba livia	Domestic Pigeon	Introduced					X		X
Ocyphaps lophotes	Crested Pigeon	LC			X	X	X	X	X
Phaps chalcoptera	Common Bronzewing	Bh LC			X	X	X	X	X
Streptopelia chinensis	Spotted Turtle-Dove	Introduced		X		X	X	X	X
Streptopelia senegalensis	Laughing Turtle-Dove	Introduced	X	X	X	X	X	X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Psittacidae Parrots									
Cacatua roseicapilla	Galah	LC	X	X	X	X	X	X	X
Cacatua sanguinea	Little Corella	LC					X		X
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	S3 VU Bp LC	X	X		X	X		X
Calyptorhynchus baudinii	Baudin's Black-Cockatoo	S2 EN Bp EN A3cde	X						X
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	S2 EN Bp EN A2bcde	X	X		X	X	X	X
Glossopsitta porphyrocephala	Purple-crowned Lorikeet	LC							
Neophema elegans	Elegant Parrot	LC				X		X	X
Platycercus icterotis icterotis	Western Rosella (western ssp)	Bp LC							X
Platycercus spurius	Red-capped Parrot	LC		X	X	X	X	X	X
Platycercus zonarius semitorquatus	Australian Ringneck Parrot	LC			X	X	X	X	
Polytelis anthopeplus	Regent Parrot	LC				X			X
Trichoglossus haematodus	Rainbow Lorikeet	Introduced		X	X	X	X		X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class / Family / *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Cuculidae Parasitic Cuckoos									
Cacomantis flabelliformis	Fan-tailed Cuckoo	LC				X			X
Chrysococcyx basalis	Horsfield's Bronze Cuckoo	LC			X	X	X	X	X
Chrysococcyx lucidus	Shining Bronze Cuckoo	LC	X		X	X	X	X	X
Cuculus pallidus	Pallid Cuckoo	LC			X			X	
Strigidae Hawk Owls									
Ninox novaeseelandiae	Boobook Owl	LC				X			X
Tytonidae Barn Owls									
Tyto alba	Barn Owl	LC				X			X
Podargidae Frogmouths									
Podargus strigoides	Tawny Frogmouth	LC				X			X
Halcyonidae Tree Kingfishers									
Dacelo novaeguineae	Laughing Kookaburra	Introduced	X	X		X	X	X	X
Todiramphus sanctus	Sacred Kingfisher	LC		X		X	X	X	X
Meropidae Bee-eaters									
Merops ornatus	Rainbow Bee-eater	JA LC	X	X		X	X	X	X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class Family *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Maluridae Fairy Wrens, GrassWrens									
Malurus splendens	Splendid Fairy-wren	Bh LC			X	X	X	X	X
Acanthizidae Thornbills, Geryones, Fieldwrens & Whitefaces									
Acanthiza apicalis	Broad-tailed Thornbill	Bh LC			X	X	X	X	X
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	Bh LC	X	X	X	X	X	X	X
Gerygone fusca	Western Gerygone	LC	X	X	X	X	X	X	X
Smicrornis brevirostris	Weebill	Bh LC		X	X	X			X
Pardalotidae Pardalotes									
Pardalotus punctatus	Spotted Pardalote	LC						X	X
Pardalotus striatus	Striated Pardalote	LC	X	X		X	X	X	X

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Class Family Species	Common Name	Conservation Status	A	B	C	D	E	F	G
Meliphagidae Honeyeaters, Chats									
Acanthorhynchus superciliosus	Western Spinebill	LC			X		X	X	X
Anthochaera carunculata	Red Wattlebird	LC	X	X	X	X	X	X	X
Anthochaera lunulata	Western Little Wattlebird	Bp LC			X	X	X	X	X
Epthianura albifrons	White-fronted Chat	LC						X	X
Lichenostomus virescens	Singing Honeyeater	LC		X	X	X	X	X	
Lichmera indistincta	Brown Honeyeater	LC	X	X	X	X	X	X	X
Manorina flavigula	Yellow-throated Miner	LC							X
Phylidonyris nigra	White-cheeked Honeyeater	Bp LC		X	X		X	X	
Phylidonyris novaehollandiae	New Holland Honeyeater	Bp LC	X		X		X	X	X
Petroicidae Australian Robins									
Microeca fascinans	Jacky Winter	LC							X
Petroica multicolor	Scarlet Robin	Bh LC				X			
Neosittidae Sitellas									
Daphoenositta chrysoptera	Varied Sittella	Bh LC						X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Pachycephalidae Crested Shrike-tit, Crested Bellbird, Shrike Thrushes, Whistlers									
Colluricincla harmonica	Grey Shrike-thrush	Bh LC			X	X	X		X
Pachycephala pectoralis	Golden Whistler	Bh LC		X	X			X	
Pachycephala rufiventris	Rufous Whistler	LC			X	X	X	X	X
Dicruridae Monarchs, Magpie Lark, Flycatchers, Fantails, Drongo									
Grallina cyanoleuca	Magpie-lark	LC	X	X	X	X	X	X	X
Rhipidura fuliginosa	Grey Fantail	LC		X	X	X	X	X	
Rhipidura leucophrys	Willie Wagtail	LC	X	X	X	X	X	X	X
Campephagidae Cuckoo-shrikes, Trillers									
Coracina novaehollandiae	Black-faced Cuckoo-shrike	LC	X	X	X	X	X	X	X
Lalage tricolor	White-winged Triller	LC				X	X	X	X
Artamidae Woodswallows, Butcherbirds, Currawongs									
Artamus cinereus	Black-faced Woodswallow	Bp LC					X	X	X
Artamus cyanopterus	Dusky Woodswallow	Bp LC						X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Cracticidae Currawongs, Magpies & Butcherbirds									
Cracticus tibicen	Australian Magpie	LC	X	X	X	X	X	X	X
Cracticus torquatus	Grey Butcherbird	LC		X	X	X	X	X	X
Corvidae Ravens, Crows									
Corvus coronoides	Australian Raven	LC	X	X	X	X	X	X	X
Motacillidae Old World Pipits, Wagtails									
Anthus australis	Australian Pipit	LC	X		X	X		X	X
Dicaeidae Flowerpeckers									
Dicaeum hirundinaceum	Mistletoebird	LC				X		X	X
Hirundinidae Swallows, Martins									
Hirundo ariel	Fairy Martin	LC						X	
Hirundo neoxena	Welcome Swallow	LC				X	X	X	X
Hirundo nigricans	Tree Martin	LC			X	X	X	X	
Sylviidae Old World Warblers									
Cincloramphus cruralis	Brown Songlark	LC	X					X	
Cincloramphus mathewsi	Rufous Songlark	LC						X	

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Class Family Species	Common Name	Conservation Status	A	B	C	D	E	F	G
Zosteropidae White-eyes									
Zosterops lateralis	Silvereye	LC		X	X	X	X	X	X
Mammalia									
Peramelidae Bandicoots									
Isoodon fusciventer	Quenda	P4 LC		X	X	X	X	X	
Phalangeridae Brushtail Possums, Cuscuses									
Trichosurus vulpecula	Common Brushtail Possum	LC				X			X
Molossidae Freetail Bats									
Ozimops kitcheneri	Southern Freetail-bat	LC							
Tadarida australis	White-striped Freetail-bat	LC							

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Vespertilionidae Ordinary Bats									
Chalinolobus gouldii	Gould's Wattled Bat	LC				X			X
Chalinolobus morio	Chocolate Wattled Bat	LC							X
Nyctophilus geoffroyi	Lesser Long-eared Bat	LC				X			X
Nyctophilus gouldi	Gould's Long-eared Bat	LC							X
Nyctophilus major major	Western Long-eared Bat	LC							
Vespadelus regulus	Southern Forest Bat	LC							X
Muridae Rats, Mice									
Mus musculus	House Mouse	Introduced				X	X	X	X
Rattus rattus	Black Rat	Introduced				X		X	X
Canidae Dogs, Foxes									
Canis lupus familiaris	Dog	Introduced			X	X			
Vulpes vulpes	Red Fox	Introduced		X	X	X	X	X	X
Felidae Cats									
Felis catus	Cat	Introduced			X	X	X		X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G
Leporidae Rabbits, Hares									
Oryctolagus cuniculus	Rabbit	Introduced		X	X	X	X	X	X

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APPENDIX C

DBCA & EPBC DATABASE SEARCH RESULTS

NatureMap
Mapping Western Australia's biodiversity

NatureMap - MKSEA - Precinct 1

Created By Greg Harewood on 25/02/2018

Kingdom	Animalia
Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	116° 00' 02'' E,32° 01' 46'' S
Buffer	10km
Group By	Species Group

Species Group	Species	Records
Amphibian	13	391
Bird	220	34019
Fish	6	29
Invertebrate	241	928
Mammal	35	986
Reptile	67	934
TOTAL	**582**	**37287**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Amphibian					
1.	25398	*Crinia georgiana (Quacking Frog)*			
2.	25399	*Crinia glauerti (Clicking Frog)*			
3.	25400	*Crinia insignifera (Squelching Froglet)*			
4.	25401	*Crinia pseudinsignifera (Bleating Froglet)*			
5.	25404	*Geocrinia leai (Ticking Frog)*			
6.	25409	*Heleioporus barycragus (Hooting Frog)*			
7.	25410	*Heleioporus eyrei (Moaning Frog)*			
8.	25412	*Heleioporus psammophilus (Sand Frog)*			
9.	25415	*Limnodynastes dorsalis (Western Banjo Frog)*			
10.	25378	*Litoria adelaidensis (Slender Tree Frog)*			
11.	25388	*Litoria moorei (Motorbike Frog)*			
12.	25420	*Myobatrachus gouldii (Turtle Frog)*			
13.	25433	*Pseudophryne guentheri (Crawling Toadlet)*			
Bird					
14.	24559	*Acanthagenys rufogularis (Spiny-cheeked Honeyeater)*			
15.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
16.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
17.	24262	*Acanthiza inornata (Western Thornbill)*			
18.	24265	*Acanthiza uropygialis (Chestnut-rumped Thornbill)*			
19.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
20.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
21.	24281	*Accipiter cirrocephalus subsp. cirrocephalus (Collared Sparrowhawk)*			
22.	25536	*Accipiter fasciatus (Brown Goshawk)*			
23.	24283	*Accipiter fasciatus subsp. didimus (Brown Goshawk)*			
24.	24282	*Accipiter fasciatus subsp. fasciatus (Brown Goshawk)*			
25.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
26.	24831	*Acrocephalus australis subsp. gouldi (Australian Reed Warbler)*			
27.	41323	*Actitis hypoleucos (Common Sandpiper)*		IA	
28.	24312	*Anas gracilis (Grey Teal)*			
29.	24313	*Anas platyrhynchos (Mallard)*			
30.	24315	*Anas rhynchotis (Australasian Shoveler)*			
31.	24316	*Anas superciliosa (Pacific Black Duck)*			
32.	47414	*Anhinga novaehollandiae (Australasian Darter)*			
33.		*Anser anser*			
34.	24561	*Anthochaera carunculata (Red Wattlebird)*			
35.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
36.	25670	*Anthus australis (Australian Pipit)*			
37.	24599	*Anthus australis subsp. australis (Australian Pipit)*			
38.	24285	*Aquila audax (Wedge-tailed Eagle)*			
39.	25557	*Ardea garzetta (Little Egret)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
40.	25559	*Ardea intermedia (Intermediate Egret)*			
41.	41324	*Ardea modesta (great egret, white egret)*		IA	
42.	24340	*Ardea novaehollandiae (White-faced Heron)*			
43.	24341	*Ardea pacifica (White-necked Heron)*			
44.	25560	*Ardea sacra (Eastern Reef Egret, Eastern Reef Heron)*			
45.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
46.	24352	*Artamus cinereus subsp. melanops (Black-faced Woodswallow)*			
47.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
48.	24356	*Artamus personatus (Masked Woodswallow)*			
49.	24318	*Aythya australis (Hardhead)*			
50.		*Barnardius zonarius*			
51.	24319	*Biziura lobata (Musk Duck)*			
52.	24359	*Burhinus grallarius (Bush Stone-curlew)*			
53.	25713	*Cacatua galerita (Sulphur-crested Cockatoo)*			
54.	25714	*Cacatua pastinator (Western Long-billed Corella)*			
55.	25715	*Cacatua roseicapilla (Galah)*			
56.	25716	*Cacatua sanguinea (Little Corella)*			
57.	24729	*Cacatua tenuirostris (Eastern Long-billed Corella)*	Y		
58.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
59.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
60.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
61.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black-Cockatoo)*		T	
62.	24733	*Calyptorhynchus baudinii (Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo)*		T	
63.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo)*		T	
64.	48400	*Calyptorhynchus sp. (white-tailed black cockatoo)*		T	
65.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
66.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
67.		*Chroicocephalus novaehollandiae*			
68.	24431	*Chrysococcyx basalis (Horsfield's Bronze Cuckoo)*			
69.	25601	*Chrysococcyx lucidus (Shining Bronze Cuckoo)*			
70.	24432	*Chrysococcyx lucidus subsp. plagosus (Shining Bronze Cuckoo)*			
71.	24288	*Circus approximans (Swamp Harrier)*			
72.	24289	*Circus assimilis (Spotted Harrier)*			
73.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
74.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
75.	24613	*Colluricincla harmonica subsp. rufiventris (Grey Shrike-thrush)*			
76.	24399	*Columba livia (Domestic Pigeon)*	Y		
77.	24361	*Coracina maxima (Ground Cuckoo-shrike)*			
78.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
79.	24362	*Coracina novaehollandiae subsp. novaehollandiae (Black-faced Cuckoo-shrike)*			
80.	24363	*Coracina novaehollandiae subsp. subpallida (Black-faced Cuckoo-shrike)*			
81.	25592	*Corvus coronoides (Australian Raven)*			
82.	24417	*Corvus coronoides subsp. perplexus (Australian Raven)*			
83.	24671	*Coturnix pectoralis (Stubble Quail)*			
84.	24420	*Cracticus nigrogularis (Pied Butcherbird)*			
85.	25595	*Cracticus tibicen (Australian Magpie)*			
86.	24422	*Cracticus tibicen subsp. dorsalis (White-backed Magpie)*			
87.	24423	*Cracticus tibicen subsp. tibicen (Black-backed Magpie)*			
88.	25596	*Cracticus torquatus (Grey Butcherbird)*			
89.	24424	*Cracticus torquatus subsp. torquatus (Grey Butcherbird)*			
90.	24322	*Cygnus atratus (Black Swan)*			
91.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
92.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
93.	24606	*Daphoenositta chrysoptera subsp. pileata (Varied Sittella, Black-capped Sitella)*			
94.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
95.	24470	*Dromaius novaehollandiae (Emu)*			
96.		*Egretta garzetta*			
97.		*Egretta novaehollandiae*			
98.		*Elanus axillaris*			
99.	24290	*Elanus caeruleus subsp. axillaris (Australian Black-shouldered Kite)*			
100.	47937	*Elseyornis melanops (Black-fronted Dotterel)*			
101.		*Eolophus roseicapillus*			
102.	24651	*Eopsaltria australis subsp. griseogularis (Western Yellow Robin)*			
103.	24652	*Eopsaltria georgiana (White-breasted Robin)*			
104.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
105.	24368	*Eurostopodus argus (Spotted Nightjar)*			
106.	25621	*Falco berigora (Brown Falcon)*			
107.	25622	*Falco cenchroides (Australian Kestrel, Nankeen Kestrel)*			

NatureMap
Mapping Western Australia's biodiversity

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
108.	24472	*Falco cenchroides subsp. cenchroides (Australian Kestrel, Nankeen Kestrel)*			
109.	25623	*Falco longipennis (Australian Hobby)*			
110.	24474	*Falco longipennis subsp. longipennis (Australian Hobby)*			
111.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
112.	24475	*Falco peregrinus subsp. macropus (Australian Peregrine Falcon)*		S	
113.	25727	*Fulica atra (Eurasian Coot)*			
114.	24761	*Fulica atra subsp. australis (Eurasian Coot)*			
115.	25729	*Gallinula tenebrosa (Dusky Moorhen)*			
116.	24763	*Gallinula tenebrosa subsp. tenebrosa (Dusky Moorhen)*			
117.	25730	*Gallirallus philippensis (Buff-banded Rail)*			
118.	24765	*Gallirallus philippensis subsp. mellori (Buff-banded Rail)*			
119.		*Gallus gallus*			
120.	42314	*Gavicalis virescens (Singing Honeyeater)*			
121.	24401	*Geopelia cuneata (Diamond Dove)*			
122.	25530	*Gerygone fusca (Western Gerygone)*			
123.	24271	*Gerygone fusca subsp. fusca (Western Gerygone)*			
124.	47962	*Glyciphila melanops (Tawny-crowned Honeyeater)*			
125.	24443	*Grallina cyanoleuca (Magpie-lark)*			
126.	24295	*Haliastur sphenurus (Whistling Kite)*			
127.	24296	*Hamirostra isura (Square-tailed Kite)*			
128.	47965	*Hieraaetus morphnoides (Little Eagle)*			
129.	25734	*Himantopus himantopus (Black-winged Stilt)*			
130.	24491	*Hirundo neoxena (Welcome Swallow)*			
131.		*Hydroprogne caspia*			
132.	24367	*Lalage tricolor (White-winged Triller)*			
133.	24511	*Larus novaehollandiae subsp. novaehollandiae (Silver Gull)*			
134.	25661	*Lichmera indistincta (Brown Honeyeater)*			
135.	24582	*Lichmera indistincta subsp. indistincta (Brown Honeyeater)*			
136.		*Lophoictinia isura*			
137.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
138.	25650	*Malurus elegans (Red-winged Fairy-wren)*			
139.	25651	*Malurus lamberti (Variegated Fairy-wren)*			
140.	24551	*Malurus pulcherrimus (Blue-breasted Fairy-wren)*			
141.	25654	*Malurus splendens (Splendid Fairy-wren)*			
142.	24552	*Malurus splendens subsp. splendens (Splendid Fairy-wren)*			
143.	24583	*Manorina flavigula (Yellow-throated Miner)*			
144.	25758	*Megalurus gramineus (Little Grassbird)*			
145.	25663	*Melithreptus brevirostris (Brown-headed Honeyeater)*			
146.	24587	*Melithreptus chloropsis (Western White-naped Honeyeater)*			
147.	24598	*Merops ornatus (Rainbow Bee-eater)*		IA	
148.		*Microcarbo melanoleucos*			
149.	25610	*Myiagra inquieta (Restless Flycatcher)*			
150.	25686	*Neochmia temporalis (Red-browed Finch)*	Y		
151.	24738	*Neophema elegans (Elegant Parrot)*			
152.	24739	*Neophema petrophila (Rock Parrot)*			
153.	25747	*Ninox connivens (Barking Owl)*			
154.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
155.	24742	*Nymphicus hollandicus (Cockatiel)*			
156.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
157.	24328	*Oxyura australis (Blue-billed Duck)*		P4	
158.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
159.	24624	*Pachycephala rufiventris subsp. rufiventris (Rufous Whistler)*			
160.		*Pandion cristatus*			
161.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
162.	24625	*Pardalotus punctatus subsp. punctatus (Spotted Pardalote)*			
163.	25682	*Pardalotus striatus (Striated Pardalote)*			
164.	24628	*Pardalotus striatus subsp. murchisoni (Striated Pardalote)*			
165.	24630	*Pardalotus striatus subsp. westraliensis (Striated Pardalote)*			
166.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
167.	48060	*Petrochelidon ariel (Fairy Martin)*			
168.	48061	*Petrochelidon nigricans (Tree Martin)*			
169.	48066	*Petroica boodang (Scarlet Robin)*			
170.	24659	*Petroica goodenovii (Red-capped Robin)*			
171.	25697	*Phalacrocorax carbo (Great Cormorant)*			
172.	25698	*Phalacrocorax melanoleucos (Little Pied Cormorant)*			
173.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
174.	25699	*Phalacrocorax varius (Pied Cormorant)*			
175.	24409	*Phaps chalcoptera (Common Bronzewing)*			
176.	25587	*Phaps elegans (Brush Bronzewing)*			
177.	48071	*Phylidonyris niger (White-cheeked Honeyeater)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
178.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
179.	24841	*Platalea flavipes (Yellow-billed Spoonbill)*			
180.	24842	*Platalea regia (Royal Spoonbill)*			
181.	25720	*Platycercus icterotis (Western Rosella)*			
182.	24745	*Platycercus icterotis subsp. icterotis (Western Rosella)*			
183.	24747	*Platycercus spurius (Red-capped Parrot)*			
184.	25721	*Platycercus zonarius (Australian Ringneck, Ring-necked Parrot)*			
185.	24750	*Platycercus zonarius subsp. semitorquatus (Twenty-eight Parrot)*			
186.	24751	*Platycercus zonarius subsp. zonarius (Port Lincoln Parrot)*			
187.	24843	*Plegadis falcinellus (Glossy Ibis)*		IA	
188.	25703	*Podargus strigoides (Tawny Frogmouth)*			
189.	24679	*Podargus strigoides subsp. brachypterus (Tawny Frogmouth)*			
190.	25704	*Podiceps cristatus (Great Crested Grebe)*			
191.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
192.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
193.	24767	*Porphyrio porphyrio subsp. bellus (Purple Swamphen)*			
194.	24770	*Porzana pusilla subsp. palustris (Baillon's Crake)*			
195.	24771	*Porzana tabuensis (Spotless Crake)*			
196.	24702	*Pterodroma brevirostris (Kerguelen Petrel)*			
197.	24703	*Pterodroma lessonii (White-headed Petrel)*			
198.	25710	*Pterodroma macroptera (Great-winged Petrel)*			
199.	24711	*Puffinus assimilis subsp. assimilis (Little Shearwater)*			
200.		*Purpureicephalus spurius*			
201.	24776	*Recurvirostra novaehollandiae (Red-necked Avocet)*			
202.	48096	*Rhipidura albiscapa (Grey Fantail)*			
203.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
204.	24454	*Rhipidura leucophrys subsp. leucophrys (Willie Wagtail)*			
205.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
206.	30948	*Smicrornis brevirostris (Weebill)*			
207.	24645	*Stagonopleura oculata (Red-eared Firetail)*			
208.	24525	*Sterna fuscata subsp. nubilosa (Sooty Tern)*			
209.	24329	*Stictonetta naevosa (Freckled Duck)*			
210.	25655	*Stipiturus malachurus (Southern Emu-wren)*			
211.	25597	*Strepera versicolor (Grey Currawong)*			
212.	24426	*Strepera versicolor subsp. plumbea (Grey Currawong)*			
213.	25589	*Streptopelia chinensis (Spotted Turtle-Dove)*	Y		
214.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
215.	30950	*Streptopelia senegalensis subsp. senegalensis (Laughing Turtle-Dove)*	Y		
216.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
217.	24682	*Tachybaptus novaehollandiae subsp. novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
218.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
219.		*Thalasseus bergii*			
220.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
221.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
222.	24309	*Todiramphus sanctus subsp. sanctus (Sacred Kingfisher)*			
223.	48141	*Tribonyx ventralis (Black-tailed Native-hen)*			
224.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
225.	24755	*Trichoglossus haematodus subsp. moluccanus (Rainbow Lorikeet)*	Y		
226.	24806	*Tringa glareola (Wood Sandpiper)*		IA	
227.	24808	*Tringa nebularia (Common Greenshank, greenshank)*		IA	
228.	48147	*Turnix varius (Painted Button-quail)*			
229.	24851	*Turnix velox (Little Button-quail)*			
230.	25762	*Tyto alba (Barn Owl)*			
231.	24852	*Tyto alba subsp. delicatula (Barn Owl)*			
232.	24386	*Vanellus tricolor (Banded Lapwing)*			
233.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			

Fish

234.		*Afurcagobius suppositus*			
235.		*Bostockia porosa*			
236.	34028	*Galaxias occidentalis (Western Minnow)*			
237.		*Nannoperca vittata*			
238.		*Phalloceros caudimaculatus*			
239.		*Urocampus carinirostris*			

Invertebrate

240.		*Acercella falcipes*			
241.		*Aganippe rhaphiduca*			
242.		*Agraptocorixa parvipunctata*			
243.		*Ainudrilus nharna*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
244.		*Akamptogonus novarae*			
245.		*Alboa worooa*			
246.		*Allodessus bistrigatus*			
247.		*Allothereua maculata*			
248.		*Alona affinis*			
249.		*Alona cf. guttata*			
250.		*Alona rigidicaudis*			
251.		*Alona setigera*			
252.		*Alonella clathratula*			
253.		*Aname mainae*			
254.		*Aname tepperi*			
255.		*Ancylidae sp.*			
256.		*Anisops thienemanni*			
257.		*Anopheles annulipes s.l.*			
258.		*Apsectrotanypus nr maculosa*			
259.		*Arachnura higginsi*			
260.		*Araneus cyphoxis*			
261.		*Araneus eburneiventris*			
262.		*Araneus eburnus*			
263.		*Araneus senicaudatus*			
264.		*Araneus talipedatus*			
265.		*Argiope protensa*			
266.		*Argiope trifasciata*			
267.		*Arrenurus (Micruracarus) sp. 1 (SAP)*			
268.		*Artema atlanta*			
269.		*Artoria linnaei*			
270.		*Artoriopsis eccentrica*			
271.		*Artoriopsis expolita*			
272.		*Artoriopsis joergi*			
273.		*Asadipus kunderang*			
274.		*Austracantha minax*			
275.		*Austrolestes analis*			
276.		*Austrolestes io*			
277.		*Backobourkia heroine*			
278.		*Badumna insignis*			
279.		*Ballarra longipalpus*			
280.		*Bennelongia sp.*			
281.		*Berosus approximans*			
282.		*Berosus australiae*			
283.		*Bezzia sp.*			
284.		*Bezzia sp. 2 (SAP)*			
285.		*Boeckella bispinosa*			
286.		*Brachionus quadridentatus*			
287.		*Caenidae sp.*			
288.		*Candonocypris novaezelandiae*			
289.		*Ceinidae sp.*			
290.		*Celaenia excavata*			
291.		*Cephalodella gibba*			
292.		*Ceratopogonidae sp.*			
293.		*Cercophonius granulosus*			
294.		*Cercophonius sulcatus*			
295.		*Ceriodaphnia sp.*			
296.		*Ceryerda cursitans*			
297.		*Chaoboridae sp.*			
298.	33939	*Cherax cainii (Marron)*			
299.		*Cherax destructor*			
300.		*Cherax preissii*			
301.		*Cherax quinquecarinatus*			
302.		*Cherax sp.*			
303.		*Chironominae sp.*			
304.		*Chydorus sp.*			
305.		*Clynotis severus*			
306.		*Coenagrionidae sp.*			
307.		*Corixidae sp.*			
308.		*Cormocephalus aurantiipes*			
309.		*Cormocephalus novaehollandiae*			
310.		*Cormocephalus rubriceps*			
311.		*Cormocephalus strigosus*			
312.		*Cormocephalus turneri*			
313.		*Corynoneura sp. (V49) (SAP)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
314.		*Cricotopus 'brevicornis'*			
315.		*Cryptochironomus griseidorsum*			
316.		*Cryptoerithus quobba*			
317.		*Culex (Culex) annulirostris*			
318.		*Culicoides sp.*			
319.		*Cyclosa trilobata*			
320.		*Cypretta sp.*			
321.		*Cyprinotus cingalensis*			
322.		*Delena cancerides*			
323.		*Diaphanosoma sp.*			
324.		*Dingosa murata*			
325.		*Dingosa serrata*			
326.		*Dinocambala ingens*			
327.		*Diptera sp.*			
328.		*Dolichopodidae sp.*			
329.		*Dunhevedia crassa*			
330.		*Dytiscidae sp.*			
331.		*Ephydridae sp.*			
332.		*Eriophora biapicata*			
333.		*Euchlanis sp.*			
334.		*Eucyrtops latior*			
335.		*Eupograpta kottae*			
336.		*Eurytion incisunguis*			Y
337.		*Eylais sp.*			
338.		*Glacidorbidae sp.*			Y
339.		*Glyptophysa sp*			
340.		*Gripopterygidae sp.*			
341.		*Gyrinidae sp.*			
342.		*Haliplus gibbus*			
343.		*Hebridae sp.*			
344.		*Hemianax papuensis*			
345.		*Hemicordulia tau*			
346.		*Hemicorduliidae sp.*			
347.		*Henicops dentatus*			
348.		*Hoggicosa storri*			
349.		*Hogna crispipes*			
350.		*Holasteron perth*			
351.		*Holasteron wamuseum*			Y
352.		*Holconia westralia*			
353.		*Hydrophilidae sp.*			
354.		*Hydropsychidae sp.*			
355.		*Hydroptilidae sp.*			
356.		*Idiommata blackwalli*			
357.		*Ilyocryptus sp.*			
358.		*Ilyodromus sp.*			
359.		*Isidorella sp.*			
360.		*Isopeda leishmanni*			
361.		*Isopeda magna*			
362.		*Isopedella cana*			
363.		*Ixodes australiensis*			
364.		*Kangarosa properipes*			
365.		*Karaops ellenae*			
366.		*Karaops jarrit*			
367.	33980	*Kawaniphila pachomai (cricket)*		P1	
368.		*Lacrimicypris "drummondi" n.sp. (SAP)*			
369.		*Lampona brevipes*			
370.		*Lampona cylindrata*			
371.		*Latonopsis brehmi*			
372.		*Latrodectus hasseltii*			
373.		*Leberis aenigmatosa*			
374.	33981	*Leioproctus bilobatus (short-tongued bee)*		P2	
375.	33983	*Leioproctus douglasiellus (short-tongued bee)*		T	
376.		*Leptoceridae sp.*			
377.		*Libellulidae sp.*			
378.		*Limbodessus shuckhardi*			
379.		*Limnadia sp.*			
380.		*Limnochares australica*			
381.		*Limnophyes vestitus (V41)*			
382.		*Longepi woodman*			
383.		*Longrita insidiosa*			

	Name ID	Species Name	Naturalised	Conservation Code	Endemic To Query Area[1]
384.		*Lycidas chlorophthalmus*			
385.		*Lycosa godeffroyi*			
386.		*Lynceus sp.*			
387.		*Macrothrix sp.*			
388.		*Maratus pavonis*			
389.		*Maraura macracantha (formerly Alona macrocantha)*			
390.		*Masasteron maini*			
391.		*Megaporus sp.*			
392.		*Mesocyclops brooksi*			
393.		*Microcyclops varicans*			
394.		*Microvelia sp.*			
395.		*Missulena granulosa*			
396.		*Missulena hoggi*			
397.		*Missulena occatoria*			
398.		*Mituliodon tarantulinus*			
399.		*Mitzoruga insularis*			
400.		*Monohelea sp. 1 (SAP)*			
401.		*Monohelea sp. 2 (SAP)*			
402.		*Myandra bicincta*			
403.		*Myandra cambridgei*			
404.		*Nematoda sp.*			
405.	33984	*Neopasiphae simplicior (short-tongued bee)*		T	
406.		*Nephila edulis*			
407.		*Nicodamus mainae*			
408.		*Notiasemus glauerti*			
409.		*Notonectidae sp.*			
410.		*Occiperipatoides gilesii*			
411.		*Ocrisiona leucocomis*			
412.		*Oecobius navus*			
413.		*Oligochaeta sp.*			
414.		*Ommatoiulus moreletii*			
415.		*Onychohydrus sp.*			
416.		*Oribatida sp.*			
417.		*Orthocladiinae sp.*			
418.		*Orthocladiinae sp. C = V44 Gymnometriocnemus (SAP)*			
419.		*Ostearius melanopygius*			
420.		*Oxyopes gracilipes*			
421.		*Oxyopes punctatus*			
422.		*Palaemonidae sp.*			
423.		*Paralampona marangaroo*			
424.		*Paramerina levidensis*			
425.		*Paramphisopus palustris*			
426.		*Parastacidae sp.*			
427.		*Phenasteron longiconductor*			
428.		*Pholcus phalangioides*			
429.		*Phreatoicidae sp.*			
430.		*Phryganoporus candidus*			
431.		*Phryganoporus gausapatus subsp. occidentalis*			Y
432.		*Physidae sp.*			
433.		*Pinkfloydia harveii*			
434.		*Planicirclus alticarinatus*			
435.		*Planorbidae sp.*			
436.		*Poltys laciniosus*			
437.		*Polygonarea repanda*			Y
438.		*Procladius paludicola*			
439.		*Procladius sp. (normal claws)*			
440.		*Raveniella cirrata*			
441.		*Raveniella peckorum*			
442.		*Rhantus suturalis*			
443.		*Scolopendra laeta*			
444.		*Scolopendra morsitans*			
445.		*Simocephalus elizabethae*			
446.		*Simuliidae sp.*			
447.		*Spencerhydrus sp.*			Y
448.		*Sphaerotrichopus ramosus*			
449.		*Steatoda capensis*			
450.		*Steatoda grossa*			
451.		*Sternopriscus sp.*			
452.		*Storena formosa*			
453.		*Storena sinuosa*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
454.		*Supunna funerea*			
455.		*Supunna picta*			
456.		*Synothele durokoppin*			
457.		*Synsphyronus magnus*			
458.		*Tabanidae sp.*			
459.		*Tamopsis perthensis*			
460.		*Tanypodinae sp.*			
461.		*Tanytarsus fuscithorax*			
462.		*Tasmanicosa leuckartii*			
463.		*Tegenaria atrica*			Y
464.		*Testudinella patina*			
465.		*Tetragnatha demissa*			
466.		*Thereuopoda lesueurii*			
467.		*Tipulidae sp.*			
468.		*Trichocerca similis*			
469.		*Trichocyclus balladong*			
470.		*Triplectides australis*			
471.		*Turbellaria sp.*			
472.		*Urodacus novaehollandiae*			
473.		*Urodacus planimanus*			
474.		*Urodacus woodwardii*			
475.		*Venator immansueta*			
476.		*Venatrix arenaris*			
477.		*Venatrix pullastra*			
478.	34113	*Westralunio carteri (Carter's Freshwater Mussel)*		T	
479.		*Westrarchaea spinosa*			
480.		*Zachria flavicoma*			

Mammal

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
481.	25449	*Antechinus flavipes (Yellow-footed Antechinus)*			
482.	24088	*Antechinus flavipes subsp. leucogaster (Yellow-footed Antechinus, Mardo)*			
483.	24162	*Bettongia penicillata subsp. ogilbyi (Woylie, Brush-tailed Bettong)*		T	
484.	24251	*Bos taurus (European Cattle)*	Y		
485.	25454	*Canis lupus (Dog, Dingo)*	Y		
486.	30883	*Canis lupus subsp. familiaris (Dog)*	Y		
487.	24086	*Cercartetus concinnus (Western Pygmy-possum, Mundarda)*			
488.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			
489.	24187	*Chalinolobus morio (Chocolate Wattled Bat)*			
490.	24092	*Dasyurus geoffroii (Chuditch, Western Quoll)*		T	
491.	24041	*Felis catus (Cat)*	Y		
492.	30916	*Funambulus pennanti (Indian Palm Squirrel)*	Y		
493.	24215	*Hydromys chrysogaster (Water-rat, Rakali)*		P4	
494.	25478	*Isoodon obesulus (Southern Brown Bandicoot)*		P4	
495.	24153	*Isoodon obesulus subsp. fusciventer (Quenda, Southern Brown Bandicoot)*		P4	
496.	24132	*Macropus fuliginosus (Western Grey Kangaroo)*			
497.	24133	*Macropus irma (Western Brush Wallaby)*		P4	
498.	24223	*Mus musculus (House Mouse)*	Y		
499.	24146	*Myrmecobius fasciatus (Numbat, Walpurti)*		T	
500.	24194	*Nyctophilus geoffroyi (Lesser Long-eared Bat)*			
501.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
502.	48070	*Phascogale tapoatafa subsp. wambenger (South-western Brush-tailed Phascogale, Wambenger)*		T	
503.	24234	*Pseudomys delicatulus (Delicate Mouse)*			
504.	24173	*Pteropus scapulatus (Little Red Flying-fox)*			
505.	24243	*Rattus fuscipes (Western Bush Rat)*			
506.	24245	*Rattus rattus (Black Rat)*	Y		
507.	24199	*Scotorepens balstoni (Inland Broad-nosed Bat)*			
508.	24145	*Setonix brachyurus (Quokka)*		T	
509.		*Sminthopsis murina*			
510.	24207	*Tachyglossus aculeatus (Short-beaked Echidna)*			
511.	24167	*Tarsipes rostratus (Honey Possum, Noolbenger)*			
512.	25521	*Trichosurus vulpecula (Common Brushtail Possum)*			
513.	24158	*Trichosurus vulpecula subsp. vulpecula (Common Brushtail Possum)*			
514.	24206	*Vespadelus regulus (Southern Forest Bat)*			
515.	24040	*Vulpes vulpes (Red Fox)*	Y		

Reptile

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
516.	25242	*Acanthophis antarcticus (Southern Death Adder)*		P3	
517.	42368	*Acritoscincus trilineatus (Western Three-lined Skink)*			
518.	25241	*Antaresia stimsoni subsp. stimsoni (Stimson's Python)*			
519.	24990	*Aprasia pulchella (Granite Worm-lizard)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
520.	24991	*Aprasia repens (Sand-plain Worm-lizard)*			
521.	42381	*Brachyurophis semifasciatus (Southern Shovel-nosed Snake)*			
522.	43380	*Chelodina colliei (South-western Snake-necked Turtle)*			
523.	24980	*Christinus marmoratus (Marbled Gecko)*			
524.	24918	*Crenadactylus ocellatus subsp. ocellatus (Clawless Gecko)*			
525.	30893	*Cryptoblepharus buchananii*			
526.	25020	*Cryptoblepharus plagiocephalus*			
527.	30899	*Ctenophorus adelaidensis (Southern Heath Dragon, Western Heath Dragon)*			
528.	24883	*Ctenophorus ornatus (Ornate Crevice-Dragon)*			
529.	25027	*Ctenotus australis*			
530.	25035	*Ctenotus delli (Dell's skink, Dell's Ctenotus)*		P4	
531.	25039	*Ctenotus fallens*			
532.	25040	*Ctenotus gemmula (Jewelled South-west Ctenotus (Swan Coastal Plain pop P3), skink)*			
533.	25047	*Ctenotus impar*			
534.	25049	*Ctenotus labillardieri*			
535.	41641	*Ctenotus ora (Coastal Plains Skink)*		P3	
536.	25766	*Delma fraseri (Fraser's Legless Lizard)*			
537.	24999	*Delma grayii*			
538.	25296	*Demansia psammophis subsp. reticulata (Yellow-faced Whipsnake)*			
539.	25325	*Dendrelaphis punctulata (Green Tree Snake)*			
540.	24929	*Diplodactylus granariensis subsp. granariensis*			
541.	24939	*Diplodactylus polyophthalmus*			
542.	24940	*Diplodactylus pulcher*			
543.	25096	*Egernia kingii (King's Skink)*			
544.	25100	*Egernia napoleonis*			
545.	25250	*Elapognathus coronatus (Crowned Snake)*			
546.	24959	*Gehyra variegata*			
547.	25115	*Hemiergis initialis subsp. initialis*			
548.	25119	*Hemiergis quadrilineata*			
549.	24961	*Heteronotia binoei (Bynoe's Gecko)*			
550.	25131	*Lerista distinguenda*			
551.	25133	*Lerista elegans*			
552.	25147	*Lerista lineata (Perth Slider, Lined Skink)*		P3	
553.	25005	*Lialis burtonis*			
554.	25184	*Menetia greyii*			
555.	25240	*Morelia spilota subsp. imbricata (Carpet Python)*			
556.	25191	*Morethia lineoocellata*			
557.	25192	*Morethia obscura*			
558.	25248	*Neelaps bimaculatus (Black-naped Snake)*			
559.	25249	*Neelaps calonotos (Black-striped Snake, black-striped burrowing snake)*		P3	
560.	25252	*Notechis scutatus (Tiger Snake)*			
561.	25253	*Parasuta gouldii*			
562.	25255	*Parasuta nigriceps*			
563.	25007	*Pletholax gracilis subsp. gracilis (Keeled Legless Lizard)*			
564.	25510	*Pogona minor (Dwarf Bearded Dragon)*			
565.	24907	*Pogona minor subsp. minor (Dwarf Bearded Dragon)*			
566.	25261	*Pseudechis australis (Mulga Snake)*			
567.	25345	*Pseudemydura umbrina (Western Swamp Tortoise, Western Swamp Turtle)*		T	
568.	25511	*Pseudonaja affinis (Dugite)*			
569.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
570.	25264	*Pseudonaja nuchalis (Gwardar, Northern Brown Snake)*			
571.	25008	*Pygopus lepidopodus (Common Scaly Foot)*			
572.	25266	*Simoselaps bertholdi (Jan's Banded Snake)*			
573.	24943	*Strophurus spinigerus subsp. inornatus*			
574.	24942	*Strophurus spinigerus subsp. spinigerus*			
575.	25203	*Tiliqua occipitalis (Western Bluetongue)*			
576.	25519	*Tiliqua rugosa*			
577.	25204	*Tiliqua rugosa subsp. aspera*			
578.	25207	*Tiliqua rugosa subsp. rugosa*			
579.	24983	*Underwoodisaurus milii (Barking Gecko)*			
580.	25218	*Varanus gouldii (Bungarra or Sand Monitor)*			
581.	25225	*Varanus rosenbergi (Heath Monitor)*			
582.	25526	*Varanus tristis (Racehorse Monitor)*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3

Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area

4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

Australian Government
Department of the Environment and Energy

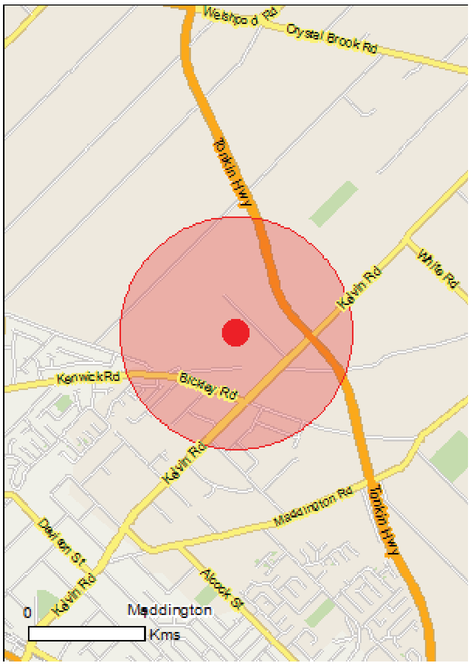
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

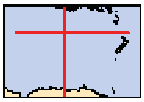
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 25/02/18 20:41:14



Coordinates
Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	30
Listed Migratory Species:	9

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	15
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	39
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area
Clay Pans of the Swan Coastal Plain	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat likely to occur within area
Calyptorhynchus baudinii Baudin's Cockatoo, Long-billed Black-Cockatoo [769]	Endangered	Roosting known to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat may occur within area
Plants		
Acacia anomala Grass Wattle, Chittering Grass Wattle [8153]	Vulnerable	Species or species habitat may occur within area
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Austrostipa bronwenae [87808]	Endangered	Species or species habitat may occur within area
Banksia mimica Summer Honeypot [82765]	Endangered	Species or species habitat likely to occur within area
Calytrix breviseta subsp. breviseta Swamp Starflower [23879]	Endangered	Species or species habitat likely to occur within area
Conospermum undulatum Wavy-leaved Smokebush [24435]	Vulnerable	Species or species habitat likely to occur within area
Diplolaena andrewsii [6601]	Endangered	Species or species habitat may occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat may occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leafed Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat likely to occur within area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat likely to occur within area
Eremophila glabra subsp. chlorella [84927]	Endangered	Species or species habitat likely to occur within area
Eucalyptus x balanites Cadda Road Mallee, Cadda Mallee [87816]	Endangered	Species or species habitat may occur within area
Goodenia arthrotricha [12448]	Endangered	Species or species habitat likely to occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea [64909]	Endangered	Species or species habitat may occur within area
Grevillea thelemanniana Spider Net Grevillea [32835]	Critically Endangered	Species or species habitat known to occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Synaphea sp. Fairbridge Farm (D. Papenfus 696) Selena's Synaphea [82881]	Critically Endangered	Species or species habitat likely to occur within area
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Extra Information

Invasive Species	[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within

Name	Status	Type of Presence
		area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-32.0295 116.00048

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX D

SIGNIFICANT SPECIES PROFILES

Unnamed Cricket *Kawaniphila pachomai*

Status and Distribution: Listed as Priority 1 by DBCA. Full distribution is not known. The NatureMap database lists only two records, one near Witchcliffe and one north of Armadale near Perth (DBCA 2018b).

Habitat: The species apparently occurs in moist, shaded uncleared forests and gullies in the south-west, mostly the Tingle forests along the South Coast (DBCA 2018b).

Likely presence in subject site: It is very unlikely that this species of cricket utilises the subject site due to its overall degraded nature and lack of favoured habitat.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Unnamed Bee *Glossurocolletes bilobatus*

Status and Distribution: Listed as Priority 2 by DBCA. This species of native bee has been collected only from the Stirling Ranges and from Kenwick (DBCA 2018b).

Habitat: Life history and habits are unknown. It has been recorded only on the flowers of *Gompholobium aristatum* on which it may be dependent. Possible threats include clearing for housing and altered fire regimes (DBCA 2018b).

Likely presence in subject site: It is very unlikely that this species of bee utilises the subject site due to its overall degraded nature and lack of favoured plant species.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Unnamed Bee *Leioproctus douglasiellus*

Status and Distribution: Listed as Scheduled 2 under the *WC Act* and as Critically Endangered under the *EPBC Act*. It is known only from specimens collected at Pearce and Forrestdale Lake.

Habitat: This species of native bee appears to be dependent on the flowers of *Goodenia filiformis*.

Likely presence in subject site: Most of the subject site has been cleared of native understory and therefore represents unsuitable as habitat for this species. Those areas with vegetation are degraded and do not contain the necessary plant species for a population of this species to persist.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Short-tongued Bee *Neopasiphae simplicior*

Status and Distribution: Listed as Scheduled 2 under the *WC Act* and as Critically Endangered under the *EPBC Act*. It is currently only known from bushland adjacent to Forrestdale Lake and Armadale Golf Course, although the holotype was collected from Cannington in 1954 (DBCA 2018b).

Habitat: This species of native bee has been collected on flowers of *Goodenia filiformis*, *Lobelia tenulor*, *Angianthus preissianus* and *Velleia* sp.

Likely presence in subject site: Most of the subject site has been cleared of native understory and therefore represents unsuitable as habitat for this species. Those areas with vegetation are degraded and do not contain the necessary plant species for a population of this species to persist.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Carter's Freshwater Mussel *Westralunio carteri*

Status and Distribution: Listed as Schedule 3 under the *WC Act* and as Vulnerable under the *EPBC Act.* Carter's freshwater mussel is the only freshwater mussel species endemic to south-western WA, ranging from the Moore River south to the Frankland River (Morgan *et al.* 2011).

Habitat: Occurs in greatest abundance in slower flowing streams with stable sediments that are soft enough for burrowing amongst woody debris and exposed tree roots. Salinity tolerance quite low (Morgan *et al*. 2011).

Likely presence in subject site: No suitable habitat for this species is present within the subject site.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Perth Lined Lerista *Lerista lineata*

Status and Distribution: Listed as Priority 3 by DBCA. Found in the lower west coast from Perth south to Leschenault Peninsula/Kemerton. It has also been found at Rottnest Island and Garden Island (Storr *et al.* 1999) and in some suburban areas of Perth (Bush *et al.* 2002).

Habitat: This small species of skink inhabits white sands (Storr *et al*. 1999) under areas of shrubs and heath where it inhabits loose soil and leaf litter (Nevill 2005) particularly in association with banksias (Bush *et al.* 2007).

Likely presence in subject site: The subject site is outside of this species current documented range and habitat appears too degraded.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat is considered likely.

Darling Range Heath Ctenotus *Ctenotus delli*

Status and Distribution: Listed as Priority 4 by DBCA. Main distribution is in the Darling Range from the Darlington/Mundaring area to near Collie (Storr *et al.* 1999).

Habitat: Humid zone, mainly laterite and clays (Storr *et al.* 1999) supporting jarrah/marri woodland with a shrub dominated understorey, sheltering in dense vegetation, inside grass trees and beneath rocks, sometimes in burrows (Nevill 2005). Occasionally found on granite outcrops (Bush *et al*. 2010).

Likely presence in subject site: The subject site is outside of this species current documented range and it contains no suitable habitat for this species to utilise.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Coastal Plains Skink *Ctenotus ora*

Status and Distribution: Listed as Priority 3 by DBCA. *Ctenotus ora* is a recently described species of medium sized skink with a restricted range in the south-west of Western Australia, most of which has been cleared for agriculture and urban development. It cannot reliably be distinguished from the more widespread *C. labillardieri* except by DNA sequences, but the two species appear to have disjunct distributions. Based on only five specimens reliably identified as *Ctenotus ora*, the species is apparently restricted to the southern Swan Coastal Plain and Cape Naturaliste area, as far north as Pinjarra and south as far as Yallingup (Kay & Keogh 2012).

Habitat: Sandy substrates with low vegetation (including heath) in open *Eucalyptus/Corymbia* woodland over *Banksia* (Kay & Keogh 2012). Individuals have been found sheltering under *Banksia* logs on white sand, and trapped in eucalypt woodland with *Banksia* or peppermint mid-storey, or heath (Bamford *et al.* 2010). Open eucalypt woodland over *Banksia* and low vegetation on sandy coastal plain and coastal dunes (Wilson and Swan 2017).

Likely presence in subject site: The subject site is outside of this species current documented range and habitat appears too degraded.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Black-striped Snake *Neelaps calonotos*

Status and Distribution: Listed as Priority 3 by DBCA. Found in the lower west coast from Lancelin to Mandurah. It is locally abundant but is under threat due to land clearing (Storr *et al*. 1999).

Habitat: This species of snake favours sandy soils supporting heath and banksia/eucalypt woodland (Nevill 2005).

Likely presence in subject site: Most of the subject site has been cleared of native understory and therefore represents unsuitable as habitat for this species. Those areas with vegetation are degraded fragmented and are unlikely to support a population or individuals of this species.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Southern Death Adder *Acanthophis antarcticus*

Status and Distribution: The southern death adder is classified as Priority 3 by DBCA. Now locally confined to the Darling Range between Mt Helena and Jarrahdale (Bush *et al*. 2002).

Habitat: In the Darling Range this species is typically found within Jarrah woodlands adjacent to granite outcrops and along densely vegetated creeks (Bush *et al.* 1995).

Likely presence in subject site: The subject site is outside of this species current documented range and it contains no suitable habitat for this species to utilise.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Malleefowl *Leipoa ocellata*

Status and Distribution: This species is listed as Schedule 3 under the *WC Act* and as Vulnerable under the *EPBC Act*. Originally common, but now generally rare to uncommon and patchily distributed.

Current distribution mainly southern arid and semi-arid zones, north to Shark Bay, Jingemarra, Colga Downs and Yeelirrie, east to Earnest Giles Range, Yeo Lake, lower Ponton Creek and to Eucla and west and south to Cockleshell Gully, the Wongan Hills, Stirling Range, Beaufort Inlet, Hatters Hill, Mt Ragged and Point Malcolm (Johnstone and Storr 1998).

Habitat: Mainly scrubs and thickets of mallee *Eucalyptus* spp., boree *Melaleuca lanceolata* and bowgada *Acacia linophylla*, also dense litter forming shrublands.

Likely presence in subject site: This species is regionally extinct and would never, under normal circumstances occur anywhere on the Swan Coastal Plain.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species will occur as it is unlikely to be present.

Australasian Bittern *Botaurus poiciloptilus*

Status and Distribution: Classified as Schedule 2 under the *WC Act* and as Endangered under the *EPBC Act*. The species is uncommon to rare (Morcombe 2004), but locally common in wetter parts of south west (Johnstone and Storr 1998). Occurs north to Moora and east to Mt Arid (Johnstone and Storr 1998).

Habitat: Freshwater wetlands, occasionally estuarine; prefers heavy vegetation (Morcombe 2004) such as beds of tall dense *Typha*, *Baumea* and sedges in freshwater swamps (Johnstone and Storr 1998).

Likely presence in subject site: The subject site contains no suitable habitat for this species.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Glossy Ibis *Plegadis falcinellus*

Status and Distribution: This species is listed as Schedule 5 under the *WC Act* and as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The glossy ibis frequents swamps and lakes throughout much of the Australian mainland but is most numerous in the north. It is a non-breeding visitor to Tasmania and the south-west of Western Australia. The Glossy ibis is both migratory and nomadic. Its range expands inland after good rains, but its main breeding areas seem to be in the Murray-Darling Basin of New South Wales and Victoria, the Macquarie Marshes in New South Wales, and in southern Queensland. Glossy ibis often move north in autumn, then return south to their main breeding areas in spring and summer (Pizzey & Knight 2012).

Habitat: Well vegetated wetlands, wet pastures, rice fields, floodwaters, floodplains, brackish or occasionally saline wetlands, mangroves, mudflats, occasionally dry grasslands (Pizzey & Knight 2012).

Likely presence in subject site: The subject site contains no suitable habitat for this species.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Painted Snipe *Rostratula benghalensis*

Status and Distribution: This species is listed as Schedule 2 under the *WC Act* and as Endangered and Migratory under the *EPBC Act*. Sparsely distributed in better watered regions: Kimberley, North West and South Western divisions. Also eastern Australia and Tasmanian (Johnstone and Storr 1998).

Habitat: Well vegetated shallows and margins of wetlands, dams, sewerage ponds, wet pastures, marshy areas, irrigation systems, lignum, tea tree scrub, open timber. Requires dense low cover (Morcombe 2004).

Likely presence in subject site: The subject site contains no suitable habitat for this species.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Other Migratory Shorebirds/Wetland Species

A number of migratory shorebirds/wetland species are listed as potentially occurring in the general area. Specific species are not discussed.

Status and Distribution: Migratory shorebirds are listed under the Schedule 5 of the *WC Act*, the *EPBC Act 1999* and under international agreements to which Australia is a signatory. All species are either widespread summer migrants to Australia or residents. State and Federal threatened species status varies between species.

Habitat: Varies between species but includes beaches and permanent/temporary wetlands varying from billabongs, swamps, lakes, floodplains, sewerage farms, saltwork ponds, estuaries, lagoons, mudflats sandbars, pastures, airfields, sports fields and lawns.

Likely presence in subject site: The subject site contains no suitable habitat for these species.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Blue-billed Duck *Oxyura australis*

Status and Distribution: Recently listed as Priority 4 by DBCA (DBCA 2018b). Rare to moderately common (most plentiful on the Swan Coastal Plain and in the Great Southern). South-western: north to Lake Pinjarrega and east to Esperance; vagrant further north and east (as far as Thundelarra and Kalgoorlie). Also south-eastern Australian and Tasmania (Johnstone and Storr 1998).

Habitat: Well vegetated freshwater swamps, large dams and lakes, winters on more open water (Morcombe 2004). Occasionally salt lakes and estuaries freshened by floodwaters (Johnstone and Storr 1998).

Likely presence in subject site: The subject site contains no suitable habitat for these species.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Osprey *Pandion haliaetus*

Status and Distribution: This species is listed as Schedule 5 under the *WC Act* and as Migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. Moderately common to very common in sheltered seas around the north and west coast islands south to 31°S; uncommon to common on mainland coasts, estuaries and large rivers north of tropic, rare to uncommon elsewhere (Johnstone and Storr 1998).

Habitat: Coasts, estuaries, bays, inlets, islands, and surrounding waters, coral atolls, reefs, lagoons, rock cliffs and stacks. Ascends larger rivers (Pizzey & Knight 2012). Construct nests on prominent headland, large trees, communication towers (Simpson & Day 2010).

Likely presence in subject site: The subject site contains no suitable habitat for these species.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Peregrine Falcon *Falco peregrinus*

Status and Distribution: This species is listed as Schedule 7 under the *WC Act*. Individuals of this species are uncommon/rare but wide ranging across Australia. Moderately common at higher levels of the Stirling Range, uncommon in hilly, north west Kimberley, Hamersley and Darling Ranges; rare or scarce elsewhere (Johnstone and Storr 1998).

Habitat: Diverse from rainforest to arid shrublands, from coastal heath to alpine (Morcombe 2004). Mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes (Johnstone and Storr 1998). The species utilises the ledges, cliff faces and large hollows/broken spouts of trees for nesting. It will also occasionally use the abandoned nests of other birds of prey.

Likely presence in subject site: This species potentially utilises some sections of the subject site as part of a much larger home range. No evidence of nesting was observed and the probability of this species breeding within the subject site can be considered to be very low.

Listed as a potential species based on available information.

Potential impact of development: Loss or modification of some habitat. However, no significant impact on this species is considered likely.

Fork-tailed Swift *Apus pacificus*

Status and Distribution: The fork-tailed swift is listed as Schedule 5 under the *WC Act* an as Migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. This species breeds in Siberia and the Himalayas and migrates to Australia in October, returning to the breeding grounds by May or June (Morcombe 2003).

Habitat: Low to very high airspace over varied habitat from rainforest to semi desert (Morcombe 2004).

Likely presence in subject site: It is potentially an occasional summer visitor to the subject site but is entirely aerial and largely independent of terrestrial habitats. Frequency of occurrence would be very low and then only for very brief periods of time.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Grey Wagtail *Motacilla cinerea*

Status and Distribution: The grey wagtail is listed as Schedule 3 under the *WC Act* and as Migratory under the *EPBC Act* including international agreements to which Australia is a signatory. A rarely recorded, accidental vagrant that has on a few occasions been recorded on widely separated parts of the Australian coastline (Pizzey & Knight 2012).

Habitat: In Australia, near running water in disused quarries, sandy, rocky streams in escarpments and rainforest, sewerage ponds, ploughed fields and airfields (Pizzey & Knight 2012).

Likely presence in subject site: Cleared paddock areas may represent suitable habitat for this species but as it is an "accidental vagrant" the likelihood of occurrence is extremely low. This species would only occur very rarely, if ever and then only for brief periods.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species will occur.

Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*

Status and Distribution: Listed as Scheduled 3 under the *WC Act* and as Vulnerable under the *EPBC Act*. Found in the humid and subhumid south west, mainly hilly interior, north to Gingin and east to Mt Helena, Christmas Tree Well, North Bannister, Mt Saddleback, Rock Gully and the upper King River (Johnstone and Storr 1998).

Habitat: Eucalypt forests, feeds on marri, jarrah, blackbutt, karri, sheoak and snottygobble. The forest red-tailed black cockatoo nests in the large hollows of Marri, Jarrah and Karri (Johnstone and Kirkby 1999). In Marri, the nest hollows of the forest red-tailed black cockatoo range from 8-14m above ground, the entrance is 12 – 41cm in diameter and the depth is one to five metres (Johnstone and Storr 1998).

Breeding commences in winter/spring. There are few records of breeding in the forest red-tailed black cockatoo (Johnstone and Storr 1998), but eggs are laid in October and November (Johnstone 1997; Johnstone and Storr 1998). Recent data however indicates that breeding in all months of the year occurs with peaks in spring and autumn–winter (Ron Johnstone pers comms). Incubation period 29 – 31 days. Young fledge at 8 to 9 weeks (Simpson and Day 2010).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging/weening could extend through

Likely presence in subject site: Some foraging evidence attributed to this species was found during field survey (chewed marri fruits). The small areas of remnant native vegetation containing marri, coastal blackbutt and sheoak trees (in addition to some scattered individual trees) within the subject site represents foraging habitat for this species. Larger native endemic trees (≥50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

Listed as a potential species based on available information.

Potential impact of development: Potential for the loss of small areas of foraging habitat and potential "breeding habitat" trees (i.e. DBH ≥50cm).

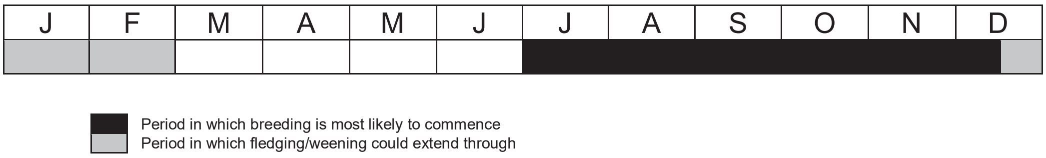
Carnaby's Black-Cockatoo *Calyptorhynchus latirostris*

Status and Distribution: Carnaby's black cockatoo is listed as Scheduled 2 under the *WC Act* and as Endangered under the *EPBC Act*. Confined to the south-west of Western Australia, north to the lower Murchison River and east to Nabawa, Wilroy, Waddi Forest, Nugadong, Manmanning, Durokoppin, Noongar (Moorine Rock), Lake Cronin, Ravensthorpe Range, head of Oldfield River, 20 km ESE of Condingup and Cape Arid; also casual on Rottnest Island (Johnstone and Storr 1998).

Habitat: Forests, woodlands, heathlands, farms; feeds on banksia, hakeas and marri. Carnaby's black cockatoo has specific nesting site requirements. Nests are mostly in smoothed-barked eucalypts with the nest hollows ranging from 2.5 to 12m above the ground, an entrance from 23-30cm diameter and a depth of 0.1-2.5m (Johnstone and Storr, 1998).

Breeding occurs in winter/spring mainly in eastern forest and wheatbelt where they can find mature hollow bearing trees to nest in (Morcombe 2004). Judging from breeding records in the Storr – Johnstone Bird Data Bank, this species is currently expanding its breeding range westward and south into the Jarrah – Marri forests of the Darling Scarp and into the tuart forests of the swan coastal plain including Yanchep, Lake Clifton and near Bunbury and possibly also in the Lancelin region. Carnaby's Black Cockatoo have also been known to breed close to the town of Mandurah, as well as at Dawesville, Lake Clifton and Baldivis (pers. comm., Ron Johnstone, WA Museum) and there are small resident populations on the southern Swan Coastal Plain near Mandurah, Lake Clifton and near Bunbury. At each of these sites the birds forage in remnant vegetation and adjacent pine plantations (Johnstone 2008).

Carnaby's Black-Cockatoo lays eggs from July or August to October or November, with most clutches being laid in August and September (Saunders 1986). Most of the breeding is in September through to December (Ron Johnstone pers comms). Birds in inland regions may begin laying up to three weeks earlier than those in coastal areas (Saunders 1977). The female incubates the eggs over a period of 28-29 days. The young depart the nest 10–12 weeks after hatching (Saunders 1977; Smith & Saunders 1986).



Likely presence in subject site: Some foraging evidence attributed to this species was found during field survey (chewed pine cones). The small areas of remnant native vegetation containing marri, coastal blackbutt and banksia trees (in addition to some scattered individual trees) within the subject site represents foraging habitat for this species. Larger native endemic trees (≥50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

Listed as a potential species based on available information.

Potential impact of development: Potential for the loss of areas of foraging habitat and potential “breeding habitat” trees (i.e. DBH ≥50cm).

Baudin’s Black-Cockatoo *Calyptorhynchus baudinii*

Status and Distribution: Listed as Scheduled 3 under the *WC Act* and as Endangered under the *EPBC Act*. Confined to the south-west of Western Australia, north to Gidgegannup, east to Mt Helena, Wandering, Quindanning, Kojonup, Frankland and King River and west to the eastern strip of the Swan Coastal Plain including West Midland, Byford, Nth Dandalup, Yarloop, Wokalup and Bunbury (Johnstone and Storr 1998). On the southern Swan Coastal Plain this cockatoo is in some areas resident but mainly a migrant moving from the deep south-west to the central and northern Darling Range. Between March and September most flocks move north and are concentrated in the northern parts of the Darling Range. During this period birds forage well out onto the southern Swan Coastal Plain to areas such as Harvey, Myalup, Bunbury, Capel, Dunsborough and Meelup. While generally more common in the Darling Range this species can also be common on parts of the southern Swan Coastal Plain especially in mid-August – September when flocks begin to return to their breeding quarters (Johnstone 2008).

Habitat: Mainly eucalypt forests where it feeds primarily on the Marri seeds, (Morcombe, 2004), *Banksia, Hakeas* and *Erodium* sp. Also strips bark from trees in search of beetle larvae (Johnstone and Storr 1998). This species of cockatoo nests in large tree hollows, 30–40 cm in diameter and more than 30 cm deep (Saunders 1974).

Baudin's Black-Cockatoo breeds in late winter and spring, from August to November or December (Gould 1972; Johnstone 1997; Saunders 1974; Saunders *et al*. 1985). Eggs laid in October (Johnstone and Storr 1998). Based on observations at currently known nest sites breeding mainly occurs within the October-December period (Ron Johnstone pers comms). Incubation is 28 – 30 days. Young fledge at 8 to 9 weeks (Simpson and Day 2010).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging/weening could extend through

<u>Likely presence in subject site</u>: Some foraging evidence attributed to this species was found during field survey (chewed marri fruits). The small areas of remnant native vegetation containing marri and banksia trees (in addition to some scattered individual trees) within the subject site represents foraging habitat for this species. Larger native endemic trees ($\geq$50cm DBH) can be considered potential breeding habitat. No actual nest or roosting sites were located during the field survey.

Listed as a potential species based on available information.

<u>Potential impact of development</u>: Potential for the loss of areas of foraging habitat and potential “breeding habitat” trees (i.e. DBH $\geq$50cm).

Chuditch *Dasyurus geoffroii*

<u>Status and Distribution</u>: Listed as Scheduled 3 under the *WC Act* and as Vulnerable under the *EPBC Act.* Formerly occurred over nearly 70 per cent of Australia. The Chuditch now has a patchy distribution throughout the Jarrah forest and mixed Karri/Marri/Jarrah forest of southwest Western Australia. Also occurs in very low numbers in the Midwest, Wheatbelt and South Coast Regions with records from Moora to the north, Yellowdine to the east and south to Hopetoun.

<u>Habitat</u>: Chuditch are known to have occupied a wide range of habitats from woodlands, dry sclerophyll (leafy) forests, riparian vegetation, beaches and deserts. Riparian vegetation appears to support higher densities of Chuditch, possibly because food supply is better or more reliable and better cover is offered by dense vegetation. Chuditch appear to utilise native vegetation along road sides in the wheatbelt (CALM 1994). The estimated home range of a male Chuditch is over 15 km^2 whilst that for females is 3-4 km^2 (Sorena and Soderquist 1995).

<u>Likely presence in subject site</u>: This species requires relatively large continuous areas of vegetation to persist and as a consequence it is rarely recorded on any section of the coastal plain given the extent of clearing and fragmentation that has occurred.

Occasional records in the Perth area are transient individuals that have originated from the Darling Range where it is known to persist.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

South-western Brush-tailed Phascogale *Phascogale tapoatafa wambenger*

Status and Distribution: Listed as Scheduled 6 under the *WC Act (1950)*. Present distribution is believed to have been reduced to approximately 50 per cent of its former range. Now known from Perth and south to Albany, west of Albany Highway. Occurs at low densities in the northern Jarrah forest. Highest densities occur in the Perup/Kingston area, Collie River valley, and near Margaret River and Busselton (DEC information pamphlet). Records are less common from wetter forests.

Habitat: This subspecies has been observed in dry sclerophyll forests and open woodlands that contain hollow-bearing trees but a sparse ground cover. A nocturnal carnivore relying on tree hollows as nest sites. The home range for a female Brush-tailed Phascogale is estimated at between 20 and 70 ha, whilst that for males is given as twice that of females. In addition, they tend to utilise a large number (approximately 20) of different nest sites throughout their range (Soderquist, 1995).

Likely presence in subject site: Current status in the wider area uncertain but fragmented nature of the vegetation remnants and limited number of hollow trees would suggest it is unlikely to occur.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat is anticipated.

Numbat *Myrmecobius fasciatus*

Status and Distribution: Listed as Scheduled 3 under the *WC Act* and as Vulnerable under the *EPBC Act*. Once occurred across much of arid and semi arid southern Australia, now restricted to a few remnant forests of Wandoo, Powderbark Wandoo or jarrah in South west WA (Menkhorst & Knight 2011). Rare, scattered. Found only at Dryandra, Perup and six other translocation sites (van Dyck & Strahan 2008).

Habitat: Generally dominated by eucalypts that provide hollow logs and branches for shelter and termites for food (van Dyck & Strahan 2008).

Likely presence in subject site: This species is locally extinct.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Quenda *Isoodon fusciventer*

Status and Distribution: Listed as Priority 4 by DBCA. Widely distributed in the south west from near Cervantes north of Perth to east of Esperance, patchy distribution through the Jarrah and Karri forest and on the Swan Coastal Plain, and inland as far as Hyden. Has been translocated to Julimar State Forest, Hills Forest Mundaring, Tutanning Nature Reserve, Boyagin Nature Reserve, Dongolocking Nature Reserve, Leschenault Conservation Park, and Karakamia and Paruna Sanctuaries (DBCA information pamphlet) and Nambung National Park (DBCA pers. coms.)

Habitat: Dense scrubby, often swampy, vegetation with dense cover up to one metre high, often feeds in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover. Populations inhabiting Jarrah and Wandoo forests are usually associated with watercourses. Quendas can thrive in more open habitat subject to exotic predator control (DBCA information pamphlet).

Likely presence in subject site: No evidence of the quenda was observed but it is known to persist in paddocks with dense grasses and small remnants in nearby areas so may occur in the subject site. Most of the subject site is however unsuitable for this species to persist.

Listed as a potential species based on available information.

Potential impact of development: Potential for the loss of small areas of marginal natural and degraded habitat.

Western Ringtail Possum *Pseudocheirus occidentalis*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act.* Common in suitable habitat (de Tores 2008). The highest densities of this species are recorded in Peppermint habitat near Busselton area; relatively high densities are found in Jarrah/Marri forest at Perup (de Tores 2008).

The Western Ringtail Possum has a restricted distribution in south-western Western Australia. Most known populations (natural and translocated) are now restricted to near coastal areas of the south west from the Dawesville area to the Waychinicup National Park. Inland, it is also known to be relatively common in a small part of the lower Collie River valley, the Perup Nature Reserve and surrounding forest blocks near Manjimup.

Habitat: The western ringtail possum was once located in a variety of habitats including Coastal Peppermint, Coastal Peppermint-Tuart, Jarrah-Marri associations, Sheoak woodland, and eucalypt woodland and mallee. Coastal populations mostly inhabit Peppermint-Tuart associations with highest densities in habitats with dense, relatively lush vegetation. Inland, the largest known populations occur in the Upper Warren area east of Manjimup (Wayne *et al* 2005). In this area the peppermint tree is naturally absent and jarrah-marri associations constitute the species refuge and foraging habitat. In areas where Peppermint is absent or rare WRPs have been observed feeding predominately on young Jarrah, *Nuytsia floribunda* and *Allocasuarina fraseriana* (G Harewood pers. obs.).

Likely presence in subject site: This species is locally extinct.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Quokka *Setonix brachyurus*

Status and Distribution: Listed as Scheduled 3 under the *WC Act* and as Vulnerable under the *EPBC Act*. Rare and restricted in south west W.A. from south of Perth to Two Peoples Bay. The distribution of the Quokka includes Rottnest and Bald Islands, and at least 25 known sites on the mainland, including Two Peoples Bay Nature Reserve, Torndirrup National Park, Mt Manypeaks National Park, Walpole-Nornalup National Park, and various swamp areas through the south-west forests from Jarrahdale to Walpole.

Habitat: Mainland populations of this species are currently restricted to densely vegetated coastal heaths, swamps, riverine habitats including tea-tree thickets on sandy soils along creek systems where they are less vulnerable to predation. The species is nocturnal.

Likely presence in subject site: This species is locally extinct and there is also an absence of suitable habitat.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Woylie *Bettongia Penicillata ogibyi*

Status and Distribution: Listed as Schedule 1 under the *WC Act* and as Endangered under the *EPBC Act*. Restricted to remnant habitat patches in south west WA where populations are managed by way of fox control and reintroduction programs (e.g. Avon Valley, Walyunga National Park and Paruna Sanctuary).

Habitat: Open forest and woodland with a low, dense, understorey of tussock grasses or woody scrub. Formerly occurred in a wider range of habitats including spinifex hummock grasslands.

Likely presence in subject site: No suitable habitat and locally extinct on coastal plain.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Western Brush Wallaby *Macropus irma*

Status and Distribution: Listed as Priority 4 by DBCA. The western brush wallaby is distributed across the south-west of Western Australia from north of Kalbarri to Cape Arid (DBCA information pamphlet).

Habitat: The species optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets. It is also found in some areas of mallee and heathland, and is uncommon in karri forest (DBCA information pamphlet).

Likely presence in subject site: Bushland within and surrounding the subject site is too small and/or fragmented to support a population of this species.

Not considered a potential species based on currently available information.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Water Rat *Hydromys chrysogaster*

Status and Distribution: Listed as Priority 4 by DBCA. The water rat is widely distributed around Australia and its offshore islands, New Guinea and some adjacent islands. It occurs in fresh brackish water habitats in the south-west of Western Australia, but occurs in marine environments along the Pilbara coastline and offshore islands. Previous survey work in the south west suggested this species was relatively common and widespread though difficult to capture (Christensen *et al.* 1985, How *et al.* 1987).

Habitat: The water rat occupies habitat in the vicinity of permanent water, fresh, brackish or marine. Likely to occur in all major rivers and most of the larger streams as well as bodies of permanent water in the lower south west (Christensen *et al.* 1985).

Likely presence in subject site: While the Yule Brook passes through the subject site it appears to be too degraded to support individuals of this species. There is also a lack of recent, local records. Based on this information this species is therefore considered unlikely to occur.

Potential impact of development: No impact on this species or its preferred habitat will occur.

DISCLAIMER

This fauna assessment report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Greg Harewood ("the Author"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints. In accordance with the scope of services, the Author has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

The conclusions are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the site at the time of preparing the report. Also it should be recognised that site conditions, can change with time.

Within the limitations imposed by the scope of services, the field assessment and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

In preparing the report, the Author has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise stated in the report, the Author has not verified the accuracy of completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. The Author will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to the Author.

The report has been prepared for the benefit of the Client and no other party. The Author assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of the Author or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

The Author will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

Appendix E

City of Gosnells: Specifications for Conservation Area Fencing

City of Gosnells: Specifications for Conservation Area Fencing

1. Strainers and Gate Posts – Treated Pine RL6 x 2.4m (1200mm in ground)
2. Intermediate Posts – Treated Pine RL5 x 2.1m (900mm in ground)
3. Maximum spacing between posts on a straight run 5m
4. Maximum straight run between “boxed” assemblies 200m
5. Posts to be spaced evenly over intermediate distances, 3 – 5m between posts
6. End assemblies (boxed corners) to comprise of 3 treated pine strainers RL6 x 2.4m with 2 rails of RL5 x 2.4m, tensioned with a diagonal support of 3.15mm High Tensile wire strained up with Gripples.
7. Fence of 7/90/30 Ringlock, or Southern Wire equivalent, available in 200m rolls. Top wire of Ringlock to be fastened using a Ringrip fastening system to a high tensile 2.5mm wire strung between the posts 900mm above the ground. Wire and Ringlock to be stapled to posts. This system facilitates easier repairs to vandalised fences.
8. Where required to exclude wind-blown rubbish and sand drift, a continuous shadecloth apron is to be attached to the top and bottom of the Ringlock using Ringrip fasteners.

9. Where required for fauna management purposes, Ringlock will be replaced with 900mm height black PVC coated cyclone chain wire mesh - 50mm diamond x 2.5mm hot dip galvanised wire extending to the ground, to be fastened using a Ringrip fastening system to black PVC coated high tensile 2.5mm wire strung between the posts 900mm, 5000mm and 100mm above the ground. In this case, maximum spacing between posts on a straight run will be 2.5m

10. A top wire is to be attached for visibility using White plastic coated Sighter wire with a 4mm wire core. The sighter wire is threaded through a drill hole in the posts.

11. Gates are 3.6m rural gates used for vehicle access.

12. Pedestrian and machinery access gates use a 1.8m width.

13. Pedestrian only gates are 900mm or a constructed “kissing” gate style.

Appendix C Priority Flora and Plant Communities Map

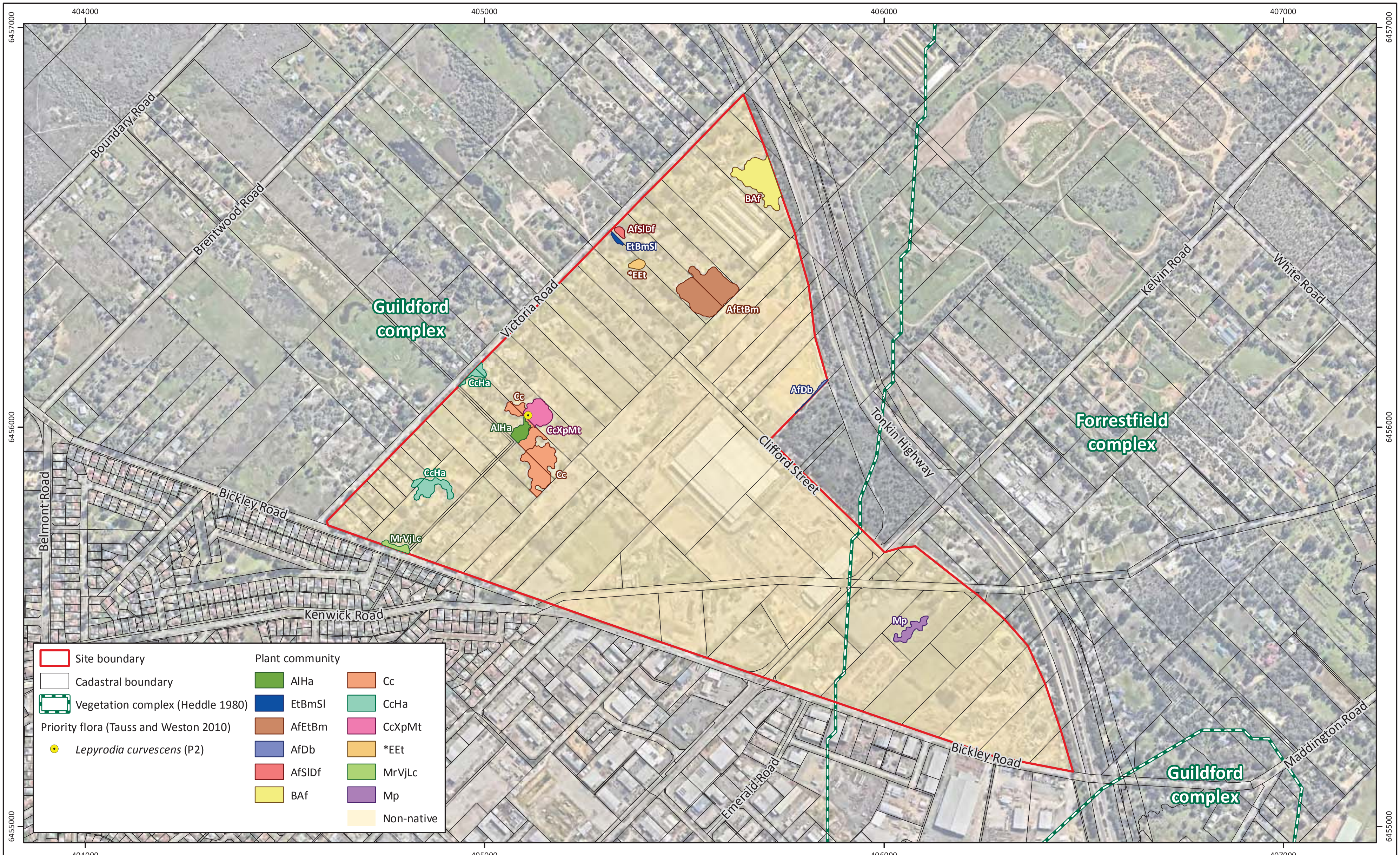


Figure 4: **Priority Flora and Plant Communities**

Project: Environmental Assessment and Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(09)--F55a
Drawn: KNM
Date: 10/01/2019
Checked: ALB
Approved: ALB
Date: 11/01/2019

Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix D Vegetation Condition Map

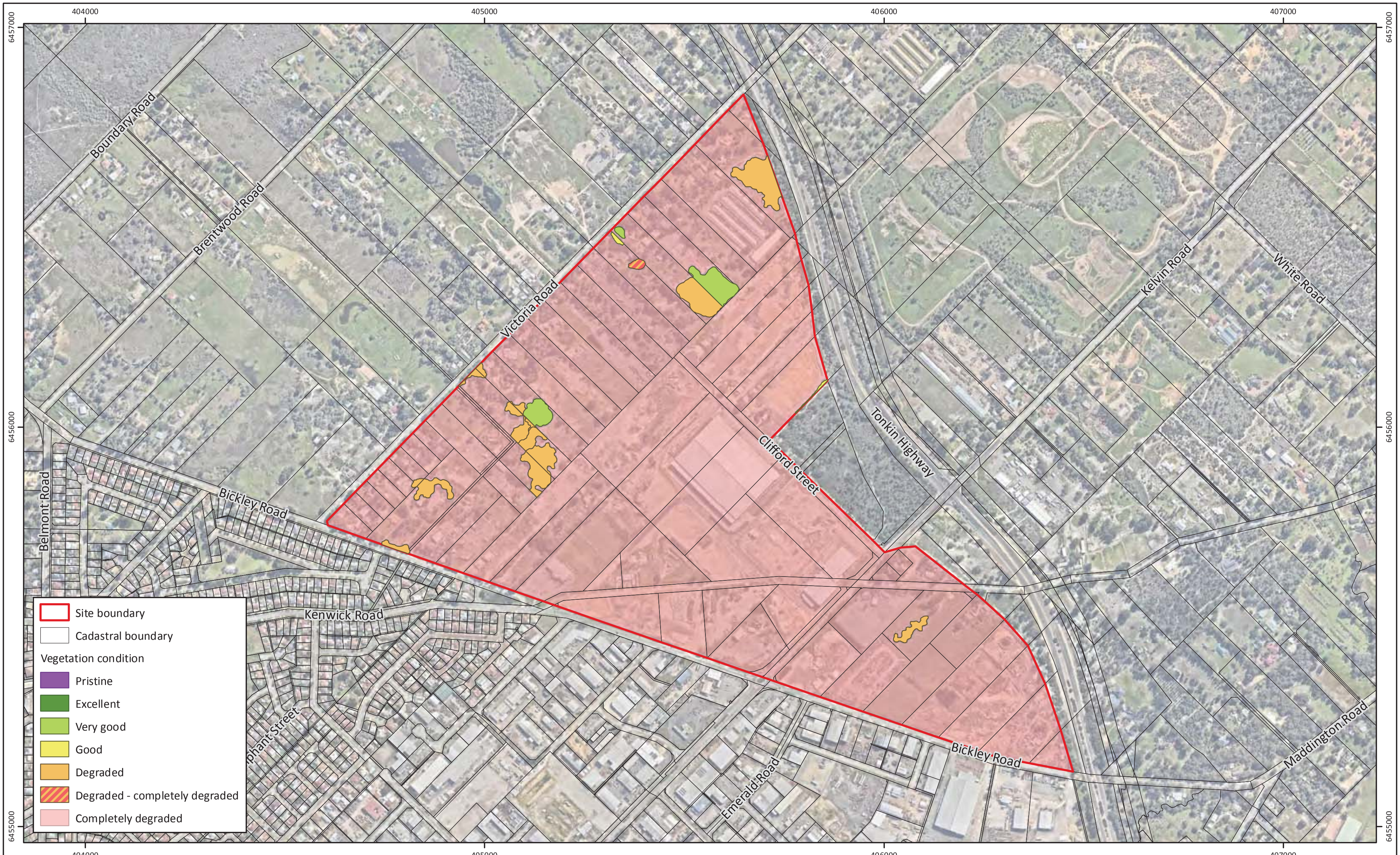


Figure 5: **Vegetation Condition**

Project: Environmental Assessment and Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(09)--F56a
Drawn: KNM
Date: 10/01/2019
Checked: ALB
Approved: ALB
Date: 11/01/2019

N

0 200 400
Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix E Conservation Significant Flora and Vegetation Map

Figure 6: **Conservation Significant Flora and Vegetation**

Project: Environmental Assessment and Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(09)--F57a
Drawn: KNM
Date: 10/01/2019
Checked: ALB
Approved: ALB
Date: 11/01/2019

N

0 200 400
Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

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Appendix F Wetland Features Map

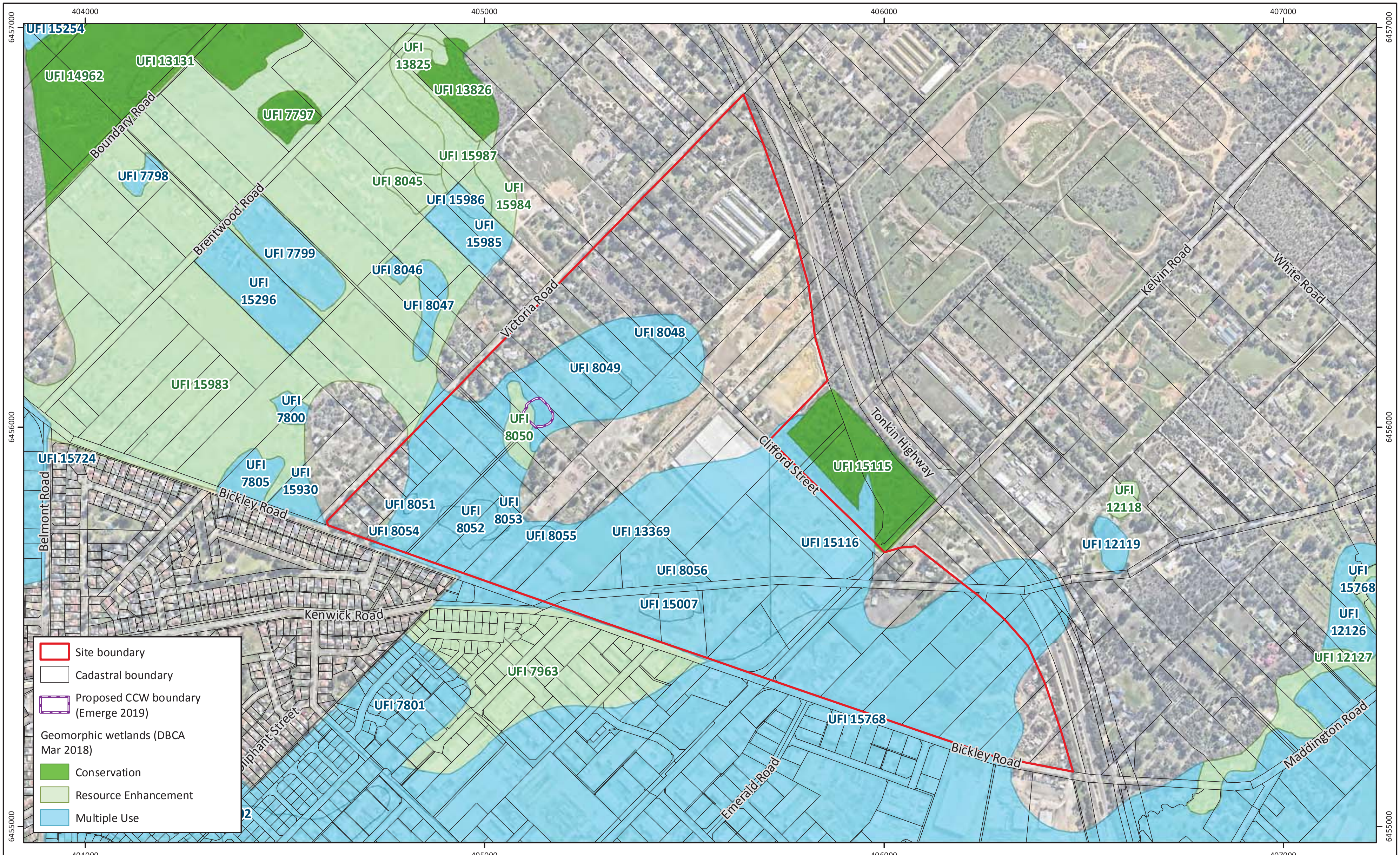

Figure 8: **Wetland Features**

Project:	Environmental Assessment and Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number:
EP17-010(09)--F59b

Drawn:	KNM
Date:	10/01/2019
Checked:	ALB
Approved:	ALB
Date:	11/01/2019

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Appendix G Structure Plan Response to Environmental Considerations Map

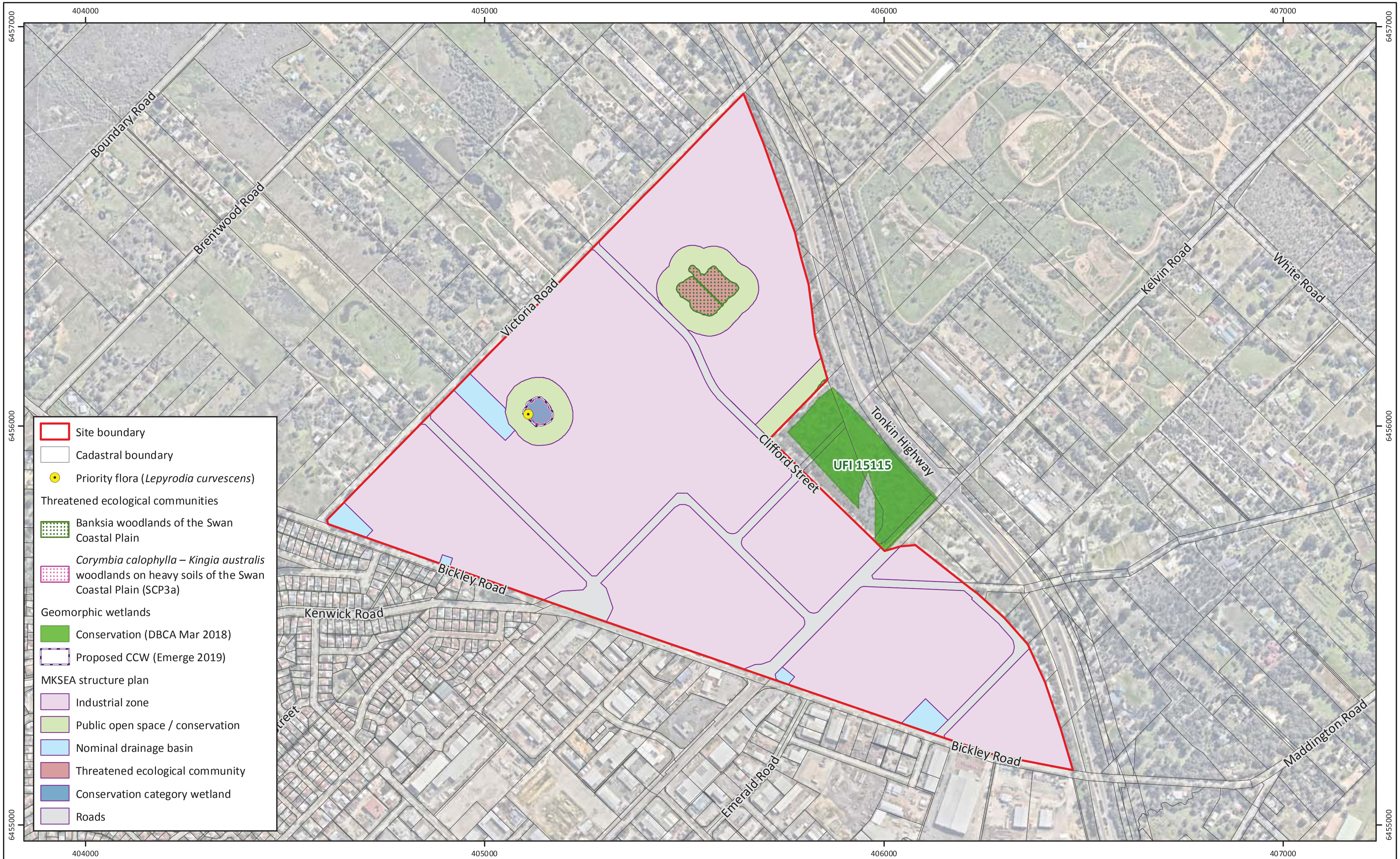

Figure 9: **Structure Plan Response to Environmental Considerations**

Project:	Environmental Assessment and Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number:
EP17-010(09)--F61f
Drawn: KNM
Date: 15/04/2019
Checked: ALB
Approved: ALB
Date: 15/04/2019

Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix H Bush Forever, Environmentally Sensitive Areas and Regional Ecological Linkages Map

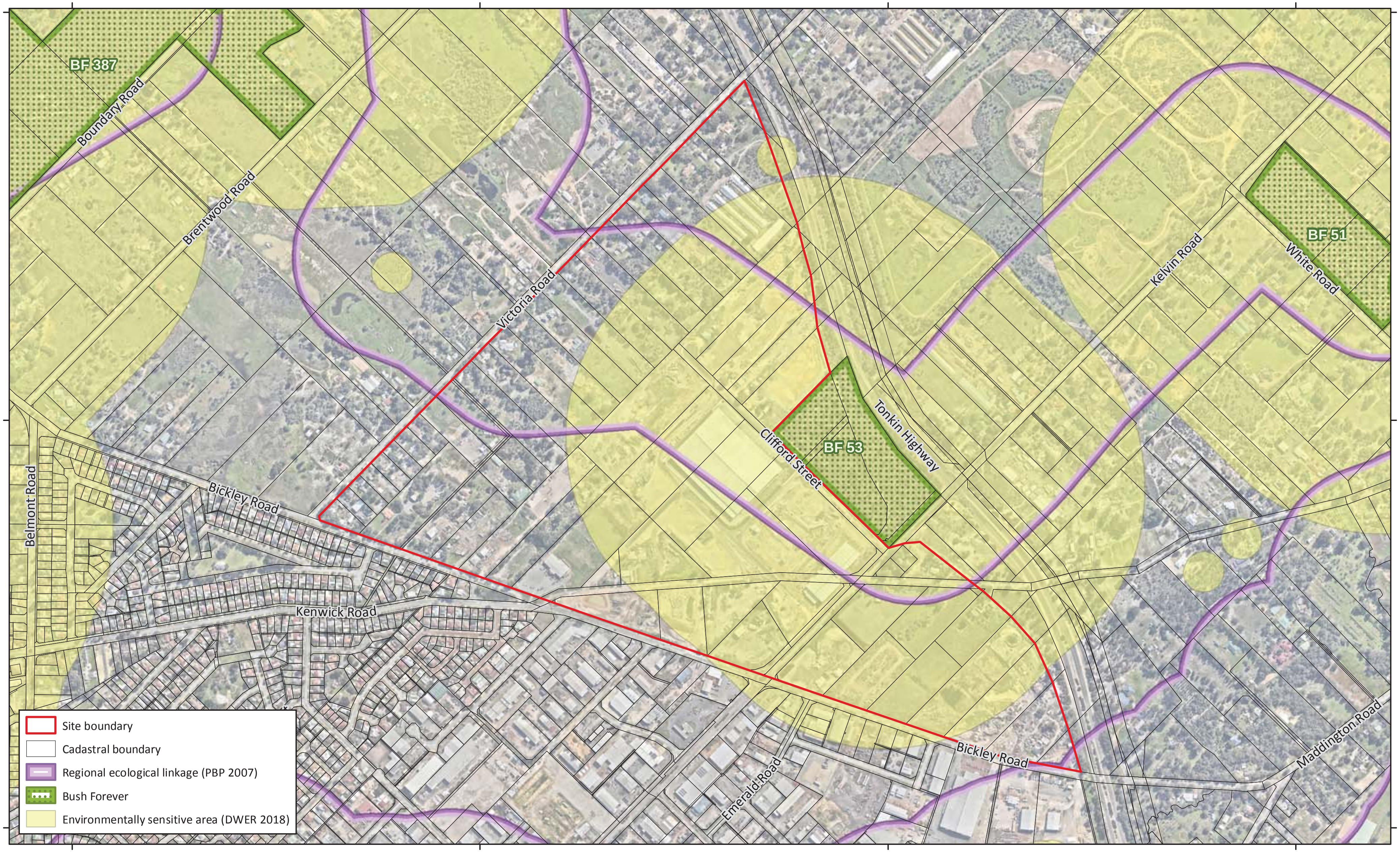

Figure 7: Bush Forever, Environmentally Sensitive Areas and Regional Ecological Linkages

Project: Environmental Assessment and Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(09)--F58
Drawn: KNM
Date: 20/03/2018
Checked: ADB
Approved: ALB
Date: 04/04/2018

N

0 200 400
Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix I Environmental Geology Map

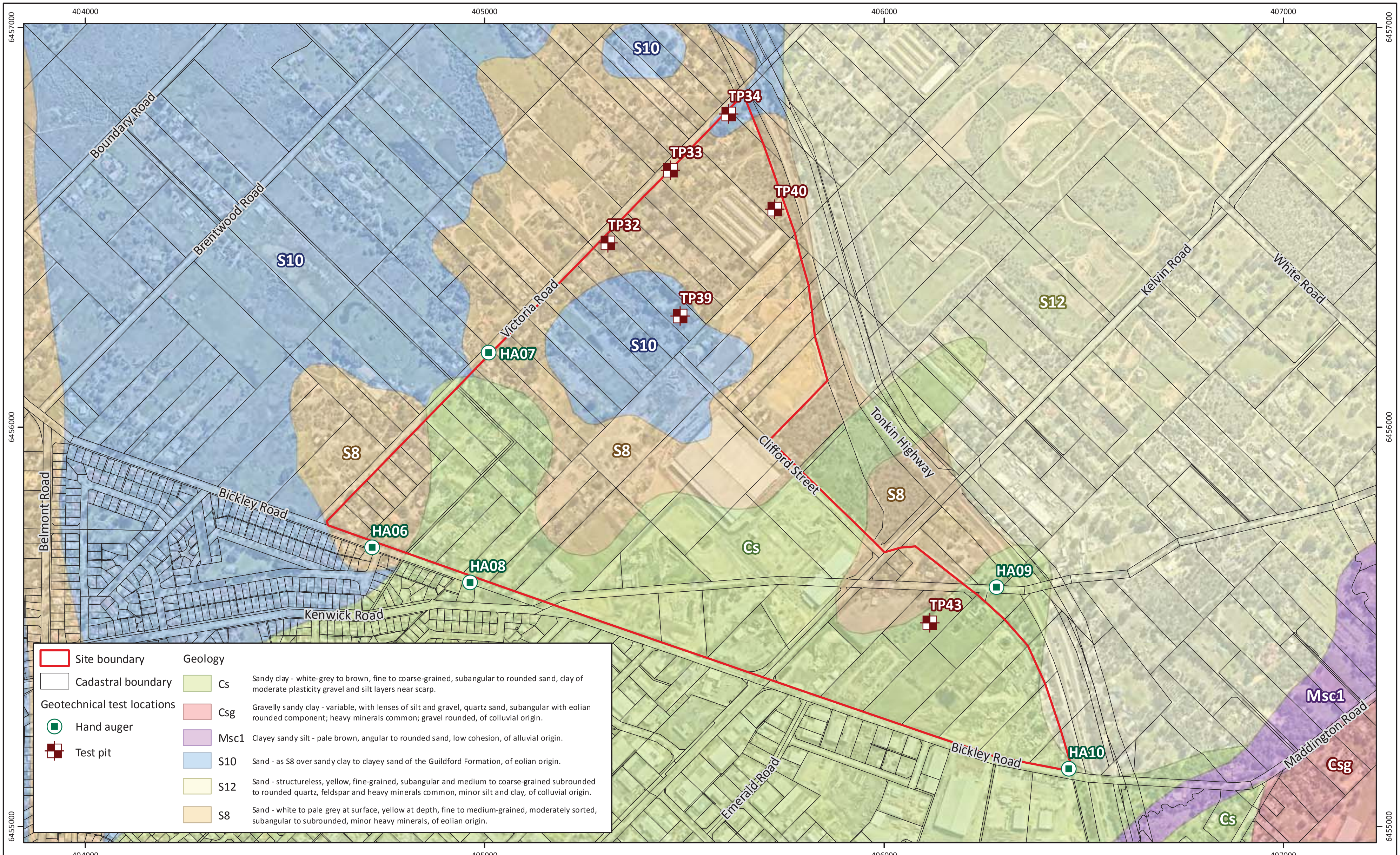

Figure 3: **Environmental Geology**

Project: Environmental Assessment and Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(09)--F54
Drawn: KNM
Date: 20/03/2018
Checked: ADB
Approved: ALB
Date: 04/04/2018

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Appendix J Acid Sulfate Soils Investigation Report

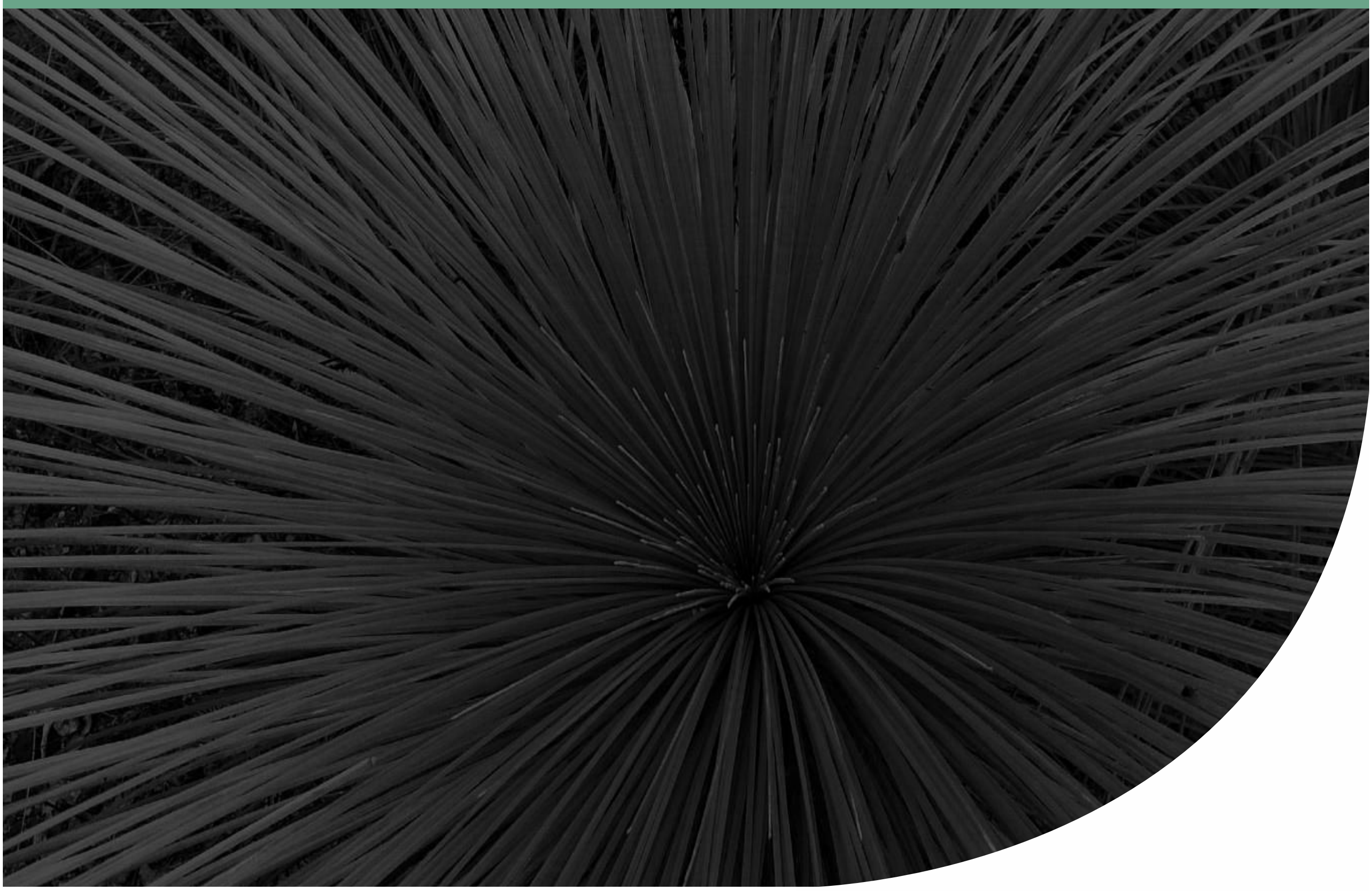
Acid Sulfate Soil Investigation

Maddington Kenwick Strategic Employment

Area Precincts 1, 2 and 3B

Project No: EP17-010(05)

Prepared for City of Gosnells
April 2018



Document Control

Doc name:	**Acid Sulfate Soil Investigation** **Maddington Kenwick Strategic Employment Area Precincts 1, 2 and 3B**				
Doc no.:	**EP17-010(05)--025**				
Version	**Date**	**Author**		**Reviewer**	
1	April 2018	Rebecca Duong	RLD	Simon Gregg	SPG
	Issued to City of Gosnells				

THIS DOCUMENT HAS BEEN PREPARED TO BE PRINTED DOUBLE SIDED

Executive Summary

Emerge Associates was engaged by the City of Gosnells to undertake an acid sulfate soil (ASS) investigation to support the Local Structure Plan (LSP) for the future development of the Maddington Kenwick Strategic Employment Area (MKSEA). MKSEA is comprised of Precincts 1, 2, 3A, 3B and 3C, of which Precincts 1, 2 and 3B are included within the scope of this investigation and are collectively referred to as the 'site'. The site is located within the City of Gosnells and totals approximately 374 ha within the suburbs of Wattle Grove, Kenwick and Maddington.

This ASS investigation report has been prepared to determine the likely presence or absence of the potential risk of ASS forming soils within the shallow soil profile across the site. The soil types encountered during the investigation have also been assessed in consideration of regional soil mapping. Future development is anticipated to require soil disturbance works and therefore additional and more detailed investigations are likely to be required to confirm the presence or absence of ASS risk when specific construction details are available.

The objective of this ASS investigation is to identify areas within the site which are likely to present a potential risk of ASS, and the scope of works for this investigation included:

- Desktop review of the topographical, geomorphological, ecological and hydrogeological attributes of the site including the relevant ASS risk mapping.
- A soil investigation involving:
  - The installation of 30 test pits and 14 soil bores to a maximum depth of 2.0 metres below ground level (mBGL) across the site.
  - Collection of soil samples from the natural soil profile at 0.5 m intervals for field pH testing using the Queensland Acid Sulfate Soil Investigation Team (QASSIT) fast field screen procedure.
  - Laboratory analysis of selected samples using the Suspension Peroxide Oxidation Combined Acidity and Sulfur (SPOCAS) analytical suite to determine the potential acidity content of the soils encountered at the site.

The fieldwork for ASS investigation was undertaken between 5 and 15 September 2017. The soils encountered on-site were broadly classified into six soil types, including:

- Topsoil (TS): Natural topsoils, with roots and organic matter, typically limited to the upper 0.3 m of the profile.
- Bassendean Sand (BS): Sands, including colours of white, yellow, grey, brown and orange, located above the water table. Soils are found either as the dominant soil type or as a thin layer (<0.5 m) overlaying the clay soils of the Guildford Formation.
- Guildford Formation (GF): Sandy clays and clayey sands with an intermittent gravel component, including colours of orange, grey, brown, yellow and red, present both above and below the water table. Soils are found both as the dominant soil type (present immediately beneath the topsoil) and also underlying Bassendean Sands.
- Silty sand (alluvium deposits) (SS): Brown, grey and orange silty sands, with an organic silt component, identified at limited locations across the site, located both above and below the water table.

- Coffee rock (CR): Weakly consolidated sands, brown to red (iron colour), occasional minor gravel component, present as a thin layer (<0.4 m) between 0.5 metres below ground level (mBGL) and 2.0 mBGL, present above the water table.

In addition to these soil types, uncontrolled fill was also identified within the upper portion of the profile at a number of locations. The fill layer contained inert waste materials including fragments of brick, tile, wood and plastics, up to a depth of 1.2 mBGL, and is not considered to be representative of natural soil conditions at these locations.

The soil types identified during the soil investigation generally align with the regional geology classifications of Bassendean Sands (map unit S8), Bassendean Sands overlying Guildford Formation (map unit S10), Guildford Formation (map units Sc and Cs) and sandy silt alluvial soils (map unit Ms4) as described by Gozzard (1986).

All 164 samples collected during the field investigation were submitted for QASSIT fast field screening, of which 33 samples were also submitted for SPOCAS analysis. A limited number of samples indicated the possible presence of potential ASS (PASS), with the results for each soil type summarised as follows:

- Soil type TS: The QASSIT results provided some indicators of PASS, however as the soils contains abundant organic material, are limited to the upper 0.3 m of the soil profile and are present wholly above groundwater level, the low pH_{FOX} results are not considered to be indicative of pyrite oxidation. The actual risk of ASS from this soil type is considered to be very low.
- Soil type BS: The QASSIT and SPOCAS results did not provide any indicators of PASS or AASS. All samples from this soil type were collected from above the groundwater table.
- Soil type GF: pH_{FOX} values of pH <3.0 were limited to five samples across three sample locations. Of the 15 samples submitted for SPOCAS analysis, a single sample from a depth of 1.0 mBGL reported a net acidity which exceeded the DWER action criteria (0.057 %S from sample TP01-1.0). The results indicate that PASS is present, but spatially limited.
- Soil type SS: The QASSIT results identified a single sample (TP03-0.5) which indicated the possible presence of PASS. While this sample indicates PASS, limited samples were collected from this soil type and therefore the presence/absence of ASS is not conclusive for this soil type.
- Soil type CR: Coffee rock was present as a thin layer at three locations. Two samples were collected from this soil type, with the results reporting no indicators of PASS, though it is known that coffee rock can present an acidification risk if disturbed.
- Soil type FILL: One sample from the fill layer indicated PASS with a pH_{FOX} value of pH <3.0. However, this sample (TP09-0.0) was collected from the surface, contained organic matter, and is comparable to the topsoil soil type. As this portion of the soil profile is permanently dry, the low pH_{FOX} result is not considered to be indicative of pyrite oxidation and the actual risk of ASS is considered to be very low. The source of the fill and it's variability is not known but could affect the representativeness of these results.

The findings of the investigation indicate that for the shallow portion of the soil profile within the site, there is no significant evidence of the presence of ASS within soil types TS, BS, CR and FILL, but there is some evidence of PASS within soil types GF and SS. More detailed investigations will be required to confirm the presence or absence of ASS specifically in relation to the deeper portion of the soil profile (and the portion that intersects groundwater) which is likely to be disturbed as a result of earthworks and services installation during development.

Overall, the findings of this investigation identified limited to no ASS risk within the upper 2.0 m of the soil profile within the site, with isolated areas of low risk. Further and more detailed investigations would be required for development areas within the site when specific information on sub-surface disturbance is known. However, the results of this investigation indicate that ASS does not appear to be a substantial risk in the shallow soils and can therefore be effectively managed during the normal subdivision process.

This Executive Summary must be read in conjunction with the remainder of the report as the Executive Summary does not provide detailed information on the specific enquiries or investigations undertaken, the rationale employed or any other mitigating circumstances. This additional information contained in the body of this report is critical in evaluating the conclusions and recommendations that have been drawn and that are presented in the Executive Summary

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1 Introduction

Emerge Associates was engaged by the City of Gosnells to undertake an acid sulfate soil (ASS) investigation to support the Local Structure Plan (LSP) for the future development of the Maddington Kenwick Strategic Employment Area (MKSEA). MKSEA is comprised of Precincts 1, 2, 3A, 3B and 3C, of which Precincts 1, 2 and 3B are included within the scope of this investigation and are collectively referred to as the 'site'. The site is shown on **Figure 1**.

This investigation aims to provide general information on the shallow geological conditions at the site in relation to ASS. Where intrusive works are required during development of the site, additional investigations are likely to be required to provide specific soil conditions.

1.1 Site identification

MKSEA is located across an area of approximately 470 hectares (ha) currently comprising approximately 200 rural residential lots within the suburbs of Wattle Grove, Kenwick and Maddington. MKSEA is predominantly located within the City of Gosnells, with a small portion of the MKSEA located within the City of Kalamunda.

The portion of MKSEA located within the site comprises two discrete areas which are spatially separated by the Greater Brixton Street Wetlands, located between Brook Road and Boundary Road. The site covers 374 ha and is generally bound by Grove Road and Roe Highway to the west, Coldwell Road to the north, Tonkin Highway to the east and Bickley Road to the south. The details for each precinct located within the site are provided in **Table 1**.

Table 1: MKSEA Precinct details

Precinct	Total area (ha)	Bound by
1	121	• Victoria Road to the north-west • Tonkin Highway to the north-east • Bickley Road to the south
2	189	• Boundary Road to the north-west • Tonkin Highway to the north-east • Victoria Road to the south-east • Bickley Road to the south
3B	64	• Coldwell Road and Grove Road to the north • Brook Road to the south-east • Bickley Road to the south-west
Total	**374**	-

The site boundary co-ordinates are shown on **Figure 2**.

1.2 Objective

The objectives of this investigation are to:

- Identify areas within the site likely to have been exposed, historically, or currently, to conditions favouring the formation of ASS via a desktop assessment.
- Determine the shallow soil types and characteristics present across the site, including an understanding of the presence and extent of ASS.

1.3 Scope of work

The scope of work undertaken for the investigation was consistent with the approved scope of work and comprised:

- Desktop review of the topographical, geomorphological, ecological and hydrogeological attributes of the site including the relevant ASS risk mapping.
- A soil investigation involving:
    - The installation of 30 test pits and 14 soil bores to a maximum depth of 2.0 metres below ground level (mBGL) across the site.
    - Collection of soil samples from the natural soil profile at 0.5 m intervals for field pH testing using the Queensland Acid Sulfate Soil Investigation Team (QASSIT) fast field screen procedure.
    - Laboratory analysis of selected samples using the Suspension Peroxide Oxidation Combined Acidity and Sulfur (SPOCAS) analytical suite to determine the potential acidity content of the soils encountered at the site.

1.4 Previous investigations

We are aware that a previous geotechnical investigation was undertaken for a portion of the site. The results are detailed in the report titled *Report on Geotechnical Investigation - Proposed Warehouse Development Lots 252 to 256 Clifford Street, Maddington, WA* (Douglas Partners 2015). Pertinent information from this report has been included in the relevant sections of this report.

In addition to this, JDSi Ground Engineering Pty Ltd (JDSi) are undertaking a geotechnical investigation for the site. The field investigations for the ASS investigation and geotechnical investigations were undertaken concurrently using the same investigation locations.

2 Site Conditions

2.1 Topography

The Light Detection and Ranging (LiDAR) dataset for the Swan Coastal Plain (DoW 2008) shows the site is generally flat, with slight increases in elevation towards the north-eastern and south-eastern portions of the site. The western portion of the site has the lowest elevation of between 7 mAHD and 13 mAHD, increasing to 20 mAHD in the northern portion of the site, and a maximum of 28 mAHD in the south-eastern portion of the site. Topography for the site as per DoW (2008) is shown on **Figure 3**.

2.2 Geology

2.2.1 Regional geology

Regional soil information detailed on the *1: 50,000 Environmental Geology Armadale* (Gozzard 1986) map indicates the site extends across five soil units:

- The central and majority of the site are likely to comprise:
  - Bassendean Sands (map unit S8), described as white to pale grey at surface, yellow at depth, fine to medium grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin.
  - Thin Bassendean Sand over Guildford Formation (map unit S10), described as Bassendean Sands over sandy clay to clayey sand of the Guildford Formation, of eolian origin.
- Small areas of Guildford Formation clayey sand (map unit Sc) located within the western portion of the site, described as silty in part, pale grey to brown, medium to coarse grained, poorly sorted, subangular to rounded, frequent heavy minerals, rare feldspar, of alluvial origin.
- Small areas of Guildford Formation sandy clay (map unit Cs) located within the southern portion of the site, described as white-grey to brown, fine to coarse grained, subangular to rounded sand, clay of moderate plasticity, gravel and silt layers near scarp.
- Small areas of sandy silt alluvium (map unit Ms4) located within the northern and western portions of the site, described as cream to pale brown alluvium, clayey in part, fine to medium grained sand, of alluvial origin.

Regional geology mapping within, and within the vicinity of, the site is shown on **Figure 4**.

2.2.2 Site geology

The geology of the shallow soil profile at the site was observed during the fieldwork. The test pits were installed within the areas mapped as Bassendean Sand, Guildford Formation (sandy clay and clayey sand) and Bassendean Sand over Guildford Formation.

The soils encountered during the investigation are generally consistent with those predicted by Gozzard (1986), although a number of sample locations within the central portion of the site encountered only Guildford Formation, where the geology unit of Bassendean Sand over Guildford Formation was mapped.

The soil profile encountered during this investigation can generally be summarised as one of the following dominant soil types:

- Bassendean Sand, comprising:
  - Occasional topsoil layer, with roots and organic matter, typically limited to the upper 0.3 m.
  - White, yellow, grey, brown and/or orange sands.
- Guildford Formation, comprising:
  - Occasional topsoil layer.
  - Orange, grey, brown, yellow and red sandy clays and/or clayey sands.
- Bassendean Sand over Guildford Formation, comprising sands overlying sandy clays or clayey sands.
- Silty sands, comprising brown, grey and orange sands, with an organic silt component, of alluvial origin.

Weakly cemented coffee rock was encountered at three locations. In all instances, the coffee rock was present as a relatively thin layer (<0.4 m thick) and was present above the observed groundwater level, at depths between 0.5 mBGL and 2.0 mBGL.

2.2.3 *Report on Geotechnical Investigation* (Douglas Partners 2015)

The geotechnical investigation undertaken by Douglas Partners was completed for a small area located in the southern portion of the site in January 2014. The investigation area is predominantly located within the Guildford Formation soil unit, and the results of the investigation were typically consistent with this soil type. A number of sample locations also encountered an underlying sand layer, beneath the sandy clay/clayey sand. Groundwater was not encountered at any location during the Douglas Partners' investigation.

2.3 ASS risk mapping

The DWER maintains ASS risk mapping (DWER 2018a) that identifies the ASS risk classification areas as follows:

- Class 1: High to moderate risk of ASS occurring within 3 m of natural soil surface.
- Class 2: Moderate to low risk of ASS occurring within 3 m of natural soil surface but high to moderate risk of ASS beyond 3 m of natural soil surface.

The risk maps do not describe the actual severity of ASS in a particular area but provide an indication that ASS could be present based on surface elevations and landforms. For each classification, the maps identify the type of works likely to present an environmental risk. Further investigation is required to determine if ASS are actually present and whether they are present in such concentrations as to pose a risk to the environment.

A review of the mapping (DWER 2018a) indicates that a band identified as a Class 1 (high to moderate) ASS risk area is located in the northern portion of the site, which is associated with the sandy silt soil type. A small area of Class 1, also associated with the sandy silt soil type, is located adjacent to the south-western site boundary. The remainder of the site is identified as Class 2 (moderate to low) ASS risk area. The DWER ASS risk mapping for the site and surrounds is shown on **Figure 5**.

2.4 Groundwater

2.4.1 Regional information

Information on the regional groundwater conditions obtained from the DWER's *Water Register* (DWER 2018b) indicates the groundwater beneath the site is a multi-layered system comprised of the following:

- Perth – Superficial Swan aquifer
- Perth – Leederville aquifer
- Perth – Yarragadee North aquifer.

The Perth – Superficial Swan aquifer is considered to be the primary aquifer of interest in relation to this investigation as this is the aquifer most likely impacted by soil disturbance.

The DWER's *Perth Groundwater Map* (DWER 2018c) indicates that groundwater within the superficial aquifer is located at approximately:

- 5.0 mAHD within the western portion of the site, corresponding to a water level approximately 2.0 mBGL and an aquifer thickness of approximately 10 m.
- 11.0 mAHD within the northern portion of the site, corresponding to a water level approximately 10.0 mBGL and an aquifer thickness of approximately 11 m.
- 9.0 mAHD within the central portion of the site, corresponding to a water level approximately 4.0 mBGL and an aquifer thickness of approximately 14 m.
- 15.0 mAHD within the southern portion of the site, corresponding to a water level approximately 10.0 mBGL and an aquifer thickness of approximately 15 m.

Regional groundwater flow direction in the vicinity of the site is expected to be in a westerly direction.

2.5 Wetlands

The Department of Conservation, Biodiversity and Attractions (DCBA) maintains the *Geomorphic Wetlands of the Swan Coastal Plain* dataset (DBCA 2018) which identifies wetland areas with a Unique Field Identifier (UFI) and categorises individual wetlands into specific management categories. This dynamic dataset is continually updated with site-specific wetland surveys providing new and relevant information. The wetland categories include:

- Conservation category wetlands (CCW) which support high levels of ecological attributes and functions. Management objectives seek to preserve these attributes and functions through reservation and protection under environmental protection policies.
- Resource enhancement wetlands (REW) which are partly modified but still support substantial functions and attributes. Management objectives seek to restore the wetland through maintenance and enhancement of the existing functions and attributes.
- Multiple use wetlands (MUW) which are heavily modified, retain few wetland attributes but still provide important hydrological functions.

A review of the current dataset (DBCA 2018) indicates a number of wetlands are present within the site, including:

- 17 CCWs, each ranging in area between 0.1 ha and 63.1 ha and totalling approximately 950 ha in total. Of these CCWs, only one wetland is named: Kenwick Swamp (UFI 7637).
- 15 REWs, each ranging in area between 0.6 ha and 106 ha and totalling approximately 1,630 ha in total. Of these REWs, only one wetland is named: Kenwick Swamp (UFI 15418).
- 28 MUWs, each ranging in area between 0.2 ha and 40 ha and totalling approximately 900 ha in total.

Many of these wetlands are small portions of an interconnected chain of wetlands, with the majority of the CCWs located within the vicinity of the site forming the Greater Brixton Street Wetlands, which are located between Brook Road and Boundary Road. The locations of the wetlands within, and in the vicinity of, the site are shown on **Figure 6.**

3 Sampling and Analysis Program and Fieldwork Summary

The ASS investigation was completed between 5 and 15 September 2017 and involved 44 sample locations of which 34 included the collection of samples. Samples were collected by JDSi in conjunction with the geotechnical investigation at 0.5 m intervals. All soil samples were subject to field pH testing using the QASSIT fast field screening method and 33 selected samples were submitted for laboratory analysis using the SPOCAS suite. Samples selected for laboratory analysis were based on the lowest oxidised field pH (pH_{FOX}) results, as well as those representative of the soil types encountered at the site.

3.1 Soil investigation summary

A total of 30 test pits and 14 soil bores were installed at the locations shown on **Figure 4**. The test pits and soil bores were installed to depths ranging from 0.5 mBGL to 2.0 mBGL. A summary of the sample locations is provided in **Table 2**, noting that the soil bores were installed via hand auger and have been denoted as 'HA' and test pits have been denoted as 'TP'. The sample locations have not been surveyed and the location co-ordinates provided in **Table 2** were recorded with a hand-held GPS. All sample depth references are recorded in relation to metres below ground level (mBGL).

Table 2: Soil bore and test pit information

Soil bore ID	Easting	Northing	Total depth	Samples collected
HA01	404890	6457068	1.20	
HA02	405328	6457510	1.80	
HA03	404281	6456018	1.50	✓
HA04	404363	6456112	0.50	✓
HA05	405640	6456844	2.00	
HA06	404718	6455699	2.00	✓
HA07	405010	6456187	1.80	
HA08	404964	6455612	1.10	✓
HA09	406282	6455600	2.00	
HA10	406463	6455145	1.00	✓
HA11	404989	6457153	0.50	
HA12	404580	6456734	1.00	
HA13	405152	6457828	0.75	
HA14	403716	6457068	0.65	
TP01	403273	6456688	1.50	✓
TP02	403557	6457411	1.80	✓
TP03	403978	6457867	2.00	✓
Units	*m*	*m*	*m*	-

Table 2: Soil bore and test pit information (continued)

Soil bore ID	Easting	Northing	Total depth	Samples collected
TP04	404123	6457982	1.80	✓
TP05	403721	6457289	2.00	✓
TP06	403979	6457375	2.00	✓
TP07	403681	6456252	2.00	✓
TP08	403765	6456386	2.00	✓
TP09	404113	6456650	1.50	✓
TP10	404258	6456846	2.00	✓
TP11	404689	6457326	2.00	✓
TP12	405047	6457608	1.35	✓
TP13	405072	6457704	1.25	✓
TP14	404040	6456159	2.00	✓
TP15	404456	6456649	2.00	✓
TP16	404600	6456660	2.00	✓
TP17	404872	6457144	2.00	✓
TP18	405018	6457144	1.00	✓
TP25	404869	6456296	1.30	✓
TP26	404742	6456524	2.00	✓
TP27	405045	6456647	2.00	✓
TP28	405170	6457017	1.80	✓
TP30	404944	6456230	2.00	✓
TP31	405200	6456448	0.60	
TP32	405309	6456461	2.00	✓
TP33	405465	6456643	2.00	✓
TP34	405611	6456784	2.00	✓
TP39	405490	6456278	2.00	✓
TP40	405726	6456546	2.00	✓
TP43	406115	6455510	2.00	✓
Units	*m*	*m*	*m*	-

The test pit and soil bore logs are provided in **Appendix A**.

Samples were only collected from selected hand auger locations due to the difficulty in retrieving samples from the narrow hole made by the hand auger. Samples were not collected at location TP31 due to an error in the field.

3.2 Sample collection

Soil samples were collected at 0.5 m intervals at the specified sample locations. Soil samples for QASSIT screening were transferred to laboratory-supplied zip lock bags and the zip lock bag was rolled to expel air and sealed. The zip lock bags were placed in a chilled esky containing ice for storage and transport to the laboratory.

3.2.1 QC samples

Of the 164 primary samples submitted for QASSIT screening, a total of 10 duplicate samples were collected, which equates to a rate of 6%. All duplicate samples were submitted for QASSIT tests.

3.2.2 Laboratory analysis

Soil samples were submitted to the laboratory for the QASSIT fast field screen testing as this provides a more controlled environment for the testing. The field pH and oxidised pH obtained from QASSIT screening are denoted pH_F and pH_{FOX} respectively.

Samples collected for QASSIT screening were retained at the laboratory for potential SPOCAS analysis. The SPOCAS analytical method was selected in preference to the chromium reducible sulphur suite as it is the method currently preferred by the DWER for Bassendean Sand.

Laboratory analysis was undertaken on 33 samples, which were selected as the samples which indicated the strongest QASSIT field screening indicators of actual ASS (AAAS) and potential ASS (PASS). Sample selection also sought to provide analysis of soil samples representative of the soil types encountered at the site. Samples submitted for laboratory analysis included:

• HA06-1.5	• TP07-0.5	• TP15-0.0	• TP30-1.0
• HA10-0.5	• TP08-1.0	• TP16-0.5	• TP32-0.5
• TP01-1.0	• TP09-1.0	• TP17-1.0	• TP33-1.0
• TP02-1.5	• TP10-1.0	• TP18-0.5	• TP34-1.5
• TP03-0.5	• TP11-0.5	• TP25-0.5	• TP39-1.0
• TP04-0.5	• TP12-0.5	• TP26-0.5	• TP40-1.0
• TP05-0.5	• TP12-1.0	• TP27-1.0	
• TP05-2.0	• TP13-0.5	• TP28-0.5	
• TP06-1.0	• TP14-0.5	• TP28-1.5	

In addition, field duplicate samples SQA02 and SQA04 were also collected and submitted for SPOCAS analysis.

3.3 Field QC methods and procedures

Field QC procedures implemented to ensure the reliability and integrity of all data gathered included:

- Documentation of all field activities.
- Creation of unique sample identification codes.
- Maintenance of chain of custody for all samples.

3.3.1 Documentation

Details of the soil profile encountered during the soil investigation were logged, including the sample collection depths.

3.3.2 Sample identification

Each sample was given a unique identifier, which comprised the soil bore name and sample depth. In addition, all samples were labelled with the:

- Site reference
- Sampling date
- Sampler's initials.

All soil QC samples used the prefix 'SQA' and were numbered sequentially.

3.3.3 Chain of custody

Every sample collected for QASSIT screening and potential laboratory analysis was entered onto a chain of custody (CoC) form. The CoC documented the sample identification, sample date, sample matrix, number and type of sample containers, and the requested analysis. Any additional comments or requirements affecting the analysis of the samples were stipulated on the CoC.

The CoC accompanied the samples during storage and transport to the laboratory. Upon receipt, the laboratory provided confirmation of the status and condition of all samples and returned a completed CoC to Emerge.

3.3.4 Sample containers, preservation and storage

All sample bags were supplied by the laboratory specifically for this project. Samples were transferred to the laboratory on the day of collection or as soon as possible thereafter. No special or unorthodox sample storage or preservation requirements were required.

3.4 Field QC samples

Field QA/QC samples are collected to assess the likelihood and extent of any bias introduced by field contamination (substances introduced in the field due to environmental factors) and sampling variability (due to sampling technique and heterogeneity of the sample matrix). The assessment of variability is undertaken by the use of replicate samples. The rationale for the rate of QA/QC samples collected during the soil investigation is outlined in the following sections.

3.4.1 Field duplicate samples

Field duplicate samples are collected simultaneously with a standard environmental sample (primary sample) from the same source under identical conditions. The duplicate sample is analysed to assess laboratory performance through a comparison of the reported results. Due to the inherent variability in ASS analysis, triplicate samples were not collected.

The collection of duplicate samples only was considered appropriate to assess the accuracy of laboratory procedures for the SPOCAS analysis. Duplicate soil samples were collected by splitting the soil from the core tray between two zip lock bags at the duplicate sample depth. A total of 10 duplicate samples were collected during the soil investigation for field pH testing. Selected QC samples were also submitted for SPOCAS analysis.

3.4.2 Field/trip and equipment rinsate blank samples

The equipment rinsate blank sample evaluates field sampling and decontamination procedures to identify the potential for cross-contamination. Given the minimal potential for cross contamination, equipment rinsate blank samples were not considered necessary.

Field blank samples are QC samples where the sample container is filled in the field to assess potential contamination from ambient concentrations. Trip blank samples are QC samples that assess contamination introduced from shipping. Given volatile contaminants are not relevant to ASS investigations, field and trip blank samples were not considered necessary.

3.4.3 QC results evaluation

3.4.3.1 Replicate sample results

Replicate sample results (field duplicate samples) were assessed using a relative percentage difference (RPD) analysis. Where a primary sample and a duplicate sample are compared, the RPD provides an indication of the precision of the results.

In accordance with the *Australian Standard 4482.1-2005* (Standards Australia 2005), we adopt an RPD acceptance criterion up to 30% of the mean concentration of the analyte. It should be noted that variations might be higher for organic analysis, due to the volatile nature of the components, and for low concentrations of analytes.

The calculation used to determine the RPD is:

$$RPD = ((Co - Cs) / ((Co + Cs)/2)) \times 100$$

Where: Co = concentration of the original sample

Cs = concentration of the duplicate sample

In calculating the RPD values the following protocols were adopted:

- Where both concentrations are below the laboratory reporting limits, no RPD is calculated.
- Where one or both concentrations are less than ten times the laboratory reporting limit no RPD is calculated.
- Where both concentrations are more than ten times the laboratory reporting limit the above formula is used.

This approach is employed by NATA accredited laboratories when assessing internal duplicate sample RPDs and acknowledges that concentrations at or around the reporting limit are too low for an accurate evaluation of the significance of the RPD. Where the adopted 30% RPD acceptance criterion is exceeded, the impact upon the accuracy and reliability of the data as a whole will be assessed on an analyte specific basis.

3.4.3.2 Laboratory QC samples

The laboratory that completed the analysis undertakes and reports internal laboratory QC procedures for all chemical analysis undertaken. The QC testing includes:

- Laboratory duplicate sample analysis at the rate of one per 10 samples.
- Method blanks at the rate of one per 20 samples.
- Laboratory control spike recovery analysis at the rate of one per 20 samples.
- Matrix spike recovery analysis at the rate of one per 20 samples.
- Surrogate spike recovery analysis for each sample.

The criteria used to assess the acceptability of the laboratory QC data and hence the reliability of the results is detailed in **Table 3**.

Table 3: Assessment criteria for laboratory QC data

QA/QC Sample Type	Assessment Criterion
Laboratory duplicate	No fail criterion for report results <10 x LoR
	<50% for reported results between 10 x LoR and 20 x LoR
	<20% for reported results between >20 x LoR
Method blank	<LoR
Organic compounds	
Matrix spike	70% to 130%
Surrogate recovery	70% to 130%
Laboratory control standards	70% to 130%
Inorganic compounds	
Matrix spike	<US EPA approved methods
Surrogate recovery	<US EPA approved methods
Laboratory control standards	<US EPA approved methods

The laboratory QC results were reviewed to confirm compliance with the acceptance limits detailed in **Table 3**. All acceptance criteria were met, and the QC laboratory documentation are provided in **Appendix B**.

3.5 Analytical laboratories

All laboratory analysis was undertaken by a NATA accredited laboratory. All primary and duplicate samples were submitted to ALS Environmental Pty Ltd (ALS) Perth for analysis. ALS is included in the ALS Environmental NATA accreditation number (825) with Perth having a site ID of 15847.

4 Quality Assurance/Quality Control Assessment

4.1 QA/QC data evaluation

4.1.1 Holding times

All soil samples were received by the laboratory and analysed within the recommended holding time.

4.1.2 RPD assessment

All RPDs were below the acceptance criterion, indicating a suitable level of repeatability in the results.

4.1.3 Laboratory QA evaluation

All SPOCAS analysis was undertaken at a laboratory with NATA accreditation confirming the appropriateness of the laboratory's method and QA procedures. The QASSIT field screening procedure is not NATA accredited but is an alternate method to conducting the screening procedure in the field which would also not be NATA accredited. It is used to identify the samples most likely to have acidity that would be detected by SPOCAS analysis and it does not impact on any treatment rates or management procedures.

4.1.4 QA/QC data evaluation summary

A review of field and laboratory QC procedures and data indicates an acceptable level of compliance with the general project requirements and objectives. As such, there is considered to be an acceptable level of confidence in the data upon which project risk decisions will be made.

5 Results

The field data and laboratory analytical results for the soil investigation are summarised in the following sections. Laboratory results are provided in the **Summary Tables** and the laboratory certificates of analysis and QC results are provided in **Appendix B**.

5.1 Soil profile observations and classification

The soils encountered on-site can be broadly classified into six soil types as outlined in **Table 4**.

Table 4: Soil classifications and descriptions

Soil type	Description	Soil type code
Topsoil	Natural topsoil, with roots and organic matter, typically limited to the upper 0.3 m of the profile.	TS
Bassendean Sand	Sands, white, yellow, grey, brown and orange. Soils are found either as the dominant soil type or as a thin layer (<0.5 m) overlying the clay soils of the Guildford Formation.	BS
Guildford Formation	Sandy clays and clayey sands with an intermittent gravel component, orange, grey, brown, yellow and red. Soils are found both as the dominant soil type (present immediately beneath the topsoil) and also underlying Bassendean Sands.	GF
Silty sand (alluvium deposits)	Brown, grey and orange silty sands, with an organic silt component, identified at limited locations across the site.	SS
Coffee rock	Weakly consolidated sands, brown to red (iron colour), occasional minor gravel component, present as a thin layer (<0.4 m) between 0.5 mBGL and 2.0 mBGL, above the observed water level.	CR

In addition to these soil types, uncontrolled fill was also identified within the upper portion of the profile at approximately half the investigation locations. The fill layer contained inert waste materials including fragments of brick, tile, wood and plastics, up to a depth of 1.2 mBGL, and is not considered to be representative of natural soil conditions at these locations.

The soil types identified during the soil investigation generally align with the regional geology classifications of Bassendean Sands (S8), Bassendean Sands overlying Guildford Formation (S10), Guildford Formation (Sc and Cs) and sandy silt alluvial soils (Ms4). Each investigation location has been assigned a soil classification in line with the regional geology mapping, in accordance with the general soil profile encountered during the investigation. The soil types identified during the investigation are shown in relation to the regional geology mapping on **Figure 4**.

5.2 Field pH test results

The field pH test results have been assessed against the criteria in DWER guideline (DER 2015a), which are summarised in **Table 5**. These criteria have been used to assess the relevance of the field screening results for likely indicators of AASS or PASS.

Table 5: Field pH test screening criteria

ASS classification	pH result	Comments
Actual acid sulfate soils (AASS)	$pH_F \leq 4$	Not conclusive as peats and heavily fertilised soils may also give $pH_F \leq 4$.
	$4 \leq pH_F \leq 5$	Indicates an acid soil and requires further consideration for a possible ASS link.
Potential acid sulfate soils (PASS)	ΔpH	ΔpH at least 1 pH unit and reaction to peroxide. The larger the change in pH the stronger the indication of the presence of PASS.
	$pH_{FOX} <3$	Strongly indicates PASS, particularly when combined with large ΔpH and strong reaction.
	$3> pH_{FOX} <4$	Moderate indicator of PASS, however organic matter may be responsible for pH decrease.
	$4> pH_{FOX} <5$	Neither positive nor negative for PASS.
	$pH_{FOX} >5$	Little net acidifying ability.

5.3 Laboratory analysis

A total of 33 primary soil samples were selected for SPOCAS analysis. The samples were selected based on the field pH test results and to be representative of the soil types identified with a bias to the more commonly occurring soil types. The samples selected for analysis comprised the following:

- Soil type TS: One sample was submitted for analysis as there were indicators of PASS. Only one sample was submitted due to the limited prevalence of the soil type within the overall profile, and because is it reasonable to expect that these soil will be permanently dry and therefore ASS is unlikely.
- Soil type BS: 13 samples were submitted for analysis. No indicators of PASS were identified in the field screening results, with all samples from this soil type collected from the dry portion of the soil profile due to the relatively shallow investigation depth. As this soil type was encountered over a significant portion of the site, and is expected to also be present below groundwater, the number of samples from this soil type that were submitted for analysis was considered to be appropriate.
- Soil type GF: 15 samples were submitted for analysis based on strong indicators of PASS from a limited number of samples. Indicators of PASS were present in samples located both above and below the groundwater table.
- Soil type SS: Three samples were submitted for analysis based on weak indicators of PASS.
- Soil type CR: No samples were submitted as there were no indicators of PASS. There was only limited occurrence of this soil type and therefore limited potential for disturbance, and consequently limited risk of significant acid generation.

The net acidity values identified by the SPOCAS analysis were compared against the DWER texture-based ASS action criteria provided in DER (2015b). The criteria are summarised in **Table 6**.

Table 6: DWER texture based criteria for soil treatment

Material type and texture	Approx. clay content	<1,000 Tonnes	>1,000 Tonnes
Coarse texture: Sands to loamy sands and peats	≤ 5%	0.03 %S	0.03 %S
Medium texture: Sandy loams to light clays	5% – 40%	0.06 %S	0.03 %S
Fine texture: Medium to heavy clays and silty clays	≥ 40%	0.1 %S	0.03 %S
Bassendean sands	-	0.03 %S	0.03 %S

As a conservative approach, all results have been assessed against a net acidity criteria of 0.03 %S.

In relation to **Table 6**, the DWER guideline (DER 2015b) recommends that for Bassendean Sand, where the analytical results indicate a sulfur content of <0.03% in combination with a pH_{FOX} <3 then the material should be treated by neutralisation with alkaline materials as if it had an inorganic sulfur content of 0.03 %S.

The net acidity value for a soil sample is calculated from components of the SPOCAS suite via the following formula:

Net acidity (%S) = Potential acidity (SPOS) + Existing acidity (TAA)

Where:

- SPOS = Peroxide Oxidisable Sulphur (%S).
- TAA = Titratable Actual Acidity (%S).

Where the Titratable Sulfidic Acidity (TSA) component of the SPOCAS analysis exceeds the sulfidic acidity predicted from the sulfur trail (SPOS), the net acidity is also calculated using the TSA to provide an additional estimate of the potential for acidification.

The results of the SPOCAS analysis for each soil type are summarised in the following sections.

5.4 Topsoil soil type

The TS soil type was present as a thin, organic layer at the soil surface which was encountered at the majority of sample locations. Topsoil was typically not encountered where fill was present as the upper portion of the profile.

A total of 19 topsoil samples were collected from the upper 0.1 m of the soil profile. All samples were submitted for field screening, and one sample (TP15-0.0) was also submitted for laboratory analysis. The results are summarised as follows:

- pH_F results ranged between pH 4.6 and pH 7.3.
- pH_{FOX} results ranged between pH 2.1 and pH 4.5.
- Sample TP15-0.0 (results of pH_F 5.8 and pH_{FOX} 3.3) returned the following results:
  - A pH_{KCl} result of pH 6.0.
  - A pH_{OX} result of pH 3.2.
  - A net acidity result of 0.015 %S.

The TS soil type contains a high amount of organic material, is limited to the upper 0.3 m of the soil profile and is present above groundwater level. The QASSIT screening indicated that the PASS may be present in this soil type, however the permanently dry nature of these soils indicates that any changes in pH as a result of oxidation are likely to be associated with the lower pH of the peroxide and negligible buffering capacity of the soil, or release of organic acids that would not occur under normal conditions. The dry conditions of this soil make it unlikely for conditions to exist for the formation and persistence of ASS.

Given this soil profile is not within the range of seasonal inundation and the acidity does not appear to be a result of pyrite oxidation, there are not considered to be indicators of AASS or PASS within the TS soil type. Therefore, these soils are not considered to not pose a significant acid generating risk if disturbed.

5.5 Bassendean Sand soil type

A total of 44 samples were collected from the BS soil type, with 13 samples submitted for laboratory analysis. A summary of the results per sample location are provided in **Table 7**.

The QASSIT results for the BS soil type do not present any indicators of PASS. The field test results are confirmed by the laboratory results which indicate net acidity of <0.03 %S for all samples. The results indicate that the BS soil type above the groundwater at the site does not pose a significant risk of acid generating potential.

The laboratory analysis for some samples reported a net acidity <0.03 %S but >0.01 %S. The DWER has indicated that consideration of potential acidification for Bassendean Sands also needs to consider net acidity results between 0.01 %S and 0.03 %S due to the low buffering capacity of this soil type. However, this consideration is only triggered where the pHFOX is <pH 3.0. The field pH testing data indicates that all samples reported pHFOX and pH 3.0 or greater, with only one sample reporting pHFOX 3.0. The data suggests that the Bassendean Sand present is unlikely to pose a significant acidification risk if disturbed.

Table 7: Field screening and laboratory results summary for the BS soil type

Test pit ID	Sample depths	Total depth	Number of samples		pH_F		pH_{FOX}		pH_{KCl}		pH_{OX}		Net Acidity	
			QASSIT	SPOCAS	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
TP02	0.5, 1.0, 1.5, 1.8	1.8	4	1	7.2	7.7	5.4	5.9	7.3	7.3	5.8	5.8	0.010	0.010
TP05	0.5, 1.0, 1.5, 2.0	2.0	4	2	5.4	6.3	4.3	5.0	6.6	6.9	4.4	5.0	0.010	0.010
TP07*	0.5	2.0	1	1	7.0	7.0	6.1	6.1	6.6	6.6	6.6	6.6	0.010	0.010
TP12*	0.5	1.35	1	1	6.9	6.9	5.2	5.2	6.5	6.5	5.7	5.7	0.015	0.015
TP13*	0.5, 1.0	1.25	2	1	6.0	6.1	3.4	3.7	6.3	6.3	4.7	4.7	0.010	0.010
TP27	0.5, 1.0, 1.5, 2.0	2.0	4	1	7.4	8.4	5.0	5.7	7.0	7.0	4.3	4.3	0.010	0.010
TP28	0.5, 1.0, 1.5, 2.0	2.0	4	2	6.6	6.9	4.2	5.1	7.0	7.0	5.1	6.1	0.010	0.010
TP30	0.5, 1.0, 1.5, 2.0	2.0	4	1	5.6	6.0	3.9	4.5	6.4	6.4	4.1	4.1	0.010	0.010
TP32	0.5, 1.0, 1.5, 2.0	2.0	4	1	6.2	6.6	4.1	5.0	6.3	6.3	3.3	3.3	0.011	0.011
TP33	0.5, 1.0, 1.5, 2.0	2.0	4	1	6.9	7.4	4.9	5.4	6.8	6.8	3.8	3.8	0.010	0.010
TP34*	0.5, 1.0	2.0	2	0	6.3	6.6	4.4	4.6	-	-	-	-	-	-
TP39*	0.5	2.0	1	0	6.4	6.4	4.1	4.1	-	-	-	-	-	-
TP40	0, 0.5, 1.0, 1.5	2.0	4	1	6.2	6.7	4.2	5.3	6.8	6.8	4.6	4.6	0.010	0.010
TP43	0, 0.5, 1.0, 1.5, 2.0	2.0	5	0	4.0	4.6	3.0	4.1	-	-	-	-	-	-
Units	*mBGL*	*mBGL*	-		*pH units*		*pH units*		*pH units*		*pH units*		*%S*	

In relation to **Table 7**, '*' indicates those test pits whose profile consists of Bassendean Sands underlain by Guildford Formation.

5.6 Guildford Formation soil type

A total of 65 samples were collected from the GF soil type, with 15 samples submitted for laboratory analysis. A summary of the results per sample location are provided in **Table 8**.

Table 8: Field screening and laboratory results summary for the GF soil type

Test pit ID	Sample depths	Total depth	Number of samples		pH_F		pH_{FOX}		pH_{KCl}		pH_{OX}		Net Acidity	
			QASSIT	SPOCAS	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
HA03	0.5, 1.0, 1.5	1.5	3	0	7.8	8.6	6.8	8.0	-	-	-	-	-	-
HA04	0, 0.5	0.5	2	0	7.5	7.8	5.9	6.4	-	-	-	-	-	-
HA06	1.5, 2.0	2.0	2	1	5.6	6.6	4.1	4.7	6.2	6.2	4.6	4.6	0.015	0.015
HA08	0.5, 1.0, 1.1	1.1	3	0	7.8	8.1	6.2	6.2	-	-	-	-	-	-
HA10	0.5, 1.0	1.0	2	1	7.3	7.4	5.2	5.3	6.0	6.0	5.1	5.1	0.010	0.010
TP01	0.5, 1.0, 1.5	1.5	3	1	7.4	8.0	7.1	7.4	9.2	9.2	7.9	7.9	0.057	0.057
TP04	0.5, 1.0, 1.5, 2.0	2.0	4	1	4.6	6.4	2.3	4.9	7.6	7.6	6.4	6.4	0.010	0.010
TP06	1.5, 2.0	2.0	2	0	7.4	7.8	7.6	8.1	-	-	-	-	-	-
TP07*	1.0, 1.5, 2.0	2.0	3	0	4.6	5.8	1.6	5.0	-	-	-	-	-	-
TP08	0.5, 1.0, 1.5, 2.0	2.0	4	1	6.1	7.7	5.3	7.5	6.9	6.9	8.2	8.2	0.010	0.010
TP09	1.0, 1.5	1.5	2	1	7.6	7.7	6.1	6.6	6.7	6.7	6.9	6.9	0.011	0.011
TP10	1.0, 1.5, 2.0	2.0	3	1	6.9	7.2	7.3	7.5	6.3	6.3	7.4	7.4	0.010	0.010
TP11	0.5, 1.0, 1.5, 2.0	2.0	4	1	6.7	7.3	5.8	7.6	6.4	6.4	6.8	6.8	0.010	0.010
TP12*	1.0, 1.35	1.35	2	1	6.8	6.8	4.3	5.7	5.9	5.9	5.2	5.2	0.015	0.015
TP13*	1.25	1.25	1	0	5.5	5.5	3.4	3.4	-	-	-	-	-	-
Units	*mBGL*	*mBGL*	-		*pH units*		*pH units*		*pH units*		*pH units*		*%S*	

Table 8: Field screening and laboratory results summary for the GF soil type (continued)

Test pit ID	Sample depths	Total depth	Number of samples		pH_F		pH_{FOX}		pH_{KCl}		pH_{OX}		Net Acidity	
			QASSIT	SPOCAS	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
TP14	0.5, 1.0, 1.5, 2.0	2.0	4	1	5.1	6.8	2.2	6.8	6.8	6.8	3.7	3.7	0.010	0.010
TP15	0.5, 1.0, 2.0	2.0	3	0	7.0	7.8	7.0	8.1	-	-	-	-	-	-
TP16	0.5, 1.0, 1.5, 2.0	2.0	4	1	8.4	9.4	6.2	7.8	7.0	7.0	6.7	6.7	0.011	0.011
TP17	0.5, 1.0, 1.5, 2.0	2.0	4	1	6.8	7.3	5.5	6.9	5.8	5.8	6.6	6.6	0.024	0.024
TP25	1.0	1.3	1	0	8.2	8.2	6.2	6.2	-	-	-	-	-	-
TP26	0.5, 1.0, 1.5, 2.0	2.0	4	1	6.0	9.2	4.4	9.0	5.9	5.9	4.8	4.8	0.027	0.027
TP34*	1.5, 2.0	2.0	2	1	5.4	5.4	4.0	4.2	6.6	6.6	5.0	5.0	0.011	0.011
TP39*	1.0, 1.5, 2.0	2.0	3	1	5.2	5.5	3.8	3.9	6.4	6.4	4.6	4.6	0.010	0.010
Units	*mBGL*	*mBGL*	-		*pH units*		*pH units*		*pH units*		*pH units*		*%S*	

In relation to **Table 8**:

- The shaded cells indicate PASS indicators for pH_{FOX} or net acidity results which exceed the DWER criteria of 0.03 %S.
- '*' indicates those test pits whose profile consists of Guildford Formation overlain by Bassendean Sands.

The QASSIT results for the GF soil type indicate PASS within five samples collected from three sample locations (TP04, TP07 and TP14), as indicated by pH_{FOX}. The samples which indicated PASS were collected from both above and below the water table. In addition, one sample (TP01-1.0) reported a net acidity of 0.057 %S which exceeds the DWER action criteria of 0.03 %S. The samples which indicate the potential for acid generation represent a minor proportion of the samples collected and a limited spatial distribution within the site. On this basis, there is considered to be limited potential for acid generation from the GF soil type.

5.7 Silty sand soil type

A total of nine samples were collected from the SS soil type, with three samples submitted for laboratory analysis. A summary of the results per sample location are provided in **Table 9**.

Table 9: Field screening and laboratory results summary for the SS soil type

Test pit ID	Sample depths	Total depth	Number of samples		pH_F		pH_{FOX}		pH_{KCl}		pH_{OX}		Net Acidity	
			QASSIT	SPOCAS	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
HA06	0.5, 1.0	2.0	2	0	7.6	8.0	5.4	5.9	-	-	-	-	-	-
TP03	0.5, 1.0, 1.5, 2.0	2.0	4	1	5.7	6.3	2.9	4.5	6.4	6.4	5.8	5.8	0.010	0.010
TP18	0.5, 1.0	1.0	2	1	7.0	7.1	3.5	3.7	7.1	7.1	6.1	6.1	0.014	0.014
TP25	0.5	1.3	1	1	5.6	5.6	3.4	3.4	6.6	6.6	4.5	4.5	0.010	0.010
Units	*mBGL*	*mBGL*	-		*pH units*		*pH units*		*pH units*		*pH units*		*%S*	

In relation to **Table 9**, the shaded cells indicate PASS indicators for pH_{FOX}.

Of those sample locations which identified the SS soil type, sample locations HA06, TP18 and TP25 contained silty sand as a thin layer within the profile and are generally located within areas of Bassendean Sand over Guildford Formation. Sample location TP03 observed the SS soil type throughout the profile and is located within the vicinity of the soil unit Ms4 (alluvium deposits) which is associated with historic wetlands. The QASSIT results for the SS soil type only indicated PASS within one sample (TP03-0.5), while the net acidity results do not exceed the DWER action criteria. Sample TP03-0.5 was collected from above the groundwater table, and the permanently dry nature of these soils indicates that any changes in pH are unlikely to be attribute to ASS. The SS soil type is spatially limited within the site and while the results indicate that it is not likely to pose a significant risk of acid generating potential if disturbed, the number of sample locations installed within the extent of map unit Ms4 is likely to be insufficient to adequately characterise this soil type.

5.8 Coffee rock soil type

A total of two samples (TP25-1.5 and TP40-2.0) were collected from the CR soil type and no samples were submitted for laboratory analysis. The results are summarised as follows:

- pH_F results ranged between pH 6.6 and pH 8.5.
- pH_{FOX} results ranged between pH 5.0 and pH 6.7.

Soil type CR appears to be limited in occurrence within the site, has limited potential for disturbance and did not present any indicators of PASS. The QASSIT results confirm that there is no significant risk of significant acid generation from soil type CR.

5.9 Fill soil type

The fill soil was present as the upper layer of the profile at 11 sample locations, up to a depth of 1.2 mBGL. A total of 16 samples were collected from within the fill layer. All samples were submitted for field screening, and one sample (TP06-1.0) was also submitted for laboratory analysis. The results are summarised as follows:

- pH_F results ranged between pH 5.3 and pH 8.8.
- pH_{FOX} results generally ranged between pH 3.0 and pH 6.4, with the exception of a single result of pH 2.5 from sample TP09-0.0.
- Sample TP06-1.0 (results of pH_F 7.4 and pH_{FOX} 6.0) returned the following results:
  - A pH_{KCl} result of pH 9.0.
  - A pH_{OX} result of pH 7.6.
  - A net acidity result of 0.026 %S.

The fill layer generally did not present any indicators of PASS, with the exception of a single sample which reported a pH_{FOX} result of pH <3.0. This sample was collected from the soil surface and the soil logs indicate that organic fines and organic matter was identified within the sample. As with the topsoil profile, the permanently dry nature of these soils indicates that any changes in pH as a result of oxidation are not likely to be associated with ASS. This soil type is not considered to be indicative of PASS and is not considered to not pose a significant acid generating risk if disturbed, though the nature of the fill type may be variable.

6 Discussion

The soil types identified during the soil investigation were generally consistent with the four broad soil categories mapped by Gozzard (1986), including Bassendean Sand (BS), Guildford Formation (GF), Bassendean Sand over Guildford Formation and silty sand alluvial deposits (SS). In addition to these mapped units, the investigation also identified three local soil types relevant for the consideration of ASS presence and distribution being topsoil (TS), minor areas of coffee rock (CR) present as a thin layer, and areas of uncontrolled fill (Fill).

The results provided limited indicators of PASS for all shallow soils across the site. The results in relation to each soil type to a maximum depth of 2.0 mBGL revealed:

- Soil type TS: The QASSIT results provided some indicators of PASS, however as the soils contain abundant organic material, are limited to the upper 0.3 m of the soil profile and are present wholly above groundwater level, the low pH_{FOX} results are not considered to be indicative of pyrite oxidation. The actual risk of ASS from this soil type is considered to be very low.
- Soil type BS: The QASSIT and SPOCAS results did not provide any indicators of PASS or AASS. All samples from this soil type were collected from above the groundwater table.
- Soil type GF: pH_{FOX} values of pH <3.0 were limited to five samples across three sample locations. Of the 15 samples submitted for SPOCAS analysis, only one sample collected from a depth of 1.0 mBGL reported a net acidity which exceeded the DWER action criteria (0.057 %S from sample TP01-1.0). The results indicate that PASS is present, but appears spatially limited within the site.
- Soil type SS: The QASSIT results identified one sample (TP03-0.5) which indicated the possible presence of PASS. While this sample indicates PASS, only limited samples were collected from this soil type and therefore the presence/absence of ASS is not conclusive for this soil type.
- Soil type CR: Coffee rock was present as a thin layer at three locations. Two samples were collected from this soil type, with the results reporting no indicators of PASS.
- Soil type FILL: One sample from the fill layer indicated PASS with a pH_{FOX} value of pH <3.0. However, this sample (TP09-0.0) was collected from the surface, contained organic matter, and is comparable to the TS soil type. As this portion of the soil profile is permanently dry, the low pH_{FOX} result is not considered to be indicative of pyrite oxidation and the actual risk of ASS is considered to be very low.

The findings of the investigation indicate that for the shallow portion of the soil profile within the site, there is no significant evidence of the presence of ASS within soil types TS, BS, CR and FILL, and there is some evidence of PASS within soil types GF and SS. More detailed investigations will be required to confirm the presence or absence of AASS and/or PASS at the site specifically in relation to the deeper portion of the soil profile (and the portion that intersects groundwater) which is likely to be disturbed as a result of earthworks and services installation during future development.

7 Conclusions

MKSEA covers approximately 200 rural residential lots within the local government authorities of the City of Gosnells and the City of Kalamunda and future development is likely to involve intrusive works with the potential for soil disturbance. This investigation identified six soil types which were generally consistent with the regional soil mapping units of Bassendean Sand, Guildford Formation, Bassendean Sand over Guildford Formation and silty sand alluvial deposits.

Overall, the findings of this investigation identified limited to no ASS risk within the upper 2.0 m of the soil profile across the site, with isolated areas of low risk.

Further and more detailed investigations would be required for development areas within the site when specific information on sub-surface disturbance is known. However, the results of this investigation indicate that ASS does not appear to be a substantial risk in the shallow soils and can therefore be effectively managed during the normal subdivision process.

8 References

8.1 General references

Department of Environment Regulation (DER) 2015a, *Identification and investigation of acid sulfate soils and acidic landscapes*, Perth.

Department of Environment Regulation (DER) 2015b, *Treatment and management of soil and water in acid sulfate soil landscapes*, Perth.

Douglas Partners 2015, *Report on Geotechnical Investigation - Proposed Warehouse Development Lots 252 to 256 Clifford Street, Maddington, WA*, Douglas Partners Pty Ltd.

Department of Water (DoW) 2008, *LiDAR Elevation Dataset, Swan Coastal Plain*, Department of Water, Perth.

Gozzard, J. R. 1986, *Armadale Part Sheets 2033 I & 2133 IV*, Geological Survey of Western Australia, Perth.

Standards Australia 2005, *AS 4482.1-2005 Guide to the Sampling and Investigation of Potentially Contaminated Soil. Part I: Non-volatile and semivolatile compounds*, Standards Australia, Sydney.

8.2 Online references

Department of Biodiversity, Conservation and Attractions (DBCA) 2018, *Geomorphic Wetland Database – Swan Coastal Plain*, viewed 17 April 2018, <https://catalogue.data.wa.gov.au/dataset/geomorphic-wetlands-swan-coastal-plain>.

Department of Water and Environmental Regulation (DWER) 2018a, *Acid Sulfate Soil – Swan Coastal Plain Database*, viewed 17 April 2018, <https://catalogue.data.wa.gov.au/dataset/acid-sulphate-soil-risk-map-swan-coastal-plain>.

Department of Water and Environmental Regulation (DWER) 2018b, *The Water Register*, viewed 17 April 2018, <http://atlases.water.wa.gov.au/ags/waterregister/>.

Department of Water and Environmental Regulation (DWER) 2018c, *Perth Groundwater Map*, viewed 17 April 2018, <https://maps.water.wa.gov.au/#/webmap/gwm>.

Figures

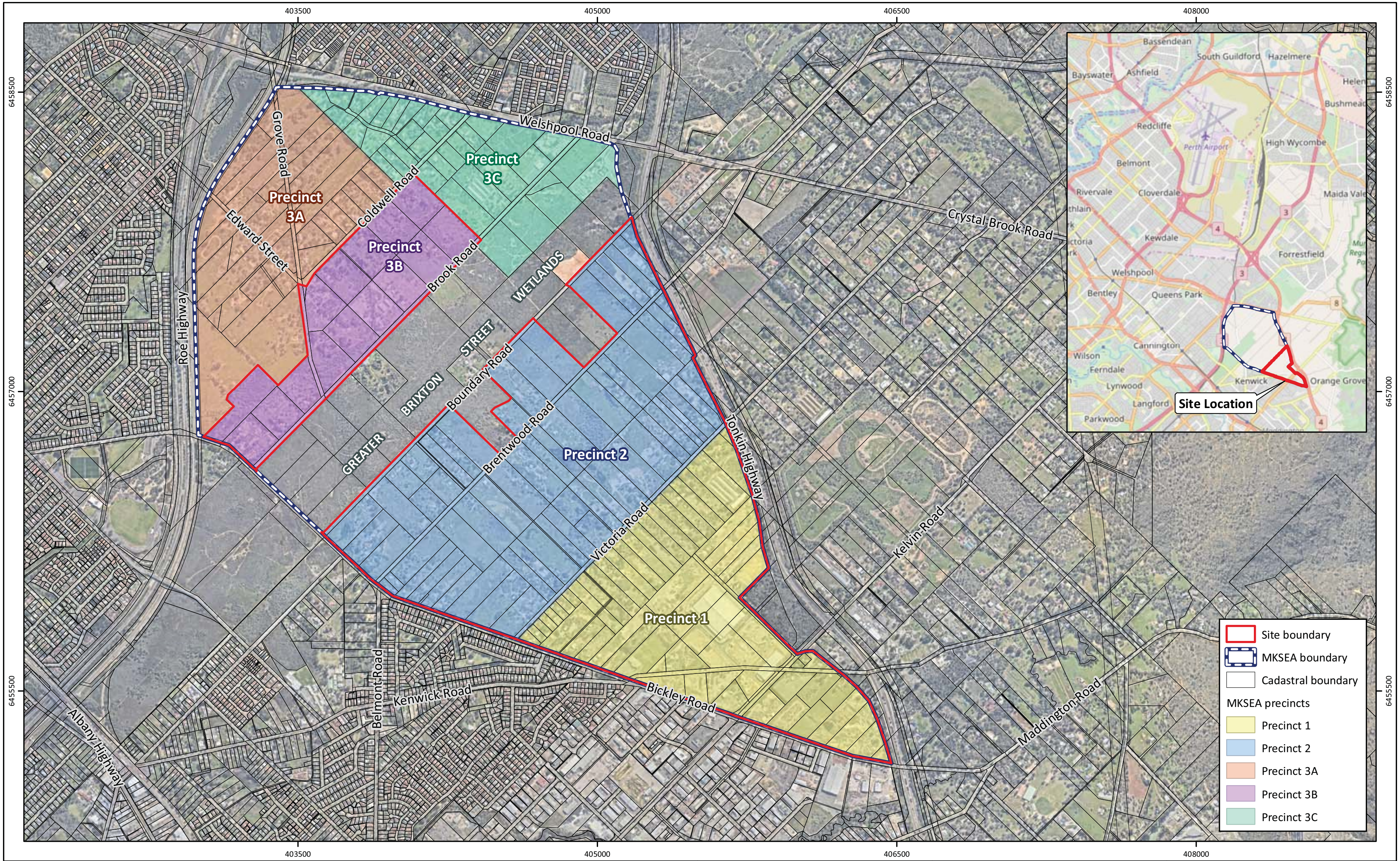


Figure 1:	**Site Locality**
Project:	Acid Sulface Soil Investigation Maddington Kenwick Strategic Employment Area Precincts 1, 2 and 3B
Client:	City of Gosnells

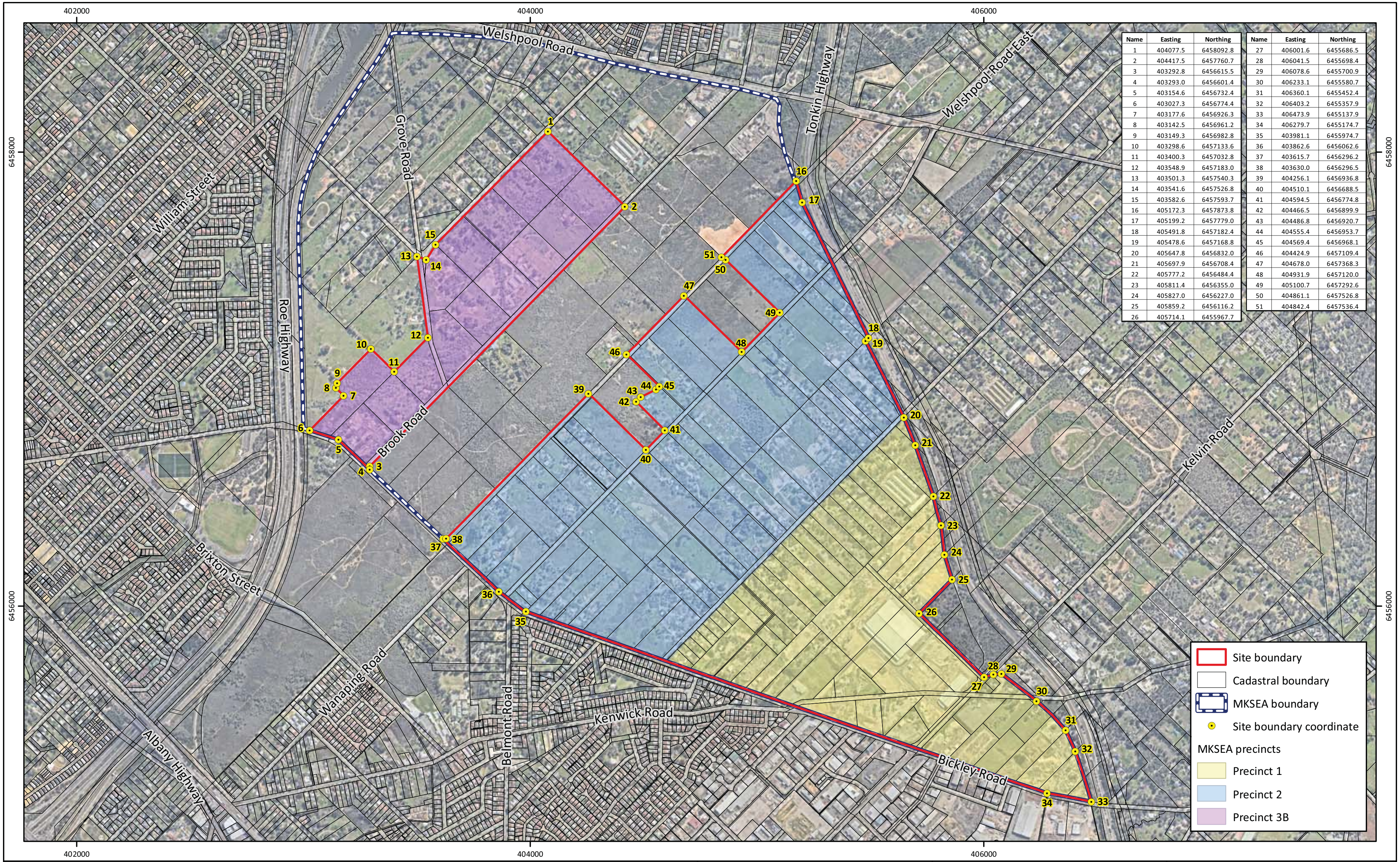
Plan Number:
EP17-010(05)--F23

Drawn:	KNM
Date:	18/04/2018
Checked:	RLD
Approved:	SPG
Date:	04/07/2018

N

0 500 1,000
Metres
Scale: 1:25,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES



Name	Easting	Northing
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2	404417.5	6457760.7
3	403292.8	6456615.5
4	403293.0	6456601.4
5	403154.6	6456732.4
6	403027.3	6456774.4
7	403177.6	6456926.3
8	403142.5	6456961.2
9	403149.3	6456982.8
10	403298.6	6457133.6
11	403400.3	6457032.8
12	403548.9	6457183.0
13	403501.3	6457540.3
14	403541.6	6457526.8
15	403582.6	6457593.7
16	405172.3	6457873.8
17	405199.2	6457779.0
18	405491.8	6457182.4
19	405478.6	6457168.8
20	405647.8	6456832.0
21	405697.9	6456708.4
22	405777.2	6456484.4
23	405811.4	6456355.0
24	405827.0	6456227.0
25	405859.2	6456116.2
26	405714.1	6455967.7

Name	Easting	Northing
27	406001.6	6455686.5
28	406041.5	6455698.4
29	406078.6	6455700.9
30	406233.1	6455580.7
31	406360.1	6455452.4
32	406403.2	6455357.9
33	406473.9	6455137.9
34	406279.7	6455174.7
35	403981.1	6455974.7
36	403862.6	6456062.6
37	403615.7	6456296.2
38	403630.0	6456296.5
39	404256.1	6456936.8
40	404510.1	6456688.5
41	404594.5	6456774.8
42	404466.5	6456899.9
43	404486.8	6456920.7
44	404555.4	6456953.7
45	404569.4	6456968.1
46	404424.9	6457109.4
47	404678.0	6457368.3
48	404931.9	6457120.0
49	405100.7	6457292.6
50	404861.1	6457526.8
51	404842.4	6457536.4

Figure 2: Site Boundary

Project: Acid Sulface Soil Investigation
Maddington Kenwick Strategic Employment Area Precincts 1, 2 and 3B

Client: City of Gosnells

Plan Number: EP17-010(05)--F24
Drawn: KNM
Date: 18/04/2018
Checked: RLD
Approved: SPG
Date: 04/07/2018

N

0 200 400 600
Metres
Scale: 1:22,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Figure 3: **Topographic Contours**

Project: Acid Sulface Soil Investigation
Maddington Kenwick Strategic Employment Area Precincts 1, 2 and 3B

Client: City of Gosnells

Plan Number:
EP17-010(05)--F25
Drawn: KNM
Date: 18/04/2018
Checked: RLD
Approved: SPG
Date: 04/07/2018

N

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Metres
Scale: 1:22,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

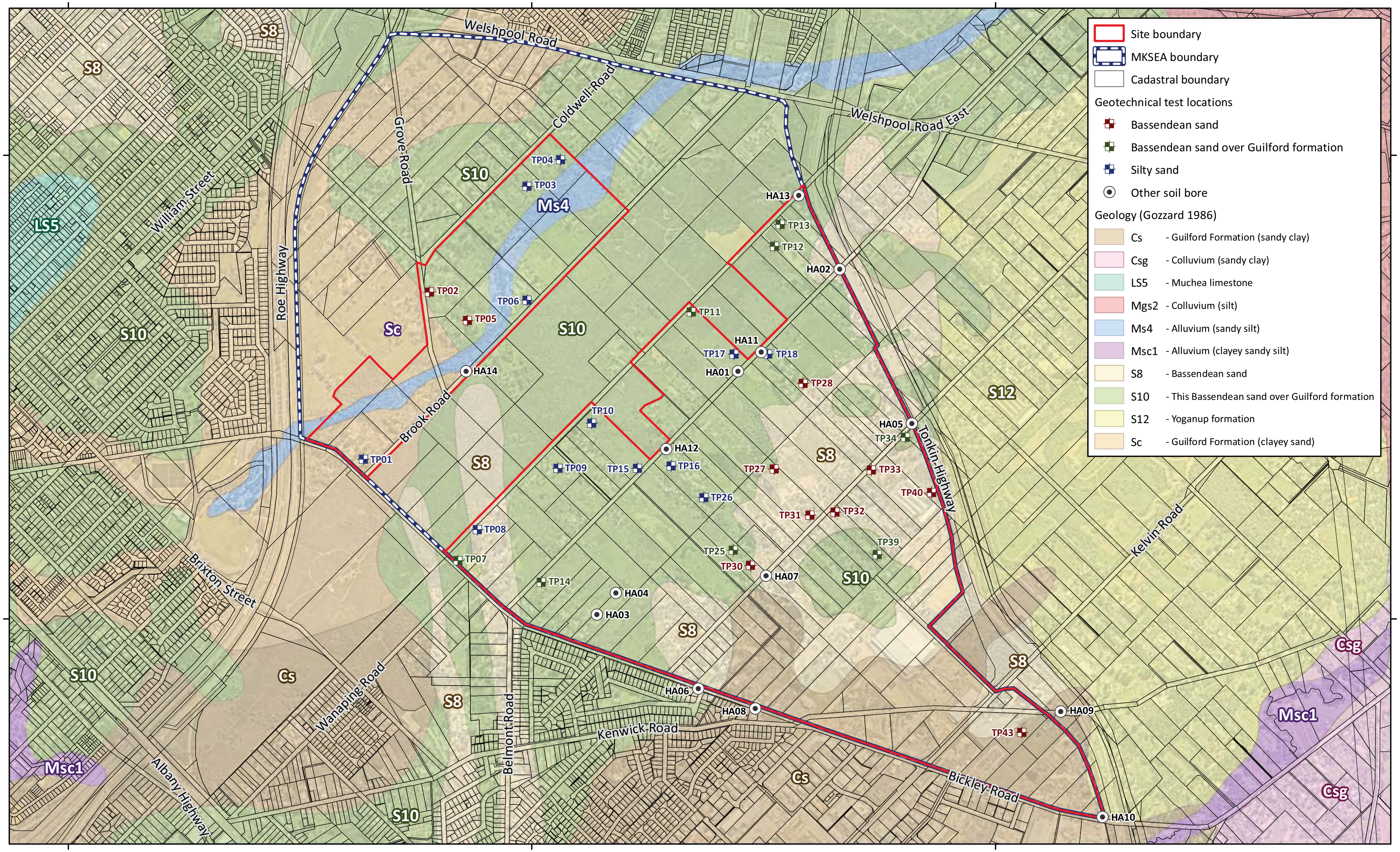

Figure 4: **Regional Geology Mapping and Soil Investigation Locations**

Project: Acid Sulface Soil Investigation
Maddington Kenwick Strategic Employment Area Precincts 1, 2 and 3B
Client: City of Gosnells

Plan Number:
EP17-010(05)--F26
Drawn: RLD
Date: 13/12/2017
Checked: RLD
Approved: SPG
Date: 04/07/2018

N

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Metres
Scale: 1:22,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

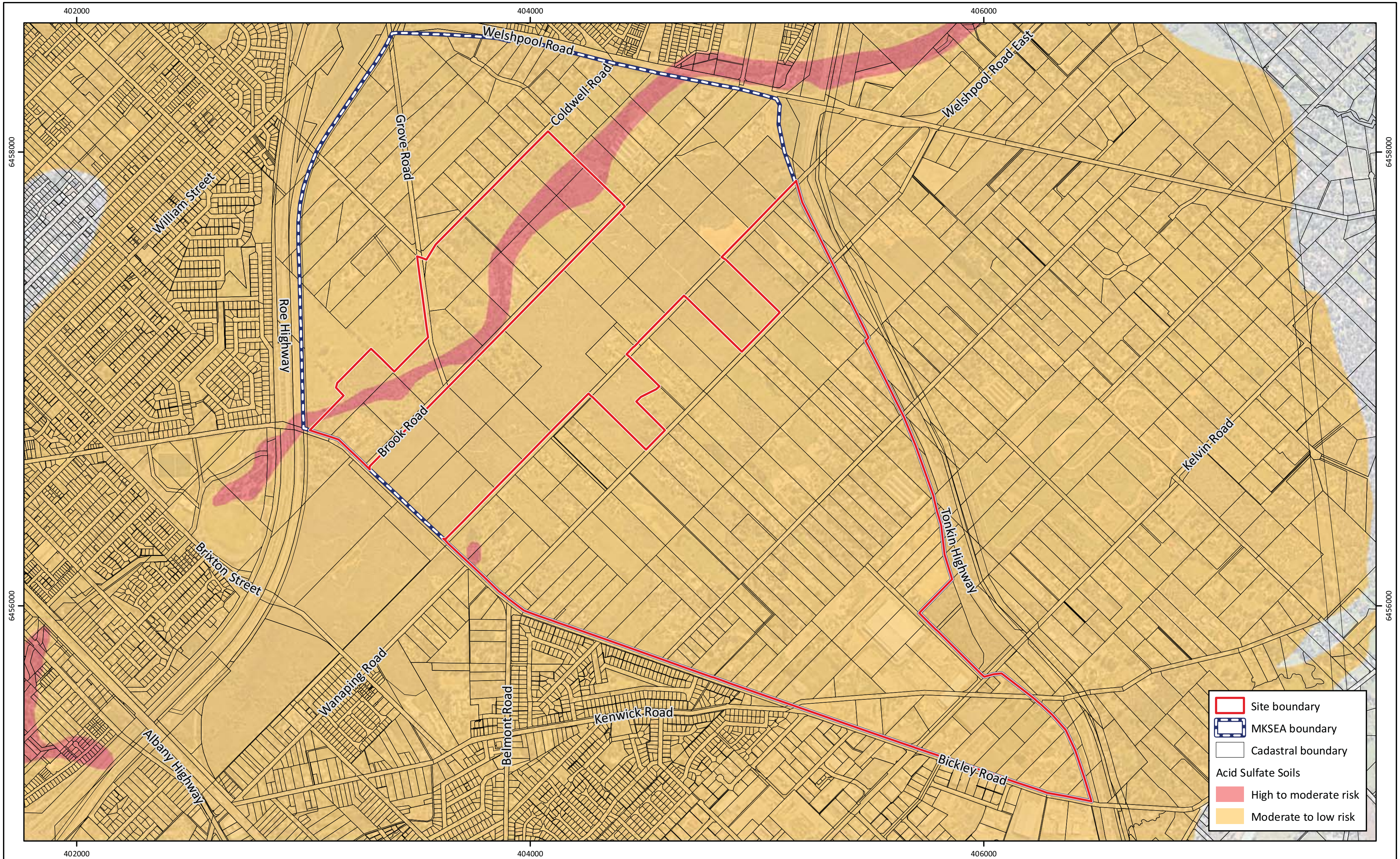

Figure 5: **Acid Sulfate Soil Risk Mapping**

Project:	Acid Sulface Soil Investigation Maddington Kenwick Strategic Employment Area Precincts 1, 2 and 3B
Client:	City of Gosnells

Plan Number:
EP17-010(05)--F27

Drawn:	KNM
Date:	19/04/2018
Checked:	RLD
Approved:	SPG
Date:	04/07/2018

emerge ASSOCIATES

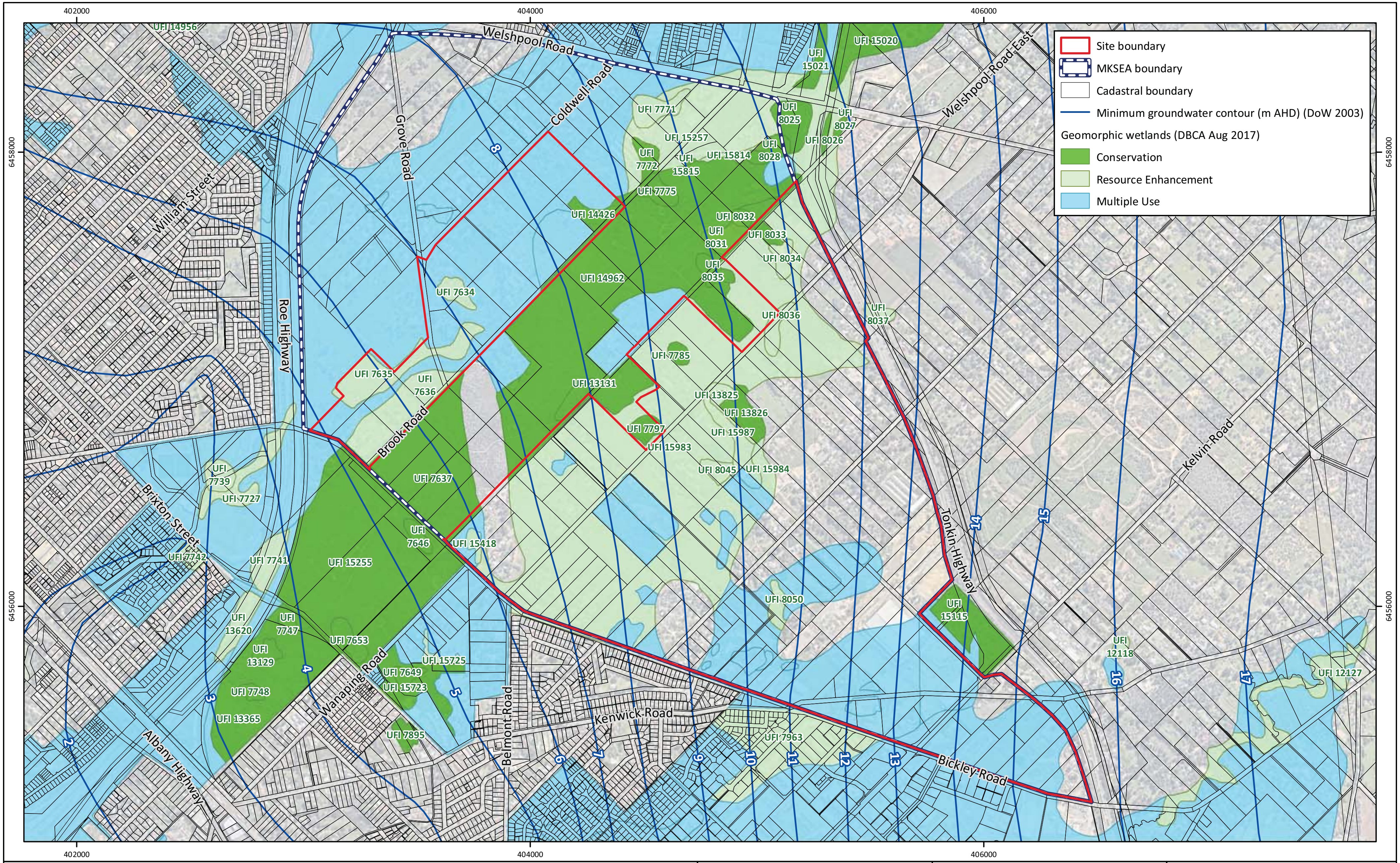

Figure 6:	**Hydrological Receptors**		
Project:	Acid Sulface Soil Investigation Maddington Kenwick Strategic Employment Area Precincts 1, 2 and 3B		
Client:	City of Gosnells		

Plan Number:
EP17-010(05)--F28

Drawn:	KNM
Date:	19/04/2018
Checked:	RLD
Approved:	SPG
Date:	04/07/2018

N

0 200 400 600
Metres

Scale: 1:22,000@A4

GDA 1994 MGA Zone 50

emerge
ASSOCIATES

Summary Tables

						QASSIT				SPOCAS								
Test Pit ID	Sample ID	Date	Soil Type	Soil Type Code	Moisture	pHF	pHFox	Δ pH	Reaction Rate	pHKCl	pHOx	TAA	TPA	TSA	SPOS	Net Acidity	Net Acidity excluding ANC	Net Acidity (calculated)
HA03	HA03-0.0	13/09/2017	Fill	FILL	Dry	8.0	5.6	2.4	Moderate	-	-	-	-	-	-	-	-	-
	HA03-0.5	13/09/2017	Sandy clay	GF	Dry	7.8	8.0	0.2	Extreme	-	-	-	-	-	-	-	-	-
	HA03-1.0	13/09/2017	Sandy clay	GF	Dry	8.6	6.8	1.8	Extreme	-	-	-	-	-	-	-	-	-
	HA03-1.5	13/09/2017	Sandy clay	GF	Dry	8.5	7.3	1.2	Extreme	-	-	-	-	-	-	-	-	-
HA04	HA04-0.0	13/09/2017	Sandy clay	GF	Dry	7.5	5.9	1.6	Strong	-	-	-	-	-	-	-	-	-
	HA04-0.5	13/09/2017	Sandy clay	GF	Dry	7.8	6.4	1.4	Extreme	-	-	-	-	-	-	-	-	-
HA06	HA06-0.0	15/09/2017	Fill	FILL	Dry	7.4	5.2	2.2	Moderate	-	-	-	-	-	-	-	-	-
	HA06-0.5	15/09/2017	Silty sand	SS	Dry	7.6	5.4	2.2	Moderate	-	-	-	-	-	-	-	-	-
	HA06-1.0	15/09/2017	Silty sand	SS	Wet	8.0	5.9	2.1	Moderate	-	-	-	-	-	-	-	-	-
	HA06-1.5	15/09/2017	Sandy clay	GF	Wet	6.6	4.7	1.9	Slight	6.2	4.6	<0.005	0.032	0.030	0.010	<0.02	<0.02	0.015
	HA06-2.0	15/09/2017	Sandy clay	GF	Wet	5.6	4.1	1.5	Slight	-	-	-	-	-	-	-	-	-
HA08	HA08-0.0	15/09/2017	Fill	FILL	Dry	6.5	4.6	1.9	Moderate	-	-	-	-	-	-	-	-	-
	HA08-0.5	15/09/2017	Sandy clay	GF	Dry	7.8	6.2	1.6	Moderate	-	-	-	-	-	-	-	-	-
	HA08-1.0	15/09/2017	Sandy clay	GF	Dry	7.9	6.2	1.7	Slight	-	-	-	-	-	-	-	-	-
	HA08-1.1	15/09/2017	Sandy clay	GF	Dry	8.1	6.2	1.9	Slight	-	-	-	-	-	-	-	-	-
HA10	HA10-0.0	15/09/2017	Fill	FILL	Dry	7.4	5.1	2.3	Moderate	-	-	-	-	-	-	-	-	-
	HA10-0.5	15/09/2017	Clayey sand	GF	Dry	7.3	5.3	2.0	Moderate	6.0	5.1	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	HA10-1.0	15/09/2017	Clayey sand	GF	Dry	7.4	5.2	2.2	Moderate	-	-	-	-	-	-	-	-	-
TP01	TP01-0.0	5/09/2017	Topsoil	TS	Dry	5.3	3.0	2.3	Moderate	-	-	-	-	-	-	-	-	-
	TP01-0.5	5/09/2017	Sandy clay	GF	Dry	7.4	7.4	0.0	Extreme	-	-	-	-	-	-	-	-	-
	TP01-1.0	5/09/2017	Clayey sand	GF	Dry	8.0	7.3	0.7	Strong	9.2	7.9	<0.005	<0.005	<0.005	0.052	<0.02	0.05	0.057
	TP01-1.5	5/09/2017	Clayey sand	GF	Wet	7.8	7.1	0.7	Strong	-	-	-	-	-	-	-	-	-
TP02	TP02-0.0	8/09/2017	Fill	FILL	Dry	8.8	6.0	2.8	Moderate	-	-	-	-	-	-	-	-	-
	TP02-0.5	8/09/2017	Sand	BS	Dry	7.6	5.4	2.2	Slight	-	-	-	-	-	-	-	-	-
	TP02-1.0	8/09/2017	Sand	BS	Dry	7.7	5.9	1.8	Slight	-	-	-	-	-	-	-	-	-
	TP02-1.5	8/09/2017	Sand	BS	Dry	7.2	5.7	1.5	Slight	7.3	5.8	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP02-1.8	8/09/2017	Sand	BS	Dry	7.2	5.6	1.6	Slight	-	-	-	-	-	-	-	-	-
TP03	TP03-0.0	5/09/2017	Topsoil	TS	Dry	5.9	2.5	3.4	Strong	-	-	-	-	-	-	-	-	-
	TP03-0.5	5/09/2017	Silty sand	SS	Dry	5.8	2.9	2.9	Moderate	6.4	5.8	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP03-1.0	5/09/2017	Silty sand	SS	Dry	5.7	3.8	1.9	Moderate	-	-	-	-	-	-	-	-	-
	TP03-1.5	5/09/2017	Silty sand	SS	Dry	6.3	4.0	2.3	Moderate	-	-	-	-	-	-	-	-	-
	TP03-2.0	5/09/2017	Silty sand	SS	Dry	6.3	4.5	1.8	Slight	-	-	-	-	-	-	-	-	-
DWER indicators of actual ASS						<4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER indicators of potential ASS						>4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER action criteria						-	-	-	-	-	-	-	-	-	-	0.03	0.03	0.03
LoR						0.1	0.1	0.1	-	0.1	0.1	0.005	0.005	0.005	0.005	0.02	0.02	0.005
Units						*pH Units*			-	*pH Units*		*% pyrite S*			*% S*	*% S*	*% S*	*% S*

						QASSIT				SPOCAS								
Test Pit ID	Sample ID	Date	Soil Type	Soil Type Code	Moisture	pHF	pHFox	ΔpH	Reaction Rate	pHKCl	pHOx	TAA	TPA	TSA	SPOS	Net Acidity	Net Acidity excluding ANC	Net Acidity (calculated)
TP04	TP04-0.0	5/09/2017	Topsoil	TS	Dry	4.6	2.2	2.4	Strong	-	-	-	-	-	-	-	-	-
	TP04-0.5	5/09/2017	Clayey sand	GF	Dry	4.6	2.3	2.3	Strong	7.6	6.4	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP04-1.0	5/09/2017	Sandy clay	GF	Wet	6.4	4.9	1.5	Strong	-	-	-	-	-	-	-	-	-
	TP04-1.5	5/09/2017	Sandy clay	GF	Wet	5.1	2.6	2.5	Strong	-	-	-	-	-	-	-	-	-
	TP04-2.0	5/09/2017	Sandy clay	GF	Wet	5.9	4.3	1.6	Strong	-	-	-	-	-	-	-	-	-
TP05	TP05-0.0	8/09/2017	Topsoil	TS	Dry	6.4	4.5	1.9	Moderate	-	-	-	-	-	-	-	-	-
	TP05-0.5	8/09/2017	Sand	BS	Dry	6.3	4.6	1.7	Moderate	6.9	4.4	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP05-1.0	8/09/2017	Sand	BS	Dry	6.2	4.6	1.6	Moderate	-	-	-	-	-	-	-	-	-
	TP05-1.5	8/09/2017	Sand	BS	Dry	6.1	5.0	1.1	Moderate	-	-	-	-	-	-	-	-	-
	TP05-2.0	8/09/2017	Sand	BS	Dry	5.4	4.3	1.1	Slight	6.6	5.0	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
TP06	TP06-0.0	5/09/2017	Fill	FILL	Dry	7.5	5.8	1.7	Moderate	-	-	-	-	-	-	-	-	-
	TP06-0.5	5/09/2017	Fill	FILL	Dry	7.4	6.0	1.4	Moderate	-	-	-	-	-	-	-	-	-
	TP06-1.0	5/09/2017	Fill	FILL	Dry	7.4	6.0	1.4	Moderate	9.0	7.6	<0.005	<0.005	<0.005	0.021	<0.02	0.02	0.026
	TP06-1.5	5/09/2017	Clayey sand	GF	Dry	7.8	7.6	0.2	Extreme	-	-	-	-	-	-	-	-	-
	TP06-2.0	5/09/2017	Clayey sand	GF	Dry	7.4	8.1	0.7	Extreme	-	-	-	-	-	-	-	-	-
TP07	TP07-0.0	5/09/2017	Topsoil	TS	Dry	6.7	3.1	3.6	Moderate	-	-	-	-	-	-	-	-	-
	TP07-0.5	5/09/2017	Sand	BS	Dry	7.0	6.1	0.9	Strong	6.6	6.6	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP07-1.0	5/09/2017	Sandy clay	GF	Dry	5.8	5.0	0.8	Strong	-	-	-	-	-	-	-	-	-
	TP07-1.5	5/09/2017	Sandy clay	GF	Dry	4.6	1.6	3.0	Extreme	-	-	-	-	-	-	-	-	-
	TP07-2.0	5/09/2017	Sandy clay	GF	Dry	4.9	2.0	2.9	Extreme	-	-	-	-	-	-	-	-	-
TP08	TP08-0.0	5/09/2017	Fill	FILL	Dry	7.7	5.3	2.4	Extreme	-	-	-	-	-	-	-	-	-
	TP08-0.5	5/09/2017	Sandy clay	GF	Wet	7.4	7.1	0.3	Extreme	-	-	-	-	-	-	-	-	-
	TP08-1.0	5/09/2017	Sandy clay	GF	Wet	6.6	7.1	0.5	Extreme	6.9	8.2	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP08-1.5	5/09/2017	Sandy clay	GF	Wet	6.1	5.3	0.8	Strong	-	-	-	-	-	-	-	-	-
	TP08-2.0	5/09/2017	Sandy clay	GF	Wet	7.7	7.5	0.2	Extreme	-	-	-	-	-	-	-	-	-
TP09	TP09-0.0	5/09/2017	Fill	FILL	Dry	5.3	2.5	2.8	Moderate	-	-	-	-	-	-	-	-	-
	TP09-0.5	5/09/2017	Fill	FILL	Dry	6.6	3.0	3.6	Moderate	-	-	-	-	-	-	-	-	-
	TP09-1.0	5/09/2017	Sandy clay	GF	Dry	7.7	6.6	1.1	Strong	6.7	6.9	<0.005	<0.005	<0.005	0.006	<0.02	<0.02	0.011
	TP09-1.5	5/09/2017	Sandy clay	GF	Dry	7.6	6.1	1.5	Moderate	-	-	-	-	-	-	-	-	-
DWER indicators of actual ASS						<4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER indicators of potential ASS						>4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER action criteria						-	-	-	-	-	-	-	-	-	-	0.03	0.03	0.03
LoR						0.1	0.1	0.1	-	0.1	0.1	0.005	0.005	0.005	0.005	0.02	0.02	0.005
Units						*pH Units*			-	*pH Units*		*% pyrite S*			*% S*	*% S*	*% S*	*% S*

						QASSIT				SPOCAS								
Test Pit ID	Sample ID	Date	Soil Type	Soil Type Code	Moisture	pHF	pHFox	∆ pH	Reaction Rate	pHKCl	pHOx	TAA	TPA	TSA	SPOS	Net Acidity	Net Acidity excluding ANC	Net Acidity (calculated)
TP10	TP10-0.0	5/09/2017	Fill	FILL	Dry	7.7	5.0	2.7	Moderate	-	-	-	-	-	-	-	-	-
	TP10-0.5	5/09/2017	Fill	FILL	Dry	7.4	6.4	1.0	Moderate	-	-	-	-	-	-	-	-	-
	TP10-1.0	5/09/2017	Sandy clay	GF	Dry	7.2	7.3	0.1	Extreme	6.3	7.4	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP10-1.5	5/09/2017	Sandy clay	GF	Dry	6.9	7.5	0.6	Extreme	-	-	-	-	-	-	-	-	-
	TP10-2.0	5/09/2017	Sandy clay	GF	Dry	6.9	7.4	0.5	Extreme	-	-	-	-	-	-	-	-	-
TP11	TP11-0.0	5/09/2017	Topsoil	TS	Dry	6.3	2.6	3.7	Moderate	-	-	-	-	-	-	-	-	-
	TP11-0.5	5/09/2017	Sandy clay	GF	Dry	7.0	6.0	1.0	Moderate	6.4	6.8	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP11-1.0	5/09/2017	Sandy clay	GF	Dry	7.3	7.6	0.3	Extreme	-	-	-	-	-	-	-	-	-
	TP11-1.5	5/09/2017	Sandy clay	GF	Dry	7.1	6.0	1.1	Strong	-	-	-	-	-	-	-	-	-
	TP11-2.0	5/09/2017	Sandy clay	GF	Dry	6.7	5.8	0.9	Strong	-	-	-	-	-	-	-	-	-
TP12	TP12-0.0	5/09/2017	Topsoil	TS	Dry	6.3	2.3	4.0	Moderate	-	-	-	-	-	-	-	-	-
	TP12-0.5	5/09/2017	Sand	BS	Dry	6.9	5.2	1.7	Moderate	6.5	5.7	<0.005	<0.005	<0.005	0.010	<0.02	<0.02	0.015
	TP12-1.0	5/09/2017	Sandy clay	GF	Dry	6.8	5.7	1.1	Strong	5.9	5.2	0.008	<0.005	<0.005	0.007	<0.02	<0.02	0.015
	TP12-1.35	5/09/2017	Sandy clay	GF	Dry	6.8	4.3	2.5	Strong	-	-	-	-	-	-	-	-	-
TP13	TP13-0.0	5/09/2017	Topsoil	TS	Dry	6.1	3.1	3.0	Moderate	-	-	-	-	-	-	-	-	-
	TP13-0.5	5/09/2017	Sand	BS	Dry	6.1	3.4	2.7	Moderate	6.3	4.7	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP13-1.0	5/09/2017	Sand	BS	Dry	6.0	3.7	2.3	Moderate	-	-	-	-	-	-	-	-	-
	TP13-1.25	5/09/2017	Sandy clay	GF	Dry	5.5	3.4	2.1	Strong	-	-	-	-	-	-	-	-	-
TP14	TP14-0.0	6/09/2017	Topsoil	TS	Dry	4.7	2.1	2.6	Moderate	-	-	-	-	-	-	-	-	-
	TP14-0.5	6/09/2017	Sandy clay	GF	Dry	5.1	2.2	2.9	Moderate	6.8	3.7	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP14-1.0	6/09/2017	Sandy clay	GF	Dry	6.6	6.8	0.2	Extreme	-	-	-	-	-	-	-	-	-
	TP14-1.5	6/09/2017	Sandy clay	GF	Dry	6.8	6.0	0.8	Slight	-	-	-	-	-	-	-	-	-
	TP14-2.0	6/09/2017	Sandy clay	GF	Dry	6.5	5.8	0.7	Moderate	-	-	-	-	-	-	-	-	-
TP15	TP15-0.0	6/09/2017	Topsoil	TS	Dry	5.8	3.3	2.5	Moderate	6.0	3.2	<0.005	0.023	0.021	0.010	<0.02	<0.02	0.015
	TP15-0.5	6/09/2017	Sandy clay	GF	Dry	7.0	7.8	0.8	Extreme	-	-	-	-	-	-	-	-	-
	TP15-1.0	6/09/2017	Sandy clay	GF	Dry	7.8	8.1	0.3	Extreme	-	-	-	-	-	-	-	-	-
	TP15-2.0	6/09/2017	Sandy clay	GF	Dry	7.8	7.0	0.8	Extreme	-	-	-	-	-	-	-	-	-
TP16	TP16-0.0	7/09/2017	Fill	FILL	Dry	8.0	5.0	3.0	Moderate	-	-	-	-	-	-	-	-	-
	TP16-0.5	7/09/2017	Clayey sand	GF	Wet	8.4	6.6	1.8	Extreme	7.0	6.7	<0.005	<0.005	<0.005	0.006	<0.02	<0.02	0.011
	TP16-1.0	7/09/2017	Clayey sand	GF	Wet	9.4	6.8	2.6	Slight	-	-	-	-	-	-	-	-	-
	TP16-1.5	7/09/2017	Clayey sand	GF	Wet	9.1	6.2	2.9	Slight	-	-	-	-	-	-	-	-	-
	TP16-2.0	7/09/2017	Clayey sand	GF	Wet	8.5	7.8	0.7	Moderate	-	-	-	-	-	-	-	-	-
DWER indicators of actual ASS						<4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER indicators of potential ASS						>4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER action criteria						-	-	-	-	-	-	-	-	-	-	0.03	0.03	0.03
LoR						0.1	0.1	0.1	-	0.1	0.1	0.005	0.005	0.005	0.005	0.02	0.02	0.005
Units						*pH Units*			-	*pH Units*		*% pyrite S*			*% S*	*% S*	*% S*	*% S*

Test Pit ID	Sample ID	Date	Soil Type	Soil Type Code	Moisture	QASSIT pHF	QASSIT pHFox	QASSIT ∆ pH	QASSIT Reaction Rate	SPOCAS pHKCl	SPOCAS pHOx	SPOCAS TAA	SPOCAS TPA	SPOCAS TSA	SPOCAS SPOS	SPOCAS Net Acidity	SPOCAS Net Acidity excluding ANC	SPOCAS Net Acidity (calculated)
TP17	TP17-0.0	5/09/2017	Topsoil	TS	Dry	5.2	2.6	2.6	Strong	-	-	-	-	-	-	-	-	-
	TP17-0.5	5/09/2017	Sandy clay	GF	Dry	6.8	6.9	-0.1	Strong	-	-	-	-	-	-	-	-	-
	TP17-1.0	5/09/2017	Sandy clay	GF	Dry	7.0	5.5	1.5	Strong	5.8	6.6	0.019	<0.005	<0.005	<0.005	0.02	0.02	0.024
	TP17-1.5	5/09/2017	Sandy clay	GF	Dry	6.7	6.1	0.6	Strong	-	-	-	-	-	-	-	-	-
	TP17-2.0	5/09/2017	Sandy clay	GF	Dry	7.3	6.4	0.9	Slight	-	-	-	-	-	-	-	-	-
TP18	TP18-0.0	5/09/2017	Topsoil	TS	Dry	7.3	4.2	3.1	Moderate	-	-	-	-	-	-	-	-	-
	TP18-0.5	5/09/2017	Silty sand	SS	Dry	7.0	3.7	3.3	Moderate	7.1	6.1	<0.005	<0.005	<0.005	0.009	<0.02	<0.02	0.014
	TP18-1.0	5/09/2017	Silty sand	SS	Wet	7.1	3.5	3.6	Moderate	-	-	-	-	-	-	-	-	-
TP25	TP25-0.0	7/09/2017	Topsoil	TS	Dry	5.7	2.4	3.3	Moderate	-	-	-	-	-	-	-	-	-
	TP25-0.5	7/09/2017	Silty sand	SS	Wet	5.6	3.4	2.2	Moderate	6.6	4.5	<0.005	<0.005	<0.005	0.005	<0.02	<0.02	0.010
	TP25-1.0	7/09/2017	Sandy clay	GF	Wet	8.2	6.2	2.0	Slight	-	-	-	-	-	-	-	-	-
	TP25-1.5	7/09/2017	Coffee rock	CR	Dry	8.5	6.7	1.8	Slight	-	-	-	-	-	-	-	-	-
TP26	TP26-0.0	7/09/2017	Topsoil	TS	Dry	5.7	2.6	3.1	Moderate	-	-	-	-	-	-	-	-	-
	TP26-0.5	7/09/2017	Clayey sand	GF	Dry	6.0	4.4	1.6	Moderate	5.9	4.8	0.008	0.015	0.008	0.019	0.03	0.03	0.027
	TP26-1.0	7/09/2017	Clayey sand	GF	Dry	8.4	6.8	1.6	Moderate	-	-	-	-	-	-	-	-	-
	TP26-1.5	7/09/2017	Sandy clay	GF	Dry	9.2	9.0	0.2	Extreme	-	-	-	-	-	-	-	-	-
	TP26-2.0	7/09/2017	Sandy clay	GF	Dry	8.8	7.0	1.8	Moderate	-	-	-	-	-	-	-	-	-
TP27	TP27-0.0	8/09/2017	Fill	FILL	Dry	8.3	5.6	2.7	Moderate	-	-	-	-	-	-	-	-	-
	TP27-0.5	8/09/2017	Sand	BS	Dry	8.4	5.7	2.7	Moderate	-	-	-	-	-	-	-	-	-
	TP27-1.0	8/09/2017	Sand	BS	Dry	8.3	5.0	3.3	Moderate	7.0	4.3	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP27-1.5	8/09/2017	Sand	BS	Dry	7.9	5.3	2.6	Moderate	-	-	-	-	-	-	-	-	-
	TP27-2.0	8/09/2017	Sand	BS	Dry	7.4	5.0	2.4	Moderate	-	-	-	-	-	-	-	-	-
TP28	TP28-0.0	5/09/2017	Fill	FILL	Dry	6.9	4.3	2.6	Moderate	-	-	-	-	-	-	-	-	-
	TP28-0.5	5/09/2017	Sand	BS	Dry	6.6	4.2	2.4	Slight	7.0	6.1	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP28-1.0	5/09/2017	Sand	BS	Dry	6.7	5.1	1.6	Slight	-	-	-	-	-	-	-	-	-
	TP28-1.5	5/09/2017	Sand	BS	Dry	6.9	4.4	2.5	Slight	7.0	5.1	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP28-2.0	5/09/2017	Sand	BS	Dry	6.7	4.8	1.9	Slight	-	-	-	-	-	-	-	-	-
TP30	TP30-0.0	7/09/2017	Topsoil	TS	Dry	6.3	4.4	1.9	Slight	-	-	-	-	-	-	-	-	-
	TP30-0.5	7/09/2017	Sand	BS	Dry	6.0	3.9	2.1	Slight	-	-	-	-	-	-	-	-	-
	TP30-1.0	7/09/2017	Sand	BS	Dry	5.6	4.5	1.1	Slight	6.4	4.1	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	TP30-1.5	7/09/2017	Sand	BS	Dry	5.6	4.5	1.1	Slight	-	-	-	-	-	-	-	-	-
	TP30-2.0	7/09/2017	Sand	BS	Dry	6.0	4.2	1.8	Slight	-	-	-	-	-	-	-	-	-
DWER indicators of actual ASS						<4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER indicators of potential ASS						>4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER action criteria						-	-	-	-	-	-	-	-	-	-	0.03	0.03	0.03
LoR						0.1	0.1	0.1	-	0.1	0.1	0.005	0.005	0.005	0.005	0.02	0.02	0.005
Units						*pH Units*			-	*pH Units*		*% pyrite S*			*% S*	*% S*	*% S*	*% S*

						QASSIT				SPOCAS								
Test Pit ID	**Sample ID**	**Date**	**Soil Type**	**Soil Type Code**	**Moisture**	**pHF**	**pHFox**	**∆ pH**	**Reaction Rate**	**pHKCl**	**pHOx**	**TAA**	**TPA**	**TSA**	**SPOS**	**Net Acidity**	**Net Acidity excluding ANC**	**Net Acidity (calculated)**
TP32	TP32-0.0	7/09/2017	Topsoil	TS	Dry	6.2	3.6	2.6	Moderate	-	-	-	-	-	-	-	-	-
	TP32-0.5	7/09/2017	Sand	BS	Dry	6.2	4.1	2.1	Moderate	6.3	3.3	<0.005	0.057	0.057	0.006	<0.02	<0.02	0.011
	TP32-1.0	7/09/2017	Sand	BS	Dry	6.6	5.0	1.6	Slight	-	-	-	-	-	-	-	-	-
	TP32-1.5	7/09/2017	Sand	BS	Dry	6.3	4.6	1.7	Moderate	-	-	-	-	-	-	-	-	-
	TP32-2.0	7/09/2017	Sand	BS	Dry	6.6	4.7	1.9	Moderate	-	-	-	-	-	-	-	-	-
TP33	TP33-0.0	7/09/2017	Topsoil	TS	Dry	6.7	4.3	2.4	Moderate	-	-	-	-	-	-	-	-	-
	TP33-0.5	7/09/2017	Sand	BS	Dry	7.1	4.9	2.2	Moderate	-	-	-	-	-	-	-	-	-
	TP33-1.0	7/09/2017	Sand	BS	Dry	6.9	4.9	2.0	Moderate	6.8	3.8	<0.005	0.017	0.017	<0.005	<0.02	<0.02	0.010
	TP33-1.5	7/09/2017	Sand	BS	Dry	7.3	5.3	2.0	Slight	-	-	-	-	-	-	-	-	-
	TP33-2.0	7/09/2017	Sand	BS	Dry	7.4	5.4	2.0	Slight	-	-	-	-	-	-	-	-	-
TP34	TP34-0.0	7/09/2017	Topsoil	TS	Dry	6.4	4.2	2.2	Moderate	-	-	-	-	-	-	-	-	-
	TP34-0.5	7/09/2017	Sand	BS	Dry	6.6	4.4	2.2	Moderate	-	-	-	-	-	-	-	-	-
	TP34-1.0	7/09/2017	Sand	BS	Dry	6.3	4.6	1.7	Moderate	-	-	-	-	-	-	-	-	-
	TP34-1.5	7/09/2017	Clayey sand	GF	Dry	5.4	4.0	1.4	Moderate	6.6	5.0	<0.005	0.015	0.015	0.006	<0.02	<0.02	0.011
	TP34-2.0	7/09/2017	Clayey sand	GF	Dry	5.4	4.2	1.2	Moderate	-	-	-	-	-	-	-	-	-
TP39	TP39-0.0	7/09/2017	Topsoil	TS	Dry	5.6	2.7	2.9	Moderate	-	-	-	-	-	-	-	-	-
	TP39-0.5	7/09/2017	Sand	BS	Dry	6.4	4.1	2.3	Moderate	-	-	-	-	-	-	-	-	-
	TP39-1.0	7/09/2017	Sandy clay	GF	Dry	5.4	3.9	1.5	Moderate	6.4	4.6	<0.005	0.024	0.024	<0.005	<0.02	<0.02	0.010
	TP39-1.5	7/09/2017	Clayey sand	GF	Dry	5.5	3.8	1.7	Moderate	-	-	-	-	-	-	-	-	-
	TP39-2.0	7/09/2017	Clayey sand	GF	Dry	5.2	3.9	1.3	Moderate	-	-	-	-	-	-	-	-	-
TP40	TP40-0.0	7/09/2017	Sand	BS	Dry	6.5	4.2	2.3	Moderate	-	-	-	-	-	-	-	-	-
	TP40-0.5	7/09/2017	Sand	BS	Dry	6.2	4.8	1.4	Slight	-	-	-	-	-	-	-	-	-
	TP40-1.0	7/09/2017	Sand	BS	Dry	6.3	4.7	1.6	Slight	6.8	4.6	<0.005	0.006	0.006	<0.005	<0.02	<0.02	0.010
	TP40-1.5	7/09/2017	Sand	BS	Dry	6.7	5.3	1.4	Slight	-	-	-	-	-	-	-	-	-
	TP40-2.0	7/09/2017	Coffee rock	CR	Dry	6.6	5.0	1.6	Moderate	-	-	-	-	-	-	-	-	-
TP43	TP43-0.0	8/09/2017	Sand	BS	Dry	4.6	3.2	1.4	Moderate	-	-	-	-	-	-	-	-	-
	TP43-0.5	8/09/2017	Sand	BS	Dry	4.4	3.3	1.1	Slight	-	-	-	-	-	-	-	-	-
	TP43-1.0	8/09/2017	Sand	BS	Dry	4.3	3.0	1.3	Slight	-	-	-	-	-	-	-	-	-
	TP43-1.5	8/09/2017	Sand	BS	Dry	4.1	4.1	0.0	Slight	-	-	-	-	-	-	-	-	-
	TP43-2.0	8/09/2017	Sand	BS	Dry	4.0	4.0	0.0	Slight	-	-	-	-	-	-	-	-	-
DWER indicators of actual ASS						<4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER indicators of potential ASS						>4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER action criteria						-	-	-	-	-	-	-	-	-	-	0.03	0.03	0.03
LoR						0.1	0.1	0.1	-	0.1	0.1	0.005	0.005	0.005	0.005	0.02	0.02	0.005
Units						*pH Units*			-	*pH Units*		*% pyrite S*			*% S*	*% S*	*% S*	*% S*

						QASSIT				SPOCAS								
Test Pit ID	Sample ID	Date	Soil Type	Soil Type Code	Moisture	pHF	pHFox	∆ pH	Reaction Rate	pHKCl	pHOx	TAA	TPA	TSA	SPOS	Net Acidity	Net Acidity excluding ANC	Net Acidity (calculated)
QA samples	SQA01	5/09/2017	-	-	-	6.7	5.2	1.5	Strong	-	-	-	-	-	-	-	-	-
	SQA02	5/09/2017	-	-	-	6.5	7.0	0.5	Extreme	6.8	7.8	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02	0.010
	SQA03	5/09/2017	-	-	-	5.9	3.4	2.5	Extreme	-	-	-	-	-	-	-	-	-
	SQA04	5/09/2017	-	-	-	6.6	5.9	0.7	Strong	6.0	6.5	0.009	<0.005	<0.005	<0.005	<0.02	<0.02	0.014
	SQA05	6/09/2017	-	-	-	6.6	6.9	0.3	Extreme	-	-	-	-	-	-	-	-	-
	SQA06	6/09/2017	-	-	-	8.0	8.9	0.9	Extreme	-	-	-	-	-	-	-	-	-
	SQA07	7/09/2017	-	-	-	8.6	6.3	2.3	Slight	-	-	-	-	-	-	-	-	-
	SQA08	7/09/2017	-	-	-	6.2	4.5	1.7	Slight	-	-	-	-	-	-	-	-	-
	SQA09	8/09/2017	-	-	-	4.1	3.2	0.9	Slight	-	-	-	-	-	-	-	-	-
	SQA1-150917	15/09/2017	-	-	-	7.8	6.2	1.6	Slight	-	-	-	-	-	-	-	-	-
DWER indicators of actual ASS						<4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER indicators of potential ASS						>4	<3	-	-	-	-	-	-	-	-	-	-	-
DWER action criteria						-	-	-	-	-	-	-	-	-	-	0.03	0.03	0.03
LoR						0.1	0.1	0.1	-	0.1	0.1	0.005	0.005	0.005	0.005	0.02	0.02	0.005
Units						*pH Units*			-	*pH Units*		*% pyrite S*			*% S*	*% S*	*% S*	*% S*

Sample ID	Date	SPOCAS							
		pHKCl	**pHOx**	**TAA (s)**	**TPA (s)**	**TSA (s)**	**SPOS (s)**	**Net Acidity (s)**	**Net Acidity excluding ANC (s)**
TP08-1.0	5/09/2017	6.9	8.2	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02
SQA02	5/09/2017	6.8	7.8	<0.005	<0.005	<0.005	<0.005	<0.02	<0.02
RPD	-	1	5	0	0	0	0	0	0
TP17-1.0	5/09/2017	5.8	6.6	0.019	<0.005	<0.005	<0.005	0.02	0.02
SQA04	5/09/2017	6	6.5	0.009	<0.005	<0.005	<0.005	<0.02	<0.02
RPD	-	3	2	71*	0	0	0	0	0
LoR		0.1	0.1	0.005	0.005	0.005	0.005	0.02	0.02
Units		*pH Units*		*% pyrite S*			*% S*	*% S*	*% S*

Notes in relation to the above table:
'*' indicates that the RPD for the selected analytes are not considered to have breached the adopted criterion as one or both of the concentrations are less than 10 times the limit of reporting.

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Appendix A

Test Pit and Soil Bore Logs

Soil Core Log ID: HA01

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 13/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404890.00
NORTHING: 6457068.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 1.20 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0														0.0m: FILL: Silty gravelly sand, orange brown. Gravel is pezolithic 5 mm diameter.	Moist
														0.2m: FILL: Silty Sand, fine to medium grained, sub-angular to sub-rounded quartz, grey. Fines are non-plastic. Trace of pezolithic gravel. Gravel is 5 mm diamteter.	Moist
														0.7m: CLAYEY SAND: Sand is medium to coarse grained, sub-angular to sub-rounded quartz, red brown. Clay is medium to high plasticity.	Wet
1														0.9m: SANDY CLAY: High plasticity clay, brown / grey, sand is fine to coarse grained, sub-angular to sub-rounded quartz. Trace of root fibres.	Moist

Total drilled depth: 1.2 mBGL

COMMENTS: Refusal

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA02

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PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 13/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405328.00
NORTHING: 6457510.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 1.80 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0														0.0m: FILL: Sand with trace of silt. Sand is fine to coarse grained, sub-angular to sub-rounded red brown. Trace of gravels/cobbles of ironstone. Gravel is pezolithic 5 mm diameter.	Dry
														0.4m: SAND: Fine to medium grained, sub-angular to sub-rounded quartz, with some silt fines.	Moist
1															

Total drilled depth: 1.8 mBGL

COMMENTS: Collapse

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA03

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 13/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404281.00
NORTHING: 6456018.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 1.50 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			HA03-0.0		8	5.6	M							0.0m: FILL: Silty sand with organic fibres, brown. Roots and rootlets.	Moist
														0.1m: FILL: Silty Sand with some brick, charcoal and wood fragments.	Moist
														0.3m: SILTY SANDY CLAY: High plasticity clay, grey / green, trace of fine to medium grained sub-angular laterite gravel. Root fibres to 120 mm. At 120 mm augering becoming harder. Possible increase in gravel content. Refusal due to hard gravelly clay.	Moist
			HA03-0.5		7.8	8	EX								
1			HA03-1.0		8.6	6.8	EX								
			HA03-1.5		8.5	7.3	EX								

Total drilled depth: 1.5 mBGL

COMMENTS: Refusal

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA04

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 13/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404363.00
NORTHING: 6456112.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 0.50 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			HA04-0.0		7.5	5.9	ST							0.0m: SANDY CLAY: High plasticity clay, orange/brown/grey. Sand is fine to coarse grained, sub-angular to sub-rounded quartz. Roots to 200 mm.	Moist
														0.2m: SANDY GRAVELLY CLAY: High plasticity clay, orange/brown/grey. Gravel is fine to coarse grained, sub-angular laterite.	Moist
			HA04-0.5		7.8	6.4	EX								

Total drilled depth: 0.5 mBGL

COMMENTS: Refusal

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA05

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 14/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405640.00
NORTHING: 6456844.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0														0.0m: FILL: Sand and gravel with topsoil, brown. Gravel is crushed limestone and pezolites. Rootlets and roots.	Dry
														0.3m: SAND: Fine to medium grained, sub-angular to sub-rounded quartz, with trace of non-plastic fines, grey.brown to white.	Dry
1														1.2m: … Weakly iron cemented cottee rock layer at 1.20m, brown, 200mm thick.	
														1.4m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, with trace to some non-plastic fines, orange/yellow. Trace of pezolithic gravel.	Dry
2														Total drilled depth: 2 mBGL	

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA06

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PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 14/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404718.00
NORTHING: 6455699.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			HA06-0.0		7.4	5.2	M							0.0m: FILL: Sandy topsoil with trace of organics, brown. Roots and rootlets.	Moist
														0.2m: FILL: Clayey gravelly sand. Clay is high plasticity. Rootlets.	Moist
			HA06-0.5		7.6	5.4	M							0.5m: SILTY SAND: Fine to medium grained, sub-rounded quartz, with non-plastic silty fines, orange/grey/brown, trace of clay fines. Rootlets. Large roots at 900 mm. Becoming wet at 950 mm.	Wet
1			HA06-1.0		8	5.9	M								
			HA06-1.5		6.6	4.7	SL	6.2	4.6	0.01	<0.005	0.03	0.015	1.4m: SANDY CLAY: Medium to high plasticity clay, sand is fine to coarse grained, sub-angular to sub-rounded quartz, grey/white/orange. Can be easily re-moulded with fingers.	Moist
2			HA06-2.0		5.6	4.1	SL								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA07

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PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 14/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405010.00
NORTHING: 6456187.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 1.80 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0														0.0m: FILL: Silty sand with some medium to coarse grained pezolithic gravels, grey/orange.	Moist
														0.4m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, grey/brown.	Moist
1															
														1.3m: CLAYEY SAND: Fine to medium grained, sub-angular quartz, with medium to high plasticity clay, grey/orange. Trace of sub-angular, medium to coarse grained laterite gravels.	Moist

Total drilled depth: 1.8 mBGL

COMMENTS: Refusal

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA08

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PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 15/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404964.00
NORTHING: 6455612.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 1.10 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			HA08-0.0		6.5	4.6	M							0.0m: FILL: Sandy topsoil with trace of organics, brown. Roots and rootlets.	Moist
														0.1m: FILL: Silty Sand, medium to coarse grained, sub-rounded quartz, trace gravels of crushed limestone, plastic and concrete, brown. Fines are non-plastic. Rootlets.	Moist
			HA08-0.5		7.8	6.2	M							0.4m: SANDY CLAY: High plasticity clay, with some fine to coarse grained, sub-angular to sub-rounded quartz, trace of fine to medium grained, rounded pezolithic gravel, orange/grey. At 100 mm becomes hard to auger.	Moist to Dry
			HA08-1.0		7.9	6.2	SL								
1			HA08-1.1		8.1	6.2	SL								

Total drilled depth: 1.1 mBGL

COMMENTS: Refusal

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA09

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 15/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 406282.00
NORTHING: 6455600.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0														0.0m: TOPSOIL: Brown sand with trace of organics, brown. Roots and rootlets.	Dry
														0.2m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, white/grey. Roots to 600 mm.	Dry
1															
2															

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

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Soil Core Log ID: HA10

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 15/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 406463.00
NORTHING: 6455145.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 1.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			HA10-0.0		7.4	5.1	M							0.0m: FILL: Silty sand with trace of fine to medium grained, rounded pezolithic gravel, grey/brown/red. Clayey at 150 mm - 300 mm.	Dry
														0.3m: CLAYEY SAND: Fine to medium grained, sub-rounded quartz, clay is medium plasticity, grey/brown.	Dry
			HA10-0.5		7.3	5.3	M	6.0	5.1	<0.005	<0.005	<0.005	0.010		
1			HA10-1.0		7.4	5.2	M								

Total drilled depth: 1 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA11

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 15/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404989.00
NORTHING: 6457153.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 0.50 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0														0.0m: TOPSOIL: Sandy clay with organic fines, brown. Roots and rootlets.	Moist
														0.2m: SANDY CLAY: High plasticity clay, sand is fine to coarse grained, sub-angular to sub-rounded, brown. Rootlets. Collapse due to groundwater.	Moist to Wet

Total drilled depth: 0.5 mBGL

COMMENTS: Collapse

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA12

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 15/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404580.00
NORTHING: 6456734.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 1.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0														0.0m: FILL: Silty sand with organic fines, trace of brick and plastic. Roots and rootlets.	Dry
														0.2m: SILTY SAND: With trace of clay fines, sand is medium to coarse grained, sub-rounded, grey. Roots and rootlets.	Moist
1															

Total drilled depth: 1 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA13

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 15/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405152.00
NORTHING: 6457828.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 0.75 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0														0.0m: FILL: Sandy topsoil with organic fines, trace of brick and tile fragments, brown. Roots and rootlets.	Moist
														0.3m: SANDY CLAY: High plasticity clay, brown. Roots and rootlets.	Moist
														0.5m: SILTY SAND: Fine to coarse grained, sub-rounded quartz, with non-plastic silty fines, grey/brown.	Moist

Total drilled depth: 0.75 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: HA14

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 15/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: HAND AUGER
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 403716.00
NORTHING: 6457068.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER: 80 mm
TOTAL DEPTH: 0.65 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0														0.0m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, grey/white. Roots to 300 mm.	Dry

Total drilled depth: 0.65 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP01

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PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 5/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 403273.00
NORTHING: 6456688.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 1.50 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP01-0.0		5.3	3	M							0.0m: TOPSOIL: Clayey sand with organic fines, brown. Roots and rootlets present.	Moist
														0.1m: SANDY CLAY: High plasticity clay, orange/grey/brown with fine to coarse subangular quartz sand. Trace of subangular gravel. Roots and rootlets present to 700 mm.	Dry
			TP01-0.5		7.4	7.4	EX								
														0.7m: CLAYEY SANDY GRAVEL: Fine to coarse grained, subangular to angular limestone, quartz, ironstone and granite clasts, white grey. Clay is intermediate plasticity. Rootlets to 900 mm. Initial groundwater level rose at 1.3 m.	Wet
1			TP01-1.0		8	7.3	ST	9.2	7.9	0.052	<0.005	<0.005	0.057		
			TP01-1.5		7.8	7.1	ST								

Total drilled depth: 1.5 mBGL

COMMENTS: Collapse

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP02

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 8/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 403557.00
NORTHING: 6457411.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 1.80 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP02-0.0		8.8	6	M							0.0m: FILL: Topsoil and sand with whole bricks, brick fragments, limestone aggregate and plastic fragments, brown. Roots and rootlets throughout.	Dry
			TP02-0.5		7.6	5.4	SL							0.4m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, with trace of non-plastic fines, white/yellow. Roots to 0.80 m. Sidewall collapse at 1.40 m.	Dry to moist
1			TP02-1.0		7.7	5.9	SL								
			TP02-1.5		7.2	5.7	SL	7.3	5.8	<0.005	<0.005	<0.005	0.010		
			TP02-1.8		7.2	5.6	SL								

Total drilled depth: 1.8 mBGL

COMMENTS: Collapse

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP03

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 5/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 403978.00
NORTHING: 6457867.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP03-0.0		5.9	2.5	ST							0.0m: TOPSOIL: Clayey sand with trace of organic fines, brown. Roots and rootlets throughout.	Moist
														0.3m: SILTY SAND: Fine to coarse grained, subangular to subrounded quartz, brown/orange/grey. Fines are non-plastic.	Moist
			TP03-0.5		5.8	2.9	M	6.4	5.8	<0.005	<0.005	<0.005	0.010		
1			TP03-1.0		5.7	3.8	M								
			TP03-1.5		6.3	4	M								
2			TP03-2.0		6.3	4.5	SL								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP04

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 5/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404123.00
NORTHING: 6457982.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 1.80 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP04-0.0		4.6	2.2	ST							0.0m: TOPSOIL: Clayey sand with trace of organic fines, brown. Rootlets throughout.	Moist
														0.2m: CLAYEY SAND: Fine to medium grained, sub-angular to sub-rounded quartz, orange/brown, clay is medium plasticity. Loose - sidewalls collapsing. Roots to 700 mm. Seepage observed at 700 mm rising to 500 m after 20 mins.	Wet
			TP04-0.5		4.6	2.3	ST	7.6	6.4	<0.005	<0.005	<0.005	0.010		
														0.7m: SANDY CLAY: Medium plasticity, grey/red/brown mottled, sand is medium to coarse grained, sub-angular to sub-rounded quartz.	Moist
1			TP04-1.0		6.4	4.9	ST								
														1.2m: … Occasional rounded to sub-rounded ironstone/pezolithic gravels from 1.20m.	
			TP04-1.5		5.1	2.6	ST								
			TP04-2.0		5.9	4.3	ST								

Total drilled depth: 1.8 mBGL

COMMENTS: Collapse

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP05

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 8/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 403721.00
NORTHING: 6457289.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S
0			TP05-0.0		6.4	4.5	M						
			TP05-0.5		6.3	4.6	M	6.9	4.4	<0.005	<0.005	<0.005	0.010
1			TP05-1.0		6.2	4.6	M						
			TP05-1.5		6.1	5	M						
2			TP05-2.0		5.4	4.3	SL	6.6	5.0	<0.005	<0.005	<0.005	0.010

MATERIAL DESCRIPTION	MOISTURE CONTENT
0.0m: TOPSOIL: Silty sand with trace of organics, brown. Roots and rootlets throughout.	Dry
0.1m: SAND: Sub-angular to sub-rounded, fine to coarse grained quartz, white/grey/brown, trace of non-plastic fines. Roots observed to 900 mm.	Moist
1.1m: SAND: Sub-angular to sub-rounded, fine to coarse grained quartz, trace of non-plastic fines, yellow/orange.	Moist
1.8m: … Some fine to coarse grained, subrounded to rounded, ironstone and pezolithic gravels (orange/red) at 1.80 m.	

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP06

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 5/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 403979.00
NORTHING: 6457375.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP06-0.0		7.5	5.8	M							0.0m: FILL: Clayey silty sand with trace of brick, tile, plastic and wood fragments, brown to black, fines include organics. Roots and rootlets throughout.	Moist
			TP06-0.5		7.4	6	M								
1			TP06-1.0		7.4	6	M	9.0	7.6	0.021	<0.005	<0.005	0.026		
														1.2m: CLAYEY SAND: Medium to coarse grained, sub-rounded to sub-angular quartz, pale grey/yellow/brown. Clay is medium plasticity.	Moist
														1.4m: … Trace of fine to coarse grained ironstone/pezolithic gravels at 1.40 m to 1.80 m.	
			TP06-1.5		7.8	7.6	EX								
2			TP06-2.0		7.4	8.1	EX								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP07

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 5/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 403681.00
NORTHING: 6456252.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP07-0.0		6.7	3.1	M							0.0m: TOPSOIL: Sandy clay with organic fragments, brown.	Moist
														0.1m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, yellow/white.	Wet
			TP07-0.5		7	6.1	ST	6.6	6.6	<0.005	<0.005	<0.005	0.010		
														0.5m: SANDY CLAY: High plasticity clay with rare organic lenses, yellow/grey/green mottled. Sand is fine to coarse grained, sub-angular to sub-rounded quartz. Occasional plant matter and wood fragments in clay matrix.	Moist
1			TP07-1.0		5.8	5	ST								
			TP07-1.5		4.6	1.6	EX								
2			TP07-2.0		4.9	2	EX								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP08

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 5/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 403765.00
NORTHING: 6456386.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP08-0.0		7.7	5.3	EX							0.0m: FILL: Clayey sand, fine to coarse grained, sub-angular to sub-rounded quartz with medium plasticity fines and trace of organics, occasional plastic and brick fragments, black/brown. Roots and rootlets in top 300 mm. Very slow seepage at 400 mm.	Moist
			TP08-0.5		7.4	7.1	EX							0.4m: SANDY CLAY: High plasticity, orange / grey / yellow. Sand is subangular to subrounded, fine to coarse grained quartz. Very slow seepage at 400 mm.	Moist to wet
1			TP08-1.0		6.6	7.1	EX	6.9	8.2	<0.005	<0.005	<0.005	0.010	1.0m: … Trace of pezolithic gravels at 1.0 m to 1.50 m.	
			TP08-1.5		6.1	5.3	ST								
2			TP08-2.0		7.7	7.5	EX								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP09

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PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 5/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404113.00
NORTHING: 6456650.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 1.50 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP09-0.0		5.3	2.5	M							0.0m: FILL: Sandy clay with topsoil, trace of brick and plastic fragments, brown. Rootlets and roots to 600 mm. Disused pipe at 500 mm.	Dry
			TP09-0.5		6.6	3	M								
1			TP09-1.0		7.7	6.6	ST	6.7	6.9	0.006	<0.005	<0.005	0.011	0.9m: SANDY CLAY: High plasticity clay, yelloow / orange brown mottled, with fine to coarse grained, sub-angular to sub-rounded quartz sand and trace of rounded ironstone/pezolithic gravel. Sidewall collapse at 1.5 m.	Moist
			TP09-1.5		7.6	6.1	M								

Total drilled depth: 1.5 mBGL

COMMENTS: Collapse

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP10

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 6/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404258.00
NORTHING: 6456846.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP10-0.0		7.7	5	M							0.0m: FILL: High plasticity clay with some sand and trace of brick and metal fragments. Brown. Roots and rootlets to 500 mm. Minor / slow seepage at 600 mm.	Moist
			TP10-0.5		7.4	6.4	M								
														0.6m: SANDY CLAY: High plasticity clay, orange / brown / yellow mottled. Sand is fine to coarse grained, sub-angular to sub-rounded quartz. Trace of rounded ironstone gravels.	Moist
1			TP10-1.0		7.2	7.3	EX	6.3	7.4	<0.005	<0.005	<0.005	0.010		
			TP10-1.5		6.9	7.5	EX								
2			TP10-2.0		6.9	7.4	EX								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP11

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PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 6/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404689.00
NORTHING: 6457326.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S
TP11-0.0		6.3	2.6	M						
TP11-0.5		7	6	M	6.4	6.8	<0.005	<0.005	<0.005	0.010
TP11-1.0		7.3	7.6	EX						
TP11-1.5		7.1	6	ST						
TP11-2.0		6.7	5.8	ST						

Depth	MATERIAL DESCRIPTION	MOISTURE CONTENT
0.0m:	TOPSOIL: Sand with trace of organic fines. Roots and rootlets.	Moist
0.1m:	SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, with trace of non-plastic fines, light brown. Rootlets throughout. Slow seepage at 300 mm.	Moist
0.3m:	SANDY CLAY: High plasticity clay, orange/grey/yellow/brown mottled, sand is fine to coarse grained, sub-angular to sub-rounded quartz. Trace rounded ironstone gravels.	Moist

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP12

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 6/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405047.00
NORTHING: 6457608.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 1.35 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP12-0.0		6.3	2.3	M							0.0m: TOPSOIL: Sandy clay with trace of organic fines. Roots and rootlets.	Moist
														0.2m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, with trace of non-plastic fines, white/yellow. Rootlets. Seepage at 500 mm on cemented clay layer.	Moist
			TP12-0.5		6.9	5.2	M	6.5	5.7	0.01	<0.005	<0.005	0.015		
														0.5m: COFFEE ROCK: Extremely low strength, weakly iron cemented, brown/red. Occasional ironstone/pezolithic gravels to 15 mm diameter.	Dry
			TP12-1.0		6.8	5.7	ST	5.9	5.2	0.007	0.008	<0.005	0.015	0.9m: SANDY GRAVELLY CLAY: Clay is high plasticity. Gravels are medium to coarse grained, laterised/iron cemented ironstone, brown/grey. Sidewall collapse at 1.35 m	Moist
1															
			TP12-1.35		6.8	4.3	ST								

Total drilled depth: 1.35 mBGL

COMMENTS: Collapse

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

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Soil Core Log ID: TP13

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 6/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405072.00
NORTHING: 6457704.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 1.25 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP13-0.0		6.1	3.1	M							0.0m: TOPSOIL: Sand with trace of organic fines, brown. Rootlets to 300 mm.	Dry
														0.1m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, with trace of non-plastic fines, yellow/grey/brown. Slow seepage at 100 mm.	Moist
			TP13-0.5		6.1	3.4	M	6.3	4.7	<0.005	<0.005	<0.005	0.010		
			TP13-1.0		6	3.7	M								
1														1.0m: SANDY CLAY: High plasticity clay, orange.yellow. Sand is fine to coarse grained, sub-angular to sub-rounded, orange/yellow. Sidewall collapse at 1.25 m.	Moist
			TP13-1.25		5.5	3.4	ST								

Total drilled depth: 1.25 mBGL

COMMENTS: Collapse

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP14

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 6/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404040.00
NORTHING: 6456159.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP14-0.0		4.7	2.1	M							0.0m: TOPSOIL: Clayey sand with trace of organics, brown. Roots and rootlets throughout.	Moist
														0.1m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, grey/white. Rootlets. Slow seepage at 400 mm.	Moist
			TP14-0.5		5.1	2.2	M	6.8	3.7	<0.005	<0.005	<0.005	0.010	0.4m: SANDY CLAY: High plasticity clay, grey/orange green. Sand is fine to coarse grained, sub-angular to sub-rounded quartz. Trace of sub-angular ironstone gravels to about 19 mm diameter.	Moist
1			TP14-1.00		6.6	6.8	EX								
			TP14-1.5		6.8	6	SL								
2			TP14-2.0		6.5	5.8	M								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

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Soil Core Log ID: TP15

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 6/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404456.00
NORTHING: 6456649.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP15-0.0		5.8	3.3	M	6.0	3.2	0.01	<0.005	0.021	0.015	0.0m: TOPSOIL: Clayey sand with trace of organics, brown.	Moist
														0.1m: Rootlets and roots. SANDY CLAY: High plasticity clay, grey/green/brown. Sand is fine to coarse grained, sub-angular quartz. Rootlets and trace of organic matter.	Moist
														0.3m: SANDY CLAY: High plasticity, orange/yellow/grey. Sand is fine to coarse grained, sub-angular to sub-rounded quartz, trace of ironstone gravels to about 19mm diameter. Slow seepage through base of test pit at 2.0 m.	Moist to wet
			TP15-0.5		7	7.8	EX								
			TP15-1.0		7.8	8.1	EX								
1														1.0m: ... Layer of coarse laterite/ironstone gravels at 1.0 m.	
2			TP15-2.0		7.8	7	EX								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP16

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 7/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404600.00
NORTHING: 6456660.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP16-0.0		8	5	M							0.0m: FILL: Topsoil, sand with trace of organic fines, and trace of brick fragments. Roots and rootlets.	Moist
														0.2m: CLAYEY SAND: Medium to coarse grained, sub-angular to sub-rounded quartz, orange/brown/grey mottled. Clay is high plasticity. Trace of fine grained, subrounded ironstone gravels. Fine rootlets throughout. Slow seepage at 300 mm.	Moist
			TP16-0.5		8.4	6.6	EX	7.0	6.7	0.006	<0.005	<0.005	0.011		
1			TP16-1.0		9.4	6.8	SL								
			TP16-1.5		9.1	6.2	SL								
2			TP16-2.0		8.5	7.8	M								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

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Soil Core Log ID: TP17

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 6/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404872.00
NORTHING: 6457144.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP17-0.0		5.2	2.6	ST							0.0m: TOPSOIL: Sandy clay with organic fines, brown. Roots and rootlets.	Moist
														0.1m: CLAYEY SAND: Fine to medium grained, sub-angular to sub-rounded quartz, light brown. With medium to high plasticity clay fines. Rootlets.	Moist
														0.3m: SANDY CLAY: High plasticity clay, orange/brown/grey mottled with fine to coarse grained, sub-angular to sub-rounded quartz. Trace of sub-rounded to rounded, medium to coarse grained ironstone gravel.	Moist
			TP17-0.5		6.8	6.9	ST								
														0.7m: … Becoming hard/cemented between 0.70 m and 1.50 m.	
1			TP17-1.0		7	5.5	ST	5.8	6.6	<0.005	0.019	<0.005	0.024		
			TP17-1.5		6.7	6.1	ST							1.5m: … Transitions back to stiff/very stiff clay at 1.50 m.	
2			TP17-2.0		7.3	6.4	SL								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP18

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 6/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405018.00
NORTHING: 6457144.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 1.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP18-0.0		7.3	4.2	M							0.0m: TOPSOIL: Clayey sand with trace of organics, brown. Roots and rootlets.	Moist
														0.1m: SILTY SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, brown/black. Fines are non-plastic. Rootlets throughout. Sidewall collapse at 0.5 m. Seepage at 700 mm initially rising to 500 mm in 20 mins. Testpit terminated at 1.0 m.	Moist
			TP18-0.5		7	3.7	M	7.1	6.1	0.009	<0.005	<0.005	0.014		
1			TP18-1.0		7.1	3.5	M								

Total drilled depth: 1 mBGL

COMMENTS: Collapse

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP25

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PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 7/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404869.00
NORTHING: 6456296.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 1.30 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP25-0.0		5.7	2.4	M							0.0m: TOPSOIL: Silty sand with trace of organic fines, brown. Roots and rootlets.	Moist
														0.1m: SILTY SAND: Fine to coarse grained, sub-angular quartz, brown/orange, fines are non-plastic, trace of sub-rounded ironstone gravel. Seepage and sidewall collapse at 0.3m.	Wet
			TP25-0.5		5.6	3.4	M	6.6	4.5	0.005	<0.005	<0.005	0.010		
														0.6m: SANDY CLAY: High plasticity clay, white/grey. Sand is fine to coarse grained, sub-angular to sub-rounded quartz.	Moist
			TP25-1.0		8.2	6.2	SL								
1														1.0m: COFFEE ROCK: Extremely low strength, weakly iron cemented, brown. Refusal on coffee rock layer.	Dry
			TP25-1.5		8.5	6.7	SL								

Total drilled depth: 1.3 mBGL

COMMENTS: Refusal

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP26

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 7/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404742.00
NORTHING: 6456524.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S
0			TP26-0.0		5.7	2.6	M						
			TP26-0.5		6	4.4	M	5.9	4.8	0.019	0.008	0.008	0.027
1			TP26-1.0		8.4	6.8	M						
			TP26-1.5		9.2	9	EX						
2			TP26-2.0		8.8	7	M						

MATERIAL DESCRIPTION	MOISTURE CONTENT
0.0m: TOPSOIL: Silty sand with organic fines, brown. Rootlets.	Dry
0.1m: CLAYEY SAND: Sand is fine to coarse grained, sub-angular to sub-rounded quartz, orange/brown. Clay is low plasticity. Extensive roots at 150 mm to 300 mm.	Moist
0.6m: CLAYEY SAND: Clay is medium plasticity, sand is medium to coarse grained sub-angular quartz, green/grey/orange mottled. Trace laterite gravel.	Moist
1.2m: SANDY CLAY: High plasticity clay, sand is medium to coarse grained, sub-angular to sub-rounded quartz, white/grey. Locally becoming laterised / hard clay lenses.	Dry

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP27

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 8/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405045.00
NORTHING: 6456647.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP27-0.0		8.3	5.6	M							0.0m: FILL: Sand with gravels and cobbles of metal/brick, concrete, limestone and rope. Brown/grey. Roots and rootlets.	Dry
			TP27-0.5		8.4	5.7	M							0.4m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, white/brown/grey. Rootlets to 700 mm.	Moist
1			TP27-1.0		8.3	5	M	7.0	4.3	<0.005	<0.005	<0.005	0.010		
			TP27-1.5		7.9	5.3	M								
2			TP27-2.0		7.4	5	M								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

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Soil Core Log ID: TP28

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 6/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405170.00
NORTHING: 6457017.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 1.80 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP28-0.0		6.9	4.3	M							0.0m: FILL: Topsoil with trace of organic fines, brown. Rootlets.	Dry
														0.1m: FILL: Sandy clay, orange brown. Rootlets.	Dry
														0.2m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, white/grey. Testpit terminated at 1.8 m due to sidewall collapse.	Dry
			TP28-0.5		6.6	4.2	SL	7.0	6.1	<0.005	<0.005	<0.005	0.010		
1			TP28-1.0		6.7	5.1	SL								
														1.2m: … … Sidewall collapse at 1.20 m.	
			TP28-1.5		6.9	4.4	SL	7.0	5.1	<0.005	<0.005	<0.005	0.010		
			TP28-2.0		6.7	4.8	SL							Total drilled depth: 1.8 mBGL	

COMMENTS: Collapse

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP30

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 7/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 404944.00
NORTHING: 6456230.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP30-0.0		6.3	4.4	SL							0.0m: TOPSOIL: Sand with trace of organic fines, brown. Rootlets to 200 mm depth.	Dry
														0.1m: SAND: Fine to medium grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, white/grey. Large roots at 500 mm. Sidewall collapse at 100 mm.	Dry
			TP30-0.5		6	3.9	SL								
1			TP30-1.0		5.6	4.5	SL	6.4	4.1	<0.005	<0.005	<0.005	0.010		
			TP30-1.5		5.6	4.5	SL								
2			TP30-2.0		6	4.2	SL								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP31

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 8/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405200.00
NORTHING: 6456448.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 0.60 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0														0.0m: TOPSOIL: Sand with trace of organic fines, brown. Roots and rootlets to 600 mm.	Dry
														0.1m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines. 10 mm diameter PVC pipe duct at 600 mm.	Dry

Total drilled depth: 0.6 mBGL

COMMENTS: Refusal

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP32

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 7/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405309.00
NORTHING: 6456461.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP32-0.0		6.2	3.6	M							0.0m: TOPSOIL: Sand with trace of organic, brown. Rootlets and roots.	Moist
														0.1m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, white/grey. Roots to 600 mm.	Moist
			TP32-0.5		6.2	4.1	M	6.3	3.3	0.006	<0.005	0.057	0.011		
1			TP32-1.0		6.6	5	SL								
														1.3m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, orange/yellow.	Moist
			TP32-1.5		6.3	4.6	M								
2			TP32-2.0		6.6	4.7	M								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP33

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 7/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405465.00
NORTHING: 6456643.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP33-0.0		6.7	4.3	M							0.0m: TOPSOIL: Silty sand with trace of organic fines, brown. Roots and rootlets.	Moist
														0.1m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, grey/white/brown. Sidewall collapse at 100 mm.	Moist
			TP33-0.5		7.1	4.9	M								
1			TP33-1.0		6.9	4.9	M	6.8	3.8	<0.005	<0.005	0.017	0.010		
			TP33-1.5		7.3	5.3	SL								
2			TP33-2.0		7.4	5.4	SL								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP34

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 7/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405611.00
NORTHING: 6456784.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP34-0.0		6.4	4.2	M							0.0m: TOPSOIL: Silty sand with trace of organics, brown. Rootlets and roots.	Dry
														0.1m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of fines, grey/white. Fine rootlets throughout.	Dry
			TP34-0.5		6.6	4.4	M								
			TP34-1.0		6.3	4.6	M								
1														1.0m: CLAYEY SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, clay is medium plasticity, orange/brown/grey mottled. Trace of rounded ironstone/pezolithic gravels.	Moist
			TP34-1.5		5.4	4	M	6.6	5.0	0.006	<0.005	0.015	0.011		
			TP34-2.0		5.4	4.2	M								
2														Total drilled depth: 2 mBGL	

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP39

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 7/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405490.00
NORTHING: 6456278.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP39-0.0		5.6	2.7	M							0.0m: TOPSOIL: Sand with organic fines, brown. Roots and rootlets.	Moist
														0.1m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, yellow/brown. Roots and rootlets throughout.	Moist
			TP39-0.5		6.4	4.1	M								
														0.5m: SANDY CLAY: High plasticity clay, sand is fine to coarse grained, sub-angular to sub-rounded quartz, trace of sub-rounded to rounded pezolithic gravel, orange/brown. Roots at 500 m to 700 mm.	Dry
1			TP39-1.0		5.4	3.9	M	6.4	4.6	<0.005	<0.005	0.024	0.010		
														1.1m: CLAYEY SANDY GRAVEL: Fine to coarse grained, subrounded to subangular ironstone, laterite and pizolithic gravel, Red/brown. Sand is fine to coarse grained, subangular to subrounded. Clay is high plasticity.	Dry
			TP39-1.5		5.5	3.8	M								
2			TP39-2.0		5.2	3.9	M								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

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Soil Core Log ID: TP40

PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 7/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 405726.00
NORTHING: 6456546.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP40-0.0		6.5	4.2	M							0.0m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, white/grey. Sidewall collapse at 500 mm.	Dry
			TP40-0.5		6.2	4.8	SL								
1			TP40-1.0		6.2	4.5	SL	6.8	4.6	<0.005	<0.005	0.006	0.010		
			TP40-1.5		6.7	5.3	SL							1.5m: … Trace of coffee rock gravel at 1.50 m.	
														1.8m: COFFEE ROCK: VExtremely low strength, very weakly iron cemented, brown. Recovered as brown sand and gravels.	Dry
2			TP40-2.0		6.6	5	M								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Soil Core Log ID: TP43

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PROJECT NAME: MKSEA Precincts 1, 2 and 3B
PROJECT NUMBER: EP17-010(05)
CLIENT: City of Gosnells
PROJECT LOCATION: Kenwick and Maddington

DATE INSTALLED: 8/09/2017
DRILLING CONTRACTOR: N/A
DRILLING METHOD: JCB 3CX
LOGGED BY: JDSi

SURVEY SOURCE: GPS
EASTING: 406115.00
NORTHING: 6455510.00
PROJECTION: MGA, GDA94

ELEVATION (GROUND LEVEL):
ELEVATION (GROUNDWATER):
BORE DIAMETER:
TOTAL DEPTH: 2.00 mBGL

DEPTH (mBGL)	DEPTH (mAHD)	LOG	SAMPLE I.D	pHff	pHf	pHfox	Reaction Rate	pHKCl	pHOX	Spos %S	TAA %S	TSA %S	Net Acidity %S	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			TP43-0.0		4.6	3.2	M							0.0m: SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, white/grey. Roots and rootlets to 500 mm. Sidewall collapse at 1.5 m.	Dry to Moist
			TP43-0.5		4.4	3.3	SL								
1			TP43-1.0		4.3	3	SL								
			TP43-1.5		4.1	4.1	SL								
2			TP43-2.0		4	4	SL								

Total drilled depth: 2 mBGL

COMMENTS: Target depth

REACTION RATE: SL = Slight, M = Moderate, ST = Strong, EX = Extreme

Appendix B

Laboratory Documentation

CHAIN OF CUSTODY

emerge ASSOCIATES Integrated Science & Design

CLIENT: Emerge Associates | POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008 | Page 1 of 5

PROJECT MANAGER: Robin Anderson | CONTACT PHONE: 9380 4988 | ALS LABORATORY: Perth

PROJECT ID.: EP17-010(05) | PROJECT NAME: MKSEA | TURNAROUND REQUIREMENTS

SAMPLER(S): Robin Anderson | SAMPLERS PHONE: 0435 273 846 | ☒ Standard (5-7 days) ☐ Non-standard (one day or asap)

QUOTE NO.: EPBQ/009/16 ORDER NO.:

Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au

Email invoice to: accounts@emergeassociates.com.au

Laboratory Batch No:

Laboratory Use:	Yes	No	N/a
Custody seal intact:	☒	☐	☐
Free ice/frozen ice bricks present:	☐	☐	☒
Random sample temp on receipt:			°C

Comments/special handling/storage or disposal

ANALYSIS REQUIRED

Additional information (likely contaminants, dilutions or specific QC analysis)

Environmental Division
Perth
Work Order Reference
EP1709754

Telephone : +61-8-9209 7655

SAMPLE DETAILS				CONTAINER INFORMATION		ANALYSIS REQUIRED
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS
1	TP01-0.5	Soil	05/09/2017	ASS x 1	1	X
2	TP01-1.0	Soil	05/09/2017	ASS x 1	1	X
3	TP01-1.5	Soil	05/09/2017	ASS x 1	1	X
4	TP01-2.0	Soil	05/09/2017	ASS x 1	1	X
5	TP03-0.0	Soil	05/09/2017	ASS x 1	1	X
6	TP03-0.5	Soil	05/09/2017	ASS x 1	1	X
7	TP03-1.0	Soil	05/09/2017	ASS x 1	1	X
8	TP03-1.5	Soil	05/09/2017	ASS x 1	1	X
9	TP03-2.0	Soil	05/09/2017	ASS x 1	1	X
10	TP04-0.0	Soil	05/09/2017	ASS x 1	1	X
11	TP04-0.5	Soil	05/09/2017	ASS x 1	1	X
12	TP04-1.0	Soil	05/09/2017	ASS x 1	1	X
13	TP04-1.5	Soil	05/09/2017	ASS x 1	1	X
14	TP04-2.0	Soil	05/09/2017	ASS x 1	1	X
15	TP06-0.0	Soil	05/09/2017	ASS x 1	1	X
				TOTAL: bags		

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Robin Andeerson	DATE: 06/09/2017	NAME : M Waddell	DATE: 6/9/17	Yes No
OF: Emerge Associates	TIME: 15:00	OF: ALS	TIME: 1540	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

CHAIN OF CUSTODY

emerge ASSOCIATES Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	ALS LABORATORY: Perth
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	TURNAROUND REQUIREMENTS
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	☒ Standard (5-7 days) ☐ Non-standard (one day or asap)
SAMPLER(S): Robin Anderson	SAMPLERS PHONE: 0435 273 846	
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au
Laboratory Batch No:	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/a
Custody seal intact:	☐	☐	☐
Free ice/frozen ice bricks present:	☐	☐	☐
Random sample temp on receipt:			°C

ANALYSIS REQUIRED

SAMPLE DETAILS				CONTAINER INFORMATION													
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS										Additional information (likely contaminants, dilutions or specific QC analysis)
16	TP06-0.5	Soil	05/09/2017	ASS x 1	1	X										
17	TP06-1.0	Soil	05/09/2017	ASS x 1	1	X										
18	TP06-1.5	Soil	05/09/2017	ASS x 1	1	X										
19	TP06-2.0	Soil	05/09/2017	ASS x 1	1	X										
20	TP07-0.0	Soil	05/09/2017	ASS x 1	1	X										
21	TP07-0.5	Soil	05/09/2017	ASS x 1	1	X										
22	TP07-1.0	Soil	05/09/2017	ASS x 1	1	X										
23	TP07-1.5	Soil	05/09/2017	ASS x 1	1	X										
24	TP07-2.0	Soil	05/09/2017	ASS x 1	1	X										
25	TP08-0.0	Soil	05/09/2017	ASS x 1	1	X										
26	TP08-0.5	Soil	05/09/2017	ASS x 1	1	X										
27	TP08-1.0	Soil	05/09/2017	ASS x 1	1	X										
28	TP08-1.5	Soil	05/09/2017	ASS x 1	1	X										
29	TP08-2.0	Soil	05/09/2017	ASS x 1	1	X										
30	TP09-0.0	Soil	05/09/2017	ASS x 1	1	X										
				TOTAL: bags												

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Robin Andeerson	DATE: 06/09/2017	NAME : MU	DATE: 6/9/17	Yes No
OF: Emerge Associates	TIME: 15:00	OF: ALS	TIME: 1540	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

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Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 3 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Robin Anderson	SAMPLERS PHONE: 0435 273 846	☒ Standard (5-7 days) ☐ Non-standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au
Laboratory Batch No:	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/a
Custody seal intact:	☐	☐	☐
Free ice/frozen ice bricks present:	☐	☐	☐
Random sample temp on receipt:			°C

ANALYSIS REQUIRED

SAMPLE DETAILS				CONTAINER INFORMATION		ANALYSIS REQUIRED	
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	Additional information (likely contaminants, dilutions or specific QC analysis)
31	TP09-0.5	Soil	05/09/2017	ASS x 1	1	X	
32	TP09-1.0	Soil	05/09/2017	ASS x 1	1	X	
33	TP09-1.5	Soil	05/09/2017	ASS x 1	1	X	
34	TP10-0.0	Soil	06/09/2017	ASS x 1	1	X	
35	TP10-0.5	Soil	06/09/2017	ASS x 1	1	X	
36	TP10-1.0	Soil	06/09/2017	ASS x 1	1	X	
37	TP10-1.5	Soil	06/09/2017	ASS x 1	1	X	
38	TP10-2.0	Soil	06/09/2017	ASS x 1	1	X	
39	TP11-0.0	Soil	06/09/2017	ASS x 1	1	X	
40	TP11-0.5	Soil	06/09/2017	ASS x 1	1	X	
41	TP11-1.0	Soil	06/09/2017	ASS x 1	1	X	
42	TP11-1.5	Soil	06/09/2017	ASS x 1	1	X	
43	TP11-2.0	Soil	06/09/2017	ASS x 1	1	X	
44	TP12-0.0	Soil	06/09/2017	ASS x 1	1	X	
45	TP12-0.5	Soil	06/09/2017	ASS x 1	1	X	
				TOTAL bags			

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Robin Andeerson	DATE: 06/09/2017	NAME : MW	DATE: 6/9/17	Yes / No
OF: Emerge Associates	TIME: 15:00	OF: ALS	TIME: 1540	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

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PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Robin Anderson	SAMPLERS PHONE: 0435 273 846	☒ Standard (5-7 days) ☐ Non-standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au
Laboratory Batch No:	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/a
Custody seal intact:	☐	☐	☐
Free ice/frozen ice bricks present:	☐	☐	☐
Random sample temp on receipt:			°C

ANALYSIS REQUIRED

SAMPLE DETAILS				CONTAINER INFORMATION													
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS										Additional information (likely contaminants, dilutions or specific QC analysis)
46	TP12-1.0	Soil	05/09/2017	ASS x 1	1	X										
47	TP12-1.35	Soil	05/09/2017	ASS x 1	1	X										
48	TP13-0.0	Soil	05/09/2017	ASS x 1	1	X										
49	TP13-0.5	Soil	06/09/2017	ASS x 1	1	X										
50	TP13-1.0	Soil	06/09/2017	ASS x 1	1	X										
51	TP13-1.25	Soil	06/09/2017	ASS x 1	1	X										
52	TP17-0.0	Soil	06/09/2017	ASS x 1	1	X										
53	TP17-0.5	Soil	06/09/2017	ASS x 1	1	X										
54	TP17-1.0	Soil	06/09/2017	ASS x 1	1	X										
55	TP17-1.5	Soil	06/09/2017	ASS x 1	1	X										
56	TP17-2.0	Soil	06/09/2017	ASS x 1	1	X										
57	TP18-0.0	Soil	06/09/2017	ASS x 1	1	X										
58	TP18-0.5	Soil	06/09/2017	ASS x 1	1	X										
59	TP18-1.0	Soil	06/09/2017	ASS x 1	1	X										
60	TP28-0.0	Soil	06/09/2017	ASS x 1	1	X										
				TOTAL bags												

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Robin Andeerson	DATE: 06/09/2017	NAME : MW	DATE: 6/9/17	Yes No
OF: Emerge Associates	TIME: 15:00	OF: ALS	TIME: 1540	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

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POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008
Page 5 of 5
PROJECT MANAGER: Robin Anderson
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QUOTE NO.: EPBQ/009/16 ORDER NO.:
Email invoice to: accounts@emergeassociates.com.au

Laboratory Batch No.:
Comments/special handling/storage or disposal

Laboratory Use:	Yes	No	N/a
Custody seal intact	☐	☐	☐
Free ice/frozen ice bricks present	☐	☐	☐
Random sample temp on receipt			°C

ANALYSIS REQUIRED

Additional information (likely contaminants, dilutions or specific QC analysis)

SAMPLE DETAILS				CONTAINER INFORMATION		ANALYSIS REQUIRED	
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	Additional information
61	TP28-0.5	Soil	05/09/2017	ASS x 1	1	X	
62	TP28-1.0	Soil	05/09/2017	ASS x 1	1	X	
63	TP28-1.5	Soil	05/09/2017	ASS x 1	1	X	
64	TP28-2.0	Soil	06/09/2017	ASS x 1	1	X	
65	SQA01	Soil	06/09/2017	ASS x 1	1	X	
66	SQA02	Soil	06/09/2017	ASS x 1	1	X	
67	SQA03	Soil	06/09/2017	ASS x 1	1	X	
68	SQA04	Soil	06/09/2017	ASS x 1	1	X	
				TOTAL bags			

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Robin Andeerson	DATE: 06/09/2017	NAME : MW	DATE: 6/9/17	Yes No
OF: Emerge Associates	TIME: 15:00	OF: AW	TIME: 1540.	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order	: **EP1709754**		
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Luke Jones
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: Robin.Anderson@emergeassociates.com.au	E-mail	: LUKE.JONES@alsglobal.com
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7631
Facsimile	: +61 08 9380 9636	Facsimile	: +61-8-9209 7600
Project	: EP17-010(05) MKSEA	Page	: 1 of 4
Order number	: ----	Quote number	: EP2016EMEASS0001 (EPBQ-009-16)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: ROBIN ANDERSON		

Dates

Date Samples Received	: 06-Sep-2017 15:40	Issue Date	: 07-Sep-2017
Client Requested Due Date	: 11-Sep-2017	Scheduled Reporting Date	: **11-Sep-2017**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 3	Temperature	: 17.3
Receipt Detail	:	No. of samples received / analysed	: 68 / 68

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- Please see scanned COC for sample discrepencies: extra samples , samples not received etc.
- Please direct any queries related to sample condition / numbering / breakages to Sample Receipt (SamplesPerth@alsenviro.com)
- Analytical work for this work order will be conducted at ALS Environmental Perth.
- Please direct any turnaround / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (14 days), Solid (60 days) from date of completion of Work Order.
- **pH analysis should be conducted within 6 hours of sampling.**

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	SOIL - EA037 ASS Field Screening Analysis
EP1709754-001	05-Sep-2017 00:00	TP01-0.0	✓
EP1709754-002	05-Sep-2017 00:00	TP01-0.5	✓
EP1709754-003	05-Sep-2017 00:00	TP01-1.0	✓
EP1709754-004	05-Sep-2017 00:00	TP01-1.5	✓
EP1709754-005	05-Sep-2017 00:00	TP03-0.0	✓
EP1709754-006	05-Sep-2017 00:00	TP03-0.5	✓
EP1709754-007	05-Sep-2017 00:00	TP03-1.0	✓
EP1709754-008	05-Sep-2017 00:00	TP03-1.5	✓
EP1709754-009	05-Sep-2017 00:00	TP03-2.0	✓
EP1709754-010	05-Sep-2017 00:00	TP04-0.0	✓
EP1709754-011	05-Sep-2017 00:00	TP04-0.5	✓
EP1709754-012	05-Sep-2017 00:00	TP04-1.0	✓
EP1709754-013	05-Sep-2017 00:00	TP04-1.5	✓
EP1709754-014	05-Sep-2017 00:00	TP04-2.0	✓
EP1709754-015	05-Sep-2017 00:00	TP06-0.0	✓
EP1709754-016	05-Sep-2017 00:00	TP06-0.5	✓
EP1709754-017	05-Sep-2017 00:00	TP06-1.0	✓
EP1709754-018	05-Sep-2017 00:00	TP06-1.5	✓
EP1709754-019	05-Sep-2017 00:00	TP06-2.0	✓
EP1709754-020	05-Sep-2017 00:00	TP07-0.0	✓
EP1709754-021	05-Sep-2017 00:00	TP07-0.5	✓
EP1709754-022	05-Sep-2017 00:00	TP07-1.0	✓
EP1709754-023	05-Sep-2017 00:00	TP07-1.5	✓
EP1709754-024	05-Sep-2017 00:00	TP07-2.0	✓
EP1709754-025	05-Sep-2017 00:00	TP08-0.0	✓
EP1709754-026	05-Sep-2017 00:00	TP08-0.5	✓
EP1709754-027	05-Sep-2017 00:00	TP08-1.0	✓
EP1709754-028	05-Sep-2017 00:00	TP08-1.5	✓
EP1709754-029	05-Sep-2017 00:00	TP08-2.0	✓
EP1709754-030	05-Sep-2017 00:00	TP09-0.0	✓
EP1709754-031	05-Sep-2017 00:00	TP09-0.5	✓
EP1709754-032	05-Sep-2017 00:00	TP09-1.0	✓
EP1709754-033	05-Sep-2017 00:00	TP09-1.5	✓
EP1709754-034	05-Sep-2017 00:00	TP10-0.0	✓
EP1709754-035	05-Sep-2017 00:00	TP10-0.5	✓

			SOIL - EA037 ASS Field Screening Analysis
EP1709754-036	05-Sep-2017 00:00	TP10-1.0	✓
EP1709754-037	05-Sep-2017 00:00	TP10-1.5	✓
EP1709754-038	05-Sep-2017 00:00	TP10-2.0	✓
EP1709754-039	05-Sep-2017 00:00	TP11-0.0	✓
EP1709754-040	05-Sep-2017 00:00	TP11-0.5	✓
EP1709754-041	05-Sep-2017 00:00	TP11-1.0	✓
EP1709754-042	05-Sep-2017 00:00	TP11-1.5	✓
EP1709754-043	05-Sep-2017 00:00	TP11-2.0	✓
EP1709754-044	05-Sep-2017 00:00	TP12-0.0	✓
EP1709754-045	05-Sep-2017 00:00	TP12-0.5	✓
EP1709754-046	05-Sep-2017 00:00	TP12-1.0	✓
EP1709754-047	05-Sep-2017 00:00	TP12-1.35	✓
EP1709754-048	05-Sep-2017 00:00	TP13-0.0	✓
EP1709754-049	05-Sep-2017 00:00	TP13-0.5	✓
EP1709754-050	05-Sep-2017 00:00	TP13-1.0	✓
EP1709754-051	05-Sep-2017 00:00	TP13-1.25	✓
EP1709754-052	05-Sep-2017 00:00	TP17-0.0	✓
EP1709754-053	05-Sep-2017 00:00	TP17-0.5	✓
EP1709754-054	05-Sep-2017 00:00	TP17-1.0	✓
EP1709754-055	05-Sep-2017 00:00	TP17-1.5	✓
EP1709754-056	05-Sep-2017 00:00	TP17-2.0	✓
EP1709754-057	05-Sep-2017 00:00	TP18-0.0	✓
EP1709754-058	05-Sep-2017 00:00	TP18-0.5	✓
EP1709754-059	05-Sep-2017 00:00	TP18-1.0	✓
EP1709754-060	05-Sep-2017 00:00	TP28-0.0	✓
EP1709754-061	05-Sep-2017 00:00	TP28-0.5	✓
EP1709754-062	05-Sep-2017 00:00	TP28-1.0	✓
EP1709754-063	05-Sep-2017 00:00	TP28-1.5	✓
EP1709754-064	05-Sep-2017 00:00	TP28-2.0	✓
EP1709754-065	05-Sep-2017 00:00	SQA01	✓
EP1709754-066	05-Sep-2017 00:00	SQA02	✓
EP1709754-067	05-Sep-2017 00:00	SQA03	✓
EP1709754-068	05-Sep-2017 00:00	SQA04	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

ACCOUNTS (INVOICES)

- A4 - AU Tax Invoice (INV)	Email	accounts@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	accounts@emergeassociates.com.au

ROBIN ANDERSON

- *AU Certificate of Analysis - NATA (COA)	Email	Robin.Anderson@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	Robin.Anderson@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	Robin.Anderson@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	Robin.Anderson@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	Robin.Anderson@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	Robin.Anderson@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	Robin.Anderson@emergeassociates.com.au

SIMON GREGG

- *AU Certificate of Analysis - NATA (COA)	Email	simon.gregg@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	simon.gregg@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	simon.gregg@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	simon.gregg@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	simon.gregg@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	simon.gregg@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	simon.gregg@emergeassociates.com.au

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1709754**	Page	: 1 of 16
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Luke Jones
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7631
Project	: EP17-010(05) MKSEA	Date Samples Received	: 06-Sep-2017 15:40
Order number	: ----	Date Analysis Commenced	: 07-Sep-2017
C-O-C number	: ----	Issue Date	: 11-Sep-2017 17:00
Sampler	: ROBIN ANDERSON		
Site	: ----		
Quote number	: EPBQ-009-16		
No. of samples received	: 68		
No. of samples analysed	: 68		

NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA037 (Rapid Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Strong; 4 - Extreme
- EA037 ASS Field Screening: NATA accreditation does not cover performance of this service.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP01-0.0	TP01-0.5	TP01-1.0	TP01-1.5	TP03-0.0
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-001	EP1709754-002	EP1709754-003	EP1709754-004	EP1709754-005
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	5.3	7.4	8.0	7.8	5.9
pH (Fox)	----	0.1	pH Unit	3.0	7.4	7.3	7.1	2.5
Reaction Rate	----	1	-	Moderate	Extreme	Strong	Strong	Strong

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP03-0.5	TP03-1.0	TP03-1.5	TP03-2.0	TP04-0.0
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-006	EP1709754-007	EP1709754-008	EP1709754-009	EP1709754-010
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**5.8**	**5.7**	**6.3**	**6.3**	**4.6**
pH (Fox)	----	0.1	pH Unit	**2.9**	**3.8**	**4.0**	**4.5**	**2.2**
Reaction Rate	----	1	-	**Moderate**	**Moderate**	**Moderate**	**Slight**	**Strong**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP04-0.5	TP04-1.0	TP04-1.5	TP04-2.0	TP06-0.0
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-011	EP1709754-012	EP1709754-013	EP1709754-014	EP1709754-015
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	4.6	6.4	5.1	5.9	7.5
pH (Fox)	----	0.1	pH Unit	2.3	4.9	2.6	4.3	5.8
Reaction Rate	----	1	-	Strong	Strong	Strong	Strong	Moderate

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

			Client sample ID	TP06-0.5	TP06-1.0	TP06-1.5	TP06-2.0	TP07-0.0
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-016	EP1709754-017	EP1709754-018	EP1709754-019	EP1709754-020
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	7.4	7.4	7.8	7.4	6.7
pH (Fox)	----	0.1	pH Unit	6.0	6.0	7.6	8.1	3.1
Reaction Rate	----	1	-	Moderate	Moderate	Extreme	Extreme	Moderate

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP07-0.5	TP07-1.0	TP07-1.5	TP07-2.0	TP08-0.0
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-021	EP1709754-022	EP1709754-023	EP1709754-024	EP1709754-025
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	7.0	5.8	4.6	4.9	7.7
pH (Fox)	----	0.1	pH Unit	6.1	5.0	1.6	2.0	5.3
Reaction Rate	----	1	-	Strong	Strong	Extreme	Extreme	Extreme

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP08-0.5	TP08-1.0	TP08-1.5	TP08-2.0	TP09-0.0
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-026	EP1709754-027	EP1709754-028	EP1709754-029	EP1709754-030
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	7.4	6.6	6.1	7.7	5.3
pH (Fox)	----	0.1	pH Unit	7.1	7.1	5.3	7.5	2.5
Reaction Rate	----	1	-	Extreme	Extreme	Strong	Extreme	Moderate

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP09-0.5	TP09-1.0	TP09-1.5	TP10-0.0	TP10-0.5
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-031	EP1709754-032	EP1709754-033	EP1709754-034	EP1709754-035
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	6.6	7.7	7.6	7.7	7.4
pH (Fox)	----	0.1	pH Unit	3.0	6.6	6.1	5.0	6.4
Reaction Rate	----	1	-	Moderate	Strong	Moderate	Moderate	Moderate

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP10-1.0	TP10-1.5	TP10-2.0	TP11-0.0	TP11-0.5
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-036	EP1709754-037	EP1709754-038	EP1709754-039	EP1709754-040
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	7.2	6.9	6.9	6.3	7.0
pH (Fox)	----	0.1	pH Unit	7.3	7.5	7.4	2.6	6.0
Reaction Rate	----	1	-	Extreme	Extreme	Extreme	Moderate	Moderate

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

			Client sample ID	TP11-1.0	TP11-1.5	TP11-2.0	TP12-0.0	TP12-0.5
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-041	EP1709754-042	EP1709754-043	EP1709754-044	EP1709754-045
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	7.3	7.1	6.7	6.3	6.9
pH (Fox)	----	0.1	pH Unit	7.6	6.0	5.8	2.3	5.2
Reaction Rate	----	1	-	Extreme	Strong	Strong	Moderate	Moderate

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP12-1.0	TP12-1.35	TP13-0.0	TP13-0.5	TP13-1.0
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-046	EP1709754-047	EP1709754-048	EP1709754-049	EP1709754-050
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	6.8	6.8	6.1	6.1	6.0
pH (Fox)	----	0.1	pH Unit	5.7	4.3	3.1	3.4	3.7
Reaction Rate	----	1	-	Strong	Strong	Moderate	Moderate	Moderate

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP13-1.25	TP17-0.0	TP17-0.5	TP17-1.0	TP17-1.5
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-051	EP1709754-052	EP1709754-053	EP1709754-054	EP1709754-055
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	5.5	5.2	6.8	7.0	6.7
pH (Fox)	----	0.1	pH Unit	3.4	2.6	6.9	5.5	6.1
Reaction Rate	----	1	-	Strong	Strong	Strong	Strong	Strong

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP17-2.0	TP18-0.0	TP18-0.5	TP18-1.0	TP28-0.0
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-056	EP1709754-057	EP1709754-058	EP1709754-059	EP1709754-060
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	7.3	7.3	7.0	7.1	6.9
pH (Fox)	----	0.1	pH Unit	6.4	4.2	3.7	3.5	4.3
Reaction Rate	----	1	-	Slight	Moderate	Moderate	Moderate	Moderate

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP28-0.5	TP28-1.0	TP28-1.5	TP28-2.0	SQA01
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709754-061	EP1709754-062	EP1709754-063	EP1709754-064	EP1709754-065
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	6.6	6.7	6.9	6.7	6.7
pH (Fox)	----	0.1	pH Unit	4.2	5.1	4.4	4.8	5.2
Reaction Rate	----	1	-	Slight	Slight	Slight	Slight	Strong

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	SQA02	SQA03	SQA04	----	----
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00	----	----
Compound	CAS Number	LOR	Unit	EP1709754-066	EP1709754-067	EP1709754-068	--------	--------
				Result	Result	Result	----	----
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**6.5**	**5.9**	**6.6**	----	----
pH (Fox)	----	0.1	pH Unit	**7.0**	**3.4**	**5.9**	----	----
Reaction Rate	----	1	-	**Extreme**	**Extreme**	**Strong**	----	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EP1709754**	Page	: 1 of 3
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Luke Jones
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7631
Project	: EP17-010(05) MKSEA	Date Samples Received	: 06-Sep-2017
Order number	: ----	Date Analysis Commenced	: 07-Sep-2017
C-O-C number	: ----	Issue Date	: 11-Sep-2017
Sampler	: ROBIN ANDERSON		
Site	: ----		
Quote number	: EPBQ-009-16		
No. of samples received	: 68		
No. of samples analysed	: 68		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA037: Ass Field Screening Analysis (QC Lot: 1102728)									
EP1709754-001	TP01-0.0	EA037: pH (F)	----	0.1	pH Unit	5.3	5.4	1.88	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	3.0	3.0	0.00	0% - 20%
EP1709754-010	TP04-0.0	EA037: pH (F)	----	0.1	pH Unit	4.6	4.4	2.44	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	2.2	2.2	0.00	0% - 20%
EA037: Ass Field Screening Analysis (QC Lot: 1102729)									
EP1709754-021	TP07-0.5	EA037: pH (F)	----	0.1	pH Unit	7.0	6.9	0.00	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	6.1	6.2	0.00	0% - 20%
EP1709754-030	TP09-0.0	EA037: pH (F)	----	0.1	pH Unit	5.3	5.4	0.00	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	2.5	2.4	5.67	0% - 20%
EA037: Ass Field Screening Analysis (QC Lot: 1102730)									
EP1709754-041	TP11-1.0	EA037: pH (F)	----	0.1	pH Unit	7.3	7.3	0.00	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	7.6	7.5	1.46	0% - 20%
EP1709754-050	TP13-1.0	EA037: pH (F)	----	0.1	pH Unit	6.0	5.9	0.00	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	3.7	3.7	0.00	0% - 20%
EA037: Ass Field Screening Analysis (QC Lot: 1102731)									
EP1709754-061	TP28-0.5	EA037: pH (F)	----	0.1	pH Unit	6.6	6.8	3.28	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	4.2	4.1	0.00	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

- **No Method Blank (MB) or Laboratory Control Spike (LCS) Results are required to be reported.**

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EP1709754**	Page	:
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Telephone	: 08 9209 7631
Project	: EP17-010(05) MKSEA	Date Samples Received	: 06-Sep-2017
Site	: ----	Issue Date	: 11-Sep-2017
Sampler	: ROBIN ANDERSON	No. of samples received	: 68
Order number	: ----	No. of samples analysed	: 68

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **<u>NO</u> Method Blank value outliers occur.**
- **<u>NO</u> Duplicate outliers occur.**
- **<u>NO</u> Laboratory Control outliers occur.**
- **<u>NO</u> Matrix Spike outliers occur.**
- **For all regular sample matrices, <u>NO</u> surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **<u>NO</u> Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **<u>NO</u> Quality Control Sample Frequency Outliers exist.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / *Container / Client Sample ID(s)*	*Sample Date*	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA037: Ass Field Screening Analysis							
Snap Lock Bag - frozen on receipt at ALS (EA037)							

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA037: Ass Field Screening Analysis - Continued								
TP01-0.0,	TP01-0.5,	**05-Sep-2017**	**07-Sep-2017**	04-Mar-2018	✓	**07-Sep-2017**	04-Mar-2018	✓
TP01-1.0,	TP01-1.5,							
TP03-0.0,	TP03-0.5,							
TP03-1.0,	TP03-1.5,							
TP03-2.0,	TP04-0.0,							
TP04-0.5,	TP04-1.0,							
TP04-1.5,	TP04-2.0,							
TP06-0.0,	TP06-0.5,							
TP06-1.0,	TP06-1.5,							
TP06-2.0,	TP07-0.0,							
TP07-0.5,	TP07-1.0,							
TP07-1.5,	TP07-2.0,							
TP08-0.0,	TP08-0.5,							
TP08-1.0,	TP08-1.5,							
TP08-2.0,	TP09-0.0,							
TP09-0.5,	TP09-1.0,							
TP09-1.5,	TP10-0.0,							
TP10-0.5,	TP10-1.0,							
TP10-1.5,	TP10-2.0,							
TP11-0.0,	TP11-0.5,							
TP11-1.0,	TP11-1.5,							
TP11-2.0,	TP12-0.0,							
TP12-0.5,	TP12-1.0,							
TP12-1.35,	TP13-0.0,							
TP13-0.5,	TP13-1.0,							
TP13-1.25,	TP17-0.0,							
TP17-0.5,	TP17-1.0,							
TP17-1.5,	TP17-2.0,							
TP18-0.0,	TP18-0.5,							
TP18-1.0,	TP28-0.0,							
TP28-0.5,	TP28-1.0,							
TP28-1.5,	TP28-2.0,							
SQA01,	SQA02,							
SQA03,	SQA04							

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
ASS Field Screening Analysis	EA037	7	68	**10.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
ASS Field Screening Analysis	EA037	SOIL	In house: Referenced to Acid Sulfate Soils Laboratory Methods Guidelines, version 2.1 June 2004. As received samples are tested for pH field and pH fox and assessed for a reaction rating.

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Drying only	EN020D	SOIL	In house

CHAIN OF CUSTODY

emerge ASSOCIATES Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 1 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Mitchell Ritikis	SAMPLERS PHONE: 0449 198 721	☒ Standard (5-7 days) ☐ Non-standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au
Laboratory Batch No	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/a
Custody seal intact	☐	☐	☒
Free ice/frozen ice bricks present	☒	☐	☐
Random sample temp on receipt			°C

ANALYSIS REQUIRED

Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	Additional information (likely contaminants, dilutions or specific QC analysis)
1	TP02-0.0	Water	8/09/2017	ASS x 1	1	X	
2	TP02-0.5	Water	8/09/2017	ASS x 1	1	X	
3	TP02-1.0	Water	8/09/2017	ASS x 1	1	X	
4	TP02-1.5	Water	8/09/2017	ASS x 1	1	X	
5	TP02-1.8	Water	8/09/2017	ASS x 1	1	X	
6	TP05-0.0	Water	8/09/2017	ASS x 1	1	X	
7	TP05-0.5	Water	8/09/2017	ASS x 1	1	X	
8	TP05-1.0	Water	8/09/2017	ASS x 1	1	X	
9	TP05-1.5	Water	8/09/2017	ASS x 1	1	X	
10	TP05-2.0	Water	8/09/2017	ASS x 1	1	X	
11	TP14-0.0	Water	6/09/2017	ASS x 1	1	X	
12	TP14-0.5	Water	6/09/2017	ASS x 1	1	X	
13	TP14-1.00	Water	6/09/2017	ASS x 1	1	X	
14	TP14-1.00 (2)	Water	6/09/2017	ASS x 1	1	X	
15	TP14-1.5	Water	6/09/2017	ASS x 1	1	X	
				TOTAL: 15 bags			

Environmental Division
Perth
Work Order Reference
EP1709951

Telephone : + 61-8-9209 7655

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME : m Wakel	DATE: 11/9/17	Yes No
OF: Emerge Associates	TIME: 9:30	OF: ALS	TIME: 1230	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: **P** = Unpreserved Plastic; **N** = Nitric Preserved Plastic; **ORC** = Nitric Preserved ORC; **SH** = Sodium Hydroxide/Cd Preserved; **S** = Sodium Hydroxide Preserved Plastic; **AG** = Amber Glass Unpreserved; **AP** = Airfreight Unpreserved Plastic; **V** = VOA Vial HCl Preserved; **VB** = VOA Vial Sodium Bisulphate Preserved; **VS** = VOA Vial Sulfuric Preserved; **AV** = Airfreight Unpreserved Vial; **SG** = Sulfuric Preserved Amber Glass; **H** = HCl preserved Plastic; **HS** = HCl Preserved Speciation bottle; **SP** = Sulfuric Preserved Plastic; **F** = Formaldehyde Preserved Glass; **Z** = Zinc Acetate Preserved Bottle; **E** = EDTA Preserved Bottles; **ST** = Sterile Bottle; **LI** = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: **J** = Jar; **ASS** = Plastic Bag for Acid Sulfate Soils; **B** = Unpreserved Bag;

CHAIN OF COUSTODY

emerge ASSOCIATES
Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 2 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Mitchell Ritikis	SAMPLERS PHONE: 0449 198 721	☒ Standard (5-7 days) ☐ Non standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au
Laboratory Batch No.:	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/a
Custody seal intact	☐	☐	☐
Free ice/frozen ice bricks present	☐	☐	☐
Random sample temp on receipt			°C

ANALYSIS REQUIRED

SAMPLE DETAILS				CONTAINER INFORMATION		ANALYSIS REQUIRED										Additional information (likely contaminants, dilutions or specific QC analysis)
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS										
16	TP14-2.0	Water	6/09/2017	ASS x 1	1	X										
17	TP15-0.0	Water	6/09/2017	ASS x 1	1	X										
18	TP15-0.5	Water	6/09/2017	ASS x 1	1	X										
19	TP15-1.0	Water	6/09/2017	ASS x 1	1	X										
20	TP15-1.0 (2)	Water	6/09/2017	ASS x 1	1	X										
21	TP15-2.0	Water	6/09/2017	ASS x 1	1	X										
22	TP16-0.0	Water	7/09/2017	ASS x 1	1	X										
23	TP16-0.5	Water	7/09/2017	ASS x 1	1	X										
24	TP16-1.0	Water	7/09/2017	ASS x 1	1	X										
25	TP16-1.5	Water	7/09/2017	ASS x 1	1	X										
26	TP16-2.0	Water	7/09/2017	ASS x 1	1	X										
27	TP25A-0.0	Water	7/09/2017	ASS x 1	1	X										
28	TP25A-0.5	Water	7/09/2017	ASS x 1	1	X										
29	TP25A-1.0	Water	7/09/2017	ASS x 1	1	X										
30	TP25A-1.0 (2)	Water	7/09/2017	ASS x 1	1	X										
				TOTAL: 15 bags												

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME : MW	DATE: 11/9	Yes No
OF: Emerge Associates	TIME: 9:30	OF:	TIME: 1230	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: **P** = Unpreserved Plastic; **N** = Nitric Preserved Plastic; **ORC** = Nitric Preserved ORC; **SH** = Sodium Hydroxide/Cd Preserved; **S** = Sodium Hydroxide Preserved Plastic; **AG** = Amber Glass Unpreserved; **AP** = Airfreight Unpreserved Plastic; **V** = VOA Vial HCl Preserved; **VB** = VOA Vial Sodium Bisulphate Preserved; **VS** = VOA Vial Sulfuric Preserved; **AV** = Airfreight Unpreserved Vial; **SG** = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; **HS** = HCl Preserved Speciation bottle; **SP** = Sulfuric Preserved Plastic; **F** = Formaldehyde Preserved Glass; **Z** = Zinc Acetate Preserved Bottle; **E** = EDTA Preserved Bottles; **ST** = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes:** J = Jar; **ASS** = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

CHAIN OF CUSTODY

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Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 3 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Mitchell Ritikis	SAMPLERS PHONE: 0449 198 721	☒ Standard (5-7 days) ☐ Non standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au
Laboratory Batch No	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/a
Custody seal intact	☐	☐	☐
Free ice/frozen ice bricks present	☐	☐	☐
Random sample temp on receipt			°C

ANALYSIS REQUIRED

SAMPLE DETAILS				CONTAINER INFORMATION		ANALYSIS REQUIRED	
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	Additional information (likely contaminants, dilutions or specific QC analysis)
31	TP25A-1.5	Water	7/09/2017	ASS x 1	1	X	
32	TP25B-0.0	Water	7/09/2017	ASS x 1	1	X	
33	TP25B-0.5	Water	7/09/2017	ASS x 1	1	X	
34	TP25B-1.0	Water	7/09/2017	ASS x 1	1	X	
35	TP25B-1.5	Water	7/09/2017	ASS x 1	1	X	
36	TP25B-2.0	Water	7/09/2017	ASS x 1	1	X	
37	TP26-0.0	Water	7/09/2017	ASS x 1	1	X	
38	TP26-0.5	Water	7/09/2017	ASS x 1	1	X	
39	TP26-1.0	Water	7/09/2017	ASS x 1	1	X	
40	TP26-1.5	Water	7/09/2017	ASS x 1	1	X	
41	TP26-2.0	Water	7/09/2017	ASS x 1	1	X	
42	TP27-0.0	Water	8/09/2017	ASS x 1	1	X	
43	TP27-0.5	Water	8/09/2017	ASS x 1	1	X	
44	TP27-1.0	Water	8/09/2017	ASS x 1	1	X	
45	TP27-1.5	Water	8/09/2017	ASS x 1	1	X	
				TOTAL: 15 bags			

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME :	DATE:	Yes No
OF: Emerge Associates	TIME: 9:30	OF:	TIME:	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: **P** = Unpreserved Plastic; **N** = Nitric Preserved Plastic; **ORC** = Nitric Preserved ORC; **SH** = Sodium Hydroxide/Cd Preserved; **S** = Sodium Hydroxide Preserved Plastic; **AG** = Amber Glass Unpreserved; **AP** = Airfreight Unpreserved Plastic; **V** = VOA Vial HCl Preserved; **VB** = VOA Vial Sodium Bisulphate Preserved; **VS** = VOA Vial Sulfuric Preserved; **AV** = Airfreight Unpreserved Vial; **SG** = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; **HS** = HCl Preserved Speciation bottle; **SP** = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; **Z** = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; **ST** = Sterile Bottle; **LI** = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

CHAIN OF COUSTODY

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CLIENT: Emerge Associates | POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008 | Page 4 of 5

PROJECT MANAGER: Robin Anderson | CONTACT PHONE: 9380 4988

PROJECT ID.: EP17-010(05) | PROJECT NAME: MKSEA

SAMPLER(S): Mitchell Ritikis | SAMPLERS PHONE: 0449 198 721

QUOTE NO.: EPBQ/009/16 ORDER NO.:

ALS LABORATORY: Perth

TURNAROUND REQUIREMENTS

☒ Standard (5-7 days) ☐ Non-standard (one day or asap)

Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au

Email invoice to: accounts@emergeassociates.com.au

Laboratory Batch No:

Laboratory Use	Yes	No	N/a
Custody seal intact:	☐	☐	☐
Free ice/frozen ice bricks present:	☐	☐	☐
Random sample temp on receipt			°C

Comments/special handling/storage or disposal

ANALYSIS REQUIRED

Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS									Additional information (likely contaminants, dilutions or specific QC analysis)
46	TP27-2.0	Water	8/09/2017	ASS x 1	1	X									
47	TP32-0.0	Water	7/09/2017	ASS x 1	1	X									
48	TP32-0.5	Water	7/09/2017	ASS x 1	1	X									
49	TP32-1.0	Water	7/09/2017	ASS x 1	1	X									
50	TP32-1.5	Water	7/09/2017	ASS x 1	1	X									
51	TP32-2.0	Water	7/09/2017	ASS x 1	1	X									
52	TP33-0.0	Water	7/09/2017	ASS x 1	1	X									
53	TP33-0.5	Water	7/09/2017	ASS x 1	1	X									
54	TP33-1.0	Water	7/09/2017	ASS x 1	1	X									
55	TP33-1.5	Water	7/09/2017	ASS x 1	1	X									
56	TP33-2.0	Water	7/09/2017	ASS x 1	1	X									
57	TP34-0.0	Water	7/09/2017	ASS x 1	1	X									
58	TP34-0.5	Water	7/09/2017	ASS x 1	1	X									
59	TP34-1.0	Water	7/09/2017	ASS x 1	1	X									
60	TP34-1.5	Water	7/09/2017	ASS x 1	1	X									
				TOTAL: 15 bags											

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME :	DATE: 11/9/17	Yes No
OF: Emerge Associates	TIME: 9:30	OF:	TIME: 1230	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: **P** = Unpreserved Plastic; **N** = Nitric Preserved Plastic; **ORC** = Nitric Preserved ORC; **SH** = Sodium Hydroxide/Cd Preserved; **S** = Sodium Hydroxide Preserved Plastic; **AG** = Amber Glass Unpreserved; **AP** = Airfreight Unpreserved Plastic; **V** = VOA Vial HCl Preserved; **VB** = VOA Vial Sodium Bisulphate Preserved; **VS** = VOA Vial Sulfuric Preserved; **AV** = Airfreight Unpreserved Vial; **SG** = Sulfuric Preserved Amber Glass; **H** = HCl preserved Plastic; **HS** = HCl Preserved Speciation bottle; **SP** = Sulfuric Preserved Plastic; **F** = Formaldehyde Preserved Glass; **Z** = Zinc Acetate Preserved Bottle; **E** = EDTA Preserved Bottles; **ST** = Sterile Bottle; **LI** = Lugols Iodine Preserved Bottles; **STT** = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: **J** = Jar; **ASS** = Plastic Bag for Acid Sulfate Soils; **B** = Unpreserved Bag;

CHAIN OF COUNTODY

emerge ASSOCIATES Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA
SAMPLER(S): Mitchell Ritikis	SAMPLERS PHONE: 0449 198 721
QUOTE NO.: EPBQ/009/16 ORDER NO.:	

ALS LABORATORY: Perth

TURNAROUND REQUIREMENTS

☒ Standard (5-7 days) ☐ Non-standard (one day or asap)

Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au

Email invoice to: accounts@emergeassociates.com.au

Laboratory Batch No:

Laboratory Use	Yes	No	N/a
Custody seal intact:	☐	☐	☐
Free ice/frozen ice bricks present:	☐	☐	☐
Random sample temp on receipt:			°C

Comments/special handling/storage or disposal

ANALYSIS REQUIRED

Additional information (likely contaminants, dilutions or specific QC analysis)

Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS
61	TP34-2.0	Water	7/09/2017	ASS x 1	1	X
62	TP39-0.0	Water	7/09/2017	ASS x 1	1	X
63	TP39-0.5	Water	7/09/2017	ASS x 1	1	X
64	TP39-1.0	Water	7/09/2017	ASS x 1	1	X
65	TP39-1.5	Water	7/09/2017	ASS x 1	1	X
66	TP39-2.0	Water	7/09/2017	ASS x 1	1	X
67	TP40-0.0	Water	7/09/2017	ASS x 1	1	X
68	TP40-0.5	Water	7/09/2017	ASS x 1	1	X
69	TP40-1.0	Water	7/09/2017	ASS x 1	1	X
70	TP40-1.0 (2)	Water	7/09/2017	ASS x 1	1	X
71	TP40-1.5	Water	7/09/2017	ASS x 1	1	X
72	TP40-2.0	Water	7/09/2017	ASS x 1	1	X
73	TP43-0.0	Water	8/09/2017	ASS x 1	1	X
74	TP43-0.5	Water	8/09/2017	ASS x 1	1	X
75	TP43-1.0	Water	8/09/2017	ASS x 1	1	X
				TOTAL: 15 bags		

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME : m L	DATE: 11/9	Yes No
OF: Emerge Associates	TIME: 9:30	OF:	TIME: 1230	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: J = Jar ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

CHAIN OF CUSTODY

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Integrated Science & Design

CLIENT: Emerge Associates | POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008 | Page 6 of 5

PROJECT MANAGER: Robin Anderson | CONTACT PHONE: 9380 4988 | ALS LABORATORY: Perth

PROJECT ID.: EP17-010(05) | PROJECT NAME: MKSEA | TURNAROUND REQUIREMENTS

SAMPLER(S): Mitchell Ritikis | SAMPLERS PHONE: 0449 198 721 | ☒ Standard (5-7 days) ☐ Non-standard (one day or asap)

QUOTE NO.: EPBQ/009/16 ORDER NO.:

Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au

Email invoice to: accounts@emergeassociates.com.au

Laboratory Batch No:

Laboratory Use	Yes	No	N/a
Custody seal intact:	☐	☐	☐
Free ice/frozen ice bricks present:	☐	☐	☐
Random sample temp on receipt:			°C

Comments/special handling/storage or disposal

ANALYSIS REQUIRED

Additional information (likely contaminants, dilutions or specific QC analysis)

Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	Additional information
76	TP43-1.0 (2)	Water	8/09/2017	ASS x 1	1	X	
77	TP43-1.5	Water	8/09/2017	ASS x 1	1	X	
78	TP43-2.0	Water	8/09/2017	ASS x 1	1	X	

TOTAL 3 bags

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME : M L	DATE: 11/9	Yes / No
OF: Emerge Associates	TIME: 9:30	OF:	TIME: 1230	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: J = Jar, ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EP1709951**

Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Luke Jones
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: Robin.Anderson@emergeassociates.com.au	E-mail	: LUKE.JONES@alsglobal.com
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7631
Facsimile	: +61 08 9380 9636	Facsimile	: +61-8-9209 7600
Project	: EP17-010(05) MKSEA	Page	: 1 of 5
Order number	: ----	Quote number	: EP2016EMEASS0001 (EPBQ-009-16)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: MITCHELL RITIKIS		

Dates

Date Samples Received	: 11-Sep-2017 12:30	Issue Date	: 12-Sep-2017
Client Requested Due Date	: 18-Sep-2017	Scheduled Reporting Date	: **18-Sep-2017**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Not Available
No. of coolers/boxes	: 4	Temperature	: 5.0 - Ice present
Receipt Detail	:	No. of samples received / analysed	: 78 / 78

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- Please see scanned COC for sample discrepencies: extra samples , samples not received etc.
- Please direct any queries related to sample condition / numbering / breakages to Sample Receipt (SamplesPerth@alsenviro.com)
- Analytical work for this work order will be conducted at ALS Environmental Perth.
- Please direct any turnaround / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (14 days), Solid (60 days) from date of completion of Work Order.
- **pH analysis should be conducted within 6 hours of sampling.**

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	SOIL - EA037 ASS Field Screening Analysis
EP1709951-001	08-Sep-2017 00:00	TP02-0.0	✓
EP1709951-002	08-Sep-2017 00:00	TP02-0.5	✓
EP1709951-003	08-Sep-2017 00:00	TP02-1.0	✓
EP1709951-004	08-Sep-2017 00:00	TP02-1.5	✓
EP1709951-005	08-Sep-2017 00:00	TP02-1.8	✓
EP1709951-006	08-Sep-2017 00:00	TP05-0.0	✓
EP1709951-007	08-Sep-2017 00:00	TP05-0.5	✓
EP1709951-008	08-Sep-2017 00:00	TP05-1.0	✓
EP1709951-009	08-Sep-2017 00:00	TP05-1.5	✓
EP1709951-010	08-Sep-2017 00:00	TP05-2.0	✓
EP1709951-011	06-Sep-2017 00:00	TP14-0.0	✓
EP1709951-012	06-Sep-2017 00:00	TP14-0.5	✓
EP1709951-013	06-Sep-2017 00:00	TP14-1.00	✓
EP1709951-014	06-Sep-2017 00:00	TP14-1.00 (2)	✓
EP1709951-015	06-Sep-2017 00:00	TP14-1.5	✓
EP1709951-016	06-Sep-2017 00:00	TP14-2.0	✓
EP1709951-017	06-Sep-2017 00:00	TP15-0.0	✓
EP1709951-018	06-Sep-2017 00:00	TP15-0.5	✓
EP1709951-019	06-Sep-2017 00:00	TP15-1.0	✓
EP1709951-020	06-Sep-2017 00:00	TP15-1.0 (2)	✓
EP1709951-021	06-Sep-2017 00:00	TP15-2.0	✓
EP1709951-022	07-Sep-2017 00:00	TP16-0.0	✓
EP1709951-023	07-Sep-2017 00:00	TP16-0.5	✓
EP1709951-024	07-Sep-2017 00:00	TP16-1.0	✓
EP1709951-025	07-Sep-2017 00:00	TP16-1.5	✓
EP1709951-026	07-Sep-2017 00:00	TP16-2.0	✓
EP1709951-027	07-Sep-2017 00:00	TP25A-0.0	✓
EP1709951-028	07-Sep-2017 00:00	TP25A-0.5	✓
EP1709951-029	07-Sep-2017 00:00	TP25A-1.0	✓
EP1709951-030	07-Sep-2017 00:00	TP25A-1.0 (2)	✓
EP1709951-031	07-Sep-2017 00:00	TP25A-1.5	✓
EP1709951-032	07-Sep-2017 00:00	TP25B-0.0	✓
EP1709951-033	07-Sep-2017 00:00	TP25B-0.5	✓
EP1709951-034	07-Sep-2017 00:00	TP25B-1.0	✓
EP1709951-035	07-Sep-2017 00:00	TP25B-1.5	✓

			SOIL - EA037 ASS Field Screening Analysis
EP1709951-036	07-Sep-2017 00:00	TP25B-2.0	✓
EP1709951-037	07-Sep-2017 00:00	TP26-0.0	✓
EP1709951-038	07-Sep-2017 00:00	TP26-0.5	✓
EP1709951-039	07-Sep-2017 00:00	TP26-1.0	✓
EP1709951-040	07-Sep-2017 00:00	TP26-1.5	✓
EP1709951-041	07-Sep-2017 00:00	TP26-2.0	✓
EP1709951-042	08-Sep-2017 00:00	TP27-0.0	✓
EP1709951-043	08-Sep-2017 00:00	TP27-0.5	✓
EP1709951-044	08-Sep-2017 00:00	TP27-1.0	✓
EP1709951-045	08-Sep-2017 00:00	TP27-1.5	✓
EP1709951-046	08-Sep-2017 00:00	TP27-2.0	✓
EP1709951-047	07-Sep-2017 00:00	TP32-0.0	✓
EP1709951-048	07-Sep-2017 00:00	TP32-0.5	✓
EP1709951-049	07-Sep-2017 00:00	TP32-1.0	✓
EP1709951-050	07-Sep-2017 00:00	TP32-1.5	✓
EP1709951-051	07-Sep-2017 00:00	TP32-2.0	✓
EP1709951-052	07-Sep-2017 00:00	TP33-0.0	✓
EP1709951-053	07-Sep-2017 00:00	TP33-0.5	✓
EP1709951-054	07-Sep-2017 00:00	TP33-1.0	✓
EP1709951-055	07-Sep-2017 00:00	TP33-1.5	✓
EP1709951-056	07-Sep-2017 00:00	TP33-2.0	✓
EP1709951-057	07-Sep-2017 00:00	TP34-0.0	✓
EP1709951-058	07-Sep-2017 00:00	TP34-0.5	✓
EP1709951-059	07-Sep-2017 00:00	TP34-1.0	✓
EP1709951-060	07-Sep-2017 00:00	TP34-1.5	✓
EP1709951-061	07-Sep-2017 00:00	TP34-2.0	✓
EP1709951-062	07-Sep-2017 00:00	TP39-0.0	✓
EP1709951-063	07-Sep-2017 00:00	TP39-0.5	✓
EP1709951-064	07-Sep-2017 00:00	TP39-1.0	✓
EP1709951-065	07-Sep-2017 00:00	TP39-1.5	✓
EP1709951-066	07-Sep-2017 00:00	TP39-2.0	✓
EP1709951-067	07-Sep-2017 00:00	TP40-0.0	✓
EP1709951-068	07-Sep-2017 00:00	TP40-0.5	✓
EP1709951-069	07-Sep-2017 00:00	TP40-1.0	✓
EP1709951-070	07-Sep-2017 00:00	TP40-1.0 (2)	✓
EP1709951-071	07-Sep-2017 00:00	TP40-1.5	✓
EP1709951-072	07-Sep-2017 00:00	TP40-2.0	✓
EP1709951-073	08-Sep-2017 00:00	TP43-0.0	✓
EP1709951-074	08-Sep-2017 00:00	TP43-0.5	✓
EP1709951-075	08-Sep-2017 00:00	TP43-1.0	✓
EP1709951-076	08-Sep-2017 00:00	TP43-1.0 (2)	✓

			SOIL - EA037 ASS Field Screening Analysis
EP1709951-077	08-Sep-2017 00:00	TP43-1.5	✓
EP1709951-078	08-Sep-2017 00:00	TP43-2.0	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

ACCOUNTS (INVOICES)		
- A4 - AU Tax Invoice (INV)	Email	accounts@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	accounts@emergeassociates.com.au
MITCHELL RITIKIS		
- *AU Certificate of Analysis - NATA (COA)	Email	mitchell.ritikis@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	mitchell.ritikis@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	mitchell.ritikis@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	mitchell.ritikis@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	mitchell.ritikis@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	mitchell.ritikis@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	mitchell.ritikis@emergeassociates.com.au
ROBIN ANDERSON		
- *AU Certificate of Analysis - NATA (COA)	Email	Robin.Anderson@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	Robin.Anderson@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	Robin.Anderson@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	Robin.Anderson@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	Robin.Anderson@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	Robin.Anderson@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	Robin.Anderson@emergeassociates.com.au
SIMON GREGG		
- *AU Certificate of Analysis - NATA (COA)	Email	simon.gregg@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	simon.gregg@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	simon.gregg@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	simon.gregg@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	simon.gregg@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	simon.gregg@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	simon.gregg@emergeassociates.com.au

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1709951**	Page	: 1 of 18
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Luke Jones
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7631
Project	: EP17-010(05) MKSEA	Date Samples Received	: 11-Sep-2017 12:30
Order number	: ----	Date Analysis Commenced	: 14-Sep-2017
C-O-C number	: ----	Issue Date	: 18-Sep-2017 10:39
Sampler	: MITCHELL RITIKIS		
Site	: ----		
Quote number	: EPBQ-009-16		
No. of samples received	: 78		
No. of samples analysed	: 78		

ilac-MRA NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA037 (Rapid Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Strong; 4 - Extreme
- EA037 ASS Field Screening: NATA accreditation does not cover performance of this service.

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL)**

			Client sample ID	TP02-0.0	TP02-0.5	TP02-1.0	TP02-1.5	TP02-1.8
			Client sampling date / time	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-001	EP1709951-002	EP1709951-003	EP1709951-004	EP1709951-005
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**8.8**	**7.6**	**7.7**	**7.2**	**7.2**
pH (Fox)	----	0.1	pH Unit	**6.0**	**5.4**	**5.9**	**5.7**	**5.6**
Reaction Rate	----	1	-	**Moderate**	**Slight**	**Slight**	**Slight**	**Slight**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP05-0.0	TP05-0.5	TP05-1.0	TP05-1.5	TP05-2.0
			Client sampling date / time	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-006	EP1709951-007	EP1709951-008	EP1709951-009	EP1709951-010
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	6.4	6.3	6.2	6.1	5.4
pH (Fox)	----	0.1	pH Unit	4.5	4.6	4.6	5.0	4.3
Reaction Rate	----	1	-	Moderate	Moderate	Moderate	Moderate	Slight

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP14-0.0	TP14-0.5	TP14-1.00	TP14-1.00 (2)	TP14-1.5
			Client sampling date / time	06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-011	EP1709951-012	EP1709951-013	EP1709951-014	EP1709951-015
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	4.7	5.1	6.6	6.6	6.8
pH (Fox)	----	0.1	pH Unit	2.1	2.2	6.8	6.9	6.0
Reaction Rate	----	1	-	Moderate	Moderate	Extreme	Extreme	Slight

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL)**

Compound	CAS Number	LOR	Unit	TP14-2.0	TP15-0.0	TP15-0.5	TP15-1.0	TP15-1.0 (2)
Client sampling date / time				06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00
				EP1709951-016	EP1709951-017	EP1709951-018	EP1709951-019	EP1709951-020
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	6.5	5.8	7.0	7.8	8.0
pH (Fox)	----	0.1	pH Unit	5.8	3.3	7.8	8.1	8.9
Reaction Rate	----	1	-	Moderate	Moderate	Extreme	Extreme	Extreme

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

			Client sample ID	TP15-2.0	TP16-0.0	TP16-0.5	TP16-1.0	TP16-1.5
			Client sampling date / time	06-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-021	EP1709951-022	EP1709951-023	EP1709951-024	EP1709951-025
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	7.8	8.0	8.4	9.4	9.1
pH (Fox)	----	0.1	pH Unit	7.0	5.0	6.6	6.8	6.2
Reaction Rate	----	1	-	Extreme	Moderate	Extreme	Slight	Slight

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP16-2.0	TP25A-0.0	TP25A-0.5	TP25A-1.0	TP25A-1.0 (2)
			Client sampling date / time	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-026	EP1709951-027	EP1709951-028	EP1709951-029	EP1709951-030
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	8.5	5.7	5.6	8.2	8.6
pH (Fox)	----	0.1	pH Unit	7.8	2.4	3.4	6.2	6.3
Reaction Rate	----	1	-	Moderate	Moderate	Moderate	Slight	Slight

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

			Client sample ID	TP25A-1.5	TP25B-0.0	TP25B-0.5	TP25B-1.0	TP25B-1.5
			Client sampling date / time	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-031	EP1709951-032	EP1709951-033	EP1709951-034	EP1709951-035
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**8.5**	**6.3**	**6.0**	**5.6**	**5.6**
pH (Fox)	----	0.1	pH Unit	**6.7**	**4.4**	**3.9**	**4.5**	**4.5**
Reaction Rate	----	1	-	**Slight**	**Slight**	**Slight**	**Slight**	**Slight**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP25B-2.0	TP26-0.0	TP26-0.5	TP26-1.0	TP26-1.5
			Client sampling date / time	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-036	EP1709951-037	EP1709951-038	EP1709951-039	EP1709951-040
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	6.0	5.7	6.0	8.4	9.2
pH (Fox)	----	0.1	pH Unit	4.2	2.6	4.4	6.8	9.0
Reaction Rate	----	1	-	Slight	Moderate	Moderate	Moderate	Extreme

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP26-2.0	TP27-0.0	TP27-0.5	TP27-1.0	TP27-1.5
			Client sampling date / time	07-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-041	EP1709951-042	EP1709951-043	EP1709951-044	EP1709951-045
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	8.8	8.3	8.4	8.3	7.9
pH (Fox)	----	0.1	pH Unit	7.0	5.6	5.7	5.0	5.3
Reaction Rate	----	1	-	Moderate	Moderate	Moderate	Moderate	Moderate

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

			Client sample ID	TP27-2.0	TP32-0.0	TP32-0.5	TP32-1.0	TP32-1.5
			Client sampling date / time	08-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-046	EP1709951-047	EP1709951-048	EP1709951-049	EP1709951-050
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	7.4	6.2	6.2	6.6	6.3
pH (Fox)	----	0.1	pH Unit	5.0	3.6	4.1	5.0	4.6
Reaction Rate	----	1	-	Moderate	Moderate	Moderate	Slight	Moderate

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP32-2.0	TP33-0.0	TP33-0.5	TP33-1.0	TP33-1.5
			Client sampling date / time	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-051	EP1709951-052	EP1709951-053	EP1709951-054	EP1709951-055
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	6.6	6.7	7.1	6.9	7.3
pH (Fox)	----	0.1	pH Unit	4.7	4.3	4.9	4.9	5.3
Reaction Rate	----	1	-	Moderate	Moderate	Moderate	Moderate	Slight

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP33-2.0	TP34-0.0	TP34-0.5	TP34-1.0	TP34-1.5
			Client sampling date / time	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-056	EP1709951-057	EP1709951-058	EP1709951-059	EP1709951-060
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	7.4	6.4	6.6	6.3	5.4
pH (Fox)	----	0.1	pH Unit	5.4	4.2	4.4	4.6	4.0
Reaction Rate	----	1	-	Slight	Moderate	Moderate	Moderate	Moderate

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP34-2.0	TP39-0.0	TP39-0.5	TP39-1.0	TP39-1.5
			Client sampling date / time	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-061	EP1709951-062	EP1709951-063	EP1709951-064	EP1709951-065
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	5.4	5.6	6.4	5.4	5.5
pH (Fox)	----	0.1	pH Unit	4.2	2.7	4.1	3.9	3.8
Reaction Rate	----	1	-	Moderate	Moderate	Moderate	Moderate	Moderate

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP39-2.0	TP40-0.0	TP40-0.5	TP40-1.0	TP40-1.0 (2)
			Client sampling date / time	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-066	EP1709951-067	EP1709951-068	EP1709951-069	EP1709951-070
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	5.2	6.5	6.2	6.3	6.2
pH (Fox)	----	0.1	pH Unit	3.9	4.2	4.8	4.7	4.5
Reaction Rate	----	1	-	Moderate	Moderate	Slight	Slight	Slight

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP40-1.5	TP40-2.0	TP43-0.0	TP43-0.5	TP43-1.0
			Client sampling date / time	07-Sep-2017 00:00	07-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1709951-071	EP1709951-072	EP1709951-073	EP1709951-074	EP1709951-075
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**6.7**	**6.6**	**4.6**	**4.4**	**4.3**
pH (Fox)	----	0.1	pH Unit	**5.3**	**5.0**	**3.2**	**3.3**	**3.0**
Reaction Rate	----	1	-	**Slight**	**Moderate**	**Moderate**	**Slight**	**Slight**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP43-1.0 (2)	TP43-1.5	TP43-2.0	----	----
			Client sampling date / time	08-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	----	----
Compound	*CAS Number*	*LOR*	*Unit*	EP1709951-076	EP1709951-077	EP1709951-078	--------	--------
				Result	Result	Result	----	----
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**4.1**	**4.1**	**4.0**	----	----
pH (Fox)	----	0.1	pH Unit	**3.2**	**4.1**	**4.0**	----	----
Reaction Rate	----	1	-	**Slight**	**Slight**	**Slight**	----	----

QUALITY CONTROL REPORT

Work Order	: **EP1709951**	Page	: 1 of 3
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Luke Jones
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7631
Project	: EP17-010(05) MKSEA	Date Samples Received	: 11-Sep-2017
Order number	: ----	Date Analysis Commenced	: 14-Sep-2017
C-O-C number	: ----	Issue Date	: 18-Sep-2017
Sampler	: MITCHELL RITIKIS		
Site	: ----		
Quote number	: EPBQ-009-16		
No. of samples received	: 78		
No. of samples analysed	: 78		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA037: Ass Field Screening Analysis (QC Lot: 1113484)									
EP1709951-001	TP02-0.0	EA037: pH (F)	----	0.1	pH Unit	8.8	9.1	2.68	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	6.0	6.0	0.00	0% - 20%
EP1709951-010	TP05-2.0	EA037: pH (F)	----	0.1	pH Unit	5.4	5.4	0.00	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	4.3	4.3	0.00	0% - 20%
EA037: Ass Field Screening Analysis (QC Lot: 1113485)									
EP1709951-021	TP15-2.0	EA037: pH (F)	----	0.1	pH Unit	7.8	7.8	0.00	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	7.0	7.0	0.00	0% - 20%
EP1709951-030	TP25A-1.0 (2)	EA037: pH (F)	----	0.1	pH Unit	8.6	8.6	1.16	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	6.3	6.3	0.00	0% - 20%
EA037: Ass Field Screening Analysis (QC Lot: 1113486)									
EP1709951-041	TP26-2.0	EA037: pH (F)	----	0.1	pH Unit	8.8	8.8	0.00	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	7.0	6.9	0.00	0% - 20%
EP1709951-050	TP32-1.5	EA037: pH (F)	----	0.1	pH Unit	6.3	6.4	2.20	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	4.6	4.5	0.00	0% - 20%
EA037: Ass Field Screening Analysis (QC Lot: 1113487)									
EP1709951-061	TP34-2.0	EA037: pH (F)	----	0.1	pH Unit	5.4	5.4	0.00	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	4.2	4.3	3.76	0% - 20%
EP1709951-070	TP40-1.0 (2)	EA037: pH (F)	----	0.1	pH Unit	6.2	6.3	1.59	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	4.5	4.7	4.13	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

- **No Method Blank (MB) or Laboratory Control Spike (LCS) Results are required to be reported.**

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EP1709951**	Page	: 1 of 5
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Telephone	: 08 9209 7631
Project	: EP17-010(05) MKSEA	Date Samples Received	: 11-Sep-2017
Site	: ----	Issue Date	: 18-Sep-2017
Sampler	: MITCHELL RITIKIS	No. of samples received	: 78
Order number	: ----	No. of samples analysed	: 78

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA037: Ass Field Screening Analysis								
Snap Lock Bag - frozen (EA037)								
TP14-0.0,	TP14-0.5,	**06-Sep-2017**	**14-Sep-2017**	05-Mar-2018	✓	**14-Sep-2017**	05-Mar-2018	✓
TP14-1.00,	TP14-1.00 (2),							
TP14-1.5,	TP14-2.0,							
TP15-0.0,	TP15-0.5,							
TP15-1.0,	TP15-1.0 (2),							
TP15-2.0								
Snap Lock Bag - frozen (EA037)								
TP16-0.0,	TP16-0.5,	**07-Sep-2017**	**14-Sep-2017**	06-Mar-2018	✓	**14-Sep-2017**	06-Mar-2018	✓
TP16-1.0,	TP16-1.5,							
TP16-2.0,	TP25A-0.0,							
TP25A-0.5,	TP25A-1.0,							
TP25A-1.0 (2),	TP25A-1.5,							
TP25B-0.0,	TP25B-0.5,							
TP25B-1.0,	TP25B-1.5,							
TP25B-2.0,	TP26-0.0,							
TP26-0.5,	TP26-1.0,							
TP26-1.5,	TP26-2.0,							
TP32-0.0,	TP32-0.5,							
TP32-1.0,	TP32-1.5,							
TP32-2.0,	TP33-0.0,							
TP33-0.5,	TP33-1.0,							
TP33-1.5,	TP33-2.0,							
TP34-0.0,	TP34-0.5,							
TP34-1.0,	TP34-1.5,							
TP34-2.0,	TP39-0.0,							
TP39-0.5,	TP39-1.0,							
TP39-1.5,	TP39-2.0,							
TP40-0.0,	TP40-0.5,							
TP40-1.0,	TP40-1.0 (2),							
TP40-1.5,	TP40-2.0							
Snap Lock Bag - frozen (EA037)								

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA037: Ass Field Screening Analysis - Continued								
TP02-0.0, TP02-1.0, TP02-1.8, TP05-0.5, TP05-1.5, TP27-0.0, TP27-1.0, TP27-2.0, TP43-0.5, TP43-1.0 (2), TP43-2.0	TP02-0.5, TP02-1.5, TP05-0.0, TP05-1.0, TP05-2.0, TP27-0.5, TP27-1.5, TP43-0.0, TP43-1.0, TP43-1.5,	**08-Sep-2017**	**14-Sep-2017**	07-Mar-2018	✓	**14-Sep-2017**	07-Mar-2018	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
ASS Field Screening Analysis	EA037	8	78	**10.26**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
ASS Field Screening Analysis	EA037	SOIL	In house: Referenced to Acid Sulfate Soils Laboratory Methods Guidelines, version 2.1 June 2004. As received samples are tested for pH field and pH fox and assessed for a reaction rating.

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Drying only	EN020D	SOIL	In house

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CHAIN OF COUSTODY

emerge ASSOCIATES Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 1 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Mitchell Ritikis	SAMPLERS PHONE: 0449 198 721	☒ Standard (5-7 days) ☐ Non-standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au
Laboratory Batch No	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/a
Custody seal intact	☐	☐	☐
Free ice/frozen ice bricks present	☐	☐	☐
Random sample temp on receipt			°C

ANALYSIS REQUIRED

SAMPLE DETAILS				CONTAINER INFORMATION		ANALYSIS REQUIRED	
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	Additional information (likely contaminants, dilutions or specific QC analysis)
1	HA03-0.0	Water	13/09/2017	ASS x 1	1	X	
2	HA03-0.5	Water	13/09/2017	ASS x 1	1	X	
3	HA03-1.0	Water	13/09/2017	ASS x 1	1	X	
4	HA03-1.5	Water	13/09/2017	ASS x 1	1	X	
5	HA04-0.0	Water	13/09/2017	ASS x 1	1	X	
6	HA04-0.5	Water	13/09/2017	ASS x 1	1	X	
				TOTAL: 15 bags			

Environmental Division
Perth
Work Order Reference
EP1710208

Telephone : +61-8-9209 7655

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 14/09/2017	NAME : M Walsh	DATE: 14/9/17	Yes No
OF: Emerge Associates	TIME: 9:00	OF: ALS	TIME: 1145	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: **P** = Unpreserved Plastic; **N** = Nitric Preserved Plastic; **ORC** = Nitric Preserved ORC; **SH** = Sodium Hydroxide/Cd Preserved; **S** = Sodium Hydroxide Preserved Plastic; **AG** = Amber Glass Unpreserved; **AP** = Airfreight Unpreserved Plastic; **V** = VOA Vial HCl Preserved; **VB** = VOA Vial Sodium Bisulphate Preserved; **VS** = VOA Vial Sulfuric Preserved; **AV** = Airfreight Unpreserved Vial; **SG** = Sulfuric Preserved Amber Glass; **H** = HCl preserved Plastic; **HS** = HCl Preserved Speciation bottle; **SP** = Sulfuric Preserved Plastic; **F** = Formaldehyde Preserved Glass; **Z** = Zinc Acetate Preserved Bottle; **E** = EDTA Preserved Bottles; **ST** = Sterile Bottle; **LI** = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: **J** = Jar; **ASS** = Plastic Bag for Acid Sulfate Soils; **B** = Unpreserved Bag;

ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EP1710208**

Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Luke Jones
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: Robin.Anderson@emergeassociates.com.au	E-mail	: LUKE.JONES@alsglobal.com
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7631
Facsimile	: +61 08 9380 9636	Facsimile	: +61-8-9209 7600
Project	: EP17-010(05) MKSEA	Page	: 1 of 3
Order number	: ----	Quote number	: EP2016EMEASS0001 (EPBQ-009-16)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: MITCHELL RITIKIS		

Dates

Date Samples Received	: 15-Sep-2017 11:45	Issue Date	: 15-Sep-2017
Client Requested Due Date	: 20-Sep-2017	Scheduled Reporting Date	: **20-Sep-2017**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Not Available
No. of coolers/boxes	: 1	Temperature	: 13.8
Receipt Detail	:	No. of samples received / analysed	: 6 / 6

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- Please see scanned COC for sample discrepencies: extra samples , samples not received etc.
- Please direct any queries related to sample condition / numbering / breakages to Sample Receipt (SamplesPerth@alsenviro.com)
- Analytical work for this work order will be conducted at ALS Environmental Perth.
- Please direct any turnaround / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (14 days), Solid (60 days) from date of completion of Work Order.
- **pH analysis should be conducted within 6 hours of sampling.**

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.
If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	SOIL - EA037 ASS Field Screening Analysis
EP1710208-001	13-Sep-2017 00:00	HA03-0.0	✓
EP1710208-002	13-Sep-2017 00:00	HA03-0.5	✓
EP1710208-003	13-Sep-2017 00:00	HA03-1.0	✓
EP1710208-004	13-Sep-2017 00:00	HA03-1.5	✓
EP1710208-005	13-Sep-2017 00:00	HA04-0.0	✓
EP1710208-006	13-Sep-2017 00:00	HA04-0.5	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

ACCOUNTS (INVOICES)		
- A4 - AU Tax Invoice (INV)	Email	accounts@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	accounts@emergeassociates.com.au
MITCHELL RITIKIS		
- *AU Certificate of Analysis - NATA (COA)	Email	mitchell.ritikis@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	mitchell.ritikis@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	mitchell.ritikis@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	mitchell.ritikis@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	mitchell.ritikis@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	mitchell.ritikis@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	mitchell.ritikis@emergeassociates.com.au
ROBIN ANDERSON		
- *AU Certificate of Analysis - NATA (COA)	Email	Robin.Anderson@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	Robin.Anderson@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	Robin.Anderson@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	Robin.Anderson@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	Robin.Anderson@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	Robin.Anderson@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	Robin.Anderson@emergeassociates.com.au
SIMON GREGG		
- *AU Certificate of Analysis - NATA (COA)	Email	simon.gregg@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	simon.gregg@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	simon.gregg@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	simon.gregg@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	simon.gregg@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	simon.gregg@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	simon.gregg@emergeassociates.com.au

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP1710208**	Page	: 1 of 4
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Luke Jones
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7631
Project	: EP17-010(05) MKSEA	Date Samples Received	: 15-Sep-2017 11:45
Order number	: ----	Date Analysis Commenced	: 15-Sep-2017
C-O-C number	: ----	Issue Date	: 19-Sep-2017 13:15
Sampler	: MITCHELL RITIKIS		
Site	: ----		
Quote number	: EPBQ-009-16		
No. of samples received	: 6		
No. of samples analysed	: 6		

ilac-MRA NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA037 (Rapid Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Strong; 4 - Extreme
- EA037 ASS Field Screening: NATA accreditation does not cover performance of this service.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	HA03-0.0	HA03-0.5	HA03-1.0	HA03-1.5	HA04-0.0
			Client sampling date / time	13-Sep-2017 00:00	13-Sep-2017 00:00	13-Sep-2017 00:00	13-Sep-2017 00:00	13-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1710208-001	EP1710208-002	EP1710208-003	EP1710208-004	EP1710208-005
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	8.0	7.8	8.6	8.5	7.5
pH (Fox)	----	0.1	pH Unit	5.6	8.0	6.8	7.3	5.9
Reaction Rate	----	1	-	Moderate	Extreme	Extreme	Extreme	Strong

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	HA04-0.5	----	----	----	----
			Client sampling date / time	13-Sep-2017 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP1710208-006	--------	--------	--------	--------
				Result	----	----	----	----
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	7.8	----	----	----	----
pH (Fox)	----	0.1	pH Unit	6.4	----	----	----	----
Reaction Rate	----	1	-	Extreme	----	----	----	----

QUALITY CONTROL REPORT

Work Order	: **EP1710208**	Page	: 1 of 3
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Luke Jones
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7631
Project	: EP17-010(05) MKSEA	Date Samples Received	: 15-Sep-2017
Order number	: ----	Date Analysis Commenced	: 15-Sep-2017
C-O-C number	: ----	Issue Date	: 19-Sep-2017
Sampler	: MITCHELL RITIKIS		
Site	: ----		
Quote number	: EPBQ-009-16		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA037: Ass Field Screening Analysis (QC Lot: 1120237)									
EP1710208-001	HA03-0.0	EA037: pH (F)	----	0.1	pH Unit	8.0	8.1	1.50	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	5.6	5.7	0.00	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

- **No Method Blank (MB) or Laboratory Control Spike (LCS) Results are required to be reported.**

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EP1710208	Page	: 1 of 4
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Telephone	: 08 9209 7631
Project	: EP17-010(05) MKSEA	Date Samples Received	: 15-Sep-2017
Site	: ----	Issue Date	: 19-Sep-2017
Sampler	: MITCHELL RITIKIS	No. of samples received	: 6
Order number	: ----	No. of samples analysed	: 6

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA037: Ass Field Screening Analysis							
Snap Lock Bag - frozen on receipt at ALS (EA037)							
HA03-0.0, HA03-0.5, HA03-1.0, HA03-1.5, HA04-0.0, HA04-0.5	**13-Sep-2017**	**15-Sep-2017**	12-Mar-2018	✓	**18-Sep-2017**	12-Mar-2018	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
ASS Field Screening Analysis	EA037	1	6	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
ASS Field Screening Analysis	EA037	SOIL	In house: Referenced to Acid Sulfate Soils Laboratory Methods Guidelines, version 2.1 June 2004. As received samples are tested for pH field and pH fox and assessed for a reaction rating.

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Drying only	EN020D	SOIL	In house

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CHAIN OF CUSTODY

emerge ASSOCIATES Integrated Science & Design

CLIENT: Emerge Associates | POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008 | Page 1 of 1

PROJECT MANAGER: Robin Anderson | CONTACT PHONE: 9380 4988 | ALS LABORATORY: Perth

PROJECT ID.: EP17-010(05) | PROJECT NAME: MKSEA | TURNAROUND REQUIREMENTS

SAMPLER(S): | SAMPLERS PHONE: | ☒ Standard (5-7 days) ☐ Non-standard (one day or asap)

QUOTE NO.: EPBQ/009/16 ORDER NO.:

Email reports to: simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au

Email invoice to: accounts@emergeassociates.com.au

Laboratory Batch No:

Laboratory Use	Yes	No	N/a
Custody seal intact:	☒	☐	☐
Free ice/frozen ice bricks present:	☐	☐	☒
Random sample temp on receipt:		4.0	°C

Comments/special handling/storage or disposal

ANALYSIS REQUIRED

Additional information (likely contaminants, dilutions or specific QC analysis)

Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS
1	HA06-0.0	Soil	15/09/2017	ASS x 1	1	X
2	HA06-0.5	Soil	15/09/2017	ASS x 1	1	X
3	HA06-1.0	Soil	15/09/2017	ASS x 1	1	X
4	HA06-1.5	Soil	15/09/2017	ASS x 1	1	X
5	HA06-2.0	Soil	15/09/2017	ASS x 1	1	X
6	HA08-0.0	Soil	15/09/2017	ASS x 1	1	X
7	HA08-0.5	Soil	15/09/2017	ASS x 1	1	X
8	HA08-1.0	Soil	15/09/2017	ASS x 1	1	X
9	HA08-1.1	Soil	15/09/2017	ASS x 1	1	X
10	HA10-0.0	Soil	15/09/2017	ASS x 1	1	X
11	HA10-0.5	Soil	15/09/2017	ASS x 1	1	X
12	HA10-1.0	Soil	15/09/2017	ASS x 1	1	X
13	SQA1-150917	Soil	15/09/2017	ASS x 1	1	X
					TOTAL:	13

Environmental Division
Perth
Work Order Reference
EP1710345

Telephone : + 61-8-9209 7655

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 19/09/2017	NAME : M Wern	DATE: 19/9/17	Yes No
OF: Emerge Associates	TIME: 9:00	OF: ALS	TIME: 1630	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: **P** = Unpreserved Plastic; **N** = Nitric Preserved Plastic; **ORC** = Nitric Preserved ORC; **SH** = Sodium Hydroxide/Cd Preserved; **S** = Sodium Hydroxide Preserved Plastic; **AG** = Amber Glass Unpreserved; **AP** = Airfreight Unpreserved Plastic; **V** = VOA Vial HCl Preserved; **VB** = VOA Vial Sodium Bisulphate Preserved; **VS** = VOA Vial Sulfuric Preserved; **AV** = Airfreight Unpreserved Vial; **SG** = Sulfuric Preserved Amber Glass; **H** = HCl preserved Plastic; **HS** = HCl Preserved Speciation bottle; **SP** = Sulfuric Preserved Plastic; **F** = Formaldehyde Preserved Glass; **Z** = Zinc Acetate Preserved Bottle; **E** = EDTA Preserved Bottles; **ST** = Sterile Bottle; **LI** = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: J = Jar; **ASS** = Plastic Bag for Acid Sulfate Soils; **B** = Unpreserved Bag;

ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order	: **EP1710345**		
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Lauren Biagioni
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: Robin.Anderson@emergeassociates.com.au	E-mail	: Lauren.biagioni@alsglobal.com
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7655
Facsimile	: +61 08 9380 9636	Facsimile	: +61-8-9209 7600
Project	: EP17-010(05) MKSEA	Page	: 1 of 3
Order number	: ----	Quote number	: EP2016EMEASS0001 (EPBQ-009-16)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	:		

Dates

Date Samples Received	: 19-Sep-2017 16:30	Issue Date	: 20-Sep-2017
Client Requested Due Date	: 26-Sep-2017	Scheduled Reporting Date	: **26-Sep-2017**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 1	Temperature	: 14.0
Receipt Detail	:	No. of samples received / analysed	: 13 / 13

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- Please see scanned COC for sample discrepencies: extra samples , samples not received etc.
- Please direct any queries related to sample condition / numbering / breakages to Sample Receipt (SamplesPerth@alsenviro.com)
- Analytical work for this work order will be conducted at ALS Environmental Perth.
- Please direct any turnaround / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- **pH analysis should be conducted within 6 hours of sampling.**

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	SOIL - EA037 ASS Field Screening Analysis
EP1710345-001	[15-Sep-2017]	HA06-0.0	✓
EP1710345-002	[15-Sep-2017]	HA06-0.5	✓
EP1710345-003	[15-Sep-2017]	HA06-1.0	✓
EP1710345-004	[15-Sep-2017]	HA06-1.5	✓
EP1710345-005	[15-Sep-2017]	HA06-2.0	✓
EP1710345-006	[15-Sep-2017]	HA08-0.0	✓
EP1710345-007	[15-Sep-2017]	HA08-0.5	✓
EP1710345-008	[15-Sep-2017]	HA08-1.0	✓
EP1710345-009	[15-Sep-2017]	HA08-1.1	✓
EP1710345-010	[15-Sep-2017]	HA10-0.0	✓
EP1710345-011	[15-Sep-2017]	HA10-0.5	✓
EP1710345-012	[15-Sep-2017]	HA10-1.0	✓
EP1710345-013	[15-Sep-2017]	SQA1-150917	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

ACCOUNTS (INVOICES)		
- A4 - AU Tax Invoice (INV)	Email	accounts@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	accounts@emergeassociates.com.au
MITCHELL RITIKIS		
- *AU Certificate of Analysis - NATA (COA)	Email	mitchell.ritikis@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	mitchell.ritikis@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	mitchell.ritikis@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	mitchell.ritikis@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	mitchell.ritikis@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	mitchell.ritikis@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	mitchell.ritikis@emergeassociates.com.au
ROBIN ANDERSON		
- *AU Certificate of Analysis - NATA (COA)	Email	Robin.Anderson@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	Robin.Anderson@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	Robin.Anderson@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	Robin.Anderson@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	Robin.Anderson@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	Robin.Anderson@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	Robin.Anderson@emergeassociates.com.au
SIMON GREGG		
- *AU Certificate of Analysis - NATA (COA)	Email	simon.gregg@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	simon.gregg@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	simon.gregg@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	simon.gregg@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	simon.gregg@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	simon.gregg@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	simon.gregg@emergeassociates.com.au

CERTIFICATE OF ANALYSIS

Work Order	: **EP1710345**	Page	: 1 of 5
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Lauren Biagioni
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7655
Project	: EP17-010(05) MKSEA	Date Samples Received	: 19-Sep-2017 16:30
Order number	: ----	Date Analysis Commenced	: 20-Sep-2017
C-O-C number	: ----	Issue Date	: 21-Sep-2017 12:04
Sampler	: ----		
Site	: ----		
Quote number	: EPBQ-009-16		
No. of samples received	: 13		
No. of samples analysed	: 13		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA037 (Rapid Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Strong; 4 - Extreme
- EA037 ASS Field Screening: NATA accreditation does not cover performance of this service.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Client sample ID*	**HA06-0.0**	**HA06-0.5**	**HA06-1.0**	**HA06-1.5**	**HA06-2.0**
			Client sampling date / time	[15-Sep-2017]	[15-Sep-2017]	[15-Sep-2017]	[15-Sep-2017]	[15-Sep-2017]
Compound	*CAS Number*	*LOR*	*Unit*	**EP1710345-001**	**EP1710345-002**	**EP1710345-003**	**EP1710345-004**	**EP1710345-005**
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**7.4**	**7.6**	**8.0**	**6.6**	**5.6**
pH (Fox)	----	0.1	pH Unit	**5.2**	**5.4**	**5.9**	**4.7**	**4.1**
Reaction Rate	----	1	-	**Moderate**	**Moderate**	**Moderate**	**Slight**	**Slight**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL)**			*Client sample ID*	**HA08-0.0**	**HA08-0.5**	**HA08-1.0**	**HA08-1.1**	**HA10-0.0**
			Client sampling date / time	[15-Sep-2017]	[15-Sep-2017]	[15-Sep-2017]	[15-Sep-2017]	[15-Sep-2017]
Compound	*CAS Number*	*LOR*	*Unit*	**EP1710345-006**	**EP1710345-007**	**EP1710345-008**	**EP1710345-009**	**EP1710345-010**
				Result	Result	Result	Result	Result
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**6.5**	**7.8**	**7.9**	**8.1**	**7.4**
pH (Fox)	----	0.1	pH Unit	**4.6**	**6.2**	**6.2**	**6.2**	**5.1**
Reaction Rate	----	1	-	**Moderate**	**Moderate**	**Slight**	**Slight**	**Moderate**

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL)**

			Client sample ID	**HA10-0.5**	**HA10-1.0**	**SQA1-150917**	**----**	**----**
			Client sampling date / time	[15-Sep-2017]	[15-Sep-2017]	[15-Sep-2017]	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP1710345-011**	**EP1710345-012**	**EP1710345-013**	**--------**	**--------**
				Result	Result	Result	----	----
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**7.3**	**7.4**	**7.8**	**----**	**----**
pH (Fox)	----	0.1	pH Unit	**5.3**	**5.2**	**6.2**	**----**	**----**
Reaction Rate	----	1	-	**Moderate**	**Moderate**	**Slight**	**----**	**----**

QUALITY CONTROL REPORT

Work Order	: **EP1710345**	Page	: 1 of 3
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Lauren Biagioni
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7655
Project	: EP17-010(05) MKSEA	Date Samples Received	: 19-Sep-2017
Order number	: ----	Date Analysis Commenced	: 20-Sep-2017
C-O-C number	: ----	Issue Date	: 21-Sep-2017
Sampler	: ----		
Site	: ----		
Quote number	: EPBQ-009-16		
No. of samples received	: 13		
No. of samples analysed	: 13		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA037: Ass Field Screening Analysis (QC Lot: 1127698)									
EP1710345-001	HA06-0.0	EA037: pH (F)	----	0.1	pH Unit	7.4	7.5	0.00	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	5.2	5.2	0.00	0% - 20%
EP1710345-010	HA10-0.0	EA037: pH (F)	----	0.1	pH Unit	7.4	7.4	0.00	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	5.1	5.2	1.93	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

- **No Method Blank (MB) or Laboratory Control Spike (LCS) Results are required to be reported.**

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

Alicia Manning

From: Simon Gregg <Simon.Gregg@emergeassociates.com.au>
Sent: Wednesday, 8 November 2017 2:30 PM
To: Samples Perth
Subject: Additional analysis request

Follow Up Flag: Follow up
Flag Status: Flagged

Categories: Rebatch, Alicia

Environmental Division
Perth
Work Order Reference
EP1712588

Telephone : +61-8-9209 7655

Good afternoon

Could you please undertake SPOCAS analysis on the samples listed below.

	Work order	Sample ID
1	EP1710345	HA06-1.5
2	EP1710345	HA10-0.5
3	EP1709754	TP01-1.0
4	EP1709951	TP02-1.5
5	EP1709754	TP03-0.5
6	EP1709754	TP04-0.5
7	EP1709951	TP05-0.5
8	EP1709951	TP05-2.0
9	EP1709754	TP06-1.0
10	EP1709754	TP07-0.5
11	EP1709754	TP08-1.0
12	EP1709754	TP09-1.0
13	EP1709754	TP10-1.0
14	EP1709754	TP11-0.5
15	EP1709754	TP12-0.5
16	EP1709754	TP12-1.0
17	EP1709754	TP13-0.5
18	EP1709951	TP14-0.5

	Work order	Sample ID
19	EP1709951	TP15-0.0
20	EP1709951	TP16-0.5
21	EP1709754	TP17-1.0
22	EP1709754	TP18-0.5
23	EP1709951	TP25A-0.5
24	EP1709951	TP26-0.5
25	EP1709951	TP27-1.0
26	EP1709754	TP28-0.5
27	EP1709754	TP28-1.5
28	EP1709951	TP25B-1.0
29	EP1709951	TP32-0.5
30	EP1709951	TP33-1.0
31	EP1709951	TP34-1.5
32	EP1709951	TP39-1.0
33	EP1709951	TP40-1.0
34	EP1709754	SQA2
35	EP1709754	SQA4

Can the results please be batched under a single new work order.

Could you also please advise us before the samples from these work orders are discarded.

Please let me know if you have any questions.

Kind regards
Simon

CHAIN OF CUSTODY

emerge ASSOCIATES
Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 1 of 1
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	[illegible]
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	[illegible]
SAMPLER(S):	SAMPLERS PHONE:	[illegible]
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au
[illegible]	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

ANALYSIS REQUIRED

Additional information (likely contaminants, dilutions or specific QC analysis)

SAMPLE DETAILS				CONTAINER INFORMATION		
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS
1	HA06-0.0	Soil	15/09/2017	ASS x 1	1	X
2	HA06-0.5	Soil	15/09/2017	ASS x 1	1	X
3	HA06-1.0	Soil	15/09/2017	ASS x 1	1	X
4	HA06-1.5	Soil	15/09/2017	ASS x 1	1	X
5	HA06-2.0	Soil	15/09/2017	ASS x 1	1	X
6	HA08-0.0	Soil	15/09/2017	ASS x 1	1	X
7	HA08-0.5	Soil	15/09/2017	ASS x 1	1	X
8	HA08-1.0	Soil	15/09/2017	ASS x 1	1	X
9	HA08-1.1	Soil	15/09/2017	ASS x 1	1	X
10	HA10-0.0	Soil	15/09/2017	ASS x 1	1	X
11	HA10-0.5	Soil	15/09/2017	ASS x 1	1	X
12	HA10-1.0	Soil	15/09/2017	ASS x 1	1	X
13	SQA1-150917	Soil	15/09/2017	ASS x 1	1	X

1 [illegible]

2 [illegible]

Environmental Division
Perth
Work Order Reference
EP1710345

TOTAL 13

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 19/09/2017	NAME : M Wern	DATE: 19/9/17	Yes No
OF: Emerge Associates	TIME: 9:00	OF: ALS	TIME: 1630	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

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Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 1 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Robin Anderson	SAMPLERS PHONE: 0435 273 846	☒ Standard (5-7 days) ☐ Non-standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au
Laboratory Batch No.	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/a
Custody seal intact	☒	☐	☐
Free ice/frozen ice bricks present	☒	☐	☐
Random sample temp on receipt			

ANALYSIS REQUIRED

	SAMPLE DETAILS				CONTAINER INFORMATION			Additional information (likely contaminants, dilutions or specific QC analysis)
	Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	
	1	TP01-0.5	Soil	05/09/2017	ASS x 1	1	X	
3	2	TP01-1.0	Soil	05/09/2017	ASS x 1	1	X	
	3	TP01-1.5	Soil	05/09/2017	ASS x 1	1	X	
	4	TP01-2.0	Soil	05/09/2017	ASS x 1	1	X	
	5	TP03-0.0	Soil	05/09/2017	ASS x 1	1	X	
5	6	TP03-0.5	Soil	05/09/2017	ASS x 1	1	X	
	7	TP03-1.0	Soil	05/09/2017	ASS x 1	1	X	
	8	TP03-1.5	Soil	05/09/2017	ASS x 1	1	X	
	9	TP03-2.0	Soil	05/09/2017	ASS x 1	1	X	
	10	TP04-0.0	Soil	05/09/2017	ASS x 1	1	X	
6	11	TP04-0.5	Soil	05/09/2017	ASS x 1	1	X	
	12	TP04-1.0	Soil	05/09/2017	ASS x 1	1	X	
	13	TP04-1.5	Soil	05/09/2017	ASS x 1	1	X	
	14	TP04-2.0	Soil	05/09/2017	ASS x 1	1	X	
	15	TP06-0.0	Soil	05/09/2017	ASS x 1	1	X	
					TOTAL Bags			

Environmental Division
Perth
Work Order Reference
EP1709754

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Robin Andeerson	DATE: 06/09/2017	NAME : M Waddell	DATE: 6/9/17	Yes No
OF: Emerge Associates	TIME: 15:00	OF: ALS	TIME: 1540	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

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CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA
SAMPLER(S): Robin Anderson	SAMPLERS PHONE: 0435 273 846
QUOTE NO.: EPBQ/009/16 ORDER NO.:	

ALS LABORATORY: Perth

TURNAROUND REQUIREMENTS:

☒ Standard (5-7 days) ☐ Non standard (one day or asap)

Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au

Email invoice to: accounts@emergeassociates.com.au

Laboratory/Batch No.:

Laboratory Use	Yes	No	N/a
Custody seal intact:	☒	☐	☐
Free ice/frozen ice bricks present:	☒	☐	☐
Random sample temp on receipt:			°C

Comments/special handling/storage or disposal

ANALYSIS REQUIRED

	Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	OASSIT FFS									Additional information (likely contaminants, dilutions or specific QC analysis)
	16	TP06-0.5	Soil	05/09/2017	ASS x 1	1	X									
9	17	TP06-1.0	Soil	05/09/2017	ASS x 1	1	X									
	18	TP06-1.5	Soil	05/09/2017	ASS x 1	1	X									
	19	TP06-2.0	Soil	05/09/2017	ASS x 1	1	X									
	20	TP07-0.0	Soil	05/09/2017	ASS x 1	1	X									
10	21	TP07-0.5	Soil	05/09/2017	ASS x 1	1	X									
	22	TP07-1.0	Soil	05/09/2017	ASS x 1	1	X									
	23	TP07-1.5	Soil	05/09/2017	ASS x 1	1	X									
	24	TP07-2.0	Soil	05/09/2017	ASS x 1	1	X									
	25	TP08-0.0	Soil	05/09/2017	ASS x 1	1	X									
	26	TP08-0.5	Soil	05/09/2017	ASS x 1	1	X									
11	27	TP08-1.0	Soil	05/09/2017	ASS x 1	1	X									
	28	TP08-1.5	Soil	05/09/2017	ASS x 1	1	X									
	29	TP08-2.0	Soil	05/09/2017	ASS x 1	1	X									
	30	TP09-0.0	Soil	05/09/2017	ASS x 1	1	X									
					TOTAL bags											

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Robin Andeerson	DATE: 06/09/2017	NAME : MU	DATE: 6/9/17	Yes No
OF: Emerge Associates	TIME: 15:00	OF: ALS	TIME: 1540	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; Li = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes:** J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag.

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CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 3 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Robin Anderson	SAMPLERS PHONE: 0435 273 846	☒ Standard (5-7 days) ☐ Non-standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au
Laboratory Batch No:	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/a
Custody seal intact:	☐	☐	☐
Free ice/frozen ice bricks present:	☐	☐	☐
Random sample temp on receipt:			°C

ANALYSIS REQUIRED

	SAMPLE DETAILS				CONTAINER INFORMATION													
	Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS											Additional information (likely contaminants, dilutions or specific QC analysis)
	31	TP09-0.5	Soil	05/09/2017	ASS x 1	1	X											
12	32	TP09-1.0	Soil	05/09/2017	ASS x 1	1	X											
	33	TP09-1.5	Soil	05/09/2017	ASS x 1	1	X											
	34	TP10-0.0	Soil	06/09/2017	ASS x 1	1	X											
	35	TP10-0.5	Soil	06/09/2017	ASS x 1	1	X											
13	36	TP10-1.0	Soil	06/09/2017	ASS x 1	1	X											
	37	TP10-1.5	Soil	06/09/2017	ASS x 1	1	X											
	38	TP10-2.0	Soil	06/09/2017	ASS x 1	1	X											
	39	TP11-0.0	Soil	06/09/2017	ASS x 1	1	X											
14	40	TP11-0.5	Soil	06/09/2017	ASS x 1	1	X											
	41	TP11-1.0	Soil	06/09/2017	ASS x 1	1	X											
	42	TP11-1.5	Soil	06/09/2017	ASS x 1	1	X											
	43	TP11-2.0	Soil	06/09/2017	ASS x 1	1	X											
	44	TP12-0.0	Soil	06/09/2017	ASS x 1	1	X											
15	45	TP12-0.5	Soil	06/09/2017	ASS x 1	1	X											
					TOTAL bags													

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Robin Andeerson	DATE: 06/09/2017	NAME : MW	DATE: 6/9/17	Yes No
OF: Emerge Associates	TIME: 15:00	OF: ALS	TIME: 1540	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

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CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 4 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Robin Anderson	SAMPLERS PHONE: 0435 273 846	☒ Standard (5-7 days) ☐ Non-standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au
Laboratory Batch No.	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au
Laboratory Use: Yes / No / N/a Custody seal intact ☐ ☐ ☐ Free ice/frozen ice bricks present ☐ ☐ ☐ Random sample temp on receipt: °C		ANALYSIS REQUIRED

	SAMPLE DETAILS				CONTAINER INFORMATION		ANALYSIS REQUIRED										Additional information (likely contaminants, dilutions or specific QC analysis)
	Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS										
16	46	TP12-1.0	Soil	05/09/2017	ASS x 1	1	X										
	47	TP12-1.35	Soil	05/09/2017	ASS x 1	1	X										
	48	TP13-0.0	Soil	05/09/2017	ASS x 1	1	X										
17	49	TP13-0.5	Soil	06/09/2017	ASS x 1	1	X										
	50	TP13-1.0	Soil	06/09/2017	ASS x 1	1	X										
	51	TP13-1.25	Soil	06/09/2017	ASS x 1	1	X										
	52	TP17-0.0	Soil	06/09/2017	ASS x 1	1	X										
	53	TP17-0.5	Soil	06/09/2017	ASS x 1	1	X										
20	54	TP17-1.0	Soil	06/09/2017	ASS x 1	1	X										
	55	TP17-1.5	Soil	06/09/2017	ASS x 1	1	X										
	56	TP17-2.0	Soil	06/09/2017	ASS x 1	1	X										
	57	TP18-0.0	Soil	06/09/2017	ASS x 1	1	X										
22	58	TP18-0.5	Soil	06/09/2017	ASS x 1	1	X										
	59	TP18-1.0	Soil	06/09/2017	ASS x 1	1	X										
	60	TP28-0.0	Soil	06/09/2017	ASS x 1	1	X										
					TOTAL bags												

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?	
NAME : Robin Andeerson	DATE: 06/09/2017	NAME : mW	DATE: 6/9/17	Yes	No
OF: Emerge Associates	TIME: 15:00	OF: ALS	TIME: 1540		
NAME :	DATE:	NAME :	DATE:		
OF:	TIME:	OF:	TIME:		

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. Soil Container Codes: J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

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Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA
SAMPLER(S): Robin Anderson	SAMPLERS PHONE: 0435 273 846
QUOTE NO.: EPBQ/009/16 ORDER NO.:	

ALS LABORATORY: Perth
TURNAROUND REQUIREMENTS
☒ Standard (5-7 days) ☐ Non-standard (one day or asap)

Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au
Email invoice to: accounts@emergeassociates.com.au

Laboratory Batch No.:

Laboratory Use	Yes	No	N/a
Custody seal intact	☐	☐	☐
Free ice/frozen ice bricks present	☐	☐	☐
Random sample temp on receipt:			

Comments/special handling/storage or disposal

ANALYSIS REQUIRED

	SAMPLE DETAILS				CONTAINER INFORMATION		ANALYSIS REQUIRED	Additional information (likely contaminants, dilutions or specific QC analysis)
	Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	
26	61	TP28-0.5	Soil	05/09/2017	ASS x 1	1	X	
	62	TP28-1.0	Soil	05/09/2017	ASS x 1	1	X	
27	63	TP28-1.5	Soil	05/09/2017	ASS x 1	1	X	
	64	TP28-2.0	Soil	06/09/2017	ASS x 1	1	X	
	65	SQA01	Soil	06/09/2017	ASS x 1	1	X	
34	66	SQA02	Soil	06/09/2017	ASS x 1	1	X	
	67	SQA03	Soil	06/09/2017	ASS x 1	1	X	
35	68	SQA04	Soil	06/09/2017	ASS x 1	1	X	

TOTAL bags

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Robin Andeerson	DATE: 06/09/2017	NAME : m W	DATE: 6/9/17	Yes No
OF: Emerge Associates	TIME: 15:00	OF: AU	TIME: 1540	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes**: J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

CHAIN OF COUSTODY

emerge ASSOCIATES
Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 1 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS:
SAMPLER(S): Mitchell Ritikis	SAMPLERS PHONE: 0449 198 721	☒ Standard (5-7 days) ☐ Non-standard (one day or except)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au
Laboratory Batch No	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/a
Custody seal intact	☐	☐	☐
Free ice/frozen ice bricks present	☐	☐	☐
Random sample temp on receipt			

ANALYSIS REQUIRED

Additional information (likely contaminants, dilutions or specific QC analysis)

	SAMPLE DETAILS				CONTAINER INFORMATION		ANALYSIS REQUIRED
	Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	CASSIT FFS
	1	TP02-0.0	Water	8/09/2017	ASS x 1	1	X
	2	TP02-0.5	Water	8/09/2017	ASS x 1	1	X
	3	TP02-1.0	Water	8/09/2017	ASS x 1	1	X
4	4	TP02-1.5	Water	8/09/2017	ASS x 1	1	X
	5	TP02-1.8	Water	8/09/2017	ASS x 1	1	X
	6	TP05-0.0	Water	8/09/2017	ASS x 1	1	X
7	7	TP05-0.5	Water	8/09/2017	ASS x 1	1	X
	8	TP05-1.0	Water	8/09/2017	ASS x 1	1	X
	9	TP05-1.5	Water	8/09/2017	ASS x 1	1	X
8	10	TP05-2.0	Water	8/09/2017	ASS x 1	1	X
	11	TP14-0.0	Water	6/09/2017	ASS x 1	1	X
18	12	TP14-0.5	Water	6/09/2017	ASS x 1	1	X
	13	TP14-1.00	Water	6/09/2017	ASS x 1	1	X
	14	TP14-1.00 (2)	Water	6/09/2017	ASS x 1	1	X
	15	TP14-1.5	Water	6/09/2017	ASS x 1	1	X
					TOTAL: 15 bags		

Environmental Division
Perth
Work Order Reference
EP1709951

RELINQUISHED BY:		RECEIVED BY:		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME : m Wakel	DATE: 11/9/17	Yes No
OF: Emerge Associates	TIME: 9:30	OF: AL	TIME: 1230	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; **ORC** = Nitric Preserved ORC; **SH** = Sodium Hydroxide/Cd Preserved; **S** = Sodium Hydroxide Preserved Plastic; **AG** = Amber Glass Unpreserved; **AP** = Airfreight Unpreserved Plastic; **V** = VOA Vial HCl Preserved; **VB** = VOA Vial Sodium Bisulphate Preserved; **VS** = VOA Vial Sulfuric Preserved; **AV** = Airfreight Unpreserved Vial; **SG** = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; **HS** = HCl Preserved Speciation bottle; **SP** = Sulfuric Preserved Plastic; **F** = Formaldehyde Preserved Glass; **Z** = Zinc Acetate Preserved Bottle; **E** = EDTA Preserved Bottles; **ST** = Sterile Bottle; **LI** = Lugols Iodine Preserved Bottles; **STT** = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes:** J = Jar; **ASS** = Plastic Bag for Acid Sulfate Soils; **B** = Unpreserved Bag;

CHAIN OF CUSTODY

emerge ASSOCIATES Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 2 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Mitchell Ritikis	SAMPLERS PHONE: 0449 198 721	☒ Standard (5-7 days) ☐ Non standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au
Laboratory Batch No.:	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/A
Custody seal intact	☐	☐	☐
Free ice/frozen ice bricks present	☐	☐	☐
Random sample temp on receipt			°C

ANALYSIS REQUIRED

	SAMPLE DETAILS				CONTAINER INFORMATION		ANALYSIS REQUIRED	Additional information (likely contaminants, dilutions or specific QC analysis)
	Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	
	16	TP14-2.0	Water	6/09/2017	ASS x 1	1	X	
19	17	TP15-0.0	Water	6/09/2017	ASS x 1	1	X	
	18	TP15-0.5	Water	6/09/2017	ASS x 1	1	X	
	19	TP15-1.0	Water	6/09/2017	ASS x 1	1	X	
	20	TP15-1.0 (2)	Water	6/09/2017	ASS x 1	1	X	
	21	TP15-2.0	Water	6/09/2017	ASS x 1	1	X	
	22	TP16-0.0	Water	7/09/2017	ASS x 1	1	X	
20	23	TP16-0.5	Water	7/09/2017	ASS x 1	1	X	
	24	TP16-1.0	Water	7/09/2017	ASS x 1	1	X	
	25	TP16-1.5	Water	7/09/2017	ASS x 1	1	X	
	26	TP16-2.0	Water	7/09/2017	ASS x 1	1	X	
	27	TP25A-0.0	Water	7/09/2017	ASS x 1	1	X	
23	28	TP25A-0.5	Water	7/09/2017	ASS x 1	1	X	
	29	TP25A-1.0	Water	7/09/2017	ASS x 1	1	X	
	30	TP25A-1.0 (2)	Water	7/09/2017	ASS x 1	1	X	
					TOTAL	15 bags		

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME : MW	DATE: 11/9	Yes No
OF: Emerge Associates	TIME: 9:30	OF:	TIME: 1230	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes:** J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

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Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 3 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Mitchell Ritikis	SAMPLERS PHONE: 0449 198 721	☒ Standard (5-7 days) ☐ Non standard
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au

Laboratory Batch No.:				Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au
Laboratory Use	Yes	No	N/a		ANALYSIS REQUIRED
Custody seal intact	☐	☐	☐		
Free ice/frozen ice bricks present	☐	☐	☐		
Random sample temp on receipt			°C		

SAMPLE DETAILS				CONTAINER INFORMATION												
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS										Additional information (likely contaminants, dilutions or specific QC analysis)
31	TP25A-1.5	Water	7/09/2017	ASS x 1	1	X										
32	TP25B-0.0	Water	7/09/2017	ASS x 1	1	X										
33	TP25B-0.5	Water	7/09/2017	ASS x 1	1	X										
28 34	TP25B-1.0	Water	7/09/2017	ASS x 1	1	X										
35	TP25B-1.5	Water	7/09/2017	ASS x 1	1	X										
36	TP25B-2.0	Water	7/09/2017	ASS x 1	1	X										
37	TP26-0.0	Water	7/09/2017	ASS x 1	1	X										
24 38	TP26-0.5	Water	7/09/2017	ASS x 1	1	X										
39	TP26-1.0	Water	7/09/2017	ASS x 1	1	X										
40	TP26-1.5	Water	7/09/2017	ASS x 1	1	X										
41	TP26-2.0	Water	7/09/2017	ASS x 1	1	X										
42	TP27-0.0	Water	8/09/2017	ASS x 1	1	X										
43	TP27-0.5	Water	8/09/2017	ASS x 1	1	X										
25 44	TP27-1.0	Water	8/09/2017	ASS x 1	1	X										
45	TP27-1.5	Water	8/09/2017	ASS x 1	1	X										
				TOTAL: 15 bags												

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME :	DATE:	Yes No
OF: Emerge Associates	TIME: 9:30	OF:	TIME:	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes:** J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

CHAIN OF COUNTODY

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CLIENT: Emerge Associates — POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008 —

PROJECT MANAGER: Robin Anderson — CONTACT PHONE: 9380 4988

PROJECT ID.: EP17-010(05) — PROJECT NAME: MKSEA

SAMPLER(S): Mitchell Ritikis — SAMPLERS PHONE: 0449 198 721

QUOTE NO.: EPBQ/009/16 ORDER NO.:

ALS LABORATORY: Perth

TURNAROUND REQUIREMENTS

☒ Standard (5-7 days) ☐ Non-standard (one day or as req'd)

Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au

Email invoice to: accounts@emergeassociates.com.au

Laboratory Batch No.:

Laboratory Use — Yes — No — N/a

Custody seal intact: ☐ ☐ ☐

Free ice/frozen ice bricks present: ☐ ☐ ☐

Random sample temp on receipt: °C

Comments/special handling/storage or disposal

ANALYSIS REQUIRED

Additional information (likely contaminants, dilutions or specific QC analysis)

Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	Additional information
66	TP27-2.0	Water	8/09/2017	ASS x 1	1	X	
67	TP32-0.0	Water	7/09/2017	ASS x 1	1	X	
29 48	TP32-0.5	Water	7/09/2017	ASS x 1	1	X	
49	TP32-1.0	Water	7/09/2017	ASS x 1	1	X	
50	TP32-1.5	Water	7/09/2017	ASS x 1	1	X	
51	TP32-2.0	Water	7/09/2017	ASS x 1	1	X	
52	TP33-0.0	Water	7/09/2017	ASS x 1	1	X	
53	TP33-0.5	Water	7/09/2017	ASS x 1	1	X	
30 54	TP33-1.0	Water	7/09/2017	ASS x 1	1	X	
55	TP33-1.5	Water	7/09/2017	ASS x 1	1	X	
56	TP33-2.0	Water	7/09/2017	ASS x 1	1	X	
57	TP34-0.0	Water	7/09/2017	ASS x 1	1	X	
58	TP34-0.5	Water	7/09/2017	ASS x 1	1	X	
59	TP34-1.0	Water	7/09/2017	ASS x 1	1	X	
31 60	TP34-1.5	Water	7/09/2017	ASS x 1	1	X	
TOTAL: 15 bags							

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME :	DATE: 11/9/17	Yes No
OF: Emerge Associates	TIME: 9:30	OF:	TIME: 1230	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes:** J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag.

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emerge ASSOCIATES
Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 5 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Mitchell Ritikis	SAMPLERS PHONE: 0449 198 721	☒ Standard (5-7 days) ☐ Non-standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au
Laboratory Batch No.:	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use — Yes / No / N/a
Custody seal intact: ☐ ☐ ☐
Free ice/frozen ice bricks present: ☐ ☐ ☐
Random sample temp on receipt: °C

ANALYSIS REQUIRED

SAMPLE DETAILS				CONTAINER INFORMATION		ANALYSIS REQUIRED	Additional information (likely contaminants, dilutions or specific QC analysis)
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	
61	TP34-2.0	Water	7/09/2017	ASS x 1	1	X	
62	TP39-0.0	Water	7/09/2017	ASS x 1	1	X	
63	TP39-0.5	Water	7/09/2017	ASS x 1	1	X	
32 64	TP39-1.0	Water	7/09/2017	ASS x 1	1	X	
65	TP39-1.5	Water	7/09/2017	ASS x 1	1	X	
66	TP39-2.0	Water	7/09/2017	ASS x 1	1	X	
67	TP40-0.0	Water	7/09/2017	ASS x 1	1	X	
68	TP40-0.5	Water	7/09/2017	ASS x 1	1	X	
33 69	TP40-1.0	Water	7/09/2017	ASS x 1	1	X	
70	TP40-1.0 (2)	Water	7/09/2017	ASS x 1	1	X	
71	TP40-1.5	Water	7/09/2017	ASS x 1	1	X	
72	TP40-2.0	Water	7/09/2017	ASS x 1	1	X	
73	TP43-0.0	Water	8/09/2017	ASS x 1	1	X	
74	TP43-0.5	Water	8/09/2017	ASS x 1	1	X	
75	TP43-1.0	Water	8/09/2017	ASS x 1	1	X	
				TOTAL: 15 bags			

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME : ML	DATE: 11/9	Yes No
OF: Emerge Associates	TIME: 9:30	OF:	TIME: 1230	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. Soil Container Codes: J = Jar; ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

CHAIN OF CUSTODY

emerge ASSOCIATES Integrated Science & Design

CLIENT: Emerge Associates	POSTAL ADDRESS: Suite 4, 26 Railway Road, Subiaco WA 6008	Page 6 of 5
PROJECT MANAGER: Robin Anderson	CONTACT PHONE: 9380 4988	ALS LABORATORY: Perth
PROJECT ID.: EP17-010(05)	PROJECT NAME: MKSEA	TURNAROUND REQUIREMENTS
SAMPLER(S): Mitchell Ritikis	SAMPLERS PHONE: 0449 198 721	☒ Standard (5-7 days) ☐ Non-standard (one day or asap)
QUOTE NO.: EPBQ/009/16 ORDER NO.:		Email reports to: robin.anderson@emergeassociates.com.au; simon.gregg@emergeassociates.com.au, Mitchell.ritikis@emergeassociates.com.au
Laboratory Batch No.:	Comments/special handling/storage or disposal	Email invoice to: accounts@emergeassociates.com.au

Laboratory Use	Yes	No	N/a
Custody seal intact:	☐	☐	☐
Free ice/frozen ice bricks present:	☐	☐	☐
Random sample temp on receipt:			°C

ANALYSIS REQUIRED

SAMPLE DETAILS				CONTAINER INFORMATION			
Lab ID	Sample ID	Matrix	Date	Type & Preservative	Total No.	QASSIT FFS	Additional information (likely contaminants, dilutions or specific QC analysis)
76	TP43-1.0 (2)	Water	8/09/2017	ASS x 1	1	X	
77	TP43-1.5	Water	8/09/2017	ASS x 1	1	X	
78	TP43-2.0	Water	8/09/2017	ASS x 1	1	X	
				TOTAL: 3 bags			

RELINQUISHED BY:		RECEIVED BY		CoC emailed to ALS?
NAME : Mitchell Ritikis	DATE: 11/09/2017	NAME : M L	DATE: 11/9	Yes / No
OF: Emerge Associates	TIME: 9:30	OF:	TIME: 1230	
NAME :	DATE:	NAME :	DATE:	
OF:	TIME:	OF:	TIME:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles. **Soil Container Codes:** J = Jar, ASS = Plastic Bag for Acid Sulfate Soils; B = Unpreserved Bag;

ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order	: **EP1712588**			
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Lauren Biagioni
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: Robin.Anderson@emergeassociates.com.au	E-mail	: Lauren.biagioni@alsglobal.com
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7655
Facsimile	: +61 08 9380 9636	Facsimile	: +61-8-9209 7600
Project	: Ex EP1710345/EP1709754/EP1709951 EP17-010(05) MKSEA	Page	: 1 of 3
Order number	: ----	Quote number	: EP2016EMEASS0001 (EPBQ-009-16)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: MITCHELL RITIKIS, ROBIN ANDERSON		

Dates

Date Samples Received	: 06-Sep-2017 15:40	Issue Date	: 09-Nov-2017
Client Requested Due Date	: 17-Nov-2017	Scheduled Reporting Date	: **17-Nov-2017**

Delivery Details

Mode of Delivery	: Samples On Hand	Security Seal	: Not Available
No. of coolers/boxes	: ----	Temperature	: ----
Receipt Detail	:	No. of samples received / analysed	: 35 / 35

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- Please see scanned COC for sample discrepencies: extra samples , samples not received etc.
- Please direct any queries related to sample condition / numbering / breakages to Sample Receipt (SamplesPerth@alsenviro.com)
- Analytical work for this work order will be conducted at ALS Environmental Perth.
- Please direct any turnaround / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- **pH analysis should be conducted within 6 hours of sampling.**

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	SOIL - EA029-WA WA - SPOCAS
EP1712588-001	15-Sep-2017 00:00	HA06-1.5	✓
EP1712588-002	15-Sep-2017 00:00	HA10-0.5	✓
EP1712588-003	05-Sep-2017 00:00	TP01-1.0	✓
EP1712588-004	08-Sep-2017 00:00	TP02-1.5	✓
EP1712588-005	05-Sep-2017 00:00	TP03-0.5	✓
EP1712588-006	05-Sep-2017 00:00	TP04-0.5	✓
EP1712588-007	08-Sep-2017 00:00	TP05-0.5	✓
EP1712588-008	08-Sep-2017 00:00	TP05-2.0	✓
EP1712588-009	05-Sep-2017 00:00	TP06-1.0	✓
EP1712588-010	05-Sep-2017 00:00	TP07-0.5	✓
EP1712588-011	05-Sep-2017 00:00	TP08-1.0	✓
EP1712588-012	06-Sep-2017 00:00	TP09-1.0	✓
EP1712588-013	06-Sep-2017 00:00	TP10-1.0	✓
EP1712588-014	06-Sep-2017 00:00	TP11-0.5	✓
EP1712588-015	06-Sep-2017 00:00	TP12-0.5	✓
EP1712588-016	05-Sep-2017 00:00	TP12-1.0	✓
EP1712588-017	06-Sep-2017 00:00	TP13-0.5	✓
EP1712588-018	06-Sep-2017 00:00	TP14-0.5	✓
EP1712588-019	06-Sep-2017 00:00	TP15-0.0	✓
EP1712588-020	07-Sep-2017 00:00	TP16-0.5	✓
EP1712588-021	06-Sep-2017 00:00	TP17-1.0	✓
EP1712588-022	06-Sep-2017 00:00	TP18-0.5	✓
EP1712588-023	07-Sep-2017 00:00	TP25A-0.5	✓
EP1712588-024	07-Sep-2017 00:00	TP26-0.5	✓
EP1712588-025	08-Sep-2017 00:00	TP27-1.0	✓
EP1712588-026	05-Sep-2017 00:00	TP28-0.5	✓
EP1712588-027	05-Sep-2017 00:00	TP28-1.5	✓
EP1712588-028	07-Sep-2017 00:00	TP25B-1.0	✓
EP1712588-029	07-Sep-2017 00:00	TP32-0.5	✓
EP1712588-030	07-Sep-2017 00:00	TP33-1.0	✓
EP1712588-031	07-Sep-2017 00:00	TP34-1.5	✓
EP1712588-032	07-Sep-2017 00:00	TP39-1.0	✓
EP1712588-033	07-Sep-2017 00:00	TP40-1.0	✓
EP1712588-034	06-Sep-2017 00:00	SQA2	✓
EP1712588-035	06-Sep-2017 00:00	SQA4	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

ACCOUNTS (INVOICES)		
- A4 - AU Tax Invoice (INV)	Email	accounts@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	accounts@emergeassociates.com.au
MITCHELL RITIKIS		
- *AU Certificate of Analysis - NATA (COA)	Email	mitchell.ritikis@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	mitchell.ritikis@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	mitchell.ritikis@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	mitchell.ritikis@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	mitchell.ritikis@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	mitchell.ritikis@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	mitchell.ritikis@emergeassociates.com.au
ROBIN ANDERSON		
- *AU Certificate of Analysis - NATA (COA)	Email	Robin.Anderson@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	Robin.Anderson@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	Robin.Anderson@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	Robin.Anderson@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	Robin.Anderson@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	Robin.Anderson@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	Robin.Anderson@emergeassociates.com.au
SIMON GREGG		
- *AU Certificate of Analysis - NATA (COA)	Email	simon.gregg@emergeassociates.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	simon.gregg@emergeassociates.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	simon.gregg@emergeassociates.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	simon.gregg@emergeassociates.com.au
- Chain of Custody (CoC) (COC)	Email	simon.gregg@emergeassociates.com.au
- EDI Format - ESDAT (ESDAT)	Email	simon.gregg@emergeassociates.com.au
- EDI Format - XTab (XTAB)	Email	simon.gregg@emergeassociates.com.au

CERTIFICATE OF ANALYSIS

Work Order	: **EP1712588**	Page	: 1 of 16
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Lauren Biagioni
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7655
Project	: Ex EP1710345/EP1709754/EP1709951 EP17-010(05) MKSEA	Date Samples Received	: 06-Sep-2017 15:40
Order number	: ----	Date Analysis Commenced	: 14-Nov-2017
C-O-C number	: ----	Issue Date	: 17-Nov-2017 16:39
Sampler	: MITCHELL RITIKIS, ROBIN ANDERSON		
Site	: ----		
Quote number	: EPBQ-009-16		
No. of samples received	: 35		
No. of samples analysed	: 35		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA029 (SPOCAS): Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA029 (SPOCAS): Excess ANC not required because pH OX less than 6.5.
- ASS: EA029 (SPOCAS): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime ($CaCO_3$) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from kg/t dry weight to kg/m3 in-situ soil, multiply reported results x wet bulk density of soil in t/m3.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	HA06-1.5	HA10-0.5	TP01-1.0	TP02-1.5	TP03-0.5
			Client sampling date / time	15-Sep-2017 00:00	15-Sep-2017 00:00	05-Sep-2017 00:00	08-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1712588-001	EP1712588-002	EP1712588-003	EP1712588-004	EP1712588-005
				Result	Result	Result	Result	Result
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	**6.2**	**6.0**	**9.2**	**7.3**	**6.4**
pH OX (23B)	----	0.1	pH Unit	**4.6**	**5.1**	**7.9**	**5.8**	**5.8**
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	**2**	<2	<2	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	**20**	<2	<2	<2	<2
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	**19**	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	<0.005
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	**0.032**	<0.005	<0.005	<0.005	<0.005
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	**0.030**	<0.005	<0.005	<0.005	<0.005
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	**0.011**	<0.005	**0.008**	<0.005	**0.007**
Peroxide Sulfur (23De)	----	0.005	% S	**0.021**	**0.006**	**0.060**	<0.005	**0.012**
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	**0.010**	<0.005	**0.052**	<0.005	<0.005
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	**6**	<5	**33**	<5	<5
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	**0.018**	**0.034**	**0.312**	**0.021**	**0.011**
Peroxide Calcium (23Wh)	----	0.005	% Ca	**0.018**	**0.034**	**38.4**	**0.025**	**0.012**
Acid Reacted Calcium (23X)	----	0.005	% Ca	<0.005	<0.005	**38.1**	<0.005	<0.005
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	<5	<5	**19000**	<5	<5
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	<0.005	<0.005	**30.5**	<0.005	<0.005
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	**0.014**	<0.005	**0.054**	<0.005	**0.034**
Peroxide Magnesium (23Tm)	----	0.005	% Mg	**0.014**	<0.005	**0.963**	<0.005	**0.036**
Acid Reacted Magnesium (23U)	----	0.005	% Mg	<0.005	<0.005	**0.909**	<0.005	<0.005
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	<5	<5	**748**	<5	<5
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	<0.005	<0.005	**1.20**	<0.005	<0.005
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.020	% CaCO3	----	----	**76.8**	----	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	----	----	**15300**	----	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.020	% S	----	----	**24.6**	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	HA06-1.5	HA10-0.5	TP01-1.0	TP02-1.5	TP03-0.5
			Client sampling date / time	15-Sep-2017 00:00	15-Sep-2017 00:00	05-Sep-2017 00:00	08-Sep-2017 00:00	05-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1712588-001	EP1712588-002	EP1712588-003	EP1712588-004	EP1712588-005
				Result	Result	Result	Result	Result
EA029-F: Excess Acid Neutralising Capacity - Continued								
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	**1**	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	**0.05**	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	**33**	<10	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	**1**	<1	**2**	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Compound	CAS Number	LOR	Unit	TP04-0.5	TP05-0.5	TP05-2.0	TP06-1.0	TP07-0.5
Client sampling date / time				05-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
				EP1712588-006	EP1712588-007	EP1712588-008	EP1712588-009	EP1712588-010
				Result	Result	Result	Result	Result
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	**7.6**	**6.9**	**6.6**	**9.0**	**6.6**
pH OX (23B)	----	0.1	pH Unit	**6.4**	**4.4**	**5.0**	**7.6**	**6.6**
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	<2	<2	<2
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	<0.005
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	<0.005
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	<0.005
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	**0.006**	<0.005	<0.005	<0.005	**0.006**
Peroxide Sulfur (23De)	----	0.005	% S	**0.010**	<0.005	**0.007**	**0.024**	**0.009**
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	<0.005	<0.005	<0.005	**0.021**	<0.005
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	<5	<5	<5	**13**	<5
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	**0.178**	**0.006**	**0.006**	**0.216**	**0.063**
Peroxide Calcium (23Wh)	----	0.005	% Ca	**0.138**	**0.008**	**0.008**	**1.35**	**0.063**
Acid Reacted Calcium (23X)	----	0.005	% Ca	<0.005	<0.005	<0.005	**1.14**	<0.005
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	<5	<5	<5	**567**	<5
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	<0.005	<0.005	<0.005	**0.909**	<0.005
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	**0.005**	<0.005	<0.005	**0.010**	**0.049**
Peroxide Magnesium (23Tm)	----	0.005	% Mg	**0.006**	<0.005	<0.005	**0.036**	**0.051**
Acid Reacted Magnesium (23U)	----	0.005	% Mg	<0.005	<0.005	<0.005	**0.026**	<0.005
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	<5	<5	<5	**22**	<5
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	<0.005	<0.005	<0.005	**0.035**	<0.005
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.020	% CaCO3	----	----	----	**3.00**	**0.048**
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	----	----	----	**598**	<10
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.020	% S	----	----	----	**0.959**	<0.020

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	TP04-0.5	TP05-0.5	TP05-2.0	TP06-1.0	TP07-0.5
Client sampling date / time				05-Sep-2017 00:00	08-Sep-2017 00:00	08-Sep-2017 00:00	05-Sep-2017 00:00	05-Sep-2017 00:00
				EP1712588-006	EP1712588-007	EP1712588-008	EP1712588-009	EP1712588-010
				Result	Result	Result	Result	Result
EA029-F: Excess Acid Neutralising Capacity - Continued								
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	<10	13	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	<1	<1	1	<1

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	TP08-1.0	TP09-1.0	TP10-1.0	TP11-0.5	TP12-0.5
Client sampling date / time				05-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00
				EP1712588-011	EP1712588-012	EP1712588-013	EP1712588-014	EP1712588-015
				Result	Result	Result	Result	Result
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	6.9	6.7	6.3	6.4	6.5
pH OX (23B)	----	0.1	pH Unit	8.2	6.9	7.4	6.8	5.7
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	2	<2	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	<2	<2	<2
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	<0.005
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	<0.005
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	<0.005
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	0.033	0.024	0.026	0.019	0.008
Peroxide Sulfur (23De)	----	0.005	% S	0.028	0.030	0.031	0.020	0.018
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	<0.005	0.006	<0.005	<0.005	0.010
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	<5	<5	<5	<5	6
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	0.155	0.051	0.021	0.134	0.018
Peroxide Calcium (23Wh)	----	0.005	% Ca	0.148	0.058	0.023	0.122	0.023
Acid Reacted Calcium (23X)	----	0.005	% Ca	<0.005	0.007	<0.005	<0.005	<0.005
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	<5	<5	<5	<5	<5
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	<0.005	0.005	<0.005	<0.005	<0.005
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	0.164	0.069	0.192	0.194	0.055
Peroxide Magnesium (23Tm)	----	0.005	% Mg	0.174	0.086	0.216	0.195	0.052
Acid Reacted Magnesium (23U)	----	0.005	% Mg	0.010	0.018	0.024	<0.005	<0.005
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	8	14	20	<5	<5
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	0.013	0.023	0.032	<0.005	<0.005
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.020	% CaCO3	0.820	0.072	0.194	0.122	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	164	14	39	24	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.020	% S	0.262	0.023	0.062	0.039	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP08-1.0	TP09-1.0	TP10-1.0	TP11-0.5	TP12-0.5
			Client sampling date / time	05-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1712588-011	EP1712588-012	EP1712588-013	EP1712588-014	EP1712588-015
				Result	Result	Result	Result	Result
EA029-F: Excess Acid Neutralising Capacity - Continued								
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	<1	<1	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP12-1.0	TP13-0.5	TP14-0.5	TP15-0.0	TP16-0.5
			Client sampling date / time	05-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1712588-016	EP1712588-017	EP1712588-018	EP1712588-019	EP1712588-020
				Result	Result	Result	Result	Result
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	5.9	6.3	6.8	6.0	7.0
pH OX (23B)	----	0.1	pH Unit	5.2	4.7	3.7	3.2	6.7
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	5	<2	<2	<2	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	<2	14	<2
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	<2	<2	13	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	0.008	<0.005	<0.005	<0.005	<0.005
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	0.023	<0.005
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	0.021	<0.005
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	0.014	<0.005	<0.005	<0.005	<0.005
Peroxide Sulfur (23De)	----	0.005	% S	0.021	<0.005	<0.005	0.011	0.009
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	0.007	<0.005	<0.005	0.010	0.006
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	<5	<5	<5	6	<5
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	0.020	0.006	0.015	0.013	0.144
Peroxide Calcium (23Wh)	----	0.005	% Ca	0.019	0.006	0.015	0.015	0.153
Acid Reacted Calcium (23X)	----	0.005	% Ca	<0.005	<0.005	<0.005	<0.005	0.010
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	<5	<5	<5	<5	<5
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	<0.005	<0.005	<0.005	<0.005	0.008
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	0.062	<0.005	<0.005	<0.005	0.125
Peroxide Magnesium (23Tm)	----	0.005	% Mg	0.060	<0.005	<0.005	<0.005	0.174
Acid Reacted Magnesium (23U)	----	0.005	% Mg	<0.005	<0.005	<0.005	<0.005	0.049
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	<5	<5	<5	<5	40
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	<0.005	<0.005	<0.005	<0.005	0.065
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.020	% CaCO3	----	----	----	----	0.326
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	----	----	----	----	65
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.020	% S	----	----	----	----	0.104

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	TP12-1.0	TP13-0.5	TP14-0.5	TP15-0.0	TP16-0.5
Client sampling date / time				05-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00	07-Sep-2017 00:00
				EP1712588-016	EP1712588-017	EP1712588-018	EP1712588-019	EP1712588-020
				Result	Result	Result	Result	Result
EA029-F: Excess Acid Neutralising Capacity - Continued								
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	**1**	<1	<1	**1**	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	**1**	<1	<1	**1**	<1

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	TP17-1.0	TP18-0.5	TP25A-0.5	TP26-0.5	TP27-1.0
			Client sampling date / time	06-Sep-2017 00:00	06-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	08-Sep-2017 00:00
				EP1712588-021	EP1712588-022	EP1712588-023	EP1712588-024	EP1712588-025
				Result	Result	Result	Result	Result
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	5.8	7.1	6.6	5.9	7.0
pH OX (23B)	----	0.1	pH Unit	6.6	6.1	4.5	4.8	4.3
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	12	<2	<2	5	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	<2	9	<2
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	<2	<2	5	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	0.019	<0.005	<0.005	0.008	<0.005
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	0.015	<0.005
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	0.008	<0.005
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	0.010	<0.005	<0.005	<0.005	<0.005
Peroxide Sulfur (23De)	----	0.005	% S	0.010	0.012	0.008	0.020	<0.005
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	<0.005	0.009	0.005	0.019	<0.005
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	<5	5	<5	12	<5
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	0.063	0.070	0.017	0.069	0.030
Peroxide Calcium (23Wh)	----	0.005	% Ca	0.064	0.094	0.022	0.072	0.029
Acid Reacted Calcium (23X)	----	0.005	% Ca	<0.005	0.023	0.005	<0.005	<0.005
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	<5	12	<5	<5	<5
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	<0.005	0.018	<0.005	<0.005	<0.005
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	0.168	0.005	0.015	0.039	<0.005
Peroxide Magnesium (23Tm)	----	0.005	% Mg	0.155	0.006	0.017	0.042	<0.005
Acid Reacted Magnesium (23U)	----	0.005	% Mg	<0.005	<0.005	<0.005	<0.005	<0.005
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	<5	<5	<5	<5	<5
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	<0.005	<0.005	<0.005	<0.005	<0.005
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.020	% CaCO3	0.122	----	----	----	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	24	----	----	----	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.020	% S	0.039	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP17-1.0	TP18-0.5	TP25A-0.5	TP26-0.5	TP27-1.0
			Client sampling date / time	06-Sep-2017 00:00	06-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	08-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1712588-021	EP1712588-022	EP1712588-023	EP1712588-024	EP1712588-025
				Result	Result	Result	Result	Result
EA029-F: Excess Acid Neutralising Capacity - Continued								
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	**0.02**	<0.02	<0.02	**0.03**	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	**12**	<10	<10	**17**	<10
Liming Rate	----	1	kg CaCO3/t	**1**	<1	<1	**1**	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.02**	<0.02	<0.02	**0.03**	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**12**	<10	<10	**17**	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	**1**	<1	<1	**1**	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP28-0.5	TP28-1.5	TP25B-1.0	TP32-0.5	TP33-1.0
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1712588-026	EP1712588-027	EP1712588-028	EP1712588-029	EP1712588-030
				Result	Result	Result	Result	Result
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	**7.0**	**7.0**	**6.4**	**6.3**	**6.8**
pH OX (23B)	----	0.1	pH Unit	**6.1**	**5.1**	**4.1**	**3.3**	**3.8**
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	<2	**35**	**11**
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	<2	<2	**35**	**11**
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	<0.005
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	**0.057**	**0.017**
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	**0.057**	**0.017**
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	<0.005	<0.005	<0.005	<0.005	<0.005
Peroxide Sulfur (23De)	----	0.005	% S	<0.005	<0.005	<0.005	**0.006**	<0.005
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	<0.005	<0.005	<0.005	**0.006**	<0.005
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	<5	<5	<5	<5	<5
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	<0.005	**0.008**	<0.005	**0.015**	**0.005**
Peroxide Calcium (23Wh)	----	0.005	% Ca	**0.008**	**0.010**	<0.005	**0.020**	**0.005**
Acid Reacted Calcium (23X)	----	0.005	% Ca	<0.005	<0.005	<0.005	**0.005**	<0.005
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	<5	<5	<5	<5	<5
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	<0.005	<0.005	<0.005	<0.005	<0.005
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	<0.005	<0.005	<0.005	<0.005	<0.005
Peroxide Magnesium (23Tm)	----	0.005	% Mg	<0.005	<0.005	<0.005	<0.005	<0.005
Acid Reacted Magnesium (23U)	----	0.005	% Mg	<0.005	<0.005	<0.005	<0.005	<0.005
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	<5	<5	<5	<5	<5
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	<0.005	<0.005	<0.005	<0.005	<0.005
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	**1**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP28-0.5	TP28-1.5	TP25B-1.0	TP32-0.5	TP33-1.0
			Client sampling date / time	05-Sep-2017 00:00	05-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1712588-026	EP1712588-027	EP1712588-028	EP1712588-029	EP1712588-030
				Result	Result	Result	Result	Result
EA029-H: Acid Base Accounting - Continued								
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	<1	<1	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP34-1.5	TP39-1.0	TP40-1.0	SQA2	SQA4
			Client sampling date / time	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00
Compound	CAS Number	LOR	Unit	EP1712588-031	EP1712588-032	EP1712588-033	EP1712588-034	EP1712588-035
				Result	Result	Result	Result	Result
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	6.6	6.4	6.8	6.8	6.0
pH OX (23B)	----	0.1	pH Unit	5.0	4.6	4.6	7.8	6.5
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	6
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	9	15	4	<2	<2
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	9	15	4	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.005	% pyrite S	<0.005	<0.005	<0.005	<0.005	0.009
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.005	% pyrite S	0.015	0.024	0.006	<0.005	<0.005
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.005	% pyrite S	0.015	0.024	0.006	<0.005	<0.005
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.005	% S	0.006	0.016	<0.005	0.033	<0.005
Peroxide Sulfur (23De)	----	0.005	% S	0.012	0.018	<0.005	0.034	0.006
Peroxide Oxidisable Sulfur (23E)	----	0.005	% S	0.006	<0.005	<0.005	<0.005	<0.005
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	5	mole H+ / t	<5	<5	<5	<5	<5
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.005	% Ca	0.006	<0.005	<0.005	0.142	0.044
Peroxide Calcium (23Wh)	----	0.005	% Ca	0.006	<0.005	<0.005	0.148	0.046
Acid Reacted Calcium (23X)	----	0.005	% Ca	<0.005	<0.005	<0.005	0.006	<0.005
acidity - Acid Reacted Calcium (a-23X)	----	5	mole H+ / t	<5	<5	<5	<5	<5
sulfidic - Acid Reacted Calcium (s-23X)	----	0.005	% S	<0.005	<0.005	<0.005	0.005	<0.005
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.005	% Mg	0.005	0.006	<0.005	0.160	0.126
Peroxide Magnesium (23Tm)	----	0.005	% Mg	0.006	0.006	<0.005	0.174	0.115
Acid Reacted Magnesium (23U)	----	0.005	% Mg	<0.005	<0.005	<0.005	0.014	<0.005
Acidity - Acid Reacted Magnesium (a-23U)	----	5	mole H+ / t	<5	<5	<5	12	<5
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.005	% S	<0.005	<0.005	<0.005	0.019	<0.005
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.020	% CaCO3	----	----	----	0.381	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	----	----	----	76	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.020	% S	----	----	----	0.122	----

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL)**			Client sample ID	**TP34-1.5**	**TP39-1.0**	**TP40-1.0**	**SQA2**	**SQA4**
			Client sampling date / time	07-Sep-2017 00:00	07-Sep-2017 00:00	07-Sep-2017 00:00	06-Sep-2017 00:00	06-Sep-2017 00:00
Compound	*CAS Number*	*LOR*	*Unit*	**EP1712588-031**	**EP1712588-032**	**EP1712588-033**	**EP1712588-034**	**EP1712588-035**
				Result	Result	Result	Result	Result
EA029-F: Excess Acid Neutralising Capacity - Continued								
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	**1**	<1	<1	<1	**1**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	<1	<1	<1	**1**

QUALITY CONTROL REPORT

Work Order	: **EP1712588**		
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Contact	: Lauren Biagioni
Address	: SUITE 4, 26 RAILWAY ROAD SUBIACO WESTERN AUSTRALIA 6008	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: +61 08 9380 4988	Telephone	: 08 9209 7655
Project	: Ex EP1710345/EP1709754/EP1709951 EP17-010(05) MKSEA	Date Samples Received	: 06-Sep-2017
Order number	: ----	Date Analysis Commenced	: 14-Nov-2017
C-O-C number	: ----	Issue Date	: 17-Nov-2017
Sampler	: MITCHELL RITIKIS, ROBIN ANDERSON		
Site	: ----		
Quote number	: EPBQ-009-16		
No. of samples received	: 35		
No. of samples analysed	: 35		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Daniel Fisher	Inorganics Analyst	Perth ASS, Malaga, WA

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key :
- Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
- CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
- LOR = Limit of reporting
- RPD = Relative Percentage Difference
- # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA029-A: pH Measurements (QC Lot: 1239798)									
EP1712588-001	HA06-1.5	EA029: pH KCl (23A)	----	0.1	pH Unit	6.2	6.3	0.00	0% - 20%
		EA029: pH OX (23B)	----	0.1	pH Unit	4.6	4.6	0.00	0% - 20%
EP1712588-011	TP08-1.0	EA029: pH KCl (23A)	----	0.1	pH Unit	6.9	6.8	0.00	0% - 20%
		EA029: pH OX (23B)	----	0.1	pH Unit	8.2	8.1	1.23	0% - 20%
EA029-A: pH Measurements (QC Lot: 1239799)									
EP1712588-021	TP17-1.0	EA029: pH KCl (23A)	----	0.1	pH Unit	5.8	5.7	0.00	0% - 20%
		EA029: pH OX (23B)	----	0.1	pH Unit	6.6	6.6	0.00	0% - 20%
EP1712588-031	TP34-1.5	EA029: pH KCl (23A)	----	0.1	pH Unit	6.6	6.6	0.00	0% - 20%
		EA029: pH OX (23B)	----	0.1	pH Unit	5.0	5.1	1.99	0% - 20%
EA029-B: Acidity Trail (QC Lot: 1239798)									
EP1712588-001	HA06-1.5	EA029: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.005	<0.005	0.00	No Limit
		EA029: sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.02	% pyrite S	0.032	0.032	0.00	No Limit
		EA029: sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.02	% pyrite S	0.030	0.030	0.00	No Limit
		EA029: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.00	No Limit
		EA029: Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	20	20	0.00	0% - 50%
		EA029: Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	19	19	0.00	No Limit
EP1712588-011	TP08-1.0	EA029: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.005	<0.005	0.00	No Limit
		EA029: sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.02	% pyrite S	<0.005	<0.005	0.00	No Limit
		EA029: sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.02	% pyrite S	<0.005	<0.005	0.00	No Limit
		EA029: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.00	No Limit
		EA029: Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	0.00	No Limit

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EA029-B: Acidity Trail (QC Lot: 1239798) - continued									
EP1712588-011	TP08-1.0	EA029: Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	<2	0.00	No Limit
EA029-B: Acidity Trail (QC Lot: 1239799)									
EP1712588-021	TP17-1.0	EA029: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	0.019	0.019	0.00	No Limit
		EA029: sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.02	% pyrite S	<0.005	<0.005	0.00	No Limit
		EA029: sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.02	% pyrite S	<0.005	<0.005	0.00	No Limit
		EA029: Titratable Actual Acidity (23F)	----	2	mole H+ / t	12	12	0.00	No Limit
		EA029: Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	0.00	No Limit
		EA029: Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	<2	0.00	No Limit
EP1712588-031	TP34-1.5	EA029: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.005	<0.005	0.00	No Limit
		EA029: sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.02	% pyrite S	0.015	0.015	0.00	No Limit
		EA029: sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.02	% pyrite S	0.015	0.015	0.00	No Limit
		EA029: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.00	No Limit
		EA029: Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	9	9	0.00	No Limit
		EA029: Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	9	9	0.00	No Limit
EA029-C: Sulfur Trail (QC Lot: 1239798)									
EP1712588-001	HA06-1.5	EA029: KCl Extractable Sulfur (23Ce)	----	0.02	% S	0.011	0.009	17.6	No Limit
		EA029: Peroxide Sulfur (23De)	----	0.02	% S	0.021	0.026	19.6	No Limit
		EA029: Peroxide Oxidisable Sulfur (23E)	----	0.02	% S	0.010	0.016	48.5	No Limit
		EA029: acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	6	10	48.5	No Limit
EP1712588-011	TP08-1.0	EA029: KCl Extractable Sulfur (23Ce)	----	0.02	% S	0.033	0.029	14.0	No Limit
		EA029: Peroxide Sulfur (23De)	----	0.02	% S	0.028	0.029	0.00	No Limit
		EA029: Peroxide Oxidisable Sulfur (23E)	----	0.02	% S	<0.005	<0.005	0.00	No Limit
		EA029: acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<5	<5	0.00	No Limit
EA029-C: Sulfur Trail (QC Lot: 1239799)									
EP1712588-021	TP17-1.0	EA029: KCl Extractable Sulfur (23Ce)	----	0.02	% S	0.010	<0.005	63.9	No Limit
		EA029: Peroxide Sulfur (23De)	----	0.02	% S	0.010	0.007	39.5	No Limit
		EA029: Peroxide Oxidisable Sulfur (23E)	----	0.02	% S	<0.005	<0.005	0.00	No Limit
		EA029: acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<5	<5	0.00	No Limit
EP1712588-031	TP34-1.5	EA029: KCl Extractable Sulfur (23Ce)	----	0.02	% S	0.006	0.007	0.00	No Limit
		EA029: Peroxide Sulfur (23De)	----	0.02	% S	0.012	0.012	0.00	No Limit
		EA029: Peroxide Oxidisable Sulfur (23E)	----	0.02	% S	0.006	0.005	0.00	No Limit
		EA029: acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<5	<5	0.00	No Limit

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EA029-D: Calcium Values (QC Lot: 1239798)									
EP1712588-001	HA06-1.5	EA029: KCl Extractable Calcium (23Vh)	----	0.02	% Ca	0.018	0.017	9.63	No Limit
		EA029: Peroxide Calcium (23Wh)	----	0.02	% Ca	0.018	0.017	0.00	No Limit
		EA029: Acid Reacted Calcium (23X)	----	0.02	% Ca	<0.005	<0.005	0.00	No Limit
		EA029: sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S	<0.005	<0.005	0.00	No Limit
		EA029: acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<5	<5	0.00	No Limit
EP1712588-011	TP08-1.0	EA029: KCl Extractable Calcium (23Vh)	----	0.02	% Ca	0.155	0.140	9.97	0% - 20%
		EA029: Peroxide Calcium (23Wh)	----	0.02	% Ca	0.148	0.161	7.96	0% - 20%
		EA029: Acid Reacted Calcium (23X)	----	0.02	% Ca	<0.005	0.021	122	No Limit
		EA029: sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S	<0.005	0.016	107	No Limit
		EA029: acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<5	10	69.1	No Limit
EA029-D: Calcium Values (QC Lot: 1239799)									
EP1712588-021	TP17-1.0	EA029: KCl Extractable Calcium (23Vh)	----	0.02	% Ca	0.063	0.056	12.8	0% - 50%
		EA029: Peroxide Calcium (23Wh)	----	0.02	% Ca	0.064	0.059	8.03	0% - 50%
		EA029: Acid Reacted Calcium (23X)	----	0.02	% Ca	<0.005	<0.005	0.00	No Limit
		EA029: sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S	<0.005	<0.005	0.00	No Limit
		EA029: acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<5	<5	0.00	No Limit
EP1712588-031	TP34-1.5	EA029: KCl Extractable Calcium (23Vh)	----	0.02	% Ca	0.006	0.006	0.00	No Limit
		EA029: Peroxide Calcium (23Wh)	----	0.02	% Ca	0.006	0.010	47.5	No Limit
		EA029: Acid Reacted Calcium (23X)	----	0.02	% Ca	<0.005	<0.005	0.00	No Limit
		EA029: sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S	<0.005	<0.005	0.00	No Limit
		EA029: acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<5	<5	0.00	No Limit
EA029-E: Magnesium Values (QC Lot: 1239798)									
EP1712588-001	HA06-1.5	EA029: KCl Extractable Magnesium (23Sm)	----	0.02	% Mg	0.014	0.013	13.2	No Limit
		EA029: Peroxide Magnesium (23Tm)	----	0.02	% Mg	0.014	0.013	0.00	No Limit
		EA029: Acid Reacted Magnesium (23U)	----	0.02	% Mg	<0.005	<0.005	0.00	No Limit
		EA029: sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S	<0.005	<0.005	0.00	No Limit
		EA029: Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<5	<5	0.00	No Limit
EP1712588-011	TP08-1.0	EA029: KCl Extractable Magnesium (23Sm)	----	0.02	% Mg	0.164	0.152	7.98	0% - 20%
		EA029: Peroxide Magnesium (23Tm)	----	0.02	% Mg	0.174	0.185	5.90	0% - 20%
		EA029: Acid Reacted Magnesium (23U)	----	0.02	% Mg	0.010	0.033	107	No Limit
		EA029: sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S	0.013	0.044	107	No Limit
		EA029: Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	8	27	107	No Limit
EA029-E: Magnesium Values (QC Lot: 1239799)									
EP1712588-021	TP17-1.0	EA029: KCl Extractable Magnesium (23Sm)	----	0.02	% Mg	0.168	0.149	11.9	0% - 20%
		EA029: Peroxide Magnesium (23Tm)	----	0.02	% Mg	0.155	0.155	0.00	0% - 20%
		EA029: Acid Reacted Magnesium (23U)	----	0.02	% Mg	<0.005	0.006	0.00	No Limit

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EA029-E: Magnesium Values (QC Lot: 1239799) - continued									
EP1712588-021	TP17-1.0	EA029: sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S	<0.005	0.007	36.8	No Limit
		EA029: Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<5	<5	0.00	No Limit
EP1712588-031	TP34-1.5	EA029: KCl Extractable Magnesium (23Sm)	----	0.02	% Mg	0.005	<0.005	0.00	No Limit
		EA029: Peroxide Magnesium (23Tm)	----	0.02	% Mg	0.006	0.006	0.00	No Limit
		EA029: Acid Reacted Magnesium (23U)	----	0.02	% Mg	<0.005	<0.005	0.00	No Limit
		EA029: sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S	<0.005	<0.005	0.00	No Limit
		EA029: Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<5	<5	0.00	No Limit
EA029-F: Excess Acid Neutralising Capacity (QC Lot: 1239798)									
EP1712588-011	TP08-1.0	EA029: Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	0.820	0.819	0.198	0% - 20%
		EA029: sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S	0.262	0.262	0.00	0% - 50%
		EA029: acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	164	164	0.00	0% - 50%
EA029-F: Excess Acid Neutralising Capacity (QC Lot: 1239799)									
EP1712588-021	TP17-1.0	EA029: Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	0.122	0.122	0.00	No Limit
		EA029: sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S	0.039	0.039	0.00	No Limit
		EA029: acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	24	24	0.00	No Limit
EA029-H: Acid Base Accounting (QC Lot: 1239798)									
EP1712588-001	HA06-1.5	EA029: Net Acidity (sulfur units)	----	0.02	% S	<0.02	0.02	0.00	No Limit
		EA029: Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	0.02	0.00	No Limit
		EA029: Liming Rate	----	1	kg CaCO3/t	1	1	0.00	No Limit
		EA029: Liming Rate excluding ANC	----	1	kg CaCO3/t	1	1	0.00	No Limit
		EA029: Net Acidity (acidity units)	----	10	mole H+ / t	<10	11	9.52	No Limit
		EA029: Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	11	9.52	No Limit
EP1712588-011	TP08-1.0	EA029: Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	0.00	No Limit
		EA029: Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	0.00	No Limit
		EA029: Liming Rate	----	1	kg CaCO3/t	<1	<1	0.00	No Limit
		EA029: Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	<1	0.00	No Limit
		EA029: Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	0.00	No Limit
		EA029: Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	0.00	No Limit
EA029-H: Acid Base Accounting (QC Lot: 1239799)									
EP1712588-021	TP17-1.0	EA029: Net Acidity (sulfur units)	----	0.02	% S	0.02	0.02	0.00	No Limit
		EA029: Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.02	0.02	0.00	No Limit
		EA029: Liming Rate	----	1	kg CaCO3/t	1	1	0.00	No Limit

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA029-H: Acid Base Accounting (QC Lot: 1239799) - continued									
EP1712588-021	TP17-1.0	EA029: Liming Rate excluding ANC	----	1	kg CaCO3/t	1	1	0.00	No Limit
		EA029: Net Acidity (acidity units)	----	10	mole H+ / t	12	15	22.2	No Limit
		EA029: Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	12	15	22.2	No Limit
EP1712588-031	TP34-1.5	EA029: Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	0.00	No Limit
		EA029: Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	<0.02	0.00	No Limit
		EA029: Liming Rate	----	1	kg CaCO3/t	1	1	0.00	No Limit
		EA029: Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	<1	0.00	No Limit
		EA029: Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	0.00	No Limit
		EA029: Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	<10	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA029-A: pH Measurements (QCLot: 1239798)								
EA029: pH KCl (23A)	----	----	pH Unit	----	5.02 pH Unit	98.8	97	103
EA029: pH OX (23B)	----	----	pH Unit	----	3.5615 pH Unit	113	92	120
EA029-A: pH Measurements (QCLot: 1239799)								
EA029: pH KCl (23A)	----	----	pH Unit	----	5.02 pH Unit	98.2	97	103
EA029: pH OX (23B)	----	----	pH Unit	----	3.5615 pH Unit	112	92	120
EA029-B: Acidity Trail (QCLot: 1239798)								
EA029: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	24.27 mole H+ / t	97.8	79	103
EA029: Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	55.0798 mole H+ / t	101	90	114
EA029: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.020	----	----	----	----
EA029: sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.02	% pyrite S	<0.020	----	----	----	----
EA029: sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.02	% pyrite S	<0.020	----	----	----	----
EA029-B: Acidity Trail (QCLot: 1239799)								
EA029: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	24.27 mole H+ / t	97.4	79	103
EA029: Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	55.0798 mole H+ / t	94.5	90	114
EA029: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.020	----	----	----	----
EA029: sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.02	% pyrite S	<0.020	----	----	----	----
EA029: sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.02	% pyrite S	<0.020	----	----	----	----
EA029-C: Sulfur Trail (QCLot: 1239798)								
EA029: KCl Extractable Sulfur (23Ce)	----	0.02	% S	<0.020	0.1671 % S	105	87	117
EA029: Peroxide Sulfur (23De)	----	0.02	% S	<0.020	0.7183 % S	92.6	89	111
EA029: Peroxide Oxidisable Sulfur (23E)	----	0.02	% S	<0.020	----	----	----	----
EA029: acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<10	----	----	----	----
EA029-C: Sulfur Trail (QCLot: 1239799)								
EA029: KCl Extractable Sulfur (23Ce)	----	0.02	% S	<0.020	0.1671 % S	103	87	117
EA029: Peroxide Sulfur (23De)	----	0.02	% S	<0.020	0.7183 % S	97.9	89	111
EA029: Peroxide Oxidisable Sulfur (23E)	----	0.02	% S	<0.020	----	----	----	----
EA029: acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<10	----	----	----	----
EA029-D: Calcium Values (QCLot: 1239798)								
EA029: KCl Extractable Calcium (23Vh)	----	0.02	% Ca	<0.020	0.4248 % Ca	109	88	110
EA029: Peroxide Calcium (23Wh)	----	0.02	% Ca	<0.020	0.7407 % Ca	93.1	92	110
EA029: Acid Reacted Calcium (23X)	----	0.02	% Ca	<0.020	----	----	----	----
EA029: acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<10	----	----	----	----
EA029: sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S	<0.020	----	----	----	----

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA029-D: Calcium Values (QCLot: 1239799)								
EA029: KCl Extractable Calcium (23Vh)	----	0.02	% Ca	<0.020	0.4248 % Ca	104	88	110
EA029: Peroxide Calcium (23Wh)	----	0.02	% Ca	<0.020	0.7407 % Ca	97.9	92	110
EA029: Acid Reacted Calcium (23X)	----	0.02	% Ca	<0.020	----	----	----	----
EA029: acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<10	----	----	----	----
EA029: sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S	<0.020	----	----	----	----
EA029-E: Magnesium Values (QCLot: 1239798)								
EA029: KCl Extractable Magnesium (23Sm)	----	0.02	% Mg	<0.020	0.0686 % Mg	107	88	114
EA029: Peroxide Magnesium (23Tm)	----	0.02	% Mg	<0.020	0.0985 % Mg	96.4	89	109
EA029: Acid Reacted Magnesium (23U)	----	0.02	% Mg	<0.020	----	----	----	----
EA029: Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<10	----	----	----	----
EA029: sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S	<0.020	----	----	----	----
EA029-E: Magnesium Values (QCLot: 1239799)								
EA029: KCl Extractable Magnesium (23Sm)	----	0.02	% Mg	<0.020	0.0686 % Mg	107	88	114
EA029: Peroxide Magnesium (23Tm)	----	0.02	% Mg	<0.020	0.0985 % Mg	103	89	109
EA029: Acid Reacted Magnesium (23U)	----	0.02	% Mg	<0.020	----	----	----	----
EA029: Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<10	----	----	----	----
EA029: sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S	<0.020	----	----	----	----

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

Work Order	: **EP1712588**	Page	: 1 of 11
Client	: **EMERGE ASSOCIATES**	Laboratory	: Environmental Division Perth
Contact	: ROBIN ANDERSON	Telephone	: 08 9209 7655
Project	: Ex EP1710345/EP1709754/EP1709951 EP17-010(05) MKSEA	Date Samples Received	: 06-Sep-2017
Site	: ----	Issue Date	: 17-Nov-2017
Sampler	: MITCHELL RITIKIS, ROBIN ANDERSON	No. of samples received	: 35
Order number	: ----	No. of samples analysed	: 35

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.
This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.
Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL** Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method		*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)			*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA029-A: pH Measurements								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP01-1.0,	TP03-0.5,	**05-Sep-2017**	**14-Nov-2017**	31-May-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP04-0.5,	TP06-1.0,							
TP07-0.5,	TP08-1.0,							
TP12-1.0,	TP28-0.5,							
TP28-1.5								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP09-1.0,	TP10-1.0,	**06-Sep-2017**	**14-Nov-2017**	01-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP11-0.5,	TP12-0.5,							
TP13-0.5,	TP14-0.5,							
TP15-0.0,	TP17-1.0,							
TP18-0.5,	SQA2,							
SQA4								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP16-0.5,	TP25A-0.5,	**07-Sep-2017**	**14-Nov-2017**	02-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP26-0.5,	TP25B-1.0,							
TP32-0.5,	TP33-1.0,							
TP34-1.5,	TP39-1.0,							
TP40-1.0								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP02-1.5,	TP05-0.5,	**08-Sep-2017**	**14-Nov-2017**	03-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP05-2.0,	TP27-1.0							
Snap Lock Bag - frozen on receipt at ALS (EA029)								
HA06-1.5,	HA10-0.5	**15-Sep-2017**	**14-Nov-2017**	10-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA029-B: Acidity Trail								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP01-1.0,	TP03-0.5,	**05-Sep-2017**	**14-Nov-2017**	31-May-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP04-0.5,	TP06-1.0,							
TP07-0.5,	TP08-1.0,							
TP12-1.0,	TP28-0.5,							
TP28-1.5								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP09-1.0,	TP10-1.0,	**06-Sep-2017**	**14-Nov-2017**	01-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP11-0.5,	TP12-0.5,							
TP13-0.5,	TP14-0.5,							
TP15-0.0,	TP17-1.0,							
TP18-0.5,	SQA2,							
SQA4								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP16-0.5,	TP25A-0.5,	**07-Sep-2017**	**14-Nov-2017**	02-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP26-0.5,	TP25B-1.0,							
TP32-0.5,	TP33-1.0,							
TP34-1.5,	TP39-1.0,							
TP40-1.0								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP02-1.5,	TP05-0.5,	**08-Sep-2017**	**14-Nov-2017**	03-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP05-2.0,	TP27-1.0							
Snap Lock Bag - frozen on receipt at ALS (EA029)								
HA06-1.5,	HA10-0.5	**15-Sep-2017**	**14-Nov-2017**	10-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
EA029-C: Sulfur Trail								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP01-1.0,	TP03-0.5,	**05-Sep-2017**	**14-Nov-2017**	31-May-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP04-0.5,	TP06-1.0,							
TP07-0.5,	TP08-1.0,							
TP12-1.0,	TP28-0.5,							
TP28-1.5								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP09-1.0,	TP10-1.0,	**06-Sep-2017**	**14-Nov-2017**	01-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP11-0.5,	TP12-0.5,							
TP13-0.5,	TP14-0.5,							
TP15-0.0,	TP17-1.0,							
TP18-0.5,	SQA2,							
SQA4								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP16-0.5,	TP25A-0.5,	**07-Sep-2017**	**14-Nov-2017**	02-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP26-0.5,	TP25B-1.0,							
TP32-0.5,	TP33-1.0,							
TP34-1.5,	TP39-1.0,							
TP40-1.0								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP02-1.5,	TP05-0.5,	**08-Sep-2017**	**14-Nov-2017**	03-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP05-2.0,	TP27-1.0							
Snap Lock Bag - frozen on receipt at ALS (EA029)								
HA06-1.5,	HA10-0.5	**15-Sep-2017**	**14-Nov-2017**	10-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
EA029-D: Calcium Values								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP01-1.0,	TP03-0.5,	**05-Sep-2017**	**14-Nov-2017**	31-May-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP04-0.5,	TP06-1.0,							
TP07-0.5,	TP08-1.0,							
TP12-1.0,	TP28-0.5,							
TP28-1.5								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP09-1.0,	TP10-1.0,	**06-Sep-2017**	**14-Nov-2017**	01-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP11-0.5,	TP12-0.5,							
TP13-0.5,	TP14-0.5,							
TP15-0.0,	TP17-1.0,							
TP18-0.5,	SQA2,							
SQA4								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP16-0.5,	TP25A-0.5,	**07-Sep-2017**	**14-Nov-2017**	02-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP26-0.5,	TP25B-1.0,							
TP32-0.5,	TP33-1.0,							
TP34-1.5,	TP39-1.0,							
TP40-1.0								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP02-1.5,	TP05-0.5,	**08-Sep-2017**	**14-Nov-2017**	03-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP05-2.0,	TP27-1.0							
Snap Lock Bag - frozen on receipt at ALS (EA029)								
HA06-1.5,	HA10-0.5	**15-Sep-2017**	**14-Nov-2017**	10-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA029-E: Magnesium Values								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP01-1.0,	TP03-0.5,	**05-Sep-2017**	**14-Nov-2017**	31-May-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP04-0.5,	TP06-1.0,							
TP07-0.5,	TP08-1.0,							
TP12-1.0,	TP28-0.5,							
TP28-1.5								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP09-1.0,	TP10-1.0,	**06-Sep-2017**	**14-Nov-2017**	01-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP11-0.5,	TP12-0.5,							
TP13-0.5,	TP14-0.5,							
TP15-0.0,	TP17-1.0,							
TP18-0.5,	SQA2,							
SQA4								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP16-0.5,	TP25A-0.5,	**07-Sep-2017**	**14-Nov-2017**	02-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP26-0.5,	TP25B-1.0,							
TP32-0.5,	TP33-1.0,							
TP34-1.5,	TP39-1.0,							
TP40-1.0								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP02-1.5,	TP05-0.5,	**08-Sep-2017**	**14-Nov-2017**	03-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP05-2.0,	TP27-1.0							
Snap Lock Bag - frozen on receipt at ALS (EA029)								
HA06-1.5,	HA10-0.5	**15-Sep-2017**	**14-Nov-2017**	10-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
EA029-F: Excess Acid Neutralising Capacity								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP01-1.0,	TP03-0.5,	**05-Sep-2017**	**14-Nov-2017**	31-May-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP04-0.5,	TP06-1.0,							
TP07-0.5,	TP08-1.0,							
TP12-1.0,	TP28-0.5,							
TP28-1.5								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP09-1.0,	TP10-1.0,	**06-Sep-2017**	**14-Nov-2017**	01-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP11-0.5,	TP12-0.5,							
TP13-0.5,	TP14-0.5,							
TP15-0.0,	TP17-1.0,							
TP18-0.5,	SQA2,							
SQA4								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP16-0.5,	TP25A-0.5,	**07-Sep-2017**	**14-Nov-2017**	02-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP26-0.5,	TP25B-1.0,							
TP32-0.5,	TP33-1.0,							
TP34-1.5,	TP39-1.0,							
TP40-1.0								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP02-1.5,	TP05-0.5,	**08-Sep-2017**	**14-Nov-2017**	03-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP05-2.0,	TP27-1.0							
Snap Lock Bag - frozen on receipt at ALS (EA029)								
HA06-1.5,	HA10-0.5	**15-Sep-2017**	**14-Nov-2017**	10-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA029-G: Retained Acidity								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP01-1.0, TP04-0.5, TP07-0.5, TP12-1.0, TP28-1.5	TP03-0.5, TP06-1.0, TP08-1.0, TP28-0.5,	**05-Sep-2017**	**14-Nov-2017**	31-May-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP09-1.0, TP11-0.5, TP13-0.5, TP15-0.0, TP18-0.5, SQA4	TP10-1.0, TP12-0.5, TP14-0.5, TP17-1.0, SQA2,	**06-Sep-2017**	**14-Nov-2017**	01-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP16-0.5, TP26-0.5, TP32-0.5, TP34-1.5, TP40-1.0	TP25A-0.5, TP25B-1.0, TP33-1.0, TP39-1.0,	**07-Sep-2017**	**14-Nov-2017**	02-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP02-1.5, TP05-2.0,	TP05-0.5, TP27-1.0	**08-Sep-2017**	**14-Nov-2017**	03-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
Snap Lock Bag - frozen on receipt at ALS (EA029)								
HA06-1.5,	HA10-0.5	**15-Sep-2017**	**14-Nov-2017**	10-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA029-H: Acid Base Accounting								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP01-1.0,	TP03-0.5,	**05-Sep-2017**	**14-Nov-2017**	31-May-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP04-0.5,	TP06-1.0,							
TP07-0.5,	TP08-1.0,							
TP12-1.0,	TP28-0.5,							
TP28-1.5								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP09-1.0,	TP10-1.0,	**06-Sep-2017**	**14-Nov-2017**	01-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP11-0.5,	TP12-0.5,							
TP13-0.5,	TP14-0.5,							
TP15-0.0,	TP17-1.0,							
TP18-0.5,	SQA2,							
SQA4								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP16-0.5,	TP25A-0.5,	**07-Sep-2017**	**14-Nov-2017**	02-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP26-0.5,	TP25B-1.0,							
TP32-0.5,	TP33-1.0,							
TP34-1.5,	TP39-1.0,							
TP40-1.0								
Snap Lock Bag - frozen on receipt at ALS (EA029)								
TP02-1.5,	TP05-0.5,	**08-Sep-2017**	**14-Nov-2017**	03-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓
TP05-2.0,	TP27-1.0							
Snap Lock Bag - frozen on receipt at ALS (EA029)								
HA06-1.5,	HA10-0.5	**15-Sep-2017**	**14-Nov-2017**	10-Jun-2020	✓	**14-Nov-2017**	12-Feb-2018	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	4	35	**11.43**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	2	35	**5.71**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	2	35	**5.71**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Suspension Peroxide Oxidation-Combined Acidity and Sulphate	EA029	SOIL	In house: Referenced to Ahern et al 2004 - a suspension peroxide oxidation method following the 'sulfur trail' by determining the level of 1M KCL extractable sulfur and the sulfur level after oxidation of soil sulphides. The 'acidity trail' is followed by measurement of TAA, TPA and TSA. Liming Rate is based on results for samples as submitted and incorporates a minimum safety factor of 1.5.

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house

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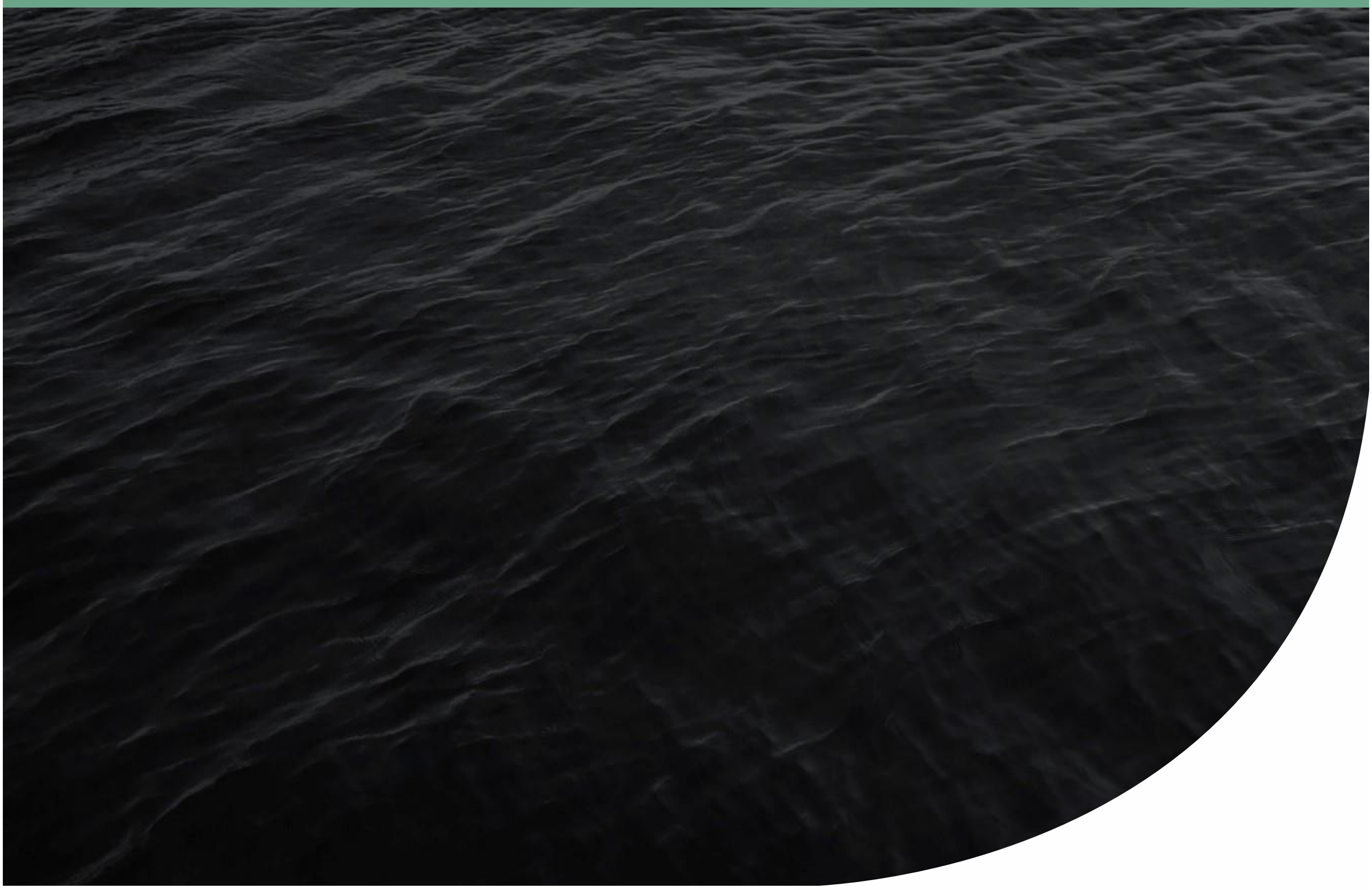
Appendix K Local Water Management Strategy

Local Water Management Strategy

Maddington Kenwick Strategic Employment Area - Precinct 1

Project No: EP17-010(11)

Prepared for City of Gosnells
April 2019



Document Control

Doc name:	Local Water Management Strategy Maddington Kenwick Strategic Employment Area - Precinct 1				
Doc no.:	EP17-010(11)--014E ASC				
Version	Date	Author		Reviewer	
1	May 2018	Aisha Chalmers	ASC	David Coremans	DPC
	For client review				
A	June 2018	Aisha Chalmers	ASC	David Coremans	DPC
	For client review				
B	July 2018	Aisha Chalmers	ASC	David Coremans	DPC
	For client review				
C	November 2018	Aisha Chalmers	ASC	David Coremans	DPC
	For submission to Department of Water and Environmental Regulation				
D	January 2019	Aisha Chalmers	ASC	David Coremans	DPC
	For submission to Department of Water and Environmental Regulation				
E	April 2019	Aisha Chalmers	ASC	David Coremans	DPC
	Updated to incorporate LSP Rev N				

Executive Summary

The Maddington Kenwick Strategic Employment Area (MKSEA) has been identified for future industrial development since 1990. Located in the City of Gosnells (CoG) and City of Kalamunda (CoK), the MSKEA has been divided into three planning precinct areas. The site has been rezoned from rural to industrial under the *Metropolitan Region Scheme* and from rural to business development under the CoG *Town Planning Scheme 6* (CoG 2002).

The CoG are progressing a structure plan (SP) for Precinct 1 (herein referred to as 'the site'), Precinct 2 and Precinct 3B. The site is bounded by Victoria Road to the west, Tonkin Highway to the north and Bickley Road to the south. Tonkin Highway and Bickley Road intersect at the south-eastern corner of the site. The lots comprising Bush Forever Site 53, bound by Tonkin Highway and Clifford Street, are adjacent to but not within the site.

The CoG have prepared a SP for the site which covers an area of 119 ha and outlines future industrial land, the proposed internal road network, areas of open space and makes provision for stormwater drainage requirements. This local water management strategy (LWMS) details the water management approach to support the SP and is intended to satisfy the requirement to prepare a LWMS in accordance with *Better Urban Water Management* (WAPC 2008).

The Judeca Investments Pty Ltd landholdings structure plan is located within the site and was supported by the *Local Water Management Strategy for MKSEA Area 1* (Area 1 LWMS) (McDowell Affleck 2016). This LWMS assumes that Area 1 maintains pre-development discharge rates and has/is being built in accordance with the Area 1 LWMS (McDowell Affleck 2016)

Water will be managed using an integrated water cycle management approach. The first step in applying integrated water cycle management is to understand the existing environment. In summary, the environmental investigations conducted to date indicate that:

- The site receives an average annual rainfall of 820 mm with the majority of the rainfall received between the months of May and August.
- Topography of the site ranges from 12 m Australian height datum (AHD) in the south west to 28 m AHD in the north east.
- Soils within the site can be characterised as topsoil or fill overlying sand, clayey, silty or gravelly materials. The depth of topsoil, fill and sand overlying less permeable material ranges from 0.3 m to over 2 m.
- The permeability of soils underlying the site is of high variability ranging from 0.2 m/day in fill overlying sandy clay to 45 m/day in sand.
- The acid sulfate soil (ASS) investigation identified limited to no ASS risk within the upper 2.0 m of the soil profile across all three MKSEA precincts, with isolated areas of low risk.
- Stormwater runoff within the site is conveyed towards Victoria Road or Bickley Road via a combination of overland flow and a number of existing man-made drains.
- Hydrological and hydraulic modelling within XPSWMM has been used to identify pre-development peak flows entering and leaving the site. In the major rainfall event, 1.1 m^3/s discharges from the site, most of which discharges towards Bickley Brook via existing pit and pipe networks, unlined drains, culverts and overland flows.

- Nutrient concentrations within existing unlined open drains were typical of sites historically utilised for grazing and rural agriculture and generally exceeded relevant guideline values.
- Groundwater beneath the site is typically perched on the low permeability soil layer beneath topsoil and the shallow sand profile.
- Maximum groundwater level (MGL) across the site ranges between 13 m AHD near the western boundary and 21 m AHD near Tonkin Highway, with depth to this perched MGL ranging from 0.9 m to 4.5 m below ground level.
- Groundwater quality beneath the site is typical of sites historically utilised for grazing and rural agriculture and nutrient concentrations generally exceed relevant surface water quality guideline values.
- The majority of the site is listed as a multiple use wetland. There is one resource enhancement wetland (REW) (UFI 8050) within the site. Vegetation within the wetland is expected to be sustained by direct rainfall and perched groundwater, and not from incoming surface water flows.
- The site has historically been used for rural lifestyle and small scale agricultural purposes with some more recent light industrial activity.

The LWMS design objectives seek to deliver best practice outcomes using a water sensitive urban design approach, including detailed management approaches for:

- Water consumption
- Wastewater management
- Stormwater quantity and quality management
- Groundwater level and quality management
- Wetland management.

The overall approach to water supply and wastewater servicing are to utilise reticulated scheme water and groundwater. Water efficiency measures (e.g. waterwise gardening (WWG)) will be implemented to reduce water requirements.

Stormwater management focuses on treating runoff from the small rainfall event as close to source as possible within lots and road reserves to mimic the existing hydrological regime. Detention structures are also required within some post-development catchments to maintain pre-development peak flow rates.

Groundwater management focuses on maintaining the MGL by specifying where the invert of treatment and detention structures can be located. These should generally follow existing drain inverts so that shallow perched groundwater conditions (which potentially feeds the wetland) are not altered. For the majority of the site, existing soil profiles will provide sufficient depth of sand to facilitate building and pavement construction. Finished flood levels of habitable buildings will need to be protected from groundwater through the use of sand fill.

Non-structural measures (e.g. education) have been proposed to ensure both stormwater and groundwater quality outcomes are met.

In summary, the recommended approach to water management for MKSEA Precinct 1 includes:

- Maintain flow regime to the wetland and sensitive environment within the site so that the hydrology feeding these is maintained.
- Avoid changes to existing groundwater controls so that groundwater conditions are maintained.
- Avoid the need for significant imported fill that could potentially alter catchment hydrology.
- Treatment of road reserve runoff via extended detention/infiltration in swales.
- Lots retain small event runoff (i.e. first 15 mm of rainfall) on site and detain some runoff up to the major event on site.
- Conveyance of minor and major event runoff from lots and road reserves will be achieved via swales and overland flow within road reserves.
- Minor and major event flows will be detained within swales and detention areas to ensure pre-development peak flows discharging from the MKSEA are maintained.

The proposed design criteria and the manner in which they are proposed to be achieved are presented in **Table E 1**. This table provides a readily auditable summary of the required outcomes which can be used in the future detailed design stage to demonstrate that the agreed objectives for water management at the site have actually been achieved.

This LWMS demonstrates that the site is capable of being developed by following the recommendations detailed in the report.

Table E 1 Water management criteria and compliance summary

Management aspect	Criteria number	Criteria description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
Water conservation	WC1	Ensure the efficient use of all water resources	Lots will be provided with potable water through the integrated water supply system	Developer / CoG	Detailed design
			Promotion of rainwater tanks, water efficient appliances and WWG principles for use within lots	CoG	Lot development approvals
			Use of water efficient fittings and toilets within lots	Lot owner / lot developer	Building construction
			Use of WWG principles across open space areas and swales (within road reserves)	Developer / CoG	Landscape design
	WC2	All lots will be connected to a reticulated sewer network	General building wastewater be serviced by reticulated sewer	Developer / CoG	Detailed design
			Wastewater from any industrial processes will be treated appropriately prior to discharge to sewer	Lot owner / lot developer	Lot development approvals
Stormwater management	SW1	Treat the small rainfall event (i.e. first 15 mm) on lots at source within the boundary of each lot.	Vegetated bio-retention areas and/or the use of waterwise landscaped areas sized to treat the small rainfall event will be located within lots.	Lot owner / lot developer	Lot development approvals
	SW2	Treat the small rainfall event (i.e. first 15 mm) from road reserves at source.	Swales within road verge will treat small event rainfall from the adjacent road bitumen.	Developer / CoG	Detailed design
	SW3	Maintain pre-development peak flow rates up to the major storm event (i.e. 1 % annual exceedance probability (AEP)) at key discharge locations.	Lot detention areas (LDAs) located within the lot will detain minor and major event runoff.	Lot owner / lot developer	Lot development approvals
			Swales and detention areas will detain the minor and major rainfall event runoff from road reserves to maintain pre-development peak flow rates.	Developer / CoG	Detailed design
	SW4	Provide conveyance of existing upstream flows through the site.	The existing culverts beneath Tonkin Highway and the flow path through the adjacent Bush Forever site will be maintained.	Developer / CoG	Detailed design

Table E 1 Water management criteria and compliance summary (continued)

Management aspect	Criteria number	Criteria description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
Stormwater management	SW5	Roads to remain passable in the minor storm event (i.e. 10% AEP).	The use of swales and a pit and pipe network will ensure roads remain passable in the minor storm event.	Developer / CoG	Detailed design
	SW6	Finished floor levels of habitable buildings should have a 300 mm clearance from the 1% AEP top water level (TWL) within water sensitive urban design (WSUD) structures.	Localised and minor sand fill may be required to ensure finished flood levels of habitable buildings meet the required clearances.	Lot owner / lot developer	Lot development approvals
	SW7	Apply appropriate non-structural measures to reduce pollutant loads.	Street sweeping on a regular basis.	Developer / CoG	For agreed maintenance period until handover to CoG
			No fertiliser use is proposed within swales, as these will be vegetated with nutrient absorbing vegetation species. Minimising fertiliser use to establish and maintain vegetation within open space areas.	Developer / CoG	Landscape implementation
			Education of lot owners regarding fertiliser application and the use of nutrient absorbing vegetation within lots.	CoG	Lot development approvals
Groundwater management	GW1	Existing drain inverts and groundwater controls will be retained to maintain the existing groundwater conditions.	The invert of existing culverts will be maintained and the invert of all WSUD structures may be set at existing drain inverts.	Developer / CoG	Detailed design
				Lot owner / lot developer	Lot development approvals
	GW2	Subsoil drains will not be used to lower groundwater levels, and where used below road pavement should be set at or above MGL, the underlying clay layer or existing drain inverts.	Any subsoil drains used to ensure pavement integrity will be set at or above MGL, the underlying clay layer or existing open drain inverts.	Developer / CoG	Detailed design

Table E 1 Water management criteria and compliance summary (continued)

Management aspect	Criteria number	Criteria description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
Groundwater management	GW3	Finished floor levels of habitable buildings should have a minimum 500 mm clearance from maximum groundwater level (MGL) or controlled groundwater level (CGL).	Sand fill may be required to ensure the required clearances to MGL or CGL are met.	Lot owner / lot developer	Lot development approvals
	GW4	Invert of WSUD structures will be set at MGL, the underlying clay layer or existing drain inverts.	Locating invert of all WSUD structures at MGL, the underlying clay layer or on existing drain inverts.	Lot owner / lot developer	Lot development approvals
				Developer / CoG	Detailed design
	GW5	Maintain or improve groundwater quality leaving the site.	Lot owners are to select landscape species from the City of Gosnells MKSEA Landscape Palette.	Lot owner / lot developer	Lot development approvals
			Landscape design and management to avoid the application of inorganic nutrients.		
			Minimal fertiliser use to establish and maintain vegetation within open space areas.	CoG	Lot development approvals
			Appropriate treatment of all wastewater within lots prior to discharge to the reticulated sewer network.	Developer / CoG	Detailed design
			Appropriate treatment of small rainfall event runoff.	Lot owner / lot developer	Lot development approvals
				Developer / CoG	Detailed design
Wetland management	Comply with WC2, SW1, SW2, SW3, SW7, GW1, GW2, GW4 and GW5				

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Abbreviation Tables

Table A1: Abbreviations – general terms

General terms	
AAMGL	Average annual maximum groundwater level
AEP	Annual exceedance probability
AHD	Australian height datum
ARI	Average recurrence interval
ASS	Acid sulfate soils
BTEX	Benzene, toluene, ethylbenzene and xylene
CAP	Contingency action plan
CCW	Conservation category wetland
CGL	Controlled groundwater level
DWMS	District water management strategy
EC	Electrical conductivity
FRP	Filterable reactive phosphorous
GPT	Gross pollutant trap
LDA	Lot detention area
LWMS	Local water management strategy
MGL	Maximum groundwater level
MKSEA	Maddington Kenwick Strategic Employment Area
MUW	Multiple use wetland
NH_4	Ammonium
NO_X	Nitrate and nitrite
NWQMS	National Water Quality Management Strategy
POS	Public open space
PRI	Phosphorus retention index
REW	Resource enhancement wetland
SP	Structure plan
TKN	Total Kjeldahl nitrogen
TN	Total nitrogen
TP	Total phosphorous

Table A1: Abbreviations – general terms (continued)

General terms	
TWL	Top water level
UWMP	Urban water management plan
WA	Western Australia
WQIP	Water quality improvement plan
WQPN	Water quality protection note
WSUD	Water sensitive urban design
WWG	Waterwise gardens

Table A2: Abbreviations – organisations

Organisations	
ABS	Australian Bureau of Statistics
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resources Management Council of Australian and New Zealand
BoM	Bureau of Meteorology
CoG	City of Gosnells
CoK	City of Kalamunda
DBCA	Department of Biodiversity, Conservation and Attractions
DER	Department of Environmental Regulation (now DWER)
DoW	Department of Water (now DWER)
DPaW	Department of Parks and Wildlife (now DBCA)
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority
SRT	Swan River Trust (now DBCA)
WALIA	Western Australian Land Information Authority
WAPC	Western Australian Planning Commission

Table A3: Abbreviations – units of measurement

Units of measurement	
ha	Hectare
kL	Kilolitres
kL/annum	Kilolitres per annum
kL/ha/annum	Kilolitres per square meter per annum
km	Kilometre
m	Metre
m AHD	Metres in relation to the Australian height datum
m/day	Meters per day
m^2	Square metre
m^3	Cubic metre
m^3/ha	Cubic metre per hectare
m^3/s	Cubic metre per second
m^3/s/ha	Cubic metre per second per hectare
mm	Millimetre
mg/L	Milligrams per litre
µg/L	Micro-grams per litre
°C	Degrees centigrade
%	Percentage
mS/cm	Millisiemens per centimetre

Terminology Tables

Table A4: Terminology - design rainfall

Equivalent average recurrence interval (ARI) terminology	Average exceedance probability (AEP) terminology utilised
1 in 1 year ARI event	1 exceedance year (EY) event
1 in 1.5 year ARI event	50% AEP event
1 in 5 year ARI event	20% AEP event
1 in 10 year ARI event	10% AEP event
1 in 20 ARI event	5% AEP event
1 in 50 ARI event	2% AEP event
1 in 100 ARI event	1% AEP event
1 in 200 ARI event	1 in 200 AEP event
1 in 500 ARI event	1 in 500 AEP event

1 Introduction

1.1 Background

The Maddington Kenwick Strategic Employment Area (MKSEA) has been identified for future industrial development since 1990. Located in the City of Gosnells (CoG) and City of Kalamunda (CoK), the MSKEA has been divided into three planning precinct areas. The CoG are progressing structure planning Precinct 1 (which is covered by this report) Precinct 2 and Precinct 3B.

Precinct 1 (herein referred to as 'the site'), is approximately 119 hectares (ha) in size and lies approximately 15 km south-east of Perth. The majority of lots are bound by Victoria Road to the west, Tonkin Highway to the north and Bickley Road to the south. Tonkin Highway and Bickley Road intersect at the south-eastern corner of the site. The lots comprising Bush Forever Site 53, bound by Tonkin Highway and Clifford Street, are adjacent to but not within the site. The location and extent of the site is shown in .

1.2 Town planning context

The site has been rezoned from 'Rural' to 'Industrial' under the *Metropolitan Region Scheme* and from 'Rural' to 'Business Development' under the CoG *Town Planning Scheme 6* (CoG 2002).

1.3 Purpose of this report

In accordance with *Local Planning Policy 5.8 Maddington Kenwick Strategic Employment Area Planning Framework* (CoG 2014), CoG have prepared a structure plan (SP) to support and guide future industrial development within the site. Following the approval of a SP, industrial development will be achieved through subdivision approvals and/or development approvals (DAs), in accordance with the approved SP layout. This local water management strategy (LWMS) details the water management approach to support the SP and is intended to satisfy the requirement to prepare a LWMS in accordance with *Better Urban Water Management* (WAPC 2008).

1.4 Policy framework

There are a number of State Government policies of relevance to the site. These policies include:

- *Town Planning Scheme No. 6* (CoG 2002)
- *State Water Strategy* (Government of WA 2003)
- *State Planning Policy 2.9 Water Resources* (WAPC 2006a)
- *State Planning Policy 2.10: Swan and Canning River System* (WAPC 2006b)
- *State Water Plan* (Government of WA 2007)
- *Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA 2008)
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC 2009)
- *Water resource considerations when controlling groundwater in urban development* (DoW 2013)
- *Liveable Neighbourhoods* (WAPC 2007, 2015)

- *Local Planning Policy 4.7: Planning and development of public open space and streetscapes* (CoG 2015).
- *Environmental Factor Guideline: Inland Waters Environmental Quality* (EPA 2016b)
- *Environmental Factor Guideline: Hydrological Processes* (EPA 2016a).

In addition to the above policies, there are a number of published guidelines and standards available that provide direction regarding the water discharge characteristics that urban developments should aim to achieve.

These are key inputs that relate either directly or indirectly to the site and include:

- *National Water Quality Management Strategy* (NWQMS) (ANZECC and ARMCANZ 2000)
- *Australian Runoff Quality* (Engineers Australia 2006)
- *Stormwater Management Manual for Western Australia* (DoW 2007)
- *Better Urban Water Management* (WAPC 2008)
- *Swan and Canning Water Quality Improvement Plan* (WQIP) (SRT 2009)
- *Decision Process for Stormwater Management in Western Australia* (DWER 2017)
- *Australian Rainfall and Runoff* (Engineers Australia 1987, 2016).

The guidance documents listed indicate a need for accurate baseline information prior to urban development. This will ensure that any future development is able to fulfil the stormwater management requirements of Department of Water and Environmental Regulation (DWER) and engineering standards specified by CoG, but will also ensure that realistic water management criteria that are practically achievable are adopted.

1.5 Previous studies

1.5.1 District Water Management Strategy

The *Report on MKSEA Precinct 1 District Water Management Strategy* (DWMS) (GHD 2010) was prepared to support rezoning of MSKEA Precinct 1 to ‘industrial’.

The key design and management objectives detailed in the DWMS include:

- Water use
    - Water usage within the predominantly industrial MKSEA Precinct 1 is to be fit for purpose and the use of scheme water to be minimised.
    - During subsequent planning stages, each site will be required to prepare a water management plan which details the sites water requirements, the water source, any onsite treatment required and how wastewater will be disposed.
- Water conservation and efficiency
    - Industry best practice in water efficiency is to be promoted and this will be dependent on the nature of the industry.
    - Meeting 5 Start Plus provisions for all new tap fittings.
    - The use of native plants is to be promoted within public open space (POS).

- Water quantity management
    - Pre-development critical discharge volume and peak flow be maintained relative to pre-development conditions, unless otherwise established through determination of ecological water requirements for sensitive environments or required for flood risk management.
    - For the critical one year average recurrence interval (ARI) event, the post-development discharge volume and peak flow rates shall be maintained relative to pre-development conditions.
    - For all other rainfall events up to the 1 in 100 year ARI event, the post-development catchment runoff shall be managed to maintain discharge peak flow rates relative to pre-development conditions.
- Water quality management
    - Maintain surface and groundwater quality at pre-development levels and where possible, improve quality of water leaving the development area.
    - If the pollutant outputs of development exceed catchment ambient conditions, the proponent shall undertake water quality improvements in the development area or, alternatively, arrange equivalent water quality improvement offsets inside the catchment. If ambient conditions have not been determined, the development should meet relevant water quality guidelines stipulated in the NWQMS (ANZECC and ARMCANZ 2000).
    - Ensure that all runoff contained in the drainage infrastructure network receives treatment prior to discharge to a receiving environment consistent with the *Stormwater Management Manual for Western Australia* (DoW 2007) as amended and as per CoG requirements.
    - All outflows from subsoils should receive treatment prior to discharge to the receiving environment or watercourse.

1.5.2 Local Water Management Strategy

The *Local Water Management Strategy for MKSEA Area 1* (Area 1 LWMS) (McDowell Affleck 2016) was prepared to support the Judeca Investments Pty Ltd landholdings structure plan. This area is a sub-set of Precinct 1.

The key design and management objectives detailed in the Area 1 LWMS are congruent with the objectives detailed in the DWMS, with the exception of the below objectives that were further refined within the LWMS:

- Water quantity management
    - Retention of up to the 1 year 1 hour ARI (with no discharge) within each development area.
    - Detention of the 20 year ARI below finished lot levels with storage devices such as soakwells, box culverts or similar with outflows not to exceed pre-development flow rates during the same event within each development area.
- Groundwater level management
    - Manage the development to minimise changes to pre-development groundwater levels (WAPC 2008). Effluent disposal areas should be at least 1.2 m above the Annual Average Maximum Groundwater Level (AAMGL) and in accordance with the CoG guidelines, building pads should have at least 0.5 m clearance of the AAMGL.

1.6 LWMS Objectives

This LWMS has been developed in consideration of the objectives and principles detailed in the overarching DWMS and *Better Urban Water Management* (WAPC 2008). This LWMS also includes the water management approach and spatial area detailed in the Area 1 LWMS. The intention is that design objectives and criteria for this LWMS accommodate the already constructed Area 1. This LWMS is intended to support the SP and is further based on the following major objectives:

- Protect sensitive receiving environments from potential impacts of land use change and future industrial uses.
- Maintain overall existing peak flow rates from the site.
- Develop a water conservation strategy for the site that will ensure the efficient use of all water resources.
- Minimise the amount of fill that needs to be imported to develop the land, which will maintain the existing hydrology.
- Maintain existing arterial flow pathways through the site to service upstream catchments.
- Incorporate appropriate best management practices into the drainage system that address the environmental and stormwater management issues identified.
- Provide a broad level stormwater management framework to support future industrial development.
- Minimise ongoing operation and maintenance costs for the land owners and CoG.
- Gain support from DWER and CoG for the proposed method to manage stormwater within the site and potential impacts on downstream areas.

Detailed design criteria for water management within the site are further discussed in **Section 4**.

2 Proposed Development

The CoG have prepared a SP for the site, which outlines the future industrial land uses, including:

- Areas to be developed for industrial land uses.
- Conservation areas and appropriate buffers.
- The provision and location of areas to accommodate stormwater drainage requirements.
- The proposed internal road network.
- Areas to be designated as open space.

The MKSEA Precinct 1 SP is provided in **Appendix A**.

The land uses set out in the SP align with those detailed in the CoG *Town Planning Scheme No.6* (CoG 2002), allowing for the progression of industrial development within Precinct 1 of the MKSEA in accordance with the established planning framework.

The key elements of the water management approach are:

- Maintain flow regime to the wetland and sensitive environment within the site so that the hydrology feeding these is maintained.
- Avoid changes to existing groundwater controls so that groundwater conditions are maintained.
- Avoid the need for significant imported fill that could potentially alter catchment hydrology.
- Treatment of road reserve runoff via extended detention/infiltration in swales.
- Lots retain small event runoff (i.e. first 15 mm of rainfall) on site and detain some runoff up to the major event on site.
- Conveyance of minor and major event runoff from lots and road reserves will be achieved via swales and overland flow within road reserves.
- Minor and major event flows will be detained within swales and detention areas to ensure pre-development peak flows discharging from the MKSEA are maintained.

MKSEA Precinct 1 discharges in part to Precinct 2. The stormwater management strategy for MKSEA Precinct 1 has therefore been progressed considering the wider Precinct 2 development. This ensures the most efficient and integrated drainage design across the MKSEA, which minimises the infrastructure provided and ongoing maintenance required.

3 Pre-development Environment

3.1 Sources of information

The following sources of information were used to provide a broad regional environmental context for the site:

- *Acid Sulfate Soil - Swan Coastal Plain database* (DER 2017)
- *Contaminated Sites Database* (DER 2017)
- *Geomorphic Wetland Database - Swan Coastal Plain* (DPaW 2017)
- *Landgate Map Viewer* (WALIA 2017)
- *LiDAR Elevation Dataset* (DoW 2017a)
- *Perth Metropolitan Region 1:50,000 Environmental Geology Series Armadale Part Sheets 2033 I & 2133 IV* (Jordan 1986)
- *Water Information Reporting* (DoW 2017b)
- *Perth Groundwater Map* (DoW 2017c)
- *Water Register* (DWER 2018)
- *Weather and Climate Statistics Data* (BoM 2017)

The CoG have previously commissioned a range of studies and investigations across the MKSEA to understand the environmental attributes and values of the area and to demonstrate the feasibility of industrial development. A number of investigations were also completed to support the *Area 1 LWMS* (McDowell Affleck 2016). The various reports associated with these investigations have been reviewed as part of the preparation of this document and include:

- *MKSEA Engineering Feasibility Study* (GHD 2005)
- MKSEA *Environmental Review: Flora, Vegetation, Fauna and Wetlands* (Cardno BSD 2005)
- *MKSEA Preliminary Transport Study* (Cardno BSD 2006)
- *MKSEA Surface Water and Groundwater Investigation and Monitoring Program* (Aquaterra 2008)
- *Preliminary Investigation of Aboriginal Heritage – City of Gosnells MKSEA* (ACHM 2009)
- *The Flora, Vegetation and Wetlands of the MKSEA* (Tauss and Weston 2010)
- *MKSEA Surface Water and Groundwater Monitoring and Investigation Report* (Endemic 2012)
- *Report on Geotechnical Investigation: Proposed Warehouse Development Lots 252 to 256 Clifford Street, Maddington, WA* (Douglas Partners 2015)
- Groundwater monitoring at Clifford Street, Maddington (D Newsome [Strategen] 2016, *pers. comm.*, 19 February)
- Clifford St, Maddington - Precinct 1 MKSEA: Information supporting the preparation of a LWMS (D Newsome [Strategen] 2016, pers. comm., 8 April).

Site-specific investigations have also been conducted to provide more detail to the existing regional information and to ensure coverage of the site beyond Area 1:

- Geotechnical investigation (JDSi 2017)
- Surface and groundwater monitoring (**Section 3.4** and **3.5**)
- Acid sulfate soil (ASS) investigation (Emerge Associates 2018a)
- Environmental assessment and management strategy (Emerge Associates 2018b)
- Flora, vegetation and wetland assessment (Emerge Associates 2018c).

3.2 Climate

The south west of Western Australia experiences a Mediterranean climate of hot dry summers and cool wet winters. An average of 820.3 millimetres (mm) of rainfall is recorded annually at the closest weather station to the site (i.e. Gosnells City weather station number 9106). The majority of this rainfall is received between the months of May and August. Mean maximum temperatures from this station range from 18.7 ^{o}C in July to 33.0 ^{o}C in February, while mean minimum temperatures range from 8.7 ^{o}C in July to 18.8 ^{o}C in February (BoM 2017).

3.3 Geotechnical conditions

3.3.1 Topography

The elevation of the site ranges from 12 m Australian height datum (m AHD) at the south-western corner to 28 m AHD at the north-eastern corner of the site (DoW 2017a) (**Figure 1**: Site Locality.

Figure 2). There are two elevated mounds located within or adjacent to the site; one along Victoria Road and one within Lot 252 Clifford Street.

3.3.2 Soils and geology

The Geological Survey of Western Australia, as documented in *Perth Metropolitan Region 1:50,000 Environmental Geology Series Armadale Part Sheets 2033 I & 2133 IV* (Jordan 1986), indicates the site is underlain by the Bassendean Sands and the Guildford Formation and is comprised of:

- Sand (S_8): white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin.
- Sand (S_{10}): white to pale grey at surface, yellow at depth, fine to medium-grained, moderately well sorted, subangular to subrounded quartz, of eolian origin, over other units.
- Sandy clay (Cs): white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp.

The mapped extent of the above soils units across the site is shown in **Figure 3**.

Results of geotechnical investigations are generally consistent with regional mapping (Douglas Partners 2015; JDSi 2017). They indicate that soils underlying the site are generally comprised of topsoil or fill (to depths ranging from 0.1 m to 0.45 m), overlying sand, clayey, silty or gravelly materials. The depth of sand overlying less permeable material within the site ranged from 0.3 m to over 2 m. **Figure 4** shows the depth of the topsoil or fill and the underlying sand across the site and demonstrates that the majority of the site is suitable for onsite retention via infiltration.

The clayey and sandy materials encountered include stiff to hard clay or clayey sand/ sandy clay. A layer of coffee rock was encountered at TP40. These areas are likely to be associated with seasonally perched groundwater. Groundwater bore log information from previous investigations undertaken on behalf of the CoG (Endemic 2012) suggest that the broader area may be underlain by a shallow calcrete horizon, though Endemic (2012) does not propose these exist within Precinct 1. No evidence of calcrete was observed in any of the geotechnical test locations installed within Precinct 1.

Permeability measured within the sand layer of Area 1 ranged from 3.4 m/day to 49 m/day Douglas Partners (2015). Permeability measured across the site (within all soil types) more recently ranged from 0.2 m/day to 8.5 m/day (JDSi 2017).

Geotechnical testing locations are shown in **Figure 3** and both geotechnical reports are provided in **Appendix B**.

3.3.3 Acid sulfate soils

Regional acid sulfate soil (ASS) risk mapping indicates that the site is classified as having a moderate to low risk of ASS occurring within 3 m of the natural soil surface, as shown in **Figure 5** (DER 2017).

The ASS investigation completed by Emerge Associates (2018a) across Precincts 1, 2 and 3B, found no significant evidence of ASS within the shallow potion of topsoil, Bassendean Sand (i.e. sands), coffee rock and fill soil types, but some evidence of potential ASS within Guildford Formation (i.e. clayey sand/sandy clay). Overall, the investigation identified limited to no ASS risk within the upper 2.0 m of the soil profile across MKSEA, with isolated areas of low risk.

3.4 Surface water

3.4.1 Existing hydrological and hydraulic features

There are no existing streamlines within or adjacent to the site.

Existing culverts beneath Tonkin Highway (2 x 750 mm diameter) allow runoff from upstream catchments to flow through Bush Forever Site 53 and into the site via two 600 mm diameter culverts beneath Clifford Street (J Miller [Main Roads Western Australia] 2017, pers. comm., 19 May). Stormwater runoff within the site is then conveyed via a combination of overland flow, unlined open drains and pipes towards Victoria Road or Bickley Road. Emerge Associates conducted a site visit on 19 July 2017 to confirm the presence of culverts and potential outflow locations. A further 375 mm diameter culvert was confirmed beneath Victoria Road, and this conveys runoff from an open drain in Precinct 1 into Precinct 2. Two sets of existing culverts (one 525 mm and one 450 mm diameter culvert) are located beneath Bickley Road and convey runoff from Precinct 1 towards the existing residential area to the south and ultimately into Bickley Brook (GHD 2010).

3.4.2 Surface water flows and levels

As part of a broader monitoring program across MKSEA, Endemic (2012) installed two surface water monitoring stations in July 2009 (labelled SW2 and SW7 in **Figure 6**) and completed the monitoring program in 2011. Gauge plates and automatic water level monitoring stations were installed to determine preliminary rating curves for each station.

Hydrographs and the resulting water level and flow rating curves for these two stations are provided in **Appendix C**. These illustrate that flows at SW2 are responsive to rainfall and SW7 rarely flows.

3.4.3 Pre-development surface runoff modelling

Emerge Associates have prepared 1D and integrated 1D-2D pre-development hydrological and hydraulic models to characterise the existing environment (using XPSWMM), and to enable comparison to the post-development environment (discussed further in **Section 6**).

Surface runoff modelling was not completed by Emerge Associates for Area 1 (i.e. catchments 2 and 3) and its upstream catchments (i.e. catchments 4, 14 and 15) shown in **Figure 7** as this has already been designed and constructed. This LWMS assumes that Area 1 maintains pre-development discharge rates and has/is being built in accordance with the Area 1 LWMS (McDowell Affleck 2016) described in **Section 1.5.2**.

The pre-development models were constructed to account for:

- Inflows from upstream catchments (some of these catchments are shown in **Figure 7**) based on topographic contours.
- Existing pit and pipe networks (primarily along Bickley Road) as informed by the CoG intramaps.
- Existing culverts (see **Figure 7**) based on site visits and data provided by Main Roads.
- The variable depth of sand across the site (see **Figure 4**), informed by geotechnical investigations.
- Depth to maximum groundwater level (MGL) across the site (see **Figure 8**).

The modelling assumptions report provided in **Appendix D** presents the detailed methods and assumptions used to develop the model.

The results of the integrated 1D-2D pre-development model were analysed to better understand the existing hydrological regime including infiltration, ponding and flow pathways in the small, minor (10% AEP) and major (1% AEP) rainfall events. **Figure 6** shows that infiltration of the small event (i.e. first 15 mm of rainfall) occurs across most of the site. Shallow ponding is evident within existing open drains or channels and within the site upstream of Bickley Road.

The extent of flooding along Bickley Road is slightly increased in a major rainfall event (see **Figure 7**). There is an overland flow path (some of which is an unlined drain) upstream of the existing culvert beneath Victoria Road. The remainder of Precinct 1 has areas of localised ponding in the major rainfall event, but no significant flow paths. Pre-development peak flows are shown in **Figure 7** and listed in **Table 1**.

Most of the outflow from the site in a major rainfall event flows towards Bickley Brook (i.e. 0.76 m^3/s). Runoff from the site enters the existing pit and pipe network or unlined drains along Bickley Road before crossing the road via the existing network, through culverts or overland flow along the road.

A smaller outflow (0.34 m^3/s) discharges towards Precinct 2 within the existing unlined drain and culvert beneath Victoria Road. This is a relatively low peak flow rate for a larger contributing area (being upstream catchment 16 and catchment P1_04 within the site). It is assumed that runoff within these areas generally infiltrates or ponds within existing unlined drains.

Table 1 Pre-development peak flows

Location	Minor rainfall event (m^3/s)	Major rainfall event (m^3/s)
Inflow from Catchment 12	0.10	0.19
Inflow from Catchment 13	0.05	0.09
Inflow from Catchment 16	0.04	0.07
Total inflows	**0.19**	**0.35**
Outflow from catchment P1_01	0.14	0.31
Outflow from catchment P1_02A	0.13	0.22
Outflow from catchment P1_04	0.22	0.34
Outflow from catchment P1_05	0.07	0.15
Outflow from catchment P1_06	0.03	0.08
Total outflow towards Precinct 2	**0.22**	**0.34**
Total outflow towards Bickley Brook	**0.37**	**0.76**

Note: this LWMS model does not include Area 1 or its comparatively large catchments upstream of Tonkin Highway.

3.4.4 Surface water quality

Surface water samples at SW2 and SW7 were collected opportunistically (Endemic 2012). All samples were analysed for physical characteristic, nutrients and metals and the first flush sampled was also analysed for benzene, toluene, ethylbenzene, and xylene, (BTEX), hydrocarbons and major pesticides (GHD 2010).

Surface water quality was compared to the ANZECC and ARMCANZ (2000) southwest Australia, slightly disturbed, lowland river protection levels (95th percentile), with total nitrogen and phosphorous compared to the concentration targets for the Yule Brook sub-catchment (SRT 2009). Where there was sufficient flow to collect surface water samples, pH was neutral to alkaline and electrical conductivity (EC) was considered typical of freshwater environments. Nutrient concentrations were typical of sites historically utilised for grazing and rural agriculture and generally exceeded guideline values (ANZECC and ARMCANZ 2000; SRT 2009). Surface water quality monitoring results are provided in **Appendix C**.

Emerge Associates completed a supplementary monitoring program during 2017. One surface water monitoring event was completed on the 22nd June 2017 following rainfall (54.8 mm was recorded on this date at the Gosnells station (BoM 2018)). However, both SW2 and SW7 were dry and therefore no additional data was able to be collected.

3.5 Groundwater

3.5.1 Groundwater levels

Data extracted from the *Perth Groundwater Map* shows that regional groundwater below the site range from 9 m AHD in the western corner to 16 m AHD in the eastern corner (DoW 2017c). Depth to regional groundwater ranges from approximately 3 m to 15 m below ground level. Generally, depth to regional groundwater is lower along Bickley Road and higher along Tonkin Highway and below elevated mounds.

As part of a broader monitoring program across MKSEA, Endemic (2012) installed four groundwater bores within the site in June 2009 (labelled GW6 to GW9 in **Figure 2**) and completed the monitoring program in November 2011. Data loggers were installed in each of the bores with manual measurements taken quarterly for calibration purposes. No perched groundwater was observed at GW9 during 2010 and 2011. Otherwise, depth to the measured (perched) groundwater ranged from approximately 1.75 m to 5 m below ground level. All bores experienced dry periods, especially during 2011. Groundwater hydrographs are provided in **Appendix E**.

Strategen installed four groundwater bores within Area 1 (labelled MB1 to MB4 in **Figure 2**) and completed a monitoring program, which included GW9, from February 2015 to January 2016 (D Newsome [Strategen] 2016, pers. comm., 19 February). These groundwater bores were installed until refusal on the underlying clayey layer in order to monitor for perched groundwater. No perched groundwater was observed within MB01 and GW9. Otherwise, depth to perched groundwater ranged from approximately 0.9 m to 4.5 m below ground level. Bore logs and groundwater level measurements are provided in **Appendix E**.

There are no DWER groundwater monitoring bores within or adjacent to the site that have been recently monitored for groundwater levels (DoW 2017). Emerge Associates completed six months of groundwater level monitoring at accessible and existing groundwater bores located across MKSEA during 2017 (some were inaccessible due to construction activities). Data loggers were installed within GW4 (located within Precinct 2) and GW7 in July 2017. Manual measurements were taken in May and November for calibration purposes. Groundwater level measurements and hydrographs are provided in **Appendix E**.

Groundwater levels measured by various parties across MKSEA were generally highest in 2009. Groundwater levels measured from 2015 were either lower or consistent with the maximum recorded groundwater level contours created by Endemic (2012). Therefore, it is proposed that these 2012 contours (shown in **Figure 2**) represent MGLs across the site. Given the underlying low permeability soil conditions in the shallow soil profile, and that these generally align with the MGL contours, the observed groundwater is most likely representative of a perched groundwater system. The (perched) MGL across the site ranges from approximately 13 m AHD to 21 m AHD. Depth to MGL across the site ranges from approximately at the surface to 6 m below ground level (see **Figure 8**).

These contours provide a general, broadscale mapping of MGL across the site and do not account for any existing groundwater controls (e.g. roadside drains) that will result in localised drawdown. Due to the low permeability soils it is anticipated that the extend of influence of these existing features is limited.

3.5.2 Groundwater quality

Endemic (2012) monitored groundwater quality within GW6 to GW9 from September 2009 to December 2010 on a quarterly basis. Physical characteristics, nutrients and metals were analysed quarterly and BTEX, hydrocarbon and major pesticides were analysed on a half yearly basis (GHD 2010).

The DWMS suggested that shallow groundwater quality be investigated for suitability for irrigation (GHD 2010), however CoG does not support the use of groundwater for irrigation across MKSEA. Endemic (2012) compared groundwater quality to long-term irrigation guidelines and domestic non-potable guidelines (DEC 2010). Groundwater pH was neutral to slightly acidic and EC considered typical of freshwater environments. No exceedances were noted for field parameters, nutrient species, BTEX, hydrocarbons or pesticides. Elevated concentrations of aluminium, iron and manganese was attributed to the presents of mineral rich soil within the site (Endemic 2012).

Nutrient concentrations measured in groundwater by Endemic (2012) were typical of sites historically utilised for grazing and rural agriculture and generally exceeded surface water quality guidelines values (ANZECC and ARMCANZ 2000; SRT 2009). The highest concentration of total nitrogen (19 mg/L) was measured at GW6 in September 2009 and was expected to be from particulate and/or organic sources.

Strategen was able to sample groundwater quality at MB04 in August 2015 (D Newsome [Strategen] 2016, pers. comm., 19 February). Groundwater quality was consistent with the concentrations measured by Endemic.

There are no DWER groundwater monitoring bores within or adjacent to the site that have been recently monitored for groundwater quality (DWER 2018). Emerge Associates completed supplementary monitoring of existing bores during November 2017. Of the bores monitored across MKSEA, three were destroyed, one was never sighted, two were not accessible, two were dry and six did not have sufficient water to successfully collect a sample. Water sampled within GW11 was not tested due to its location within Precinct 3A (beyond the precincts being progressed by the CoG) and within a lot undergoing active construction.

Groundwater quality monitoring results from all programs are provided in **Appendix E** and summarised in **Table 2**.

Table 2 Summary of groundwater quality monitoring results

Analyte	Average	Minimum	Maximum	Standard deviation
Temperature (°C)	20.3	17.2	23.3	1.9
pH	6.78	5.47	7.55	0.57
EC (mS/com)	1.302	0.148	10.520	2.790
Total nitrogen (TN) (mg/L)	5.35	2.30	19.00	5.22
Nitrate (mg/L)	1.610	0.040	7.681	2.266
Nitrite (mg/L)	0.039	0.005	0.100	0.043

Table 2 Summary of groundwater quality monitoring results (continued)

Analyte	Average	Minimum	Maximum	Standard deviation
Nitrate and nitrite (NO_X) (mg/L)	1.88	0.04	7.70	2.94
Total kjeldhal nitrogen (TKN)	3.50	0.10	12.00	3.19
Total phosphorous (TP)	0.30	0.05	1.11	0.30
Filterable reactive phosphorus (FRP)	0.039	0.005	0.160	0.054

3.6 Environmental assets and water-dependent ecosystems

3.6.1 Bush Forever

The Clifford Street Bushland (Bush Forever Site 53) is located between Clifford Street and Tonkin Highway. This is however adjacent to the site, and is not within the site boundary (see **Figure 9**).

3.6.2 Wetlands

There are 13 wetlands mapped in the *Geomorphic Wetland Database* within/adjacent to the site (DPaW 2017), as listed in **Table 3** and shown in **Figure 9**. There is one resource enhancement wetland (REW) and 12 multiple use wetlands (MUW). Very small areas (<0.01 ha) of conservation category wetland (UFI 15115, which is also associated with Bush Forever Site 53) and REW (UFI 15983) occur however are not considered relevant to planning of the site due to their size and location.

Table 3 Details of geomorphic wetlands located in the site

UFI number	Wetland type	Conservation status
8048	Palusplain	Multiple use
8049	Palusplain	Multiple use
8051	Sumpland	Multiple use
8052	Palusplain	Multiple use
8053	Sumpland	Multiple use
8054	Sumpland	Multiple use
8055	Dampland	Multiple use
8056	Palusplain	Multiple use
13369	Palusplain	Multiple use
15007	Sumpland	Multiple use
15116	Palusplain	Multiple use
15768	Palusplain	Multiple use

Table 3 Details of geomorphic wetlands located in the site (continued)

UFI number	Wetland type	Conservation status
8050	Sumpland	Resource enhancement

3.6.2.1 Wetland assessment

The wetland assessment completed by Emerge Associates (2018c) determined that 12 of the 13 mapped wetlands are aligned with their current geomorphic classification and management category.

The depth of topsoil, fill or sand above the lower permeability layer beneath this wetland ranges from 1.3 m in the western corner to 2.1 m in the eastern corner (see **Figure 4**). The pre-development surface runoff modelling showed minimal ponding within this wetland in the small rainfall event except within existing open drains or channels (see **Appendix B**). MGL beneath the wetland ranges from approximately at the surface in the western corner to 4 m below natural surface in the eastern corner (see **Figure 2**). As noted previously, MGL is more likely a reflection of seasonally perched groundwater across the majority of the site rather than a permanent superficial aquifer. Therefore, infiltration of frequent, small rainfall events and recharge from these directly at source result in groundwater perching beneath this wetland. Consequently, vegetation within the wetland is expected to be sustained by direct rainfall and perched groundwater, and not from incoming surface water flows. Replication of the existing hydrological regime (i.e. infiltrating the small rainfall event as close to source as possible) is therefore necessary to maintain the hydrology of the wetland.

3.7 Current and historical land uses

Review of historical images available from 1953 onwards shows that large areas of the site were cleared of native vegetation around 1965, with continual clearing until 2017 (WALIA 2017). It is likely that vegetation was cleared for grazing and/or cropping purposes.

Since 2012, development has occurred within the southern and central portion of the site. Most recently (2017) this has resulted in the construction of most of the proposed roads within Precinct 1 and subsequent build out of many of the proposed industrial lots. There is an operating poultry farm located within Lot 988 Victoria Road.

A search of the *Contaminated Sites Database* found there to be no classified contaminated sites within the site (DWER 2018). There are two classified contaminated sites located within 200 m of the southern site boundary (i.e. Bickley Road). Any potential contamination from these contaminated sites is not considered to impact on industrial use within the site given these are also located within an existing industrial precinct, and are hydrologically downstream of the site.

3.8 Summary of existing environment

In summary, the environmental investigations conducted to date indicate that:

- The site receives an average annual rainfall of 820 mm with the majority of the rainfall received between the months of May and August.
- Topography of the site ranges from 12 m AHD in the south west to 28 m AHD in the north east.
- Soils within the site can be characterised as topsoil or fill overlying sand, clayey, silty or gravelly materials. The depth of topsoil, fill and sand overlying less permeable material ranges from 0.3 m to over 2 m.
- The permeability of soils underlying the site is of high variability ranging from 0.2 m/day in fill overlying sandy clay to 45 m/day in sand.
- The ASS investigation identified limited to no ASS risk within the upper 2.0 m of the soil profile across MKSEA, with isolated areas of low risk.
- There are a number of existing man-made drains across the site that drain towards Victoria Road or Bickley Road.
- Hydrological and hydraulic modelling within XPSWMM has been used to identify pre-development peak flows entering and leaving the site. In the major rainfall event, 1.1 m^3/s discharges from the site, most of which discharges towards Bickley Brook via existing pit and pipe networks, unlined drains, culverts and overland flows.
- Nutrient concentrations within existing unlined open drains were typical of sites historically utilised for grazing and rural agriculture and generally exceeded relevant guideline values.
- Groundwater beneath the site is typically perched on the low permeability soil layer beneath topsoil and the shallow sand profile.
- MGL across the site ranges between 13 m AHD near the western boundary and 21 m AHD near Tonkin Highway, with depth to this perched MGL ranging from 0.9 m to 4.5 m below ground level.
- Groundwater quality beneath the site is typical of sites historically utilised for grazing and rural agriculture and nutrient concentrations generally exceed relevant surface water quality guideline values.
- The majority of the site is listed as a multiple use wetland. There is one resource enhancement wetland (REW) (UFI 8050) within the site.
- The site has historically been used for rural lifestyle and small scale agricultural purposes with some more recent light industrial activity.

4 Design Criteria and Objectives

This section outlines the objectives and design criteria that this LWMS and future Urban Water Management Plans (UWMP) must achieve. The water management strategy covers stormwater management, groundwater management and water consumption. Design criteria are based on those discussed in **Section 1.5**, updated to be relevant to the characteristics and design approach for Precinct 1.

4.1 Water conservation and wastewater

Water conservation design criteria are proposed which are consistent with the guidelines presented in *Better Urban Water Management* (WAPC 2008) and in consideration of the criteria proposed in the DWMS (GHD 2010). This LWMS proposes the following water conservation criteria:

Criteria WC1 Ensure the efficient use of all water resources.

Criteria WC2 All lots will be connected to a reticulated sewer network.

The manner in which these objectives will be achieved is further detailed in **Section 5**.

4.2 Stormwater management

The principle behind stormwater management at the site is to mimic the pre-development hydrological conditions, as described in **Section 3.4.3**. The principles and guidance documents discussed in **Section 1.4** and **1.5** have guided the stormwater management criteria.

This LWMS proposes the following stormwater management design criteria:

Criteria SW1 Treat the small rainfall event (i.e. first 15 mm) on lots at source within the boundary of each lot.

Criteria SW2 Treat the small rainfall event (i.e. first 15 mm) on road reserves at source.

Criteria SW3 Maintain pre-development peak flow rates up to the major storm event (i.e. 1 % annual exceedance probability (AEP)) at key discharge locations.

Criteria SW4 Provide conveyance of existing upstream flows through the site.

Criteria SW5 Roads to remain passable in the minor storm event (i.e. 10% AEP).

Criteria SW6 Finished floor levels of habitable buildings should have a 300 mm clearance from the 1% AEP top water level (TWL) within water sensitive urban design (WSUD) structures.

Criteria SW7 Apply appropriate non-structural measures to reduce pollutant loads.

The manner in which these objectives will be achieved is further detailed in **Section 6**.

4.3 Groundwater management

The principle behind the groundwater management strategy is to maintain the existing groundwater hydrology. This LWMS proposes the following groundwater management criteria:

Criteria GW1 Existing drain inverts and groundwater controls will be retained to maintain the existing groundwater conditions.

Criteria GW2 Subsoil drains will not be used to lower groundwater levels, and where used below road pavement should be set at or above MGL, the underlying clay layer or existing drain inverts.

Criteria GW3 Finished floor levels of habitable buildings should have a minimum 500 mm clearance from MGL or controlled groundwater level (CGL).

Criteria GW4 Invert of WSUD structures will be set at MGL, the underlying clay layer or existing drain inverts.

Criteria GW5 Maintain or improve groundwater quality leaving the site.

The manner in which these objectives will be achieved is further detailed in **Section 7**.

4.4 Wetland management

The principles behind wetland management are to maintain the existing hydrological regime and ensure protection of water quality within wetlands. Design criteria presented above are also relevant to the successful management of the wetland (specifically **Criteria WC2**, **SW1**, **SW2**, **SW3**, **SW7**, **GW1**, **GW2**, **GW4** and **GW5**). Additional criteria are therefore not proposed specifically for wetlands to avoid unnecessary repetition.

The manner in which the criteria detailed for stormwater and groundwater management are achieved relevant to wetland management is detailed in **Section 8**.

5 Water Conservation and Wastewater

5.1 Fit-for-purpose water use

5.1.1 Scheme water

The MKSEA operates within the Water Corporation integrated water supply system and therefore will be supplied by scheme water.

5.1.2 Groundwater

The Water Register (DWER 2018) indicates that the superficial aquifer underlying the site is located within the Perth groundwater area and the City of Gosnells sub area. The Serbian Community Centre of WA has an 18,750 kL/annum groundwater licence (GWL62893) from the Perth - Superficial Swan aquifer. In the event a transfer of the existing groundwater licence was not successful, 2,054,646 kL is currently available from the superficial aquifer (as of 15 February 2018).

The total area of open space (including environmental assets) in Precinct 1 is approximately 10 hectares. If all of this open space was irrigated at a rate of 6,750 kL/ha/annum, a total of 67,500 kL would be required per annum.

The CoG does not support the use of groundwater for irrigation of landscaping in MKSEA, and therefore alternative approaches to using groundwater will be required.

It is not anticipated that any of the environmental assets or public open space areas will require ongoing permanent irrigation. The open space that provides a buffer to the adjacent Bush Forever site and the majority of the other two open space areas are proposed to have non-irrigated revegetation planting. Planting of revegetation species using tube stock should occur in winter to ensure establishment prior to summer without the need for irrigation. Additional planting should occur the following winter to address any sparsely vegetated areas.

A landscape concept and cross-section that demonstrates the principles of how for the open space area containing the proposed conservation area will be treated is provided in **Appendix F**.

Any irrigation of road verges will be the responsibility of the adjacent lot owner. The City will not be responsible for ongoing irrigation of road verges.

5.2 Water conservation measures

5.2.1 Lot scale

In order to ensure that water is used efficiently, lot owners will be encouraged to utilise rainwater tanks, water efficient appliances and employ waterwise gardening (WWG) principles (described in **Section 5.2.2**) across any landscaped areas. Water efficient fittings and toilets are mandated through the building licence process. Given the large lot industrial uses the water savings achieved by these measures are likely to be nominal.

5.2.2 Estate scale

Water use can be reduced on a development scale within open space areas by employing WWG measures. The following water efficiency measures will be used within the development:

- Improve soil with conditioner certified to Australian Standard AS4454 to a minimum depth of 300 mm for garden beds.
- Design and install any irrigation system according to best water efficient practices.
    - Control systems must be able to irrigate different zones with different irrigation rates.
    - Emitters must disperse coarse droplets or be subterranean.
    - Utilise subsoil irrigation where appropriate.
- Landscape with native, preferably endemic, species.
- Mulch garden beds to 100 mm with a product certified to Australian Standard AS4454.
- Minimise use of slow fertilisers and these are only to be utilised on initial planting.

WWG principles will be adopted within open space areas and swales (within road reserves) within the development. Any irrigation of road verges will be the responsibility of the adjacent lot owner.

5.3 Wastewater management

Wastewater is water that is associated with buildings/site offices (except roof runoff) and any specific industrial uses. Stormwater runoff is treated as a separate, independent system and is discussed in detail in **Section 6**.

It is proposed that general building wastewater be serviced by reticulated sewer (following the implementation of Water Corporation's capital works program). All industrial lots within Precinct 1 are able to be serviced a by reticulated sewer network proposed for Precincts 1, 2 and 3B of MKSEA that responds to the proposed structure plan (see **Appendix A**) (L Coyle [Cossill & Webley] 2018, pers. comm., 26 April). Any wastewater produced from industrial processes will be treated appropriately, in accordance with *Water Quality Protection Note (WQPN) 51: Industrial wastewater management and disposal* (DoW 2009). Therefore, it is anticipated that all wastewater will be ultimately discharged to the Water Corporation's reticulated sewer network and that there will be no onsite retention of wastewater.

Appropriate wastewater infrastructure design will protect the surrounding environment and achieve water management **Criteria WC2**, **SW7** and **GW5**, identified in **Section 4**.

5.4 Water conservation design criteria compliance

A summary of the proposed water conservation design criteria and how these are addressed within the site is provided in **Table 4**.

Table 4 Water conservation compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
WC1	Ensure the efficient use of all water resources	Lots will be provided with potable water through the integrated water supply system
		Promotion of rainwater tanks, water efficient appliances and WWG principles for use within lots
		Use of water efficient fittings and toilets within lots
		Use of WWG principles across open space areas and swales (within road reserves)
WC2	All lots will be connected to a reticulated sewer network	General building wastewater be serviced by reticulated sewer
		Wastewater from any industrial processes will be treated appropriately prior to discharge to sewer

6 Stormwater Management

6.1 Stormwater management

The principle behind the stormwater management strategy for the site is to maintain the existing hydrology by treating the small rainfall event as close to source as possible, matching pre-development flow rates leaving MKSEA and maintaining upstream flows through the site.

The stormwater management strategy consists of two main components:

- Lot drainage
- Development drainage

Each component has been designed to achieve the objectives and criteria stated in **Section 4.2**. The sizing of each component has been determined using XPSWMM hydrological and hydraulic software. The modelling assumptions report provided in **Appendix D** presents the detailed methods and assumptions used to develop the model.

This drainage strategy does not apply to Area 1, as this has/ is being built in accordance with the Area 1 LWMS (McDowell Affleck 2016) described in **Section 1.5.2**. Flows from upstream catchments (i.e. from the Bush Forever site) will be sustained by maintaining the twin 600 mm diameter culverts beneath Clifford Street and utilising an arterial drainage pipe system to convey flows from these culverts towards Bickley Road. A separate pit and pipe network will convey runoff from lots and road reserves within Area 1 towards one of the two detention areas. Treatment of the small rainfall event and detention of major event runoff are provided by both individual lots and across the estate within two detention areas to maintain pre-development discharge rates. The drainage strategy for Area 1 is detailed within the Area 1 LWMS (McDowell Affleck 2016) and as indicated is not proposed to be changed by this LWMS. Surface runoff modelling completed for this LWMS assumes that Area 1 maintains pre-development discharge rates.

6.2 Lot drainage

6.2.1 Treatment of the small rainfall event

Treatment of stormwater runoff will occur at source within lots. Onsite treatment of the small event (first 15 mm) can be achieved via a number of strategies. For many lots across the site, the small rainfall event should be infiltrated within the lot to replicate the existing hydrological regime. It is understood that the site constraints within or beneath some lots may make infiltration difficult and in these instances. Lot treatment strategies may include:

- Vegetated bio-retention areas to infiltrate the small event (Payne *et al.* 2015).
- Waterwise landscaped areas to infiltrate the small event.
- Subsurface soakage/soakwells where there is sufficient clearance to MGL or the underlying low permeability layer (see **Figure 10**). The invert of soakage structures must be at or above MGL or the low permeability layer.
- Retention (rainwater) tanks in areas where low depth to MGL or the underlying low permeability layer makes infiltration on site difficult to achieve (see **Figure 10**).

The invert of treatment structures should be at or above MGL (as shown in **Figure 2**) or determined through additional onsite monitoring as discussed in **Section 10.2.1**). This will replicate the existing hydrological regime by allowing the small rainfall event to infiltrate to the lower permeability layer for the majority of the year.

In order to treat the small event, individual lot strategies must cater for the first 15 mm of runoff from all impervious areas (roofs, car parks etc.). The volume per lot area required to be treated is 142.5 m^3/ha (assuming 95% of the lot will be impervious and, conservatively, that no infiltration will occur). This volume can be reduced where it can be demonstrated that localised site characteristics will accommodate infiltration and/or for lots that have a lower proportion of imperviousness. Requirements for lots within Area 1 were provided in the Area 1 LWMS (McDowell Affleck 2016).

The selection and design of lot treatment structures are the responsibility of the lot owner and should be selected to suit individual site characteristics and the intended development of the lot. The design of lot drainage will be submitted to the CoG within a development application (DA). The use of treatment on lot will assist in achieving Criteria **SW1**, **GW4** and **GW5**.

6.2.2 Detention of minor and major event runoff

Lot detention areas (LDA) will achieve flood detention at source. These are required to detain surface runoff from lots to ensure post-development peak flow rates leaving the site are consistent with the existing environment. The area designed to detain the major rainfall event can potentially be via infiltration, storage/rainwater tank(s), car park areas or other hardstand areas, or a more formalised storage area within lots.

The detention volume required to be provided by lots within Precinct one is 207.5 m^3/ha. This is in addition to the 142.5 m^3/ha required for treatment. Surface runoff modelling completed for LDAs is conservative, with no infiltration losses allowed for. Consequently, the required storage volume within individual lots can be decreased if it can be demonstrated that infiltration can be achieved; this is expected to be possible within some lots in Precinct 1 (see **Figure 10**). Requirements for lots within Area 1 were provided in the Area 1 LWMS (McDowell Affleck 2016).

A low flow discharge or connection to the drainage network may be required to ensure that LDAs dry out if the LDA invert is located at MGL (see **Figure2**) or close to the underlying clay layer (see **Figure 4**). This discharge or connection must be free draining (i.e. the outlet must be set above the invert of the downstream drainage network and have a minimum grade of 1:500. A maximum flooding depth of 300 mm and average flood depth of 50 mm is recommended within car park areas if these are used for detention. Indicative inverts for the proposed drainage network (i.e. roadside swales and detention areas) and their implications for minimum lot levels are discussed in **Section 7.1.1** and **7.1.2**, respectively. These are also shown on **Figure 15**.

Runoff from LDAs in the minor and major events will occur via appropriately sized gully pits, discharge piping and/or weir structures towards the development drainage network.

The specific design of LDAs to ensure the appropriate volume of storage is provided within the lot is the responsibility of the lot owner. The use of LDAs will assist in achieving **Criteria SW3** and **GW4**.

6.3 Estate drainage

6.3.1 Roadside swales

Treatment of stormwater runoff from road reserves will occur at source. Swales will be located within road verges to infiltrate and treat small event (first 15 mm) runoff from the adjacent road pavement as close to source as possible in order to mimic the pre-development hydrological regime.

Swales are proposed along the downstream side of the road within Precinct 1 (but outside Area 1) where the soil profile allows for onsite infiltration (see **Figure 4**). The swales will be located immediately adjacent to road pavement and include:

- 1:4 side slopes
- 1.2 m wide base
- Total top width 6 m

The width and depth of the swales are driven by the need to achieve appropriate side slopes adjacent to road pavement and clearance of drainage crossings beneath road pavement.

Swales within Victoria Road have a potential maximum depth of 600 mm, however maximum water depth within the swales will be 340 mm and across the remaining road reserves will have a maximum water depth of 240 mm. Road reserves across the structure plan are a minimum 20 m wide and consequently swales are anticipated to have an inundated top width of 2.1 m to 3.9 m. The swale profiles can be revised in the future to meet localised site and servicing requirements, provided that the treatment and detention volumes specified in this LWMS are achieved. Further storage could also be forced within the swales by introducing minor weir structures and by varying the routing of the lots in to swales. A typical road cross-section that accommodates a roadside swale is provided in **Figure 12, Figure 13** and **Figure 14**.

The invert of swales should be at or above MGL so that groundwater is not intersected (as shown in **Figure 1**: Site Locality.

Figure 2 or determined through additional onsite monitoring as discussed in **Section 10.2.1**). This will replicate the hydrological regime by allowing the small rainfall event to infiltrate close to source and to the lower permeability layer for the majority of the year. Setting swales at or above MGL will avoid mobilisation of perched groundwater across the site. This is further described in **Section 7.1.1**.

Swales will be vegetated with reeds and rushes suitable for removing nutrients (Payne *et al.* 2015). A layer of high phosphorus retention index (PRI) >10 soil or engineered media should be located beneath the invert of the swale to provide treatment as runoff infiltrates towards the underlying lower permeability layer (Payne *et al.* 2015).

Table 5 and **Figure 11** provide the volume that will be treated with the swale profile. Swales are proposed along the full length of proposed road reserves to treat runoff as close to source as possible. **Table** 5 demonstrates that the required volume can be treated within swales located along a section of the road reserve, and also provides the swale depths in frequent, minor and major runoff events. **Figure 12** illustrates the areas inundated by the small rainfall event.

Table 5 Treatment of small event runoff within swales

Swale	Length (m)	Small event - 15 mm			10% AEP			1% AEP		
		Volume (m^3)	Top width (m)	Depth (m)	Volume (m^3)	Top width (m)	Depth (m)	Volume (m^3)	Top width (m)	Depth (m)
P1_01	590	115	1.8	0.07	328	2.8	0.20	335	2.8	0.20
P1_02a	152	30	1.8	0.07	72	2.56	0.17	80	2.71	0.19
P1_05 S	565	188	2.2	0.12	358	3.0	0.23	381	3.1	0.24
P1_05 N	328	91	2.0	0.10	174	2.7	0.19	185	2.8	0.20
P2_01 Victoria Road	939	442	2.5	0.17	781	3.6	0.30	890	3.9	0.34
P2_04 Victoria Road	169	23	1.6	0.05	53	2.1	0.11	57	2.2	0.12
P2_05 Victoria Road	252	50	1.8	0.07	58	1.9	0.08	112	2.5	0.16

**P2 treatment swales are located along the north-western verge of Victoria Road within Precinct 2.*

The exception to using swales for conveyance will be those catchments which have minimal clearance to MGL, are underlain by shallow clays and are proposed to service lots within the composite zone. In these areas lots are likely to be smaller, cross-overs will become an additional consideration (reducing the amount of swale that can physically be constructed) and some lots may discharge towards the existing Bickley Road. Therefore the use of a pit and pipe network to convey stormwater runoff towards a detention area and/or discharge location may be considered at these locations.

The small rainfall event on road reserves within Area 1 is treated within one of two detention areas located within Area 1 (McDowell Affleck 2016). It is assumed the existing Kelvin Road provides appropriate treatment and detention of runoff from road pavement. The use of swales will achieve **Criteria SW2**, **SW3**, **SW4**, **SW5**, **GW1**, **GW4** and **GW5**.

6.3.2 Detention areas

Runoff from road reserves and lots will be conveyed towards Bickley Road or Victoria Road within roadside swales and overland flow within road reserves themselves. These detention areas are only required to detain infrequent and major event runoff, and are not intended to be inundated in response to small and frequent rainfall events. It is assumed that the capacities of swales (as provided in **Table 5**) are fully utilised prior to runoff entering downstream detention areas. Detention areas will be utilised to ensure post-development peak flow rates leaving Precinct 1 are consistent with the existing environment.

Detention areas within catchments P1_01, P1_02, P1_06 and P1_07 as shown in **Figure 11** are nominally assumed to have 1:6 side slopes and a 1.2 m maximum water depth. The invert of detention areas can be set at MGL, on the underlying lower permeability layer, or consistent with any existing invert (where relevant). This is further described in **Section 7.1.1**. Discharge from detention areas can be controlled via a number of outlet options such as v-notch weir, low flow pipe and weir combinations, etc. The design of detention areas and finished lot levels will be such that habitable floor levels will be at least 300 mm above the TWL to ensure protection from flooding during extreme rainfall events.

The requirements provided in **Table 6** can be revised in the future, provided that the pre-development peak flows discharging from the site (shown in **Figure 7**) are maintained. The inundation areas for the minor and major rainfall events are shown in **Figure 13** and **Figure 14**, respectively.

Table 6 Detention of minor and major event runoff within detention areas

Catchment	Minor rainfall event (10% AEP)			Major rainfall event (1% AEP)		
	Volume (m^3)	Max water depth (m)	Surface area (m^2)	Volume (m^3)	Max water depth (m)	Surface area (m^2)
P1_01	625	0.3	2535	3570	1.2	3795
P1_02*	-	-	-	615	1.2	900
P1_05	2095	0.4	6075	7845	1.2	7735
P1_06*	-	-	-	235	1.2	420
P1_07	345	0.4	1120	1615	1.2	1905

** Capacity of LDAs are sufficient to detain minor rainfall event within lots (10% AEP).*

Detention areas have previously been proposed and constructed in response to the Area 1 LWMS (McDowell Affleck 2016), and this LWMS does not seek to change these. It is assumed the existing Kelvin Road provides appropriate treatment and detention of runoff from road pavement.

The use of detention areas will assist in achieving **Criteria SW3**, **SW5**, **GW1** and **GW4**.

6.4 Drainage design assessment

6.4.1 Estate drainage

As detailed previously, the stormwater management strategy aims to match pre-development flows leaving the site in a major rainfall event. **Table 7** details the pre- and post-development peak flow rates in a minor and major rainfall event at each outflow location shown in **Figure 11**. The post-development discharge locations are shown in **Figure 11**.

Table 7 Pre- and post-development peak flow comparison

Location	Minor rainfall event (10% AEP) peak flow (m^3/s)		Major rainfall event (1% AEP)peak flow (m^3/s)	
	Pre-development	Post-development	Pre-development	Post-development
Outflow from catchment P1_01	0.14	0.13	0.31	0.31
Outflow from catchment P1_02	0.13	0.12	0.22	0.23
Outflow from catchment P1_05	0.22	0.17	0.34	0.26
Outflow from catchment P1_06	0.07	0.07	0.15	0.14

Outflow from catchment P1_07	0.03	0.03	0.08	0.07
Total outflow towards Precinct 2	**0.22**	**0.17**	**0.34**	**0.26**
Total outflow towards Bickley Brook	**0.37**	**0.35**	**0.76**	**0.75**

As described in **Section 6.1** and in the Area 1 LWMS (McDowell Affleck 2016), upstream inflows from pre-development catchments 4, 14 and 15 (see **Figure 7**) will be maintained through the site via an arterial drainage pipe system towards Bickley Road and overland flow within road reserves.

6.5 Non-structural water quality measures

The structural measures proposed within the site provide both a detention and treatment function. A number of non-structural measures will also be implemented to help reduce nutrient loads within stormwater runoff. These measures include:

- Street sweeping on a regular basis.
- No ongoing fertiliser use is proposed within swales, as these will be vegetated with nutrient absorbing vegetation species.
- Minimising fertiliser use to establish and maintain vegetation within open space areas.
- Education of lot owners regarding fertiliser application and the use of nutrient absorbing vegetation within LDAs, swales and landscaped areas.

The above measures will assist in achieving **Criteria SW7**.

6.6 Stormwater design criteria compliance

A summary of the proposed stormwater management design criteria and how these are addressed within the site is provided in **Table 8**.

Table 8 Stormwater management compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
SW1	Treat the small rainfall event (i.e. first 15 mm) on lots at source within the boundary of each lot.	Vegetated bio-retention areas and/or the use of waterwise landscaped areas sized to treat the small rainfall event will be located within lots.
SW2	Treat the small rainfall event (i.e. first 15 mm) from road reserves at source.	Swales within road verge will treat small event rainfall from the adjacent road bitumen.
SW3	Maintain pre-development peak flow rates up to the major storm event (i.e. 1 % AEP) at key discharge locations.	LDAs located within the lot will detain minor and major event runoff.
		Swales and detention areas will detain the minor and major rainfall event runoff from road reserves to maintain pre-development peak flow rates.
SW4	Provide conveyance of existing upstream flows through the site.	The existing culverts beneath Tonkin Highway and the flow path through the adjacent Bush Forever site will be maintained.
SW5	Roads to remain passable in the minor storm event (i.e. 10% AEP).	The use of swales and a pit and pipe network will ensure roads remain passable in the minor storm event.
SW6	Finished floor levels of habitable buildings should have a 300 mm clearance from the 1% AEP TWL within WSUD structures.	Localised and minor sand fill may be required to ensure finished floor levels of habitable buildings meet the required clearances.
SW7	Apply appropriate non-structural measures to reduce pollutant loads.	Street sweeping on a regular basis.
		No fertiliser use is proposed within swales, as these will be vegetated with nutrient absorbing vegetation species. Minimising fertiliser use to establish and maintain vegetation within open space areas.
		Education of lot owners regarding fertiliser application and the use of nutrient absorbing vegetation within lots.

7 Groundwater Management Strategy

The principle behind groundwater management is to maintain the existing hydrology across the site, provide appropriate protection from groundwater inundation, and maintain or improve the existing groundwater quality.

7.1 Groundwater level management

MGL is mostly a reflection of seasonally perched groundwater created by infiltration of small rainfall events and varies across the site between approximately at the surface to 6 m below existing surface. The existing perched groundwater regime will be maintained by:

- Implementation of the stormwater management strategy detailed in **Section 6**, which will maintain pre-development recharge of the perched groundwater system.
- Avoiding modifications to the underlying lower permeability layers that alters the grade of the layer.
- Avoiding groundwater abstraction from the superficial aquifer.
- Retaining key existing drainage inverts, which will minimise changes to the existing groundwater conditions.

7.1.1 Development groundwater level management

Design of swales (within road reserves) should replicate the existing hydrological regime by maintaining existing inverts and allowing the small rainfall event to infiltrate close to source towards the lower permeability layer for the majority of the year, and will avoid changes to perched groundwater across the site. To comply with **Criteria GW4**, the invert of swales should be:

1. No lower than the existing open drain invert.

At or above MGL (as shown in Figure 1: Site Locality.

2. Figure 2 **Figure 2**) or determined through additional onsite monitoring as discussed in **Section 10.2.1**).
3. Have a minimum grade towards the relevant detention area and/or key discharge location of 1:750.
4. Generally, be no deeper than 0.5 m below the natural surface.

Indicative swale inverts based on the above requirements and critical control points (i.e. the inverts of existing culverts) are shown in **Figure 15**. Where required, sand fill will be utilised to ensure swales (within road reserves) meet the above requirements.

Surface runoff modelling (see **Appendix D**) has assumed that no infiltration into the underlying soils will occur from detention areas (including the two constructed within Area 1), as the invert of these could potentially be as low as MGL, the underlying low permeability layer or at existing drainage inverts (where relevant), which complies with **Criteria GW4**. Indicative detention area inverts that comply with **Criteria GW4** and consider existing levels within Victoria Road and Bickley Road are provided in **Figure 15**.

This does not preclude infiltration from occurring into the underlying soil, but ensures that swales and detention areas are appropriately sized. Future sizing of WSUD structures may account for infiltration where it can be demonstrated that this can be achieved by the underlying soils.

Given the industrial nature of the site and the large distance between road reserves, it is not proposed to control groundwater levels through the use of subsoil drains within road reserves (consistent with **Criteria GW4**). Consequently, groundwater could potentially rise into the higher permeability sand fill due to capillary action where sand fill and onsite infiltration is used. The proposed swale network will provide control of groundwater beneath road reserves to preserve pavement.

Where a pit and pipe network may be considered appropriate (see **Section 6.3.1**), subsoil drains may be used beneath road pavement to ensure pavement integrity. It is not intended for these to provide a control for groundwater beneath the full depth of lots, and they will need to be set at a level which allows grade and discharge to a downstream detention area (which will be set at or above MGL, the clay layer or an existing drainage invert) or other appropriate outlet (e.g. pit).

7.1.2 Groundwater level management within lot

The management of groundwater levels within lots is the responsibility of the lot owner and specific to the uses proposed within the lot.

Indicative swale and detention area inverts have been provided in **Figure 15** to comply with **Criteria GW4**. Consequently, minimum lot level requirements can be determined based upon the proposed road reserve cross-section (see **Appendix F**) to ensure habitable floor levels of buildings comply with **Criteria SW6** and achieve a clearance to TWLs of 0.3 m. Lots on the downstream side of the road reserve (i.e. adjacent to the proposed swale) must have a clearance of 0.6 m (or 0.7 m along Victoria Road only) above the swale invert. Lots on the upstream side of the road reserve (i.e. on the opposite side to the proposed swale) must have a clearance of approximately 1.3 m from the swale invert. This allows for 0.6 m cover over a 0.3 m pipe to convey runoff into the swale.

Through further detailed design within UWMP/DAs, some lots may not decide to grade the entire lot towards the road reserve and associated swale but may elect to fully retain the required volumes on site. This is a choice for individual lot owners and is likely to be influenced by local site characteristics and the intended use for each lot.

As specified by **Criteria GW3**, habitable floor levels of buildings will also be required to have a minimum clearance of 0.5 m from MGL or CGL. CGL is defined as the invert of adjacent roadside swales or subsoil drains (which are discussed in **Section 7.1.1**). Imported fill can be utilised to ensure clearances from habitable floor of buildings are achieved. Lot owners may also propose to utilise imported fill across other portions of the lot (e.g. for hardstand).

The invert of at-lot treatment structures should be at or above MGL (as shown in **Figure 2**) or determined through additional onsite monitoring as discussed in **Section 10.2.1**) or existing open drain inverts, which complies with **Criteria GW4**. This will replicate the hydrological regime by allowing the small rainfall event to infiltrate towards the lower permeability layer for the majority of the year.

Surface runoff modelling (see **Appendix D**) used to determine LDA requirements (provided in **Section 6.2.2**) has assumed that LDAs will not be able to infiltrate stormwater runoff. The invert of these structures can therefore be located at or above MGL or the underlying low permeability layer shown in **Figure 10** (where groundwater is clearly perched above this), which complies with **Criteria GW4**.

7.2 Groundwater quality management

The main objective of the management of groundwater quality is to maintain the existing groundwater quality. This can be achieved by reducing the total nutrient load into groundwater that originates from newly developed areas and by treatment of surface water runoff prior to infiltration to groundwater. **Criteria GW5** will be achieved across the site by:

- Lot owners are to select landscape species from the City of Gosnells MKSEA Landscape Palette.
- Landscape design and management to avoid the application of inorganic nutrients.
- Minimal fertiliser use to establish and maintain vegetation within open space areas.
- Appropriate treatment of small rainfall event runoff.

7.2.1 Groundwater design criteria compliance

A summary of the proposed groundwater management design criteria and how these are addressed within the site is provided in **Table 9**.

Table 9 Groundwater management compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
GW1	Existing drain inverts and groundwater controls will be retained to maintain the existing groundwater conditions.	The invert of existing culverts will be maintained and the invert of all WSUD structures may be set at existing drain inverts.
GW2	Subsoil drains will not be used to lower groundwater levels, and where used below road pavement should be set at or above MGL, the underlying clay layer or existing drain inverts.	Any subsoil drains used to ensure pavement integrity will be set at or above MGL, the underlying clay layer or existing open drain inverts.
GW3	Finished floor levels of habitable buildings should have a minimum 500 mm clearance from MGL or CGL.	Sand fill may be required to ensure the required clearances to MGL or CGL are met.
GW4	Invert of WSUD structures will be set at MGL, the underlying clay layer or existing drain inverts.	Locating invert of all WSUD structures at MGL, the underlying clay layer or on existing drain inverts.
GW5	Maintain or improve groundwater quality leaving the site.	Lot owners are to select landscape species from the City of Gosnells MKSEA Landscape Palette.
		Landscape design and management to avoid the application of inorganic nutrients.
		Minimal fertiliser use to establish and maintain vegetation within open space areas.
		Appropriate treatment of small rainfall event runoff.

8 Wetland Management Strategy

As described in **Section 4.4**, the principles behind wetland management are to maintain the existing hydrological regime and ensure protection of water quality within wetlands. The wetland and conservation area management strategy, as described within the EAMS (Emerge Associates 2018b), presents the following broad objectives:

- Separate the wetland from the adjacent land use(s) that might threaten its desired values, through either spatial separation or the use of physical barriers.
- Preserve and protect the existing conservation values of the wetlands.
- Prevent any activity that may lead to further loss or degradation.
- Restore ecological integrity and function through revegetation of degraded areas.
- Manage and maintain ecological values.
- Transfer the public open space containing the wetlands and buffers into public ownership and reserve this land for 'Local Open Space' under the CoG TPS No. 6.

Vegetation within the wetland is expected to be sustained by a combination of direct rainfall and perched groundwater. Replication of the existing hydrological regime (i.e. infiltrating the small rainfall event as close to source as possible for the majority of the year) is therefore essential to maintaining the wetland. This has been achieved by complying with **Criteria SW1**, **SW2**, **SW3**, **GW1**, **GW2** and **GW4**.

The management strategies proposed to protect water quality within the wetland are consistent with the actions required to comply with **Criteria WC2**, **SW7** and **GW5**, and includes:

- The appropriate treatment of all wastewater within lots, and then discharge to sewer
- Minimising pollutant loads entering stormwater runoff and to shallow perched groundwater from lots and open space areas
- Treating stormwater runoff both within lots and more broadly across the site.

The summaries for how the above design criteria will be achieved are provided in **Table 4**, **Table 8** and **Table 9**.

9 Future Subdivision and Development Approval

The requirement to undertake preparation of more detailed water management plans to support subdivision is generally imposed as a condition of subdivision. The development of any future UWMP should follow the guidance provided in *UWMPs: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* (DoW 2008).

Development of areas progressed under Development Approval (DA) may not be required to prepare additional water management plans (i.e. UWMP) to support the application. In this case, detailed designs presented in DAs should be reviewed in conjunction with the design criteria presented in this LWMS to ensure the appropriate elements of the water management strategy discussed herein are implemented.

While strategies have been provided within this LWMS that address planning for water management within the site, future development stages will need to clarify details not provided within this LWMS. The main areas that will require further clarification include:

- Implementation of water conservation strategies
- Confirmation of irrigation source
- Stormwater treatment and detention within lots
- Modelling and configuration of estate drainage structures
- Imported fill specifications and requirements
- Non-structural water quality improvement measures
- Nutrients and management and maintenance requirements
- Construction period management strategy
- Monitoring and evaluation program.

These are further detailed in the following sections. Ongoing monitoring of groundwater will be detailed in the UWMP or DA applications (where no subdivision is proposed to occur), however in this LWMS is also outlined broadly in **Section 10**.

9.1 Implementation of water conservative strategies

A number of potential measures to conserve water have been presented within this LWMS. These water conservation strategies will be incorporated into the design and the ongoing maintenance of all open spaces within the site and landscaped areas within lots. Design measures that will be incorporated into the water conservation strategy will be further detailed within the future UWMPs produced for Precinct 1 or DAs for individual lot development.

9.2 Confirmation of irrigation source

None of the environmental assets or public open space areas will require ongoing irrigation. Planting of revegetation species tube stock should occur in winter to ensure establishment prior to summer without the need for irrigation.

The *Water Register* (DWER 2018) indicates that the superficial aquifer underlying the site is located within the Perth groundwater area and the CoG sub area, and records show that 2,054,646 kL is currently available from the superficial aquifer (as of 15 February 2018). However, CoG does not support the use of groundwater to irrigate landscaped areas.

It is expected that where any irrigation is proposed, future UWMPs/DAs will demonstrate that an adequate water source has been obtained to meet irrigation requirements, or that an appropriate contingency plan has been established. Any ongoing irrigation of road verges adjacent to lots will be the responsibility of the lot owner.

9.3 Stormwater treatment and detention within lots

The stormwater management strategy assumes that all lots will treat the small rainfall event at source and detain runoff from the minor and major rainfall events to allow pre-development flow rates leaving the site to be maintained. It is acknowledged that some form of planning control may be required to ensure that the required lot storage is provided.

It is the lot owner's responsibility to ensure that the appropriate storage is provided within lot, consistent with the details provided in **Section 6.2**. Where development areas progress through subdivision, the UWMP should utilise site specific information (e.g. geotechnical investigations, infiltration testing etc) to refine lot drainage requirements. It is recommended that the UWMP include an updated plan to illustrate depth to the low permeability layer in both the pre-development and post-development scenarios.

Lot designs, including stormwater drainage, are to be approved by CoG at building approval or DA stage prior to construction, and therefore will not be available for inclusion in an UWMP. Further, it is not known what size lots will be, nor the uses or development format of the lots. The DA will also need to demonstrate sufficient clearance to MGL or the underlying low permeability layer (where relevant) through geotechnical investigations and/or engineering drawings and that provision has been made for each lot to connect to the drainage network.

9.4 Modelling and configuration of estate drainage structures

The design of the drainage system to date has been undertaken at an appropriate level for structure planning and runoff-routing computer modelling of the stormwater drainage system may need to be reviewed once detailed drainage design has commenced for the area.

While the drainage catchments have been defined based on the SP, it is possible that these could undergo some change to accommodate stakeholder feedback prior to final subdivision design. The exact location and shape of WSUD structures will still need to be specified and presented within future UWMPs/DAs.

In order to review the final swale and detention area configurations (including their inverts), the hydrological model developed to support this LWMS may need to be refined in light of stakeholder feedback or to accommodate other design considerations. It is expected that the civil drainage designs will be progressed to a level that provides detailed cross-sections, sizes of storage areas, pipe sizes, inverts, etc. It is also expected that site specific geotechnical investigations and/or infiltration testing (as appropriate) has been completed. The ultimate aim of revising the hydrological model will be to confirm that the post-development runoff volumes are able to meet the performance criteria proposed in **Section 4** of this LWMS.

Land ownership within the SP area is fragmented and consequently it is difficult to determine when each landholding will be developed. Therefore catchment boundaries given in this LWMS can be modified at future stages as long as the modified catchments (and associated WSUD structures) are modelled and comply with the design criteria provided in **Section 4**. Some lots could also be subdivided without development of the ultimate drainage system which may require the use of temporary detention structures (that also comply with the criteria given in **Section 4**).

The exception to the requirement to revise the surface runoff modelling is if the catchment details and WSUD structure designs are consistent with the assumptions made in this LWMS. If this were the case it would be acceptable to provide design calculations for the drainage network and WSUD structures to demonstrate compliance with the LWMS.

9.5 Imported fill specifications and requirements

As discussed previously, the use of sand fill may be required to ensure **Criteria GW1**, **GW2** and **GW3** are achieved. Existing topography within conservation areas and their buffers will be maintained. It is also proposed that inverts of existing open drains be maintained as much as possible. Further, finished earthwork levels across the site will need to tie into surrounding and adjacent road reserve levels. Therefore, it is anticipated that finished earthwork levels will not substantially vary from natural surface (e.g. ± 500 mm) unless it can be demonstrated within future UWMPs/DAs that a greater change does not alter the catchments and the stormwater management strategy outlined within this LWMS.

Soils beneath treatment areas would ideally have high PRI to ensure at-source nutrient retention leading to the protection of the underlying aquifer. The in situ soils can potentially provide the necessary treatment should the PRI be sufficient.

Future UWMPs/DAs will confirm the requirement for sand fill and whether or not high PRI soils or equivalent engineered soil media need to be imported.

9.6 Non-structural water quality improvement measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual for Western Australia* (DoW 2007).

Some measures will be more appropriately implemented at a local government level, such as street sweeping. Many can be implemented relatively easily within the design and maintenance of the Precinct 1 drainage network, including swales and detention areas. Others are more appropriately managed by individual lot owners (e.g. fertiliser application on landscaped areas). It is expected that the future UWMPs/DAs will provide a list of appropriate non-structural measures including timing and responsible parties.

9.7 Nutrients, management and maintenance requirements

Landscape design should demonstrate low water and nutrient demand, thereby avoiding or reducing the application of inorganic nutrients.

The management measures to be implemented to address surface water quality (e.g. the use of vegetation within lot treatment and swales) will require ongoing maintenance. Ongoing management and any irrigation of road verges will be the responsibility of the lot owner. Open space areas with drainage assets will be created and maintained by CoG, though future conservation areas may be managed and maintained by other agencies.

It is expected that the future UWMPs will set out the design (e.g. landscape surface treatments) maintenance actions (e.g. nutrient application), timing (e.g. how often it will occur), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions). Alternatively, these actions could be specified within a dedicated management plan, whichever is most appropriate. Given that approval from the CoG and DWER will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

9.8 Construction period management strategy

It is anticipated that the construction stage will require some management of various aspects (e.g. dust, surface runoff, noise, traffic etc.). The management measures undertaken for construction management will be addressed in the future UWMPs, DAs or a separate construction management plan. Given the fragmented land holdings, it is possible that road design and implementation will need to be undertaken by the CoG. In this case the appropriate construction measures and their implementation will be the responsibility of the CoG.

10 Monitoring and Maintenance

The intent of the below monitoring programs and maintenance requirements are to ensure the stormwater and groundwater management functions of WSUD structures (i.e. roadside swales, and detention areas) are achieved. Ongoing maintenance measures for other open space, conservation or buffer areas are addressed in the Precinct 1 EAMS (Emerge Associates 2018b).

10.1 Management and maintenance

The overall condition of Precinct 1 once developed will be monitored on a bi-annual basis by the CoG. If a coordinated approach between some lots is taken and subdivision of lots occurs, landowners may also need to undertake their own post-development monitoring. This monitoring will be implemented after the completion of the civil and landscaping works and will continue for a period of two years.

The monitoring program should include a visual assessment to monitor the overall condition of Precinct 1, with the aim to ascertain that the maintenance activities are achieving the overall management objectives for the site. The parameters that will be monitored include:

- Nutrients and water quality
- Gross pollutants
- Terrestrial weeds
- Vegetation density
- Paths, walkways and other infrastructure.

Where applicable, the management and maintenance objectives will be detailed within future UWMPs/DAs along with details of the corresponding monitoring program. Where undertaken by the CoG, the monitoring should comply with this LWMS.

10.2 Monitoring

10.2.1 Pre-development monitoring

In addition to the pre-development groundwater monitoring presented in **Section 3.5**, and detailed in **Appendix E**, it is recommended that an additional winter of groundwater level monitoring be undertaken by the subdivision/lot developer to confirm groundwater levels and quality. This is particularly relevant for lots located near Tonkin Highway (where data is most scarce) and within the western portion of the site (where MGL contours are close to the natural surface). This monitoring should be site specific with the duration and locations dependent on the area being developed.

As described in **Section 3.4**, some surface water monitoring was completed in 2009 and 2010. Additional surface water quality monitoring should be completed at the key inflow and outflow locations especially where there are accessible existing culverts (see **Figure 7**) to allow the interim trigger values presented in **Table 11** to be refined.

10.2.2 Post-development monitoring

Post-development monitoring will be carried out by the CoG to ensure that the proposed storage and treatment measures (detailed in **Section 6**) are working as intended. If a coordinated approach between some lots is taken and subdivision of lots occurs, landowners may also need to undertake their own post-development monitoring. An upstream-downstream comparison for groundwater across the site is proposed to confirm that the measures are performing as intended.

10.2.2.1 Recommended post-development monitoring program

The proposed locations for groundwater monitoring are proposed to provide an indication of the effects of development on water quality beneath the site.

Water quality monitoring will be conducted on a quarterly basis. A summary of the post-development monitoring program is shown in **Table 10.** The post-development monitoring should be conducted for at least two years post construction of the detention storage and treatment measures, any estate scale landscaping and landscaping/revegetation of the buffers. The proposed locations for post-development groundwater quality monitoring are shown **Figure 11**.

Table 10 Post-development monitoring program summary

Monitoring Type	Locations	Frequency	Parameters
Groundwater	Bores upstream and downstream of the CCW and buffer area and the site itself	Quarterly (typically Jan, April, July, Oct)	In situ pH, EC, temperature. Sample TN, TKN, ammonium (NH_4), NO_X, TP, FRP.
Surface water	At accessible key inflow and outflow locations of the site	Monthly over winter (typically from June to October)	In situ pH, EC, temperature. Sample total suspended solids, TN, TKN, NH_4, NO_X, TP, FRP.

10.2.2.2 Post development trigger values

Interim water quality targets have been derived from background levels measured during monitoring prior to development, provided **Section 3.4.4**, **Section 3.5.2** and in **Appendix C** and **E**. Trigger values have also been established in consideration of the NWQMS (ANZECC and ARMCANZ 2000) and the Swan-Canning WQIP (SRT 2009) guideline trigger values. The trigger criteria proposed are shown in **Table 11.** These values may be subject to change in the event that site specific pre-development monitoring is undertaken as proposed in **Section 10.2.1**.

Table 11 Groundwater quality trigger values

Analyte	pH	EC (mS/cm)	TN (mg/L)	NH_4 (mg/L)	NOx (mg/L)	TKN (mg/l)	TP (mg/L)	FRP (mg/L)	TSS (mg/L)
Groundwater	6.5 - 8.0	0.3 -1.5	5.35	0.08	1.88	3.5	0.3	0.04	NA
Surface water	6.5 - 8.0	0.3 – 0.8	2.04	0.08	0.23	1.89	0.11	0.02	20.9

10.3 Contingency action plan

A contingency action plan (CAP) has been proposed in this LWMS (in the following section). Where relevant, it should also be further detailed and implemented as a part of each UWMP/DA. The CAP is effectively a plan of steps that will be undertaken should certain water quality criteria be reached.

10.3.1 Trigger criteria

As indicated, the trigger values proposed in **Section 10.2.2.2** have been derived from groundwater quality measured during pre-development monitoring. These values should be reviewed in the future to include any data gained from any additional monitoring.

10.3.2 Contingency actions

If the results from the initial monitoring occasion indicate that nutrient concentrations exceed the nominated trigger values, a number of contingency measures may be employed.

The first action that should be undertaken if trigger criteria are exceeded is to repeat the monitoring to remove the potential for sampling error. If the repeat monitoring still shows results which breach the trigger value, the next action will be to compare groundwater monitoring results for the upstream (incoming) nutrient concentrations with the downstream (outgoing) nutrient concentrations.

If the downstream nutrient concentrations are >20% higher than the upstream nutrient concentrations, the following actions should be undertaken:

1. Review nutrient application practices to identify source if possible.
2. Conduct surveillance of Precinct 1 to determine any other potential and obvious nutrient inputs, including within lot treatment structures.
3. Remove source if possible (e.g. fertiliser input, etc).

If the downstream nutrient concentrations are found to be generally consistent with the upstream concentrations the next action will be to conduct a site-specific comparison of background data collected within the site prior to development. There is some amount of variability (both spatially and temporally) in nutrient concentrations experienced across the site and the trigger values may need to be modified following additional monitoring. This information should then be used as a management tool in consultation with DWER to determine if the trigger values should be revised.

Following the implementation of the above contingency measures the water quality will be re-sampled. If the results of the analysis still show water quality characteristics which breach the trigger values an additional set of upstream/downstream monitoring bores should be installed at another key representative area (e.g. another conservation area or additional bores upstream and downstream of Precinct 1). The additional bores will be sampled as per the ongoing sampling regime already being undertaken. If the results from the second area demonstrate results consistent with the first area, DWER will be informed of the results, and the CoG will work with DWER to determine if the results are representative of a broader catchment management issue, and whether any additional contingency actions need to be implemented.

Additional contingency actions may include:

- Removal of sediments within treatment areas.
- Thinning of vegetated treatment areas to ensure removal of accumulated nutrients (i.e. within plants) from the system where observations indicated excessive plant growth.
- Supplementary planting of vegetated treatment areas where plant density is low (e.g. <4 plants/m^2).

10.4 Reporting

A post-development monitoring report should be prepared annually. These should be reviewed to determine any changes that should be made to the ongoing management of drainage assets and open space areas.

11 Implementation

The LWMS is a key supportive document for the SP for MKSEA Precinct 1. The development of the LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with an integrated water cycle management approach. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide the development of the future UWMPs/DAs and individual lot development.

11.1 Roles and responsibility

The LWMS provides a framework that the CoG can utilise to assist in establishing stormwater management methods that have been based upon site-specific investigations and which are consistent with relevant State and Local Government policies.

The responsibility for working within the framework established within the LWMS rests with the CoG (where they are the proponent, and will need to upgrade any of the roads and construct drainage infrastructure), future subdivision developers, and lot owners/lot developers. The roles are summarised in **Table 12** below. Responsibilities related to non-structural measures will be detailed in future UWMPs / DAs, as detailed in **Section 9.6**.

Table 12 Roles and responsibility

Role	Responsibility
Implement and maintain in-lot stormwater treatment structures	Lot owner/lot developer
Implement and maintain LDAs	
Provision of lot drainage connection points	Subdivision developer (where subdivision occurs in a coordinated manner) or CoG
Construct and maintain swales within road reserves	
Construct and maintain detention areas	
Post-development monitoring program	CoG

In order to support any future subdivisions, it is anticipated that future UWMPs will be developed in consultation with the CoG and DWER and in consideration of other relevant policies and documents. Where DA applications are prepared these should be undertaken consistent with this LWMS and in close consultation with CoG.

11.2 Funding

Consistent with the *Town Planning Scheme No 6* (CoG 2002), it is anticipated that a developer contribution scheme will be prepared by the CoG for the site. This will determine how costs for administration and infrastructure required to support development will be shared. This may include the provision of open space, drainage construction and wetland buffer treatment.

Funding for within-lot drainage infrastructure will be the responsibility of the lot owner.

11.3 Review

It is not anticipated that this LWMS will be reviewed, unless additional land parcels/lots are added to the SP area prior to subdivision, or the SP undergoes significant change post-lodgment of the LWMS. If additional areas are required to be covered by the LWMS it is most likely that an addendum to cover these areas could be prepared. If the SP is substantially modified surface runoff modelling undertaken for this LWMS will need to be reviewed and the criteria proposed revised to ensure that all are still appropriate.

11.4 Conclusions and recommendations

The recommended approach to water management for MKSEA Precinct 1 includes:

- Maintain flow regime to the wetland and sensitive environment within the site so that the hydrology feeding these is maintained.
- Avoid changes to existing groundwater controls so that groundwater conditions are maintained.
- Avoid the need for significant imported fill that could potentially alter catchment hydrology.
- Treatment of road reserve runoff via extended detention/infiltration in swales.
- Lots retain small event runoff (i.e. first 15 mm of rainfall) on site and detain some runoff up to the major event on site.
- Conveyance of minor and major event runoff from lots and road reserves will be achieved via swales and overland flow within road reserves.
- Minor and major event flows will be detained within swales and detention areas to ensure pre-development peak flows discharging from the MKSEA are maintained.

This LWMS demonstrates that, by following the recommendations detailed above, sensitive downstream environments will be protected and that the site is capable of being developed for the intended industrial uses.

12 References

12.1 General references

Australian Cultural Heritage Management (ACHM) 2009, *Preliminary Investigation of Aboriginal Heritage - City of Gosnells Maddington Kenwick Strategic Employment Area* (MKSEA).

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC and ARMCANZ) 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, National Water Quality Management Strategy, Commonwealth of Australia, Canberra.

Aquaterra 2008, *MKSEA Surface Water and Groundwater Investigation and Monitoring Program*.

Cardno BSD 2005, *Maddington-Kenwick Strategic Industrial Area - Environmental Review: Flora, Vegetation, Fauna and Wetlands*.

Cardno BSD 2006, *Maddington Kenwick Strategic Employment Area - Preliminary Transport Study*.

City of Gosnells (CoG) 2002, *Town Planning Scheme No. 6*, Perth.

City of Gosnells (CoG) 2015, *Local Planning Policy 4.7: Planning and development of public open space and streetscapes*, Perth.

Department of Environment and Conservation (DEC) 2010, *Assessment Levels for Soil, Sediment and Groundwater*, Perth.

Department of Water (DoW) 2007, *Stormwater Management Manual for Western Australia*, Department of Water, Perth.

Department of Water (DoW) 2008, *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions*, Perth.

Department of Water (DoW) 2009, *Water Quality Protection Note 51: Industrial wastewater management and disposal*, Perth.

Department of Water (DoW) 2013, *Water resource considerations when controlling groundwater levels in urban development*, Perth.

Department of Water and Environmental Regulation (DWER) 2017, *Decision Process for Stormwater Management in Western Australia*, Government of Western Australia, Perth.

Emerge Associates 2018b, *Environmental Assessment and Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1*.

Emerge Associates 2018c, *Flora, Vegetation and Wetland Assessment Maddington Kenwick Strategic Employment Area - Precinct 1*.

Endemic 2012, *Final MKSEA Surface Water and Groundwater Monitoring and Investigation Report*.

Engineers Australia 1987, *Australian Rainfall and Runoff*, National Committee for Water Engineering, Canberra.

Engineers Australia 2006, *Australian Runoff Quality: A guide to Water Sensitive Urban Design*, National Committee for Water Engineering, Engineers Australia, Canberra.

Engineers Australia 2016, *Australian Rainfall and Runoff*, National Committee for Water Engineering, Canberra.

Environmental Protection Authority (EPA) 2008, *Guidance Statement No. 33: Environmental Guidance for Planning and Development*, Environmental Protection Authority, Perth.

Environmental Protection Authority (EPA) 2016a, *Environmental Factor Guideline: Hydrological Processes*, Western Australia.

Environmental Protection Authority (EPA) 2016b, *Environmental Factor Guideline: Inland Waters Environmental Quality*, Western Australia.

GHD 2005, *Maddington Kenwick Strategic Employment Area Engineering Feasibility Study*.

Government of WA 2007, *State Water Plan*, Perth.

JDSi Consulting Engineers (JDSi) 2017, *Geotechnical Investigation Report: Maddington Kenwick Strategic Employment Area Park A Study Area (Precinct 1)*, Perth.

Jordan, J. E. 1986, *Armadale Part Sheets 2033 I and 2133 IV*, Geological Survey of Western Australia, Department on Minerals and Energy, Perth.

McDowell Affleck 2016, *Local Water Management Strategy for Maddington Kenwick Strategic Employment Area (MKSEA) Area 1*.

Payne, E., Hatt, B., Deletic, A., Dobbie, M., McCarthy, D. and Chandrasena, G. 2015, *Adoption Guidelines for Stormwater Biofiltration Systems*, Cooperation Research Centre for Water Sensitive Cities, Melbourne.

Swan River Trust (SRT) 2009, *Swan Canning Water Quality Improvement Plan*, Government of Western Australia, East Perth.

Tauss, C. and Weston, A. S. 2010, *The flora, vegetation and wetlands of the Maddington-Kenwick Strategic Emplyment Area*.

Western Australian Planning Commission (WAPC) 2006a, *State Planning Policy 2.9: Water Resources*, Gazetted in December 2006, Perth.

Western Australian Planning Commission (WAPC) 2006b, *State Planning Policy 2.10: Swan-Canning River System*, Perth.

Western Australian Planning Commission (WAPC) 2007, *Liveable Neighbourhoods (Edition 4)*, Western Australian Planning Commission and Department for Planning and Infrastructure, Perth.

Western Australian Planning Commission (WAPC) 2008, *Better Urban Water Management*, Perth.

Western Australian Planning Commission (WAPC) 2009, *Planning Bulletin No. 64 Acid Sulfate Soils*, January 2009, Perth.

Western Australian Planning Commission (WAPC) 2015, *Draft Liveable Neighbourhoods*, Department of Planning, Perth.

12.2 Online references

Bureau of Meteorology (BoM) 2017, *Climate Averages,* viewed 28th February 2017 and 17th August 2017, <http://www.bom.gov.au/climate/data/>.

Department of Environment Regulation (DER) 2017, *Acid Sulfate Soil – Swan Coastal Plain Database*, viewed 25 May 2017 <http:// https://www2.landgate.wa.gov.au/bmvf/app/waatlas/>.

Department of Parks and Wildlife (DPaW) 2017, *Geomorphic Wetland Database – Swan Coastal Plain*, viewed 1 June 2017 <https://www2.landgate.wa.gov.au/bmvf/app/waatlas/>.

Department of Water (DoW) 2017a, *LiDAR Elevation Dataset*, extracted on 4 April 2017, DoW.

Department of Water (DoW) 2017b, *Water Information Reporting*, viewed 30 May 2017 < http://water.wa.gov.au/maps-and-data/maps/water-information-reporting2/>.

Department of Water (DoW) 2017b, *Perth Groundwater Map*, viewed 30 May 2017 <https://maps.water.wa.gov.au/#/webmap/gwm>.

Department of Water and Environment Regulation (DWER) 2018, *Contaminated Sites Database*, viewed 1 June 2017, <https://secure.dec.wa.gov.au/idelve/css/>.

Department of Water and Environmental Regulation (DWER) 2018, *Water Register*, viewed 14 February 2018, <https://maps.water.wa.gov.au/#/webmap/register>.

West Australian Land Information Authority (WALIA) 2017, *Landgate Map Viewer*, viewed 3rd April 2017, <http://landgate.wa.gov.au>.

Figures

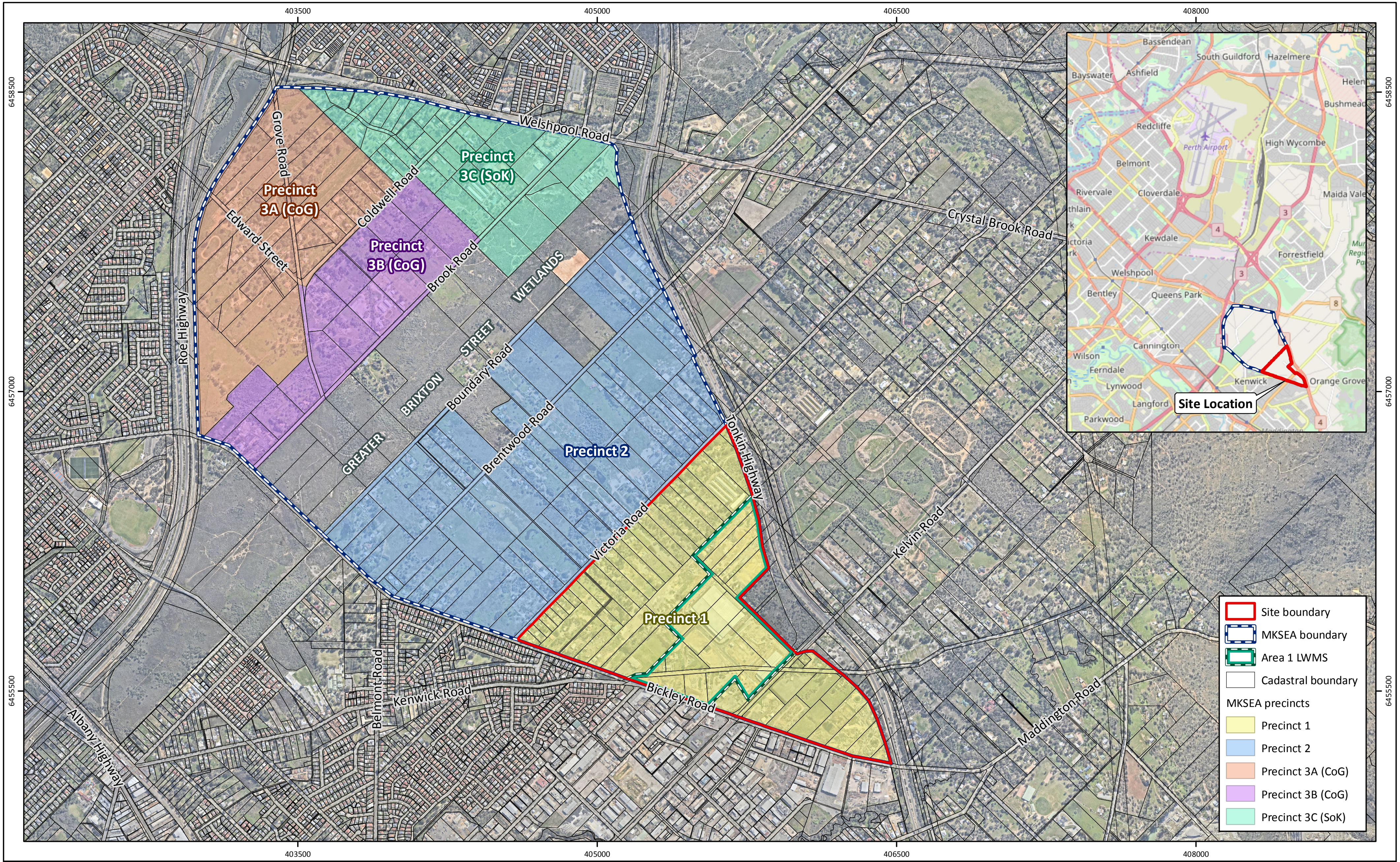

Figure 1: **Site Locality**

Project:	Local Water Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number:
EP17-010(11)--F64

Drawn:	KNM
Date:	06/04/2018
Checked:	ASC
Approved:	DPC
Date:	23/04/2018

N

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Scale: 1:25,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

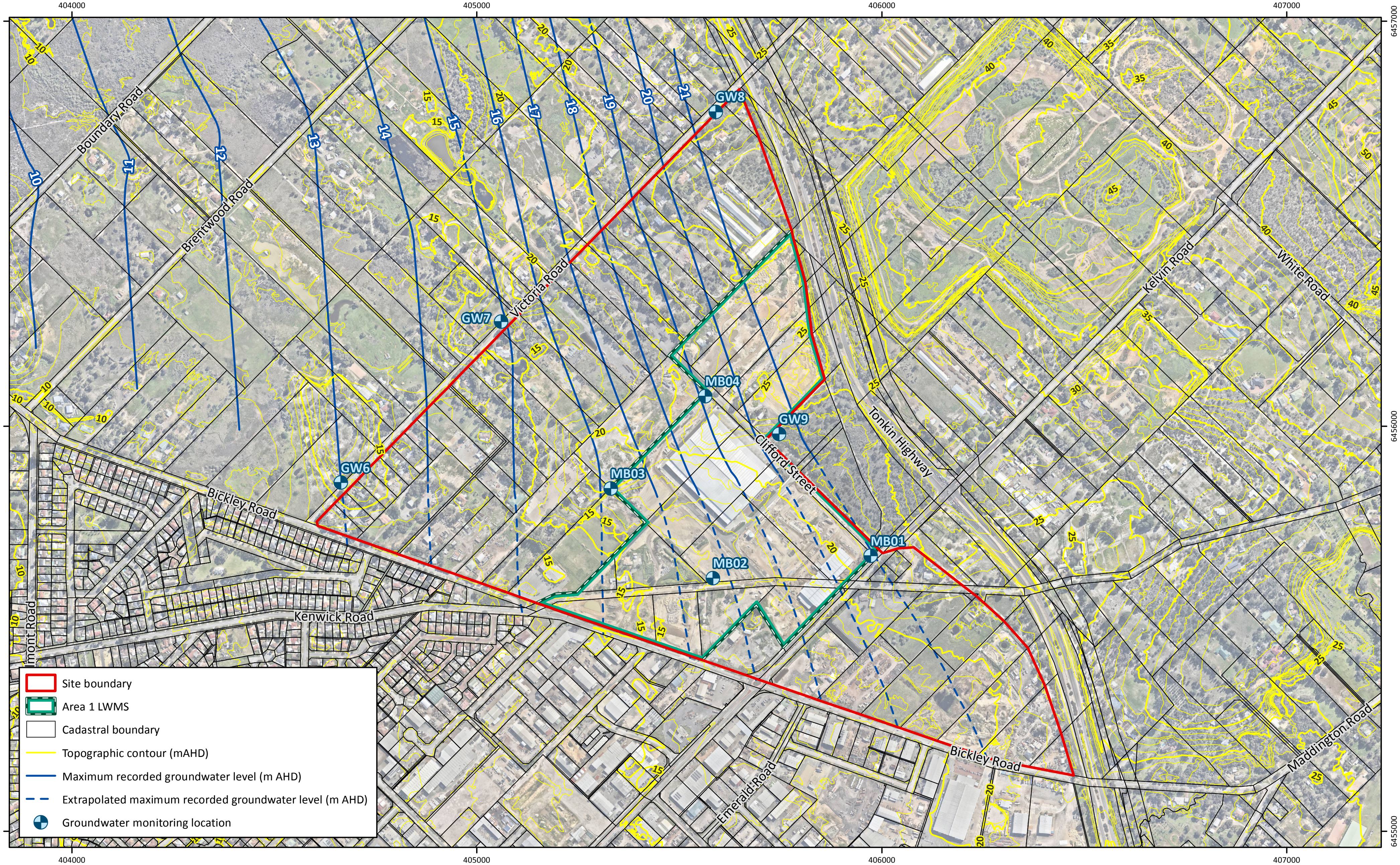

Figure 2: **Topographic Contours**

Project:	Local Water Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number: **EP17-010(11)--F65**
Drawn: KNM
Date: 06/04/2018
Checked: ASC
Approved: DPC
Date: 23/04/2018

N

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Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

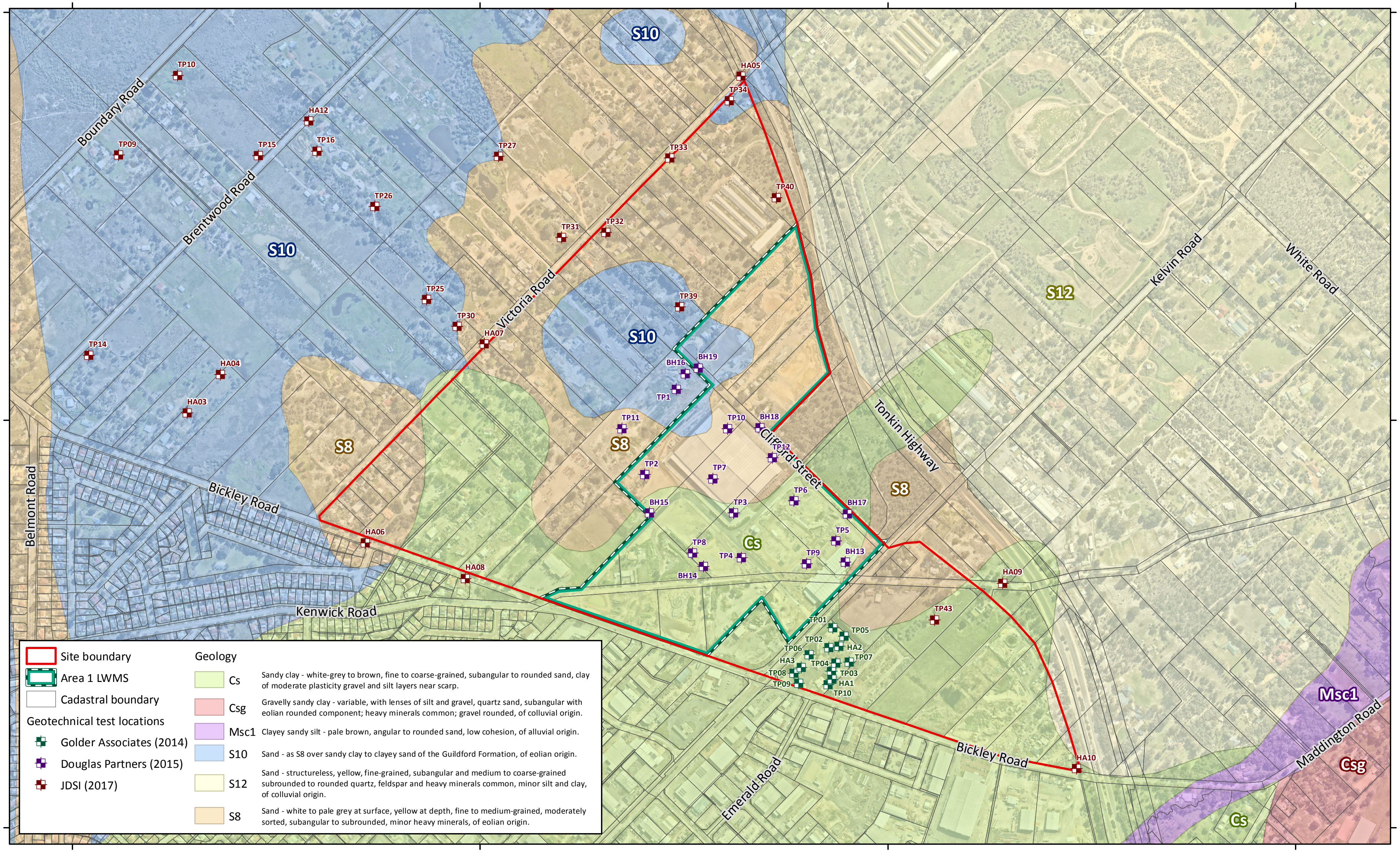

Figure 3: Environmental Geology

Project:	Local Water Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number:
EP17-010(11)--F66

Drawn:	KNM
Date:	06/04/2018
Checked:	ASC
Approved:	DPC
Date:	23/04/2018

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Metres
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GDA 1994 MGA Zone 50

emerge ASSOCIATES

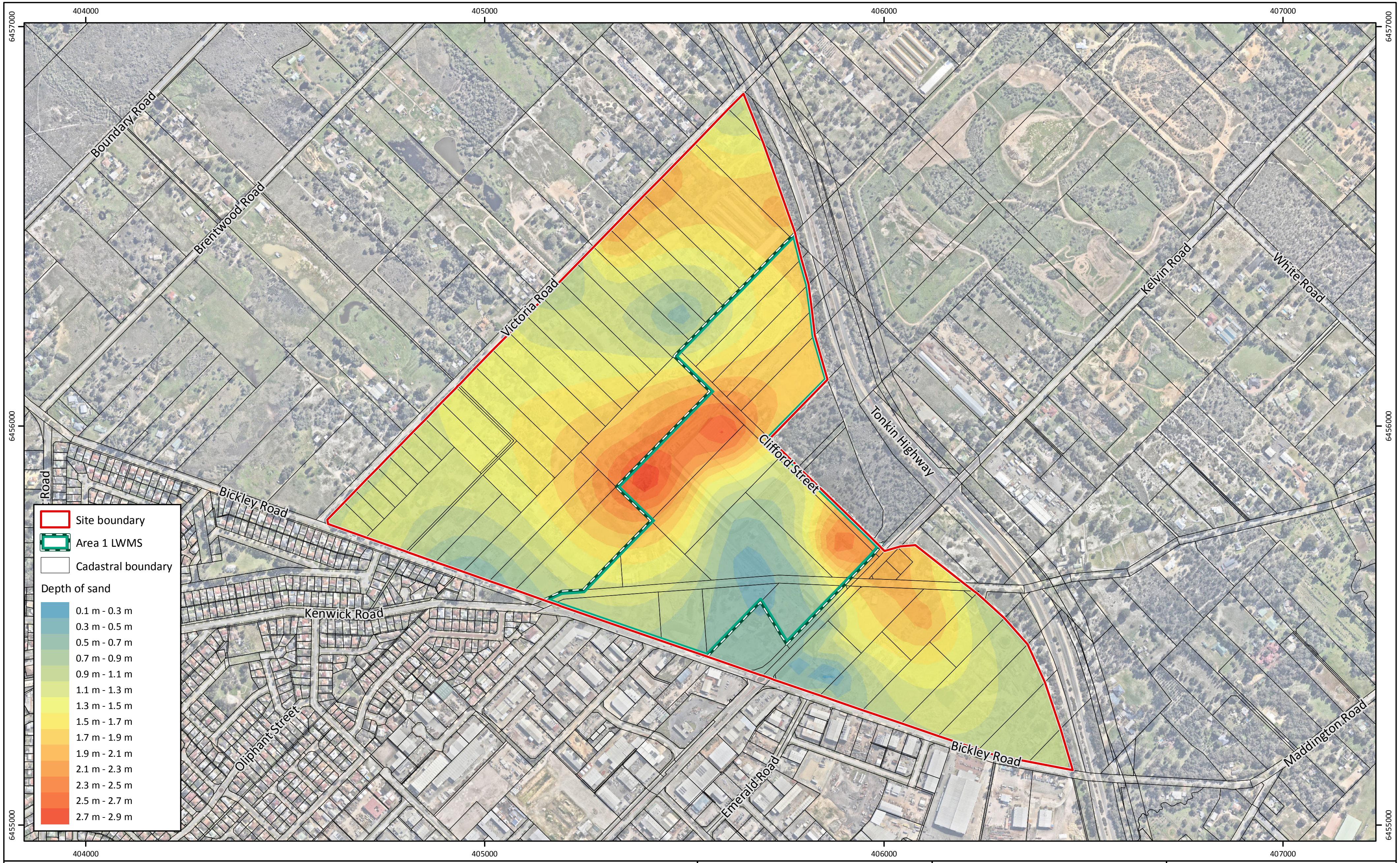

Figure 4: **Sand Depth**

Project:	Local Water Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number:
EP17-010(11)--F67

Drawn:	KNM
Date:	06/04/2018
Checked:	ASC
Approved:	DPC
Date:	23/04/2018

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

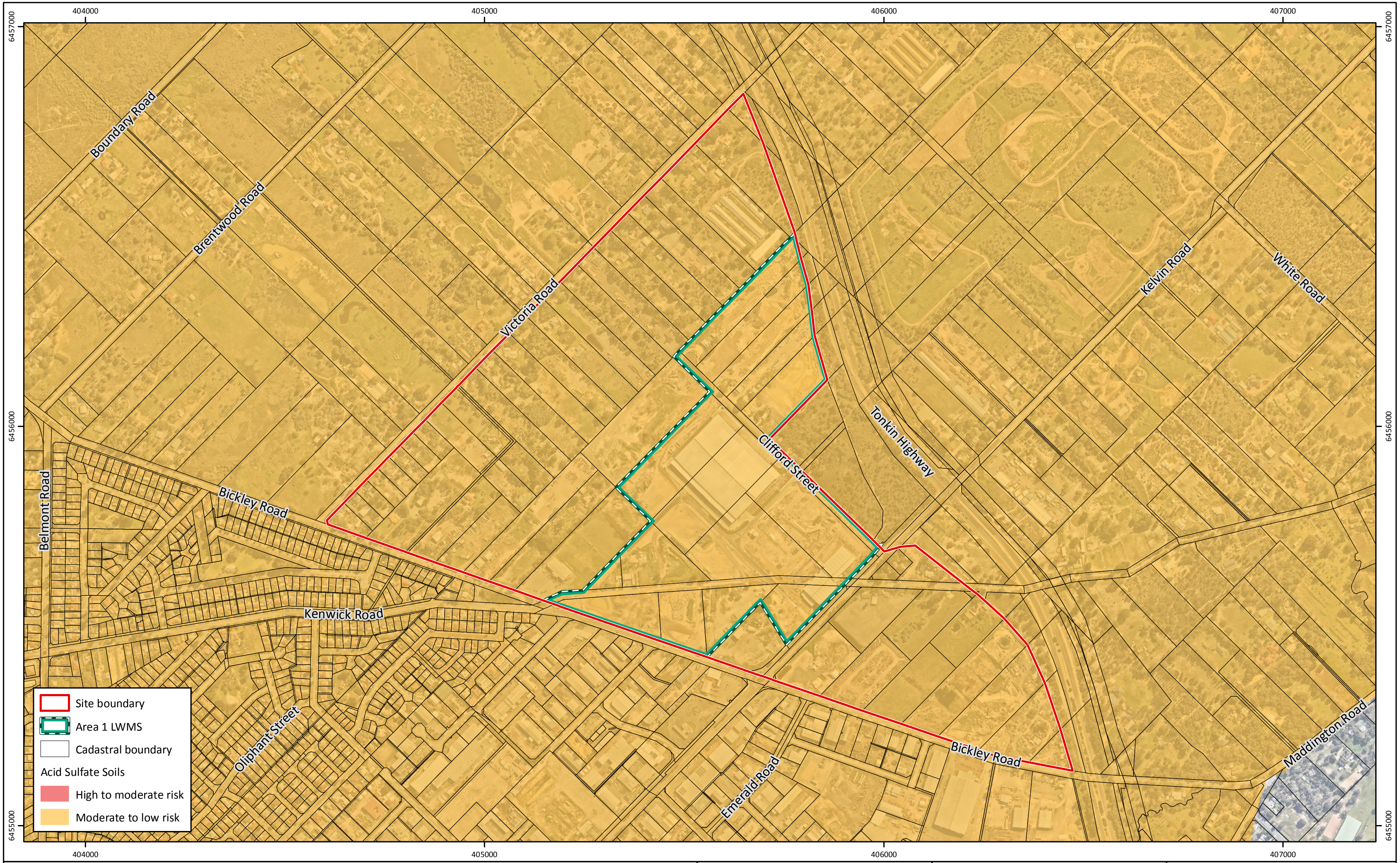

Figure 5: Acid Sulfate Soils Mapping

Project:	Local Water Management Strategy Maddington Kenwick Strategic Employment Area Precinct 1
Client:	City of Gosnells

Plan Number:
EP17-010(11)--F68

Drawn:	KNM
Date:	06/04/2018
Checked:	ASC
Approved:	DPC
Date:	23/04/2018

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Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

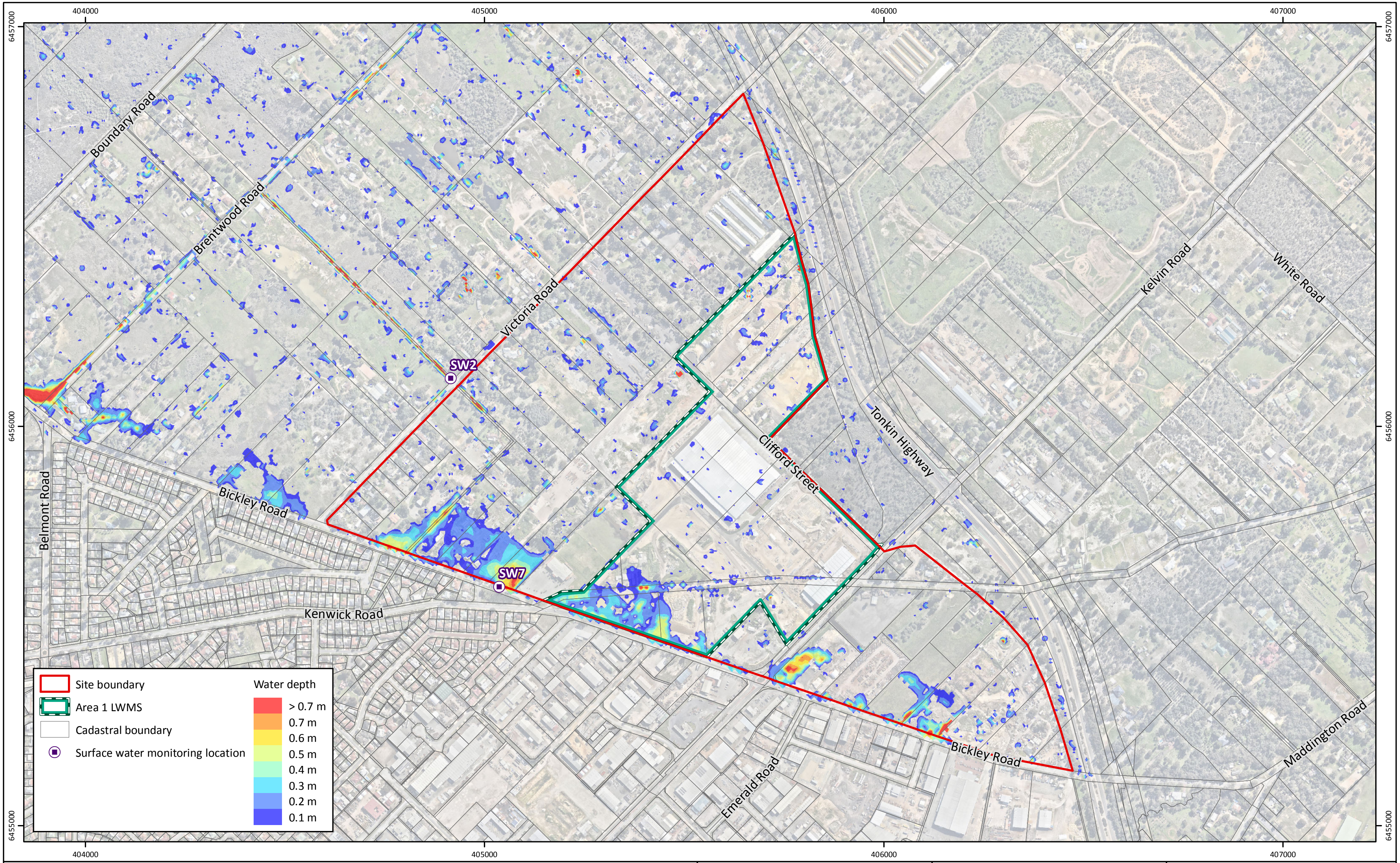

Figure 6: **Existing Hydrological Regime – Small Rainfall Event**

Project: Local Water Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(11)--F69

Drawn:	KNM
Date:	14/04/2018
Checked:	ASC
Approved:	DPC
Date:	24/04/2018

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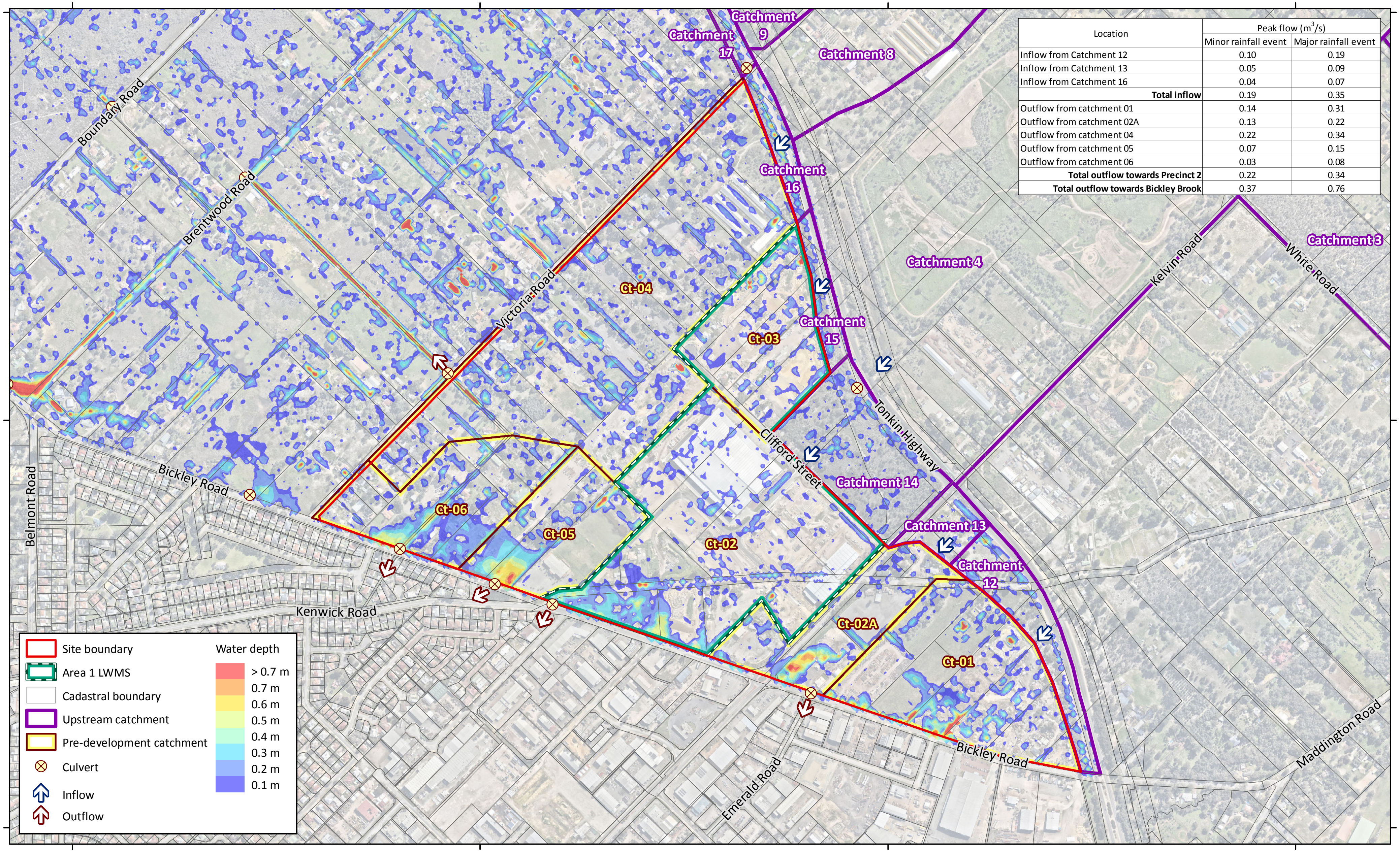
Scale: 1:12,500@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES



Location	Peak flow (m^3/s)	
	Minor rainfall event	Major rainfall event
Inflow from Catchment 12	0.10	0.19
Inflow from Catchment 13	0.05	0.09
Inflow from Catchment 16	0.04	0.07
Total inflow	0.19	0.35
Outflow from catchment 01	0.14	0.31
Outflow from catchment 02A	0.13	0.22
Outflow from catchment 04	0.22	0.34
Outflow from catchment 05	0.07	0.15
Outflow from catchment 06	0.03	0.08
Total outflow towards Precinct 2	0.22	0.34
Total outflow towards Bickley Brook	0.37	0.76

Figure 7: Existing Hydrological Regime – Minor and Major Rainfall Event

Project: Local Water Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1
Client: City of Gosnells

Plan Number:
EP17-010(11)--F70b
Drawn: KNM
Date: 04/07/2018
Checked: ASC
Approved: DPC
Date: 04/07/2018

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emerge ASSOCIATES

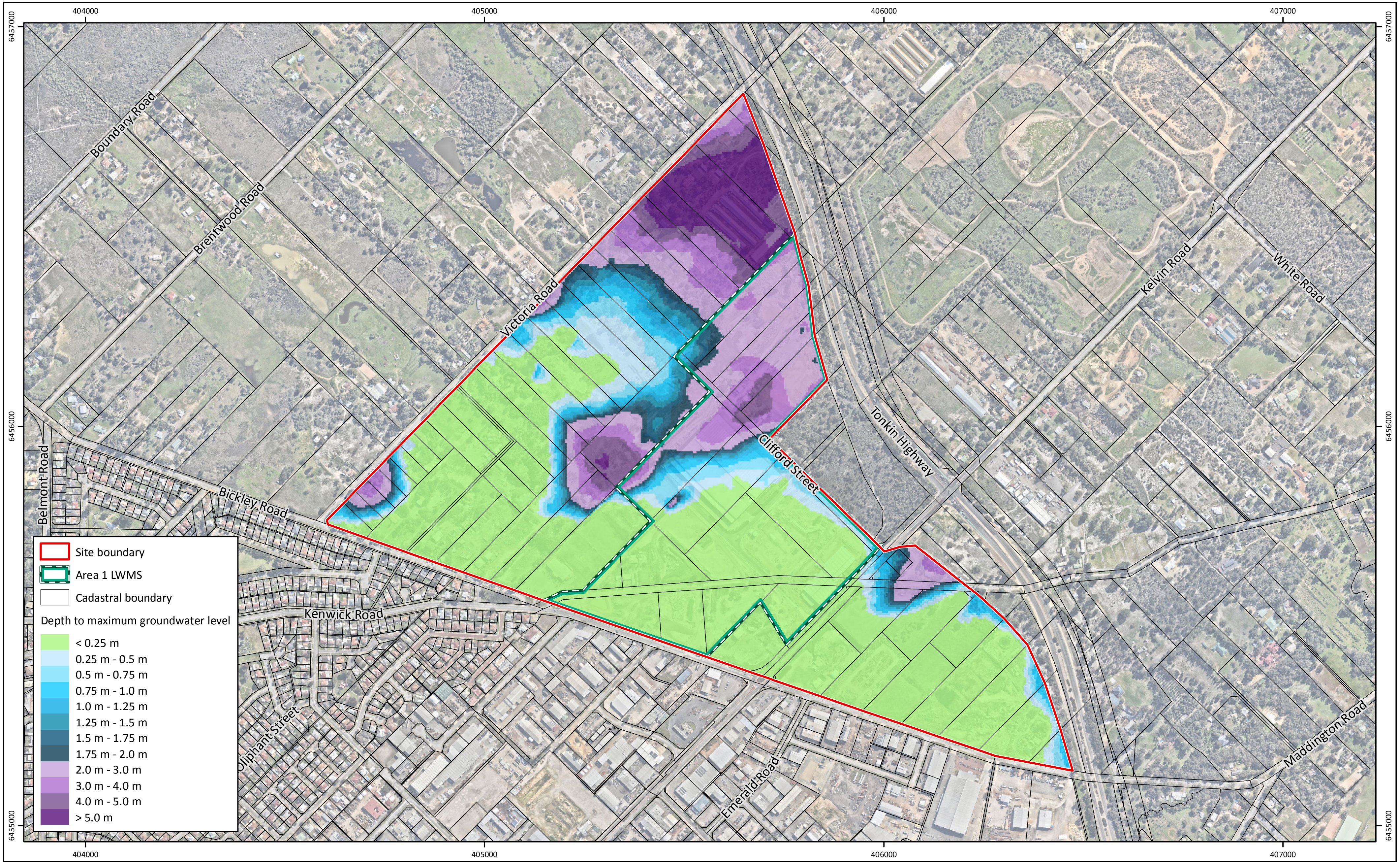

Figure 8: **Depth to Maximum Groundwater Level**

Project: Local Water Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(11)--F72
Drawn: KNM
Date: 27/04/2018
Checked: ASC
Approved: DPC
Date: 01/05/2018

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

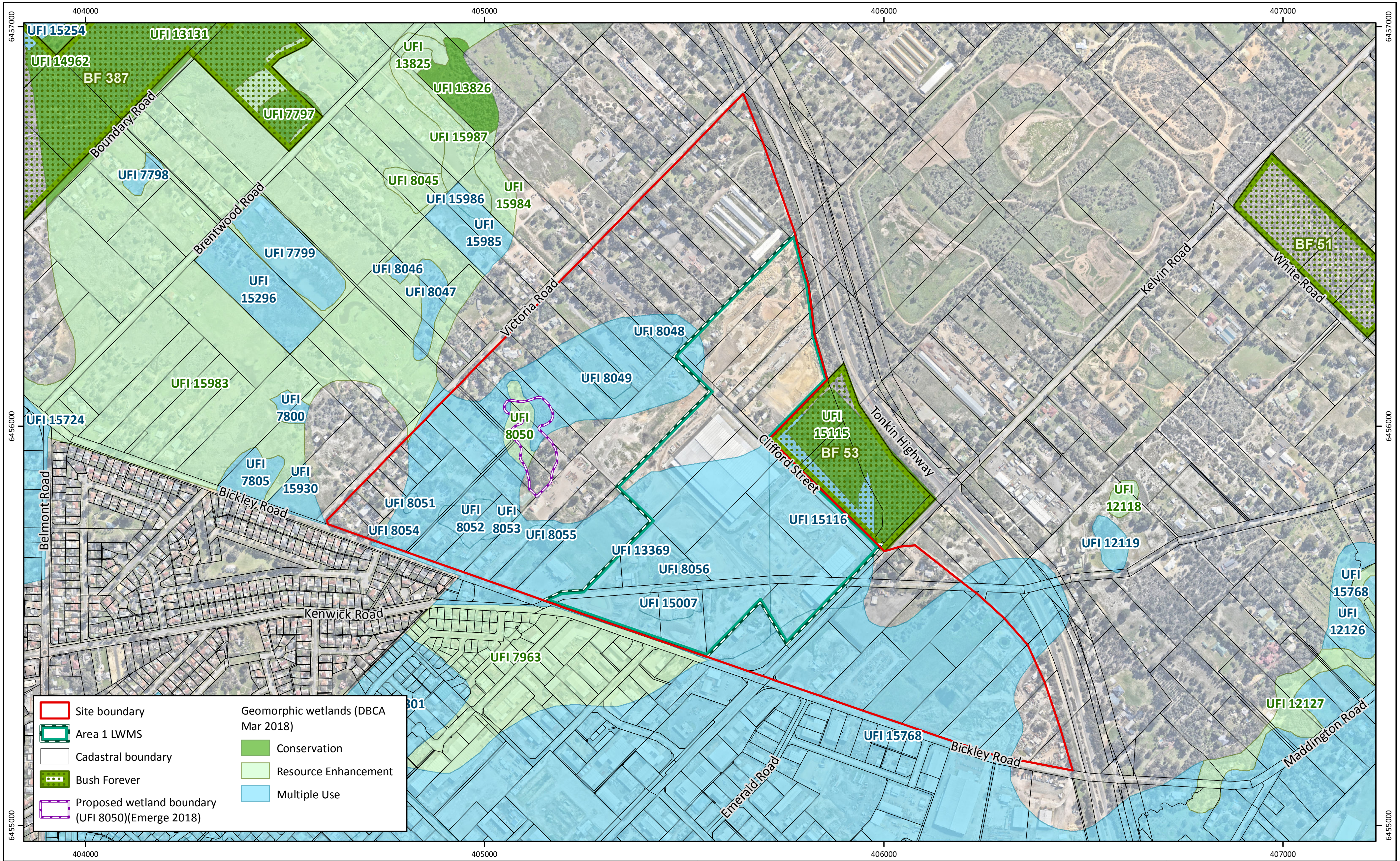

Figure 9: **Environmental Assets and Water Dependant Ecosystems**

Project: Local Water Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number: EP17-010(11)--F71
Drawn: KNM
Date: 06/04/2018
Checked: ASC
Approved: DPC
Date: 23/04/2018

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emerge ASSOCIATES

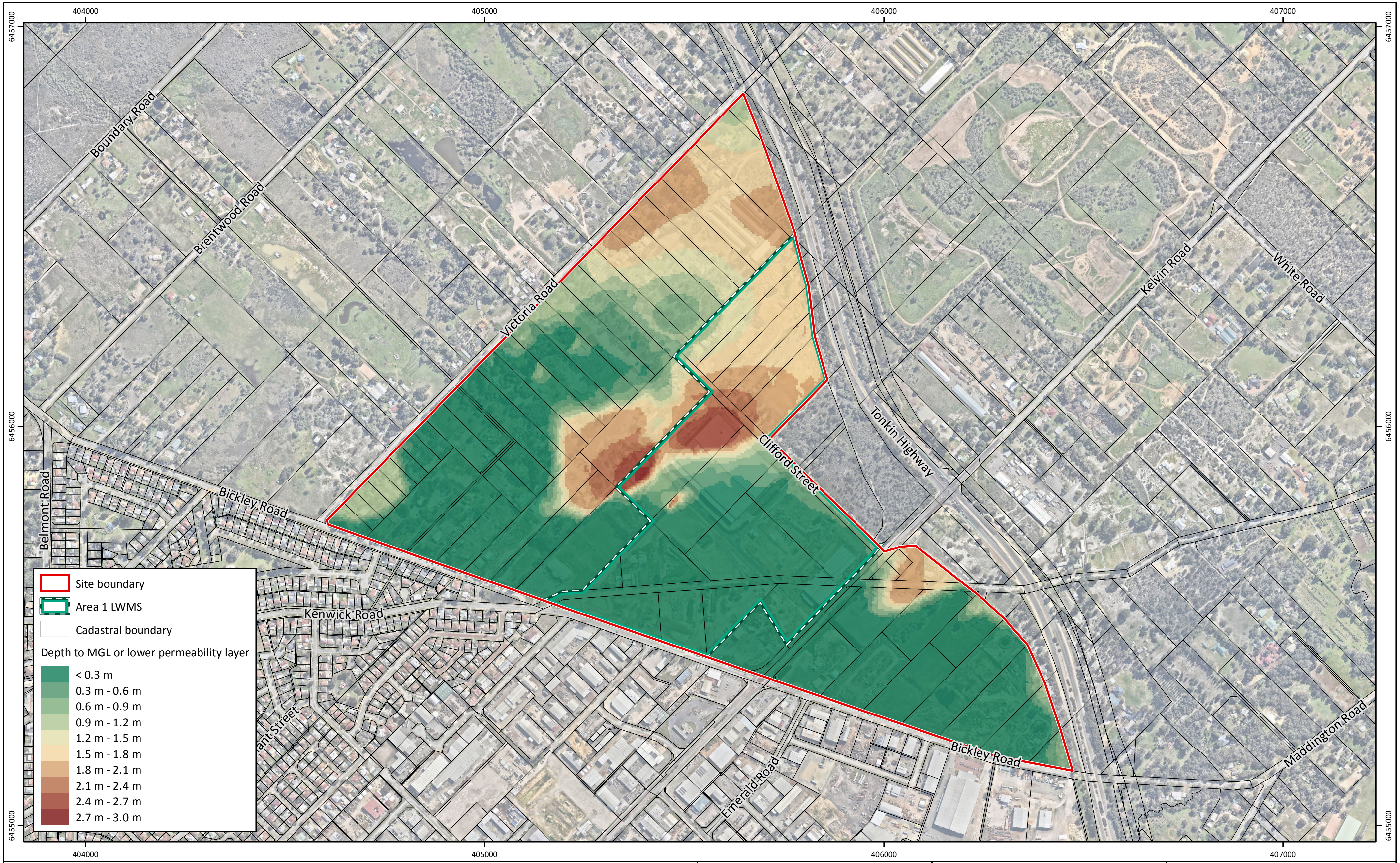

Figure 10: Depth to MGL or Lower Permeability Layer

Project: Local Water Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1
Client: City of Gosnells

Plan Number:
EP17-010(11)--F82
Drawn: KNM
Date: 27/04/2018
Checked: ASC
Approved: DPC
Date: 01/05/2018

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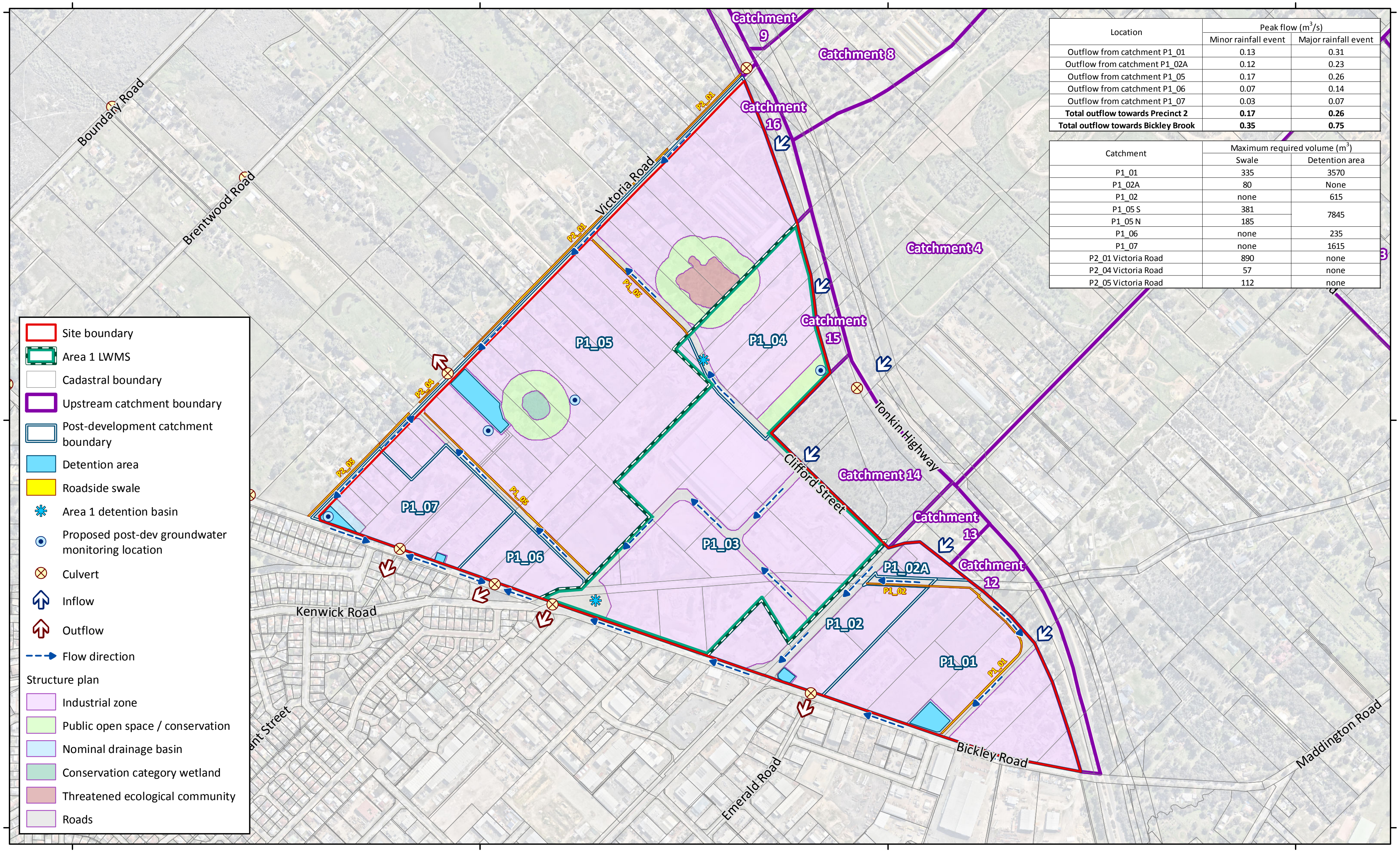
emerge ASSOCIATES



Location	Peak flow (m^3/s)	
	Minor rainfall event	Major rainfall event
Outflow from catchment P1_01	0.13	0.31
Outflow from catchment P1_02A	0.12	0.23
Outflow from catchment P1_05	0.17	0.26
Outflow from catchment P1_06	0.07	0.14
Outflow from catchment P1_07	0.03	0.07
Total outflow towards Precinct 2	**0.17**	**0.26**
Total outflow towards Bickley Brook	**0.35**	**0.75**

Catchment	Maximum required volume (m^3)	
	Swale	Detention area
P1_01	335	3570
P1_02A	80	None
P1_02	none	615
P1_05 S	381	7845
P1_05 N	185	
P1_06	none	235
P1_07	none	1615
P2_01 Victoria Road	890	none
P2_04 Victoria Road	57	none
P2_05 Victoria Road	112	none

Figure 11: Stormwater Management Plan

Project: Local Water Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(11)--F83e
Drawn: KNM
Date: 15/04/2019
Checked: ASC
Approved: DPC
Date: 15/04/2019

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

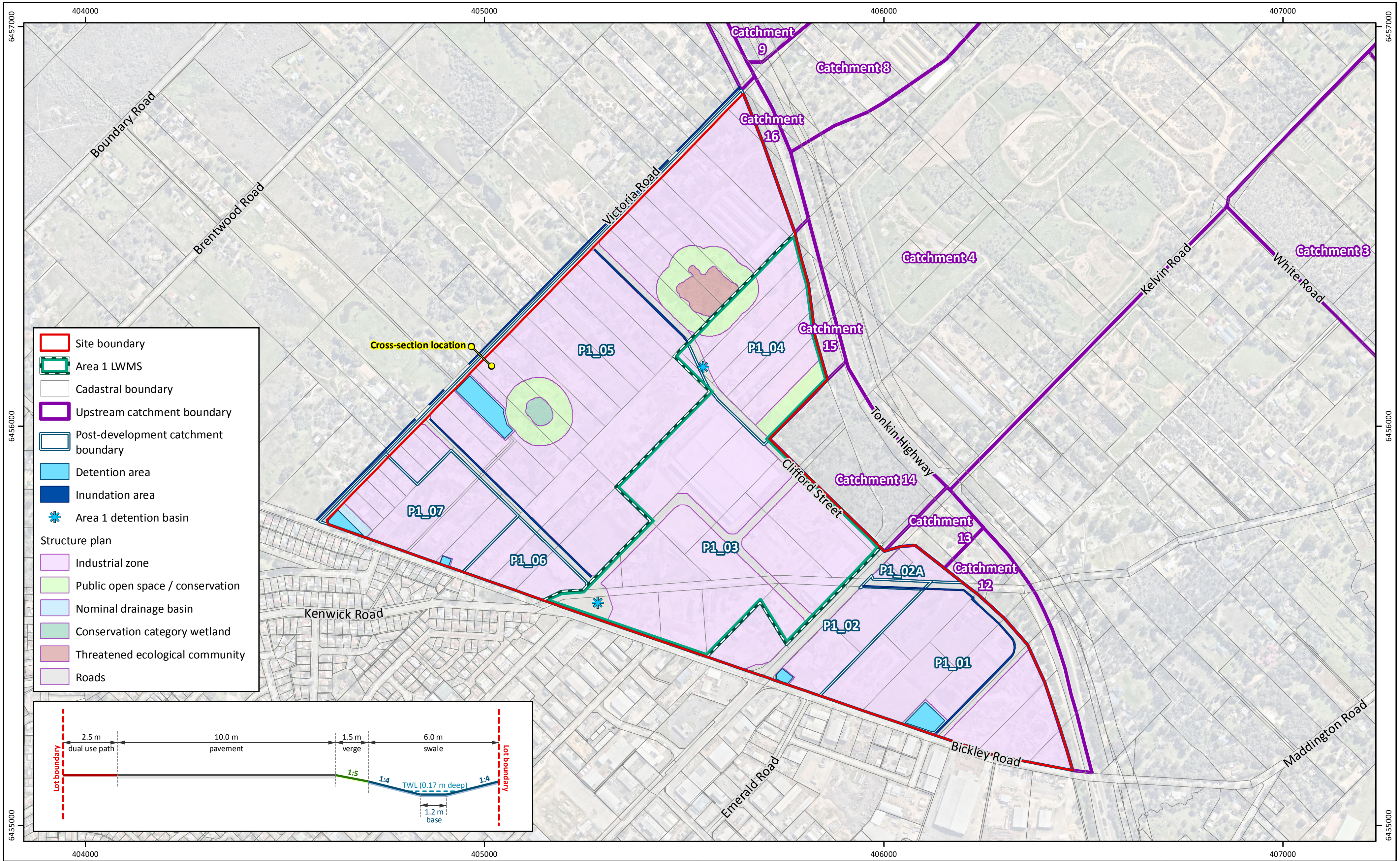

Figure 12: **Inundation Mapping – Small Rainfall Event**

Project: Local Water Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number:
EP17-010(11)--F84e
Drawn: KNM
Date: 15/04/2019
Checked: ASC
Approved: DPC
Date: 15/04/2019

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

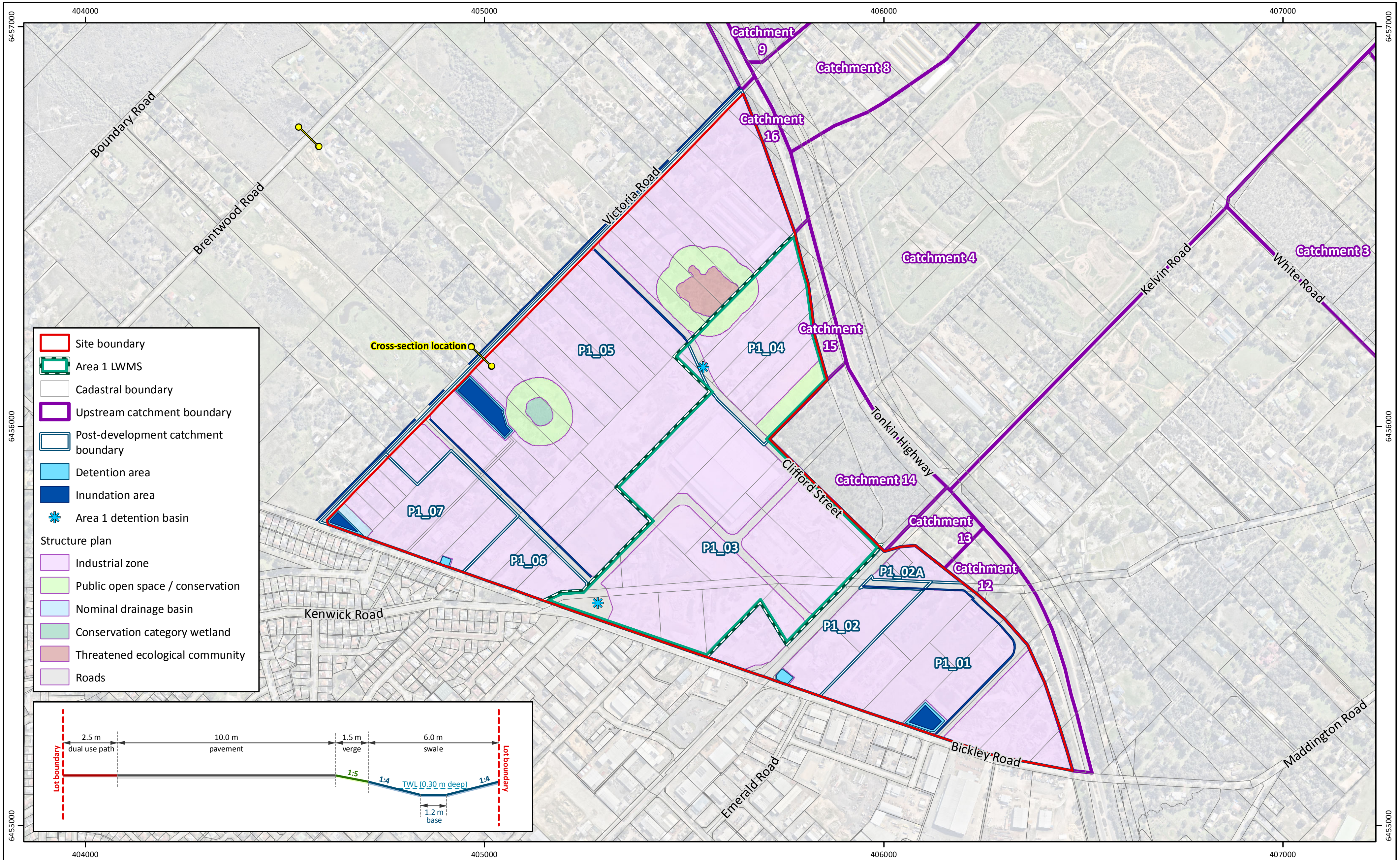

Figure 13: **Inundation Mapping – Minor Rainfall Event**

Project: Local Water Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number: EP17-010(11)--F85e
Drawn: KNM
Date: 15/04/2019
Checked: ASC
Approved: DPC
Date: 15/04/2019

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

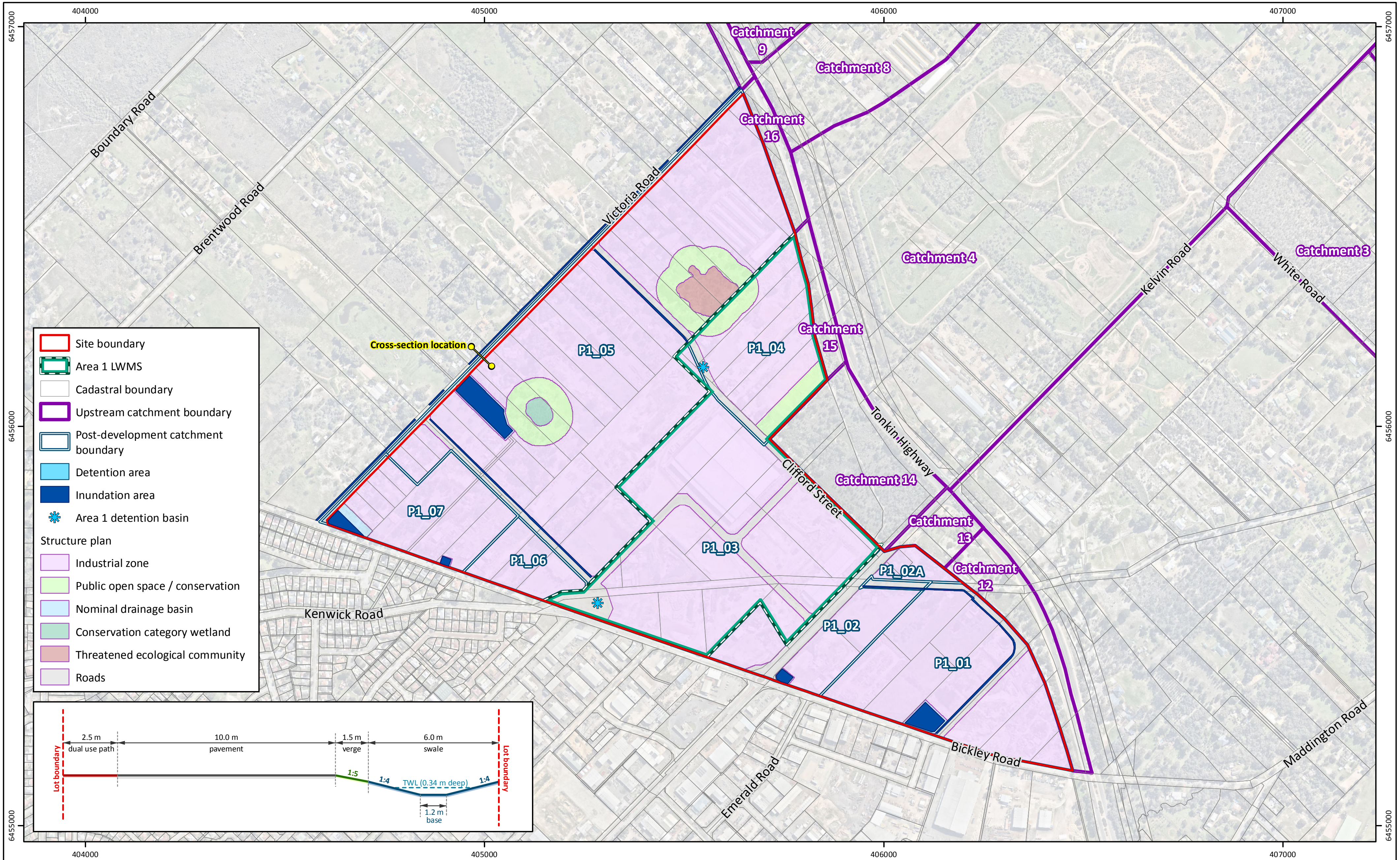

Figure 14: Inundation Mapping – Major Rainfall Event

Project: Local Water Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1

Client: City of Gosnells

Plan Number: EP17-010(11)--F86e
Drawn: KNM
Date: 15/04/2019
Checked: ASC
Approved: DPC
Date: 15/04/2019

Scale: 1:12,500@A4
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emerge ASSOCIATES

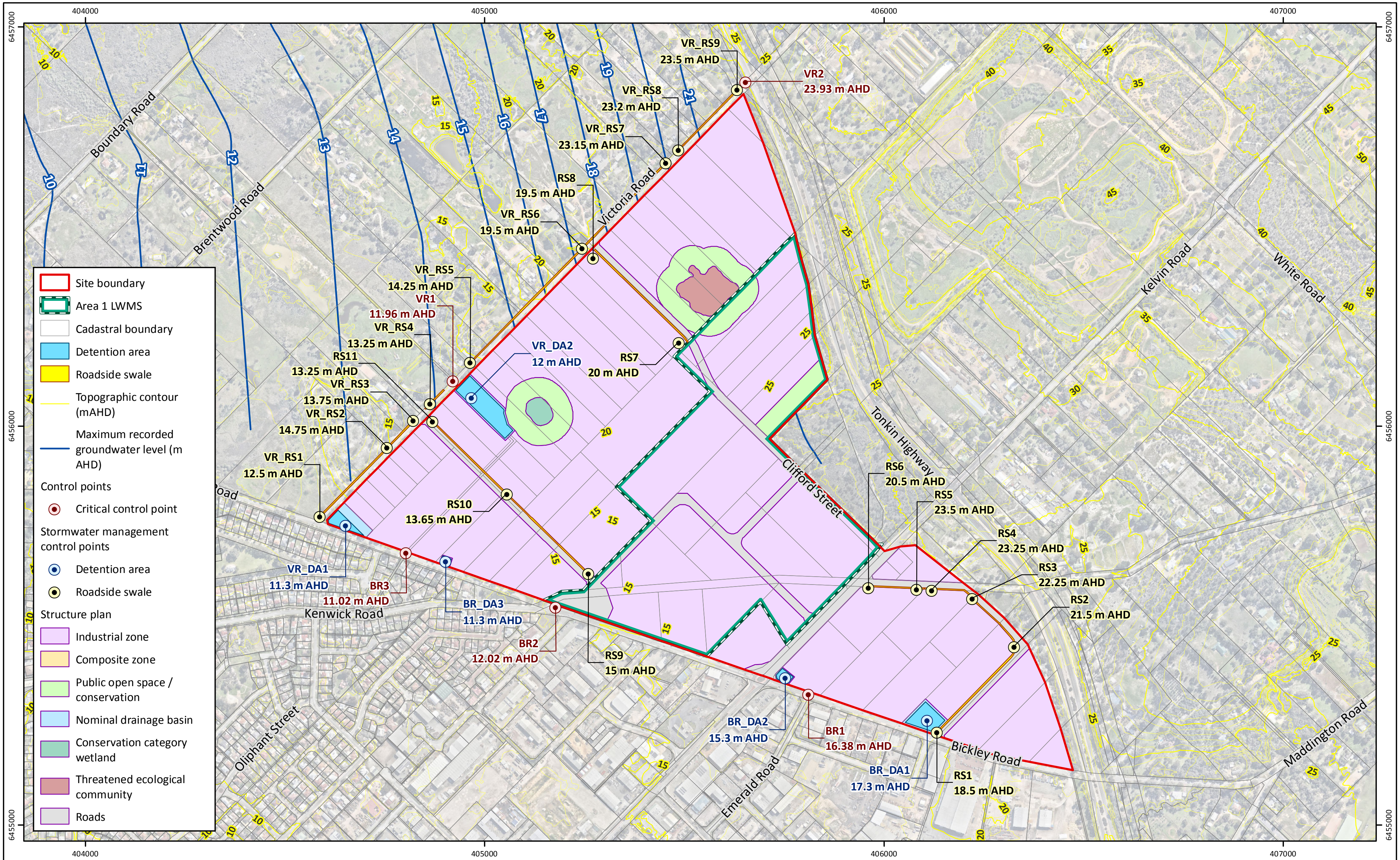

Figure 15: Critical Control Points and Stormwater Management Control Points

Project: Local Water Management Strategy
Maddington Kenwick Strategic Employment Area Precinct 1
Client: City of Gosnells

Plan Number: EP17-010(11)--F129b
Drawn: KNM
Date: 15/04/2019
Checked: ASC
Approved: DPC
Date: 15/04/2019

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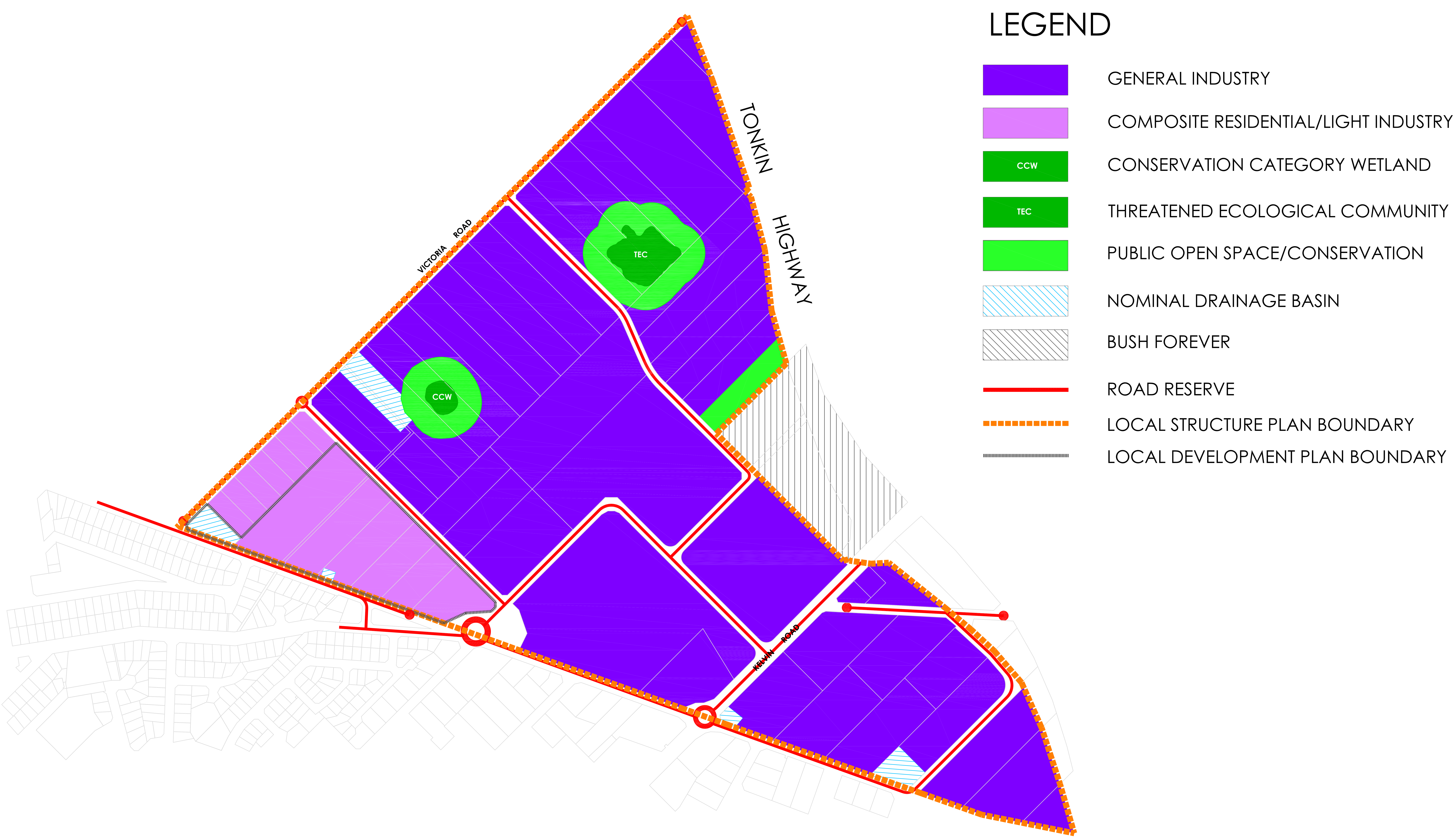
Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix A

Structure Plan



MADDINGTON KENWICK STRATEGIC EMPLOYMENT AREA

Draft Local Structure Plan - Precinct One

City of Gosnells

ISSUE	DESCRIPTION	YYMMDD	DRAWN	APPV'D
N	Precinct One	190329	AD	AD

PROJECT MKSEA
CLIENT COG
SCALE 1:4000 SHEET A1
0 80 160m

DRAWING NUMBER UD 001
REV N
REFERENCE NUMBER

Issued for design intent only. All areas and dimensions are subject to detail design + survey.

CITY OF GOSNELLS

Appendix B

Geotechnical Investigations

Douglas Partners

2015 report on geotechnical investigation

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on Geotechnical Investigation

Proposed Warehouse Development
Lots 252 to 256 Clifford Street, Maddington, WA

Prepared for
Juceda Investments Pty Ltd

Project 82411
February 2015

Douglas Partners

Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	82411	Document No.	1
Document title	Report on Geotechnical Investigation Proposed Warehouse Development		
Site address	Lots 252 to 256 Clifton Street, Maddington, WA		
Report prepared for	Juceda Investments Pty Ltd		
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1	1	-	Kevin Cunningham

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		10.02.2015
Reviewer		10 February 2015

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Report on Geotechnical Investigation
Proposed Warehouse Development
Lots 252 to 256 Clifton Street, Maddington, WA

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed development at Lots 252 to 256 Clifford Street in Maddington, WA. The investigation was commissioned in an email dated 9 January 2014 from Mr Ian Beacham on behalf of Juceda Investments Pty Ltd and was undertaken in accordance with Douglas Partners' proposal dated 23 December 2014.

The proposed development comprises several industrial warehouses (six in the master plan provided to DP), with associated car parking and civil works.

The aim of the investigation was to assess the subsurface soil and groundwater conditions across the general site in order to:

- the geotechnical suitability of the site for the proposed development;
- the site classification in accordance with the requirements of AS 2870-2011;
- site preparation, compaction, and earthworks;
- appropriate foundation system(s) for the proposed structures, including foundation design parameters such as allowable bearing pressures for strip footing and estimated settlements;
- the depth to groundwater, if encountered;
- a design California bearing ratio (CBR) for the likely pavement subgrade at the site;
- the existing pavement profile and subgrade CBR of Clifford Road; and
- the permeability of the soils and suitability for on-site stormwater disposal

The investigation included the excavation of 12 test pits, the drilling of four hand auger boreholes for the performance of four in situ permeability tests, the drilling of three power auger boreholes through the existing Clifton Street pavement and laboratory testing of selected samples. The details of this field work are presented in this report.

2. Site Description

The site covers Lots 252 to 256 Clifton Street in Maddington, Western Australia. It is bound by Clifford Street to the northeast, Kenwick Road reserve to the south and neighbouring rural residential properties on the remaining boundaries. Lots 252 to 254 were vacant and Lots 255 to 256 was in use as a residence with associated horse yards and training areas.

At the time of the investigation, Lot 252 and 253 were devoid of any structures apart from a dilapidated one near the western corner of the site. A hardstand area, understood to be previously used for trucks and heavy vehicles was located to the south west of the house and sheds and Lot 254. The hardstand is approximately half the width of Lot 254 and extends almost to the south western boundary of the site. In addition to the house and sheds in the northern area of Lot 255, a small dilapidated shed was observed towards the western boundary of Lot 256.

Vegetation at the site generally comprised grass, shrubs and trees estimated up to 20 m in height. Some areas of fly tipped rubbish were observed across the site as well as equipment and other debris remaining from previous uses of the area.

According to a survey plan provided by the client, the surface levels across the site vary between a low point of RL 16 m AHD on the south western boundary and a high point of RL 23 m near the north eastern boundary.

The Armadale 1:50,000 Environmental Geology sheet indicates that shallow sub surface conditions beneath the site can be broadly divided into three areas. The southern part of the site is indicated to be underlain by Guildford Formation, described as sandy clay but can be locally variable, comprising a variety of interbedded soils from sand to highly plastic and reactive clay. Most of the remaining area of the site is indicated to be underlain by Bassendean sand (pale grey at the surface, yellow at depth fine to medium grained sand of eolian origin). Part of the northern end of the site, approximately comprising the eastern part of Lot 252 and the western part of Lot 23, is indicated to be underlain by thin Bassendean sand over Guildford Formation.

The Perth Groundwater Atlas (2004) indicates that the groundwater level in May 2003 varied across the site from approximately RL 12 m AHD in the west (approximately 4 m below ground level) to RL 14 m AHD on the eastern side (approximately 12 m below ground level).

3. Field Work Methods

Field work for the investigation was carried out on 14 January 2014 and comprised the excavation of 12 test pits (TP1 to TP12), the drilling of four hand auger boreholes for permeability testing in the lots (BH13 to BH16) and the drilling of three power auger boreholes within the existing pavement of Clifford Street (BH17 to BH19).

The test pits (TP1 to TP12) were excavated to a maximum depth of 3.0 m using a 5.5 tonne excavator equipped with a 650 mm wide toothed bucket.

The boreholes within the lots (BH13 to BH16) were drilled to a maximum depth of 1.2 m using a 110 mm hand auger.

The boreholes through the existing Clifton Street pavement (BH17 to BH19) were drilled to a maximum depth of 1 m using a 300 mm diameter power auger attached to an 8 tonne excavator.

Each test pit and borehole was logged in general accordance with AS 1726–1993 by a suitably experienced engineer from DP. Soil samples were recovered from selected locations for subsequent laboratory testing.

PSP tests were carried out adjacent to the test pit and borehole locations in accordance with AS 1289.6.3.3 to assess the in-situ density of the shallow soils.

Test locations were determined using a GPS and are marked on Drawing 1, Appendix A. Surface elevations at each test location were interpolated from a site survey provided by the client. Levels are quoted relative to the Australian Height Datum (AHD) on the logs in Appendix B.

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing are presented in Appendix B, together with notes defining descriptive terms and classification methods used.

A summary of the general ground conditions encountered within the lots is:

- **Filling (Sand and Silty Sandy Gravel)** – variably compacted, red-brown fine to medium grained sand to 0.15 m at TP1 and blue-grey fine silty sand gravel ('cracker dust') to 0.2 m in TP7.
- **Topsoil (Sand)** – generally grey or dark grey, sandy topsoil with some silt and rootlets to depths of between 0.05 m and 0.15 m at TP2 to TP5 and TP9 to TP11.
- **Sand** – generally medium dense to dense grey, light grey fine to medium grained sand with a trace of silt at all test locations to depths varying between 0.4 m and the extent of the investigation at 3 m. The sand was loose to a depth of 1.5 m at TP2 and to 0.8 m at TP11. The sand extended to the full depth of the investigation at TP2, TP5, TP10 and TP11.
- **Clayey and sandy materials of the Guildford Formation**, encountered underlying the sand in across most of the site except for the northern two lots and the southern corner. The materials encountered included:
    - **Clay** – stiff to hard, blue-green, orange-brown or light brown, low to high plasticity clay;
    - **Clayey Sand / Sandy Clay**– generally very stiff to hard, orange-brown mottled light grey medium to high plasticity clay, with some gravel and sand in some locations, encountered below the sand or clay at most locations, except where sand extended to the full depth of the investigation.
    - **Sand** – generally light grey or light blue grey, fine to medium grained sand with some clay encountered below the clayey sand.

A summary of the pavement dipping results from BH17 to BH19 is:

- **Existing Pavement** – encountered in the existing car park (BH7) as follows:
    - **Spray Seal** – dark grey, inverted double/double spray seal, 25 mm aggregate over 12 mm aggregate, thickness of 0.03 m.
    - **Basecourse (Sandy Gravel)** – grey, fined to medium sized sandy gravel basecourse with some silt, with a thickness of 0.05 m. The gravel is angular crushed granite.

- **Subbase (Sandy Gravel)** – light yellow, fine to coarse sized sandy gravel subbase with a trace of silt, encountered in BH18 and BH19 underlying the basecourse to a depth of between 0.18 m and 0.25 m. The gravel is limestone.
- **Subbase (Gravelly Sand)** – light orange-brown, fine to medium grained gravelly sand subbase with a trace of silt, encountered underlying the basecourse or upper subbase in all three pavement boreholes to depths of between 0.3 m and 0.45 m. The gravel is fine to medium sized lateritic rock.

- **Sand** – generally medium dense to dense light yellow or grey, fine to medium grained sand with a trace of silt encountered below the pavement in all three pavement boreholes.

4.2 Groundwater

No free groundwater was observed at the test locations excavated, probed and drilled on 14 January 2015.

As noted in Section 2, the Perth Groundwater Atlas indicates that the regional superficial aquifer level lies approximately 4 m below the lowest part of the site.

It should be noted that groundwater levels are affected by climatic conditions and soil permeability and will therefore vary with time.

4.3 Permeability Testing

Four in situ permeability tests using the falling head method were carried at BH13 to BH16. A field permeability value was estimated using Hvorslev's method (1951). Permeability values can also be derived using grading results from laboratory testing and Hazen's formula, which applies for sand in a loose state.

Results of the permeability analysis are summarised in Table 1 (next page).

Table 1: Summary of In Situ Permeability Testing

Test Location	Depth (m)	Measured Permeability (m/s) [1]	Derived Permeability (m/s) [2]	In Situ Condition of Tested Material
BH13	0.75	0.4×10^{-4}	1.0×10^{-4}	Medium dense sand, some silt
BH14	0.4	2.4×10^{-4}	1.4×10^{-4}	Dense filling (sand), with some silt
BH15	1.2	1.4×10^{-4}	0.8×10^{-4}	Medium dense sand, with a trace of silt
BH16	0.35	5.7×10^{-4}	1.7×10^{-4}	Medium dense sand, with a trace of silt

Notes: [1]: Hvorslev's method.
[2]: Hazen's formula – requires particle size distribution test results, which are still in progress.

5. Laboratory Testing

A geotechnical laboratory testing programme has been commissioned with a NATA registered laboratory and comprised the determination of:

- the particle size distribution of six samples;
- the Atterberg Limits and linear shrinkage of three samples;
- the shrink swell index of one sample; and
- the modified maximum dry density and California bearing ratio of two samples.

The detailed test report sheets are given in Appendix C, with the results summarised in Table 2 (next page).

Table 2: Results of Laboratory Testing

Test	Depth (m)	Fines (%)	Sand (%)	Gravel (%)	LL (%)	PL (%)	PI (%)	LS (%)	MMDD (t/m^3)	CBR (%)	CBR Swell (%)	Shrink/ Swell Index (%)	Material
TP3	0.95-1.35	-	-	-	-	-	-	-	-	-	-	2.0	Slightly Sandy Clay
TP4	0.8	48	34	18	59	20	39	9.5	-	-	-	-	Gravelly Sandy Clay
TP8	0.5	-	-	-	-	-	-	-	1.95	25	0	-	Slightly Silty Sand
TP9	1.2	-	-	-	58	20	38	13.5	-	-	-	-	Sandy Clay
TP12	1.4	43	39	18	55	20	35	12.0	-	-	-	-	Gravelly Sandy Clay
BH13	0.5	6	94	0	-	-	-	-	-	-	-	-	Sand
BH14	0.4	5	88	7	-	-	-	-	-	-	-	-	Filling (Sand)
BH15	0.9	5	95	0	-	-	-	-	-	-	-	-	Sand
BH16	0.35	4	96	0	-	-	-	-	-	-	-	-	Sand
BH18	0.5 – 1.0	-	-	-	-	-	-	-	1.80	16	0	-	Sand

Notes on Table 3:
- The % fines is the amount of particles smaller than 75 µm;
- The % sand is the amount of particles larger than 75 µm and smaller than 2.36 mm;
- The % gravel is the amount of particles larger than 2.36 mm and smaller than 60 mm;
-LL: liquid limit -PL: plastic limit -PI: plasticity index -LS: linear shrinkage
-MMDD: Maximum Modified Dry Density -CBR: California Bearing Ratio

6. Proposed Development

It is understood that the proposed development of the site will comprise a number of industrial warehouses (the current master plan indicates six), with associated internal access road, hard standing and car parking areas.

7. Comments

7.1 Site Suitability

The investigation indicates that the site is generally underlain by generally medium dense sand, which in most areas of the site overlies stiff to hard clay or clayey sand of the Guildford Formation.

Therefore, from a geotechnical standpoint, the land is physically capable of development for the proposed warehouse development, provided that the provisions outlined in the subsequent subsections of the report are taken into consideration, and the recommendations implemented.

7.2 Site Classification

The shallow ground conditions beneath the site include generally medium dense to dense sand, overlying stiff to hard low to high plasticity clayey materials of the Guildford Formation across most of the site. The clayey material was not encountered in the northern part of the site or in the southern corner. Filling was encountered at some locations associated with previous developments. The encountered filling should be considered as uncontrolled filling in its current condition

Therefore, the site in its current condition should be classified as 'Class P' in strict accordance with AS 2870-2011.

However, based on field observations and laboratory test results, the sand filling encountered by the investigation is considered to conform to the requirements of suitable filling materials outlined in AS3798 – 2011, provided it is suitably compacted. Therefore, provided the site preparation and recommendations outlined in Section 7.3 are carried out, the site classification could be readily amended to an equivalent Class 'A' or Class 'S', as follows:

- the areas of the site where the clayey materials of the Guildford Formation were not encountered could be readily amended to an equivalent Class 'A'; and
- the areas where the clayey materials of the Guildford Formation were encountered within 1.8 m of the existing ground surface could be readily amended to an equivalent Class 'S'.

The interpolatedextent of the site suitable to be an equivalent Class 'S' area, based on the findings of the investigation and laboratory testing, is shown on Figure 3, Appendix A, with the remaining areas of the site being an equivalent Class 'A'.

The Class 'S' area could be further modified to an equivalent Class 'A' if at least 1.8 m of medium dense or denser clean sand is present above the clay material. In the worst encountered case of TP4, this would require an additional 1.4 m of compacted clean sand filling to be placed above the existing ground level.

It should be noted that AS 2870 - 2011 applies to single houses, townhouses and the like classified as Class 1 and 10a under the Building Code of Australia. It also applies to light industrial and commercial buildings if they are similar in size, loading and superstructure flexibility to those designs included in AS 2870 - 2011.

7.3 Site Preparation

7.3.1 Site Stripping

All deleterious material, including (if encountered) demolition rubble, debris, topsoil and vegetation should be stripped from the proposed development areas of the site. Tree roots remaining from any clearing operations should be completely removed.

7.3.2 Proof Rolling

Following removal of unsuitable material and prior to any filling, it is recommended that the exposed ground beneath building envelopes and pavement areas be proof rolled with a smooth drum roller of 10 tonnes minimum deadweight. Any areas that show signs of excessive deformation during compaction should be compacted until deformation ceases or, alternatively, the poor quality material should be excavated and replaced with suitable structural filling and compacted. Care should be taken not to run heavy plant immediately adjacent to existing buildings and services.

7.3.3 Re-use of Sand Filling and In-Situ Sand

The naturally occurring sand and the existing filling encountered at the site should be suitable for re-use as structural fill, provided it is free from organic material and particles greater than 150 mm in size.

It should be noted that this study has not assessed whether unacceptable levels of contaminants exist within the filling material as this was outside the scope of the investigation. Such levels, if they occur, may limit or prevent the use of this material. DP would be pleased to assist with this matter if required.

7.3.4 Imported Filling

If required, imported filling should comprise free draining, cohesionless, well graded sand that:

- Contains less than 5% by weight of particles less than 75 microns in size.
- Contains no particles greater than 150 mm in size.
- Is free of organic and other deleterious materials.

It is recommended that test certificates are reviewed and approved by the geotechnical engineer prior to importing material to site.

7.3.5 Fill Placement

Any fill should be placed in layers not exceeding 300 mm loose thickness and compacted near optimum moisture content with a roller of 10 tonne minimum deadweight. Care should be taken not to run heavy plant immediately adjacent to existing structures and services. It is recommended that earthworks be carried out with regular inspections by a geotechnical engineer.

7.3.6 Compaction Testing

Compaction control of the sand filling could be carried out using a Perth sand penetrometer (PSP) test in accordance with test method AS 1289.6.3.3. All areas within the proposed building envelopes should be compacted to achieve a minimum blow count of 8 blows per 300 mm penetration to a depth of not less than 0.5 m below foundation level.

During construction, some loosening of the surface materials in foundation excavations is expected. Therefore the top 300 mm in the base of any excavation should be re-compacted using a vibratory plate compactor prior to construction of any footings. Confirmation of adequate compaction should be carried out as outlined above.

7.4 Shallow Foundation Design

Shallow foundation systems comprising slab, pad and strip footings should be suitable to support the proposed structures. Footings of buildings covered by AS 2870-2011 should be designed to satisfy the requirements of this standard for the site classification listed in Section 7.2, provided that site preparation is carried out as detailed in Section 7.3.

AS 2870-2011 applies to single houses, townhouses and the like classified as Class 1 and 10a under the Building Code of Australia. For buildings not covered by AS 2870-2011, the following presumptive allowable bearing pressures are suggested for foundation design of strip footings of minimum width of 0.5 m and pad footings between 0.5 m and 2 m in size founded at a minimum depth of 0.5 m in medium dense sand or in clay that is at least very stiff:

- 200 kPa in the areas shown as Class ‘S’ in Figure 3; and
- 250 kPa elsewhere on the site.

This should ensure that total and differential settlements will be less than 15 mm. The above settlement estimate does not incorporate possible movements induced by the seasonal swelling and shrinkage of the reactive clayey materials beneath the site.

7.5 Pavement Design

Based on observation of the dense sandy soils underlying the surface of the site, and assuming the recommendations in Section 7.3 are followed, a subgrade California bearing ratio (CBR) of 12% is suggested for pavement design, provided the subgrade is compacted to not less than 95% of modified maximum dry density.

In the event the subgrade comprises imported sand filling, the pavement should be designed using an appropriate CBR of that material. A presumptive design CBR value of 12% is suggested for clean sand filling, however, this value should be confirmed prior to pavement construction once the type of filling material is known and its CBR has been assessed.

7.6 Stormwater Disposal and Drainage

The investigation encountered generally medium dense to dense sand, which overlay clayey materials of the Guildford Formation across much of the site. Where the clayey materials were encountered (the Class 'S' area on Figure 3), the depth of the clay or clayey sand varied between 0.4 m and 1.4 m. The groundwater was not encountered during the investigation. The Perth Groundwater Atlas (2004) indicates that the groundwater level was estimated to be at approximately RL 12 m AHD in May 2003, approximately 4 m below the current site elevation of the lowest part of the site.

Results of the analyses of in situ permeability tests in Section 4.3 indicate soil permeability values of between 0.4×10^{-4} m/s and 5.7×10^{-4} m/s (approximately 3.4 m/day to 49 m/day) for the sand and sand filling. Correlation with the grading results using the Hazen formula, which assumes sand in loose conditions, indicates a similar range of permeability values of between 0.8×10^{-4} m/s to 1.7×10^{-4} m/s (approximately 7 m/day to 15 m/day).

Based on these results, a design permeability value of 0.4×10^{-4} m/s (approximately 3.4 m/day) is suggested for the sand. However, account should be made in the design of the presence of the clayey materials underlying the sand. Infiltration water is likely to pond on these materials. A permeability of 1×10^{-6} (approximately 0.1 m per day) is suggested for the clay or clayey sand.

The infiltration capability commonly reduces over time due to silt build up at the base of soakwells and therefore the soakwells must be cleaned and maintained on a regular basis.

8. References

1. Australian Standard AS 1289-2000, Methods of Testing Soils for Engineering Purposes.
2. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
3. Australian Standard AS 1170.4-2007, Earthquake Actions in Australia.
4. Australian Standard AS 1726-1996, Geotechnical Site Investigation.
5. Australian Standard AS 2870-2011, Residential Slabs and Footings.
6. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004.

9. Limitations

Douglas Partners (DP) has prepared this report for a project at Lots 252 to 256 Clifton Street, Maddington, WA in general accordance with DP's proposal dated 23 December 2014 and acceptance received from Mr Ian Beacham on behalf of Juceda Investments Pty Ltd on 9 January 2015. The report is provided for the exclusive use of the Juceda Investments Pty Ltd for this project only and for the purpose(s) described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About this Report
Drawings

About this Report

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

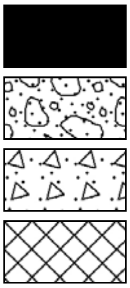
Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

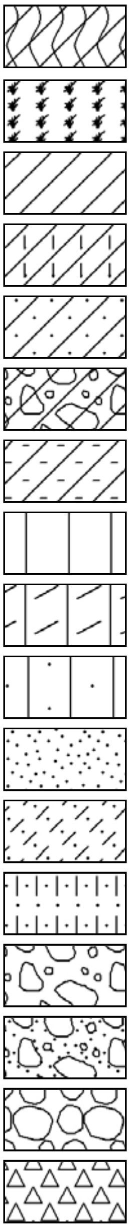
Graphic Symbols for Soil and Rock

General



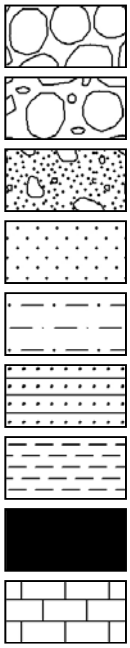
Asphalt
Road base
Concrete
Filling

Soils



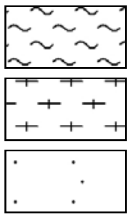
Topsoil
Peat
Clay
Silty clay
Sandy clay
Gravelly clay
Shaly clay
Silt
Clayey silt
Sandy silt
Sand
Clayey sand
Silty sand
Gravel
Sandy gravel
Cobbles, boulders
Talus

Sedimentary Rocks



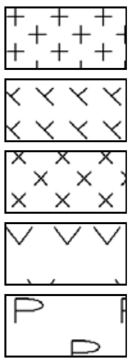
Boulder conglomerate
Conglomerate
Conglomeratic sandstone
Sandstone
Siltstone
Laminite
Mudstone, claystone, shale
Coal
Limestone

Metamorphic Rocks



Slate, phyllite, schist
Gneiss
Quartzite

Igneous Rocks



Granite
Dolerite, basalt, andesite
Dacite, epidote
Tuff, breccia
Porphyry

Legend

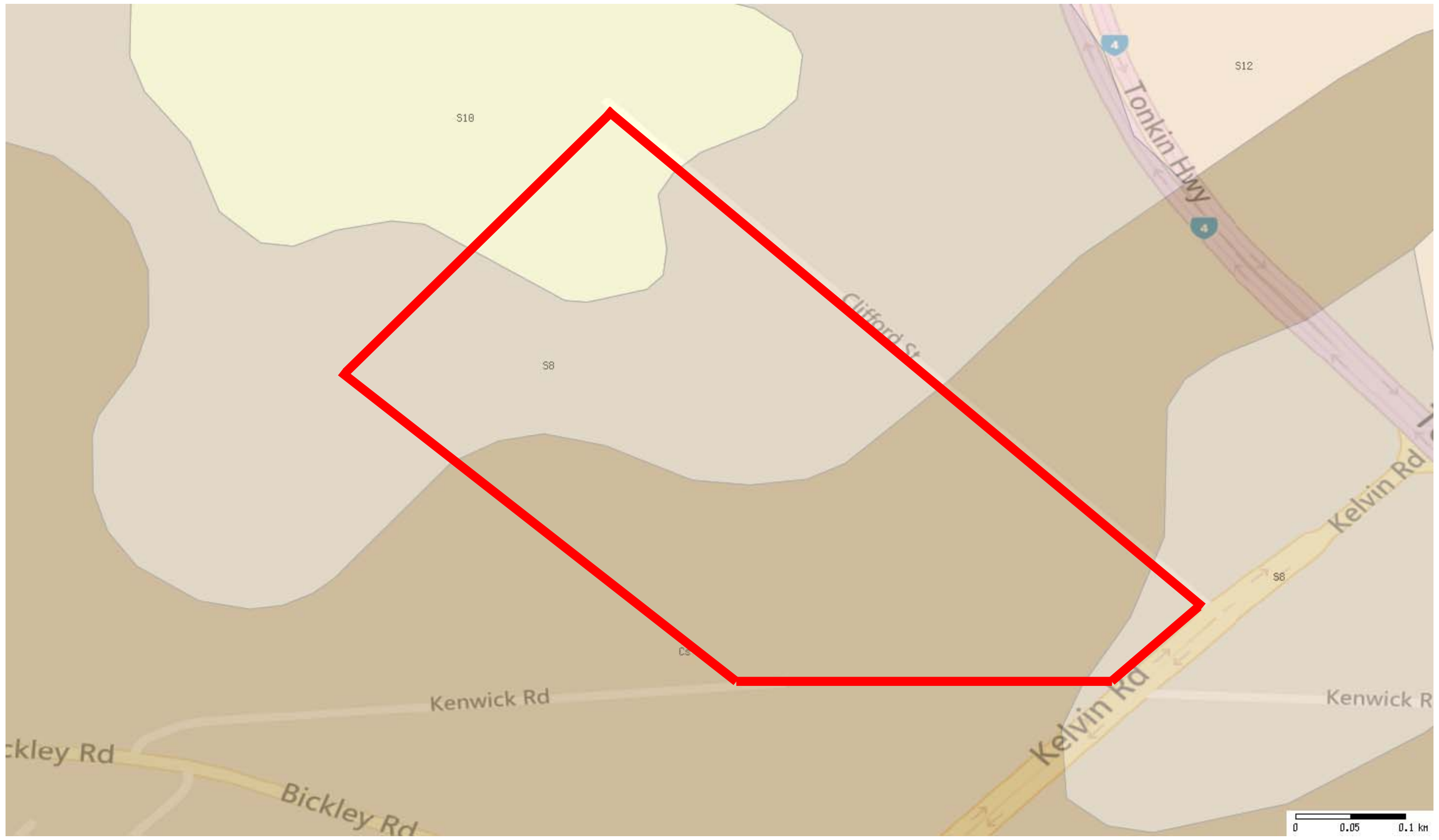
Approximate site boundary

Approximate scale:

0m 100m 200m

N

Details	
Map Sheet Name	20331 ARMADALE 1:50,000 ENVIRONMENTAL GEOLOGY
Environmental Geology Code	**S10**
Equivalent Geological Unit	**Thin Bassendean Sand over Guildford Formation (Qpb/Qpa)**
Lithology	SAND
Description	SAND - white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, of eolian origin (S8), over sandy clay to clayey sand of the Guildford Formation
Environmental Geology Code	**S8**
Equivalent Geological Unit	**Bassendean Sand (Qpb)**
Lithology	SAND
Description	SAND - white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin
Environmental Geology Code	**Cs**
Equivalent Geological Unit	**Guildford Formation (Qpa)**
Lithology	SANDY CLAY
Description	SANDY CLAY - white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp



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Geotechnics / Environment / Groundwater

CLIENT: Juceda Investments Pty Ltd	**Extract from Armadale 1:50 000 Environmental Geology Map**	PROJECT No:	82411
OFFICE: Perth	**Lots 252 to 256 Clifford Street**	DRAWING No:	1
DATE: 19 January 2015	**Maddington, WA**	REVISION:	A

Aerial Image Source: Nearmap (flown 7 December 2014)

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Juceda Investments Pty Ltd	**Location of Tests**	PROJECT No: 82411
	OFFICE: Perth	**Lots 252 to 256 Clifford Street**	DRAWING No: 2
	DATE: 19 January 2015	**Maddington, WA**	REVISION: B

Aerial Image Source: Nearmap (flown 7 December 2014)

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Juceda Investments Pty Ltd	Approximate Extent of Class 'S' Within the Site	PROJECT No: 82411
	OFFICE: Perth	Lots 252 to 256 Clifford Street	DRAWING No: 3
	DATE: 3 February 2015	Maddington, WA	REVISION: A

Appendix B

Results of Field Work

TEST PIT LOG

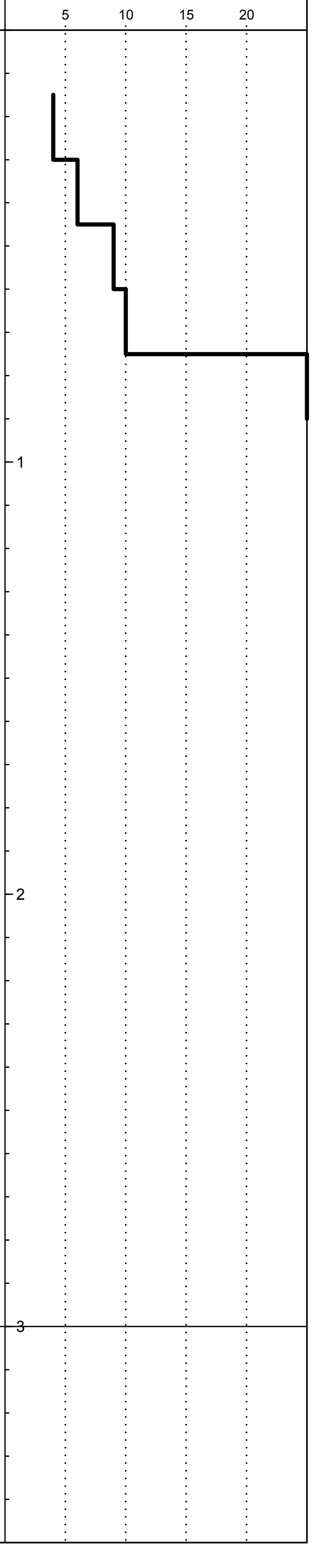
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 19.9 m AHD*
EASTING:
NORTHING:

PIT No: TP1
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		FILLING (SAND) - very dense, red-brown, fine to medium grained, silty gravelly, slight silty sand, dry.		D	0.1			
	0.15	SAND - dense, grey, fine to medium grained sand with a trace of silt, dry. Roots observed to 0.35 m depth.						
19	1	- becoming light brown mottled red-brown and orange brown, dry to moist, slightly clayey sand from 1.2 m depth.		D	1.8			
18	2 / 2.0	CLAYEY SAND - firm to stiff, light grey mottled red-brown and orange brown, fine to medium grained clayey sand with some medium to coarse laterite gravel and cobbles, dry to moist.						
17	3 / 3.0	Pit discontinued at 3.0m (target)		E	3.0	1		

Dynamic Penetrometer Test
(blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

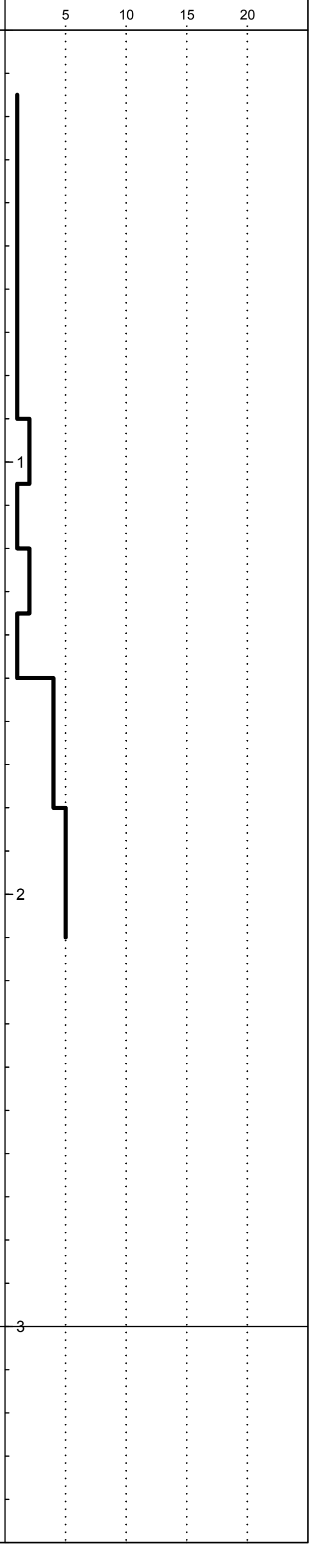
TEST PIT LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 19.4 m AHD*
EASTING:
NORTHING:

PIT No: TP2
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL (SAND) - grey, fine to medium grained sandy topsoil, with some silt and rootlets, dry.		D	0.1				
19	0.15	SAND - loose, light grey-white fine to medium grained sand with a trace of silt, dry. Roots observed to 0.4 m depth.							
18	1								
		- becoming moist and medium dense from 1.8 m depth.							
17	2								
	3.0	Pit discontinued at 3.0m (target)		E	3.0	2			
16									



RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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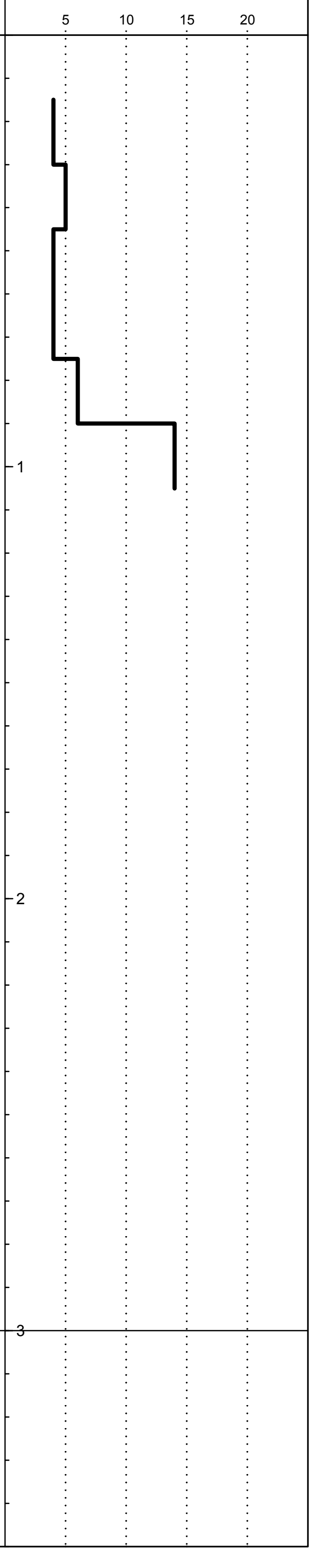
TEST PIT LOG

CLIENT: Juceda Investments	**SURFACE LEVEL:** 17.4 m AHD*	**PIT No:** TP3	
PROJECT: Lots 252-256 Clifford Street	**EASTING:**	**PROJECT No:** 82411	
LOCATION: Maddington	**NORTHING:**	**DATE:** 14/1/2015	
		SHEET 1 OF 1	

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	0.1	TOPSOIL (SAND) - brown, fine to medium grained sandy topsoil, with some silt and rootlets, dry.		D	0.1			
17	0.7	SAND - medium dense, light grey-white fine to medium grained sand with a trace of silt, dry. - becoming slightly clayey from 0.6 m depth.						
	1.2	CLAY - stiff, blue-green mottled brown slightly sandy clay, dry to moist, low to medium plasticity. Sand is fine grained.			0.75		PP = 200 kPa	
				U	0.95		PP = 200 kPa	
16	1.7	CLAYEY SAND - very stiff, light blue-grey, fine to medium grained clayey sand, moist.			1.3 1.35		PP = 350 kPa	
15	3.0	SAND - light blue-grey, fine to medium grained sand with some clay, moist. - becoming light brown and with a trace of clay from 2.7 m depth.						
14		Pit discontinued at 3.0m (target)		E	3.0	3		

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

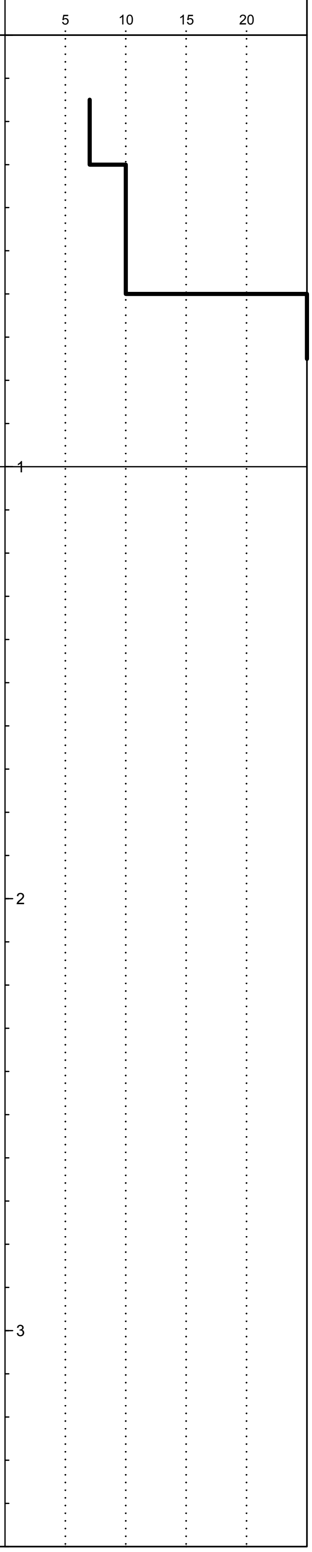
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 16.8 m AHD*
EASTING:
NORTHING:

PIT No: TP4
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL (SAND) - dark grey, fine to medium grained sandy topsoil, with some silt and rootlets, dry.						
	0.1	SAND - dense, grey, fine to medium grained sand with a trace of silt, dry.		D	0.1			
	0.4	GRAVELLY SANDY CLAY - very stiff, orange-brown mottled light grey, gravelly sandy clay, dry, high plasticity. Fine to coarse grained sand. Fine to coarse sized gravel. Slow digging. - becoming hard from 0.5 m depth.			0.5		PP >600 kPa	
16				D	0.8			
	1.0	Pit discontinued at 1.0m (very slow digging)		E	1.0	4		
15	2							
14	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

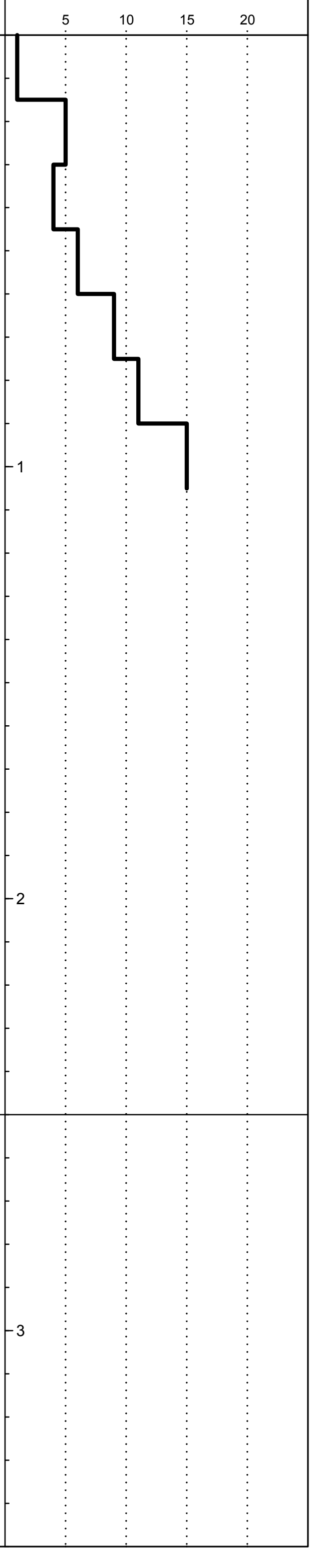
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 19.9 m AHD*
EASTING:
NORTHING:

PIT No: TP5
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		SAND - medium dense, grey, fine to medium grained sand with a trace of silt, dry.		D	0.1			
		- becoming dry to moist, brown, fine to coarse grained sand with a trace of clay from 0.3 m depth.						
		- becoming orange-brown mottled light grey, slightly clayey sand with som fine to medium sized laterite gravel, medium plasticity from 0.5 m depth.						
19	1							
		- becoming dry, light grey, fine to medium grained sand with some silt from 1.2 m depth. Slow digging.						
18	2	- becoming dry to moist, light grey mottled brown, fine to medium grained sand with some clay from 2.0 m depth.						
	2.5	Pit discontinued at 2.5m (very slow digging)		E	2.5	5		
17	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

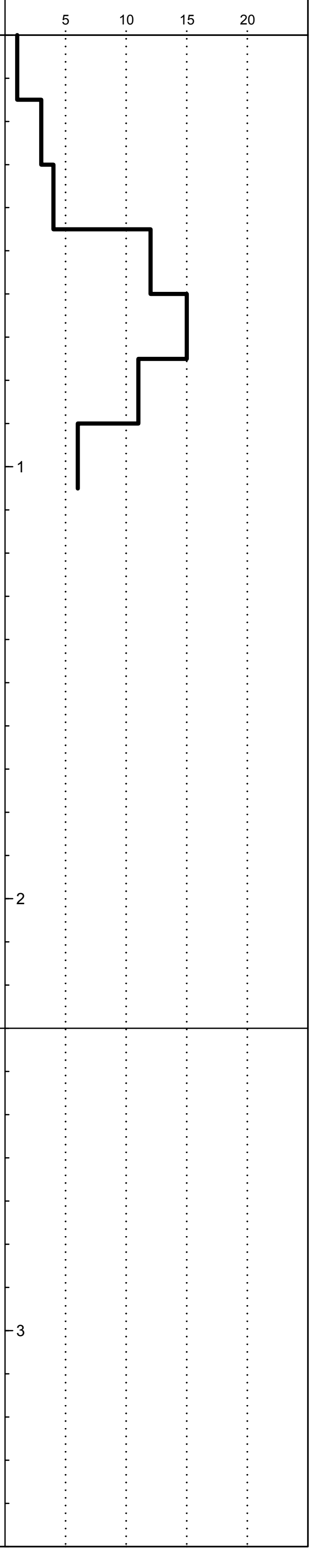
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 20.0 m AHD*
EASTING:
NORTHING:

PIT No: TP6
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
20		SAND - medium dense, light grey, fine to medium dense sand with a trace of silt, dry.		D	0.1			
		- becoming light brown, fine to coarse grained sand from 0.3 m depth.						
		- becoming moist, light brown, fine to coarse grained, slightly gravelly sand with a trace of clay from 0.6 m depth. Gravel is fine to coarse sized laterite.						
19	1.0	CLAYEY SAND - very stiff, light brown, fine to coarse grained clayey sand with some gravel, moist, medium to high plasticity. Gravel is fine to coarse sized laterite. Slow digging.		D	1.4			
18		- becoming hard and light grey from 2.0 m depth.						
	2.3	Pit discontinued at 2.3m (very slow digging)		E	2.3	6		
17	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

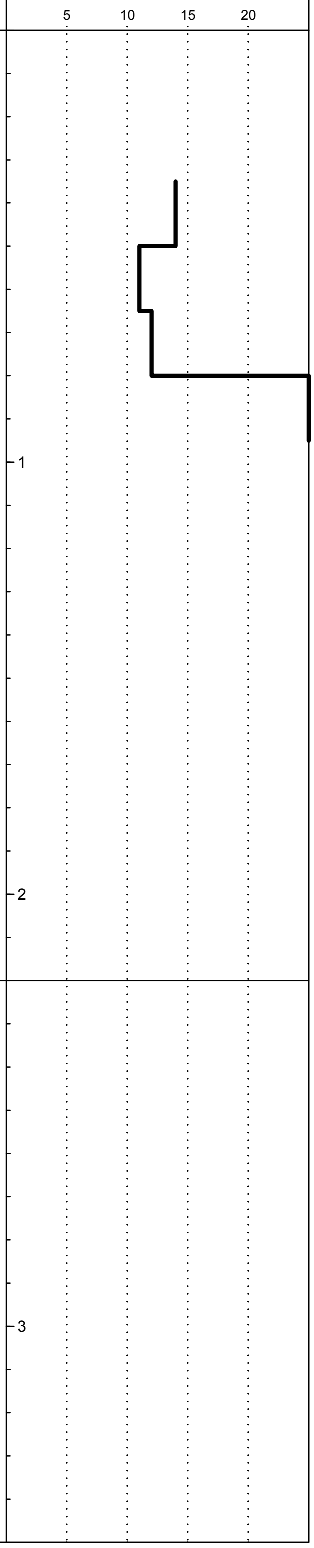
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 18.5 m AHD*
EASTING:
NORTHING:

PIT No: TP7
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		FILLING (SILTY SANDY GRAVEL) - blue-grey, fine sized silty sandy gravel, dry. Also known as 'cracker dust'.						
18	0.2	SAND - very dense, grey, fine to medium grained sand with a trace of silt, dry to moist. - becoming light grey from 0.4 m depth. - becoming light brown from 0.8 m depth. - becoming orange-brown, fine to coarse grained, slightly gravelly, slightly clayey sand from 1.1 m depth. Gravel is fine to coarse sized laterite.		B	0.5			
17	1.4	CLAY - very stiff to hard, orange-brown mottled light grey, slightly gravelly, slightly sandy clay, dry. Gravel is fine to coarse sized laterite.		D	1.6			
	2.0	CLAYEY SAND - hard, light grey, fine to medium grained clayey sand.						
16	2.2	Pit discontinued at 2.2m (very slow digging)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

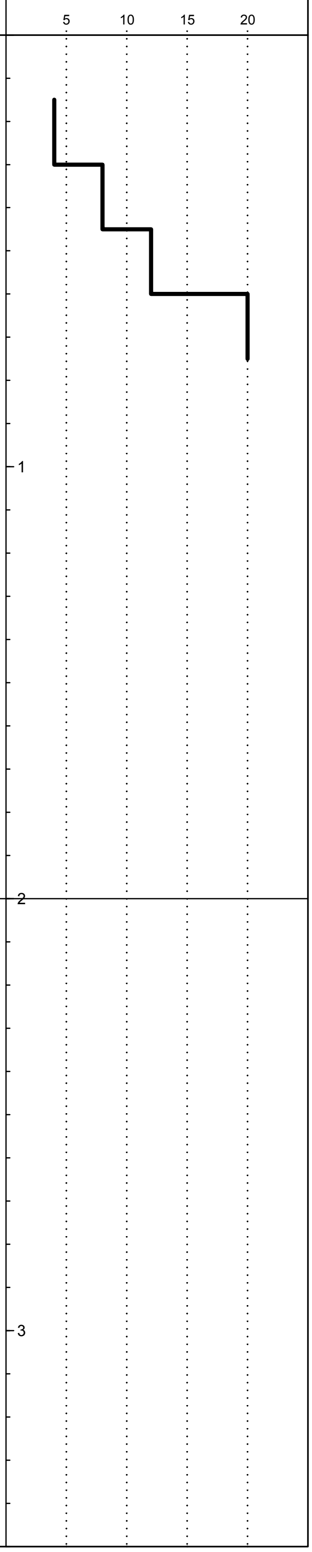
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 16.0 m AHD*
EASTING:
NORTHING:

PIT No: TP8
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling Type	Sampling Depth	Sample	Results & Comments	Water
16	0.15	TOPSOIL - dark grey, fine to medium grained sandy topsoil with some silt, dry.					
	1.2	SAND - dense, grey, fine to medium grained sand with some silt, dry. - becoming very dense, brown, fine grained slightly silty sand with a trace of clay, dry. - becoming light brown, fine to medium grained sand with a trace of silt, dry.	B	0.5			
15	1						
	1.6	CLAYEY SAND - very stiff to hard, orange-brown mottled grey, fine to medium grained clayey sand, dry to moist, medium plasticity. Slow digging.	D	1.4			
14	2 / 2.0	SAND - hard/cemented, light grey, fine to medium grained slightly clayey sand, dry.					
		Pit discontinued at 2.0m (very slow digging)					
13	3						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

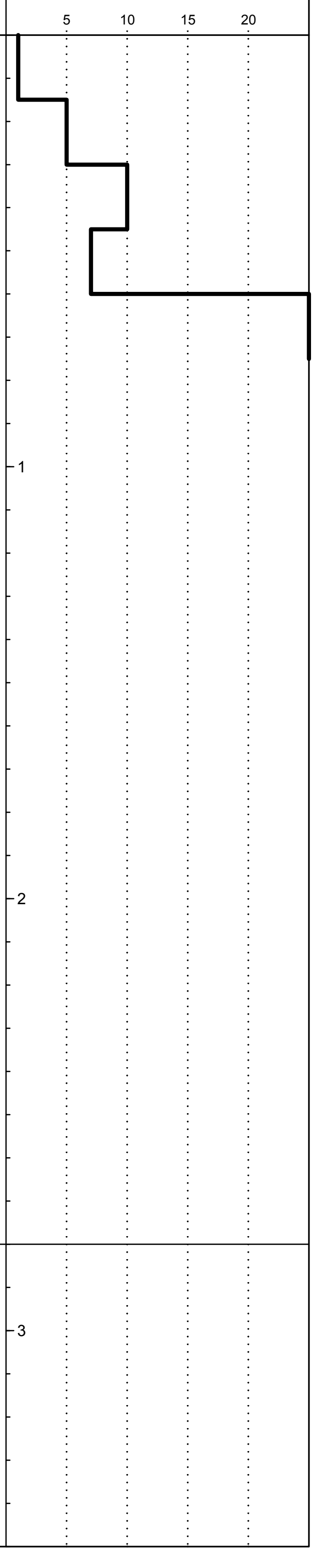
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 18.7 m AHD*
EASTING:
NORTHING:

PIT No: TP9
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
	0.1	TOPSOIL - grey, fine to medium grained sandy topsoil with some silt and rootlets, dry.						
18	0.8	SAND - medium dense to dense, light grey, fine to medium grained sand with a trace of silt, dry. - becoming orange-brown, fine to coarse grained slightly clayey sand with some laterite gravel from 0.6 m depth.						
		SANDY CLAY - very stiff, orange-brown mottled light grey sandy clay with some gravel, moist, high plasticity.			0.9		PP = 200 kPa	
17	1			D	1.2			
16	2				2.5		PP = 550 kPa	
	2.8	Pit discontinued at 2.8m (very slow digging)						
	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

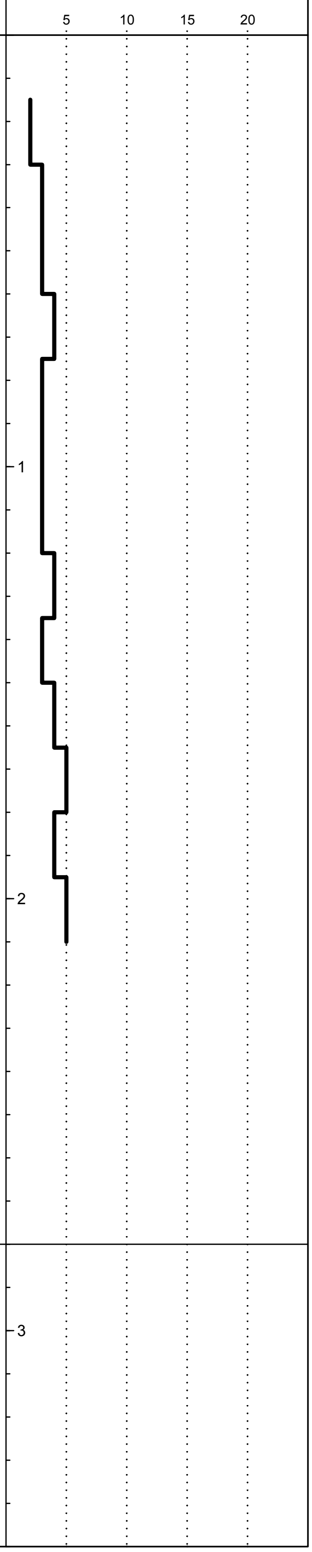
TEST PIT LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 22.9 m AHD*
EASTING:
NORTHING:

PIT No: TP10
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - grey, fine to medium grained sandy topsoil with a trace of silt and rootlets, dry.							
22	1	SAND - medium dense, light grey-white, fine to medium grained sand with a trace of silt, dry.							
21	2								
20	2.8	Pit discontinued at 2.8m (collapse)							
	3								



RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	⊳	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

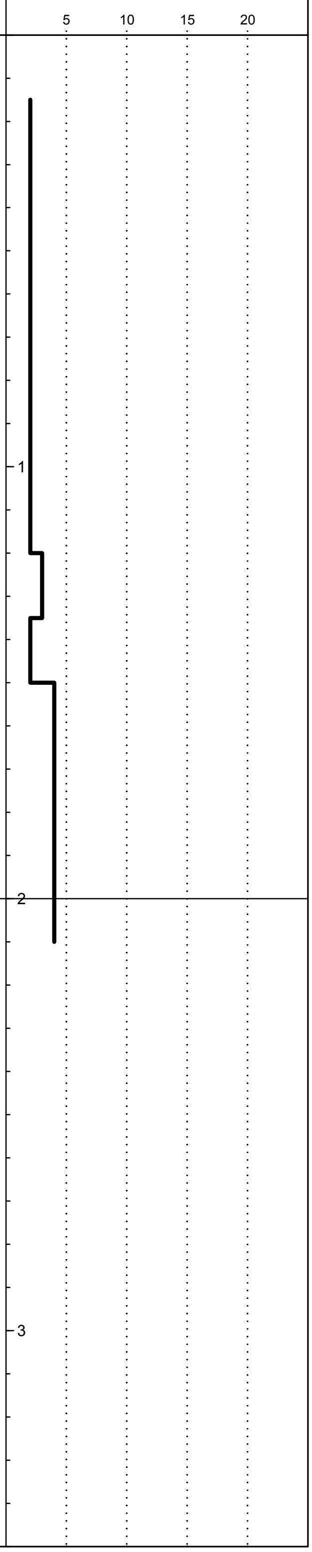
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 22.0 m AHD*
EASTING:
NORTHING:

PIT No: TP11
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
22	0.05	TOPSOIL - grey, fine to medium grained sandy topsoil with a trace of silt and rootlets, dry.						
		SAND - medium dense, light grey, fine to medium grained sand with a trace of silt, dry.						
		- becoming loose to medium dense from 0.7 m depth.						
21	1							
		- becoming medium dense from 1.8 m depth.						
20	2 2.0	Pit discontinued at 2.0m (collapse)						
19	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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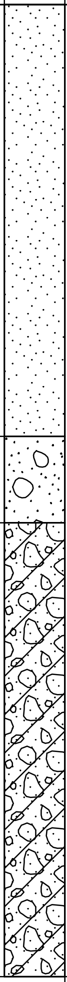
TEST PIT LOG

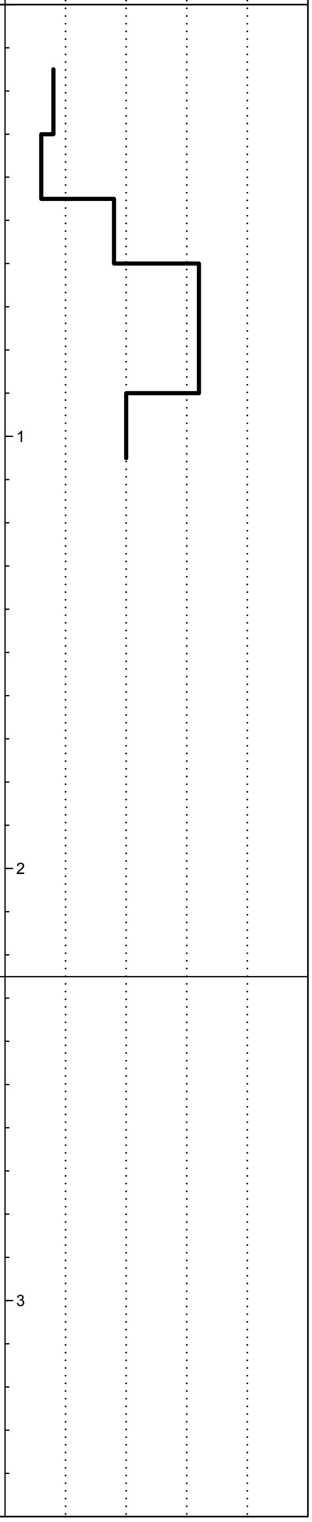
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 20.6 m AHD*
EASTING:
NORTHING:

PIT No: TP12
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		SAND - medium dense to dense, grey, fine to medium grained sand with some silt, dry. - becoming dry to moist, light grey-brown from 0.2 m depth. - becoming dense from 0.5 m depth.							
20									
	1.0	GRAVELLY SAND - light brown, fine to medium grained, slighly clayey gravelly sand, dry to moist.							
	1.2	GRAVELLY SANDY CLAY - very stiff to hard, light brown mottled light grey, gravelly sandy clay, moist, high plasticity. Sand is fine to coarse grained. Gravel is fine to coarse sized. Occasional laterite boulders. Slow digging.		D	1.4				
19									
	2.25	Pit discontinued at 2.25m (very slow digging)							
18									





RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

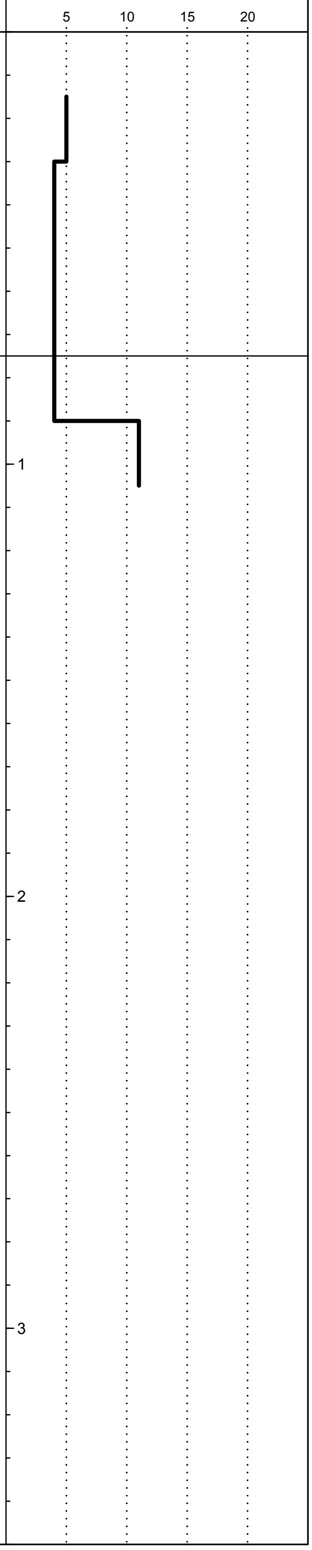
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 19.8 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH13
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	0.05	TOPSOIL (SAND) - light grey, fine to medium grained sand with some silt and rootlets, dry.						
	0.75	SAND - medium dense, light grey-white, fine to medium grained sand with some silt, dry. - becoming dry to moist from 0.15 m depth.		D	0.5 0.75			
19		Bore discontinued at 0.75m (target)						
	1							
18								
	2							
17								
	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 110 mm auger. **DRILLER:** DJB **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: Hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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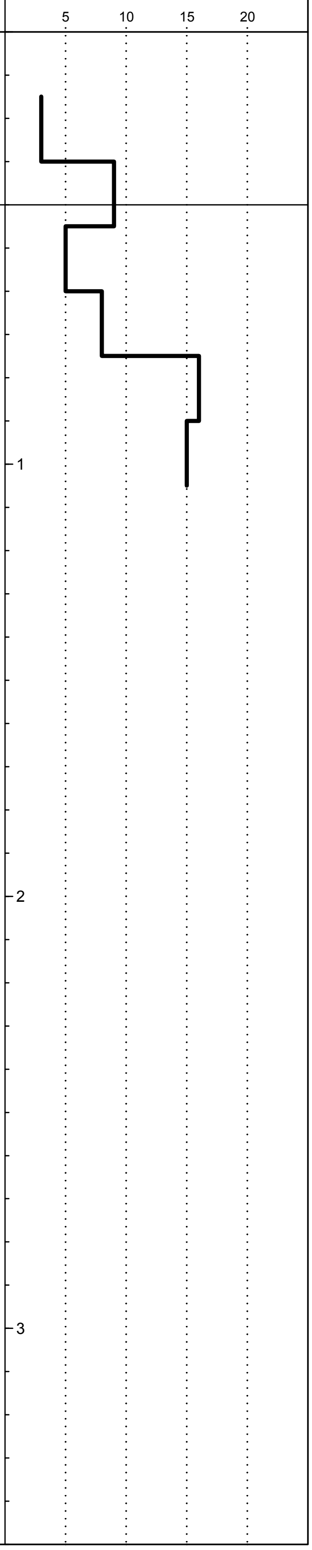
BOREHOLE LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 16.1 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH14
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
16		FILLING (SAND) - dense, grey, fine to medium grained sand with some silt and fine to medium gravel sized fragments of brick, dry. - no brick fragments from 0.2 m depth.							
	0.4	Bore discontinued at 0.4m (target)		D	0.4				
15	1								
14	2								
13	3								



RIG: 110 mm auger. **DRILLER:** DJB **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: Hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 16.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH15
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
16		SAND - medium dense, light grey, fine to medium grained sand with a trace of silt, dry. - becoming dry to moist from 0.3 m depth.		D	0.9 1.15				
15	1								
	1.2	Bore discontinued at 1.2m (target)							
14	2								
13	3								

RIG: 110 mm auger. **DRILLER:** DJB **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: Hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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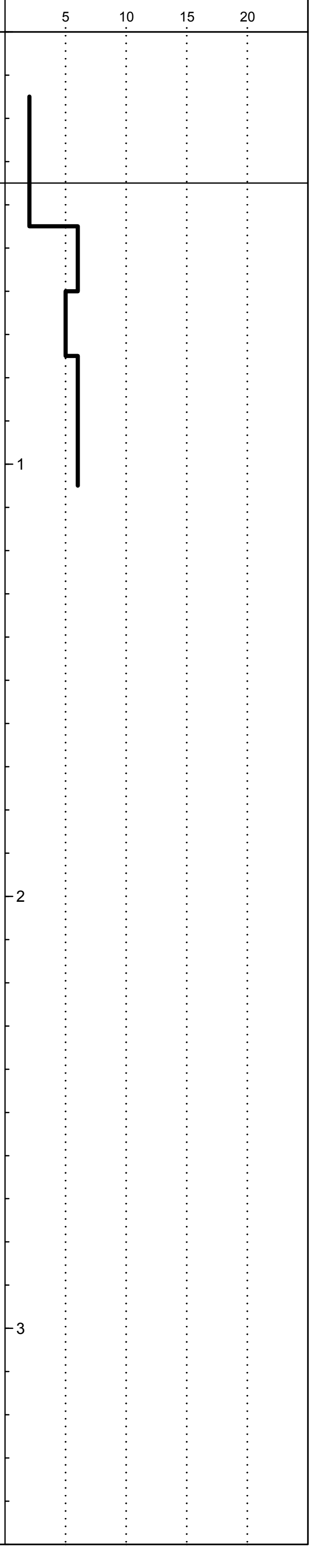
BOREHOLE LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 20.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH16
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		SAND - medium dense, grey, fine to medium grained sand with a trace of silt, dry.							
	0.35	Bore discontinued at 0.35m (target)		D	0.35				



RIG: 110 mm auger. **DRILLER:** DJB **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: Hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

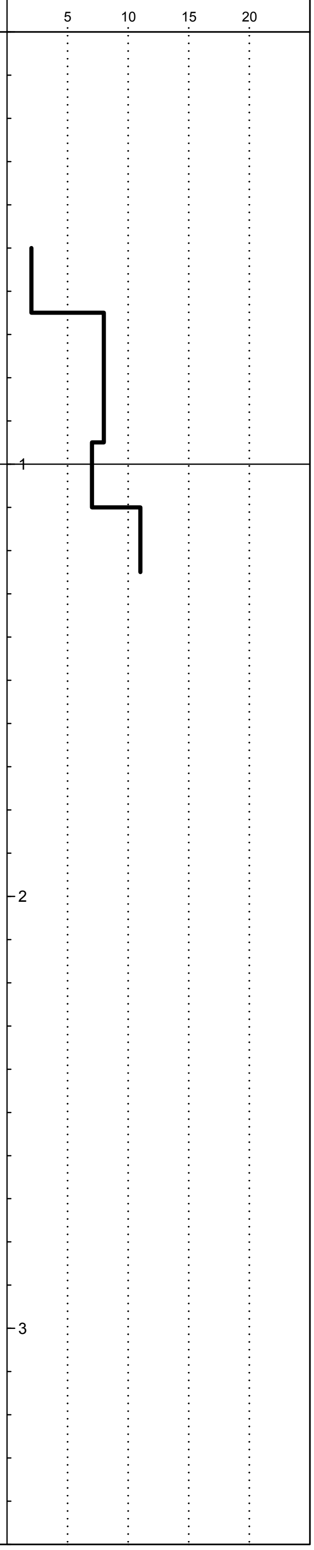
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 21.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH17
PROJECT No: 82411
DATE: 29/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
	0.03	SPRAY SEAL - dark grey, inverted double/double spray seal. 25 mm aggregate over 12 mm aggregate.						
	0.08	BASECOURSE (SANDY GRAVEL) - grey, fine to medium sized sandy gravel with some silt, dry. Gravel is angular, granitic rock.						
	0.3	SUBBASE (GRAVELLY SAND) - light orange-brown, fine to medium grained gravelly sand with a trace of silt, dry. Gravel is fine to medium sized lateritic rock.						
21		SAND - medium dense to dense, light grey, fine to medium grained sand with a trace of silt, dry. - becoming moist and light brown from 0.55 m depth.						
	1.0	Bore discontinued at 1.0m (target)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 8t excavator with power auger **DRILLER:** RME **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: 300 mm diameter power auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
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BOREHOLE LOG

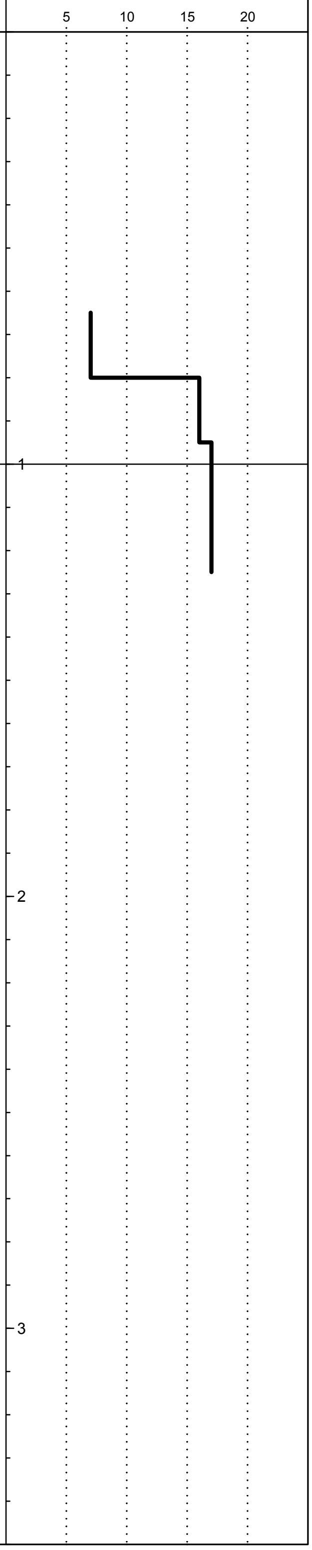
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 21.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH18
PROJECT No: 82411
DATE: 29/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
	0.03	SPRAY SEAL - dark grey, inverted double/double spray seal. 25 mm aggregate over 12 mm aggregate.					
	0.08	BASECOURSE (SANDY GRAVEL) - grey, fine to medium sized sandy gravel with some silt, dry. Gravel is angular, granitic rock.					
	0.18	SUBBASE (SANDY GRAVEL) - light yellow, fine to coarse sized sandy gravel with a trace of silt, dry. Gravel is limestone. Sand is fine to medium grained.					
21	0.45	SUBBASE (GRAVELLY SAND) - light orange-brown, fine to medium grained gravelly sand with a trace of silt, dry. Gravel is fine to medium sized lateritic rock.					
		SAND - dense, grey, fine to medium grained sand with a trace of silt, dry.	B	0.5			
	1.0			1.0			
		Bore discontinued at 1.0m (target)					

Dynamic Penetrometer Test (blows per 150mm)



RIG: 8t excavator with power auger **DRILLER:** RME **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: 300 mm diameter power auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

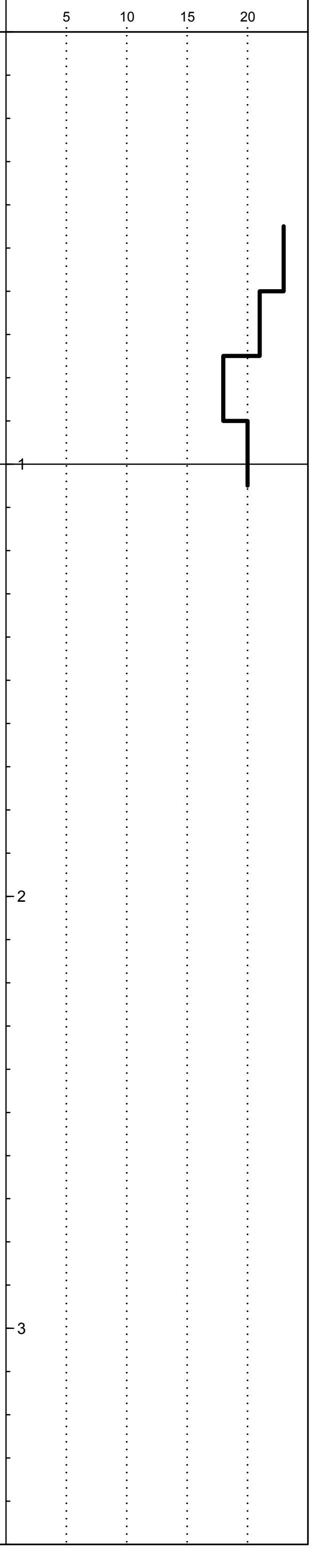
BOREHOLE LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 21.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH19
PROJECT No: 82411
DATE: 29/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
21	0.03	SPRAY SEAL - dark grey, inverted double/double spray seal. 25 mm aggregate over 12 mm aggregate.							
	0.08	BASECOURSE (SANDY GRAVEL) - grey, fine to medium sized sandy gravel with some silt, dry. Gravel is angular, granitic rock.							
	0.25	SUBBASE (GRAVELLY SAND) - light yellow, fine to medium grained gravely sand with a trace of silt, dry. Gravel is fine to coarse sized limestone.							
	0.35	SUBBASE (GRAVELLY SAND) - light orange-brown, fine to medium grained gravelly sand with a trace of silt, dry. Gravel is fine to medium sized lateritic rock.							
		SAND - very dense, grey, fine to medium grained sand with a trace of silt, dry.							
20	1 — 1.0	Bore discontinued at 1.0m (target)							
19	2								
18	3								



RIG: 8t excavator with power auger **DRILLER:** RME **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: 300 mm diameter power auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

Appendix C

Results of Laboratory Testing

Mining & Civil Geotest Pty Ltd

Determination of the Shrinkage Index of a Soil
Shrink Swell Index
AS 1289.7.1.1

Ph (08) 9414 8022 Fax (08) 9414 8011
Email matt@mcgeotest.com.au
Unit 1/1 Pusey Road, JANDAKOT WA 6164

		Job No:	60017
		Report No:	60017-P15/236
		Date of issue:	27 January 2015
Client:	Juceda Investments Pty Ltd	Date Tested:	19 January 2015
Project:	Lots 252 to 256 Clifford Street	Tested By:	W Old
Location:	Maddington, WA	Checked By:	M van Herk
Sample:	TP3 0.95 - 1.35m	Sample No:	P15/236

Sample details

Sample description : Brown Clay

Sample Type : 48 mm Ø tube sample

Swell Specimen		**Shrinkage Specimen**	
Dry Density - Initial (t/m^{3})	1.68	Moisture Content Initial (%)	19.5
Moisture Content - Initial (%)	19.8	Length/Diameter Ratio	2.7
Moisture Content - Final (%)	21.1	Extent of Crumbling	Nil
Overburden Pressure (kPa)	25	Extent of Cracking	Nil
Significant Inert Inclusions (%)	3		

Shrink-Swell Index

I_{ss} = **2.0** % Vertical strain per pF change in Total suction

Client address: 36 O'Malley Street, Osborne Park

Tested as received

Approved Signature

Matthew van Herk

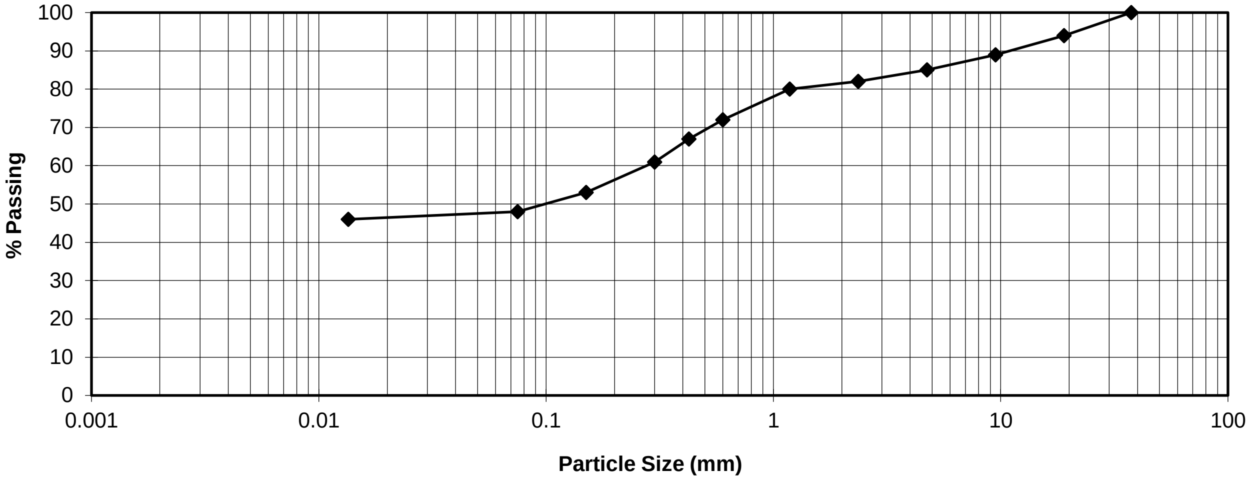
Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022   Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P15/237
Sample No:	P15/237
Issue Date:	27 January 2015

Client: Juceda Investments Pty Ltd
Project: Lots 252 to 256 Clifford Street
Location: Maddington, WA

Sample location: TP4
Sample Depth(m): 0.80



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	94
9.5	89
4.75	85
2.36	82
1.18	80
0.600	72
0.425	67
0.300	61
0.150	53
0.075	48
0.0135	46

Plasticity index tests
AS 1289

Liquid limit 3.1.1	59	%
Plastic limit 3.2.1	20	%
Plasticity index 3.3.1	39	%
Linear shrinkage 3.4.1	9.5	%

Cracked ☐

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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WORLD RECOGNISED ACCREDITATION

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Approved signature

Matthew van Herk

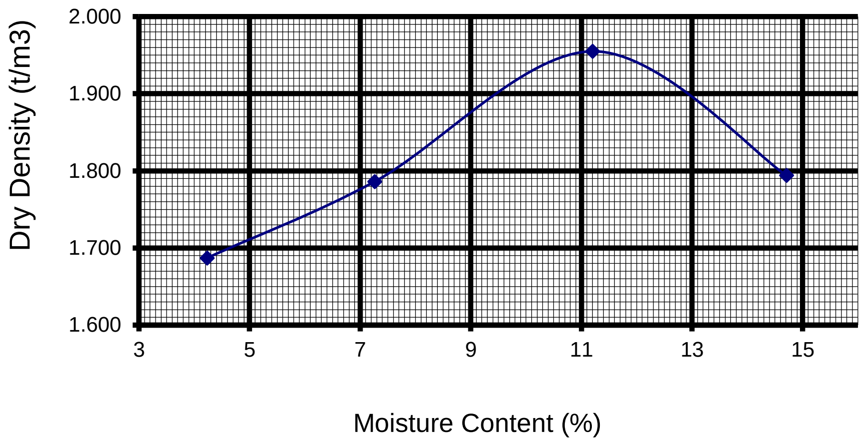
Mining &
Civil
Geotest Pty Ltd
Unit 1/1 Pusey Road, JANDAKOT WA 6164
Ph (08) 9414 8022
Fax (08)9414 8011
Email matt@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P15/238	**Project:**	Lots 252 to 256 Clifford Street
Sample No:	P15/238	**Client:**	Juceda Investments Pty Ltd
Location:	Maddington, WA	**Date of Issue:**	27 January 2015
	TP8 0.5m	**Job No:**	60017

Maximum Dry Density t/m^3:	1.955	**Conditions at Test**	
Optimum Moisture Content %:	11.2	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	13.2
Mass of hammer kg	4.9	Entire Moisture Ratio %	117.8
Number of layers	5	Top 30mm Moisture Content %	13.7
Number of blows/layer	16	Top 30mm Moisture Ratio %	121.9
Conditions after Compaction		Swell %	0.0
Dry Density t/m^3	1.856	C.B.R. at 5.0 mm Penetration %	25
Moisture Content %	11.5	**Conditions after Soaking**	
Density Ratio %	95.0	Dry Density t/m^3	1.856
Moisture Ratio %	103.0	Moisture Content %	14.5
Soaked / Unsoaked	Soaked	Dry Density Ratio %	95.0
		Moisture Ratio %	129.5

Comments:



Client Address: 36 O'Malley Street, Osborne Park

ASMDD-CBR June 2009

Approved Signature Matthew van Herk

Particle Size Distribution & Plasticity Index tests

Mining & Civil Geotest Pty Ltd

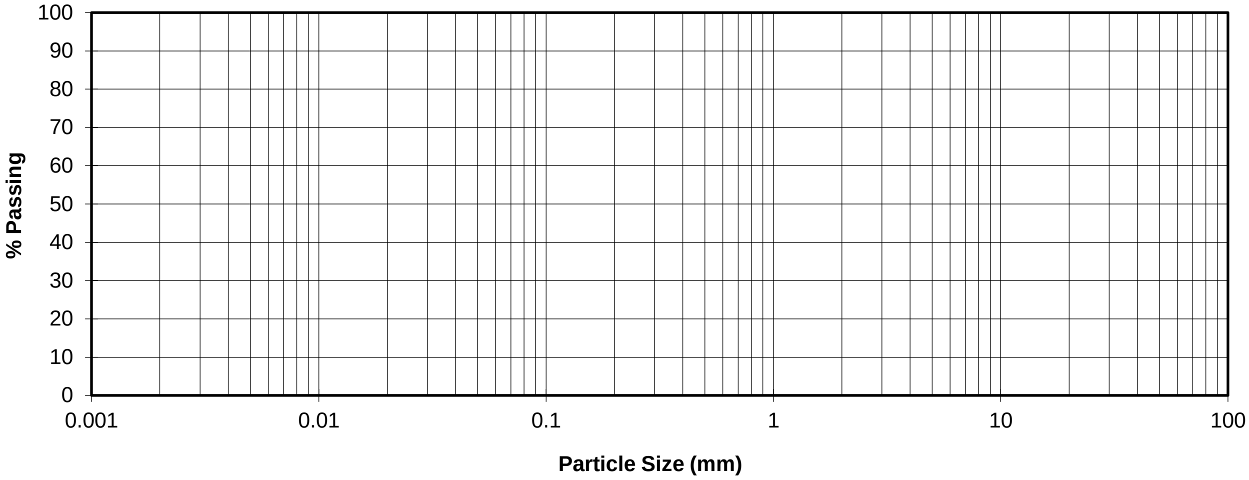
unit1/1 Pusey Road, Jandakot, WA 6164

Ph (08) 9414 8022   Fax (08) 9414 8011

Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P15/239
Sample No:	P15/239
Issue Date:	27 January 2015

Client:	Juceda Investments Pty Ltd	Sample location:	TP9
Project:	Lots 252 to 256 Clifford Street	Sample Depth(m):	1.20
Location:	Maddington, WA		



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	
1.18	
0.600	
0.425	
0.300	
0.150	
0.075	
0.0135	

Plasticity index tests
AS 1289

Liquid limit 3.1.1	58	%
Plastic limit 3.2.1	20	%
Plasticity index 3.3.1	38	%
Linear shrinkage 3.4.1	13.5	%

Cracked ☑

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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Matthew van Herk

AS PSDPI May 2009

Particle Size Distribution & Plasticity Index tests

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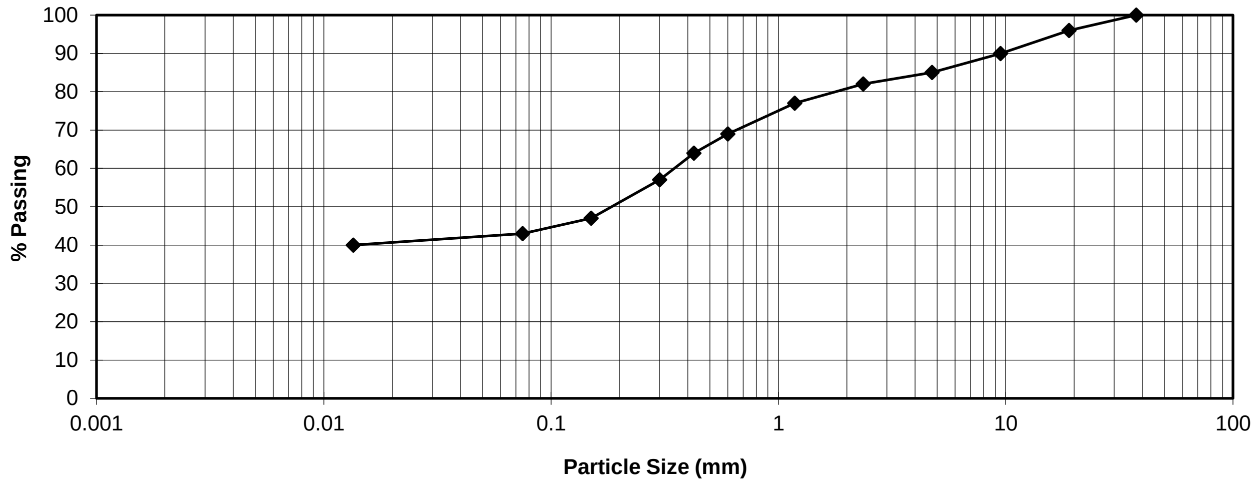
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022   Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P15/240
Sample No:	P15/240
Issue Date:	27 January 2015

Client:	Juceda Investments Pty Ltd	Sample location:	TP12
Project:	Lots 252 to 256 Clifford Street	Sample Depth(m):	1.40
Location:	Maddington, WA		



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	96
9.5	90
4.75	85
2.36	82
1.18	77
0.600	69
0.425	64
0.300	57
0.150	47
0.075	43
0.0135	40

Plasticity index tests
AS 1289

Liquid limit 3.1.1	55	%
Plastic limit 3.2.1	20	%
Plasticity index 3.3.1	35	%
Linear shrinkage 3.4.1	12.0	%

Cracked ☑

Curled ☑

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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Particle Size Distribution & Plasticity Index tests

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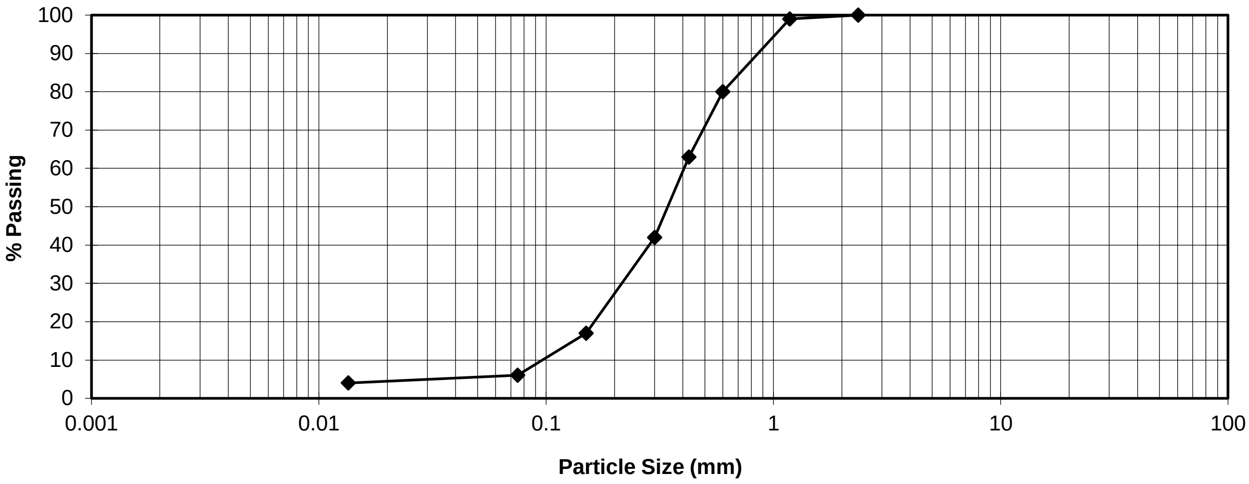
Email: matt@mcgeotest.com.au

Job No: 60017
Report No: 60017-P15/241
Sample No: P15/241
Issue Date: 27 January 2015

Client:	Juceda Investments Pty Ltd	Sample location:	BH13
Project:	Lots 252 to 256 Clifford Street	Sample Depth(m):	0.50
Location:	Maddington, WA		



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	99
0.600	80
0.425	63
0.300	42
0.150	17
0.075	6
0.0135	4

Plasticity index tests
AS 1289

Liquid limit 3.1.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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Particle Size Distribution & Plasticity Index tests

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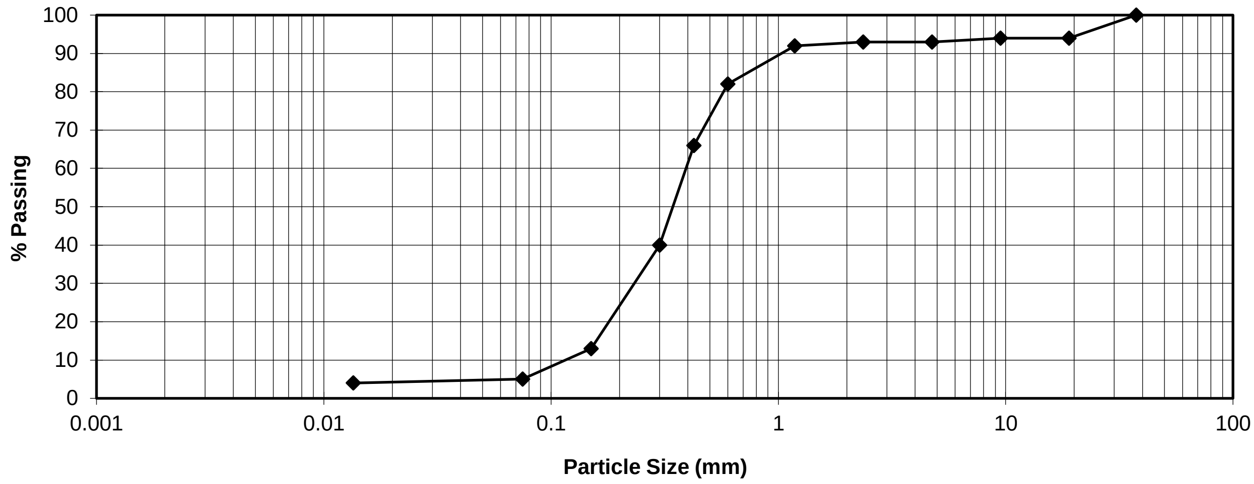
Email: matt@mcgeotest.com.au

Job No: 60017
Report No: 60017-P15/242
Sample No: P15/242
Issue Date: 27 January 2015

Client: Juceda Investments Pty Ltd
Project: Lots 252 to 256 Clifford Street
Location: Maddington, WA

Sample location: BH14
Sample Depth(m): 0.40



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	94
9.5	94
4.75	93
2.36	93
1.18	92
0.600	82
0.425	66
0.300	40
0.150	13
0.075	5
0.0135	4

Plasticity index tests
AS 1289

Liquid limit 3.1.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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Particle Size Distribution & Plasticity Index tests

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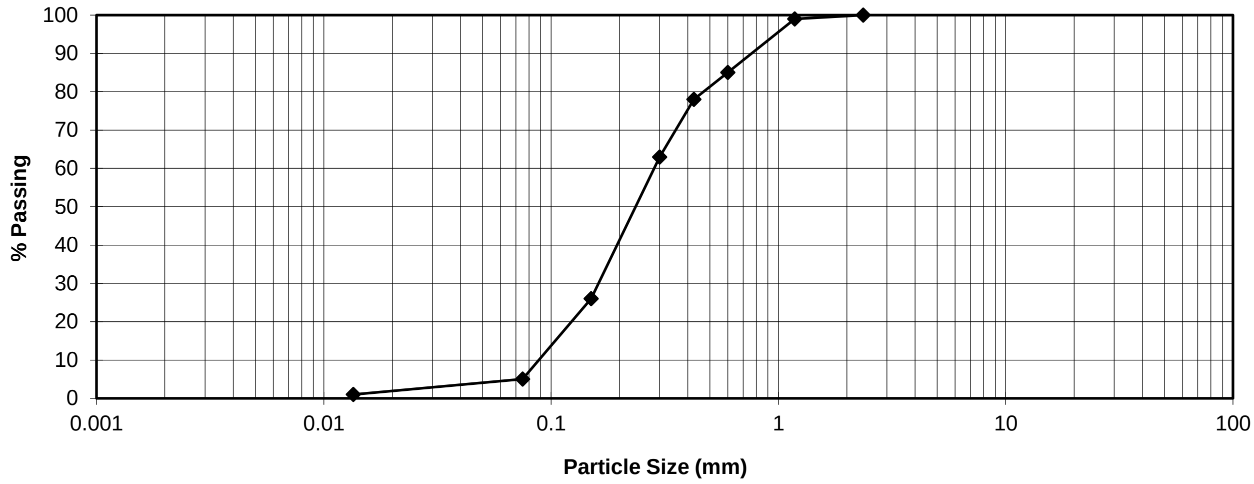
Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P15/243
Sample No:	P15/243
Issue Date:	27 January 2015

Client: Juceda Investments Pty Ltd
Project: Lots 252 to 256 Clifford Street
Location: Maddington, WA

Sample location: BH15
Sample Depth(m): 0.90



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	99
0.600	85
0.425	78
0.300	63
0.150	26
0.075	5
0.0135	1

Plasticity index tests
AS 1289

Liquid limit 3.1.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

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Matthew van Herk

AS PSDPI May 2009

Particle Size Distribution & Plasticity Index tests

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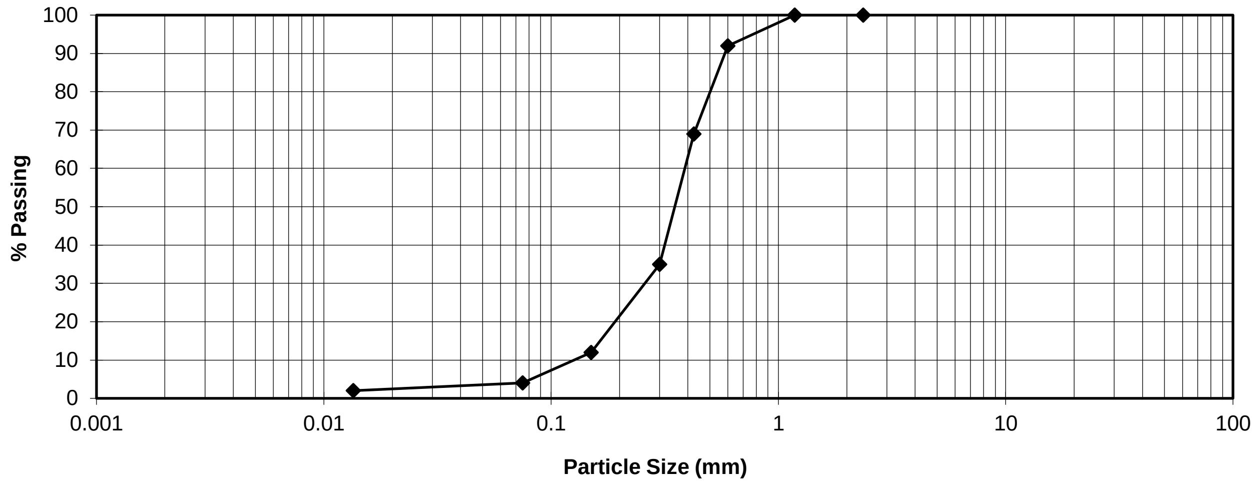
Ph (08) 9414 8022   Fax (08) 9414 8011

Email: matt@mcgeotest.com.au

Job No:	60017
Report No:	60017-P15/244
Sample No:	P15/244
Issue Date:	27 January 2015

Client:	Juceda Investments Pty Ltd	Sample location:	BH16
Project:	Lots 252 to 256 Clifford Street	Sample Depth(m):	0.35
Location:	Maddington, WA		



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	92
0.425	69
0.300	35
0.150	12
0.075	4
0.0135	2

Plasticity index tests
AS 1289

Liquid limit 3.1.1	NA	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

Approved signature

Matthew van Herk

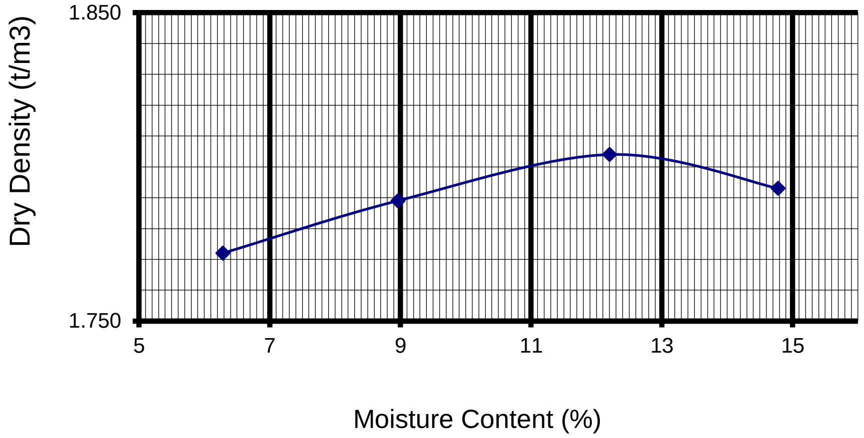
Mining &
Civil
Geotest Pty Ltd
Unit 1/1 Pusey Road, JANDAKOT WA 6164
Ph (08) 9414 8022
Fax (08)9414 8011
Email matt@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P15/513	**Project:**	Lots 252 to 256 Clifford Street
Sample No:	P15/513	**Client:**	Maddington, WA
Location:	Maddington, WA	**Date of Issue:**	8 February 2015
	BH18 0.5 - 1.0m	**Job No:**	60017

Maximum Dry Density t/m^3:	1.804	**Conditions at Test**	
Optimum Moisture Content %:	12.2	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	13.1
Mass of hammer kg	4.9	Entire Moisture Ratio %	107.0
Number of layers	5	Top 30mm Moisture Content %	12.5
Number of blows/layer	16	Top 30mm Moisture Ratio %	103.0
Conditions after Compaction		Swell %	0.0
Dry Density t/m^3	1.718	C.B.R. at 5.0 mm Penetration %	16
Moisture Content %	11.9	**Conditions after Soaking**	
Density Ratio %	95.0	Dry Density t/m^3	1.718
Moisture Ratio %	97.5	Moisture Content %	14.4
Soaked / Unsoaked	Soaked	Dry Density Ratio %	95.0
		Moisture Ratio %	118.0

Comments:



Client Address: 36 O'Malley Street, Osborne Park

ASMDD-CBR June 2009

Approved Signature Matthew van Herk

JDSi

2017 report on geotechnical investigation

JDSi GROUND ENGINEERING

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F: 08 9227 8617

Level 6, 1 Nash St
Perth WA 6000

PO Box 8523
Perth BC WA 8649

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GEOTECHNICAL INVESTIGATION REPORT

Maddington Kenwick Strategic Employment Area

Part A Study Area (Precinct 1)

JDS161173
March 2018

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Workzone,
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Perth WA 6000
PO Box 8523
Perth BC WA 6849
ABN 69 611 127 676
jdsi.com.au

Maddington Kenwick Strategic Employment Area – Part A Study Area (Precinct 1)
Geotechnical Investigation Report

Prepared for
Emerge Associates Pty Ltd
Suite 4, 26 Railway Parade
Subiaco WA 6008

Our ref: JDS161173-R01-Rev1

Prepared by
JDSi Ground Engineering Pty Ltd
Workzone, Level 6, 1 Nash Street
Perth WA 6000

22 March 2018

Document authorisation

For and on behalf of JDSi Ground Engineering Pty Ltd

Colin Dickson

Principal Geotechnical Engineer

Quality information

Revision history

Revision	Description	Date	Author	Reviewer	Signatory
Rev0	Issued to Client	21 December 2017	CD	RM	CD
Rev1	Issued to Client	22 March 2018	IHR	RM	CD

Distribution

Report Status	No. of copies	Format	Distributed to	Date
Rev0	1	PDF	Emerge Associates Pty Ltd	21 December 2017
Rev0	1	PDF	JDSi Ground Engineering Report Library	21 December 2017
Rev1	1	PDF	Emerge Associates Pty Ltd	22 March 2018
Rev1	1	PDF	JDSi Ground Engineering Report Library	22 March 2018

TABLE OF CONTENTS

IMPORTANT INFORMATION SHEETS

TABLES

FIGURES

APPENDICES

1 Introduction

This report presents the results of a geotechnical investigation carried out by JDSi Ground Engineering Pty Ltd (JDSi) on behalf of Emerge Associates Pty Ltd (Emerge Associates) at the Maddington Kenwick Strategic Employment Area (MKSEA) project site ("the MKSEA site").

This report has been reissued as Revision 1 with amendments to testing location coordinates.

This report includes information gathered during geotechnical investigations completed across the MKSEA site, but is focused on geotechnical conditions in the Part A Study Area only (Precinct 1). The extent of the MKSEA site and the Precinct Areas are presented on the Indicative Local Structure Plan – September 2015 issued by the City of Gosnells and included as ***Appendix A***.

The geotechnical investigations completed by JDSi and reported in this document were completed concurrently with the investigations undertaken for the Part B Study Area (Precinct 2, 3B and 3C). Further details, including investigation logs, for the Part B Study Area, were been reported separately in JDSi Report Ref. JD161173-R02-Rev0, dated December 2017.

The geotechnical assessment summarised in this report is intended to provide specific geotechnical assessment and advice to support the Environmental Assessment and Management Strategy and Local Water Management Strategy for structure planning purposes. The density of investigation points has been reduced from that required typically for more detailed design and interpretive assessment. Further studies will be required to provide geotechnical information required for detailed design development and to obtain development approvals.

This work was commissioned by David Coremans of Emerge Associates via a signed Client Authorisation form dated 20 July 2017.

This report, and the information presented herein, must be read in conjunction with JDSi's "*Your Geotechnical Report*" information sheets attached to this report.

2 Site description

2.1 The MKSEA site

The MKSEA site was first identified for future industrial development by the State Planning Commission (now defunct) in 1990 as part of the Metroplan strategic document. The area was also identified for future industrial development in the Foothills Structure Plan published in 1992.

The City of Gosnells has advocated for the future strategic industrial use of the MKSEA site and subdivided it into three planning areas, in addition to the area located within the Shire of Kalamunda Local Government Boundary.

The MKSEA site covers a combined total area of about 513 Ha and is subdivided into the following precincts on the Indicative Local Structure Plan (City Of Gosnells, September 2015):

- Precinct 1 – about 125ha of land bound by Victoria Road, Tonkin Highway and Bickley Road;
- Precinct 2 – about 185ha of land bound by Victoria Road, Tonkin Highway and Bickley Road;
- Precinct 3 – about 156ha of land and includes sub-precincts 3A and 3B and is bound by Roe Highway, Bickley Road, Brook Road and the Shire of Kalamunda Boundary; and
- Precinct 3C (also known as the Welshpool East Industrial Precinct) – about 47.44 ha of land within the Shire of Kalamunda boundary and abuts Precincts 3A and 3B.

2.2 Part A study area

The Part A study area (the study area) comprises Precinct 1 of the MKSEA site. The study area is located in the Bickley Brook surface water catchment but does not include the Clifford Street Bushland site (Bush Forever Site 53). The study area currently includes properties and residences owned by the public and private sectors. The study area contains a number of Threatened Ecological Communities (TEC).

Figure 1, Site Investigation Plan, shows the extent of the study area, including the existing cadastral layout and the location of Bush Forever Site 53. Figure 1 also includes the location of geotechnical investigation points across the study area.

Based on published topography, the surface levels across the study area range from about 13.5 m AHD on the southern boundary to about 28 m AHD on the northern boundary. The ground surface in the northern portion of the study is typically higher than the ground surface on the southern boundary. Some of the existing lots within the study area have been earthworked as part of their current or previous phases of development. The ground surface on the developed lots is typically elevated in comparison with surrounding lots.

3 Proposed development

Based on the information provided by the City of Gosnells, we understand that Precinct 1 has been re-zoned from Rural to Industrial under the Metropolitan Region Scheme and the City's Town Planning Scheme (TPS 6).

The future land use under this zoning is expected to comprise non-heavy industrial. The Western Australian Planning Commission's (WAPC) Economic and Employment Lands Strategy non-heavy industrial Perth Metropolitan and Peel Regions (WAPC 2013) identifies the zoning timeframe from Precinct 1 as short-term (0 – 4 Years planning timeframe).

4 Project objectives

The objectives of the geotechnical study were to:

- Assess subsurface soil and groundwater conditions across the site, including the depth to groundwater where encountered during the investigations;
- Provide location coordinates for investigation positions and supporting figures;
- Map/ describe the study area's soils, including acid sulphate soils and infiltration capacity;
- Assess and comment on the suitability of the on-site stormwater disposal via infiltration by drainage basins or soakage systems;
- Assess the nature and extent of less permeable, potentially confining layers, across the site;

- Provide a site classification in accordance with AS2870-2011 "*Residential Slabs and Footings*" and recommendations for suitable footing systems for the proposed development;
- Provide recommendations for improving the current Site Classification to achieve a minimum of an "S-Class" site classification in accordance with AS2870-2011 (where applicable based on encountered ground conditions); and
- Provide geotechnical design parameters for the subgrade for future flexible pavement design (by others).

5 Client Supplied Information

The following geotechnical reports and information have been provided by the City of Gosnells for use in compiling this report and included as ***Appendix D*** and ***Appendix E,*** respectively:

- Golder Associates Pty Ltd (May 2014) "Geotechnical Investigation, 558 Bickley Road, Maddington";
- Douglas Partners Pty Ltd (February 2015) "Report on Geotechnical Investigation, Proposed Warehouse Development, Lots 252 to 256 Clifford Street, Maddington, WA".

6 Fieldwork

6.1 General

Fieldwork for Study Area A was carried out between 7 September and 15 September 2017 under the full time attendance of a Geotechnical Engineer from JDSi.

The approximate investigation locations were selected in advance of the fieldwork by JDSi and were positioned on existing lots where landowners had given permission to access their land for the purposes of completing this study. A map and contact details for sites where permission to access each individual lot had been granted was provided by Emerge Associates. Final access arrangements and the final position of each investigation location were completed on site by JDSi.

At each proposed investigation location the Landowner, or their nominated representative, were asked by JDSi to confirm the location of buried services and any sensitive infrastructure prior to any intrusive work being undertaken.

At some locations, intrusive investigations were cancelled on site. This was usually because the Landowner, or their nominated representative, were not available to attend site during the work, or because the location of buried services could not be confirmed.

Where test pits could not be advanced on lot areas, the decision was taken to advance boreholes using hand auger techniques in road reserves to provide additional information on the subsurface conditions for this study.

6.2 Fieldwork Summary

The fieldwork completed across the study area included:

- Six test pits (TP32, TP33, TP34, TP39, TP40 and TP43), advanced using an 8 tonne rubber tyred backhoe, each to a target depth of about 2.0 m below existing ground level;
- Five boreholes (HA06 to HA10), advanced using an 80 mm diameter hand auger to depths of about 1.0 m and 2.0 m below existing ground level;
- 11 dynamic cone penetrometer tests (DCPs) advanced through undisturbed ground adjacent to each test pit or borehole to a maximum depth of 0.9 m below existing ground level.
- Five falling head infiltration tests completed within the boreholes at a depth of about 1.0 m below existing ground level;
- Recovery of representative disturbed bulk soil samples for geotechnical laboratory testing; and
- Recovery of small disturbed samples at 0.5 m depth intervals within the test pits and boreholes for laboratory ASS/ PASS testing by Emerge Associates.

The investigation locations were recorded on site by the JDSi site engineer using a hand-held GPS unit. The approximate investigation locations are shown the Site Investigation Plan presented on ***Figure 1*** and the co-ordinates of the investigation positions are shown on the investigation logs and summarised in Table 1.

Surface elevations were not recorded by JDSi and all depths referenced in this report are in metres below existing ground level.

Table 1 – Summary of Investigation Locations

Hole Reference	Type	Date completed	Final Depth (m bgl)	Co-ordinates (MGA94 Zone 50)	
				Easting (m)	Northing (m)
TP32	Test pit	7/09/2017	2.0	405309	6456461
TP33	Test pit	7/09/2017	2.0	405465	6456643
TP34	Test pit	7/09/2017	2.0	405611	6456784
TP39	Test pit	7/09/2017	2.0	405490	6456278
TP40	Test pit	7/09/2017	2.0	405726	6456546
TP43	Test pit	8/09/2017	2.0	406115	6455510
HA06	Hand Auger Borehole	14/09/2017	2.0	404718	6455699
HA07	Hand Auger Borehole	14/09/2017	1.8	405010	6456187
HA08	Hand Auger Borehole	15/09/2017	1.1	404964	6455612
HA09	Hand Auger Borehole	15/09/2017	2.0	406282	6455600
HA10	Hand Auger Borehole	15/09/2017	1.0	406463	6455145

6.2.1 Test Pitting

The test pits were logged by JDSi in general accordance with the soil description guidance included in AS1726-2017 "*Geotechnical Site Investigations*". The test pit logs are presented in ***Appendix B***, together with explanatory notes explaining the soil description terms used.

Where encountered, water level readings were recorded in the test pits at times and under conditions stated on the investigation logs. Groundwater levels will vary over time in response to environmental factors, including rainfall, temperature, and other factors. The depths indicated in this report do not represent maximum or highest groundwater levels.

6.2.2 Hand Augered Boreholes

Boreholes were augered using an 80 mm diameter auger and logged on site by JDSi in accordance with the soil description guidance included in AS1726-2017 "*Geotechnical Site Investigations*". The borehole logs are presented in ***Appendix B***, together with explanatory notes explaining the soil description terms used.

6.2.3 Penetrometer Testing

DCPs were completed through undisturbed ground adjacent to the test pit and borehole investigation locations, to provide an indication of the penetration resistance of the near surface soils to a maximum depth of 0.9 m. The testing was completed in accordance with the test method described in AS1289.6.3.2. The results from the DCPs (blows/ 100 mm penetration) are summarised in Table 2, below.

6.2.4 Infiltration Testing

Falling head infiltration testing was completed at HA06, HA07, HA08, HA09 and HA10 using the "*inverse auger hole method*" described by Cocks (2007)[1]. The results of the infiltration testing is summarised in Table 3.

Table 2 – Summary of Dynamic Cone Penetrometer Testing

Depth Increment (mm)	DCP Location Reference										
	TP32	TP33	TP34	TP39	TP40	TP43	HA06	HA07	HA08	HA09	HA10
0-100	SET	SET	SET	SET	SET	SET	SET	SET	SET	SET	EX
100-200	2	2	2	2	2	1	9	HB	8	5	EX
200-300	2	2	2	3	2	2	7	Ex	12	6	SET
300-400	2	1	3	3	3	2	13	Ex	15+	6	6
400-500	2	2	3	4	4	1	15+	SET	-	5	4
500-600	2	2	3	4	4	2	-	7	-	4	3
600-700	2	1	3	3	4	2	-	6	-	3	3
700-800	3	2	3	3	5	2	-	6	-	3	4
800-900	3	2	3	2	5	2	-	5	-	3	3

Notes: All depths recorded in mm relative to existing ground surface

[1] Cocks G (2007) "*Disposal of Stormwater Runoff by Soakage in Perth Western Australia*" Journal and News of the Australian Geomechanics Society, Volume 42 No.3 pp101-114.

Ex – excavation due to presence of fill or obstruction (refer to logs in Appendix B).

Table 3 – Summary of Infiltration Test Results

Test Location	Soil Type (s)	Pipe Embedment Depth (m)	Estimated Permeability, k (m/day)		
			Test 1	Test 2	Test 3
HA06	FILL over Silty SAND over Sandy CLAY	0.95	0.7	0.5	0.4
HA07	FILL over SAND over Clayey SAND	1.0	1.6	1.0	0.8
HA08	FILL over Sandy CLAY	1.0	0.2	0.2	0.2
HA09	SAND	1.0	8.5	7.7	7.5
HA10	FILL over Clayey SAND	1.0	0.6	0.4	0.3

7 Description of laboratory testing

A summary of the geotechnical laboratory testing scheduled on disturbed samples recovered from the study area by Materials Consultants Pty Ltd, a NATA accredited laboratory, is presented in Table 4.

A summary of the laboratory test results is included in Table 5 and copies of the laboratory test certificates are included in ***Appendix C***.

Table 4 – Extent of Geotechnical Laboratory Testing

Type of Test	Test Method Reference	Number of Tests Completed
Particle Size Distribution	AS1289.3.6.1	3
Atterberg Consistency Limits	AS1289.3.1.1, 3.2.1, 3.3.1, 3.4.1, 2.1.1	3
Laboratory Compaction Test (modified compactive effort)	AS1289 5.2.1	1
California Bearing Ratio (4 day soaked)	AS1289 6.1.1	1

Table 5 – Summary of Laboratory Test Results

Test Reference	Sample Depth Range (m)	Particle Size Distribution			Atterberg Consistency Limits				CBR(%) *1	OMC (%)	MMDD (t/m^3)
		% Gravel	% Sand	% Fines	Liquid Limit %	Plastic Limit %	Plasticity Index %	Linear Shrinkage %			
TP32	0.2 to 1.0	0	96	4	NO	NP	NP	0	NT	NT	NT
TP39	1.1 to 2.0	51	31	18	54	18	36	11.5	NT	NT	NT
TP40	0.0 to 1.5	0	97	3	NO	NP	NP	0	20	13.5	1.75

Notes: California Bearing Ratio (CBR) soaked and remoulded to a dry density ratio of 95% MMDD, 4.5kg surcharge, CBR obtained at 2.5mm penetration
OMC – Optimum Moisture Content
NT – Not Tested
MMDD – Maximum Modified Dry Density

8 Site conditions

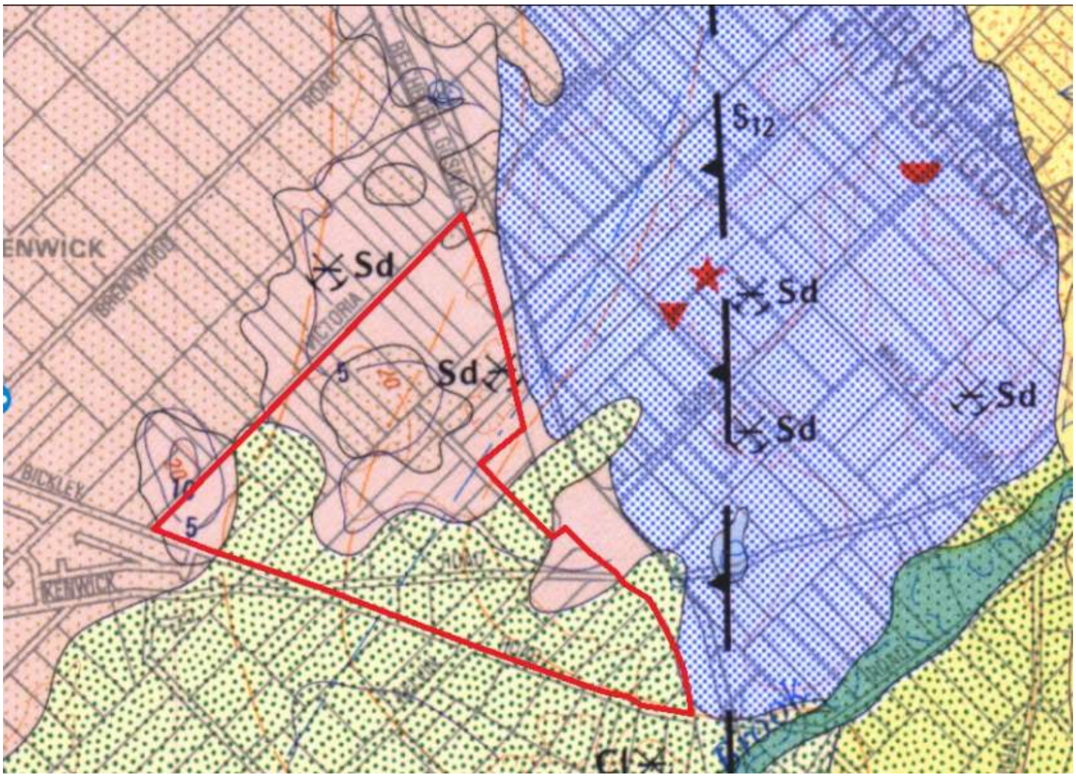
8.1 Published Information

The 1:50,000 scale Environmental Geology Map "*Armadale*" indicates that the study area, in its natural state, is expected to be underlain by the following soil units:

- Bassendean Sand (S_8) and Thin Bassendean Sand over Guildford Formation Soils (S_{10}) comprising white to pale brown sand of eolian origin overlying sand clay to clayey sand of the Guildford Formation. These units are expected to underlie ground with higher elevations across the study area, including the northwestern and northern boundaries; overlying
- Sandy Clay (C_s) of the Guildford Formation comprising white-grey to brown Clay with gravel and silt layers close to the Darling Scarp. This unit is expected to cover southern and southeastern areas of the site at lower elevations.

An extract from the published geology map is presented as Plate 1. The approximate study area boundary is shown as a red polygon.

Plate 1 – Extract from 1:50,000 Scale Environmental Geology Map "*Armadale*"



Historical groundwater contours published on the Perth Groundwater Map (https://maps.water.wa.gov.au/#/webmap/gwm) indicate that minimum site groundwater elevations beneath the study area range from about 12 m AHD on the southwest boundary, to about 16 m AHD on the southeast boundary. The historic groundwater data suggests that the maximum depth to groundwater will be between about 1.5 m (on the southern boundary) to about 12 m on the northern boundary.

The study area is located outside of the coverage area for the historic maximum groundwater levels, but it is likely that groundwater will be located at, or close to, existing surface level following wet weather periods. The depth to groundwater at the site is likely to be heavily influenced by the depth of clayey soils (Guilford Formation), or depth to other low permeability layers (such as Coffee Rock).

8.2 Encountered subsurface conditions

8.2.1 Ground Conditions

The ground conditions encountered at the investigation locations completed across the study area during the recent fieldwork by JDSi were generally consistent with the published geological mapping. The main differences with the published geology was the presence of Fill materials, that were encountered in the majority of the hand auger locations, and the presence of Topsoil, encountered at most test pit locations.

The JDSi investigations confirmed the presence of differing soil types ranging from Sand with less than 5% fines, to gravelly, sandy and silty soils with varying proportions of medium and high plasticity clay fines. The ground conditions encountered by JDSi were in general agreement with the expected ground conditions based on the published geological mapping.

The general ground conditions encountered by JDSi across the study area can be summarised as:

- A thin layer of ***Topsoil*** or ***Fill***, observed to maximum depths of up to 0.45 m; overlying
- ***Sand (SP)*** – comprising fine to coarse grained subangular to subrounded quartz with trace non-plastic fines to depths of between 0.5 m and >2 m. This layer was not encountered at HA08 or HA10. (At HA06 this layer comprised Silty Sand to a depth of 1.45 m); overlying
- ***Sandy Clay/ Clayey Sand (CH or SC)*** – comprising fine to medium grained sand and high plasticity clay fines and locally with trace lateritic gravels. This layer, where present, was encountered from depths of between 0.3 m and 1.30 m to the maximum investigated depths. This layer was not encountered at TP33, TP32 TP40, TP43, or HA09.

A layer of ***Coffee Rock*** (indurated sand) was encountered at TP40, below the Sand (SP) layer, at a depth of about 1.80 m.

Access across the site was limited only to areas where access permission was granted by landowners. To supplement the limited investigation information gathered by JDSi, we have reviewed and considered the information presented in the Client Supplied reports by Golder Associates (2014) and Douglas Partners (2015). A summary of the ground conditions reported from the previously completed geotechnical investigations is included below.

<u>Golder Associates (2014)</u>

A total of 13 locations were investigated using a combination of test pits (TP01 to TP10) and hand augered boreholes (HA1 to HA3) across 558 Bickley Road, Maddington. The Golder investigations reached maximum depths of between 0.6 m and 3 m. The ground conditions reported by Golder typically comprised Topsoil and Fill, overlying Sand, overlying Sandy Clay and Clayey Sand. The clay fines were high plasticity.

The ground conditions reported by Golder are consistent with the ground conditions encountered during the JDSi geotechnical investigations

The approximate location of the investigation points completed by Golder Associates have been included on ***Figure 1***, and copies of the investigation logs are included in ***Appendix D***.

Douglas Partners (2015)

A total of 19 locations were investigated using a combination of test pits (TP1 to TP12), hand augered boreholes (BH13 to BH16) and power augered boreholes (BH17 to BH19) across Lots 252 to 256 Clifford Street, Maddington. The Douglas Partners investigations extended to maximum depths of between 1 m and 3 m. The ground conditions reported by Douglas Partners typically comprised Fill and Topsoil, overlying Sand, overlying Clayey Sand/ Sandy Clay with high plasticity fines.

The ground conditions encountered by Douglas Partners are consistent with the ground conditions encountered during the JDSi geotechnical investigations.

The approximate location of the investigation points completed by Douglas Partners have been included on ***Figure 1***, and copies of the investigation logs are included in ***Appendix E***.

8.2.2 Groundwater

Groundwater levels measured during the course of the investigation are presented in Table 6. The groundwater depths were recorded on the dates stated in Table 6 and as stated on the investigation logs. The groundwater depths presented in this report do not represent maximum levels or highest groundwater levels.

Table 6 – Summary of Encountered Groundwater Levels

Testpit No.	Date of Reading	Depth to Groundwater (m)	Borehole No.	Date of Reading	Depth to Groundwater (m)
TP32	7/09/2017	GNE	**HA06**	14/09/2017	1.1
TP33	7/09/2017	GNE	**HA07**	14/09/2017	1.3
TP34	7/09/2017	GNE	**HA08**	15/09/2017	GNE
TP39	7/09/2017	GNE	**HA09**	15/09/2017	GNE
TP40	7/09/2017	GNE	**HA10**	15/09/2017	GNE
TP43	7/09/2017	0.6			

Notes: GNE – Groundwater not encountered

Groundwater was encountered at one investigation location by Golder Associates in May 2014 (TP09, at a depth of 0.7 m). Groundwater was not encountered in the investigations advanced by Douglas Partners in February 2015.

9 Geotechnical assessment

9.1 General

This report is intended to support structure planning for Study Area A and is based on a relatively low-density of geotechnical investigation locations. Further and more detailed geotechnical investigations will be required to provide more detailed information on subsurface conditions.

9.2 Preliminary site classifications

Preliminary site classifications have been assessed for the study area in accordance with AS2870-2011 "*Residential Slabs and Footings*".

Based on the subsurface conditions encountered across the study area, the following preliminary site classifications can be expected:

- "*Class P*" – on sites where Uncontrolled Fill is present, where existing or historic developments have significantly disturbed the ground surface, and where ground bearing pressures are inadequate to support the proposed development;
- "*Class A*" – on sites where inert sand (Bassendean Sand or Approved Sand Fill with less than 5% fines) is present to depths of at least 1.80 m over Guildford Formation soils;
- "*Class S*" – in areas where inert sand (Bassendean Sand or Approved Sand Fill with less than 5% fines) is present to a depth of at least 1.0 m over Guildford Formation soils;
- "*Class M*" – in areas where inert sand (Bassendean Sand or Approved Sand Fill with less than 5% fines) is present to a depth of at least 0.6 m over Guildford Formation soils; and
- "*Class H1" to "Class E*" - in areas where Guildford Formation soils are present at a depth of less than 0.6 m.

For all future developments within the study area, it is recommended that Approved Fill is placed and compacted to raise site levels to provide a <u>minimum</u> separation of 0.6 m between the final site development surface and the highest design groundwater surface.

The final site classification for the proposed development(s) at the study area will depend on the earthworks completed and the ground conditions assessed for detailed design and construction purposes. It is recommended that an experienced geotechnical engineer be engaged during the design and construction process for all proposed developments to provide advice on design and construction.

AS2870-2011 is limited to single or double storey residential structures that are subject to maximum bearing pressures of 100 kPa. The proposed development(s) may not strictly be applicable to AS2870-2011. This must be considered by the structural engineers and appropriate measures included in their design.

9.3 Geotechnical ground improvement to achieve a "Class S"

To achieve a "*Class S*" site classification within the study area in accordance with AS2870-2011 "Residential Slabs and Footings", a minimum of 1.0 m of inert fill (Approved Sand Fill with less than 5% fines) must be placed and compacted above Guildford Formation Soils. A minimum separation of 0.6 m between the final site development surface and the highest design groundwater surface is also recommended to achieve a "Class S" site classification within the study area.

Where there is less than 1.0 m of inert sand above Guildford Formation soils, bulk earthworks using imported Approved Sand Fill will be required to raise site levels.

On sites where loose sands or soft clays are present, geotechnical ground improvement works will be required to improve the ground bearing properties to achieve a minimum allowable bearing pressure of 100 kPa in accordance with AS2870-2011.

9.4 Stormwater Disposal

Based on the results of the infiltration testing across the study area, we expect that sites underlain by a minumum of 0.6 m of Bassendean Sand or Approved Sand Fill with less than 5% fines will be suitable for stormwater disposal by soakage. Sites underlain by less than 0.6 m of Bassendean Sand over Guildford Formation soils will not be suitable for on site stormwater disposal by soakage.

For the purposes of preliminary soakage design, the following maximum design infiltration rates are considered appropriate and should be confirmed by additional in-situ testing to provide deatiled design informaton:

- Bassendean Sand - greater than 1.8 m cover over Guildford Formation: k = 5m/day;
- Bassendean Sand - between 0.6 m and 1.8 m cover over Guildford Formation: k=1 m/day; and
- Guildford Formation soils (Sandy Clay/ Clayey Sand): k = 0m/day (i.e. practically impermeable).

The above preliminary values are considered appropriate to allow for a reduced permeability as a consequence of:

- Densification of sand during site preparation works;
- Natural variation in sands; and
- Potential clogging of sand around soakwells.

Where possible, soakwells should not be placed within 5 m of footings or slabs on ground (subject to local council regulations). Discharge from soakwells has been known to promote densification of loose sandy soils, leading to settlements on slabs and footings. Where soakwells are placed closer than 5m, more deatiled assessments will be required by an experienced geotechncial engineer to consider potential impacts on adjacent structures and provide appropriate recommendations on a suitable minuimum distance between soakwells and footings.

9.5 Design CBR for Flexible Pavements

Where design of flexible pavements is to be undertaken, a Subgrade California Bearing Ratio (CBR) of 10 % may be assumed where the subgrade is sand with less than 5% fines. This CBR value assumes that subsoil drainage has been designed to keep the subgrade dry, the depth to the highest design groundwater surface is greater than 0.5 m below subgrade level and the sandy subgrade has been compacted to a dry density ratio of at least 95 % maximum modified dry density (MMDD).

High plasticity clays are present across the MKSEA project site and are sensitive to moisture changes and are likely to offer poor subgrade conditions. Laboratory testing on clay soils for this study have reported soaked CBR values of 2% or less on high plasticity clay soils. It is recommended that clay subgrades be investigated and assessed carefully on a location specific basis. High plasticity clays are typically unsuitable for subgrades in areas with high groundwater levels. It is likely that subgrade stabilisation or geotechnical ground improvement will be required for pavement construction on clay soils within the study area.

10 References

The following published information sources have been reviewed by JDSi in compiling this report:

- Standards Australia (2011) "*Residential Slabs and Footings*" Australian Standard AS2870 – 2011.

- Standards Australia (2007) "*Guidelines on Earthworks for Commercial and Residential Developments*" Australian Standard AS3798 – 2007.
- Standards Australia "*Geotechnical Site Investigations*" Australian Standard AS1726-2017.
- Jordan J.E (1986) "Armadale" Part Sheets 2033 I and 2133 IV Perth Metropolitan Region, Environmental Geology Series, Geological Survey of Western Australia.

"Your Geotechnical Report"

1 Introduction

The information contained in this document is to inform JDSi's clients of the reasonable expectations of a geotechnical report and options to mitigate geotechnical risks and consequences. This information is provided to help clients understand where JDSi's responsibility as a geotechnical engineer, acting reasonably, begin and end. In doing so, it also highlights the responsibility of our client and third parties.

Please contact the JDSi Project Director should you not understand the report and the limitations of the information provided.

2 Collection and Interpretation of Data

Geotechnical investigations identify subsurface conditions only at the point of investigation. The material encountered during the investigation is recorded on logs and based on a visual assessment and (if undertaken) supported by laboratory test results. In the case of an Electric Friction Cone Penetrometer Test (CPT), the data recorded is a tip pressure and sleeve friction on a rod; from which ground conditions are inferred.

Actual conditions may differ from those encountered during the investigations and / or inferred a distance from the investigation stations. In addition, the actual interface between materials or units may be gradual or more abrupt than inferred from the results of the investigation.

A Chartered Geotechnical Engineer and / or Engineering Geologist should be retained through the various stages of the project to identify variances, conduct additional tests if required, and provide recommendations to address geotechnical / geological issues identified on site. The Chartered Geotechnical Engineer / Engineering Geologist should also review the actual conditions encountered to confirm that they are consistent with those inferred in this report.

3 Change in Subsurface Conditions

The geotechnical recommendations and parameters provided in this report are based on the ground conditions encountered at the time of the geotechnical investigation. Changes in the ground conditions can occur over time and include, but are not limited to, the following:

- Filling or excavation works (or other anthropologic events);
- Flooding;
- Groundwater fluctuations;
- Earthquakes or other such events;
- Works on neighbouring sites impacting on the subject site; and,
- Migration of pollutants from neighbouring properties.

JDSi should be consulted if there is any protracted delay in the issue of this report and the use of the recommendations provided.

It is important to note that where ground conditions have changed, additional geotechnical investigations and testing may be required to assess the impacts of the changed ground conditions.

4 Specificity of Report

This geotechnical report has been prepared for a specific project and design; therefore, it has been written to address specific geotechnical issues. In doing so, the following has been taken into account:

- The project objectives as described in the report;
- The client's budget and programme constraints;
- The specific site mentioned in the report; and,
- The nature and extent of the development at the site.

This report should not be used for any other purpose other than what has been specifically described and should not be relied upon if:

- The report was not written for you;
- The report was not written for your specific site;
- The report does not address your specific development;
- There is a significant delay between undertaking the report and developing the site; or,
- Significant changes to the site have occurred.

Where the information and recommendations contained within this report are being used by others, JDSi should be engaged during the design process to engage with the other members of the design team and review works being produced by the other design team members to confirm that it is consistent with the geotechnical report.

5 Environmental Issues

Unless specifically addressed in this report, environmental and contamination considerations are not included. The investigation methods required for environmental investigation often differ to those used for geotechnical investigations and the information contained within this report may not be appropriate for use by environmental engineering consultants and scientists.

This report was not prepared to address environmental issues and the client is responsible to ensure environmental considerations have been taken into account for the project. JDSi can provide information on environmental engineering consultants, should this be required.

6 Construction

The method of ground investigation used for geotechnical investigations limits JDSi's ability to know every detail about the ground conditions on site. JDSi use reasonable engineering judgement to form an assessment of the subsurface conditions at the site based on information obtained at specific locations.

Ground conditions may be encountered during construction that were not anticipated during the geotechnical investigation. Should this be the case, JDSi should be engaged to provide construction support as a means of mitigating the consequence of encountering unexpected ground conditions.

7 Responsibility of Others

JDSi has prepared this report for the use by our client. JDSi does not accept any responsibility from any third party, other than our client, who uses the information contained in this report. JDSi takes no responsibility for any damages suffered by any third party as a consequence of any decisions or action that have been made based on this report.

Further information regarding the responsibility of clients and other third parties should also be obtained from the following:

- "Guidelines for the Provision of Geotechnical Information in Construction", published by the Institution of Engineers Australia;
- Australian Standard AS 2870 – 2011, Residential Slabs and Footings;
- Australian Standard, AS 5100 – 2004, Bridge Design Set; and,
- Any other Standard or Code of Practice applicable to the development.

Figures – Site Investigation Plan

PLAN (PART A)

SCALE 1:1000

LEGEND

HA	HAND AUGER (JDSI)
TP	TEST PIT (JDSI)
HA	HAND AUGER (GOLDER 2014)
TP	TEST PIT (GOLDER 2014)
TP	TEST PIT (DOUGLAS PARTNERS 2015)
	BUSH FOREVER SITES
	LOCAL GOVERNMENT AUTHORITY BOUNDARY

JDSi

GROUND ENGINEERING

□DS161173

MKSEA Structure Plan De□inition Study

□IG□RE 1 - SITE I□VESTIGATIO□ PLA□

□DS161173-R01-□IG□RE1-REV 0

Appendix A – Indicative Local Structure Plan (City of Gosnells, September 2015)

NOTES

1. This indicative Local Structure Plan (LSP) has been prepared exclusively for the purpose of supporting the MRS Amendment to rezone the project area for industrial development. It is expected other planning proposals will result from future detailed design within MKSEA.
2. Comprehensive investigations have identified the environmentally constrained land within MKSEA for structure planning purposes. Further investigation of environmentally constrained land is required as part of the preparation of future planning proposals.
3. All road reserves depicted in the Indicative LSP are notionally 30 metres in width.
4. Vehicular access to Kelvin Road and the final configuration of all intersections is subject to further investigation and approval from Main Roads WA.
5. This indicative LSP proposes the closure of Bickley Road at its western end and the restriction of access to this road for industrial traffic.
6. Satisfactory interim and ultimate access arrangements are required for those properties currently serviced by existing roads proposed to be closed.
7. All CCW buffers are notionally 50m and subject to further environmental investigations and approval.
8. Satisfactory arrangements will need to be made to share the cost of infrastructure provision and transfer all land identified for drainage, conservation and other open space purposes from private to public ownership.
9. Land uses fronting the southern side of Welshpool Road and the northern side of Bickley Road should provide a suitable transition to nearby residential areas.

MADDINGTON KENWICK STRATEGIC EMPLOYMENT AREA
INDICATIVE LOCAL STRUCTURE PLAN - SEPTEMBER 2015

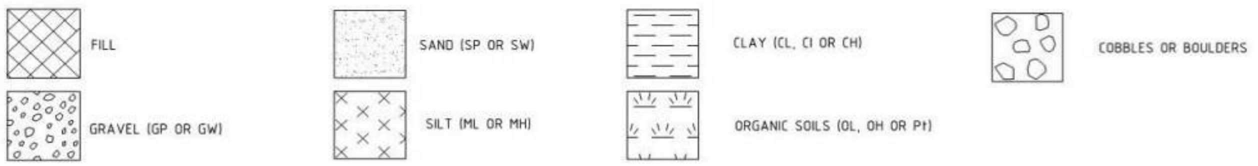
CITY OF GOSNELLS

Appendix B – Results of Field Investigation

- Explanatory Notes
- Investigation Logs

EXPLANATORY NOTES - SOIL DESCRIPTION

JDSi GROUND ENGINEERING



Combinations of these basic symbols can be used to indicate mixed materials (eg. Clayey Gravel)

GP	Poorly Graded Gravel	SM	Silty Sand	CH	High Plasticity Clay
GW	Well Graded Gravel	SC	Clayey Sand	OL	Organic Soils (LP)
GM	Silty Gravel	ML	Low Plasticity Silt	OH	Organic Soils (HP)
GC	Clayey Gravel	MH	High Plasticity Silt	PT	Peat
SP	Poorly Graded Sand	CL	Low Plasticity Clay	Describe	Cobbles and Boulders
SW	Well Graded Sand	CI	Medium Plasticity Clay	Fill	Fill

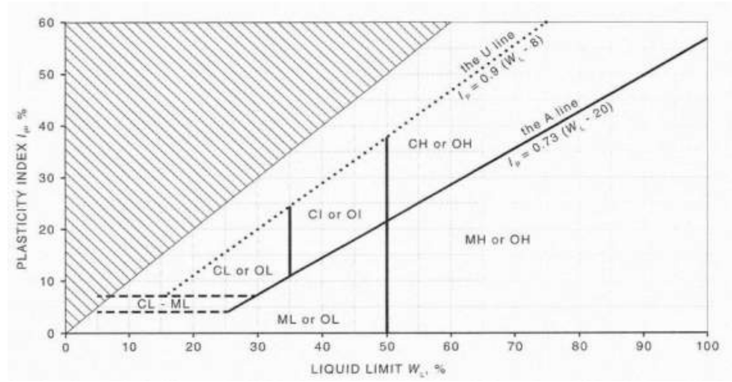
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726:2017, Section 6.2. Material properties are assessed in the field by visual/tactile methods in combination with field testing techniques (where used).

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2 to 6
SAND	Coarse	0.6 to 2.0
	Medium	0.2 to 0.6
	Fine	0.075 to 0.2
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY PROPERTIES



MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties if primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

RESISTENCE TO EXCAVATION

Symbol	Term	Description
VE	Very easy	All resistances are relative to the selected method of excavation.
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

MOISTURE CONDITION — AS1726-1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays and silts may be brittle or friable and powdery
M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY — AS1726-1993

Symbol	Term	Undrained Shear Strength (kPa)	SPT "N"	DCP blows per 100mm	Symbol	Term	Density Index (%)	SPT "N"	DCP blows per 100mm	PSP blows per 300mm
VS	Very soft	0 to 12	0 to 2	<1	VL	Very Loose	<15	0 to 4	<1	0 to 2
S	Soft	12 to 25	2 to 4	<1	L	Loose	15 to 35	4 to 10	1 to 2	2 to 6
F	Firm	25 to 50	4 to 8	1 to 2	MD	Medium Dense	35 to 65	10 to 30	2 to 3	6 to 8
St	Stiff	50 to 100	8 to 15	3 to 4	D	Dense	65 to 85	30 to 50	4 to 8	8 to 15
VSt	Very Stiff	100 to 200	15 to 30	5 to 10	VD	Very Dense	>85	>50	>8	>15
H	Hard	>200	>30	>10	Note: PSP correlations only valid 450mm depth					

Consistency and density may also be inferred from excavation performance and material behaviour.

NON-CORED BOREHOLE NUMBER: HA06

PAGE: 1 OF 1

PROJECT NUMBER: JDS161173
PROJECT NAME: MKSEA PROJECT
PROJECT LOCATION: MADDINGTON / KENWICK

JDSi GROUND ENGINEERING

DATUM: MGA94 Zone 50	DRILL MODEL AND MOUNTING: HAND AUGER	DATE STARTED: 14/09/2017
ELEVATION:	HOLE DIAMETER (mm): 80 mm	DATE COMPLETED: 14/09/2017
EASTING (m): 404718	INCLINATION: -90	LOGGED BY: CBD
NORTHING (m): 6455699	BEARING:	CHECKED BY: JQP

METHOD (DRILLING)	WATER	DEPTH (m)	MATERIAL DESCRIPTION (Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
Hand Auger		0.0 – 0.20m	FILL: Sandy topsoil with trace of organics, brown.		M		Roots and rootlets.
Hand Auger		0.20m – 0.45m	FILL: Clayey gravelly sand. Clay is high plasticity.		M		Rootlets.
Hand Auger		0.45m – 1.40m	SILTY SAND: Fine to medium grained, sub-rounded quartz, orange/grey/brown, with non-plastic silty fines, trace of clay fines.	SM	W	D	Rootlets. Large roots at 0.90m Becoming wet at 0.95m
Hand Auger	13/09/2017 (at 2.0)	1.40m – 2.00m	SANDY CLAY: Medium to high plasticity clay, grey/white/orange, sand is fine to coarse grained, sub-angular to sub-rounded quartz.	CI-CH	M	S to F	Can be easily re-moulded with fingers.
		2.00m	Hole Terminated at 2.00 m Target depth				

Columns also printed: PENETRATION (VE E F H), SUPPORT, SAMPLES & FIELD TESTS, Elevation (m AHD), GRAPHIC LOG. Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0.

METHOD
AS - Auger Screwing
RR - Rock Roller
WB - Washbore
HA - Hand Auger
DPP Direct Push Probe

SUPPORT
C - Casing

PENETRATION
VE E F H VH
No Resistance

WATER
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE
D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

NON-CORED BOREHOLE NUMBER: HA07

PAGE: 1 OF 1

PROJECT NUMBER: **JDS161173**
PROJECT NAME: **MKSEA PROJECT**
PROJECT LOCATION: **MADDINGTON / KENWICK**

JDSi GROUND ENGINEERING

DATUM: **MGA94 Zone 50**	DRILL MODEL AND MOUNTING: **HAND AUGER**	DATE STARTED: **14/09/2017**
ELEVATION:	HOLE DIAMETER (mm): **80 mm**	DATE COMPLETED: **14/09/2017**
EASTING (m): **404718**	INCLINATION: **-90**	LOGGED BY: **CBD**
NORTHING (m): **6455699**	BEARING:	CHECKED BY: **JQP**

DRILLING | MATERIAL

METHOD	PENETRATION (VE E F H VH)	SUPPORT	WATER	SAMPLES & FIELD TESTS	DEPTH (m)	Elevation (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
Hand Auger					0.0 – 0.35m				FILL: Silty sand with some medium to coarse grained lateritic gravels, grey/orange.	M		
Hand Auger					0.35m – 1.30m			SP	SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, grey/brown, trace of non-plastic fines.	M	D	
Hand Auger			13/09/2017		1.30m – 1.80m			SC	CLAYEY SAND: Fine to medium grained, sub-angular quartz, grey/orange, with medium to high plasticity clay, trace of sub-angular, medium to coarse grained lateritic gravels.	M	VSt	
					1.80m				Hole Terminated at 1.80 m Refusal			

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

METHOD
AS - Auger Screwing
RR - Rock Roller
WB - Washbore
HA - Hand Auger
DPP Direct Push Probe

SUPPORT
C - Casing

PENETRATION
VE E F H VH
No Resistance

WATER
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE
D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

NON-CORED BOREHOLE NUMBER: HA08

PAGE: 1 OF 1

PROJECT NUMBER: **JDS161173**
PROJECT NAME: **MKSEA PROJECT**
PROJECT LOCATION: **MADDINGTON / KENWICK**

JDSi GROUND ENGINEERING

DATUM:	**MGA94 Zone 50**	DRILL MODEL AND MOUNTING:	**HAND AUGER**	DATE STARTED:	**15/09/2017**
ELEVATION:		HOLE DIAMETER (mm):	**80 mm**	DATE COMPLETED:	**15/09/2017**
EASTING (m):	**404964**	INCLINATION:	**-90**	LOGGED BY:	**CBD**
NORTHING (m):	**6455612**	BEARING:		CHECKED BY:	**JQP**

DRILLING: METHOD	PENETRATION (VE E F H VH)	SUPPORT	WATER	SAMPLES & FIELD TESTS	DEPTH (m)	Elevation (m AHD)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
Hand Auger			Not Encountered		0.0 – 0.10m				FILL: Sandy topsoil with trace of organics, brown.	M		Roots and rootlets.
					0.10m – 0.40m				FILL: Silty Sand, medium to coarse grained, sub-rounded quartz, trace gravels of crushed limestone, plastic and concrete, brown. Fines are non-plastic.	M		Rootlets.
					0.40m – 1.10m			CH	SANDY CLAY: High plasticity clay, with some fine to coarse grained, sub-angular to sub-rounded quartz, orange/grey, trace of fine to medium grained, rounded lateritic gravel.	M to D	St to VSt	At 1.0m becomes hard to auger.
					1.10m				Hole Terminated at 1.10 m Refusal			

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

METHOD
AS - Auger Screwing
RR - Rock Roller
WB - Washbore
HA - Hand Auger
DPP Direct Push Probe

SUPPORT
C - Casing

PENETRATION
VE E F H VH
No Resistance

WATER
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE
D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

NON-CORED BOREHOLE NUMBER: HA09

PAGE: 1 OF 1

PROJECT NUMBER: **JDS161173**
PROJECT NAME: **MKSEA PROJECT**
PROJECT LOCATION: **MADDINGTON / KENWICK**

JDSi GROUND ENGINEERING

DATUM: **MGA94 Zone 50**	DRILL MODEL AND MOUNTING: **HAND AUGER**	DATE STARTED: **15/09/2017**
ELEVATION:	HOLE DIAMETER (mm): **80 mm**	DATE COMPLETED: **15/09/2017**
EASTING (m): **406282**	INCLINATION: **-90**	LOGGED BY: **CBD**
NORTHING (m): **6455600**	BEARING:	CHECKED BY: **JQP**

DRILLING						MATERIAL					
METHOD	PENETRATION (VE E F H)	SUPPORT	WATER	SAMPLES & FIELD TESTS	DEPTH (m)	Elevation (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
Hand Auger			Not Encountered		0.0 – 0.15m				TOPSOIL: Brown sand with trace of organics, brown.			Roots and rootlets.
Hand Auger			Not Encountered		0.15m – 2.00m			SP	SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, white/grey, trace of non-plastic fines.	D	MD to D	Roots to 0.60m.
					2.00m				Hole Terminated at 2.00 m Target depth			

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

METHOD
AS - Auger Screwing
RR - Rock Roller
WB - Washbore
HA - Hand Auger
DPP Direct Push Probe

SUPPORT
C - Casing

PENETRATION
VE E F H VH
No Resistance

WATER
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE
D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

NON-CORED BOREHOLE NUMBER: HA10

PROJECT NUMBER: JDS161173
PROJECT NAME: MKSEA PROJECT
PROJECT LOCATION: MADDINGTON / KENWICK

JDSi GROUND ENGINEERING

DATUM: MGA94 Zone 50	DRILL MODEL AND MOUNTING: HAND AUGER	DATE STARTED: 15/09/2017
ELEVATION:	HOLE DIAMETER (mm): 80 mm	DATE COMPLETED: 15/09/2017
EASTING (m): 406453	INCLINATION: -90	LOGGED BY: CBD
NORTHING (m): 6455739	BEARING:	CHECKED BY: JQP

DRILLING						MATERIAL					
METHOD	PENETRATION (VE E F H)	SUPPORT	WATER	SAMPLES & FIELD TESTS	DEPTH (m)	Elevation (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
Hand Auger			Not Encountered		0.0 – 0.30m				FILL: Silty sand grey/brown/red, with trace of fine to medium grained, rounded lateritic gravel.	D		Clayey at 0.15m - 0.30m.
					0.30m – 1.00m			SC	CLAYEY SAND: Fine to medium grained, sub-rounded quartz, grey/brown, clay is medium plasticity.	D	MD	
					1.00m				Hole Terminated at 1.00 m Target depth			

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

METHOD
AS - Auger Screwing
RR - Rock Roller
WB - Washbore
HA - Hand Auger
DPP Direct Push Probe

SUPPORT
C - Casing

PENETRATION
VE E F H VH
No Resistance

WATER
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE
D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

TEST PIT NUMBER: TP32

PAGE: 1 OF 1

PROJECT NUMBER: **JDS161173**
PROJECT NAME: **MKSEA PROJECT**
PROJECT LOCATION: **MADDINGTON / KENWICK**

JDSi GROUND ENGINEERING

DATUM: **MGA94 Zone 50**	EQUIPMENT: **JCB 3CX**	DATE STARTED: **7/09/2017**
ELEVATION:	EXCAVATION LENGTH: **2.5 m**	DATE COMPLETED: **7/09/2017**
EASTING (m): **405309**	EXCAVATION WIDTH: **0.5 m**	LOGGED BY: **CBD**
NORTHING (m): **6456461**	EXCAVATION ORIENTATION:	CHECKED BY: **JQP**

EXCAVATION: PENETRATION (VE E F H)	SUPPORT	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	Elevation (m AHD)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
		Not Encountered		0.0				TOPSOIL: Sand with trace of organic, brown.	M		Rootlets and roots.
			B (0.20m – 1.00m)	0.10m			SP	SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, white/grey.	M	MD	Roots to 0.60m.
				1.30m			SP	SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, orange/yellow.	M	MD	
				2.00m				Hole Terminated at 2.00 m Target depth			

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

METHOD
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper

SUPPORT
T Timbering

PENETRATION
VE E F H VH
No Resistance

WATER
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS
U - Undisturbed Sample
D - Disturbed Sample
B - Bulk Disturbed Sample
MC - Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE
D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

TEST PIT NUMBER: TP33

PAGE: 1 OF 1

PROJECT NUMBER: JDS161173
PROJECT NAME: MKSEA PROJECT
PROJECT LOCATION: MADDINGTON / KENWICK

JDSi GROUND ENGINEERING

DATUM: MGA94 Zone 50	EQUIPMENT: JCB 3CX	DATE STARTED: 7/09/2017
ELEVATION:	EXCAVATION LENGTH: 2.5 m	DATE COMPLETED: 7/09/2017
EASTING (m): 405465	EXCAVATION WIDTH: 0.5 m	LOGGED BY: CBD
NORTHING (m): 6456643	EXCAVATION ORIENTATION:	CHECKED BY: JQP

EXCAVATION						MATERIAL					
PENETRATION (VE E F H)	SUPPORT	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	Elevation (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
		Not Encountered		0.0 – 0.10m				TOPSOIL: Silty sand with trace of organic fines, brown.	M		Roots and rootlets.
				0.10m – 2.00m			SP	SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, grey/white/brown.	M	L to MD	Sidewall collapse at 1.0m.
				2.00m				Hole Terminated at 2.00 m Target depth			

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

METHOD
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper

SUPPORT
- T Timbering

PENETRATION
VE E F H VH — No Resistance

WATER
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

SAMPLES & FIELD TESTS
- U - Undisturbed Sample
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE
- D - Dry
- M - Moist
- W - Wet

CONSISTENCY/ RELATIVE DENSITY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard
- Fr - Friable
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

JDSI LIBRARY REV 2.GLB Log JDSI TEST PIT JDS161173 - LOGS.GPJ <<DrawingFile>> 20/12/2017 16:42 8.30.004 Datgel Lab and In Situ Tool - DGD | Lib: JDSI 1.00 2015-12-09 Prj: JDSI 1.00 2015-12-09

TEST PIT NUMBER: TP34

PAGE: 1 OF 1

PROJECT NUMBER: JDS161173
PROJECT NAME: MKSEA PROJECT
PROJECT LOCATION: MADDINGTON / KENWICK

JDSi GROUND ENGINEERING

DATUM:	MGA94 Zone 50	EQUIPMENT:	JCB 3CX	DATE STARTED:	7/09/2017
ELEVATION:		EXCAVATION LENGTH:	2.5 m	DATE COMPLETED:	7/09/2017
EASTING (m):	405611	EXCAVATION WIDTH:	0.5 m	LOGGED BY:	CBD
NORTHING (m):	6456784	EXCAVATION ORIENTATION:		CHECKED BY:	JQP

EXCAVATION						MATERIAL					
PENETRATION (VE E F H)	SUPPORT	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	Elevation (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
		Not Encountered		0.0 – 0.10m				TOPSOIL: Silty sand with trace of organics, brown.	D		Rootlets and roots.
				0.10m – 1.00m (0.5)			SP	SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of fines, grey/white.	D	MD	Fine rootlets throughout.
			1.00m B 2.00m	1.00m – 2.00m (1.0, 1.5)			SC	CLAYEY SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, clay is medium plasticity, orange/brown/grey mottled.	M	MD	Trace of rounded ironstone/lateritic gravels.
				2.0 – 3.0 (2.5)				Hole Terminated at 2.00 m Target depth			

METHOD

N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper

SUPPORT

T Timbering

PENETRATION

VE E F H VH — No Resistance

WATER

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS

U - Undisturbed Sample
D - Disturbed Sample
B - Bulk Disturbed Sample
MC - Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY

VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

TEST PIT NUMBER: TP39

PAGE: 1 OF 1

PROJECT NUMBER: JDS161173
PROJECT NAME: MKSEA PROJECT
PROJECT LOCATION: MADDINGTON / KENWICK

JDSi GROUND ENGINEERING

DATUM: MGA94 Zone 50	EQUIPMENT: JCB 3CX	DATE STARTED: 7/09/2017
ELEVATION:	EXCAVATION LENGTH: 2.5 m	DATE COMPLETED: 7/09/2017
EASTING (m): 405490	EXCAVATION WIDTH: 0.5 m	LOGGED BY: CBD
NORTHING (m): 6456278	EXCAVATION ORIENTATION:	CHECKED BY: JQP

EXCAVATION | MATERIAL

Depth (m)	Groundwater levels	Samples & field tests	Classification symbol	Material description	Moisture condition	Consistency / relative density	Structure & other observations
0.0–0.07m	Not Encountered			TOPSOIL: Sand with organic fines, brown.	M		Roots and rootlets.
0.07–0.50m			SP	SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, yellow/brown.	M	MD	Roots and rootlets throughout.
0.50–1.10m			CH	SANDY CLAY: High plasticity clay, sand is fine to coarse grained, sub-angular to sub-rounded quartz, trace of sub-rounded to rounded lateritic gravel, orange/brown.	D to M	St	Roots at 0.50m - 0.70m.
1.10–2.00m		1.10m B 2.00m	GC	CLAYEY SANDY GRAVEL: Fine to coarse grained, subrounded to subangular ironstone, laterite and lateritic gravel, Red/brown. Sand is fine to coarse grained, subangular to subrounded. Clay is high plasticity.	D	D	
2.00m				Hole Terminated at 2.00 m Target depth			

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

Column headings: PENETRATION (VE E F H), SUPPORT, GROUND WATER LEVELS, SAMPLES & FIELD TESTS, DEPTH (m), Elevation (m AHD), GRAPHIC LOG, CLASSIFICATION SYMBOL, MATERIAL DESCRIPTION (Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin), MOISTURE CONDITION, CONSISTENCY RELATIVE DENSITY, STRUCTURE & Other Observations

METHOD

N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper

SUPPORT

T Timbering

PENETRATION

VE E F H VH — No Resistance

WATER

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS

U - Undisturbed Sample
D - Disturbed Sample
B - Bulk Disturbed Sample
MC - Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION

Based on Unified Classification System

MOISTURE

D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY

VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

TEST PIT NUMBER: TP40

PROJECT NUMBER: **JDS161173**
PROJECT NAME: **MKSEA PROJECT**
PROJECT LOCATION: **MADDINGTON / KENWICK**

JDSi GROUND ENGINEERING

DATUM: **MGA94 Zone 50**	EQUIPMENT: **JCB 3CX**	DATE STARTED: **7/09/2017**
ELEVATION:	EXCAVATION LENGTH: **2.5 m**	DATE COMPLETED: **7/09/2017**
EASTING (m): **405726**	EXCAVATION WIDTH: **0.5 m**	LOGGED BY: **CBD**
NORTHING (m): **6456546**	EXCAVATION ORIENTATION:	CHECKED BY: **JQP**

EXCAVATION: PENETRATION (VE E F H)	SUPPORT	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	Elevation (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
		Not Encountered	B (to 1.50m)	0.0 – 1.80			SP	SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, white/grey. … … Trace of coffee rock gravel at 1.50m.	D	L to MD	Sidewall collapse at 0.5m.
				1.80 – 2.00				COFFEE ROCK: Extremely low strength, very weakly iron cemented, brown.	D		Recovered as brown sand and gravels.
				2.00				Hole Terminated at 2.00 m Target depth			

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

METHOD
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper

SUPPORT
- T Timbering

PENETRATION
VE E F H VH — No Resistance

WATER
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

SAMPLES & FIELD TESTS
- U - Undisturbed Sample
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE
- D - Dry
- M - Moist
- W - Wet

CONSISTENCY/ RELATIVE DENSITY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard
- Fr - Friable
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

TEST PIT NUMBER: TP43

PAGE: 1 OF 1

PROJECT NUMBER: **JDS161173**
PROJECT NAME: **MKSEA PROJECT**
PROJECT LOCATION: **MADDINGTON / KENWICK**

JDSi GROUND ENGINEERING

DATUM: **MGA94 Zone 50**	EQUIPMENT: **JCB 3CX**	DATE STARTED: **8/09/2017**
ELEVATION:	EXCAVATION LENGTH: **2.5 m**	DATE COMPLETED: **8/09/2017**
EASTING (m): **406115**	EXCAVATION WIDTH: **0.5 m**	LOGGED BY: **CBD**
NORTHING (m): **6455510**	EXCAVATION ORIENTATION:	CHECKED BY: **JQP**

EXCAVATION						MATERIAL					
PENETRATION (VE E F H)	SUPPORT	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	Elevation (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
				0.0			SP	SAND: Fine to coarse grained, sub-angular to sub-rounded quartz, trace of non-plastic fines, white/grey.	D to M	L	Roots and rootlets to 0.50m.
			0.20m								
		08/09/17	B	0.5							
			1.50m	1.0					M		
				1.5							Sidewall collapse at 1.5m.
				2.0				2.00m Hole Terminated at 2.00 m Target depth			
				2.5							
				3.0							

METHOD
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper

SUPPORT
T Timbering

PENETRATION
VE E F H VH
No Resistance

WATER
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

SAMPLES & FIELD TESTS
U - Undisturbed Sample
D - Disturbed Sample
B - Bulk Disturbed Sample
MC - Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

CLASSIFICATION SYMBOLS & SOIL DESCRIPTION
Based on Unified Classification System

MOISTURE
D - Dry
M - Moist
W - Wet

CONSISTENCY/ RELATIVE DENSITY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

Appendix C – Laboratory Test Results

MATERIALS CONSULTANTS PTY. LTD.

INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386

300 COLLIER ROAD, BASSENDEAN, WA 6054 TELEPHONE: (08) 6278 3755 FACSIMILE: (08) 6278 4411
Email: admin@matcons.com.au

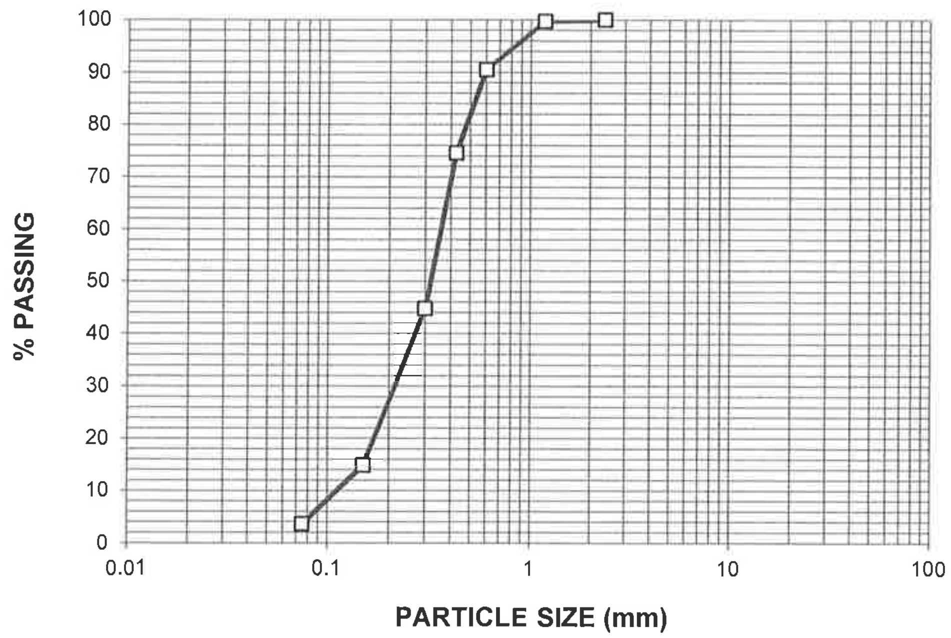
TEST CERTIFICATE

PARTICLE SIZE DISTRIBUTION

STANDARD METHOD OF ANALYSIS BY SIEVING : AS 1289.3.6.1

CLIENT:	JDSi Ground Engineering Pty Ltd, PO Box 8523, Perth BC, WA, 6849
JOB NO. :	149_106
SAMPLE NO. :	162
CLIENT REFERENCE :	TP32 - 0.20m to 1.00m
DATE TESTED :	13.09.2017 & 15.09.2017
SAMPLE DESCRIPTION :	Sand
PROJECT :	MKSEA Project, Kenwick - Job No JDS161173

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
2.36	100
1.18	100
0.600	91
0.425	75
0.300	45
0.150	15
0.075	4

Sampling Procedures: Tested as received.

Remarks: Wet sieved.

NATA Accredited for compliance with ISO/IEC 17025

ACCREDITED FOR TECHNICAL COMPETENCE

Approved :

M Snow, Signatory

Date: 19.09.2017

CERTIFICATE NO. MC 149_106 _1 **ISSUE 1**

MATERIALS CONSULTANTS PTY. LTD.
INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386
300 COLLIER ROAD, BASSENDEAN, WA 6054 TELEPHONE: (08) 6278 3755 FACSIMILE: (08) 6278 4411
Email: admin@matcons.com.au

TEST CERTIFICATE

CONSISTENCY LIMIT - ATTERBERG

TEST METHODS: AS 1289.3.1.1, AS 1289.3.2.1, AS 1289.3.3.1, AS 1289.3.4.1, MOISTURE CONTENT : AS 1289.2.1.1

CLIENT:	JDSi Ground Engineering Pty Ltd, PO Box 8523, Perth BC, WA, 6849
JOB NO.:	149_106
SAMPLE NO.:	162
CLIENT REFERENCE:	TP32 - 0.20m to 1.00m
DATE TESTED:	15.09.2017
SAMPLE DESCRIPTION:	Sand
PROJECT:	MKSEA Project, Kenwick - Job No JDS161173

LIQUID LIMIT	**Not Obtainable**
PLASTIC LIMIT	**Non Plastic**
PLASTICITY INDEX	**Non Plastic**
LINEAR SHRINKAGE	**0.0 %**

Sampling Procedures:	Tested as received.
Remarks:	Oven dried (50° C) Dry sieved.

Linear Shrinkage has been conducted at 21.4% moisture content in accordance with AS 1289.2.1.1

AS 1289.3.4.1 requires that the Linear Shrinkage be determined at the Liquid Limit of the soil for a standard test.

NATA

Accredited for compliance with ISO/IEC 17025

ACCREDITED FOR **TECHNICAL COMPETENCE**

Approved

M Snow, Signatory

Date: 19.09.2017

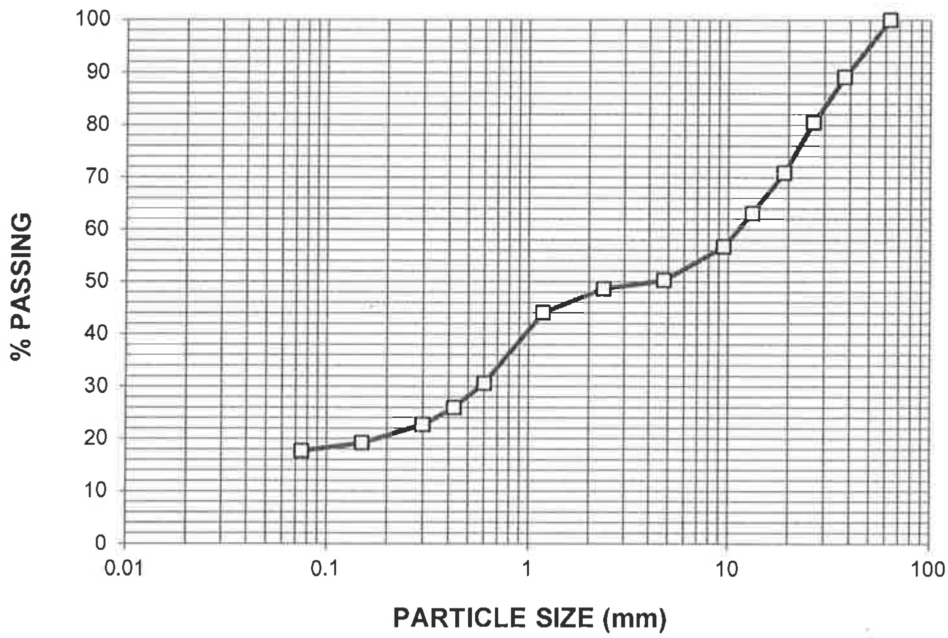
CERTIFICATE NO. MC 149_106 _2 **ISSUE 1**

MATERIALS CONSULTANTS PTY. LTD.
INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386
300 COLLIER ROAD, BASSENDEAN, WA 6054 TELEPHONE: (08) 6278 3755 FACSIMILE: (08) 6278 4411
Email: admin@matcons.com.au

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION
STANDARD METHOD OF ANALYSIS BY SIEVING : AS 1289.3.6.1

CLIENT: JDSi Ground Engineering Pty Ltd, PO Box 8523, Perth BC, WA, 6849
JOB NO. : 149_107
SAMPLE NO. : 163
CLIENT REFERENCE : TP39 - 1.10m to 2.00m
DATE TESTED : 13.09.2017 & 18.09.2017
SAMPLE DESCRIPTION : Clayey Sandy Gravel
PROJECT : MKSEA Project, Kenwick - Job No JDS161173

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
63.0	100
37.5	89
26.5	80
19.0	71
13.2	63
9.5	57
4.75	50
2.36	49
1.18	44
0.600	31
0.425	26
0.300	23
0.150	19
0.075	18

Sampling Procedures: Tested as received.
Remarks: Wet sieved.
Particle Size Distribution test conducted on 15.83 kg of material.
AS 1289.3.6.1 requires 45 kg of material for a standard test.

NATA
Accredited for compliance with ISO/IEC 17025
ACCREDITED FOR TECHNICAL COMPETENCE

Approved:
M Snow, Signatory
Date: 22.09.2017

CERTIFICATE NO. MC 149_107 _1 ISSUE 1

EXCEL\CALC\MCP19_23 [149_107psd] REV 003 DATE: 30.11.2015

MATERIALS CONSULTANTS PTY. LTD.
INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386

300 COLLIER ROAD, BASSENDEAN, WA 6054 TELEPHONE: (08) 6278 3755 FACSIMILE: (08) 6278 4411
Email: admin@matcons.com.au

TEST CERTIFICATE

CONSISTENCY LIMIT - ATTERBERG

TEST METHODS: AS 1289.3.1.1, AS 1289.3.2.1, AS 1289.3.3.1, AS 1289.3.4.1, MOISTURE CONTENT : AS 1289.2.1.1

CLIENT:	JDSi Ground Engineering Pty Ltd, PO Box 8523, Perth BC, WA, 6849
JOB NO.:	149_107
SAMPLE NO.:	163
CLIENT REFERENCE:	TP39 - 1.10m to 2.00m
DATE TESTED:	15.09.2017
SAMPLE DESCRIPTION:	Clayey Sandy Gravel
PROJECT:	MKSEA Project, Kenwick - Job No JDS161173

LIQUID LIMIT	**54 %**
PLASTIC LIMIT	**18 %**
PLASTICITY INDEX	**36 %**
LINEAR SHRINKAGE	**11.5 %**

Sampling Procedures:	Tested as received.
Remarks:	Oven dried (50° C) Dry sieved.

NATA

Accredited for compliance with ISO/IEC 17025

ACCREDITED FOR TECHNICAL COMPETENCE

Approved

M Snow, Signatory

Date: 22.09.2017

CERTIFICATE NO. MC 149_107 _2 **ISSUE 1**

MATERIALS CONSULTANTS PTY. LTD.
INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386

300 COLLIER ROAD, BASSENDEAN, WA 6054 TELEPHONE: (08) 6278 3755 FACSIMILE: (08) 6278 4411
Email: admin@matcons.com.au

TEST CERTIFICATE

CALIFORNIA BEARING RATIO : AS 1289.6.1.1

CLIENT:	JDSi Ground Engineering Pty Ltd, PO Box 8523, Perth BC, WA, 6849
JOB NO.:	149_108
SAMPLE NO.:	164
CLIENT REFERENCE:	TP40 - 0.00m to 1.50m
DATE TESTED:	19.09.2017
SAMPLE DESCRIPTION:	Sand
PROJECT:	MKSEA Project, Kenwick - Job No JDS161173

TEST CONDITIONS OF SPECIMEN

PERIOD OF SOAKING	4 days
SURCHARGING OF SPECIMEN	4.50 kg

COMPACTIVE EFFORT USED IN MOULDING SPECIMEN: 10 blows, 5 layers using a modified hammer

TEST RESULTS

MAXIMUM DRY DENSITY	1.75 t/m³
OPTIMUM MOISTURE CONTENT	13.6 %
% Retained on the 19mm sieve	0%
OVERSIZE MATERIAL	Excluded
DRY DENSITY	
SPECIMEN BEFORE SOAKING	1.67 t/m³
SPECIMEN AFTER SOAKING	1.67 t/m³
DRY DENSITY RATIO	
SPECIMEN BEFORE SOAKING	95.0 %
SPECIMEN AFTER SOAKING	95.5 %
MOISTURE CONTENT (AS 1289.2.1.1)	
SPECIMEN AT COMPACTION	13.3 %
SPECIMEN AFTER SOAKING	17.0 %
TOP 30 mm LAYER OF SPECIMEN AFTER PENETRATION	15.3 %
REMAINING DEPTH OF SPECIMEN AFTER PENETRATION	16.9 %
MOISTURE RATIO	
SPECIMEN AT COMPACTION	97.5 %
SPECIMEN AFTER SOAKING	125.0 %
TOP 30 mm LAYER OF SPECIMEN AFTER PENETRATION	112.5 %
REMAINING DEPTH OF SPECIMEN AFTER PENETRATION	124.0 %
SPECIMEN SWELL	-0.5%*

CALIFORNIA BEARING RATIO **20 % AT 2.50mm PENETRATION**

REMARKS: California Bearing Ratio Tested as received.
*This test result represents consolidation during soaking.

Accredited for compliance with ISO/IEC 17025
ACCREDITED FOR TECHNICAL COMPETENCE

APPROVED
M Snow, Signatory

DATE 20.09.2017

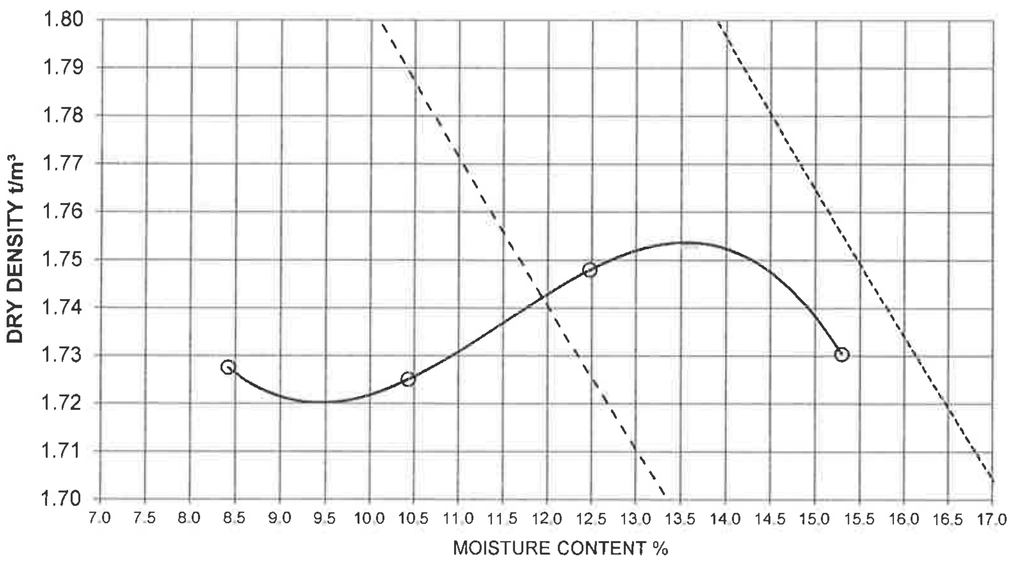
CERTIFICATE NO. MC 149_108 _1 ISSUE 1

MATERIALS CONSULTANTS PTY. LTD.
INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386
300 COLLIER ROAD, BASSENDEAN, WA 6054 TELEPHONE: (08) 6278 3755 FACSIMILE: (08) 6278 4411
Email: admin@matcons.com.au

TEST CERTIFICATE

DETERMINATION OF THE DRY DENSITY/MOISTURE CONTENT RELATIONSHIP OF A SOIL USING MODIFIED COMPACTIVE EFFORT : AS1289.5.2.1

CLIENT:	JDSi Ground Engineering Pty Ltd, PO Box 8523, Perth BC, WA, 6849
JOB NO.:	149_108
SAMPLE NO.:	164
CLIENT REFERENCE:	TP40 - 0.00m to 1.50m
DATE TESTED:	14.09.2017
SAMPLE DESCRIPTION:	Sand
FEATURE:	-
PROJECT:	MKSEA Project, Kenwick - Job No JDS161173



MODIFIED MAXIMUM DRY DENSITY	**1.75 t/m³**
MODIFIED OPTIMUM MOISTURE CONTENT	**13.5 %**
PER CENT RETAINED 19.0 mm SIEVE	**0 %**
PER CENT RETAINED 37.5 mm SIEVE	**0 %**

SAMPLING PROCEDURES: Tested as received.

REMARKS: Type A Mould (1 litre) used for this test.
AS 1289.3.1.1 used to determine Liquid Limit
Curing Time: 2 hrs

NATA

Accredited for compliance with ISO/IEC 17025

ACCREDITED FOR TECHNICAL COMPETENCE

APPROVED :

M Snow, Signatory

DATE : 19.09.2017

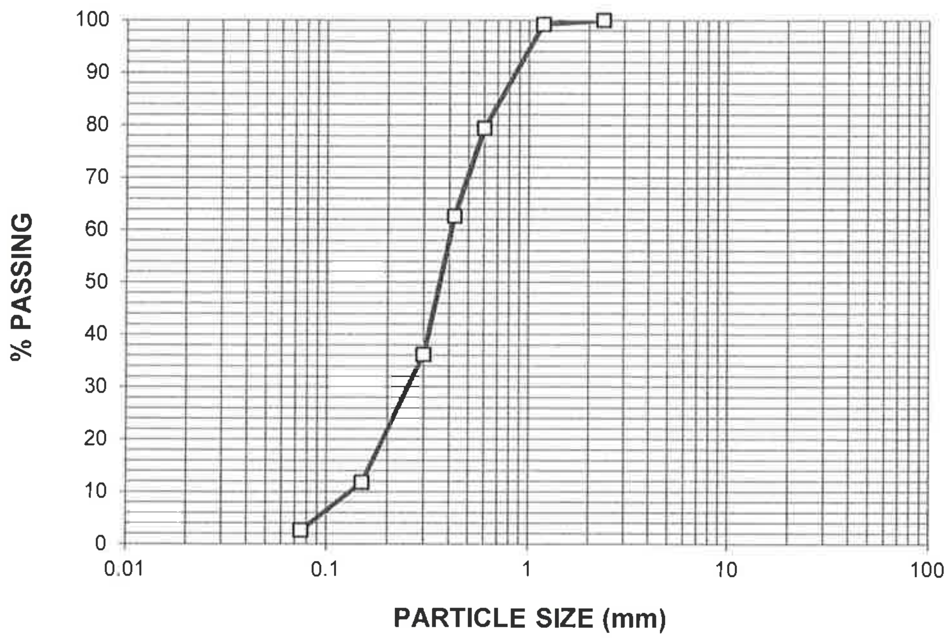
CERTIFICATE NO. MC 149_108 _2 ISSUE 1

MATERIALS CONSULTANTS PTY. LTD.
INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386
300 COLLIER ROAD, BASSENDEAN, WA 6054 TELEPHONE: (08) 6278 3755 FACSIMILE: (08) 6278 4411
Email: admin@matcons.com.au

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION
STANDARD METHOD OF ANALYSIS BY SIEVING : AS 1289.3.6.1

CLIENT: JDSi Ground Engineering Pty Ltd, PO Box 8523, Perth BC, WA, 6849
JOB NO. : 149_108
SAMPLE NO. : 164
CLIENT REFERENCE : TP40 - 0.00m to 1.50m
DATE TESTED : 13.09.2017 & 15.09.2017
SAMPLE DESCRIPTION : Sand
PROJECT : MKSEA Project, Kenwick - Job No JDS161173

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
2.36	100
1.18	99
0.600	79
0.425	63
0.300	36
0.150	12
0.075	3

Sampling Procedures: Tested as received.
Remarks: Wet sieved.

Accredited for compliance with ISO/IEC 17025
ACCREDITED FOR TECHNICAL COMPETENCE

Approved :
M Snow, Signatory
Date: 19.09.2017

CERTIFICATE NO. MC 149_108 _3 ISSUE 1

EXCEL\CALC\MC_SS236 [149_108psd.xlsm] REV 002 DATE: 08.12.2015

MATERIALS CONSULTANTS PTY. LTD.

INDEPENDENT TESTING LABORATORIES: NATA ACCREDITATION No 1763 : ABN 67 126 947 386

300 COLLIER ROAD, BASSENDEAN, WA 6054 TELEPHONE: (08) 6278 3755 FACSIMILE: (08) 6278 4411
Email: admin@matcons.com.au

TEST CERTIFICATE

CONSISTENCY LIMIT - ATTERBERG

TEST METHODS: AS 1289.3.1.1, AS 1289.3.2.1, AS 1289.3.3.1, AS 1289.3.4.1, MOISTURE CONTENT : AS 1289.2.1.1

CLIENT:	JDSi Ground Engineering Pty Ltd, PO Box 8523, Perth BC, WA, 6849
JOB NO.:	149_108
SAMPLE NO.:	164
CLIENT REFERENCE:	TP40 - 0.00m to 1.50m
DATE TESTED:	15.09.2017
SAMPLE DESCRIPTION:	Sand
PROJECT:	MKSEA Project, Kenwick - Job No JDS161173

LIQUID LIMIT	**Not Obtainable**
PLASTIC LIMIT	**Non Plastic**
PLASTICITY INDEX	**Non Plastic**
LINEAR SHRINKAGE	**0.0 %**

Sampling Procedures:	Tested as received.
Remarks:	Oven dried (50° C) Dry sieved.

Linear Shrinkage has been conducted at 22.2% moisture content in accordance with AS 1289.2.1.1

AS 1289.3.4.1 requires that the Linear Shrinkage be determined at the Liquid Limit of the soil for a standard test.

NATA

Accredited for compliance with ISO/IEC 17025

ACCREDITED FOR **TECHNICAL COMPETENCE**

Approved

M Snow, Signatory

Date: 19.09.2017

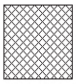
CERTIFICATE NO. MC 149_108 _4 **ISSUE 1**

Appendix D – Factual Investigation Logs from Golder Associates Report (2014)

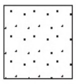
APPENDIX A

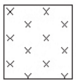
Test Pit Reports

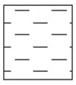
METHOD OF SOIL DESCRIPTION
USED ON BOREHOLE AND TEST PIT REPORTS

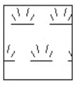
 FILL

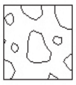
 GRAVEL (GP or GW)

 SAND (SP or SW)

 SILT (ML or MH)

 CLAY (CL, CI or CH)

 ORGANIC SOILS (OL or OH or Pt)

 COBBLES or BOULDERS

Combinations of these basic symbols may be used to indicate mixed materials such as sandy clay.

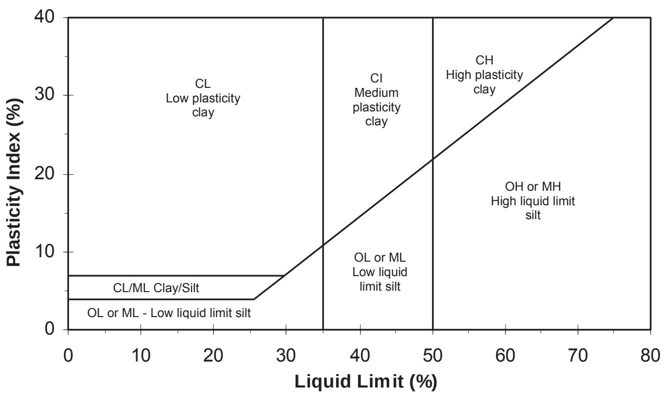
CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil and Rock is classified and described in Reports of Boreholes and Test Pits using the preferred method given in AS1726 – 1993, (Amdt1 – 1994 and Amdt2 – 1994), Appendix A. The material properties are assessed in the field by visual/tactile methods.

Particle Size

Major Division	Sub Division	Particle Size
BOULDERS		> 200 mm
COBBLES		63 to 200 mm
GRAVEL	Coarse	20 to 63 mm
	Medium	6.0 to 20 mm
	Fine	2.0 to 6.0 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties



MOISTURE CONDITION

AS1726 - 1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays & Silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition & may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726 - 1993

Symbol	Term	Undrained Shear Strength
VS	Very Soft	0 to 12 kPa
S	Soft	12 to 25 kPa
F	Firm	25 to 50 kPa
St	Stiff	50 to 100 kPa
VSt	Very Stiff	100 to 200 kPa
H	Hard	Above 200 kPa

Symbol	Term	Density Index %	SPT “N” #
VL	Very Loose	Less than 15	0 to 4
L	Loose	15 to 35	4 to 10
MD	Medium Dense	35 to 65	10 to 30
D	Dense	65 to 85	30 to 50
VD	Very Dense	Above 85	Above 50

In the absence of test results, consistency and density may be assessed from correlations with the observed behaviour of the material.
SPT correlations are not stated in AS1726 – 1993, and may be subject to corrections for overburden pressure and equipment type.

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT REPORTS

Golder Associates

DRILLING/EXCAVATION METHOD

AS*	Auger Screwing	RD	Rotary blade or drag bit	NQ	Diamond Core - 47 mm
AD*	Auger Drilling	RT	Rotary Tricone bit	NMLC	Diamond Core - 52 mm
*V	V-Bit	RAB	Rotary Air Blast	HQ	Diamond Core - 63 mm
*T	TC-Bit, e.g. ADT	RC	Reverse Circulation	HMLC	Diamond Core – 63mm
HA	Hand Auger	PT	Push Tube	BH	Tractor Mounted Backhoe
ADH	Hollow Auger	CT	Cable Tool Rig	EX	Tracked Hydraulic Excavator
DTC	Diatube Coring	JET	Jetting	EE	Existing Excavation
WB	Washbore or Bailer	NDD	Non-destructive digging	HAND	Excavated by Hand Methods

PENETRATION/EXCAVATION RESISTANCE

L **Low resistance.** Rapid penetration possible with little effort from the equipment used.

M **Medium resistance.** Excavation/possible at an acceptable rate with moderate effort from the equipment used.

H **High resistance** to penetration/excavation. Further penetration is possible at a slow rate and requires significant effort from the equipment.

R **Refusal or Practical Refusal.** No further progress possible without the risk of damage or unacceptable wear to the digging implement or machine.

These assessments are subjective and are dependent on many factors including the equipment power, weight, condition of excavation or drilling tools, and the experience of the operator.

WATER

▽	Water level at date shown	◁	Partial water loss
▷	Water inflow	◀	Complete water loss

GROUNDWATER NOT OBSERVED — The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

GROUNDWATER NOT ENCOUNTERED — The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11 N=18	4,7,11 = Blows per 150mm. N = Blows per 300mm penetration following 150mm seating
30/80mm	Where practical refusal occurs, the blows and penetration for that interval are reported
RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB	Hammer double bouncing on anvil
DS	Disturbed sample
BDS	Bulk disturbed sample
G	Gas Sample
W	Water Sample
FP	Field permeability test over section noted
FV	Field vane shear test expressed as uncorrected shear strength (s_v = peak value, s_r = residual value)
PID	Photoionisation Detector reading in ppm
PM	Pressuremeter test over section noted
PP	Pocket penetrometer test expressed as instrument reading in kPa
U63	Thin walled tube sample - number indicates nominal sample diameter in millimetres
WPT	Water pressure tests
DCP	Dynamic cone penetration test
CPT	Static cone penetration test
CPTu	Static cone penetration test with pore pressure (u) measurement

Ranking of Visually Observable Contamination and Odour (for specific soil contamination assessment projects)

R = 0	No visible evidence of contamination	R = A	No non-natural odours identified
R = 1	Slight evidence of visible contamination	R = B	Slight non-natural odours identified
R = 2	Visible contamination	R = C	Moderate non-natural odours identified
R = 3	Significant visible contamination	R = D	Strong non-natural odours identified

ROCK CORE RECOVERY

TCR = Total Core Recovery (%)

$$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100$$

SCR = Solid Core Recovery (%)

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum \text{Axial lengths of core} > 100\text{ mm}}{\text{Length of core run}} \times 100$$

TERMS FOR ROCK MATERIAL STRENGTH & WEATHERING AND ABBREVIATIONS FOR DEFECT DESCRIPTIONS

STRENGTH

Symbol	Term	Point Load Index, $Is_{(50)}$ (MPa)	Field Guide
EL	Extremely Low	< 0.03	Easily remoulded by hand to a material with soil properties.
VL	Very Low	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30 mm can be broken by finger pressure.
L	Low	0.1 to 0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
M	Medium	0.3 to 1	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
H	High	1 to 3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow; rock rings under hammer.
VH	Very High	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
EH	Extremely High	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

ROCK STRENGTH TEST RESULTS

u	Point Load Strength Index, $I_s(50)$, Axial test (MPa)
w	Point Load Strength Index, $I_s(50)$, Diametral test (MPa)

Relationship between $I_s(50)$ and UCS (unconfined compressive strength) will vary with rock type and strength, and should be determined on a site-specific basis. UCS is typically 10 to 30 x $I_s(50)$, but can be as low as 5.

ROCK MATERIAL WEATHERING

Symbol		Term	Field Guide
RS		Residual Soil	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
EW		Extremely Weathered	Rock is weathered to such an extent that it has soil properties - i.e. it either disintegrates or can be remoulded, in water.
DW	HW	Distinctly Weathered	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores. In some environments it is convenient to subdivide into Highly Weathered and Moderately Weathered, with the degree of alteration typically less for MW.
	MW		
SW		Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength relative to fresh rock.
FR		Fresh	Rock shows no sign of decomposition or staining.

ABBREVIATIONS FOR DEFECT TYPES AND DESCRIPTIONS

Defect Type

B	Bedding parting
X	Foliation
C	Contact
L	Cleavage
J	Joint
SS/SZ	Sheared seam/zone (Fault)
CS/CZ	Crushed seam/zone (Fault)
DS/DZ	Decomposed seam/zone
IS/IZ	Infilled seam/zone
S	Schistocity
V	Vein

Coating or Infilling

Cn	Clean
Sn	Stain
Vr	Veneer
Ct	Coating or Infill

Planarity

Pl	Planar
Un	Undulating
St	Stepped

Roughness

Sl	Slickensided
Sm	Smooth
Ro	Rough

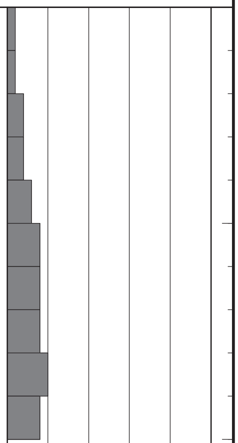
Vertical Boreholes – The dip (inclination from horizontal) of the defect is given.
Inclined Boreholes – The inclination is measured as the acute angle to the core axis.

REPORT OF TEST PIT: TP01

SHEET: 1 OF 1

CLIENT: Rowe Group	COORDS: 405865 m E 6455491 m N MGA94 50	MACHINE: Backhoe	
PROJECT: 558 Bickley Road		CONTRACTOR: Nick Cornwell	
LOCATION: Maddington	PIT DEPTH: 3.00 m	LOGGED: DW	DATE: 12/5/14
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	CHECKED: JMT	DATE: 16/5/14

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm 0 5 10 15 20 25
EX	L		0.0	0.20				SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace rootlets	D - M	L		
				0.60				SP	SAND fine to medium grained, grey, trace silt		MD		
	M		0.5 – 1.5	1.70				SC	Clayey SAND fine to coarse grained, pale brown and orange/brown, approximately 15% - 25% medium plasticity clay	M	D		
			2.0 – 2.5						pale grey and orange/brown				
			3.0						TEST PIT DISCONTINUED @ 3.00 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED				
			3.5										



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REPORT OF TEST PIT PHOTOGRAPHS: TP01

CLIENT: Rowe Group	COORDS: 405865 m E 6455491 m N MGA94 50	SHEET: 1 OF 1
PROJECT: 558 Bickley Road		MACHINE: Backhoe
LOCATION: Maddington	PIT DEPTH: 3.00 m	CONTRACTOR: Nick Cornwell
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	LOGGED: DW DATE: 12/5/14
		CHECKED: JMT DATE: 16/5/14

1. Test Pit

2. Spoil

This report of test pit photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

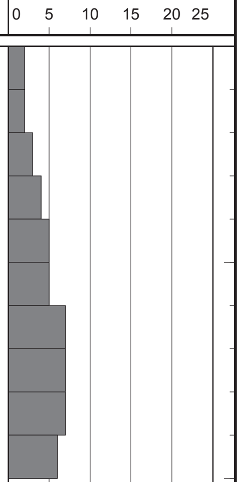
REPORT OF TEST PIT: TP02

Golder Associates

CLIENT: Rowe Group	COORDS: 405856 m E 6455442 m N MGA94 50	SHEET: 1 OF 1	
PROJECT: 558 Bickley Road		MACHINE: Backhoe	
		CONTRACTOR: Nick Cornwell	
LOCATION: Maddington	PIT DEPTH: 3.00 m	LOGGED: DW	DATE: 12/5/14
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	CHECKED: JMT	DATE: 16/5/14

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
EX	L		0.0					SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace rootlets	M	MD	
				0.15				SP	SAND fine to medium grained, grey		D	
				0.80					with some medium plasticity clay			
	M			1.10				SC	Clayey SAND fine to coarse grained, grey and brown, approximately 20% - 30% medium plasticity clay			
				2.30					pale grey and brown, approximately 12% - 20% low plasticity clay	W		
			2.5		DS 2.5-2.7 m							
			3.0						TEST PIT DISCONTINUED @ 3.00 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED			
			3.5									

DCP TEST
(AS1289.6.3.2)
Blows per 100 mm



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GAP gINT FN. F01i
RL3

REPORT OF TEST PIT PHOTOGRAPHS: TP02

SHEET: 1 OF 1

CLIENT:	Rowe Group	COORDS: 405856 m E 6455442 m N MGA94 50	MACHINE: Backhoe		
PROJECT:	558 Bickley Road		CONTRACTOR: Nick Cornwell		
LOCATION:	Maddington	PIT DEPTH: 3.00 m	LOGGED: DW	DATE: 12/5/14	
JOB NO:	147642074	BUCKET TYPE: 600 mm toothed	CHECKED: JMT	DATE: 16/5/14	

1. Test Pit

2. Spoil

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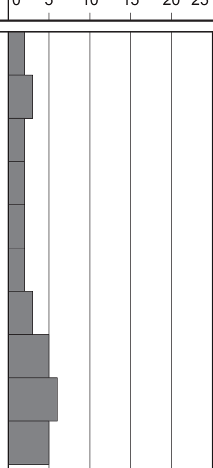
REPORT OF TEST PIT: TP03

SHEET: 1 OF 1

CLIENT: Rowe Group	COORDS: 405862 m E 6455384 m N MGA94 50	MACHINE: Backhoe	
PROJECT: 558 Bickley Road		CONTRACTOR: Nick Cornwell	
LOCATION: Maddington	PIT DEPTH: 3.00 m	LOGGED: DW	DATE: 12/5/14
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	CHECKED: JMT	DATE: 16/5/14

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
EX	M		0.0	0.05				SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace rootlets	M	MD	
								SC	Clayey SAND fine to coarse grained, grey and brown, approximately 25% - 35% medium plasticity clay			
			0.5		DS 0.6-0.8 m							
			1.0	1.20					fine to medium grained, pale grey and brown		D	
			1.5									
	H		2.0									
			2.5									
			3.0						TEST PIT DISCONTINUED @ 3.00 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED			
			3.5									

DCP TEST (AS1289.6.3.2) Blows per 100 mm



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GAP gINT FN. F01i RL3

GAP 8_08.04 LIB.GLB Log GAP NON-CORED FULL PAGE 147642074 558 BICKLEY.GPJ <<DrawingFile>> 16/05/2014 12:05 8.30.003 Datgel Tools

REPORT OF TEST PIT PHOTOGRAPHS: TP03

Golder Associates

CLIENT: Rowe Group	COORDS: 405862 m E 6455384 m N MGA94 50	SHEET: 1 OF 1	
PROJECT: 558 Bickley Road		MACHINE: Backhoe	
LOCATION: Maddington	PIT DEPTH: 3.00 m	CONTRACTOR: Nick Cornwell	
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	LOGGED: DW	DATE: 12/5/14
		CHECKED: JMT	DATE: 16/5/14

1. Test Pit

2. Spoil

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REPORT OF TEST PIT: TP04

SHEET: 1 OF 1

CLIENT: Rowe Group	COORDS: 405872 m E 6455404 m N MGA94 50	MACHINE: Backhoe	
PROJECT: 558 Bickley Road		CONTRACTOR: Nick Cornwell	
LOCATION: Maddington	PIT DEPTH: 1.50 m	LOGGED: DW	DATE: 12/5/14
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	CHECKED: JMT	DATE: 16/5/14

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm (0 5 10 15 20 25)
EX	L		0.0					SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace rootlets	M	MD		
EX	L			0.20				SP	SAND fine to medium grained, grey, trace silt	M	MD		
EX	M		0.5	0.60				SC	Clayey SAND fine to coarse grained, grey and brown, approximately 20% - 30% medium plasticity clay	M	MD - D		
			1.5						TEST PIT DISCONTINUED @ 1.50 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED				

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

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GAP gINT FN. F01i
RL3

REPORT OF TEST PIT PHOTOGRAPHS: TP04

CLIENT: Rowe Group	COORDS: 405872 m E 6455404 m N MGA94 50	SHEET: 1 OF 1
PROJECT: 558 Bickley Road		MACHINE: Backhoe
LOCATION: Maddington	PIT DEPTH: 1.50 m	CONTRACTOR: Nick Cornwell
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	LOGGED: DW DATE: 12/5/14
		CHECKED: JMT DATE: 16/5/14

1. Test Pit

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REPORT OF TEST PIT: TP05

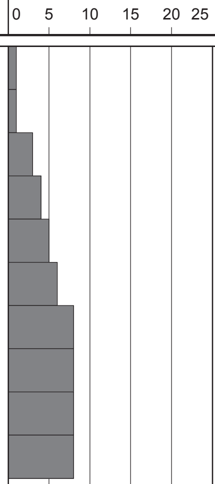
Golder Associates

CLIENT: Rowe Group	COORDS: 405893 m E 6455470 m N MGA94 50	SHEET: 1 OF 1	
PROJECT: 558 Bickley Road		MACHINE: Backhoe	
		CONTRACTOR: Nick Cornwell	
LOCATION: Maddington	PIT DEPTH: 1.50 m	LOGGED: DW	DATE: 12/5/14
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	CHECKED: JMT	DATE: 16/5/14

METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
EX	L		0.0	0.15				SP	FILL: SAND fine to coarse grained, grey, trace fine to medium gravel	M	L	
				0.35				SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace roots and rootlets		MD	
			0.5 – 1.5					SP	SAND fine to medium grained, pale brown, trace fines			
			1.5						TEST PIT DISCONTINUED @ 1.50 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED			

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

DCP TEST (AS1289.6.3.2) Blows per 100 mm



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REPORT OF TEST PIT PHOTOGRAPHS: TP05

				SHEET: 1 OF 1	
CLIENT:	Rowe Group	COORDS: 405893 m E 6455470 m N MGA94 50		MACHINE: Backhoe	
PROJECT:	558 Bickley Road			CONTRACTOR: Nick Cornwell	
LOCATION:	Maddington	PIT DEPTH: 1.50 m		LOGGED: DW	DATE: 12/5/14
JOB NO:	147642074	BUCKET TYPE: 600 mm toothed		CHECKED: JMT	DATE: 16/5/14

1. Test Pit

2. Spoil

This report of test pit photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

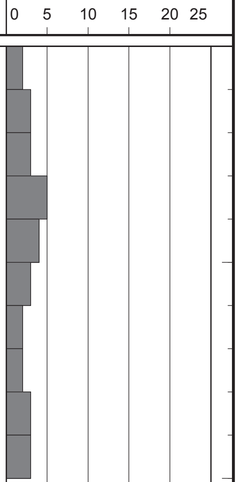
REPORT OF TEST PIT: TP06

Golder Associates

CLIENT: Rowe Group	COORDS: 405807 m E 6455424 m N MGA94 50	SHEET: 1 OF 1	
PROJECT: 558 Bickley Road		MACHINE: Backhoe	
LOCATION: Maddington	PIT DEPTH: 1.50 m	CONTRACTOR: Nick Cornwell	
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	LOGGED: DW	DATE: 12/5/14
		CHECKED: JMT	DATE: 16/5/14

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
EX	L		0.0	0.10				SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace rootlets	M		
EX	L			0.80				SP	SAND fine to coarse grained, grey, trace fines	D - M	MD	
EX	M-H			1.20				CH	Sandy CLAY high plasticity, grey and brown, approximately 30% - 40% fine to coarse grained sand	D - M	St	
EX	M-H		1.5		DS 1.2-1.4 m			SC	Clayey SAND fine to coarse grained, pale grey and brown, approximately 25% - 35% medium plasticity clay, trace fine to medium gravel	D - M	D	
									TEST PIT DISCONTINUED @ 1.50 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED			

DCP TEST (AS1289.6.3.2) Blows per 100 mm



Depth scale (metres): 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

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REPORT OF TEST PIT PHOTOGRAPHS: TP06

CLIENT: Rowe Group	COORDS: 405807 m E 6455424 m N MGA94 50	SHEET: 1 OF 1
PROJECT: 558 Bickley Road		MACHINE: Backhoe
LOCATION: Maddington		CONTRACTOR: Nick Cornwell
	PIT DEPTH: 1.50 m	LOGGED: DW DATE: 12/5/14
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	CHECKED: JMT DATE: 16/5/14

1. Test Pit

2. Spoil

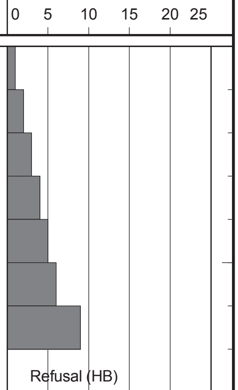
This report of test pit photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

REPORT OF TEST PIT: TP07

Golder Associates

CLIENT: Rowe Group	COORDS: 405905 m E 6455406 m N MGA94 50	SHEET: 1 OF 1	
PROJECT: 558 Bickley Road		MACHINE: Backhoe	
		CONTRACTOR: Nick Cornwell	
LOCATION: Maddington	PIT DEPTH: 1.50 m	LOGGED: DW	DATE: 12/5/14
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	CHECKED: JMT	DATE: 16/5/14

Excavation: METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	Sampling: SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
EX	L		0.0					SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace rootlets	M	L - MD		
EX	L			0.30				SP	SAND fine to medium grained, grey	M			Refusal (HB)
EX	M-H		1.0	0.80	DS 1.0-1.2 m			SC	Clayey SAND fine to medium grained, pale grey, approximately 15% - 25% medium plasticity clay	M	D		
			1.5						TEST PIT DISCONTINUED @ 1.50 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED				



Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

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REPORT OF TEST PIT PHOTOGRAPHS: TP07

		SHEET: 1 OF 1
CLIENT: Rowe Group	COORDS: 405905 m E 6455406 m N MGA94 50	MACHINE: Backhoe
PROJECT: 558 Bickley Road		CONTRACTOR: Nick Cornwell
LOCATION: Maddington	PIT DEPTH: 1.50 m	LOGGED: DW DATE: 12/5/14
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	CHECKED: JMT DATE: 16/5/14

1. Test Pit

2. Spoil

This report of test pit photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

REPORT OF TEST PIT: TP08

SHEET: 1 OF 1

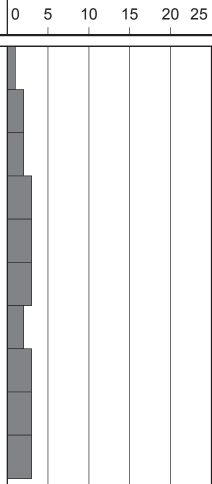
CLIENT: Rowe Group
PROJECT: 558 Bickley Road
LOCATION: Maddington
JOB NO: 147642074

COORDS: 405770 m E 6455379 m N MGA94 50
PIT DEPTH: 1.50 m
BUCKET TYPE: 600 mm toothed

MACHINE: Backhoe
CONTRACTOR: Nick Cornwell
LOGGED: DW DATE: 12/5/14
CHECKED: JMT DATE: 16/5/14

Excavation: METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	Sampling: SAMPLE OR FIELD TEST	RECOVERED	Field Material Description: GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
EX	L		0.0					SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace rootlets	M	L - MD	
				0.25				SP	SAND fine to coarse grained, grey, trace fines		MD	
	M-H		0.5	0.60				CH	Sandy CLAY high plasticity, grey and brown, approximately 30% - 40% fine to coarse grained sand		F - St	
			1.0	1.40				SC	Clayey SAND fine to coarse grained, pale grey and brown, approximately 15% - 25% medium plasticity clay		D	
			1.5						TEST PIT DISCONTINUED @ 1.50 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED			
			2.0									
			2.5									
			3.0									
			3.5									

DCP TEST (AS1289.6.3.2) Blows per 100 mm



This report of test pit must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

REPORT OF TEST PIT PHOTOGRAPHS: TP08

CLIENT: Rowe Group	COORDS: 405770 m E 6455379 m N MGA94 50	SHEET: 1 OF 1	
PROJECT: 558 Bickley Road		MACHINE: Backhoe	
LOCATION: Maddington	PIT DEPTH: 1.50 m	CONTRACTOR: Nick Cornwell	
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	LOGGED: DW	DATE: 12/5/14
		CHECKED: JMT	DATE: 16/5/14

1. Test Pit

2. Spoil

This report of test pit photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

REPORT OF TEST PIT: TP09

CLIENT: Rowe Group		SHEET: 1 OF 1	
PROJECT: 558 Bickley Road	COORDS: 405782 m E 6455354 m N MGA94 50	MACHINE: Backhoe	
LOCATION: Maddington		CONTRACTOR: Nick Cornwell	
JOB NO: 147642074	PIT DEPTH: 1.50 m	LOGGED: DW	DATE: 12/5/14
	BUCKET TYPE: 600 mm toothed	CHECKED: JMT	DATE: 16/5/14

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm (0 5 10 15 20 25)
EX	L		0.0					SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace rootlets	M	MD		
EX	L			*0.20*				SP	SAND fine to coarse grained, pale brown, trace fines	M	MD		
EX	M-H		0.5 – 1.0	*0.70*	DS 1.0-1.2 m			CH	Sandy CLAY high plasticity, grey and brown, approximately 30% - 40% fine to coarse grained sand	M	St	water infiltration at 0.7 m. Inferred perched water	
			1.5						TEST PIT DISCONTINUED @ 1.50 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED				

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

This report of test pit must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01i RL3

GAP 8_08.04 LIB.GLB Log GAP NON-CORED FULL PAGE 147642074 558 BICKLEY.GPJ <<DrawingFile>> 16/05/2014 12:08 8.30.003 Datgel Tools

REPORT OF TEST PIT PHOTOGRAPHS: TP09

CLIENT: Rowe Group	COORDS: 405782 m E 6455354 m N MGA94 50	SHEET: 1 OF 1
PROJECT: 558 Bickley Road		MACHINE: Backhoe
LOCATION: Maddington	PIT DEPTH: 1.50 m	CONTRACTOR: Nick Cornwell
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	LOGGED: DW DATE: 12/5/14
		CHECKED: JMT DATE: 16/5/14

1. Test Pit

2. Spoil

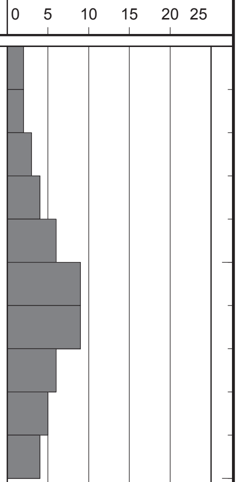
This report of test pit photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

REPORT OF TEST PIT: TP10

CLIENT: Rowe Group	COORDS: 405853 m E 6455351 m N MGA94 50	SHEET: 1 OF 1	
PROJECT: 558 Bickley Road		MACHINE: Backhoe	
LOCATION: Maddington	PIT DEPTH: 1.50 m	CONTRACTOR: Nick Cornwell	
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	LOGGED: DW	DATE: 12/5/14
		CHECKED: JMT	DATE: 16/5/14

Excavation: METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	Sampling: SAMPLE OR FIELD TEST	RECOVERED	Field Material Description: GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
EX	L		0.0					SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace rootlets	M	MD		
EX	L			0.15				SP	SAND fine to medium grained, grey and pale brown, trace silt	M	MD / D		
EX	H			0.80				SC	Clayey SAND fine to coarse grained, brown and grey, approximately 25% - 35% medium to high plasticity clay, clay content increasing with depth	M	D		
			1.5						TEST PIT DISCONTINUED @ 1.50 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED				

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5



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GAP gINT FN. F01i RL3

REPORT OF TEST PIT PHOTOGRAPHS: TP10

CLIENT: Rowe Group	COORDS: 405853 m E 6455351 m N MGA94 50	SHEET: 1 OF 1	
PROJECT: 558 Bickley Road		MACHINE: Backhoe	
LOCATION: Maddington	PIT DEPTH: 1.50 m	CONTRACTOR: Nick Cornwell	
JOB NO: 147642074	BUCKET TYPE: 600 mm toothed	LOGGED: DW	DATE: 12/5/14
		CHECKED: JMT	DATE: 16/5/14

1. Test Pit

2. Spoil

This report of test pit photographs must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

APPENDIX B

Hand Auger Reports

METHOD OF SOIL DESCRIPTION
USED ON BOREHOLE AND TEST PIT REPORTS

FILL

GRAVEL (GP or GW)

SAND (SP or SW)

SILT (ML or MH)

CLAY (CL, CI or CH)

ORGANIC SOILS (OL or OH or Pt)

COBBLES or BOULDERS

Combinations of these basic symbols may be used to indicate mixed materials such as sandy clay.

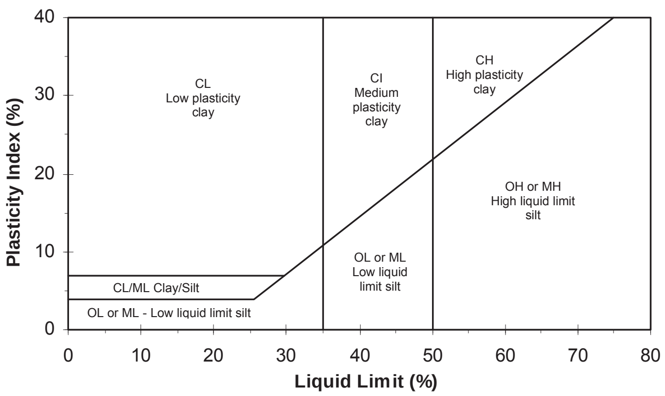
CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil and Rock is classified and described in Reports of Boreholes and Test Pits using the preferred method given in AS1726 – 1993, (Amdt1 – 1994 and Amdt2 – 1994), Appendix A. The material properties are assessed in the field by visual/tactile methods.

Particle Size

Major Division	Sub Division	Particle Size
BOULDERS		> 200 mm
COBBLES		63 to 200 mm
GRAVEL	Coarse	20 to 63 mm
	Medium	6.0 to 20 mm
	Fine	2.0 to 6.0 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties



MOISTURE CONDITION

AS1726 - 1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays & Silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition & may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726 - 1993

Symbol	Term	Undrained Shear Strength
VS	Very Soft	0 to 12 kPa
S	Soft	12 to 25 kPa
F	Firm	25 to 50 kPa
St	Stiff	50 to 100 kPa
VSt	Very Stiff	100 to 200 kPa
H	Hard	Above 200 kPa

Symbol	Term	Density Index %	SPT “N” #
VL	Very Loose	Less than 15	0 to 4
L	Loose	15 to 35	4 to 10
MD	Medium Dense	35 to 65	10 to 30
D	Dense	65 to 85	30 to 50
VD	Very Dense	Above 85	Above 50

In the absence of test results, consistency and density may be assessed from correlations with the observed behaviour of the material.
SPT correlations are not stated in AS1726 – 1993, and may be subject to corrections for overburden pressure and equipment type.

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT REPORTS

Golder Associates

DRILLING/EXCAVATION METHOD

AS*	Auger Screwing	RD	Rotary blade or drag bit	NQ	Diamond Core - 47 mm
AD*	Auger Drilling	RT	Rotary Tricone bit	NMLC	Diamond Core - 52 mm
*V	V-Bit	RAB	Rotary Air Blast	HQ	Diamond Core - 63 mm
*T	TC-Bit, e.g. ADT	RC	Reverse Circulation	HMLC	Diamond Core – 63mm
HA	Hand Auger	PT	Push Tube	BH	Tractor Mounted Backhoe
ADH	Hollow Auger	CT	Cable Tool Rig	EX	Tracked Hydraulic Excavator
DTC	Diatube Coring	JET	Jetting	EE	Existing Excavation
WB	Washbore or Bailer	NDD	Non-destructive digging	HAND	Excavated by Hand Methods

PENETRATION/EXCAVATION RESISTANCE

L **Low resistance.** Rapid penetration possible with little effort from the equipment used.

M **Medium resistance.** Excavation/possible at an acceptable rate with moderate effort from the equipment used.

H **High resistance** to penetration/excavation. Further penetration is possible at a slow rate and requires significant effort from the equipment.

R **Refusal or Practical Refusal.** No further progress possible without the risk of damage or unacceptable wear to the digging implement or machine.

These assessments are subjective and are dependent on many factors including the equipment power, weight, condition of excavation or drilling tools, and the experience of the operator.

WATER

▽	Water level at date shown	◁	Partial water loss
▷	Water inflow	◀	Complete water loss

GROUNDWATER NOT OBSERVED — The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

GROUNDWATER NOT ENCOUNTERED — The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11 N=18	4,7,11 = Blows per 150mm. N = Blows per 300mm penetration following 150mm seating
30/80mm	Where practical refusal occurs, the blows and penetration for that interval are reported
RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB	Hammer double bouncing on anvil
DS	Disturbed sample
BDS	Bulk disturbed sample
G	Gas Sample
W	Water Sample
FP	Field permeability test over section noted
FV	Field vane shear test expressed as uncorrected shear strength (s_v = peak value, s_r = residual value)
PID	Photoionisation Detector reading in ppm
PM	Pressuremeter test over section noted
PP	Pocket penetrometer test expressed as instrument reading in kPa
U63	Thin walled tube sample - number indicates nominal sample diameter in millimetres
WPT	Water pressure tests
DCP	Dynamic cone penetration test
CPT	Static cone penetration test
CPTu	Static cone penetration test with pore pressure (u) measurement

Ranking of Visually Observable Contamination and Odour (for specific soil contamination assessment projects)

R = 0	No visible evidence of contamination	R = A	No non-natural odours identified
R = 1	Slight evidence of visible contamination	R = B	Slight non-natural odours identified
R = 2	Visible contamination	R = C	Moderate non-natural odours identified
R = 3	Significant visible contamination	R = D	Strong non-natural odours identified

ROCK CORE RECOVERY

TCR = Total Core Recovery (%)

$$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100$$

SCR = Solid Core Recovery (%)

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum \text{Axial lengths of core} > 100\text{ mm}}{\text{Length of core run}} \times 100$$

Golder Associates

TERMS FOR ROCK MATERIAL STRENGTH & WEATHERING AND ABBREVIATIONS FOR DEFECT DESCRIPTIONS

STRENGTH

Symbol	Term	Point Load Index, $Is_{(50)}$ (MPa)	Field Guide
EL	Extremely Low	< 0.03	Easily remoulded by hand to a material with soil properties.
VL	Very Low	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30 mm can be broken by finger pressure.
L	Low	0.1 to 0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
M	Medium	0.3 to 1	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
H	High	1 to 3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow; rock rings under hammer.
VH	Very High	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
EH	Extremely High	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

ROCK STRENGTH TEST RESULTS

u	Point Load Strength Index, $I_s(50)$, Axial test (MPa)
w	Point Load Strength Index, $I_s(50)$, Diametral test (MPa)

Relationship between $I_s(50)$ and UCS (unconfined compressive strength) will vary with rock type and strength, and should be determined on a site-specific basis. UCS is typically 10 to 30 x $I_s(50)$, but can be as low as 5.

ROCK MATERIAL WEATHERING

Symbol		Term	Field Guide
RS		Residual Soil	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
EW		Extremely Weathered	Rock is weathered to such an extent that it has soil properties - i.e. it either disintegrates or can be remoulded, in water.
DW	HW	Distinctly Weathered	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores. In some environments it is convenient to subdivide into Highly Weathered and Moderately Weathered, with the degree of alteration typically less for MW.
	MW		
SW		Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength relative to fresh rock.
FR		Fresh	Rock shows no sign of decomposition or staining.

ABBREVIATIONS FOR DEFECT TYPES AND DESCRIPTIONS

Defect Type

B	Bedding parting
X	Foliation
C	Contact
L	Cleavage
J	Joint
SS/SZ	Sheared seam/zone (Fault)
CS/CZ	Crushed seam/zone (Fault)
DS/DZ	Decomposed seam/zone
IS/IZ	Infilled seam/zone
S	Schistocity
V	Vein

Coating or Infilling

Cn	Clean
Sn	Stain
Vr	Veneer
Ct	Coating or Infill

Planarity

Pl	Planar
Un	Undulating
St	Stepped

Roughness

Sl	Slickensided
Sm	Smooth
Ro	Rough

Vertical Boreholes – The dip (inclination from horizontal) of the defect is given.
Inclined Boreholes – The inclination is measured as the acute angle to the core axis.

REPORT OF HAND AUGERED BOREHOLE: HA1

Golder Associates

SHEET: 1 OF 1

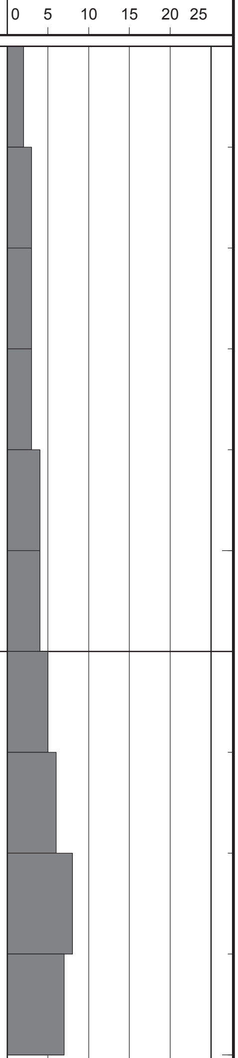
CLIENT: Rowe Group
PROJECT: 558 Bickley Road
LOCATION: Maddington
JOB NO: 147642074

COORDS: 405863 m E 6455364 m N MGA94 50
INCLINATION: -90°
HOLE DEPTH: 0.60 m

LOGGED: DW — DATE: 12/5/14
CHECKED: JMT — DATE: 16/5/14

METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	L		0.0					SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace rootlets	D - M	MD	
HA	M-H			0.10				SC	Clayey SAND fine to coarse grained, orange brown, approximately 20% - 30% medium plasticity clay	D - M	MD, D	
			0.5									
									END OF HAND AUGER @ 0.60 m REFUSAL GROUNDWATER NOT ENCOUNTERED BACKFILLED			
			1.0									
			1.5									

DCP TEST (AS1289.6.3.2) Blows per 100 mm



This report of hand augered borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

REPORT OF HAND AUGERED BOREHOLE: HA2

Golder Associates

SHEET: 1 OF 1

CLIENT: Rowe Group
PROJECT: 558 Bickley Road
LOCATION: Maddington
JOB NO: 147642074

COORDS: 405880 m E 6455445 m N MGA94 50
INCLINATION: -90°
HOLE DEPTH: 1.00 m

LOGGED: DW — DATE: 12/5/14
CHECKED: JMT — DATE: 16/5/14

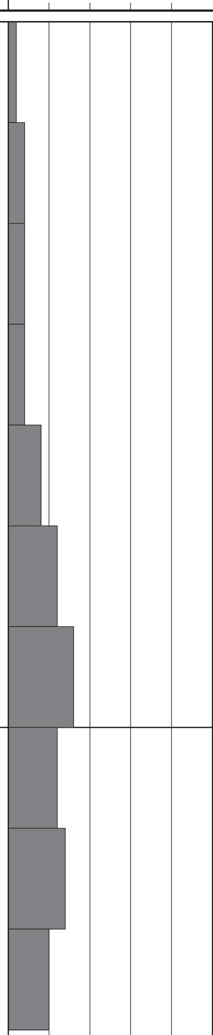
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
HA	L		0.0					SP	TOPSOIL: SAND fine to coarse grained, dark grey, trace silt, trace rootlets	M	L		
				0.20				SP	SAND fine to medium grained, grey		MD		
			0.5										
											D		
			1.0						END OF HAND AUGER @ 1.00 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED				
			1.5										

This report of hand augered borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

REPORT OF HAND AUGERED BOREHOLE: HA3

CLIENT: Rowe Group			
PROJECT: 558 Bickley Road	COORDS: 405788 m E 6455394 m N MGA94 50		
LOCATION: Maddington	INCLINATION: -90°	LOGGED: DW	DATE: 12/5/14
JOB NO: 147642074	HOLE DEPTH: 0.70 m	CHECKED: JMT	DATE: 16/5/14

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
HA	L		0.0					SP	SAND fine to coarse grained, dark grey, trace silt, trace rootlets	D - M	L		
HA	M-H			0.20				CH	Sandy CLAY high plasticity, grey and brown, approximately 30% - 40% fine to coarse grained sand	D - M	F St - VSt		
HA	M-H		0.5	0.55				SC	Clayey SAND fine to coarse grained, grey and orange brown, approximately 20% - 30% medium plasticity clay	D - M	D		
			1.0 1.5						END OF HAND AUGER @ 0.70 m REFUSAL GROUNDWATER NOT ENCOUNTERED BACKFILLED				



This report of hand augered borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

APPENDIX C

Laboratory Certificates

Appendix E – Factual Investigation Logs from Douglas Partners Report (2015)

Appendix B

Results of Field Work

TEST PIT LOG

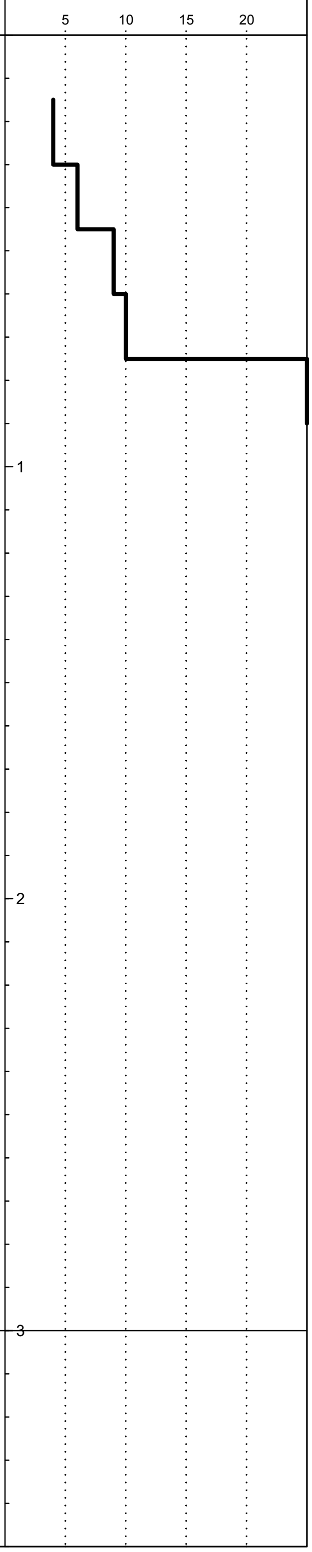
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 19.9 m AHD*
EASTING:
NORTHING:

PIT No: TP1
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		FILLING (SAND) - very dense, red-brown, fine to medium grained, silty gravelly, slight silty sand, dry.		D	0.1			
	0.15	SAND - dense, grey, fine to medium grained sand with a trace of silt, dry. Roots observed to 0.35 m depth.						
19	1							
		- becoming light brown mottled red-brown and orange brown, dry to moist, slightly clayey sand from 1.2 m depth.						
				D	1.8			
18	2 2.0	CLAYEY SAND - firm to stiff, light grey mottled red-brown and orange brown, fine to medium grained clayey sand with some medium to coarse laterite gravel and cobbles, dry to moist.						
17								
	3 3.0	Pit discontinued at 3.0m (target)		E	3.0	1		

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

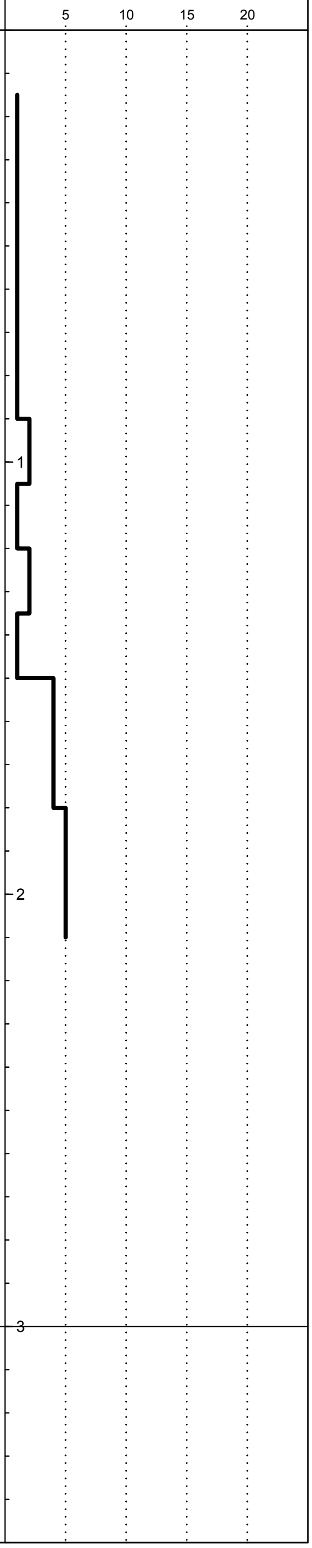
SURFACE LEVEL: 19.4 m AHD*
EASTING:
NORTHING:

PIT No: TP2
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL (SAND) - grey, fine to medium grained sandy topsoil, with some silt and rootlets, dry.		D	0.1			
	0.15	SAND - loose, light grey-white fine to medium grained sand with a trace of silt, dry. Roots observed to 0.4 m depth.						
		- becoming moist and medium dense from 1.8 m depth.						
	3.0	Pit discontinued at 3.0m (target)		E	3.0	2		

RL scale: 19, 18, 17, 16. Depth scale: 1, 2, 3.

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

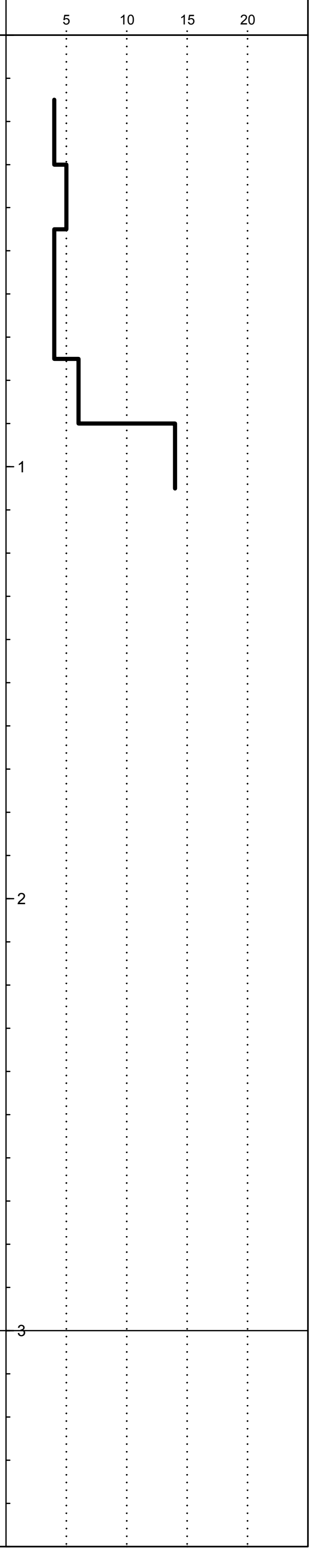
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 17.4 m AHD*
EASTING:
NORTHING:

PIT No: TP3
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL (SAND) - brown, fine to medium grained sandy topsoil, with some silt and rootlets, dry.						
	0.1	SAND - medium dense, light grey-white fine to medium grained sand with a trace of silt, dry.		D	0.1			
17								
		- becoming slightly clayey from 0.6 m depth.						
	0.7	CLAY - stiff, blue-green mottled brown slightly sandy clay, dry to moist, low to medium plasticity. Sand is fine grained.			0.75		PP = 200 kPa	
					0.95		PP = 200 kPa	
	1			U				
	1.2	CLAYEY SAND - very stiff, light blue-grey, fine to medium grained clayey sand, moist.			1.3		PP = 350 kPa	
					1.35			
16								
	1.7	SAND - light blue-grey, fine to medium grained sand with some clay, moist.						
	2							
15								
		- becoming light brown and with a trace of clay from 2.7 m depth.						
	3	3.0 Pit discontinued at 3.0m (target)		E	3.0	3		
14								

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 16.8 m AHD*
EASTING:
NORTHING:

PIT No: TP4
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL (SAND) - dark grey, fine to medium grained sandy topsoil, with some silt and rootlets, dry.							
	0.1	SAND - dense, grey, fine to medium grained sand with a trace of silt, dry.		D	0.1				
	0.4	GRAVELLY SANDY CLAY - very stiff, orange-brown mottled light grey, gravelly sandy clay, dry, high plasticity. Fine to coarse grained sand. Fine to coarse sized gravel. Slow digging. - becoming hard from 0.5 m depth.			0.5		PP >600 kPa		
16				D	0.8				
	1 1.0	Pit discontinued at 1.0m (very slow digging)		E	1.0	4			
15	2								
14	3								

RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

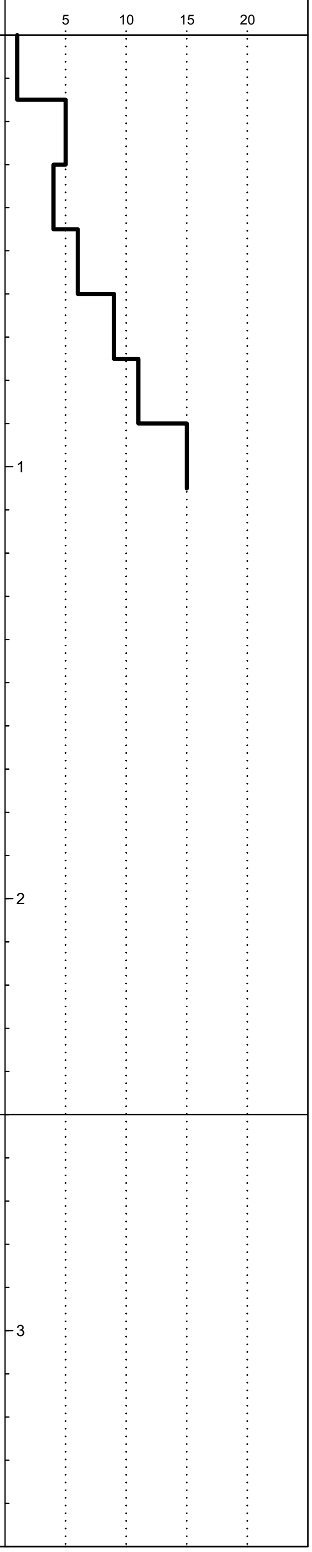
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 19.9 m AHD*
EASTING:
NORTHING:

PIT No: TP5
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		SAND - medium dense, grey, fine to medium grained sand with a trace of silt, dry.		D	0.1			
		- becoming dry to moist, brown, fine to coarse grained sand with a trace of clay from 0.3 m depth.						
		- becoming orange-brown mottled light grey, slightly clayey sand with som fine to medium sized laterite gravel, medium plasticity from 0.5 m depth.						
19	1							
		- becoming dry, light grey, fine to medium grained sand with some silt from 1.2 m depth. Slow digging.						
18	2							
		- becoming dry to moist, light grey mottled brown, fine to medium grained sand with some clay from 2.0 m depth.						
	2.5	Pit discontinued at 2.5m (very slow digging)		E	2.5	5		
17	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

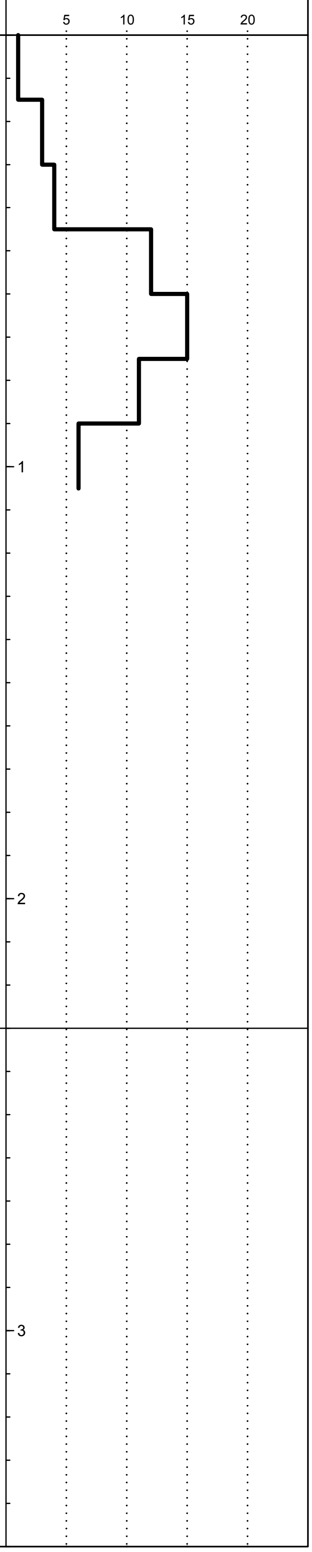
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 20.0 m AHD*
EASTING:
NORTHING:

PIT No: TP6
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
20		SAND - medium dense, light grey, fine to medium dense sand with a trace of silt, dry.	D	0.1			
		- becoming light brown, fine to coarse grained sand from 0.3 m depth.					
		- becoming moist, light brown, fine to coarse grained, slightly gravelly sand with a trace of clay from 0.6 m depth. Gravel is fine to coarse sized laterite.					
19	1 — 1.0	CLAYEY SAND - very stiff, light brown, fine to coarse grained clayey sand with some gravel, moist, medium to high plasticity. Gravel is fine to coarse sized laterite. Slow digging.	D	1.4			
18	2	- becoming hard and light grey from 2.0 m depth.					
	2.3	Pit discontinued at 2.3m (very slow digging)	E	2.3	6		
17	3						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

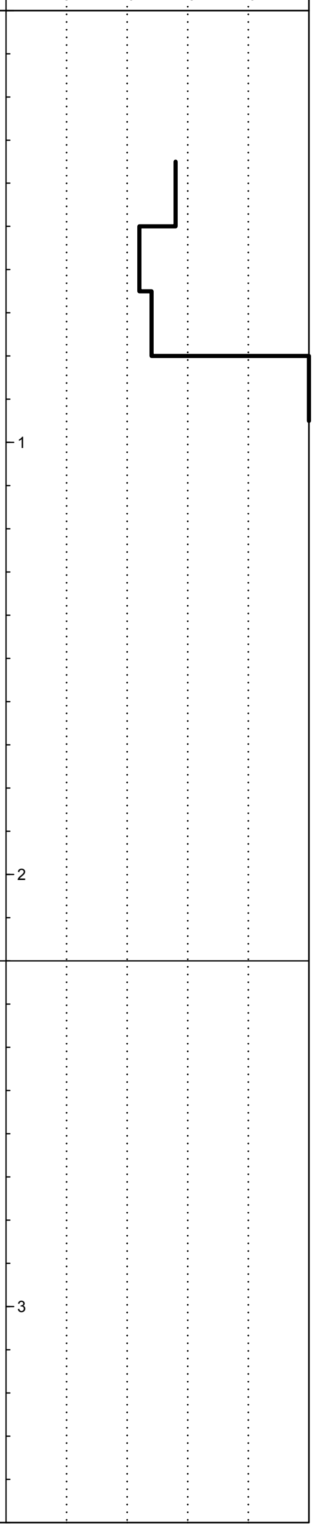
SURFACE LEVEL: 18.5 m AHD*
EASTING:
NORTHING:

PIT No: TP7
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
0.0–0.2	FILLING (SILTY SANDY GRAVEL) - blue-grey, fine sized silty sandy gravel, dry. Also known as 'cracker dust'.						
0.2–1.4	SAND - very dense, grey, fine to medium grained sand with a trace of silt, dry to moist. - becoming light grey from 0.4 m depth. - becoming light brown from 0.8 m depth. - becoming orange-brown, fine to coarse grained, slightly gravelly, slightly clayey sand from 1.1 m depth. Gravel is fine to coarse sized laterite.		B	0.5			
1.4–2.0	CLAY - very stiff to hard, orange-brown mottled light grey, slightly gravelly, slightly sandy clay, dry. Gravel is fine to coarse sized laterite.		D	1.6			
2.0–2.2	CLAYEY SAND - hard, light grey, fine to medium grained clayey sand.						
2.2	Pit discontinued at 2.2m (very slow digging)						

RL: 18, 17, 16

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

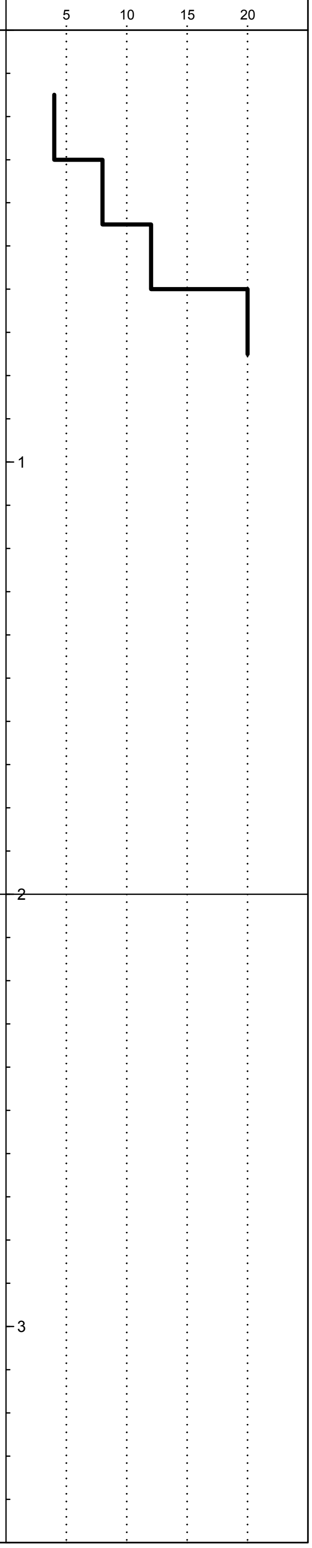
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 16.0 m AHD*
EASTING:
NORTHING:

PIT No: TP8
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
16		TOPSOIL - dark grey, fine to medium grained sandy topsoil with some silt, dry.						
	0.15	SAND - dense, grey, fine to medium grained sand with some silt, dry.						
		- becoming very dense, brown, fine grained slightly silty sand with a trace of clay, dry.		B	0.5			
		- becoming light brown, fine to medium grained sand with a trace of silt, dry.						
15	1							
	1.2	CLAYEY SAND - very stiff to hard, orange-brown mottled grey, fine to medium grained clayey sand, dry to moist, medium plasticity. Slow digging.		D	1.4			
	1.6	SAND - hard/cemented, light grey, fine to medium grained slightly clayey sand, dry.						
14	2 2.0	Pit discontinued at 2.0m (very slow digging)						
13	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 18.7 m AHD*
EASTING:
NORTHING:

PIT No: TP9
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - grey, fine to medium grained sandy topsoil with some silt and rootlets, dry.							
	0.1	SAND - medium dense to dense, light grey, fine to medium grained sand with a trace of silt, dry.							
18		- becoming orange-brown, fine to coarse grained slightly clayey sand with some laterite gravel from 0.6 m depth.							
	0.8	SANDY CLAY - very stiff, orange-brown mottled light grey sandy clay with some gravel, moist, high plasticity.			0.9		PP = 200 kPa		
	1								1
				D	1.2				
17									
	2								2
					2.5		PP = 550 kPa		
16									
	2.8	Pit discontinued at 2.8m (very slow digging)							
	3								3

RIG: 5.5t excavator with 650 mm toothed bucket. **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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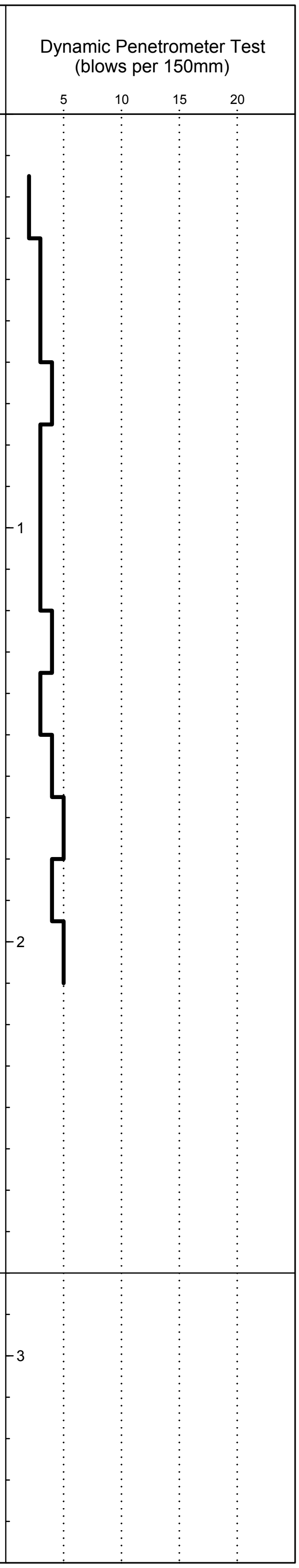
TEST PIT LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 22.9 m AHD*
EASTING:
NORTHING:

PIT No: TP10
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - grey, fine to medium grained sandy topsoil with a trace of silt and rootlets, dry.							
22	1	SAND - medium dense, light grey-white, fine to medium grained sand with a trace of silt, dry.							
21	2								
20	2.8	Pit discontinued at 2.8m (collapse)							
	3								



RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

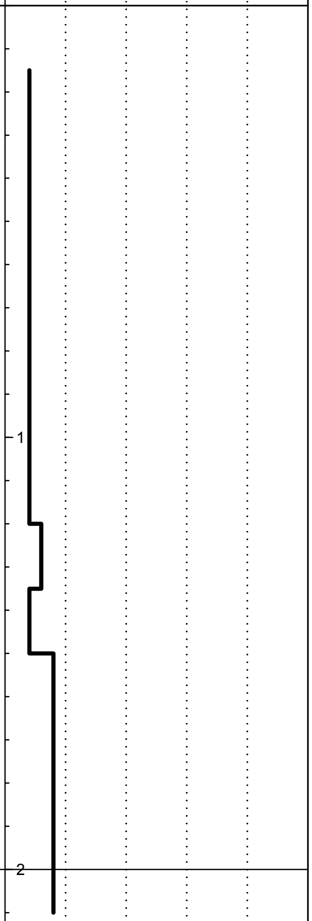
TEST PIT LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 22.0 m AHD*
EASTING:
NORTHING:

PIT No: TP11
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
22	0.05	TOPSOIL - grey, fine to medium grained sandy topsoil with a trace of silt and rootlets, dry.							
		SAND - medium dense, light grey, fine to medium grained sand with a trace of silt, dry.							
		- becoming loose to medium dense from 0.7 m depth.							
21	1								1
		- becoming medium dense from 1.8 m depth.							
20	2 2.0	Pit discontinued at 2.0m (collapse)							2
19	3								3



RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

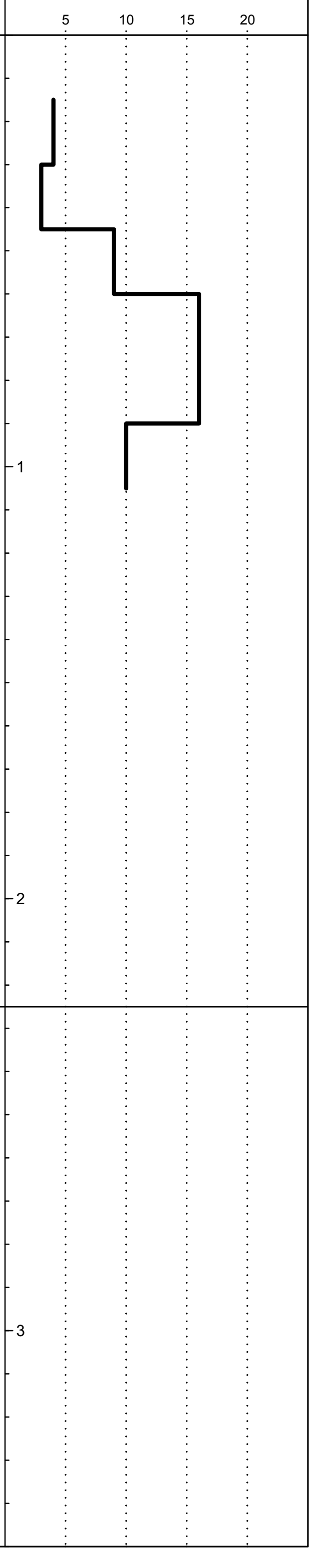
SURFACE LEVEL: 20.6 m AHD*
EASTING:
NORTHING:

PIT No: TP12
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		SAND - medium dense to dense, grey, fine to medium grained sand with some silt, dry. - becoming dry to moist, light grey-brown from 0.2 m depth. - becoming dense from 0.5 m depth.						
	1.0	GRAVELLY SAND - light brown, fine to medium grained, slighly clayey gravelly sand, dry to moist.						
	1.2	GRAVELLY SANDY CLAY - very stiff to hard, light brown mottled light grey, gravelly sandy clay, moist, high plasticity. Sand is fine to coarse grained. Gravel is fine to coarse sized. Occasional laterite boulders. Slow digging.		D	1.4			
	2.25	Pit discontinued at 2.25m (very slow digging)						

RL scale: 20, 19, 18. Depth scale: 1, 2, 3.

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5.5t excavator with 650 mm toothed bucket.
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

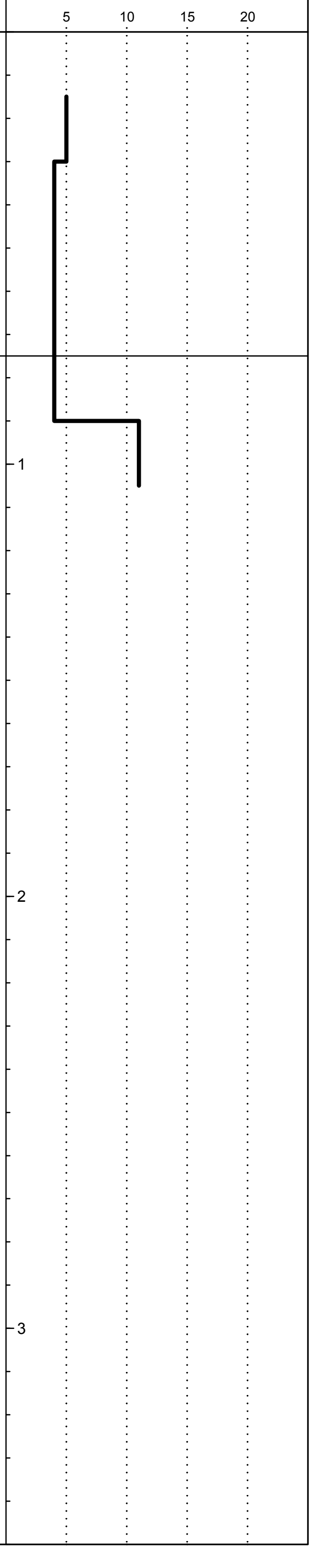
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 19.8 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH13
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
	0.05	TOPSOIL (SAND) - light grey, fine to medium grained sand with some silt and rootlets, dry.						
		SAND - medium dense, light grey-white, fine to medium grained sand with some silt, dry. - becoming dry to moist from 0.15 m depth.		D	0.5 0.75			
19	0.75	Bore discontinued at 0.75m (target)						
	1							
18								
	2							
17								
	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 110 mm auger. **DRILLER:** DJB **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: Hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

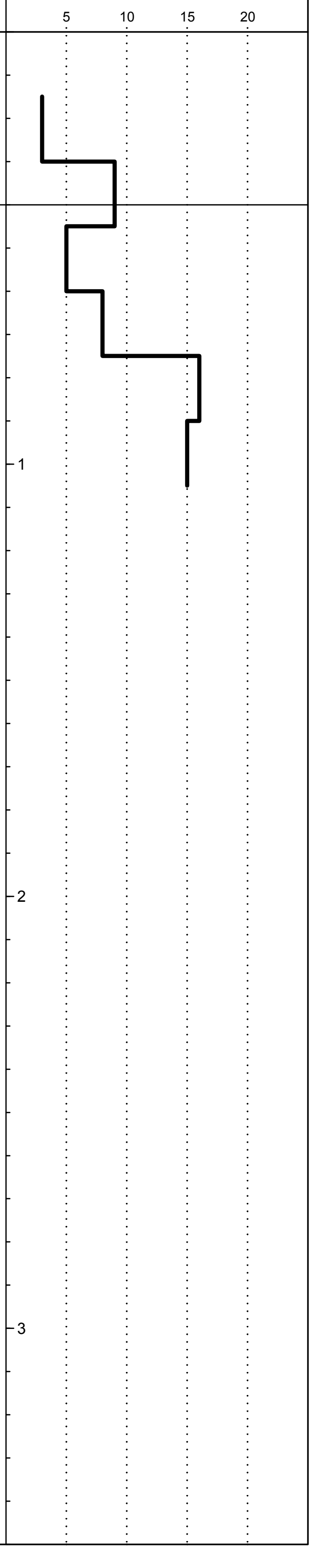
BOREHOLE LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 16.1 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH14
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
16		FILLING (SAND) - dense, grey, fine to medium grained sand with some silt and fine to medium gravel sized fragments of brick, dry. - no brick fragments from 0.2 m depth.							
	0.4	Bore discontinued at 0.4m (target)		D	0.4				
15	1								
14	2								
13	3								



RIG: 110 mm auger. **DRILLER:** DJB **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: Hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

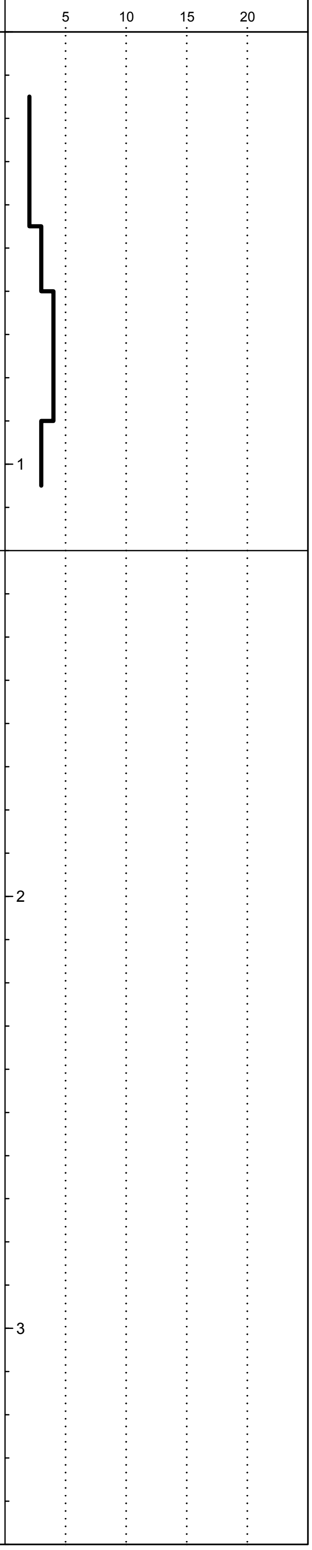
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 16.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH15
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
16		SAND - medium dense, light grey, fine to medium grained sand with a trace of silt, dry. - becoming dry to moist from 0.3 m depth.						
15	1			D	0.9 1.15			
	1.2	Bore discontinued at 1.2m (target)						
14	2							
13	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 110 mm auger. **DRILLER:** DJB **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: Hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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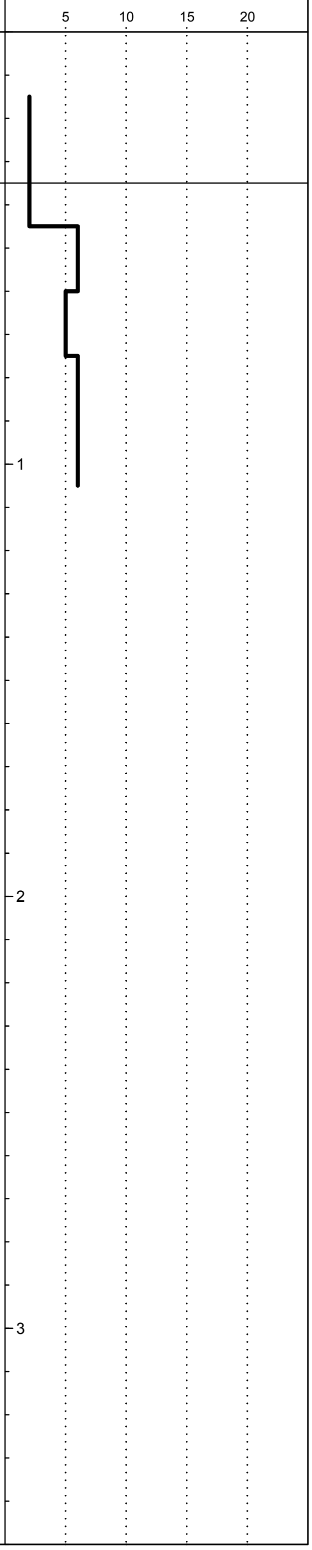
BOREHOLE LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 20.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH16
PROJECT No: 82411
DATE: 14/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		SAND - medium dense, grey, fine to medium grained sand with a trace of silt, dry.							
	0.35	Bore discontinued at 0.35m (target)		D	0.35				



RIG: 110 mm auger. **DRILLER:** DJB **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: Hand auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

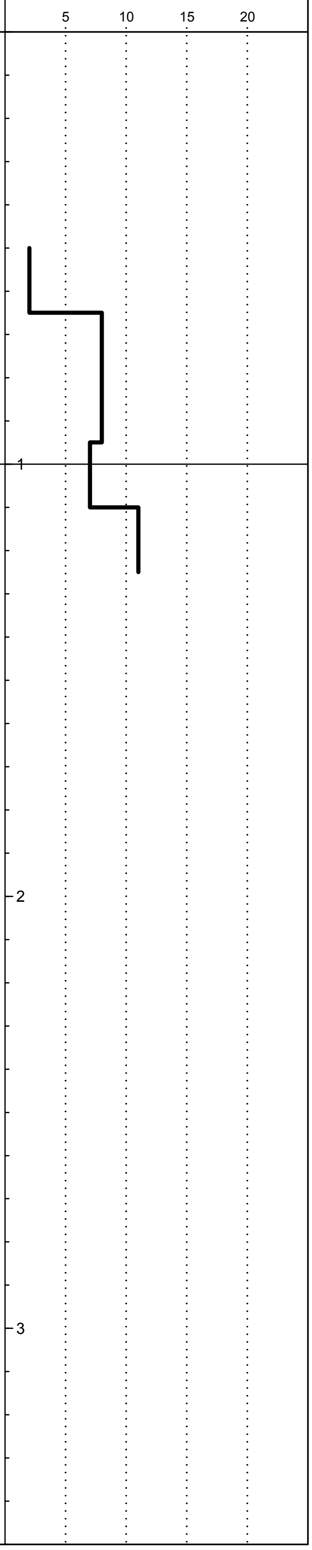
CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 21.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH17
PROJECT No: 82411
DATE: 29/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	0.03	SPRAY SEAL - dark grey, inverted double/double spray seal. 25 mm aggregate over 12 mm aggregate.						
	0.08	BASECOURSE (SANDY GRAVEL) - grey, fine to medium sized sandy gravel with some silt, dry. Gravel is angular, granitic rock.						
	0.3	SUBBASE (GRAVELLY SAND) - light orange-brown, fine to medium grained gravelly sand with a trace of silt, dry. Gravel is fine to medium sized lateritic rock.						
21		SAND - medium dense to dense, light grey, fine to medium grained sand with a trace of silt, dry. - becoming moist and light brown from 0.55 m depth.						
	1 1.0	Bore discontinued at 1.0m (target)						
20								
	2							
19								
	3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 8t excavator with power auger **DRILLER:** RME **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: 300 mm diameter power auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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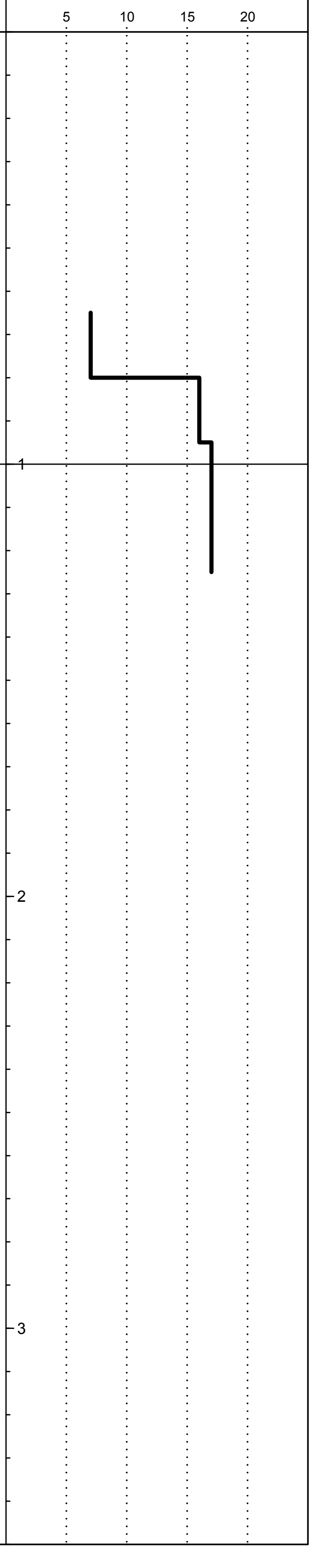
BOREHOLE LOG

CLIENT: Juceda Investments		**SURFACE LEVEL:** 21.5 m AHD*	**BORE No:** BH18
PROJECT: Lots 252-256 Clifford Street		**EASTING:**	**PROJECT No:** 82411
LOCATION: Maddington		**NORTHING:**	**DATE:** 29/1/2015
		DIP/AZIMUTH: 90°/--	**SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
	0.03	SPRAY SEAL - dark grey, inverted double/double spray seal. 25 mm aggregate over 12 mm aggregate.					
	0.08	BASECOURSE (SANDY GRAVEL) - grey, fine to medium sized sandy gravel with some silt, dry. Gravel is angular, granitic rock.					
	0.18	SUBBASE (SANDY GRAVEL) - light yellow, fine to coarse sized sandy gravel with a trace of silt, dry. Gravel is limestone. Sand is fine to medium grained.					
21	0.45	SUBBASE (GRAVELLY SAND) - light orange-brown, fine to medium grained gravelly sand with a trace of silt, dry. Gravel is fine to medium sized lateritic rock.		0.5			
		SAND - dense, grey, fine to medium grained sand with a trace of silt, dry.	B				
	1 1.0	Bore discontinued at 1.0m (target)		1.0			
20							
	2						
19							
	3						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 8t excavator with power auger **DRILLER:** RME **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: 300 mm diameter power auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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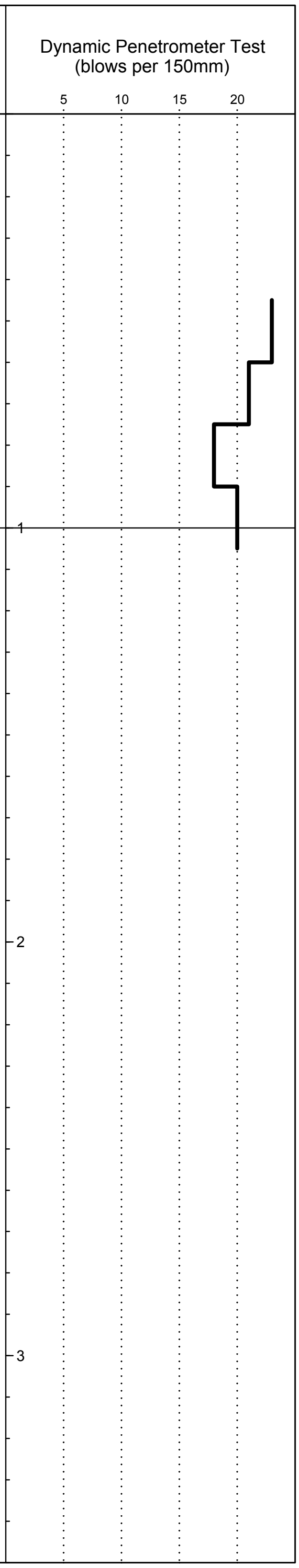
BOREHOLE LOG

CLIENT: Juceda Investments
PROJECT: Lots 252-256 Clifford Street
LOCATION: Maddington

SURFACE LEVEL: 21.0 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH19
PROJECT No: 82411
DATE: 29/1/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
21	0.03	SPRAY SEAL - dark grey, inverted double/double spray seal. 25 mm aggregate over 12 mm aggregate.					
	0.08	BASECOURSE (SANDY GRAVEL) - grey, fine to medium sized sandy gravel with some silt, dry. Gravel is angular, granitic rock.					
	0.25	SUBBASE (GRAVELLY SAND) - light yellow, fine to medium grained gravely sand with a trace of silt, dry. Gravel is fine to coarse sized limestone.					
	0.35	SUBBASE (GRAVELLY SAND) - light orange-brown, fine to medium grained gravelly sand with a trace of silt, dry. Gravel is fine to medium sized lateritic rock.					
		SAND - very dense, grey, fine to medium grained sand with a trace of silt, dry.					
20	1 — 1.0	Bore discontinued at 1.0m (target)					
19	2						
18	3						



RIG: 8t excavator with power auger **DRILLER:** RME **LOGGED:** DJB **CASING:** NA
TYPE OF BORING: 300 mm diameter power auger.
WATER OBSERVATIONS: No free groundwater observed.
REMARKS: *Surface level interpolated from survey data provided by client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Appendix C

Surface Water Monitoring Results

Table C. 1 Surface water quality monitoring across MKSEA in June 2017

	M1	M2	SW1	SW2	SW3	SW5	SW6	SW7
Location	Yule Brook in Precinct 3C	Yule Brook in Precinct 3A	Precinct 2	Precinct 2	Precinct 3B	Bush Forever Site 387	Precinct 2	Precinct 1
Temperature (°C)	14.6	14.6	15.4	Dry	15.4	15.9	16.2	Dry
Electrical conductivity (µS/cm)	230.5	229.4	495.1		660	165.7	538.7	
Dissolved oxygen (mg/L)	7.06	7.23	2.91		5.24	5.72	5.67	
Dissolved oxygen (% saturation)	69.4	71.2	29.1		52.4	58.0	57.8	
pH	6.32	7.14	6.94		7.18	7.15	7.20	
Redox (mV)	229.2	227.6	232.6		226.2	221.1	224.3	
Total suspended solids (mg/L)	26	24	14		8	8	31	
Ammonia as N (mg/L)	0.04	0.02	0.03		0.06	0.02	0.06	
Nitrite as N (mg/L)	<0.01	<0.01	<0.01		0.02	0.01	0.01	
Nitrate as N (mg/L)	0.33	0.34	0.22		0.80	0.81	1.49	
Nitrite and nitrate as N (mg/L)	0.33	0.34	0.22		0.82	0.82	1.50	
Total Kjeldahl nitrogen (mg/L)	0.5	0.5	1.1		1.5	1.5	1.0	
Total nitrogen (mg/L)	0.8	0.8	1.3		2.3	2.3	2.5	
Total phosphorus as P (mg/L)	0.05	0.07	0.61		0.19	0.14	0.12	
Reactive phosphorus as P (mg/L)	<0.01	<0.01	0.46		0.08	0.02	0.02	

Note: Site SW4 was not installed during the DWMS monitoring program (Endemic 2012)

Table 1515: Surface Water Quality results for the MKSEA: Field Parameters and Nutrients – 2009 monitoring.

Sample ID	Date	Field Parameters									Nutrients						
		Temp	pH	Electrical Conductivity	Dissolved Oxygen	Redox	TSS	TDS	BOD	COD	TN	NOx_N	NO2_N	Nitrate-NO3	TKN	TP	FRP
	units	ºC		mS/cm	mg/L	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Marine trigger		-	8.0-8.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LT Irrigation trigger		-	6.0-8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M1	30-Jun-09	12.6	6.22	430	8.7	8.8	<1	280	7.0	<5	1.10	<0.760	<0.023	<0.74	0.32	0.02	<0.005
M2	30-Jun-09	12.8	6.41	450	8.5	-1.0	<1	290	<5	10.0	1.10	0.85	<0.028	<0.82	0.29	0.02	<0.005
SW1	30-Jun-09	16.2	6.68	1300	5.6	5.6	100	860	36.0	150.0	7.70	3.1	0.073	3	4.6	0.94	0.11
SW2	30-Jun-09	Insufficient or no flow															
SW3	30-Jun-09	12.8	6.45	1300	5.8	5.8	3	820	8.0	120.0	3.10	1.3	0.048	1.3	1.8	0.28	0.18
SW5	30-Jun-09	16.8	7.09	430	10.2	10.2	<1	280	8.0	570.0	2.60	1.2	0.032	1.1	1.4	0.04	<0.005
SW6	30-Jun-09	Insufficient or no flow															
SW7	30-Jun-09	Insufficient or no flow															
M1	11-Aug-09	14.8	6.58	410	8.6	-	2	158	53.0	6.0	0.88	0.52	0.008	<0.52	0.36	0.01	<0.005
M2	11-Aug-09	15	7.2	556	8.3	-	1	212	50.0	12.0	1.00	0.53	0.014	0.51957	0.48	<0.02	<0.005
SW1	11-Aug-09	16	7.18	1448	9.1	-	40	578	20.0	650.0	4.30	1.6	0.028	1.5813	2.7	0.35	0.19
SW2	11-Aug-09	Insufficient or no flow															
SW3	11-Aug-09	14.4	7.36	1900	6.7	-	22	770	20.0	450.0	3.60	0.22	0.019	0.2259	3.4	0.3	0.17
SW5	11-Aug-09	17.5	7.99	502	10.7	-	<1	192	57.0	350.0	1.60	0.04	0.007	0.04518	1.5	0.03	<0.005
SW6	11-Aug-09	16.4	7.3	1334	3.5	-	100	529	210.0	400.0	5.20	3.4	0.013	3.3885	1.9	0.17	0.025
SW7	11-Aug-09	Insufficient or no flow															
M1	18-Aug-09	-	7.2	240	-	-	66	150	<5	100.0	1.50	0.47	0.015225	0.4518	1	0.06	<0.005
M2	18-Aug-09	-	7	360	-	-	58	230	<5	300.0	1.80	0.58	0.01218	0.56475	1.2	0.08	0.005
SW1	18-Aug-09	-	7	420	-	-	19	270	<5	500.0	3.10	0.37	0.009135	0.36144	2.8	0.53	0.32
SW2	18-Aug-09	Insufficient or no flow															
SW3	18-Aug-09	-	7	560	-	-	60	360	<5	300.0	2.10	0.21	0.009135	0.20331	1.9	0.18	0.023
SW5	18-Aug-09	-	7	170	-	-	7	110	<5	400.0	1.90	0.037	0.00609	0.02259	1.8	0.05	0.005
SW6	18-Aug-09	-	7.3	440	-	-	27	280	7.0	300.0	3.30	0.9	0.015225	0.88101	2.4	0.63	0.51
SW7	18-Aug-09	-	7.3	290	-	-	19	180	<5	400.0	1.90	0.05	0.009135	0.04518	1.9	0.06	0.008
M1	11-Sep-09	15.8	7.98	399	8.0	-	8	150	<5	<5	0.71	0.56	<0.005	0.56475	0.15	0.01	<0.005
M2	11-Sep-09	16.6	7.83	601	7.8	-	14	230	<5	<5	1.10	0.46	0.005	0.4518	0.68	0.05	<0.005
SW1	11-Sep-09	16.1	7.7	1060	5.8	-	20	417	<5	100.0	3.20	0.25	0.006	0.24849	2.9	0.6	0.25
SW2	11-Sep-09	16	7.81	742	5.7		11	288	<5	48.0	2.40	0.62	0.033	0.58734	1.8	0.09	0.01
SW3	11-Sep-09	15	7.45	1050	7.2	-	30	417	<5	64.0	1.90	0.066	<0.005	0.06777	1.8	0.18	0.037
SW5	11-Sep-09	17.2	7.81	408	8.5	-	6	154	<5	60.0	1.60	0.008	<0.005	<0.1	1.6	0.04	<0.005
SW6	11-Sep-09	17	7.87	796	6.5	-	4	310	<5	36.0	2.30	0.77	<0.005	0.76806	1.6	0.27	0.15
SW7	11-Sep-09	17.2	7.67	662	5.7	-	7	254	<5	68.0	1.90	0.014	<0.005	<0.1	1.9	0.07	<0.005
M1	16-Sep-09	16.2	8	428	8.0		6	162	<5	52.0	1.10	-	<0.005	0.63252	1.1	0.01	<0.005
M2	16-Sep-09	16.4	7.86	555	8.0	-	9	213	<5	60.0	1.00	-	0.005	0.54216	1	0.02	<0.005
SW1	16-Sep-09	18.7	7.44	242	5.9	-	8	289	13.0	92.0	2.80	-	0.011	0.92619	2.8	0.3	0.14
SW2	16-Sep-09	17.5	7.51	674	6.2	-	6	258	<5	120.0	2.50	-	0.033	0.51957	2.5	0.1	0.015
SW3	16-Sep-09	20.1	7.9	1264	7.3	-	16	501	<5	340.0	2.20	-	0.006	0.11295	2.2	0.18	0.088
SW5	16-Sep-09	22.4	8.31	428	7.7	-	5	162	18.0	300.0	2.10	-	<0.005	0.006777	2.1	0.07	<0.005
SW6	16-Sep-09	16.8	7.81	1058	5.8	-	4	417	<5	240.0	4.00	-	0.007	2.430684	4	0.14	0.09
SW7	16-Sep-09	18.2	7.37	785	4.5	-	23	305	13.0	350.0	2.70	-	<0.005	0.033885	2.7	0.08	<0.005
M1	2-Nov-09	16.7	7.78	320	7.8	-8.0	<1	119	32.0	<5	0.63	0.36	<0.01	0.36144	0.27	0.5	<0.005
M2	2-Nov-09	19.2	7.75	572	9.0	-30.1	5	219	28.0	<5	0.64	0.27	<0.01	0.27108	0.37	0.5	<0.005
SW1	2-Nov-09	Insufficient or no flow															
SW2	2-Nov-09	Insufficient or no flow															
SW3	2-Nov-09	Insufficient or no flow															
SW5	2-Nov-09	Insufficient or no flow															
SW6	2-Nov-09	Insufficient or no flow															
SW7	2-Nov-09	Insufficient or no flow															
M1	19-Nov-09	17.7	7.45	246	7.4	-43.4	35		32.0	16.0	1.30	0.24	<0.005	0.24849	1.1	0.16	<0.005
M2	19-Nov-09	18	7.45	282	5.2	-44.6	35		49.0	100.0	1.20	1.2	0.008	1.17468	<0.05	0.05	<0.005
SW1	19-Nov-09	22.3	7.48	3640	4.9	-46.2	36		67.0	10000.0	3.20	0.54	0.089	0.4518	2.7	0.49	0.21
SW2	19-Nov-09	Insufficient or no flow															
SW3	19-Nov-09	26.2	7.83	3480	7.3	-64.2	35		64.0	10000.0	3.00	1.2	0.026	1.17468	1.9	0.1	0.016
SW4	19-Nov-09	-	-	-	-	-	14	-	59.0	300.0	2.30	0.51	0.007	0.49698	1.8	0.11	<0.005
SW5	19-Nov-09	28	7.88	422	5.9	-67.8	-	-	-	-	-	-	-	-	-	-	-
SW6	19-Nov-09	Insufficient or no flow															
SW7	19-Nov-09	Insufficient or no flow															

Table 1616: Surface Water Quality for the MKSEA: Field Parameters and Nutrients – 2010 Monitoring.

Sample ID	Date	Field Parameters									Nutrients						
		Temp	pH	Electrical Conductivity	Dissolved Oxygen	Redox	TSS	TDS	BOD	COD	TN	NOx_N	NO2_N	Nitrate-NO3	TKN	TP	FRP
	units	ºC		mS/cm	mg/L	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Marine trigger		-	8.0-8.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LT Irrigation trigger		-	6.0-8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M1	24-Jun-10	11.5	7.36	319	6.8	-15.4	<5	117	10	9	0.6	0.26	<0.01	0.26	0.3	0.01	<0.01
M2	24-Jun-10	11.2	7.69	388	6.6	-35.5	<5	146	6	11	0.6	0.23	<0.01	0.23	0.4	0.02	<0.01
SW1	24-Jun-10	Insufficient or no flow															
SW2	24-Jun-10	Insufficient or no flow															
SW3	24-Jun-10	11.8	7.79	1534	5.1	-42.3	<5	610	8	59	1.2	0.01	<0.01	0.01	1.2	0.19	0.12
SW5	24-Jun-10	16.7	8.11	279	6.9	-61.2	<5	103	8	73	1.7	0.04	<0.01	0.04	1.7	0.1	0.02
SW6	24-Jun-10	Insufficient or no flow															
SW7	24-Jun-10	Insufficient or no flow															
M1	9-Jul-10	12.2	7.06	185	10.1	99.5	25	120	12	13	0.6	0.24	<0.01	0.24	0.4	0.05	<0.01
M2	9-Jul-10	12	7.13	199	6.9	119.0	16	129	23	16	0.7	0.22	<0.01	0.22	0.5	0.04	<0.01
SW1	9-Jul-10	13.9	7.02	429	7.7	102.9	10	270	15	52	1.9	0.42	<0.01	0.42	1.5	0.25	0.24
SW2	9-Jul-10	13.6	6.97	313	6.5	108.3	36	204	8	25	1.1	0.14	<0.01	0.14	1	0.13	0.04
SW3	9-Jul-10	12	7.01	477	8.6	132.0	5	310	12	53	1.5	0.22	<0.01	0.22	1.3	0.12	0.09
SW5	9-Jul-10	12.4	7	139	9.4	216.0	13	90	17	57	1.6	0.2	0.02	0.18	1.4	0.04	0.02
SW6	9-Jul-10	13	6.81	36	9.8	141.0	5	23	12	<5	0.4	0.13	0.02	0.11	0.3	0.07	0.02
SW7	9-Jul-10	Insufficient or no flow															
M1	13-Jul-10	11.5	7.43	460	6.9	-20.4	<5	181	2	22	1.1	0.83	<0.01	0.83	0.3	0.01	<0.01
M2	13-Jul-10	12.3	8.13	386	6.4	-62.8	11	145	3	32	1.3	0.73	<0.01	0.73	0.6	0.03	<0.01
SW1	13-Jul-10	13	7.57	950	3.8	-29.3	234	371	5	233	5	2.31	0.02	2.29	2.7	0.37	0.11
SW2	13-Jul-10	12.5	7.82	690	5.4	-43.0	<5	265	5	49	2.2	0.74	0.03	0.71	1.5	0.1	0.02
SW3	13-Jul-10	12.6	7.89	750	5.2	-47.6	20	290	<2	86	1.9	0.16	<0.01	0.16	1.7	0.18	0.1
SW5	13-Jul-10	14.6	7.64	301	7.3	-32.7	<5	111	<2	83	1.5	0.03	<0.01	0.03	1.5	0.53	<0.01
SW6	13-Jul-10	15.8	7.64	1279	0.7	-33.0	<5	500	3	186	2.4	1.54	0.02	1.52	0.9	0.07	0.02
SW7	13-Jul-10	13	7.79	630	2.6	-42.3	<5	239	<2	88	1.6	0.01	<0.01	0.01	1.6	0.1	<0.01
M1	12-Aug-10	12.8	6.86	330	6.8	-	11	123	<2	31	0.9	0.3	<0.01	0.3	0.6	0.04	<0.01
M2	12-Aug-10	12.5	7.69	284	6.1	-	10	106	<2	20	0.7	0.3	<0.01	0.3	0.4	0.03	<0.01
SW1	12-Aug-10	13.7	7.63	2400	4.9	-	10	811	<2	57	3.6	1.69	0.04	1.66	1.9	0.25	0.13
SW2	12-Aug-10	Insufficient or no flow															
SW3	12-Aug-10	14.3	7.32	871	5.6	-	<5	337	<2	73	2	0.22	0.01	0.21	1.8	0.13	0.03
SW5	12-Aug-10	15.3	8.33	325	6.6	-	5	121	<2	36	2.1	0.38	<0.01	0.38	1.7	0.11	0.02
SW6	12-Aug-10	14.5	7.88	159	3.4	-	7	57	<2	16	0.8	0.28	<0.01	0.28	0.5	0.06	0.02
SW7	12-Aug-10	Insufficient or no flow															
M1	1-Sep-10	14	8.32	460	6.7	-	<5	174	2	45	0.6	0.25	<0.01	0.25	0.4	<0.02	<0.01
M2	1-Sep-10	14	8.14	572	7.8	-	<5	217	<2	48	0.5	0.22	<0.01	0.22	0.3	<0.01	<0.01
SW1	1-Sep-10	16.1	8.04	3390	5.0	-	26	1390	6	115	3.3	1.36	0.04	1.32	1.9	0.2	0.1
SW2	1-Sep-10	17.4	8.2	700	4.0	-	44	270	17	83	2.1	0.01	<0.01	0.01	2.1	0.23	0.01
SW3	1-Sep-10	18.7	7.37	2815	2.5	-	6	1135	7	122	1.4	0.01	<0.01	0.01	1.4	0.14	0.15
SW5	1-Sep-10	21.5	9.34	371	11.6	-	16	1.39	11	102	3	0.26	0.07	0.2	2.7	<0.05	0.04
SW6	1-Sep-10	16.2	7.9	316	2.9	-	<5	117	7	77	0.9	0.04	<0.01	0.04	0.9	0.05	0.02
SW7	1-Sep-10	Insufficient or no flow															
M1	23-Sep-10	13.4	7.85	6180	6.3	-	10	2360	-	-	0.8	0.19	<0.01	0.19	0.6	0.02	<0.01
M2	23-Sep-10	13.4	7.33	8590	5.5	-	<5	334	-	-	0.4	0.04	<0.01	0.04	0.4	0.03	<0.01
SW1	23-Sep-10	17.7	7.43	4110	4.3	-	14	170	-	-	2.2	0.03	<0.01	0.03	2.2	0.14	0.03
SW2	23-Sep-10	Insufficient or no flow															
SW3	23-Sep-10	Insufficient or no flow															
SW5	23-Sep-10	Insufficient or no flow															
SW6	23-Sep-10	Insufficient or no flow															
SW7	23-Sep-10	Insufficient or no flow															
M1	14-Oct-10	17.9	8.1	956				374	-	-	0.8	0.038	0.024	0.014	0.76	0.02	<0.005
M2	14-Oct-10	16.9	7.35	1850				745	-	-	0.83	0.034	<0.005	0.034	0.8	0.02	<0.005
SW1	14-Oct-10	Insufficient or no flow															
SW2	14-Oct-10	Insufficient or no flow															
SW3	14-Oct-10	Insufficient or no flow															
SW5	14-Oct-10	Insufficient or no flow															
SW6	14-Oct-10	Insufficient or no flow															
SW7	14-Oct-10	Insufficient or no flow															

Table 1717: Surface Water Quality Results for the MKSEA: Metals – 2009 and 2010 Monitoring.

Sample ID	Date	Metals												
		Aluminium	Arsenic	Cadmium	Cobalt	Chromium	Copper	Iron	Mercury	Manganese	Nickel	Lead	Selenium	Zinc
	units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Marine trigger		-	-	0.0007	0.001	0.0044	0.0013	1	0.0001	-	0.007	0.0044	-	0.015
LT Irrigation trigger		5	0.1	0.01	0.05	0.1	0.2	0.20	0.002	0.2	0.2	2	0.02	2
M1	18-Aug-09	0.24	0.004	<0.0001	<0.005	<0.001	0.002	0.11	<0.0001	<0.001	<0.005	<0.001	<0.002	0.015
M2	18-Aug-09	0.044	0.001	<0.0001	<0.005	<0.001	0.002	0.07	<0.0001	0.034	<0.005	<0.001	0.003	0.01
SW1	18-Aug-09	0.49	0.002	<0.0001	<0.005	0.001	0.002	0.87	<0.0001	0.016	<0.005	<0.001	0.002	0.035
SW2	18-Aug-09	Insufficient or no flow												
SW3	18-Aug-09	0.12	0.004	<0.0001	<0.005	<0.001	0.002	0.26	<0.0001	0.16	<0.005	<0.001	0.002	0.012
SW5	18-Aug-09	0.11	0.004	<0.0001	<0.005	<0.001	0.002	0.39	<0.0001	0.004	<0.005	<0.001	0.002	0.022
SW6	18-Aug-09	0.15	0.003	<0.0001	<0.005	<0.001	0.002	0.31	<0.0001	0.01	<0.005	<0.001	0.002	0.03
SW7	18-Aug-09	0.24	0.003	<0.0001	<0.005	<0.001	0.002	0.32	<0.0001	0.006	<0.005	<0.001	0.001	0.016
M1	11-Sep-09	0.12	0.002	<0.0001	<0.028	<0.006	0.012	0.21	<0.0001	0.007	0.004	0.001	<0.001	0.048
M2	11-Sep-09	0.3	<0.001	<0.0001	<0.028	<0.006	0.011	0.48	<0.0001	0.045	0.005	0.003	<0.001	0.041
SW1	11-Sep-09	0.28	0.003	<0.0001	<0.028	<0.006	0.014	2.5	<0.0001	0.079	0.005	0.001	0.002	0.047
SW2	11-Sep-09	0.15	0.002	<0.0001	<0.028	<0.006	0.014	1.1	<0.0001	0.018	0.005	0.001	0.002	0.042
SW3	11-Sep-09	1.5	0.002	<0.0001	<0.028	<0.006	0.013	1.3	<0.0001	0.18	0.014	<0.001	0.001	0.044
SW5	11-Sep-09	0.57	<0.001	<0.0001	<0.028	<0.006	0.013	0.81	<0.0001	0.011	0.007	0.002	0.003	0.039
SW6	11-Sep-09	0.11	0.003	<0.0001	<0.028	<0.006	0.016	0.56	<0.0001	<0.006	0.005	0.001	0.003	0.054
SW7	11-Sep-09	0.36	0.002	<0.0001	<0.028	<0.006	0.047	1	<0.0001	0.08	0.006	0.002	0.003	0.04
M1	9-Jul-10	1.37	<0.001	<0.0001	<0.001	0.001	0.004	1.52	<0.0001	0.016	<0.001	0.004	<0.01	0.015
M2	9-Jul-10	1.55	<0.001	<0.0001	<0.001	0.001	0.003	1.39	<0.0001	0.011	<0.001	0.002	<0.01	0.009
SW1	9-Jul-10	0.74	0.002	<0.0001	<0.001	<0.001	0.005	0.89	<0.0001	0.01	0.001	0.002	<0.01	0.029
SW2	9-Jul-10	2.42	<0.001	<0.0001	0.001	0.002	0.007	2.14	<0.0001	0.046	0.002	0.006	<0.01	0.03
SW3	9-Jul-10	0.79	<0.001	<0.0001	<0.001	<0.001	0.003	0.98	<0.0001	0.01	<0.001	<0.001	<0.01	0.012
SW5	9-Jul-10	1.25	<0.001	<0.0001	<0.001	0.001	0.002	1.66	<0.0001	0.009	<0.001	0.001	<0.01	0.011
SW6	9-Jul-10	1.21	<0.001	<0.0001	<0.001	0.002	0.008	0.76	<0.0001	0.005	<0.001	0.005	<0.01	0.031
SW7	9-Jul-10	Insufficient or no flow												
M1	12-Aug-10	0.32	<0.001	<0.0001	<0.001	0.002	0.006	1.09	<0.0001	0.018	<0.001	0.003	<0.01	0.011
M2	12-Aug-10	0.44	<0.001	<0.0001	<0.001	<0.001	0.003	1.19	<0.0001	0.017	<0.001	0.001	<0.01	0.007
SW1	12-Aug-10	0.25	0.002	<0.0001	0.001	<0.001	0.004	1.89	0.0001	0.074	<0.001	0.002	<0.01	0.025
SW2	12-Aug-10	Insufficient or no flow												
SW3	12-Aug-10	0.24	<0.001	<0.0001	<0.001	<0.001	0.005	0.23	<0.0001	0.017	0.001	<0.001	<0.01	0.006
SW5	12-Aug-10	0.46	0.001	<0.0001	<0.001	<0.001	0.003	0.69	<0.0001	0.007	<0.001	<0.001	<0.01	<0.005
SW6	12-Aug-10	0.31	<0.001	<0.0001	<0.001	<0.001	0.007	0.29	<0.0001	0.004	<0.001	0.002	<0.01	0.026
SW7	12-Aug-10	Insufficient or no flow												
M1	23-Sep-10	0.27	<0.001	<0.0001	<0.001	<0.001	0.003	0.77	<0.0001	0.017	<0.001	0.002	<0.01	0.182
M2	23-Sep-10	0.22	<0.001	<0.0001	0.001	<0.001	0.002	1.19	<0.0001	0.097	<0.001	<0.001	<0.01	0.045
SW1	23-Sep-10	0.12	0.002	<0.0001	0.002	<0.001	0.003	1.5	<0.0001	0.105	0.002	<0.001	<0.01	0.013
SW2	23-Sep-10	Insufficient or no flow												
SW3	23-Sep-10	Insufficient or no flow												
SW5	23-Sep-10	Insufficient or no flow												
SW6	23-Sep-10	Insufficient or no flow												
SW7	23-Sep-10	Insufficient or no flow												
M1	14-Oct-10	<0.02	<0.001	<0.002	<0.005	<0.005	<0.005	0.24	0.028	<0.0001	<0.005	0.001	0.003	0.01
M2	14-Oct-10	<0.02	<0.001	<0.002	<0.005	<0.005	<0.005	0.07	0.16	<0.0001	<0.005	<0.001	0.003	0.02
SW1	14-Oct-10	Insufficient or no flow												
SW2	14-Oct-10	Insufficient or no flow												
SW3	14-Oct-10	Insufficient or no flow												
SW5	14-Oct-10	Insufficient or no flow												
SW6	14-Oct-10	Insufficient or no flow												
SW7	14-Oct-10	Insufficient or no flow												

Table 1818: Surface Water Quality Results for the MKSEA: Total Petroleum Hydrocarbons, BTEX, Polynuclear Aromatic Hydrocarbons – 2009 and 2010 monitoring.

Sample ID	Date	TPH and BTEX									Polynuclear Aromatic Hydrocarbons															
		TPH	C6-9	C10-14	C15-28	C29-36	Benzene	Toluene	Ethylbenzene	Xylene	Napthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(b)flruoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1.2.3cd)pyrene	Dibenz(a.h)anthracerene	Benzo(g.h.i)perylene
	units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Marine trigger		-	-	-	-	-	500	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LT Irrigation trigger		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M1	18-Sep-09	290	<20	<50	200	110	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
M2	18-Sep-09	60	<20	<50	<100	60	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
SW1	18-Sep-09	<50	<20	<50	<100	<50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
SW2	18-Sep-09	Insufficient or no flow																								
SW3	18-Sep-09	<50	<20	<50	<100	<50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
SW5	18-Sep-09	<50	<20	<50	<100	<50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
SW6	18-Sep-09	180	<20	<50	100	50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
SW7	18-Sep-09	340	<20	<50	200	100	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.6	<1.0	<1.0	<1.0
M1	13-Jul-10	<50	<20	<50	<100	<50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
M2	13-Jul-10	<50	<20	<50	<100	<50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
SW1	13-Jul-10	<50	<20	<50	<100	<50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
SW2	13-Jul-10	200	<20	<50	150	50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
SW3	13-Jul-10	<50	<20	<50	<100	<50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
SW5	13-Jul-10	<50	<20	<50	<100	<50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
SW6	13-Jul-10	<50	<20	<50	<100	<50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
SW7	13-Jul-10	<50	<20	<50	<100	<50	<1	<2	<2	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0

Table 1919: Surface Water Quality Results for the MKSEA: Organochloride and Organophosphate Pesticides – 2009 and 2010 monitoring

Sample ID	Date	OC/OPs																																		
		alpha-BHC	Hexachlorobenzene	beta-BHC	Gamma_BHC	Delta-BHC	Heptachlor	Aldrin	Heptaclor epoxide	Trans-Chlordane	Alpha–Endosulfan	Cis-Chlordane	Dieldrin	4.4 - DDE	Endrin aldehyde	Endosulfan Sulfate	4.4 DDT	Endrin Ketone	Methoxychlor	Dichlorvos	Demeton-S-methyl	Monocrotophos	Dimethoate	Diazinon	Chlorpyrifos-methyl	Parathion-methyl	Malathion	Fenthion	Chlorpyrifos	Parathion	Pirimphos-ethyl	Chlorfenvinphos (Z)	Bromophos-ethyl	Fenamiphos	Prothiofos	Ethion
	units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Marine trigger		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	0.009	-	-	-	-	-	-	-
LT Irrigation trigger		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M1	18-Sep-09	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
M2	18-Sep-09	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SW1	18-Sep-09	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SW2	18-Sep-09	Insufficient or no flow																																		
SW3	18-Sep-09	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SW5	18-Sep-09	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SW6	18-Sep-09	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SW7	18-Sep-09	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.6	<0.6	<2	<0.6	<0.6	<0.6	<2	<0.6	<0.6	<0.6	<2	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
M1	13-Jul-10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
M2	13-Jul-10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SW1	13-Jul-10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SW2	13-Jul-10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SW3	13-Jul-10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SW5	13-Jul-10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SW6	13-Jul-10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SW7	13-Jul-10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<2	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

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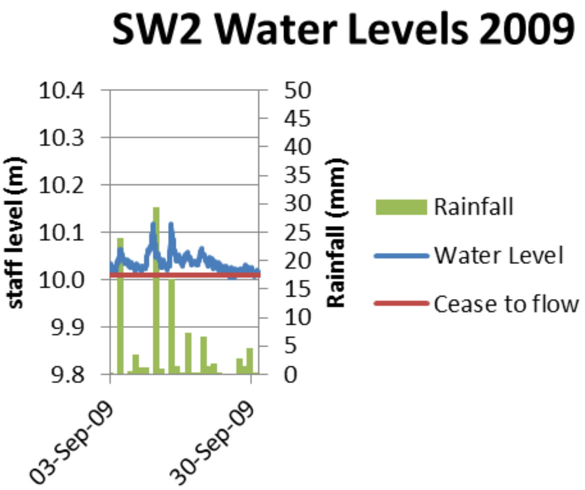
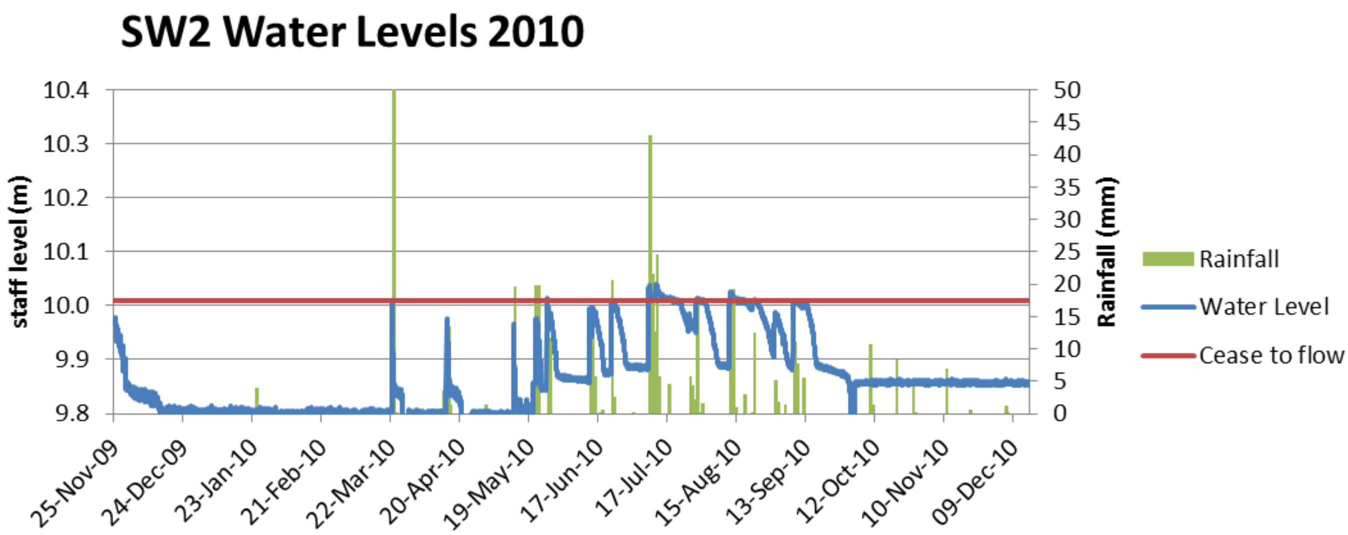
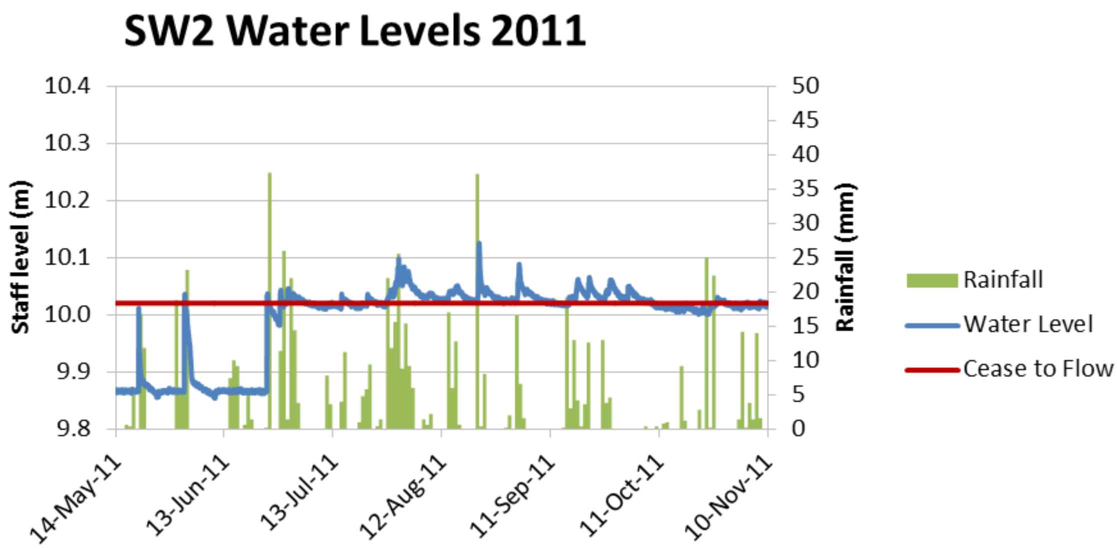
Figure 22: Surface water hydrographs for SW1





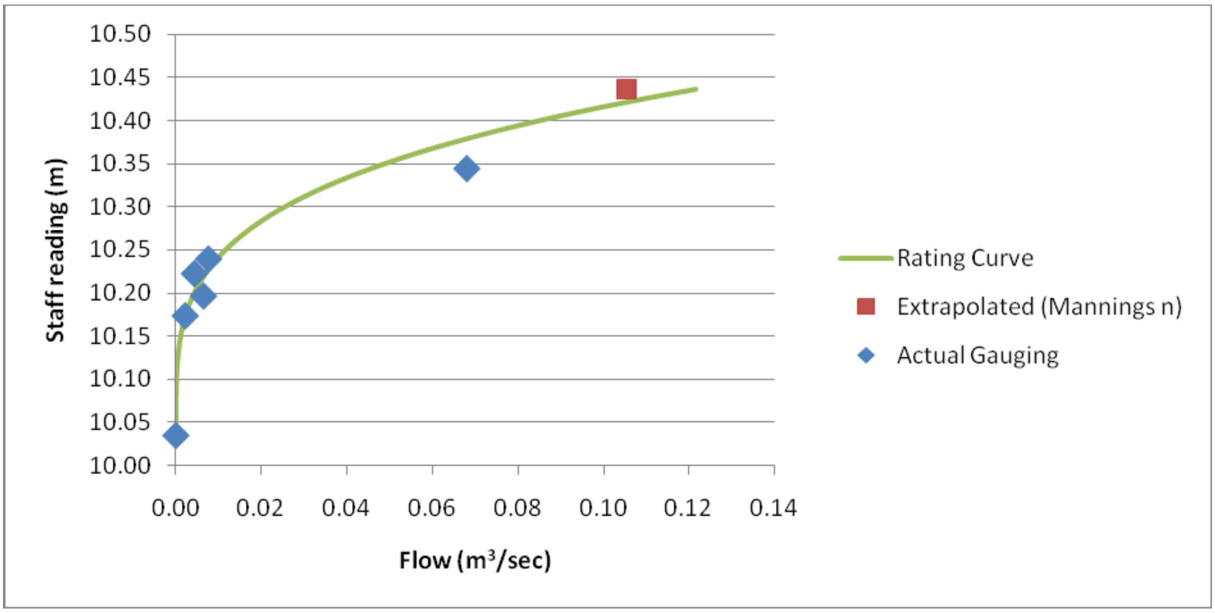


SW1

Stage application: 10.035- 10.436

Method: Log-Log linear curve fitted to 6 actual gauging points from 10.035-10.345 and one extrapolated point (see introduction).

Log(Discharge)= 3.7692*(log(Depth above CTF)) + 0.5808



SW2

Stage application: 10.025- 10.128

Method: Log-log linear interpolation between 4 actual gauging points and extrapolated to highest stage.

log(Q)	log(depth above CTF)
-1.65758	-0.98716
-2.20038	-1.3279
-2.61979	-1.61979
-3.54212	-2.1549

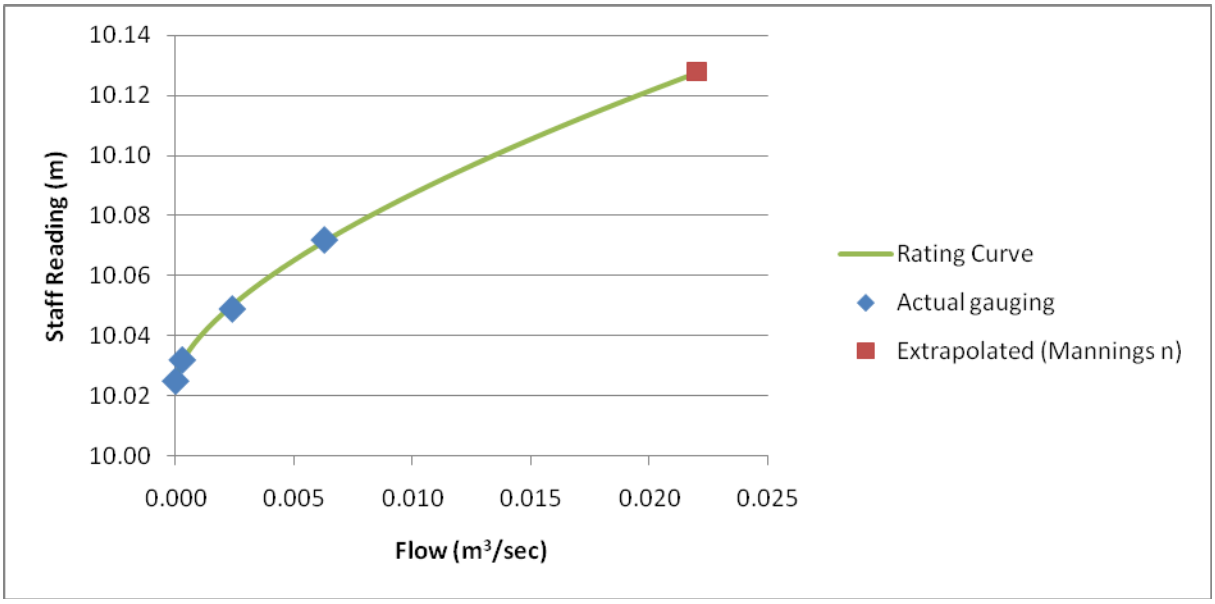
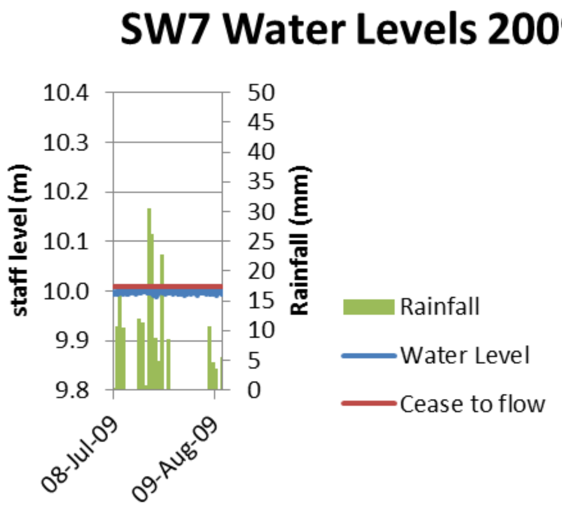
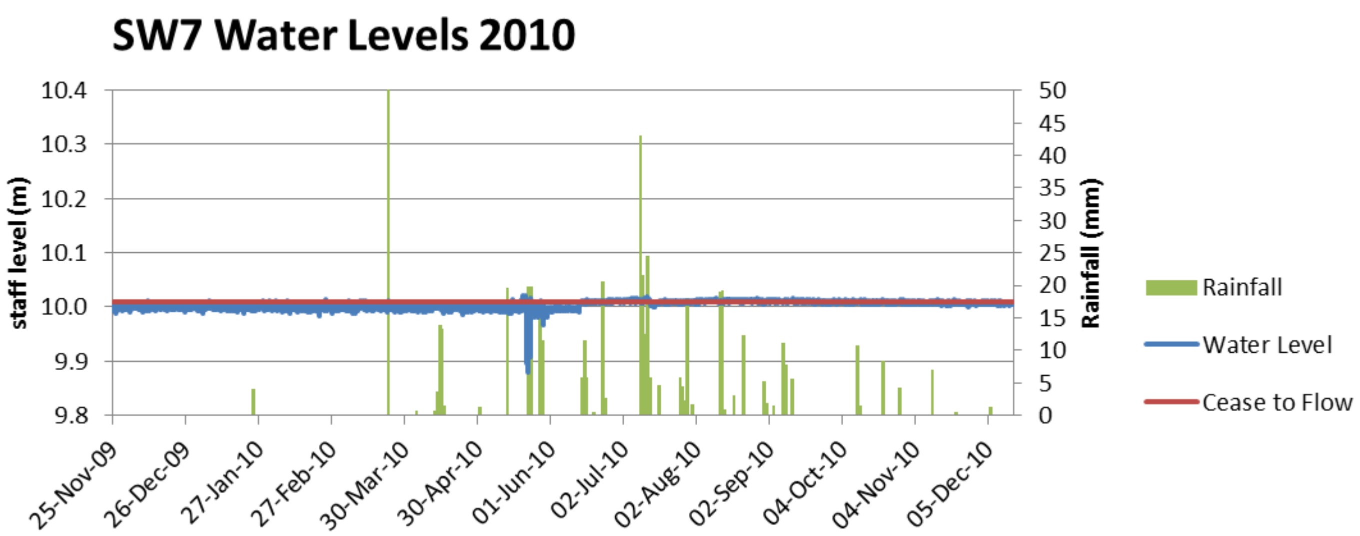
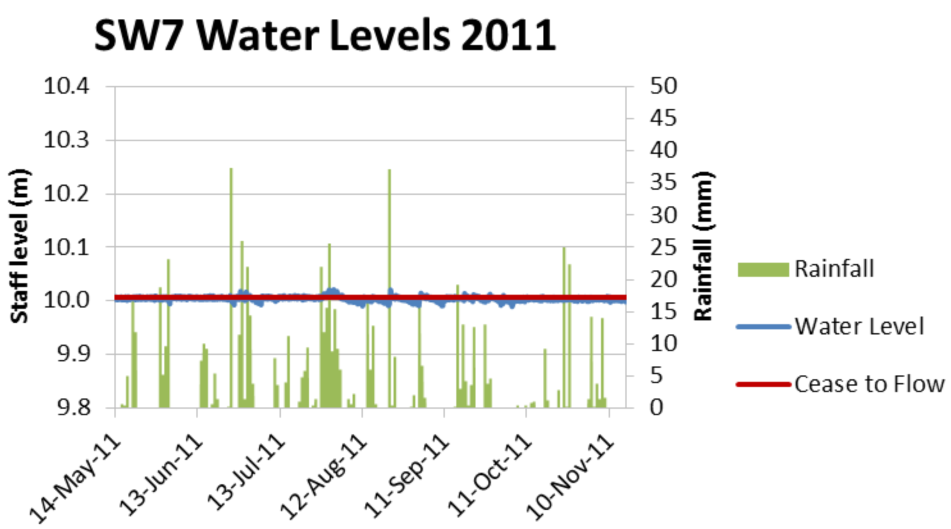


Figure 26: Surface water hydrographs for SW6





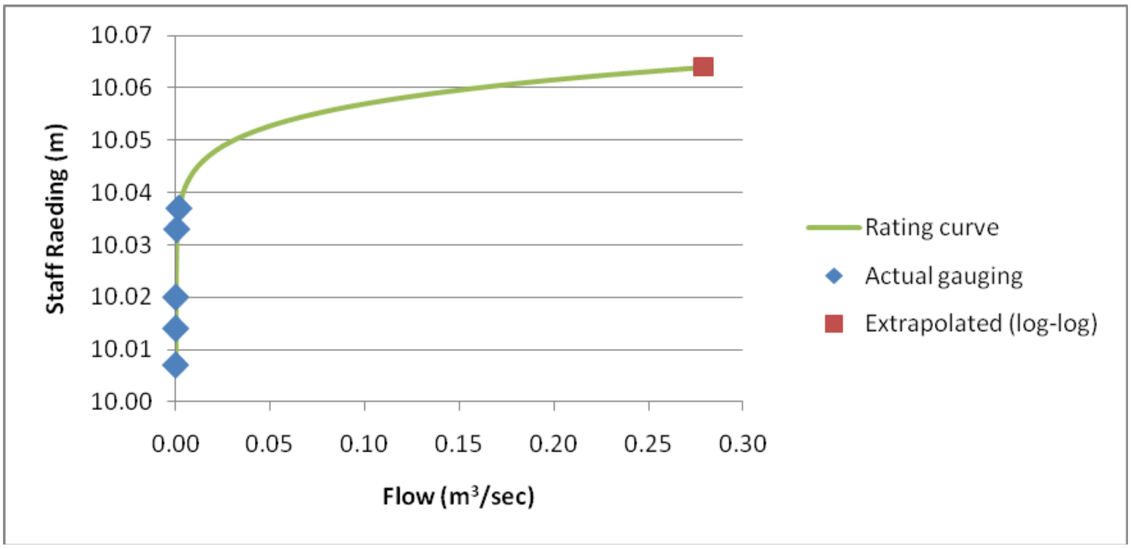


SW7

Stage application: 10.007- 10.064

Method: Log-log linear interpolation between 5 actual gauging points and extrapolated to highest stage.

log(Q)	log(depth above CTF)
-0.55441	-1.24413
-2.75129	-1.52288
-3.24109	-1.58503
-4.27572	-1.88606
-4.5376	-2.1549



Appendix D

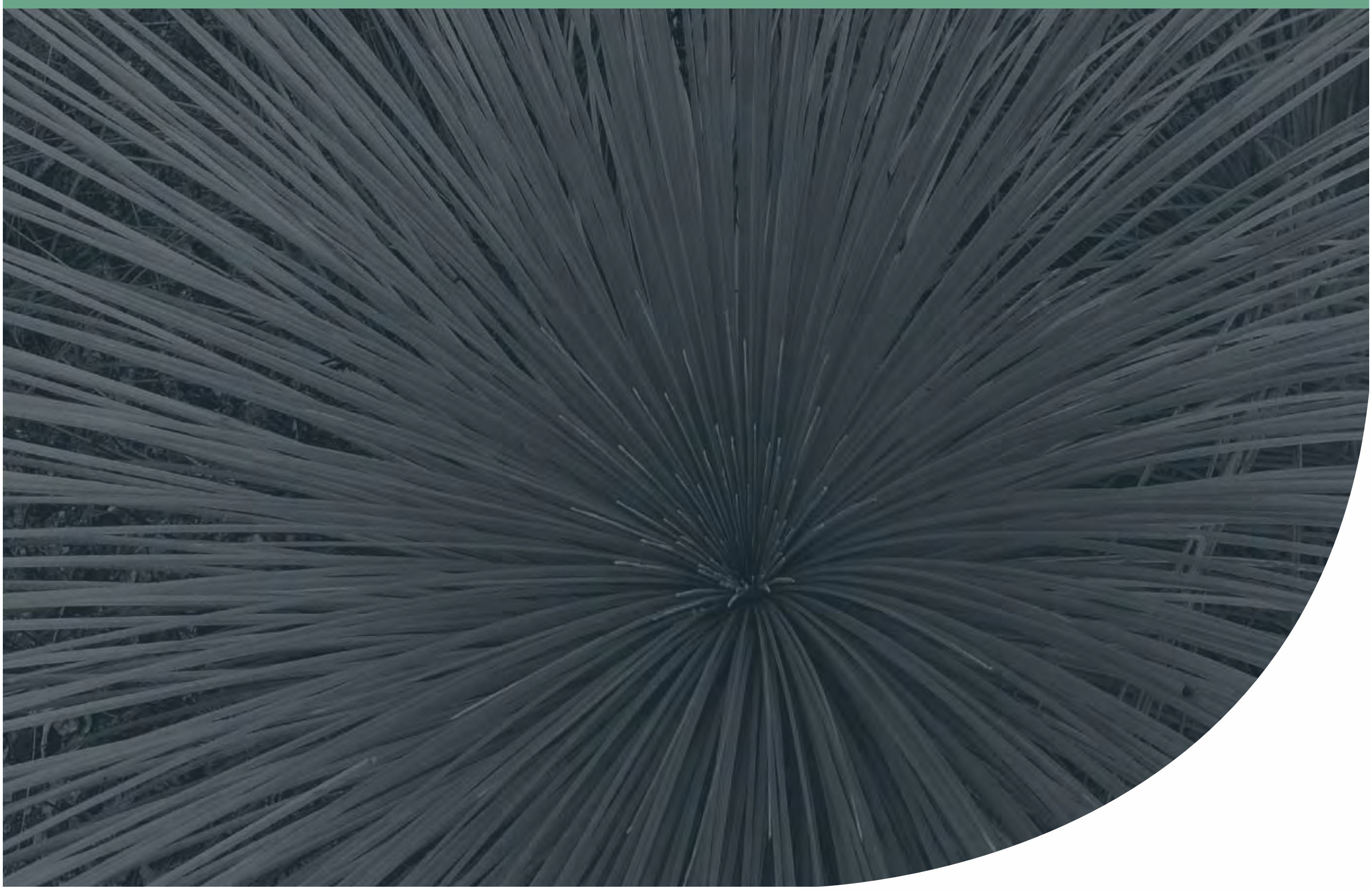
Surface Runoff Modelling Report

Modelling Assumptions Report

Maddington Kenwick Strategic Employment Area - Precinct 1 and 2

Project No: EP17-010(08)

Prepared for City of Gosnells
November 2018



Document Control

Doc name:	Modelling Assumptions Report Maddington Kenwick Strategic Employment Area - Precinct 1 and 2				
Doc no.:	EP17-010(08)--030				
Version	**Date**	**Author**		**Reviewer**	
1	June 2018	Justin Temmen	JRT	David Coremans	DPC
	Appendix to LWMS Precinct 1 and LWMS Precinct 2				
A	November 2018	Aisha Chalmers	ASC	David Coremans	DPC
	Appendix to LWMS Precinct 1 and LWMS Precinct 2				

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1 Modelling Assumptions

XPSWMM hydrologic and hydraulic modelling software was used to model and assess the surface water runoff volumes and peak flows within Precinct 1 and 2 of the Maddington Kenwick Strategic Employment Area (MKSEA) subdivision, referred to herein as 'the site'. Pre- and post-development 1D models and a pre-development integrated 1D-2D model were constructed for determining existing storage characteristics, peak flows entering and leaving the site, and required treatment and detention volumes. These models were informed using design rainfall, inflows from upstream catchments, a Digital Terrain Model (DTM) of the MKSEA pre-development topography, and analysis of existing features including culverts and swales.

The 1D and integrated 1D-2D models of the pre-development site were prepared to identify:

- The existing hydrological regime across the site to characterise the pre-development peak flows entering and exiting the site (1D, integrated1D-2D).
- The extent and depth of flooding in critical rainfall events (integrated 1D-2D).
- The storage characteristics within localised sub-catchments (integrated 1D-2D).

The 1D hydraulic component of the integrated 1D-2D pre-development model is linked to the 2D hydraulic component of the model through nodes and natural channel sections. Interconnection allows the 2D surface runoff to enter and exit from 1D components dynamically, depending on the hydraulic head of the connected 2D cells and 1D elements. **Section 2** details the pre-development model assumptions.

A post-development model demonstrates that the surface water management strategy proposed for the site maintains the pre-development peak flow rates leaving the site. The modelling assumptions used for the post-development environment are detailed in **Section 3**.

The hydrologic component of the software uses the runoff (pre) and Laurenson (post) non-linear runoff-routing method to simulate runoff from design storm events. Key assumptions regarding the hydrologic model include:

- Runoff is proportional to slope, area, infiltration and percentage of imperviousness of a catchment, as well as catchment width in the pre-development scenario.
- Infiltration rates and percentage imperviousness have been selected based on experience with model preparation for similar soil conditions.
- Sub-catchment areas and slopes are determined from the digital terrain model, aerial imagery and assessment of existing hydraulic structures.

Runoff from each sub-catchment is routed through the catchment using the hydraulic component of XPSWMM. Generally, assumptions associated with the hydraulic component of the model include:

- Virtual links (i.e. purely for model construction, not equivalent to flow path onsite) between nodes within a sub-catchment are given the length of 10 m and slope of 0.05 to minimise the lag time of conveying the water from a sub-catchment node to a 'storage' node, a 'dummy intermediate' node or a conduit/link.

- Links between sub-catchment storages act as conveyance channels (e.g. sheet flow within roads in a major, i.e. 1% average exceedance probability (AEP), rainfall event). These links are given lengths and slopes that are representative of the site conditions and actual pathway lengths between catchments.
- Channels are designed with a width of 5 m, roughness (Manning's n) of 0.014 and are trapezoidal in shape. This allows for easy conveyance and represents concrete pipes and road surfaces within the model.
- Ponding conditions have been disallowed within small rainfall event (first 15mm) treatment storage nodes (e.g. swales) for events greater than the small event.

Surface runoff modelling was not completed by Emerge Associates for Area 1 (i.e. catchments 2 and 3) and its upstream catchments (i.e. catchments 4, 14 and 15) shown in **Figure 1** as this has already been designed and constructed. This LWMS assumes that Area 1 maintains pre-development discharge rates and has/is being built in accordance with the Area 1 LWMS (McDowell Affleck 2016).

1.1 Design storm and critical duration

Design rainfall events for the site are the small rainfall (first 15 mm) event, the minor (i.e. 10% AEP) 36 hour event, and the major (i.e. 1% AEP) 36 hour event. These design rainfall events have been chosen for consistency with those reported within MKSEA Stage 3A Local Water Management Strategy (LWMS) (Emerge Associates 2017)., which modelled flows in Yule Brook. The design event (provided by Water Corporation) for Yule Brook accounts for the larger Yule Brook catchment, and is the primary discharge location for MKSEA. It is therefore appropriate to guide design event selection for the broader MKSEA.

2 Pre-development Model

2.1 Integrated 1D-2D model

The site was represented using an integrated 1D-2D model in order to verify flow paths and determine if there is any existing storage within the site for the small, minor and major rainfall events.

LiDAR data has been used to create a DTM for the site. The 2D model boundaries are consistent with the Precinct 1 and Precinct 2 site boundaries. The 2D model incorporates tail water conditions that would be experienced at the site discharge locations (discussed further in **Section 2.1.3**). Assumptions associated with the 2D component of the model include:

- A 10 m x 10 m 2D grid size and a 5 second time step to represent the relatively low and flat catchments.
- Rainfall on grid was used to model the pre-development environment so that runoff is hydraulically routed after allowing for infiltration and storage losses within the catchment.
- Culvert levels have been added to incorporate the eroded flow entry locations not represented in the topographical dataset.
- 1D links are coupled in to the 2D network by nodes which represent the actual flow path and culvert conditions.
- A minimum depth of 2 mm was used to determine 'wet' cells.

The 2D component of the model was coupled with the 1D component to provide a complete and dynamic analysis of catchments contributing runoff to the site. The 1D upstream and downstream catchments are linked to the 2D model at the eastern and northern boundaries. The 2D model routes flows from the coupled 1D model simultaneously with the 2D surface runoff analysis.

2.1.1 Catchment analysis

The site and upstream catchments are shown in **Figure 1** and Figure 11 of the respective LWMS for each precinct, and a breakdown of the modelled catchment characteristics is provided in **Table 1** and **Table 2** for Precinct 1 and Precinct 2 respectively.

Table 1 Pre-development catchment characteristics – Precinct 1

Catchment	Slope	Impervious percentage (%)	Sub-catchment area (ha)
Catchment 01	0.02	10	286.2
Catchment 02			
Catchment 03			
Catchment 04			
Catchment 07			
Catchment 12	0.02	20	5.2
Catchment 13	0.01	10	2.2
Catchment 14	0.02	2	9.4

Table 1 Pre-development catchment characteristics – Precinct 1 (continued)

Catchment	Slope	Impervious percentage (%)	Sub-catchment area (ha)
Catchment 15	0.01	30	1.9
Catchment 16	0.01	30	2.0
Ct-01	0.02	30	16.1
Ct-02	0.02	30	27.7
Ct-02A	0.02	30	8.8
Ct-03	0.02	30	10.4
Ct-04	0.02	30	39.8
Ct-05	0.02	30	2.6
Ct-06	0.02	30	3.3
Total			***415.6***

Table 2 Pre-development catchment characteristics – Precinct 2

Catchment	Slope	Impervious percentage (%)	Sub-catchment area (ha)
Catchment 05	0.01	25	3.3
Catchment 06	0.01	5	97.1
Catchment 08	0.01	10	11.7
Catchment 09	0.01	5	7.2
Catchment 10	0.01	10	51.4
Catchment 11	0.01	5	32.2
Catchment 17	0.01	30	2.9
Catchment 18	0.01	30	1.6
Catchment 19	0.01	5	14.1
Ct-07	0.01	15	11.4
Ct-08	0.01	15	20.6
Ct-09	0.01	15	5.1
Ct-10	0.01	15	121.8
Ct-11	0.01	15	13.7
DS Ct-01	0.01	0	23.8
DS Ct-02	0.01	5	106.4
Total			***524.3***

2.1.2 Catchment characteristics

Pre-development catchment boundaries contributing to the development site were based on site topography, and are shown in **Figure 1** and Figure 11 of the respective LWMS for each precinct.

An “initial loss - continual loss” infiltration model was adopted to represent the pre-development environment. Infiltration loss and surface roughness parameters were refined through a model calibration process, and characteristics were assigned based upon the soil profile across the site. Higher Manning’s values were used to represent buildings to simulate the limited overland flow paths. Pre-development land-use characteristics are summarised in **Table 3**. Figure 4 and Figure 8 of the respective LWMS documents illustrate the soil profiles, and maximum groundwater levels as determined by Endemic (Endemic 2012), respectively.

Table 3 1D and 2D MKSEA pre-development catchment parameters

Land type	Initial loss (mm)	Continual loss (mm)	Roughness
Buildings	1	0.1	3
Road Surface	1	0.1	0.02
Road Verge	9	1.5	0.05
Sand (0-0.3 m deep)	5	0.5	0.08
Sand (0.3-1.3 m deep)	10	1.5	0.08
Sand (1.3+ m deep)	15	2.5	0.08

2.1.3 Pre-development site hydraulics

The details for existing drainage infrastructure within Precinct 1 and Precinct 2 were taken from the City of Gosnells Intramaps (CoG 2018), were provided by Main Roads WA (J Miller [MRWA] 2017, pers. comm., 19th May), or determined using DTM data where aerial imagery determined the presence of infrastructure but where survey was not available. Culvert configuration, location, and size were confirmed by Emerge Associates (where visible inspection was possible), during onsite investigations in 2017 and 2018.

2.1.3.1 Culverts

Details of culverts as modelled are provided in **Table 4** and **Table 5**. These culverts were assigned Manning’s values of 0.014. Culvert locations are shown on **Figure 1** (with labels) and Figure 11 of the respective LWMS for each precinct.

Table 4 Upstream culverts

Location	Details	Length (m)	Downstream invert elevation (m AHD)	Upstream invert elevation (m AHD)
Tonkin Hwy Culvert AA	1x 300 mm	42	20.75	21
Tonkin Hwy Culvert 01	2x 900 mm	55	19.42	19.67
Tonkin Hwy Culvert 02	1x 450 mm	48	20.46	22
Tonkin Hwy Culvert 03	1x 450 mm	49	22.75	23

Table 4 Upstream culverts (continued)

Location	Details	Length (m)	Downstream invert elevation (m AHD)	Upstream invert elevation (m AHD)
Tonkin Hwy Culvert 04	1x 375 mm	47	23	23.75
Tonkin Hwy Culvert 05	1x 375 mm	52	23.93	24.89
Tonkin Hwy Culvert 06	1x 750 mm	52	24.27	25.07

Table 5 Downstream culverts

Location	Details	Length (m)	Downstream invert elevation (m AHD)	Upstream invert elevation (m AHD)
P1_W1 (Bickley Road 01) *	1x 600 mm	20	16.05	16.38
P1_W2 (Bickley Road 02) *	1x 750 mm	20	12	12.02
P1_W3 (Bickley Road 03)	1x 450 mm	22	11.94	11.95
P1_W4 (Bickley Road 04)	1x 525 mm	20	10.96	11.02
P1_N1 (Victoria Road 01)	1x 375 mm	25	11.81	11.96
P2_W1 (Bickley Road 05)	Discharge to pit/pipe	20	10.15	10.28
P2_W2 (Bickley Road 06)	2x 900 mm	20	8.34	8.44
P2_W3 (Bickley Road 07)	1x 300 mm	27	8.1	8.11
P2_10 (Brentwood Road 01)	2x 375 mm	25	10.91	11.03
P2_N1 (Boundary Road 01)	1x 900 mm	25	10.11	10.11

** Pit and pipe network infrastructure.*

Note: Not all culverts have been surveyed at this time. Future updates and / or design modelling should be informed by a complete survey.

2.1.3.2 Tailwater conditions

Catchments discharging towards the Bickley Road site boundary (both channel and pit & pipe networks) are assumed to have a 'free outfall' condition for accepting runoff from the pre-development site. It has been assumed that existing infrastructure has the capacity to accept pre-development flows. As matching pre-development flows at this boundary is a design outcome, the free-outfall condition is deemed suitable at this stage of design.

Runoff from most of Precinct 2 ultimately reaches Yule Brook, which is located beyond the Precinct 2 site boundary. Catchments downstream of Precinct 2 (as listed in **Table 2** and shown in **Figure 1**) have been included in the model. Runoff from these catchments discharges into Yule Brook beneath Brook Road. A stage hydrograph at this discharge location represents flows within Yule Brook and provides an appropriate tailwater condition for Precinct 2. Yule Brook at this location has an invert of 7.55 m AHD as presented in the Yule Brook Main Drain Long Sections (Water Corporation 2008) (see **Appendix A**).

The corresponding top water levels for each rainfall event are detailed in **Table 6** and were confirmed by the Water Corporation (G Undale [Water Corporation] 2018, pers. comm., 7th May).

Table 6 Tailwater conditions

Event	Minor event (10% AEP)	Major event (1% AEP)
Top water level (m AHD) at node YUA033A	10.40	10.61

Tailwater conditions provided by Water Corporation are consistent within the 1D and integrated 1D-2D models.

2.2 1D model

The site was represented using a 1D model in order to determine peak flow rates discharging from the site in a small, minor and major rainfall events. Assumptions associated with the 1D component of the model include:

- Catchments are directly linked to the 1D link nodes that represent the appropriate flow path. These links are given actual lengths, slopes and cross sections determined from the site topography.
- Catchment nodes within the 1D model are modelled as storage, with magnitudes of pre-development catchment storage estimated from 2D flood maps generated by the 1D-2D integrated model.
- The culverts are modelled as 1D links with their actual sizes (detailed in **Section 2.1.3**).
- Culvert losses and head wall conditions are chosen based on data collected during site visits.
- All flow path sections within Yule Brook are modelled as natural channels based on the DTM, and designed with surface roughness (Manning's n) of 0.025 in the central channel and 0.03 on the banks.
- Flow path sections of other drainage channels are modelled as trapezoidal sections designed with constant roughness of 0.08.

2.2.1 Catchment analysis

The catchment analysis for the 1D model was consistent with the integrated 1D-2D model, as discussed in **Section 2.1.1**.

2.2.2 Catchment characteristics

The 1D pre-development model was utilised to assess pre-development hydrology within the site, along with runoff inflow from external upstream catchments.

A breakdown of catchment areas within the development site and external catchments are given in **Section 2.1.1**. Pre-development catchment boundaries contributing to the development site were based on site topography, and are shown in **Figure 1** and Figure 11 of the respective LWMS for each precinct.

An “initial loss - continual loss” infiltration model was adopted to represent the pre-development environment. Pre-development land-use characteristics assumed within the 1D model are summarised in **Table 7**.

Table 7 1D MKSEA pre-development catchment parameters

Land type	Initial loss (mm)	Continual loss (mm)	Roughness
Pervious (upstream)	15	2.5	0.05
Impervious (upstream)	1	0.1	0.02

2.2.3 Pre-development site hydraulics

The pre-development site hydraulics data for the 1D model was consistent with the integrated 1D-2D model, as discussed in **Section 2.1.3**.

3 Post-development Model

A 1D post-development model has been developed to determine required treatment and detention volumes and demonstrate that the proposed stormwater management strategy for the site can maintain the existing hydrological regime.

3.1 Upstream catchment characteristics

The post-development model assumes upstream contributing catchment areas, downstream catchments and inflow locations consistent with those presented in the pre-development model (detailed in **Section 2**).

3.2 Catchment characteristics

3.2.1 Catchment analysis

The post-development catchments within the site were modelled as 1D components.

The post-development catchment areas have been determined using the existing topography of the site and the proposed road layout within the Local Structure Plan (LSP), provided in Appendix A of the LWMS. Land types within the catchments were guided by the LSP. A summary of post-development catchment information is provided in **Table 8** and **Table 9** with the post-development catchment boundaries shown in Figure 11 of the respective LWMS for each precinct.

POS and buffers to threatened ecological community (TEC) and conservation category wetland (CCW) areas are assumed to infiltrate surface runoff from all but the 20 m strip adjacent to roads and existing drainage channels. Lots that have a frontage to road reserves but back on to an ultimate discharge location (i.e. POS/buffer adjacent to the Greater Brixton Street Wetlands) are assumed to discharge towards the ultimate discharge location with the exception of a 20 m strip adjacent to the road reserve.

Table 8 MKSEA post-development catchment areas – Precinct 1

Catchment	Slope	Area (ha)				
		Total area	Total road reserve	Road pavement	Road verge	Open space
P1_01	0.02	16.07	0.85	0.85	0.36	0.00
P1_02	0.02	8.50	1.24	1.24	0.53	0.00
P1_02A Road (Undeveloped)	0.02	0.30	0.21	0.21	0.09	0.00
P1_05	0.02	38.24	2.57	2.57	1.10	1.29
P1_06	0.02	3.35	0.00	0.00	0.00	0.00
P1_07	0.02	8.35	0.16	0.16	0.07	0.00

Table 9 MKSEA post-development catchment areas – Precinct 2

Catchment	Slope	Area (ha)				
		Total area	Total road reserve	Road pavement	Road verge	Open space
P2_01	0.02	27.64	1.00	0.70	0.30	0
P2_02	0.02	46.31	2.68	1.87	0.80	0.62
P2_03	0.02	14.98	1.26	0.88	0.38	0.11
P2_04	0.02	37.23	4.27	2.99	1.28	10.72
P2_05	0.02	13.47	0.58	0.41	0.17	0.12
P2_06	0.02	18.30	1.63	1.14	0.49	0.00
P2_07	0.02	10.37	0.95	0.66	0.28	0.00
P2_08	0.02	4.31	0.73	0.51	0.22	0.38

3.2.2 Catchment characteristics

An “initial loss - continual loss” infiltration model was adopted to represent the post-development environment, with loss values assigned based on project team experience on analogous projects in the area similar to the site. **Table 10** provides the loss and roughness parameters used within the post-development model.

Table 10 Post-development infiltration and roughness parameters

Land type	Initial loss (mm)	Continual loss (mm/hr)	Manning’s ‘n’
Road surface	1	0.1	0.02
Road verge	9	2	0.02
Roof	1	0.1	0.02
Paved impervious surfaces	1	0.1	0.02
Landscaped areas	15	2.5	0.08
POS and TEC	15	1.5	0.08
Multi-use corridor (MUC)	10	1.5	0.08

The land use type areas and loss rates used were predominantly based upon the following assumptions:

- Lot assumptions:
  - Typical industrial lots are assumed consistent with other industrial developments in the greater Perth metropolitan area, having 50% roof area, 45% impervious area (e.g. car parks) and 5% pervious garden.
  - Lots will provide onsite retention storage for the small rainfall event (first 15 mm).
  - Lots will provide onsite detention storage sized to maintain the pre-development minor and major event peak flows discharging from the site (as detailed in Section 6.3 of the LWMS).
  - Landscaped areas will have higher infiltration rates as it is likely that sand and/or mulch will be used.

- Road reserve assumptions:
  - Road reserves contain 30% pervious verge and 70% impervious bitumen and other paved areas (e.g. foot paths, parking bays, etc.).
  - There will be no infiltration on roads, pavements and driveways. There will however be some minor absorption storage loss, which is accounted for in the initial and continuing loss values.
  - The road verge area will have an impervious footpath and some driveway crossovers and it is therefore anticipated that the averaged initial loss will be lower than open space initial loss rates.

3.2.3 Site hydraulics

Stormwater management structures for the treatment and detention of stormwater runoff were modelled to ensure pre-development flow rates are maintained in the post-development scenario.

- Estate drainage assumptions:
  - The small rainfall event (first 15 mm) runoff is primarily treated within swales. Swales are designed with consistent Manning's roughness (0.02 to base and side slopes) in order to retain and treat the small rainfall event road runoff.
    - Treatment swales are modelled as trapezoidal channels with 0.3 m depth, 1.2 m base width and 1:6 side slopes.
    - Swales are assumed to convey runoff from upstream catchments and catchments within the site (up to the major rainfall event). Swales are assumed to be on both sides of all existing roads and one side of new roads proposed by the LSP.
    - Swales are designed assuming interconnection between catchments; therefore design capacity exceeds required treatment volume in order to facilitate ultimate discharge of runoff generated by events exceeding the small rainfall (first 15 mm) event.
  - Detention areas will detain major event runoff (up to the major (i.e. 1% AEP) rainfall event) from road reserves and open space, and additional flows from lots for some catchments (see Section 7 of the LWMS).
    - Detention areas assume a maximum inundation depth of 1.2 m with 1:6 side slopes.
    - In order to match pre- and post- development peak flows, detention areas have been designed with low-flow and/or weir outlets.
    - The infiltration rate beneath detention areas is assumed negligible.

Volumes leaving the system through evapotranspiration were assumed to be negligible when compared to the total runoff volume and since the duration of model was comparatively short. Therefore default XPSWMM evapotranspiration assumptions are used.

4 References

4.1 General references

Emerge Associates 2017, *Local Water Management Strategy Maddington Kenwick Strategic Employment Area - Precinct 3A*.

Endemic 2012, *MKSEA Surface Water and Groundwater Monitoring and Invesitgation Report* (Final)

McDowell Affleck 2016, *Local Water Management Strategy for Maddington Kenwick Strategic Employment Area (MKSEA) Area 1*.

4.2 Online references

City of Gosnells (CoG) 2018, *City of Gosnells Intramaps*, viewed May 2018, <https://maps.gosnells.wa.gov.au/intramaps80/default.htm?project=Gosnells>.

Figures

Figure 1: Pre-development catchments and existing culverts.

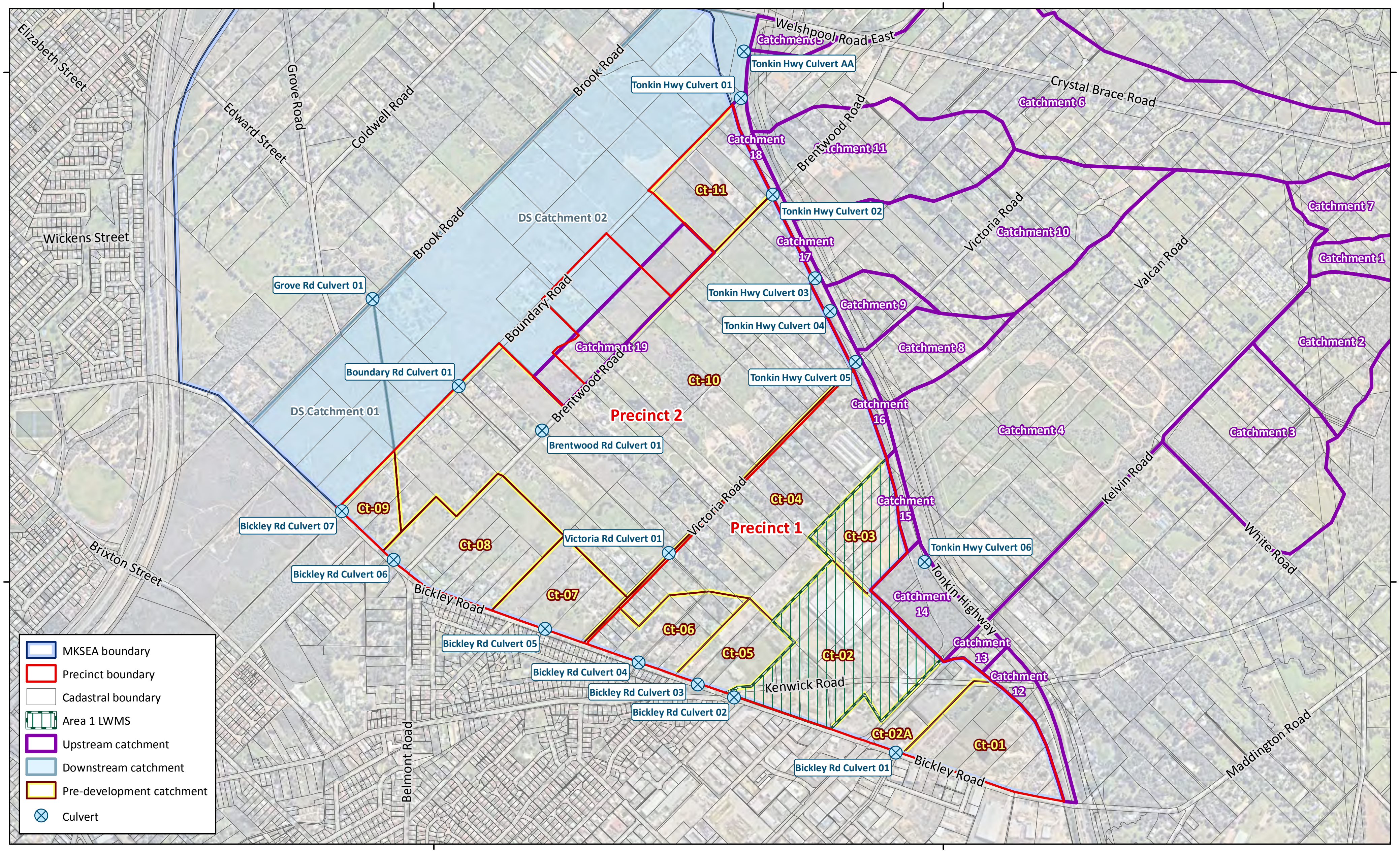


Figure 1: **Pre-development Catchments and Existing Culverts**

Project: Local Water Management Plan
MKSEA Structure Plan Support

Client: City of Gosnells

Plan Number:
EP17-010(08)--F113
Drawn: KNM
Date: 02/07/2018
Checked: JRT
Approved: ASC
Date: 03/07/2018

N

0 200 400 600
Metres
Scale: 1:20,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix A

Yule Brook Long Section (Water Corporation)

THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.

JOINS FIGURE D1.1

JOINS FIGURE D1.3

Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)	Invert level (m AHD)
1760	4.80	4.22	4.72	-	2.30
1890	5.03	4.32	4.78	2.53	2.53
2183	5.20	4.55	4.93	2.60	-
2184	5.20	5.10	5.43	-	3.00
2218	5.60	5.13	5.47	3.03	3.03
2229	5.60	5.23	5.60	3.04	3.04
2364	6.00	5.40	5.84	3.20	3.20
2438	6.00	5.46	5.93	3.41	3.41
2508	6.00	5.48	5.97	3.60	3.60
2869	8.80	7.17	7.79	4.20	4.20
2940	8.90	7.31	7.95	4.66	4.66
3045	7.75	7.35	8.01	5.20	5.20
3050	7.79	7.48	8.02	5.24	5.24
3057	7.80	7.48	8.02	5.57	5.57
3069	8.50	7.60	8.15	5.53	5.53
3126	8.50	7.73	8.26	5.70	5.70
3315	8.90	8.50	8.89	6.30	.

Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
15500x2500	22.67	26.92
15500x2500	22.67	26.92
	-	-
14600 x2200	22.67	26.93
10000 x2000	22.67	26.93
11825x1800	22.66	26.97
11825x1800	22.72	27.25
11825x1700	15.43	16.90
8500x1700	15.45	16.92
3/2400x1800	15.56	17.02
10200x2400	15.56	17.02
3/1493	21.77	26.67
13600 x2200	15.61	17.26
3/2400 x1800	15.63	17.46
20000 x1800	17.59	20.59
20000x1800	16.82	22.21

YULE BROOK MAIN DRAIN 2 OF 4

Hgls and Flows Ultimate System

LONGITUDINAL SECTION

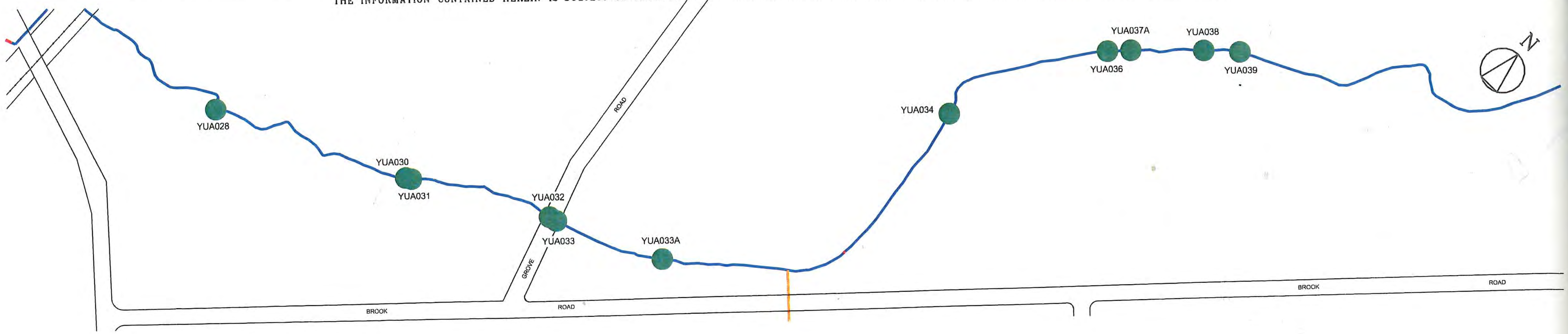
Ultimate Development

Figure D1.2

WATER CORPORATION

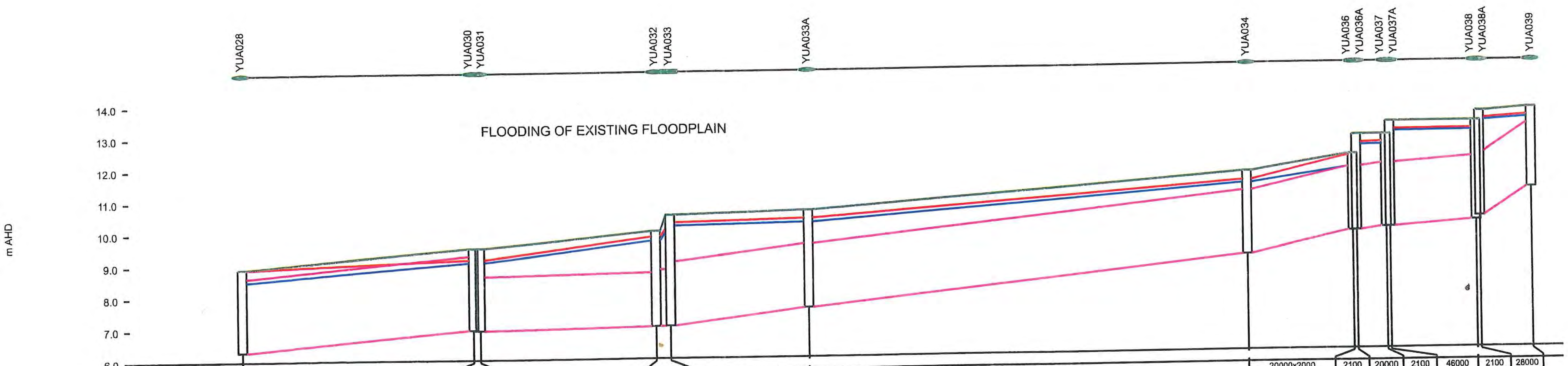
PROJECT N°: DP217 DATE: 20/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.



JOINS FIGURE D1.2

JOINS FIGURE D1.4



Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
3315	8.90	8.50	8.89	- / 6.30
3573	9.50	9.05	9.15	6.91 / 6.94
3580	9.50	9.05	9.15	6.95 / 6.92
3765	10.00	9.70	9.82	7.01 / 7.01
3774	10.50	10.16	10.26	7.02 / 7.02
3918	10.60	10.23	10.35	7.55 / 7.55
4380	11.60	11.24	11.33	9.00 / 9.00
4490	12.10	11.69	12.05	9.69 / 9.69
4494	12.70	12.37	12.45	9.70 / 9.70
4524	12.70	12.38	12.46	9.79 / 9.79
4528	13.10	12.79	12.85	9.80 / 9.80
4618	13.10	12.80	12.86	9.98 / 9.98
4622	13.40	13.10	13.16	10.11 / 10.11
4677	13.50	13.18	13.26	11.00 / -

Section (chainage)	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
3315–3573	20000x2000	15.80	25.00
3573–3580	3/1340	19.29	27.01
3580–3765	20000x1700	15.33	23.35
3765–3774	2/1791	15.21	23.91
3774–3918	20000x2000	21.19	28.95
3918–4380	20000x2000	14.77	21.44
4380–4490	20000x2000	15.37	18.94
4490–4494	2100 x1800	16.25	23.05
4494–4524	20000 x2000	17.97	20.14
4524–4528	2100 x1800	17.32	21.55
4528–4618	46000 x2000	20.50	23.47
4618–4622	2100 x1800	19.97	23.91
4622–4677	28000 x2000	13.15	20.37

YULE BROOK MAIN DRAIN 3 OF 4

Hgls and Flows Ultimate System Ultimate Development

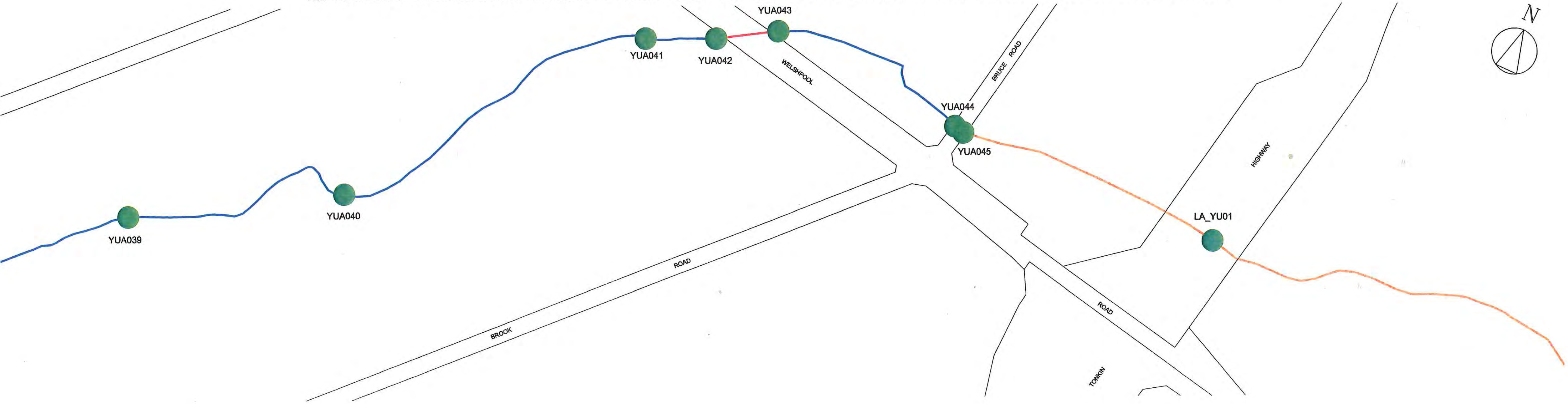
Figure D1.3

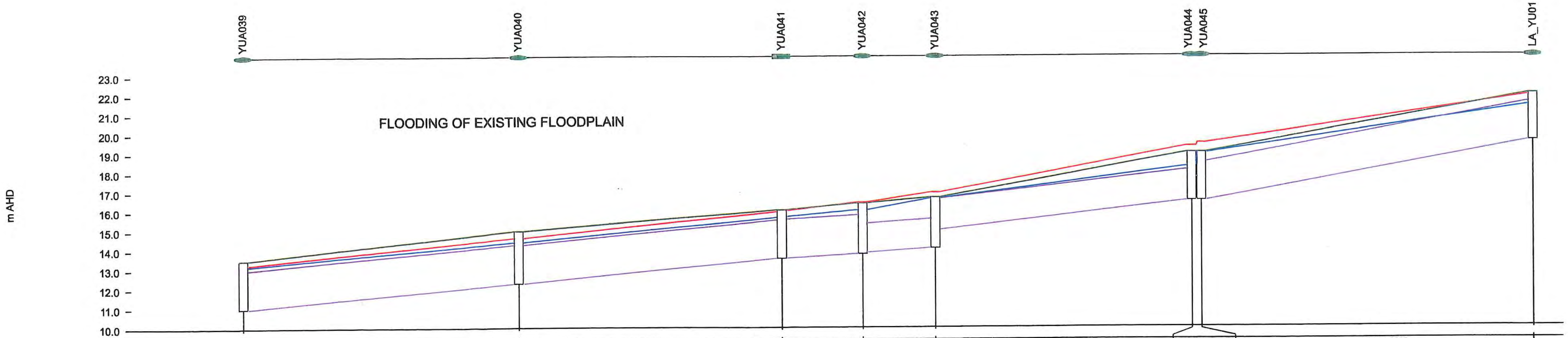
AUTHOR: FLETTNO DESIGN FILE: YuleBrk LSect.dgn

WATER CORPORATION

PROJECT N°: DP217 DATE: 20/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.





	YUA039		YUA040		YUA041		YUA042		YUA043		YUA044		YUA045		LA_YU01
Size (mm)		20000x2000		20000x2000		20000x2000		2/1800x1500 +1500		22000x1600		2/1800x1200 + 1200x1200		20000x2000	
Chainage (m)	4677		4965		5240		5325		5401		5671		5681		6027
Ground level (m AHD)	13.50		15.00		16.06		16.40		16.70		18.99		18.99		22.00
10 year ARI HGL level (m AHD)	13.16		14.43		15.69		16.04		16.64		18.27		18.96		21.40
100 year ARI HGL level (m AHD)	13.26		14.64		15.98		16.44		16.95		19.32		19.47		21.90
Invert level (m AHD)	- / 11.00		12.28 / 12.28		13.56 / 13.56		13.78 / 13.85		14.08 / 15.02		16.50 / 16.50		16.50 / 16.50		19.57 / -
Max 10 year ARI flow (m3/s)		18.11		16.51		17.21		16.95		16.95		17.44		17.34	
Max 100 year ARI flow (m3/s)		19.43		19.79		20.43		22.90		20.71		31.26 21.28?		21.53	

YULE BROOK MAIN DRAIN 4 OF 4

Hgls and Flows Ultimate System

LONGITUDINAL SECTION

Ultimate Development

Figure D1.4

WATER CORPORATION

ROJECT N°: DP217 DATE: 20/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

Appendix E

Groundwater Monitoring Results

Table E. 1 Groundwater level monitoring across MKSEA

Groundwater monitoring location ID	Location	Installer	Easting	Northing	30/5/2017 (m AHD)	6/7/2017 (m AHD)	24/11/2017 (m AHD)
GW1	Precinct 3C	Endemic	403746	6458393	10.82	-	11.25
GW2	Bush Forever Site 387	Endemic	404354	6457624	Destroyed		
GW3	Precinct 2	Endemic	403634	6456299	Dry	-	8.06
GW4	Bush Forever Site 387	Endemic	404395	6456985	12.04	12.48	Dry
GW5	Precinct 2	Endemic	405055	6457747	17.77	-	17.71
GW6	Precinct 2	Endemic	404664	6455861	11.37	-	No access
GW7	Precinct 2	Endemic	405060	6456259	14.00	-	14.12
GW8	Precinct 2	Endemic	405590	6456777	20.60		20.58
GW9	Precinct 1	Endemic	405746	6455981	Destroyed		
GW11	Precinct 3A	Endemic	403216	6457825	Dry	-	9.61
GW12	Precinct 3B	Endemic	403440	6456803	No access		
MB01	Precinct 1	Strategen	405972	6455680	Dry	-	Dry
MB02	Precinct 1	Strategen	405582	6455625	Could not find		
MB03	Precinct 1	Strategen	405330	6455847	Dry	-	15.90
MB04	Precinct 1	Strategen	405564	6456074	Destroyed		

Note: Divers were installed at GW4 and GW7 in July 2017.

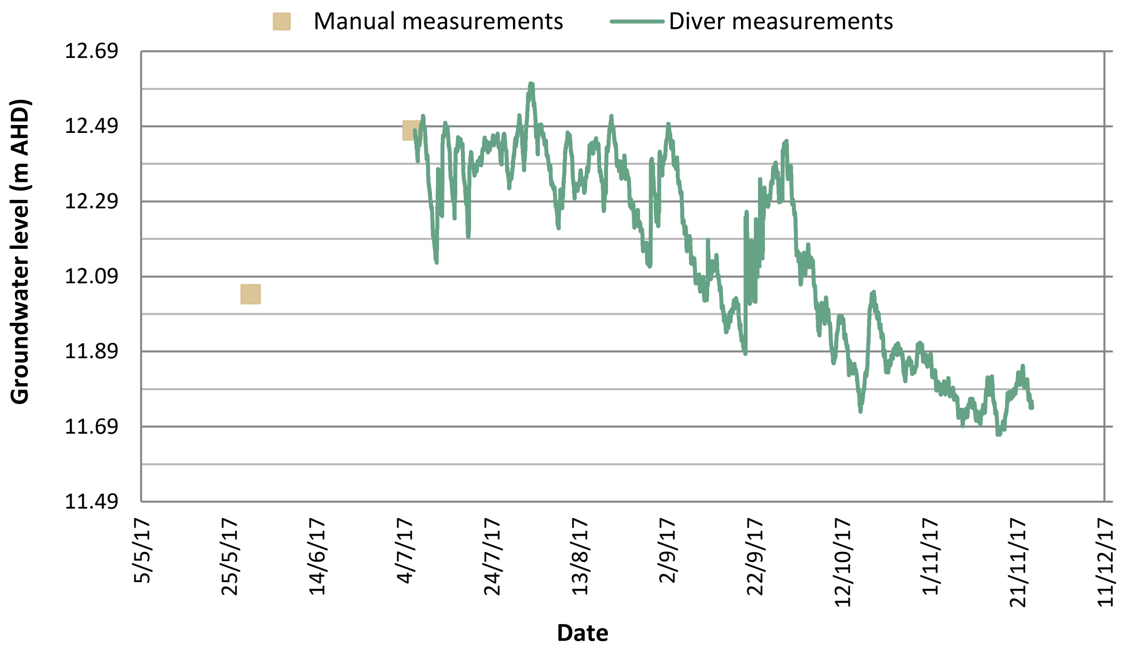


Plate 1: Groundwater levels measured by diver at GW4

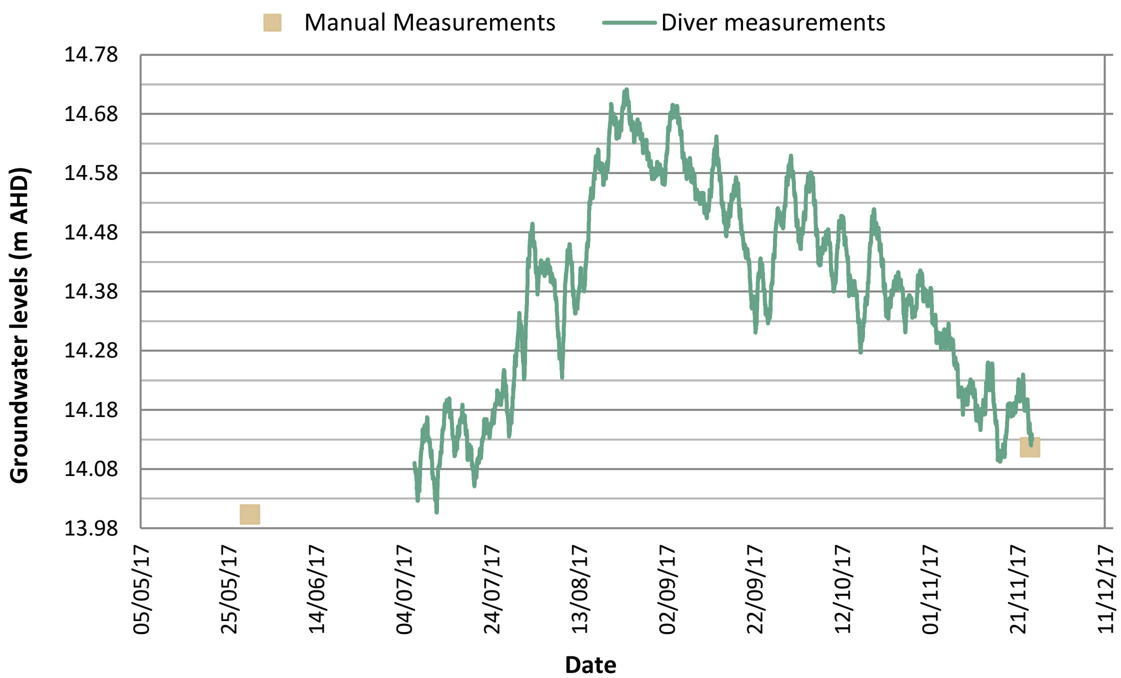


Plate 2: Groundwater levels measured by diver at GW7

Table 99: Ground water Quality Results for the MKSEA: Field Parameters and Nutrients.

Sample ID	Date	Field Parameters									Nutrients						
		Temp	pH	Electrical Conductivity	Dissolved Oxygen	Redox	TSS	TDS	BOD	COD	TN	NOx_N	NO2_N	Nitrate-NO3	TKN	TP	FRP
	units	ºC		mS/cm	mg/L	mV	mg/L	ppk	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Domestic non-potable trigger values		-	-	-	-	-	-	-	-	-	-	-	30	500	-	-	-
LT Irrigation trigger values		-	6-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW01	9-Sep-09	18.4	7.37	4.810	0.0	-22.0	130	2.02	53.0	500.0	3.30	<0.005	<0.005	<0.01	3.3	0.27	<0.005
GW02	9-Sep-09	17.2	6.96	23.960	6.2	-3.4	10000	10.88	82.0	10000.0	3.10	<0.005	<0.005	<0.01	3.1	0.12	<0.005
GW03	9-Sep-09	15.9	7.11	0.525	1.1	-9.2	200	0.2	82.0	61.0	0.76	0.015	0.011	<0.01	0.75	0.07	<0.005
GW04	9-Sep-09	Insufficient sample for analysis															
GW05	9-Sep-09	16.4	7.23	0.653	0.6	-14.9	3300	0.251	7.0	580.0	3.80	0.015	<0.005	<0.01	3.8	0.07	<0.005
GW06	9-Sep-09	19.4	6.99	0.586	1.3	2.9	1600	0.225	7.0	1600.0	19.00	7.7	0.006	7.6806	12	0.21	<0.005
GW07	9-Sep-09	18.3	7.31	0.278	6.9	-17.1	4900	0.103	78.0	720.0	4.70	1.2	<0.005	1.19727	3.5	0.28	<0.005
GW08	10-Sep-09	18.3	7.3	0.240	0.0	-16.8	1700	0.88	64.0	190.0	2.30	0.38	0.018	0.36144	2	0.22	<0.005
GW09	9-Sep-09	17.2	7.02	0.523	1.0	0.6	-	0.2	-	-	-	-	-	-	-	-	-
GW11	9-Sep-09	18.3	6.73	0.220	6.9	7.8	2500	0.0796	74.0	190.0	3.20	0.12	<0.005	0.119727	3	0.97	0.078
GW12	9-Sep-09	15.5	7.39	8.830	0.5	-22.6	710	8.76	92.0	290.0	3.90	<0.005	<0.005	<0.01	3.9	0.99	0.68
GW01	25-Nov-09	21.9	7.84	3.750	0.2	-65.0	2900	0.91	-	-	3.30	-	<0.1	<0.01	3.2	0.15	<0.005
GW02	25-Nov-09	23.6	6.12	19.690	4.8	28.9	-	-	60.0	6400.0	2.00	-	<0.1	0.02259	1.9	<0.01	<0.005
GW03	25-Nov-09	20.6	7.25	2.258	1.6	-34.5	24000	0.158	50.0	4800.0	1.20	-	<0.1	0.04518	1.2	0.17	0.081
GW04	25-Nov-09	-	-	-	-	-	7000	0.202	-	-	-	-	-	-	-	-	-
GW05	25-Nov-09	22	7.79	0.421	4.2	-48.0	1300	0.093	42.0	9600.0	3.10	-	<0.1	0.04518	3	0.05	<0.005
GW06	25-Nov-09	20.1	6.88	0.533	0.3	9.5	-	0.0534	24.0	13000.0	4.20	-	<0.1	1.06173	3	0.25	<0.005
GW07	25-Nov-09	21.7	7.05	0.251	2.8	-17.9	-	-	39.0	8000.0	3.30	-	<0.1	1.42317	1.8	0.15	0.11
GW08	25-Nov-09	21.6	7.55	0.148	1.9	-36.4	3700	0.097	-	-	2.80	-	<0.1	0.24849	2.4	0.09	0.16
GW09	25-Nov-09	-	-	-	-	-	8800	12	-	-	-	-	-	-	-	-	-
GW11	25-Nov-09	21.3	6.91	0.263	0.9	-9.6	-	-	21.0	6400.0	2.30	-	<0.1	0.51957	1.7	0.48	0.11
GW12	25-Nov-09	19.9	7.68	26.6	0.2	-51.5	-	-	71.0	11000	2.70	-	<0.1	<0.01	2.6	1.4	<0.005
GW01	23-Mar-10	Insufficient sample for analysis															
GW02	23-Mar-10	Insufficient sample for analysis															
GW03	23-Mar-10	Insufficient sample for analysis															
GW04	23-Mar-10	Insufficient sample for analysis															
GW05	23-Mar-10	Insufficient sample for analysis															
GW06	23-Mar-10	23.2	6.02	0.578	0.0	30.1	-	0.22	120.0	120.0	-	-	-	-	-	-	<0.005
GW07	23-Mar-10	Insufficient sample for analysis															
GW08	23-Mar-10	Insufficient sample for analysis															
GW09	23-Mar-10	Insufficient sample for analysis															
GW11	23-Mar-10	Insufficient sample for analysis															
GW12	23-Mar-10	Insufficient sample for analysis															
GW01	24-Jun-10	17.9	7.81	4.22	0.1	-43.5	918.000	1.75	5	91	-	0.05	<0.01	0.05	2.2	0.17	0.02
GW02	24-Jun-10	Insufficient sample for analysis															
GW03	24-Jun-10	16.3	7.73	0.824	0.3	-38.8	<5	0.318	6	30	-	7.55	<0.01	7.55	9	0.05	<0.01
GW04	24-Jun-10	16.1	8.02	0.422	1.4	-53.5	-	0.198	-	-	-	0.06	0.02	0.03	1.9	0.26	0.07
GW05	24-Jun-10	15.5	7.27	0.783	4.8	-11.7	320.000	0.304	<2	93	-	0.58	<0.01	0.58	2.8	0.1	<0.01
GW06	24-Jun-10	19.6	6.81	0.638	0.0	26.2	1420.000	0.246	8	197	-	0.08	<0.01	0.08	2.6	0.3	<0.01
GW07	24-Jun-10	Insufficient sample for analysis															
GW08	24-Jun-10	Insufficient sample for analysis															
GW09	24-Jun-10	Insufficient sample for analysis															
GW11	24-Jun-10	Insufficient sample for analysis															
GW12	24-Jun-10	16.9	8.18	7.23	4.4	-62.0	-	3.05	-	-	-	0.54	<0.01	0.54	2.6	0.52	0.07
GW01	23-Sep-10	19.1	7.85	4.61	2.7	-	390	1.93	-	-	8.5	0.07	<0.01	0.07	8.4	1.08	<0.01
GW02	23-Sep-10	19.6	4.15	3.3	3.6	-	306	1.1	-	-	<1.0	0.02	<0.01	0.02	<1.0	0.95	<0.01
GW03	23-Sep-10	18.2	7.38	5.53	1.8	-	422	2.05	-	-	1.2	0.06	<0.01	0.06	1.1	0.08	<0.01
GW04	23-Sep-10	-	-	-	-	-	220	-	-	-	7.8	4.02	0.07	3.95	3.8	0.64	<0.01
GW05	23-Sep-10	18.2	7.16	4.9	4.3	-	30	1.86	-	-	6.2	4.5	<0.01	4.5	1.7	0.12	<0.01
GW06	23-Sep-10	20.3	6.29	10.52	3.0	-	-	4.09	-	-	-	-	-	-	-	-	-
GW07	23-Sep-10	Insufficient sample for analysis															
GW08	23-Sep-10	Insufficient sample for analysis															
GW09	23-Sep-10	-	-	-	-	-	-	-	-	-	4.1	0.04	<0.01	0.04	4.1	1.11	0.08
GW11	23-Sep-10	21.2	7.22	8.41	4.2	-	60	0.324	-	-	2.1	0.61	<0.01	0.61	1.5	0.26	0.05
GW12	23-Sep-10	16.7	7.24	2.076	3.2	-	-	0.933	-	-	-	-	-	-	-	-	-
GW01	15-Dec-10	29.8	7.87	40.6	5	-	-	14	-	-	8.9	<0.01	-	-	8.9	0.39	-
GW02	15-Dec-10	25.9	4.86	15.8	4.2	-	1060	7.3	-	-	2.1	0.02	<0.01	0.02	2.1	0.24	0.01
GW03	15-Dec-10	26	8.17	20.1	-	-	-	6.46	-	-	-	-	-	-	-	-	-
GW04	15-Dec-10																
GW05	15-Dec-10																
GW06	16-Dec-10	23.3	6.7	1.075	6.2	-	686	0.417	-	-	-	-	-	-	-	-	-
GW07	15-Dec-10	Insufficient sample for analysis															
GW08	15-Dec-10	Insufficient sample for analysis															
GW09	15-Dec-10	Insufficient sample for analysis															
GW11	15-Dec-10	Insufficient sample for analysis															
GW12	15-Dec-10	25	6.98	20.98	3.0	-	1480	9.8	-	-	8.4	0.08	0.02	0.05	8.3	1.5	0.09

Table 1010: Groundwater Quality results for the MKSEA: Metals.

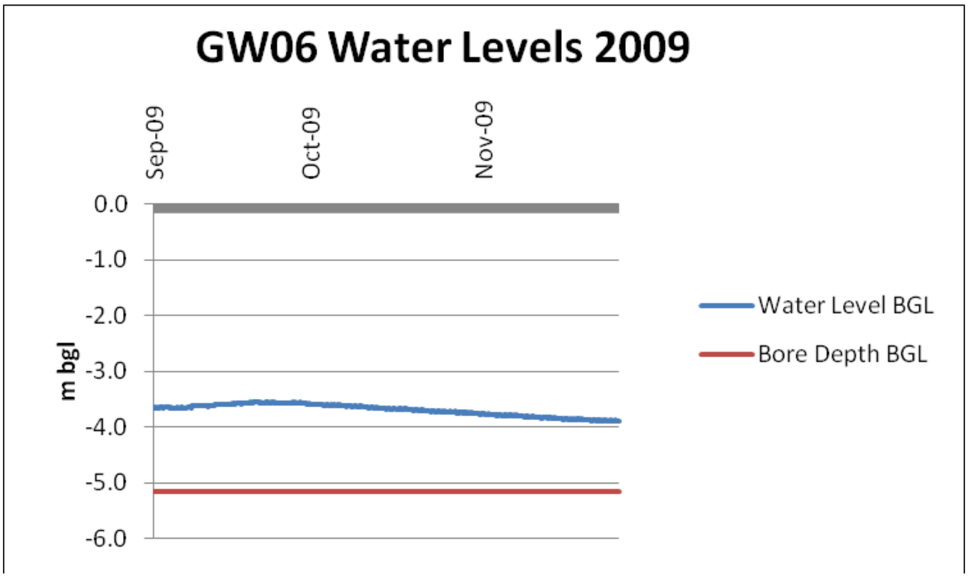
Sample ID	Date	Metals												
		Aluminium	Arsenic	Cadmium	Cobalt	Chromium	Copper	Iron	Mercury	Manganese	Nickel	Lead	Selenium	Zinc
	units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Domestic non-potable trigger		2	0.07	0.02	-	0.5	20	3	0.01	5	0.2	0.1	0.1	30
LT Irrigation trigger		5	0.1	0.01	0.05	0.1	0.2	0.20	0.002	0.2	0.2	2	0.02	2
GW01	9-Sep-09	5.7	<0.05	<0.001	<0.005	0.013	0.015	6	0.0015	0.04	<0.005	<0.01	<0.1	<0.005
GW02	9-Sep-09	200	0.2	0.033	0.032	0.43	0.3	970	0.0057	6.9	0.21	0.1	<0.1	0.66
GW03	9-Sep-09	1.8	<0.05	<0.001	<0.005	0.002	0.002	3	0.0003	0.04	<0.005	0.017	<0.1	<0.005
GW04	9-Sep-09	Insufficient sample for analysis												
GW05	9-Sep-09	4.3	<0.05	<0.001	<0.005	0.043	0.017	21	0.0005	0.062	0.014	0.017	<0.1	<0.005
GW06	9-Sep-09	30	<0.05	<0.001	<0.005	0.049	0.029	12	0.0004	0.027	0.004	0.014	<0.1	0.11
GW07	9-Sep-09	7	<0.05	<0.001	<0.005	0.008	<0.005	3.4	0.0006	0.006	<0.005	0.15	<0.1	<0.005
GW08	10-Sep-09	44	<0.05	0.0034	<0.005	0.74	0.18	76	0.0006	0.26	0.089	0.068	<0.1	0.36
GW09	9-Sep-09	Insufficient sample for analysis												
GW11	9-Sep-09	19	<0.05	<0.001	<0.005	0.007	0.005	1.9	0.0008	0.004	<0.005	0.15	<0.1	0.13
GW12	9-Sep-09	1.9	<0.05	<0.001	<0.005	0.015	0.013	10	0.0004	0.45	0.002	<0.01	<0.1	0.14
GW01	25-Nov-09	Insufficient sample for analysis												
GW02	25-Nov-09	38	<0.001	<0.0001	0.041	0.028	0.041	51	<0.0001	2.4	0.1	0.011	0.016	0.15
GW03	25-Nov-09	7	<0.001	<0.0001	0.012	0.006	0.007	9	<0.0001	0.12	0.009	0.044	0.002	0.085
GW04	25-Nov-09	Insufficient sample for analysis												
GW05	25-Nov-09	90	0.013	0.0006	<0.005	1.2	0.41	310	<0.0001	0.69	0.42	0.19	0.01	1.1
GW06	25-Nov-09	52	0.006	<0.0001	0.017	0.32	0.21	39	<0.0001	0.1	0.066	0.064	0.002	0.35
GW07	25-Nov-09	2	0.001	<0.0001	0.021	0.005	0.007	1.2	<0.0001	0.008	0.011	0.047	0.002	0.057
GW08	25-Nov-09	38	0.005	<0.0001	0.006	1	0.38	82	<0.0001	0.24	0.98	0.036	0.002	0.61
GW09	25-Nov-09	Insufficient sample for analysis												
GW11	25-Nov-09	19	0.003	<0.0001	0.02	0.008	0.01	1.4	<0.0001	0.004	0.013	0.041	<0.001	0.12
GW12	25-Nov-09	65	0.019	0.0001	0.017	1.7	0.48	210	<0.0001	1.5	0.2	0.088	<0.01	1.9
GW01	24-Jun-10	1.36	0.001	<0.00005	0.002	0.003	0.011	1	<0.0001	0.003	0.007	0.001	0.001	0.001
GW02	24-Jun-10	Insufficient sample for analysis												
GW03	24-Jun-10	0.01	<0.0002	<0.00005	<0.0001	0.001	0.003	0.018	<0.0001	0.003	0.004	<0.0001	<0.0002	<0.001
GW04	24-Jun-10	0.045	0.003	<0.00005	0.002	0.045	0.019	0.193	<0.0001	0.048	0.011	0.001	0.001	0.007
GW05	24-Jun-10	0.074	0.001	<0.00005	0.001	0.002	0.005	0.139	<0.0001	0.001	0.017	<0.0001	0.001	<0.001
GW06	24-Jun-10	0.081	<0.0002	<0.00005	0.001	0.001	0.003	0.201	<0.0001	0.005	0.001	<0.0001	<0.0002	0.001
GW07	24-Jun-10	Insufficient sample for analysis												
GW08	24-Jun-10	Insufficient sample for analysis												
GW09	24-Jun-10	Insufficient sample for analysis												
GW11	24-Jun-10	Insufficient sample for analysis												
GW12	24-Jun-10	0.009	0.005	<0.05	0.003	0.002	0.018	0.194	<0.0001	0.17	0.026	0.001	0.003	0.01
GW01	23-Sep-10	36.7	0.006	0.0001	0.148	0.107	0.164	37.6	0.0003	0.219	0.096	0.048	<0.01	0.326
GW02	23-Sep-10	45.7	0.011	0.0002	0.093	0.091	0.049	48.2	<0.0001	1.75	0.192	0.015	<0.01	1.68
GW03	23-Sep-10	1.04	<0.001	<0.0001	0.001	0.005	0.005	1.38	0.0001	0.03	0.003	0.003	<0.01	0.034
GW04	23-Sep-10	3.95	0.001	<0.0001	0.002	0.012	0.008	8.74	0.0002	0.015	0.01	0.01	<0.01	0.03
GW05	23-Sep-10	3.79	0.002	<0.0001	0.004	0.014	0.007	31.2	<0.0001	0.02	0.005	0.008	<0.01	0.299
GW06	23-Sep-10	Insufficient sample for analysis												
GW07	23-Sep-10	Insufficient sample for analysis												
GW08	23-Sep-10	Insufficient sample for analysis												
GW09	23-Sep-10	16.2	0.004	<0.0001	0.002	0.012	0.01	1.11	0.0002	0.021	0.011	0.039	<0.01	0.089
GW11	23-Sep-10	0.95	0.006	0.0001	0.006	0.095	0.036	2.21	<0.0001	0.118	0.222	0.001	<0.01	0.038
GW12	23-Sep-10	Insufficient sample for analysis												
GW01	15-Dec-10	45.4	0.007	0.0004	0.147	0.19	0.14	43.4	<0.0001	0.257	0.115	0.05	<0.01	0.421
GW02	15-Dec-10	Insufficient sample for analysis												
GW03	15-Dec-10	Insufficient sample for analysis												
GW04	15-Dec-10	Insufficient sample for analysis												
GW05	15-Dec-10	Insufficient sample for analysis												
GW06	16-Dec-10	Insufficient sample for analysis												
GW07	15-Dec-10	Insufficient sample for analysis												
GW08	15-Dec-10	Insufficient sample for analysis												
GW09	15-Dec-10	Insufficient sample for analysis												
GW11	15-Dec-10	Insufficient sample for analysis												
GW12	15-Dec-10	Insufficient sample for analysis												

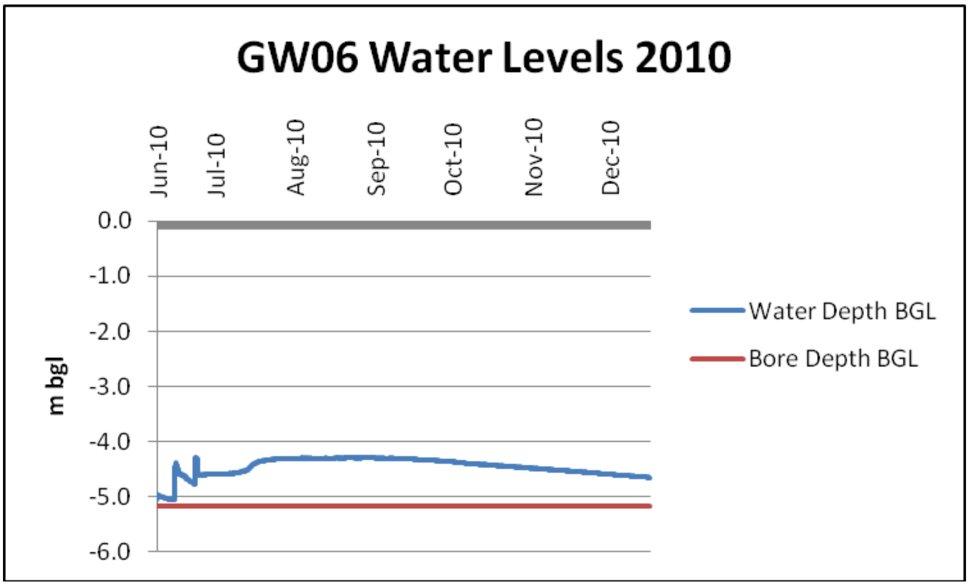
Table 1111: Groundwater Quality Results for the MKSEA: Total Petroleum Hydrocarbons and BTEX, Polynuclear Aromatic Hydrocarbons.

Sample ID	Date	TPH and BTEX									Polynuclear Aromatic Hydrocarbons															
		TPH	C6-9	C10-14	C15-28	C29-36	Benzene	Toluene	Ethylbenzene	Xylene	Napthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(b)flruoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1.2.3cd)pyrene	Dibenz(a.h)anthracerene	Benzo(g.h.i)perylene
	units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Domestic non-potable		-	-	-	-	-	10	25	3	20	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-
LT Irrigation		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW01	9-Sep-09	<260	<20	<40	<100	<100	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW02	9-Sep-09	<260	<20	<40	<100	<100	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW03	9-Sep-09	<260	<20	<40	<100	<100	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW04	9-Sep-09	<260	<20	<40	<100	<100	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW05	9-Sep-09	<260	<20	<40	<100	<100	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW06	9-Sep-09	<260	<20	<40	<100	<100	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW07	9-Sep-09	<260	<20	<40	<100	<100	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW08	10-Sep-09	401	<20	<40	401	<100	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW09	9-Sep-09	<260	<20	<40	<100	<100	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW11	9-Sep-09	<260	<20	<40	<100	<100	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW12	9-Sep-09	<260	<20	<40	<100	<100	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW01	24-Sep-09	-	-	-	-	-	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
GW02	24-Sep-09	-	-	-	-	-	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
GW03	24-Sep-09	-	-	-	-	-	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
GW04	24-Sep-09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW05	24-Sep-09	-	-	-	-	-	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
GW06	24-Sep-09	-	-	-	-	-	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
GW07	24-Sep-09	-	-	-	-	-	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
GW08	24-Sep-09	-	-	-	-	-	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
GW09	24-Sep-09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW11	24-Sep-09	-	-	-	-	-	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
GW12	24-Sep-09	-	-	-	-	-	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
GW01	24-Jun-10	-	<20	<50	<100	<50	<0.5	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
GW02	24-Jun-10	Insufficient sample for analysis																								
GW03	24-Jun-10	-	<20	<50	<100	<50	<0.5	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
GW04	24-Jun-10	-	-	-	-	-	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW05	24-Jun-10		<20	<50	<100	<50	<0.5	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
GW06	24-Jun-10		<20	<50	<100	<50	<0.5	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0
GW07	24-Jun-10	Insufficient sample for analysis																								
GW08	24-Jun-10	Insufficient sample for analysis																								
GW09	24-Jun-10	Insufficient sample for analysis																								
GW11	24-Jun-10	Insufficient sample for analysis																								
GW12	24-Jun-10	-	-	-	-	-	<0.5	<1.0	<1.0	<3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1212: Groundwater Quality Results for the MKSEA: Organochloride and Organophosphate Pesticides.

Sample ID	DATE	alpha-BHC	Hexachlorobenzene (HCB)	beta-BHC	gamma-BHC	delta-BHC	Heptachlor	Aldrin	Heptachlor epoxide	trans-Chlordane	alpha-Endosulfan	cis-Chlordane	Dieldrin	4.4`-DDE	Endrin aldehyde	Endosulfan sulfate	4.4`-DDT	Endrin ketone	Endrin	Dichlorvos	Demeton-S-methyl	Monocrotophos	Dimethoate	Diazinon	Chlorpyrifos-methyl	Parathion-methyl	Malathion	Fenthion	Chlorpyrifos	Parathion	Pirimphos-ethyl	Chlorfenvinphos (Z)	Bromophos-ethyl	Fenamiphos	Prothiofos	Ethion
	units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Domestic non-potable		-	-	-	-	-	-	3	3	10	-	10	3	-	-	-	200	-	-	-	-	-	-	1	-	0.3	-	-	10	10	-	-	-	-	-	-
LT Irrigation		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GW01	24/9/09	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-	<1.0
GW02	24/9/09	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-	<1.0
GW03	24/9/09	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-	<1.0
GW04	24/9/09	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-	<1.0
GW05	24/9/09	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-	<1.0
GW06	24/9/09	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-	<1.0
GW07	24/9/09	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-	<1.0
GW08	24/9/09	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-	<1.0
GW09	24/9/09	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-	<1.0
GW11	24/9/09	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-	<1.0
GW12	24/9/09	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-	-	-	-	<1.0
GW01	24/6/10	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.09	<0.10	<0.10	<0.10	<0.100	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
GW02	24/6/10	Insufficient sample for analysis																																		
GW03	24/6/10	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.09	<0.10	<0.10	<0.10	<0.100	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
GW04	24/6/10	Insufficient sample for analysis																																		
GW05	24/6/10	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.09	<0.10	<0.10	<0.10	<0.100	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
GW06	24/6/10	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.100	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
GW07	24/6/10	Insufficient sample for analysis																																		
GW08	24/6/10	Insufficient sample for analysis																																		
GW09	24/6/10	Insufficient sample for analysis																																		
GW11	24/6/10	Insufficient sample for analysis																																		
GW12	24/6/10	Insufficient sample for analysis																																		





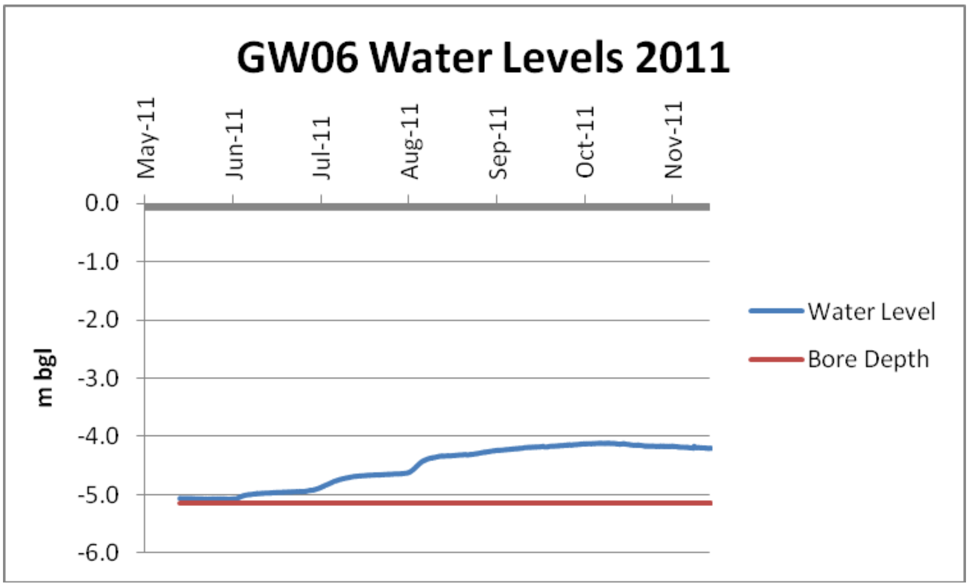
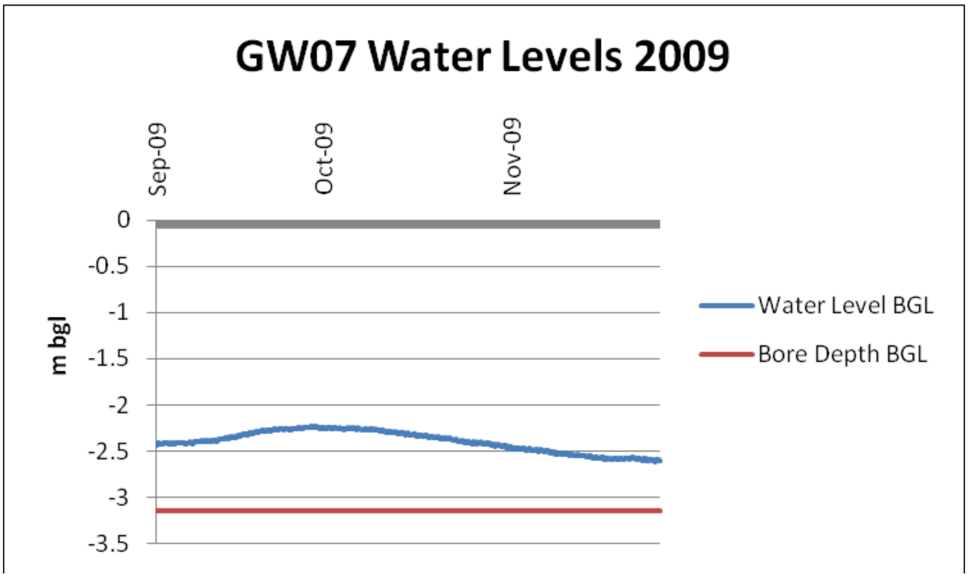
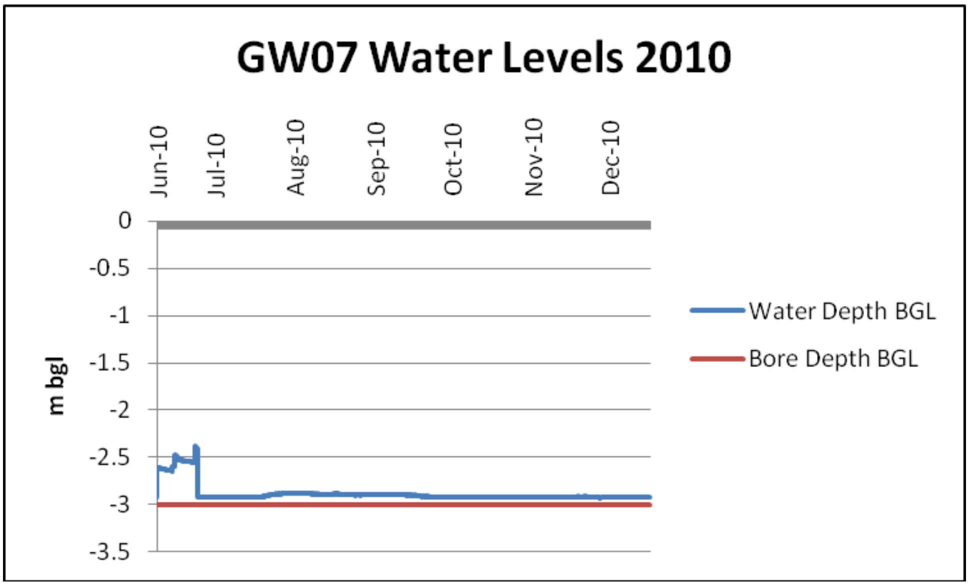


Figure 7: Groundwater hydrographs for GW06





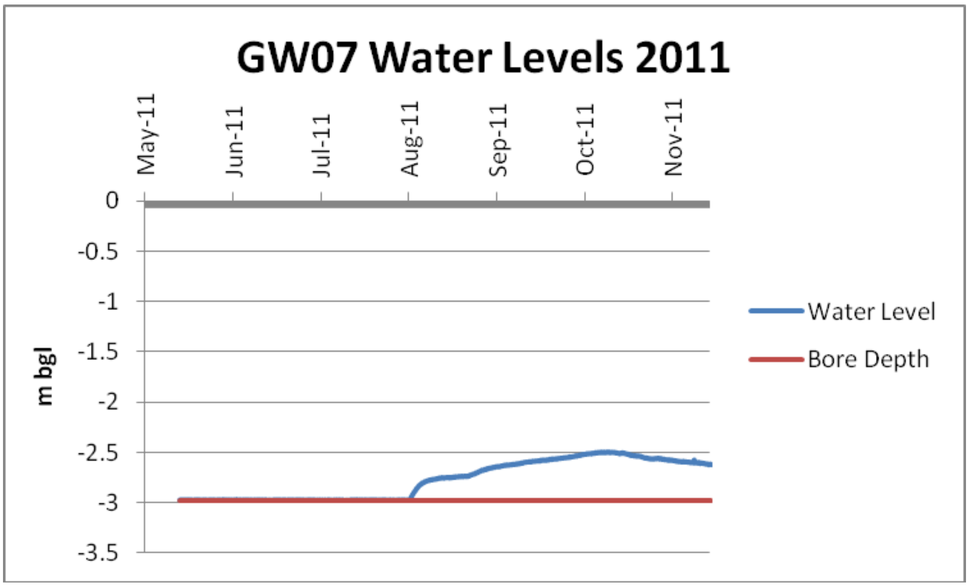
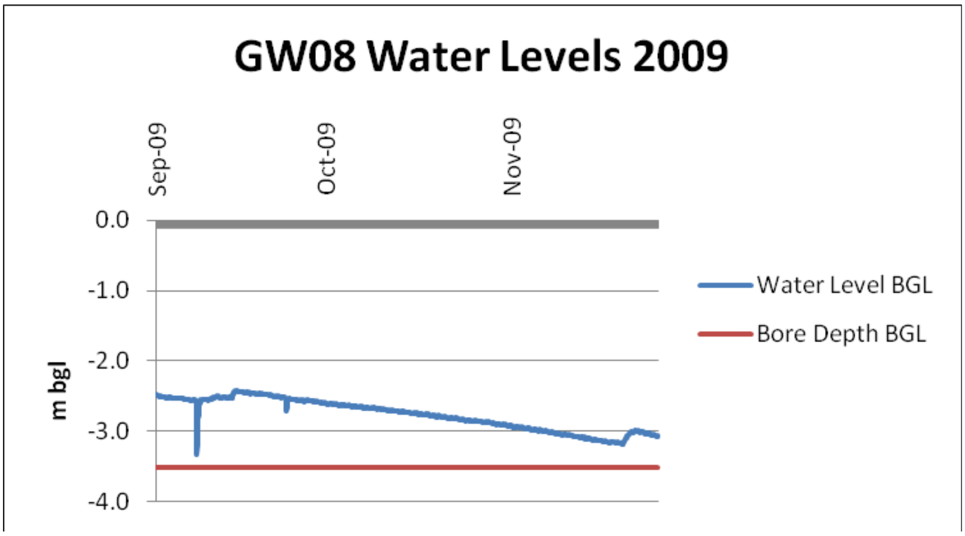
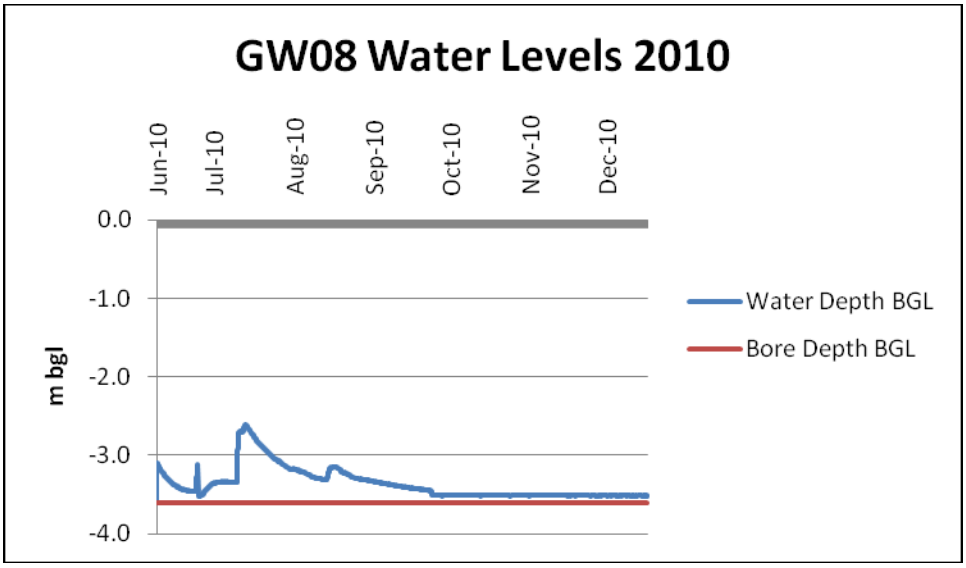


Figure 8: Groundwater hydrographs for GW07





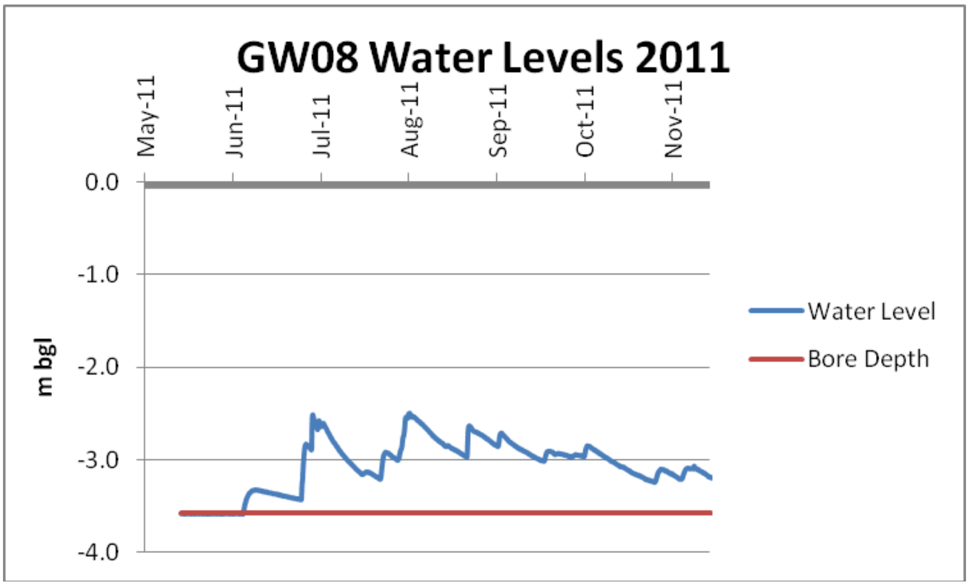
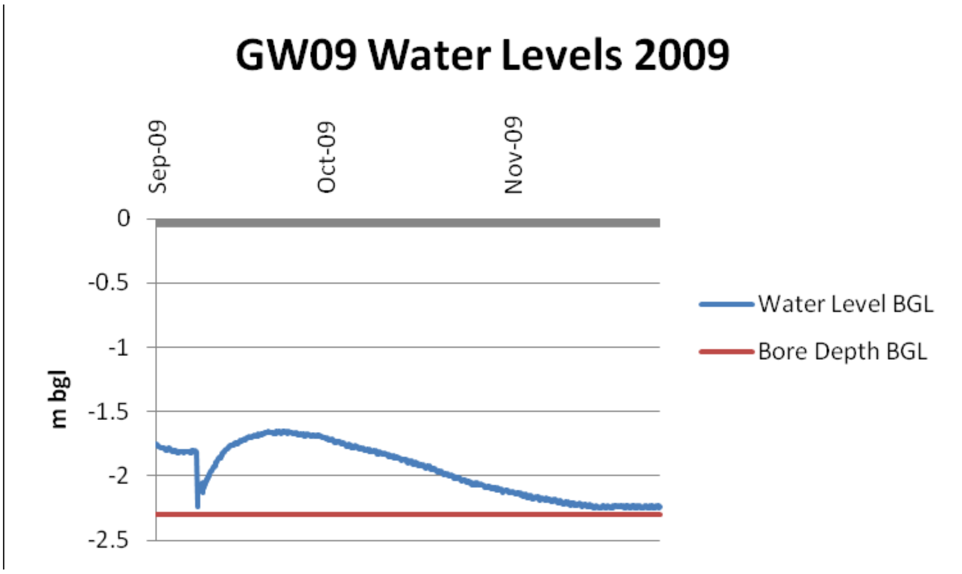
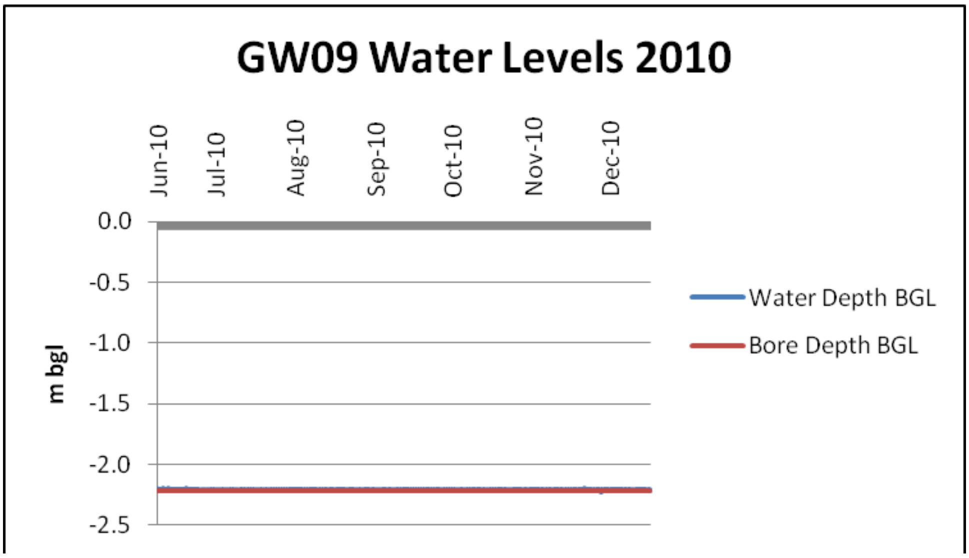


Figure 9: Groundwater hydrographs for GW08





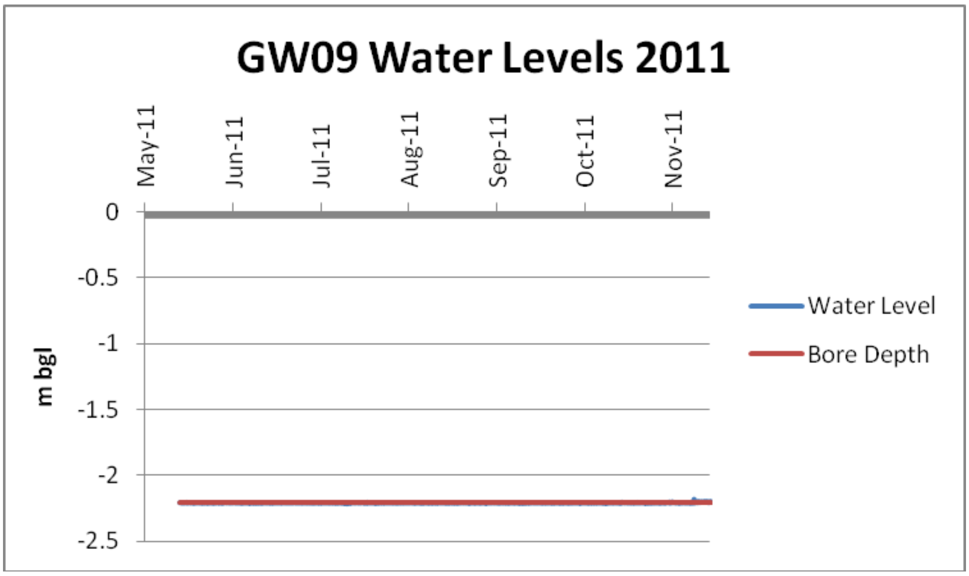


Figure 10: Groundwater hydrographs for GW09

TABLE B: Groundwater Analytical Water Quality Results

			Nutrients							Field Parameters					Lab Parameters		
			Total Nitrogen	TKN	Total Phosphorus	Phosphate (as P)	Nitrate-N	Nitrite-N	Ammonia (as N)	pH	Electrical Conductivity (SPC)	Redox	TDS	Dissolved Oxygen	pH	Electrical Conductivity (C)	TDS
FWG			1 [1]	NE	0.1 [1]	NE	NE	NE	0.9	6.5-8.5[1]	300-1,500 [2]	NE	NE	NE	6.5-8.5[1]	300-1,500 [2]	NE
SCWQIP (short term limits)			2	NE	0.2	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
SCWQIP (long term limits)			0.5	NE	0.05	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
LIWG			5	NE	0.05	NE	NE	NE	NE	6.0-8.5	1,900-4,500 [3]	NE	1,500	NE	NE	1,900-4,500 [3]	1,500
NPUG			NE	NE	NE	NE	113	9	NE	NE	NE	NE	NE	NE	NE	NE	NE
Limits of Reporting (LOR)			0.1	0.1	0.05	0.005	0.005	0.005	0.005	-		-		-	-	-	
Sample ID	Lab ID	Date Sampled	mg/L							pH units	µs/cm	mV	mg/L	ppm	pH units	µs/cm	mg/L
MB04	169582-2	10/08/2015	2.4	<0.1	<0.05	0.008	2.4	<0.005	0.016	5.47	253	125.3	164.45	4.8	6	210	120
Drain	169582-1	10/08/2015	2.3	2.3	0.05	0.009	0.015	<0.005	0.01	6.75	446	85.4	287.3	10.11	7.7	380	230

Notes:

NG = Regulatory guideline value not established

[1] value derived from SRT (2008) Healthy Rivers Action Plan

[2] value derived from ANZECC (2000) - trigger values for slightly moderately disturbed wetland ecosystems

< Indicates sample results below the laboratory limit of reporting (LOR)

\- Not Analysed

Regulatory Guidelines:

NHMRC & NRMMC (2011) *Australian Drinking Water Guidelines* and ANZECC & ARMCANZ (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

(blue)	shading indicates concentration exceeds the FWG (Fresh Water Guidelines for slightly - moderately disturbed systems).
(green)	shading indicates concentration exceeds the LIWG (Long-term Irrigation Water Guidelines).
(red)	shading indicates concentration exceeds the NPUG (Non-Potable Groundwater Use - Department of Health, 2014).
(yellow)	shading indicates concentration exceeds the Swan Canning Water Quality Improvement Plan (short term limits)
(purple)	shading indicates concentration exceeds the Swan Canning Water Quality Improvement Plan (long term limits)

TABLE A: GROUNDWATER FIELD OBSERVATIONS

Sample Identification Number	Sample Date	Depth to groundwater		pH	Electrical Conductivity	Comments
Units		mbtoc	mAHD	pH Unit	mS/cm	
MW01						
Feb-15	13/02/15	-	-	-	-	Bore is dry
Mar-15	10/03/15	-	-	-	-	Bore is dry
Apr-15	10/04/15	-	-	-	-	Bore is dry
May-15	7/05/15	-	-	-	-	Bore is dry
Jun-15	9/06/15	-	-	-	-	Bore is dry
Jul-15	9/07/15	-	-	-	-	Bore is dry
Aug-15	10/08/15	-	-	-	-	Bore is dry
Sep-15	10/09/15	-	-	-	-	Bore is dry
Dec-15	15/12/15	-	-	-	-	Bore is dry
Jan-16	13/01/16	-	-	-	-	Bore is dry
MW02						
Feb-15	13/02/15	-	-	-	-	Bore is dry
Mar-15	10/03/15	-	-	-	-	Bore is dry
Apr-15	10/04/15	-	-	-	-	Bore is dry
May-15	7/05/15	-	-	-	-	Bore is dry
Jun-15	9/06/15	-	-	-	-	Bore is dry
Jul-15	9/07/15	-	-	-	-	Bore is dry
Aug-15	10/08/15	-	-	-	-	Bore is dry
Sep-15	10/09/15	1.372	16.63	-	-	-
Dec-15	15/12/15	-	-	-	-	Bore is dry
Jan-16	13/01/16	-	-	-	-	Bore is dry
MW03						
Feb-15	13/02/15	-	-	-	-	Bore is dry
Mar-15	10/03/15	-	-	-	-	Bore is dry
Apr-15	10/04/15	-	-	-	-	Bore is dry
May-15	7/05/15	-	-	-	-	Bore is dry
Jun-15	9/06/15	-	-	-	-	Bore is dry
Jul-15	9/07/15	-	-	-	-	Bore is dry
Aug-15	10/08/15	-	-	-	-	Bore is dry
Sep-15	10/09/15	-	-	-	-	Bore is dry
Dec-15	15/12/15	5.041	15.62	-	-	-
Jan-16	13/01/16	-	-	-	-	Bore is dry
MW04						
Feb-15	13/02/15	-		-	-	Bore is dry
Mar-15	10/03/15	-		-	-	Bore is dry
Apr-15	10/04/15	-		-	-	Bore is dry
May-15	7/05/15	-		-	-	Bore is dry
Jun-15	9/06/15	3.910	17.997	-	-	-
Jul-15	9/07/15	3.055	18.852	-	-	-
Aug-15	10/08/15	3.050	18.857	5.47	0.25	-
Sep-15	10/09/15	3.059	18.848	-	-	-
Dec-15	15/12/15	3.936	17.971	-	-	-
Jan-16	13/01/16	4.117	17.790	-	-	-
GW9						
Feb-15	13/02/15	-	-	-	-	Bore is dry
Mar-15	10/03/15	-	-	-	-	Bore is dry
Apr-15	10/04/15	-	-	-	-	Bore is dry
May-15	7/05/15	-	-	-	-	Bore is dry
Jun-15	9/06/15	-	-	-	-	Bore is dry
Jul-15	9/07/15	-	-	-	-	Bore is dry
Aug-15	10/08/15	-	-	-	-	Bore is dry
Sep-15	10/09/15	-	-	-	-	Bore is dry
Dec-15	15/12/15	-	-	-	-	Bore is dry
Jan-16	13/01/16	-	-	-	-	Bore is dry
WET8						
Feb-15	13/02/15	-	-	-	-	Bore is dry
Mar-15	10/03/15	-	-	-	-	Bore is dry
Apr-15	10/04/15	-	-	-	-	Bore is dry
May-15	7/05/15	-	-	-	-	Bore is dry
Jun-15	9/06/15	-	-	-	-	Bore is dry
Jul-15	9/07/15	-	-	-	-	Bore is dry
Aug-15	10/08/15	-	-	-	-	Bore is dry
Sep-15	10/09/15	-	-	-	-	Bore is dry
Dec-15	15/12/15	-	-	-	-	Bore is dry
Jan-16	13/01/16	-	-	-	-	Bore is dry
DoW (675B)						
Feb-15	13/02/15	-	-	-	-	Bore is locked
Mar-15	10/03/15	2.310	15.481	-	-	-
Apr-15	10/04/15	2.370	15.421	-	-	-
May-15	7/05/15	2.300	15.491	-	-	-
Jun-15	9/06/15	2.210	15.581	-	-	-
Jul-15	9/07/15	2.100	15.691	-	-	-
Aug-15	10/08/15	2.020	15.771	-	-	-
Sep-15	10/09/15	1.944	15.847	-	-	-
Dec-15	15/12/15	2.126	15.665	-	-	-
Jan-16	13/01/16	2.21	15.580	-	-	-

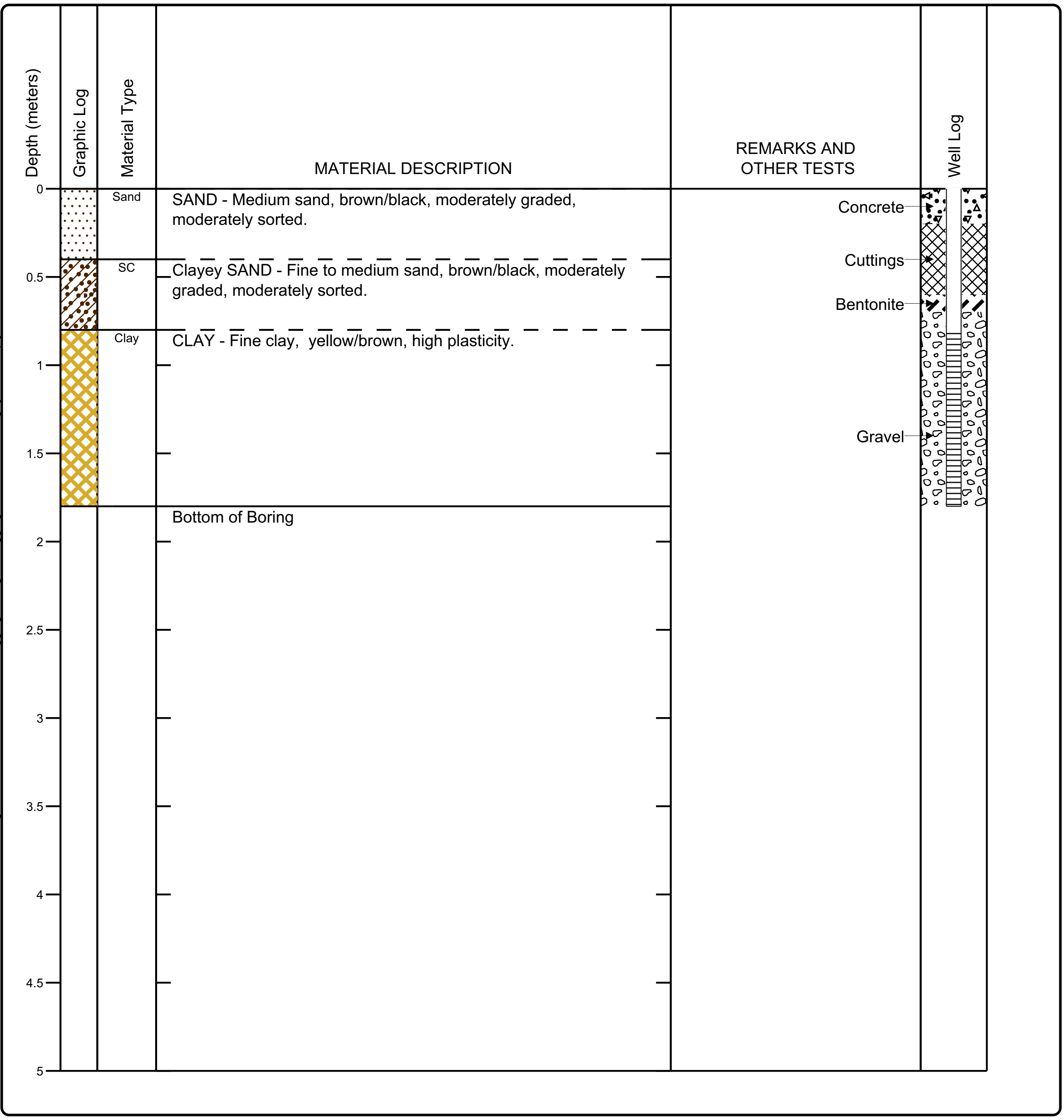
Project: **Clifford Street Maddington - Hydrology Assessment** Project Location: **Maddington** Project Number: **JEC14345.02**	MB 01 **Sheet 1 of 1**

Date(s) Drilled **05/02/2015**	Logged By **JS**	
Drilling Method **Hollow flight auger**	Drill Bit Size/Type **100mm**	Total Depth of Borehole **1.8 Mbgl**
Drill Rig Type **Truck mounted**	Drilling Contractor **E-drill**	
Groundwater Level **N/A**	Sampling Method(s) **N/A**	
Borehole Backfill **N/A**	Location **GDA94 (MGA50) - 405972.556 Easting (m) 6455679.980 Northing (m)**	

Depth (meters)	Graphic Log	Material Type	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS	Well Log
0		Fill	FILL - Medium sand, yellow/orange, moderately graded.	Concrete	
		SP	SAND - Medium sand, grey/black, poorly graded.	Cuttings	
0.5				Bentonite	
		Clay	CLAY - Fine clay, orange/red, moderate plasticity.		
1					
1.5				Gravel	
			Bottom of Boring		
2					
2.5					
3					
3.5					
4					
4.5					
5					

Project: **Clifford Street Maddington - Hydrology Assessment**	MB 02
Project Location: **Maddington**	**Sheet 1 of 1**
Project Number: **JEC14345.02**	

Date(s) Drilled **05/02/2015**	Logged By **JS**	
Drilling Method **Hollow flight auger**	Drill Bit Size/Type **100mm**	Total Depth of Borehole **1.8 Mbgl**
Drill Rig Type **Truck mounted**	Drilling Contractor **E-drill**	
Groundwater Level **N/A**	Sampling Method(s) **N/A**	
Borehole Backfill **N/A**	Location **GDA94 (MGA50) - 405582.573 Easting (m) 6455625.351 Northing (m)**	



Project: **Clifford Street Maddington - Hydrology Assessment**	MB 03
Project Location: **Maddington**	**Sheet 1 of 1**
Project Number: **JEC14345.02**	

Date(s) Drilled **05/02/2015**	Logged By **JS**	
Drilling Method **Hollow flight auger**	Drill Bit Size/Type **100mm**	Total Depth of Borehole **4.5 Mbgl**
Drill Rig Type **Truck mounted**	Drilling Contractor **E-drill**	
Groundwater Level **N/A**	Sampling Method(s) **N/A**	
Borehole Backfill **N/A**	Location **GDA94 (MGA50) - 405330.301 Easting (m) 6455846.678 Northing (m)**	

Depth (meters)	Graphic Log	Material Type	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS	Well Log
0		Sand	SAND -Fine to medium sand, grey, moderately graded, moderately sorted, dry.	Concrete	
0.5					
1				Cuttings	
1.5				Bentonite	
2					
2.5					
3				Gravel	
3.5					
4					
4.5		CH	Sandy CLAY - Fine to medium clay, red/yellow, moderately graded, moderately sorted, moist.		
			Bottom of Boring		
5					

N:\2014\JEC\JEC14345.02 Clifford Street Water Management\Bore installation\Bore logging\Boring GS logging\JEC- Clifford st.bg4[CEP SB.tpl]

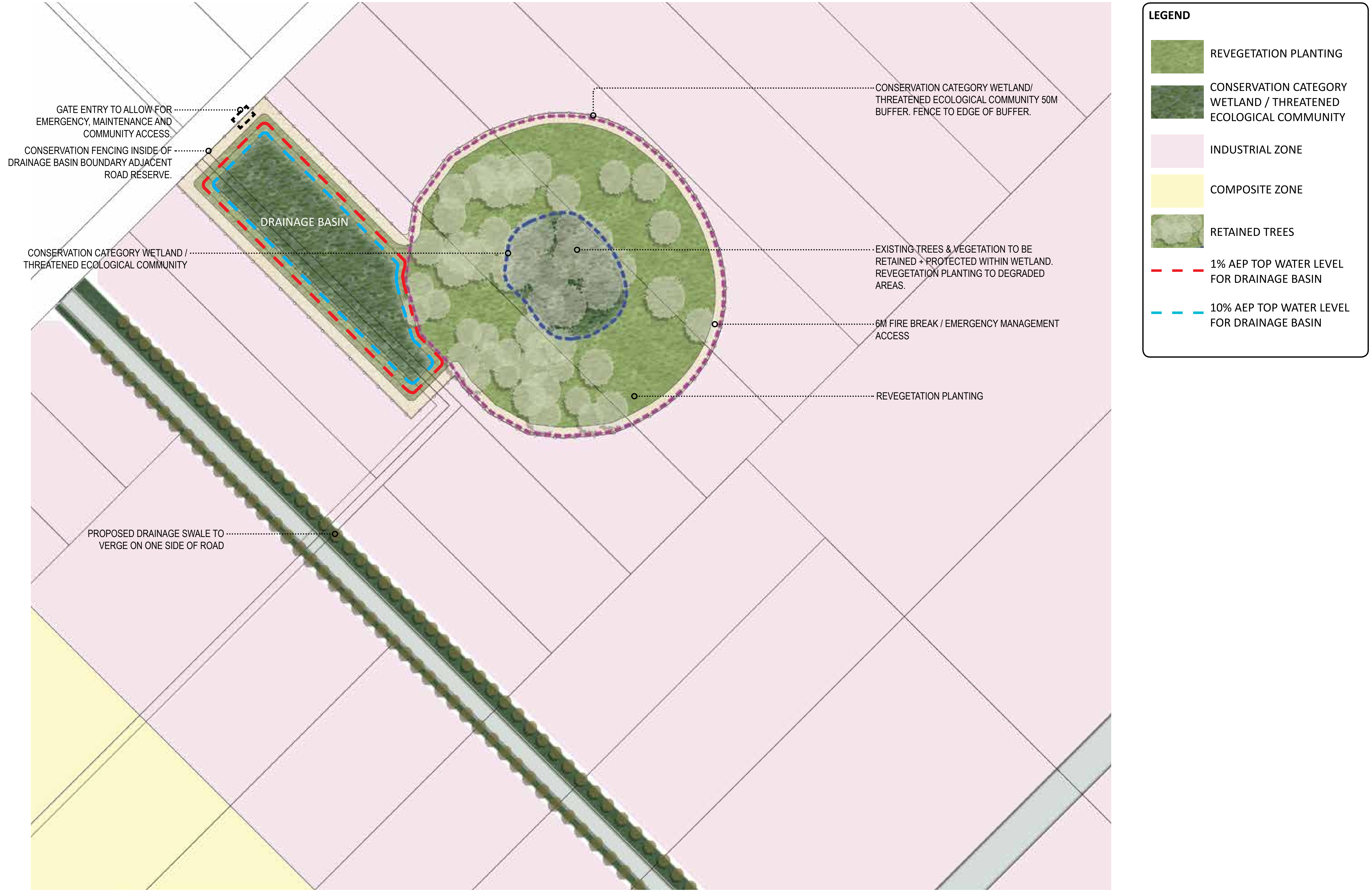
Project: **Clifford Street Maddington - Hydrology Assessment**	MB 04
Project Location: **Maddington**	**Sheet 1 of 1**
Project Number: **JEC14345.02**	

Date(s) Drilled **05/02/2015**	Logged By **JS**	
Drilling Method **Hollow flight auger**	Drill Bit Size/Type **100mm**	Total Depth of Borehole **3.75 Mbgl**
Drill Rig Type **Truck mounted**	Drilling Contractor **E-drill**	
Groundwater Level **N/A**	Sampling Method(s) **N/A**	
Borehole Backfill **N/A**	Location **GDA94 (MGA50) - 405564.071 Easting (m) 6456074.233 Northing (m)**	

Depth (meters)	Graphic Log	Material Type	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS	Well Log
0		Sand	SAND -Medium sand, black, moderately graded, moderately sorted.	Concrete	
		Sand	SAND - Medium to coarse sand, black, moderately graded, moderately sorted.	Cuttings	
0.5				Bentonite	
1					
1.5		Sand	SAND - Medium sand, yellow/grey, moderately graded, moderately sorted.		
2				Gravel	
2.5		SC	Clayey SAND - Medium sand, yellow/brown, low plasticity, well graded, poorly sorted, moist.		
3		CH	Sandy CLAY - Fine clay, red/orange, moderate plasticity, moderately graded, moderately sorted, wet.		
3.5					
			Bottom of Boring		
4					
4.5					
5					

Appendix F

Landscape Concept



MKSEA - City of Gosnells

CONCEPT PLAN A

DWG **MKSEA-01**
REV **G**
DATE **11-01-19**

0 10 20 30 40 50 m

SCALE **1 : 2000 @ A3**

emerge ASSOCIATES

U:\CURRENTPROJECTS\MKSEA-CityofGosnells\(XX-01)PhotosDrawings&Scans\(XX-01)02_ConceptPlans,Scans&Graphics\02_LIVEDwgs\01_OverallProjectPlans\03INDD\MKSEA-Plan&SectionsConceptA.indd

Appendix L Bushfire Management Plan

Bushfire Management Plan

Maddington Kenwick Strategic Employment Area- Precinct 1

Prepared for City of Gosnells

By Urbaqua

April 2019

urbaqua
land and water solutions

Disclaimer and Limitation

This document is published in accordance with and subject to an agreement between Urbaqua and the Client, City of Gosnells, for who it has been prepared for their exclusive use. It has been prepared using the standard of skill and care ordinarily exercised by environmental professionals in the preparation of such Documents.

This report is a qualitative assessment only, based on the scope of services defined by the Client, budgetary and time constraints imposed by the Client, the information supplied by the Client (and its agents), and the method consistent with the preceding. Urbaqua has not attempted to verify the accuracy or completeness of the information supplied.

This Bushfire Management Plan provides strategic assessment of the subject site only. A subsequent Bushfire Management Plan and/or Bushfire Attack Level (BAL) Assessment may be required to support future development applications. The recommendations contained in this report are considered to be prudent minimum standards only, based on the author's experience as well as standards prescribed by relevant authorities. It is expressly stated that Urbaqua and the author do not guarantee that if such standards are complied with or if a property owner exercises prudence, that a building or property will not be damaged or that lives will not be lost in a bush fire.

Fire is an extremely unpredictable force of nature. Changing climatic factors (whether predictable or otherwise) either before or at the time of a fire can also significantly affect the nature of a fire and in a bushfire prone area it is not possible to completely guard against bushfire.

Further, the growth, planting or removal of vegetation; poor maintenance of any fire prevention measures; addition of structures not included in this report; or other activity can and will change the bushfire threat to all properties detailed in the report. The achievement of the level of implementation of fire precautions will depend on the actions of the landowner or occupiers of the land, over which Urbaqua has no control. If the proponent becomes concerned about changing factors then a Bushfire Management Plan should be requested.

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EXECUTIVE SUMMARY

This bushfire management plan has been undertaken to support structure planning for Precinct 1 of the Maddington Kenwick Strategic Employment Area (MKSEA) in the City of Gosnells (Figure 1).

A portion of the subject land is identified as a bush fire prone area, designated by the Fire and Emergency Services (FES) Commissioner. This report has been prepared to meet the requirements of *State Planning Policy 3.7: Planning in Bushfire Prone Areas* (SPP 3.7) (2015) and the *Guidelines for Planning in Bushfire Prone Areas* and associated appendices, Version 1.3 (WAPC, 2017). This plan provides advice consistent with the nature of a strategic proposal and demonstrates that, on completion, the proposed development will be able to comply with bushfire protection criteria in the Guidelines.

A vegetation class assessment was conducted for the subject land and adjacent areas for a minimum of 150 metres. As the road and lot layout is known, a bushfire attack level (BAL) assessment was undertaken and a BAL contour plan has been developed to show the indicative future BALs. This information may be used to guide the future development of the site, consistent with *AS3959 Construction of buildings in Bushfire Prone Areas*.

Bushfire hazard on and adjacent to the site ranges from low to extreme; however, the vegetation which poses the hazard has significant environmental values which are protected by State and Commonwealth legislation. No development is proposed within the areas of vegetation, as they will be reserved for public open space. A 6m firebreak within each area will be maintained by the City. Additional separation of development from bushfire hazard will be achieved through the establishment of asset protection zones (APZ) on individual lots. The APZs will ensure that the potential radiant heat impact of a fire on any future development will not exceed 29kW/m² (BAL-29).

Any future residential dwelling (Class 1-3 or 10 building) in the Composite Zone will need to be constructed to meet the requirements of *AS3959 Construction of buildings in Bushfire Prone Areas*.

Any development located within areas other than BAL-LOW within the General Industry Zone should by supported by a Risk Management Plan for any flammable on-site hazards. The risk management plan should also outline measures to reduce the risk of activities on-site resulting in any fire risk to the areas of high value vegetation.

Any roads, driveways, cul-de-sacs or accessways will be constructed and reticulated water and hydrants will be provided in accordance with this Bushfire Management Plan.

The bushfire mitigation and management strategies outlined in this management plan comply with the acceptable solutions of control for each of the Bushfire Protection Criteria detailed in *Guidelines for Planning in Bushfire Prone Areas* (v1.3, 2017). It is therefore considered that this bushfire management plan demonstrates compliance with the objectives and provisions of *State Planning Policy 3.7: Planning in Bushfire Prone Areas*.

This bushfire management plan is to be endorsed by the City of Gosnells and the Department of Fire and Emergency Services and is required to be reviewed and updated where necessary.

CONTENTS

Figures

Tables

1 INTRODUCTION

The City of Gosnells has engaged Urbaqua to prepare a Bushfire management plan to support preparation of a local structure plan for Precinct 1 of the Maddington Kenwick Strategic Employment Area (MKSEA) (Figure 1) in the City of Gosnells (Figure 2).

A portion of the subject land is identified as a bush fire prone area, designated by the Fire and Emergency Services (FES) Commissioner (Figure 3). This report has been prepared to meet the requirements of *State Planning Policy 3.7: Planning in Bushfire Prone Areas* (SPP 3.7) (2015) and the *Guidelines for Planning in Bushfire Prone Areas* (V1.3, WAPC, 2017). Consistent with the policy and guidelines, this report has been prepared on the basis of project completion (full development) of the proposed structure plan. Additional measures may therefore be required to address piecemeal or interim development.

Any identified bushfire risk will be addressed as part of the future subdivision and development approvals process, consistent with the requirements of *State Planning Policy 3.7: Planning in Bushfire Prone Areas* (SPP 3.7) (2015), the Building Code of Australia and *Australian Standards (AS3959-2009): Construction of buildings in bushfire prone area* where these apply.

1.1 Proposal details

The subject land consists of approximately 40.5 hectares of land bound by Tonkin Hwy, Victoria Rd and Bickley Rd in Maddington in the City of Gosnells.

It is largely used for rural and rural residential purposes which include a poultry farm, keeping of livestock, equestrian activities, local businesses with animal keeping (kennels and catteries), and other small industrial-type businesses such as depots. A large portion of the precinct has recently been cleared for large lot commercial development, including a new Bunnings depot and associated roads and services.

The draft MKSEA Local Structure Plan allocates the bulk of the precinct for industrial use. An area allocated as a 'Composite Zone' is located in the north-west corner and this will provide for Composite Residential/Light Industry uses. In this zone, any proposed Light Industrial development is required to have a residential dwelling as frontage (residential purposes within the first 35 metres). The purpose of the zone is to provide a residential buffer or graduation to the existing residences of the other side of Bickley Road.

Areas of local open space have also been identified to protect the values of a number of important wetlands and bushland.

1.1.1 Planning background

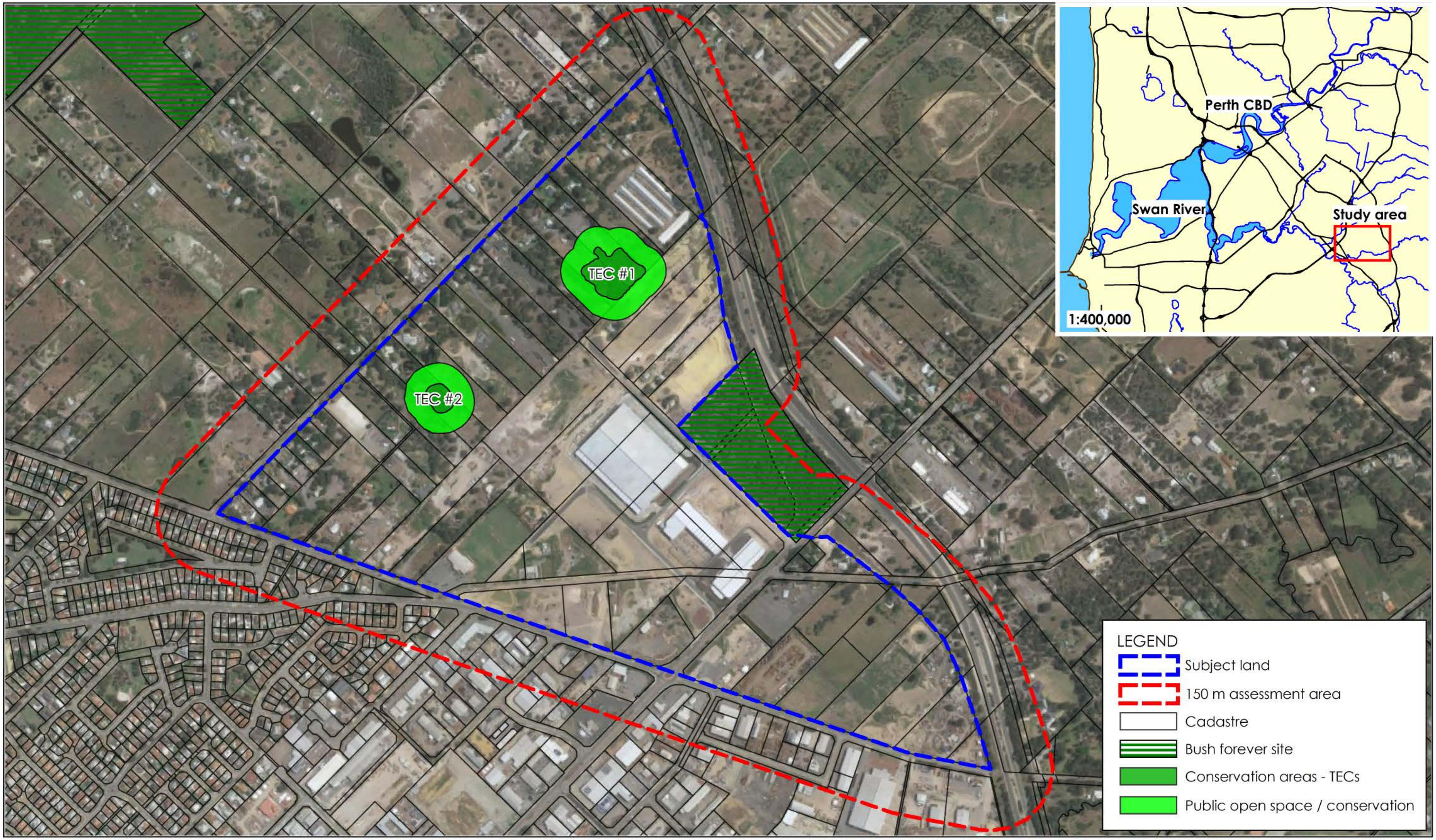
The subject land is zoned 'Industrial' under the Metropolitan Region Scheme and 'Business Development' in the City of Gosnells Town Planning Scheme No 6.

Land surrounding the subject land to the north-west is zoned 'General Rural'. Land to the east is contained within a Regional Road Reserve, while land to the south is zoned 'General Industry' and 'Residential'.

The draft MKSEA Local Structure Plan (Figure 1) has been prepared by the City of Gosnells to clarify road alignments and open space provision for the protection of regionally significant environmental values.

Figure 1: Draft MKSEA Precinct 1 local structure plan (Source: City of Gosnells)

City of Gosnells - Maddington Kenwick Strategic Employment Area, Precinct 1 Bushfire Management Plan
Figure 2 - Location Plan



Data source: Landgate, MRWA, DPLH, Created by:AT Projection: MGA: zone 50.

urbaqua land and water solutions

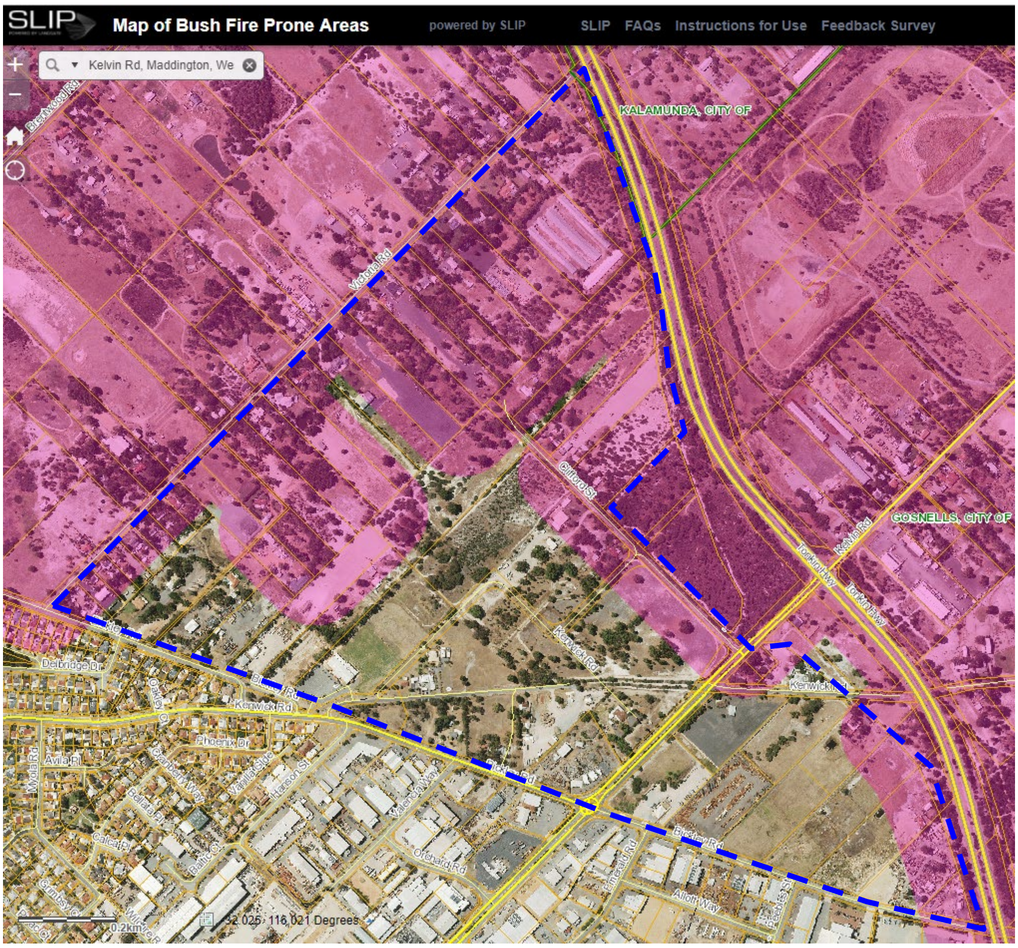


Figure 3: Map of Bushfire Prone Areas for the subject site (Source: DFES, 2018)

1.2 Bushfire management guidelines, specifications and minimum standards

Requirement 2 of City of Gosnells *Annual Fire Hazard Reduction Notice* (Attachment 1) stipulates that:

> *At all times throughout the year, all owners or occupiers of land zoned other than 'General Rural' or 'Special Rural' under the Scheme are required to clear and maintain the land free of all flammable matter to a height no greater than 10cm.*

This requirement is therefore applicable to the study area and all lands adjacent, with the exception of that to the north of Victoria Road.

Other specifications or standards relevant to this bushfire management plan are derived from and consistent with:

- *Fire and Emergency Services Act 1998*
- *Bush Fires Act 1954*
- *Planning and Development (local planning Scheme amendment) Regulations 2015*
- State Planning Policy 3.7: Planning in Bushfire Prone Areas (WAPC, 2015);
- *Guidelines for Planning for Bushfire Prone Areas* and appendices, Version 1.3 (WAPC, 2017) and
- Australian Standards (AS3959-2009): *Construction of buildings in bushfire prone areas*.

2 ENVIRONMENTAL CONSIDERATIONS

Although the subject land has been largely cleared and used predominantly for rural and rural residential purposes for a number of years, it contains or is adjacent to three sites of environmental value:

- Bush Forever site 53, Clifford St Bushland, is located to the east of the subject land, north of Kelvin Rd (Figure 2). This site contains threatened ecological communities (TEC) and Declared Rare Flora which are protected by both Federal and State environmental legislation. This site is also categorised as a Conservation Category Wetland in the Department of Biodiversity, Conservation and Attractions Geomorphic Wetlands of the Swan Coastal Plain database;
- Resource Enhancement wetland (UFI 8050) is located in the north-western portion of the site. This wetland contains a TEC; and
- An area of TEC is to be retained in the north-eastern portion of the site.

These areas have been identified for retention and protection in the draft Local structure plan and will be retained in Local Open Space (Figure 1).

2.1 Native Vegetation – modification and clearing

The vegetation complex that exists within the study area is the Guildford Complex. The natural vegetation of the Guildford Complex is typical of wetlands, with sheoaks and paperbarks or marri and flooded gum woodlands. Poorly drained flats give rise to shrublands, herblands and sedgelands.

The floristic description of the Clifford St Bushland in *Bush Forever (*WAPC, 2000, Vol 1 pg 163) is that of *Allocasuarina fraseriana* Low Open Woodland; *Eucalyptus calophylla* Woodland; Mixed Open Shrubland; *Eucalyptus calophylla* and *Eucalyptus wandoo* Woodland.

Current land use across the study area has resulted in a modified environment compared to the pre-clearing vegetation extent. The majority of the study area has been cleared to allow rural-residential development and more recently industrial/large scale commercial development (i.e. Bunnings), however some small sections of native vegetation remain which largely consist of mature shrubs with understory grasses. In some areas, tall trees have been planted as windbreaks or for screening with a managed grassland understory.

Some bushfire risk arises from vegetation within the two wetland areas to be retained, as well as from Bush Forever Site 53. It is noted that the proposed development will result in the clearing of the remaining areas of vegetation within the subject land.

Vegetation also exists in the assessment area outside the subject land along the road reserve adjacent Tonkin Highway. The vegetation north of Kelvin Road is less than 20m in width with a managed understory so it is not considered to represent a bushfire hazard; however, vegetation in the road reserve east of Tonkin Hwy between Kenwick Road and Bickley Road is considered to present a fire hazard.

2.2 Re-vegetation/Landscape Plans

Revegetation of significant wetland areas and their buffers will be undertaken in areas indicated on the draft Structure Plan as public open space. The revegetation will replicate the current species composition of each wetland, and accordingly, the classification of pre-development vegetation type will extend into the buffer (POS) areas in future.

The City of Gosnells will maintain a 6m firebreak around each area of public open space.

Some landscaping of road reserves is likely to consist of individual trees without understory and as such is not considered to have the potential to create a fire hazard.

It is likely that the area will contain a number of drainage swales located in road reserves. These swales are likely to be less than 2m in width and will contain vegetation to uptake nutrients from stormwater such as reeds and rushes. The width of the swales and type of vegetation is considered to be low threat vegetation, as the form and function is consistent with a "nature strip" as documented in AS3959 Clause 2.2.3.2(f).

Some areas on the draft structure plan are indicated as "Nominal drainage basin". The exact size of the basin will be determined as part of more detailed investigations; however, it is understood that the basins are to be planted with similar vegetation to the swales (i.e. rushes and reeds) although the City has indicated that this vegetation should be classed as Class C: Shrubland. The location of most of these basins is such that they are at least 100m from any classified vegetation and are under 1ha in size and are so not considered to represent a bushfire threat and are excluded under AS3959 Clause 2.2.3.2(b). The basin on the corner of Bickley Road and Victoria Ave is within 100m of the classified vegetation to the north of Victoria Road. The City has indicated that this basin is likely to be 0.26ha in size, with the balance of the lot to maintained as low threat vegetation. This portion of the lot has therefore been classified in accordance with the City's instructions.

3 BUSHFIRE ASSESSMENT RESULTS

3.1 Assessment Inputs

In order to identify the potential bushfire risks, it is necessary to describe the bushfire problem associated with the subject land. The assessment takes into consideration the:

- the topography and slope of the subject land;
- type and classification of vegetation present on and adjacent to the subject land;
- distances between the classifiable vegetation; and
- current and proposed future land use.

3.1.1 Slope

The study area has generally flat topography and grades gently from 11mAHD in the north-west to 30mAHD in the north-east, as shown in Figure 4.

The effective slope (that is the slope that will affect the behaviour of an approaching bushfire) underneath the vegetation is a combination of upslope, flat land and Downslope >0 to 5 degrees. As this slope, where it exists is gentle, slope is not considered to be a significant factor in terms of increasing bushfire hazard.

3.1.2 Current land use within 150m assessment area

The majority of land within the assessment area is not zoned 'General Rural' or 'Special Rural' in the City of Gosnells local planning scheme. Accordingly, this land is subject to Clause 2 of the City of Gosnells Annual Fire Hazard Reduction Notice which requires all owners or occupiers of this land to clear and maintain the land free of all flammable matter to a height no greater than 10cm.

However, land to the north of the subject land within the 150m assessment area is currently zoned 'General Rural' in the City of Gosnells local planning scheme. It is subject to Clause 1 of the City of Gosnells Annual Fire Hazard Reduction Notice which requires owners and occupiers to:

a. *Clear and maintain the land free of all flammable matter to a height no greater than 10cm; or*
b. *Maintain a mineral earth firebreak immediately inside all external boundaries of each lot on the land and maintain a mineral earth firebreak within 20m of all haystacks and stockpiled flammable matter.*

Mineral earth firebreaks must be continuous (no dead ends) and maintained to a minimum standard of 3m wide by 4m high (vertical clearance) so as to provide unimpeded access for emergency vehicles. Driveways must also be maintained to these standards.

This land currently contains peri-urban land uses which comprise large lots, many of which are operating as transport/storage type industries. At the time of assessment, there was limited continuous understory with a high fuel load and the canopy that did exist was generally planted as a screen or windbreak at the front of the properties. Fire risk from these properties at the time of assessment was considered to be low.

Other land use outside the subject land which contains vegetation is the road reserve along Tonkin Hwy. Although the vegetation along the majority of this reserve consists of a row of trees which operate as a wind break which backs on to managed rural residential properties or a turf farm, a small area of vegetation extends beyond the road reserve to the north of the Orange Grove Primary School. This vegetation presents a fire risk.

3.1.3 Future land use

The proposed future development is not considered to be classified as either "minor development" or "unavoidable development" as defined by *State Planning Policy 3.7: Planning in Bushfire Prone Areas* (WAPC, 2015).

The future land use is for general and light industry, with some residential use permitted in the composite zone. The subject land will contain two areas of local open space, to be reserved for parks and recreation under the local scheme. This will facilitate the protection of important wetlands and vegetation including threatened ecological communities.

Land adjacent to the subject land to the north is within MKSEA Precinct 2. This land is proposed for future industrial use and is therefore unlikely to pose a bushfire threat in the future. Clearing of a number of properties has already commenced to facilitate future development.

High risk land use

State Planning Policy 3.7 defines High-risk land use as:

> *"A land use which may lead to the potential ignition, prolonged duration and/or increased intensity of a bushfire. Such uses may also expose the community, fire fighters and the surrounding environment to dangerous, uncontrolled substances during a bushfire event. Examples of what constitutes a high-risk land use are provided in the Guidelines."*

The *Guidelines for Planning in Bushfire Prone Areas* (WAPC, 2017) states high risk land uses may include, but are not limited to:

> *service stations, landfill sites, bulk storage of hazardous materials, fuel depots and certain heavy industries as well as military bases, power generating land uses, saw-mills, highways and railways, among other uses meeting the definition."*

The *Guidelines for Planning in Bushfire Prone Areas* state that

> *"The bushfire construction requirements of the Building Code of Australia only apply to certain types of residential buildings (being Class 1, 2 or 3 buildings and/or Class 10a buildings or decks associated with a Class 1, 2 or 3 building) in designated bushfire prone areas. As such, AS 3959 does not apply to all buildings. Only vulnerable or high-risk land uses that fall within the relevant classes of buildings as set out in the Building Code of Australia will be required to comply with the bushfire construction requirements of the Building Code of Australia. As such, the planning process focuses on the location and siting of vulnerable and high risk land uses rather than the application of bushfire construction requirements."*

Although it is unlikely that many high-risk land uses will be located within the proposed general industry, light industry or composite zone, service stations require planning approval and/or are discretionary under the scheme. Accordingly, the City can exercise its discretionary powers to refuse an application should a service station be proposed within 100m of any classified vegetation.

It is therefore recommended that consideration is given to the control of land use such that high risk land uses are not located within 100m of any classified vegetation.

Policy provision 6.6 is subsequently addressed through future development at individual lot scale requiring a Risk Management Plan for any flammable on-site hazards.

3.1.4 Vegetation types

On the basis of a site visit on 29 March 2018, vegetation at the site and within 150m was assessed. Vegetation within 100m was classified according to the descriptions provided in AS 3959 – 2009, and includes the following three vegetation types:

- Class B Woodland – Woodland (B5): Trees 10-30m high. 10-30% foliage cover dominated by Eucalypts; understory or low trees to tall shrubs typically dominated by Acacia, Callitris or Casuarina.
- Open woodland classified as Class G Grassland as per Note 2 of AS3959 Table 2.3: "Overstoreys of open woodland, low open woodland, tall open shrub land and low open shrubland should be classified to the vegetation type on the basis of their understoreys; others to be classified on the basis of their overstoreys."
- Class D Scrub – Closed scrub (D13): found in wet areas and/or areas affected by poor soil fertility or shallow soils; >30% foliage cover. Dry heaths occur in rocky areas. Shrubs>2m high. Typical of coastal wetlands and tall heaths.
- Class G Grassland – tussock grassland (G22): all forms of grassland including situations with shrubs and trees if the foliage cover is less than 10%
- Low threat vegetation – AS3959 2.2.3.2(f) - grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks.

The vegetation within the subject land and 150m surrounding is shown in Table 1 and Figure 4.

Table 1: Vegetation classification

Photo point		Vegetation class	Vegetation type	Description
1 Plot 1		Class G: grassland Slope All upslopes and flat land	Open woodland classified as Class G Grassland	All forms of grassland including situations with shrubs and trees if the foliage cover is less than 10%

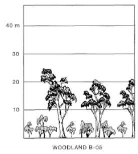
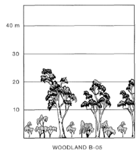
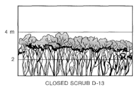
Photo point		Vegetation class	Vegetation type	Description
2 Plot 1		Class G: grassland Effective Slope: All upslopes and flat land	Open woodland classified as Class G Grassland	All forms of grassland including situations with shrubs and trees if the foliage cover is less than 10%
3 Plot 2		Class B: Woodland Effective slope: Downslope >0 to 5 degrees to the west and upslopes and flat land to the east	Woodlands B-05 	Trees 10-30m high. 10-30% foliage cover dominated by Eucalypts; understory or low trees to tall shrubs typically dominated by Acacia, Callitris or Casuarina
4 Plot 2		Class B: Woodland Effective slope: Downslope >0 to 5 degrees to the west and upslopes and flat land to the east	Woodlands B-05 	Trees 10-30m high. 10-30% foliage cover dominated by Eucalypts; understory or low trees to tall shrubs typically dominated by Acacia, Callitris or Casuarina
5 Plot 3		Class D: Scrub Effective slope: Downslope >0 to 5 degrees to the south west and upslopes and flat land to the northeast	Closed scrub (D13) 	Found in wet areas and/or areas affected by poor soil fertility or shallow soils; >30% foliage cover. Dry heaths occur in rocky areas. Shrubs>2m high. Typical of coastal wetlands and tall heaths

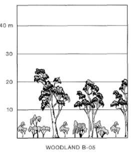
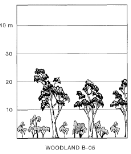
Photo point		Vegetation class	Vegetation type	Description
6 Plot 4		Class B: Woodland Effective slope: Downslope >0 to 5 degrees to the south west and upslopes and flat land to the north	Woodlands B-05 	Trees 10-30m high. 10-30% foliage cover dominated by Eucalypts; understory or low trees to tall shrubs typically dominated by Acacia, Callitris or Casuarina
7 Plot 4		Class B: Woodland The vegetation in Plot 4 is a mix of *Allocasuarina fraseriana* low open woodland, *Eucalyptus calophylla* woodland, mixed open shrubland, and *Eucalyptus calophylla / Eucalyptus wandoo* woodland. This is consistent with the description of Woodland (above).	Woodlands B-05 	Trees 10-30m high. 10-30% foliage cover dominated by Eucalypts; understory or low trees to tall shrubs typically dominated by Acacia, Callitris or Casuarina
8 Plot 5		Low Threat Exclusion Clause 2.2.3.2 (f) This plot is reserved for Primary Regional Roads and subject to Requirement 2 of the Annual Fire Hazard Reduction Notice	Managed grassland	Grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks

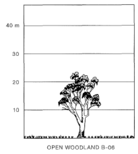
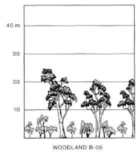
Photo point		Vegetation class	Vegetation type	Description
9 Plot 6		Class G: Grassland Effective slope: Downslope >0 to 5 degrees	Open woodland (B06) classified as Class G: grassland 	All forms of grassland including situations with shrubs and trees if the foliage cover is less than 10%
10 Plot 7		Low Threat Exclusion Clause 2.2.3.2 (f) This plot is reserved for Primary Regional Roads and subject to Requirement 2 of the Annual Fire Hazard Reduction Notice	Road reserve (windbreak, less than 20m in width)	Grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks
11 Plot 7		Low Threat Exclusion Clause 2.2.3.2 (f) This plot is reserved for Primary Regional Roads and subject to Requirement 2 of the Annual Fire Hazard Reduction Notice	Road reserve (windbreak, less than 20m in width)	Grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks
12 Plot 8		Low Threat Exclusion Clause 2.2.3.2 (f) This plot is reserved for Primary Regional Roads and subject to Requirement 2 of the Annual Fire Hazard Reduction Notice	Road reserve (windbreak, less than 20m in width)	Grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks

Photo point		Vegetation class	Vegetation type	Description
13 Plot 9		Class B: Woodland Effective slope: Downslope >0 to 5 degrees	Woodlands B-05 	Trees 10-30m high. 10-30% foliage cover dominated by Eucalypts; understory or low trees to tall shrubs typically dominated by Acacia, Callitris or Casuarina

3.2 Assessment outputs

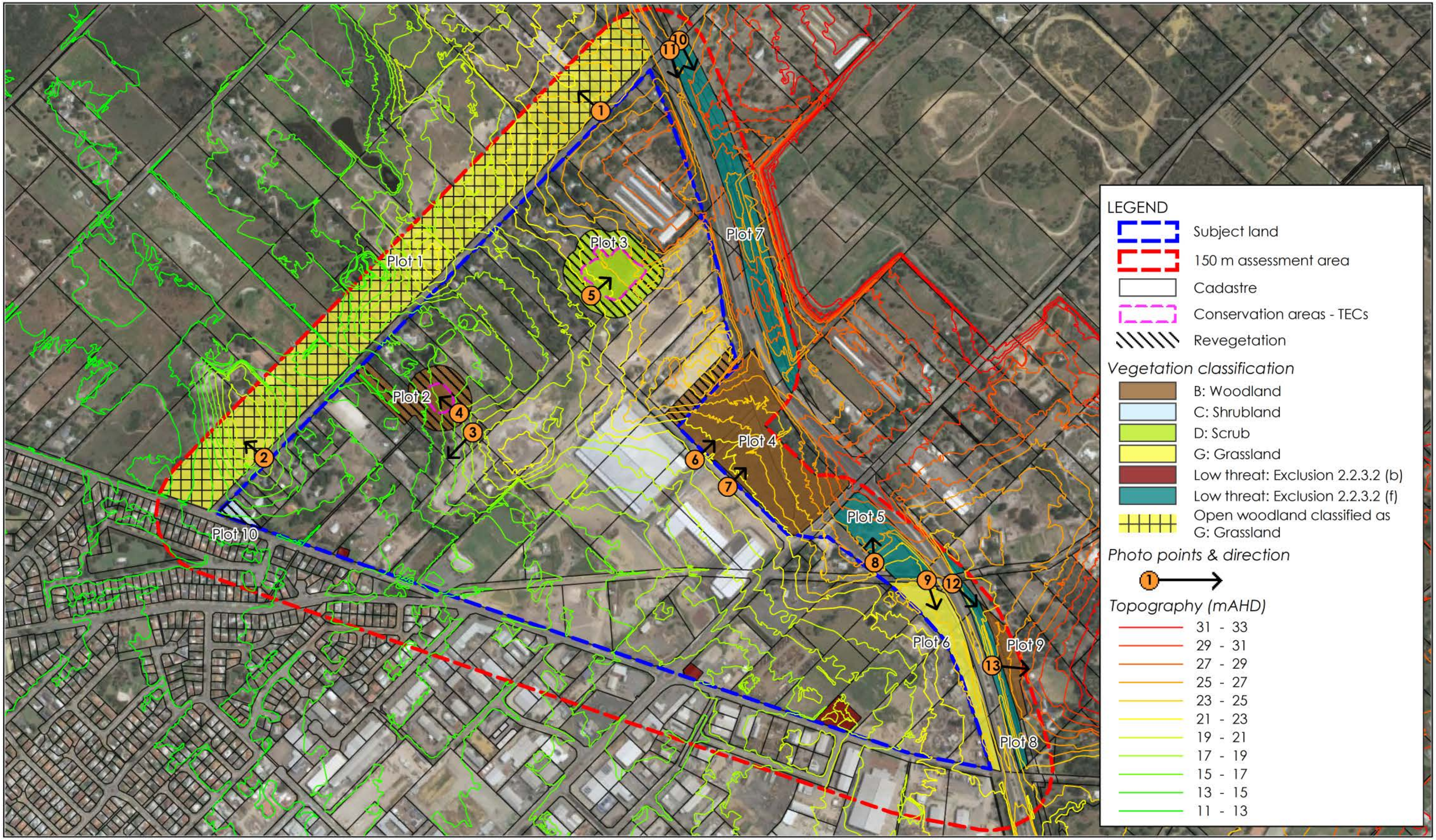
Consistent with Appendix Two of the *Guidelines for Planning in Bushfire Prone Areas* (V1.3, WAPC, 2017), as this bushfire management plan is to support an application where the indicative development footprint is known, a Bushfire Attack Level (BAL) assessment has been undertaken in accordance with Method 1 of AS3959: Construction of buildings in bushfire prone areas.

A BAL contour map has been created for the proposed future development which shows indicative BAL ratings for the site (Figure 5) consistent with Appendix 3 of the *Guidelines for Planning in Bushfire Prone Areas* (V1.3, WAPC, 2017). The BAL contour map was prepared on the basis of FDI 80; the vegetation classification shown in Table 1; and slope shown on Figure 4. An excerpt from AS3959 is provided in Table 2. As the City has indicated that the revegetated drainage basin is to be classified as Class C: Shrubland, this information has been added to the table below.

Table 2: Excerpt from AS 3959, Table 2.4.3, Distance (m) of the site from the predominant vegetation class

FDI 80 (1090 K)	Vegetation classification and slope						
Bushfire attack levels (BALs)	Class B: Woodland Upslope & flat land	Class B: Woodland Downslope 0 to 5 degrees	Class C: Shrubland Upslope & flat land	Class C: Shrubland Downslope 0 to 5 degrees	Class D: Scrub Upslope & flat land	Class D: Scrub Downslope 0 to 5 degrees	Class G: Grassland Upslopes and flat land
BAL-FZ	<10m	<13m	<7m	<7m	<10m	<11m	< 6m
BAL-40	10-<14	13-<17	7-<9	7-<10	10-<13	11-<15	6-< 8
BAL-29	14-<20	17-<25	9-<13	10-<15	13-<19	15-<22	8-< 12
BAL-19	20-<29	25-<35	13-<19	15-<22	19-<27	22-<31	12-<17
BAL-12.5	29-<100	35-<100	19-<100	22-<100	27-<100	31-<100	17-< 50
BAL-LOW	Beyond 100m						Beyond 50m

City of Gosnells - Maddington Kenwick Strategic Employment Area, Precinct 1 Bushfire Management Plan
Figure 4 - Post-development vegetation classification and slope



Data source: Landgate, MRWA, DPLH, Created by:AT Projection: MGA: zone 50.

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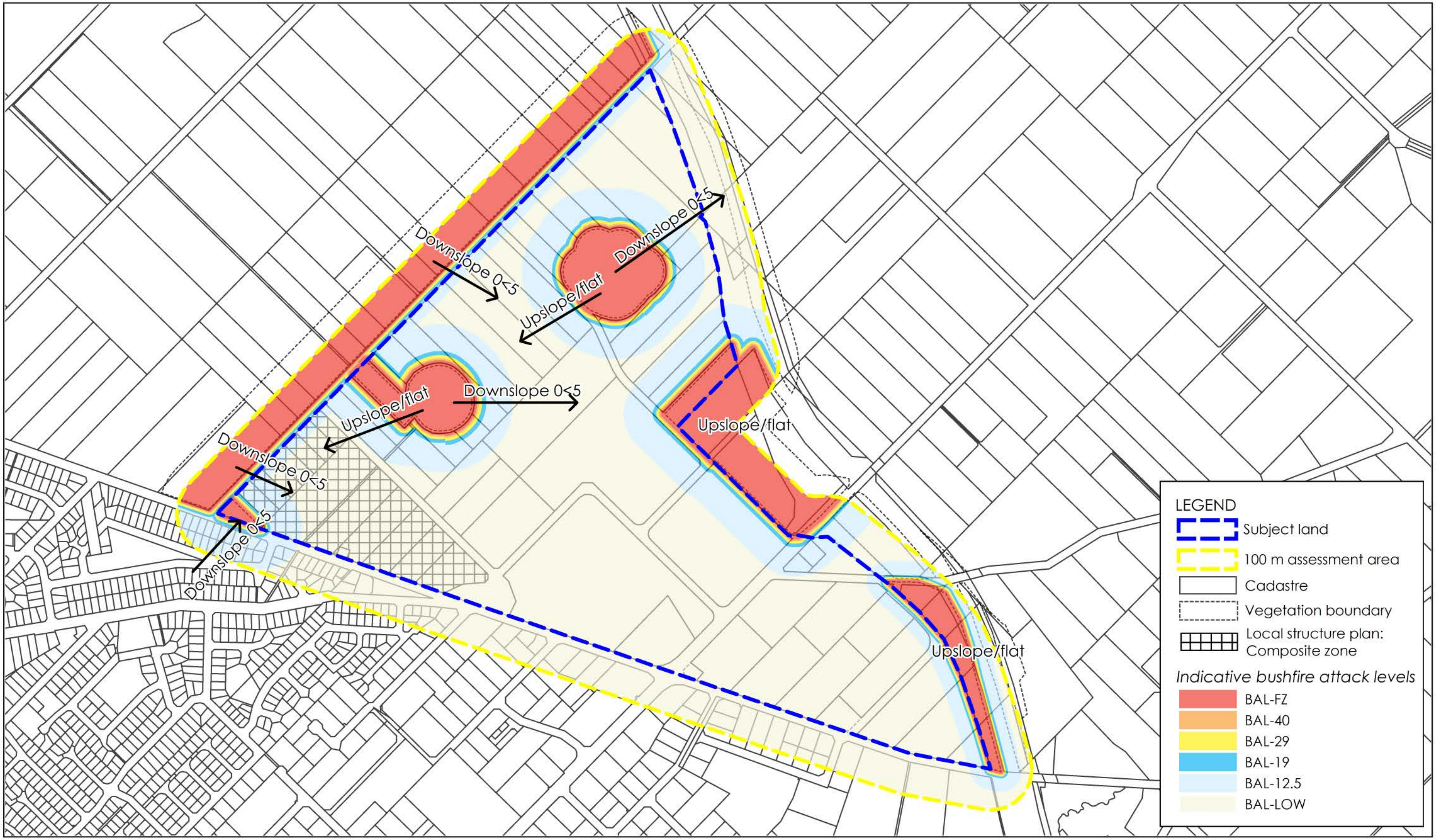
City of Gosnells - Maddington Kenwick Strategic Employment Area, Precinct 1 Bushfire Management Plan
Figure 5 - BAL contour map



Data source: Landgate, MRWA, DPLH, Created by:AT Projection: MGA: zone 50.

N
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metres
Scale 1:12,000 @ A4

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4 IDENTIFICATION OF BUSHFIRE HAZARD ISSUES

The subject land contains and is adjacent to areas of regionally significant vegetation which have the potential to create a bushfire risk; however, it is considered that the bushfire risk to the proposed development can be adequately managed through appropriate location and siting and design of development, as well as necessary vehicular access and water supply which will be provided to the development.

4.1 Location

Fire risk exists from the vegetation which is to be retained and revegetated within subject land, as well as that from the adjacent Bush Forever Site. No development will be permitted within the wetland areas or their buffers, as they will be reserved for public open space (POS) to protect the significant environmental values.

Bushfire risk to development will be managed through separation from the vegetation via a 6m firebreak which will be maintained within the POS area by the City. It is noted that BAL-FZ and BAL-40 contours extend beyond the edge of the POS. No development will be permitted within this area through the establishment of asset protection zones (see 4.2).

Fire risk from the drainage basin on the corner of Bickley Rd and Victoria Rd will be managed by ensuring the land around the basin within the lot is maintained by the City of Gosnells in a low threat state. Therefore, it is considered that any future development will be located in an area that is subject to or BAL–29 or below.

4.2 Siting and design of development

Bushfire risk from vegetation within the subject land is associated with wetland and woodland areas that have significant recognised environmental values including the presence of species that are protected by State and Federal legislation. These areas are to be retained and protected through the establishment of reserves for local open space.

Adequate separation of the vegetation from development will be achieved through the maintenance of a 6m firebreak within the POS area and the creation of asset protection zones (APZ) on the adjacent land. The asset protection zones and the land surrounding the drainage basin on Bickley and Victoria Roads will be required to be managed to meet the following criteria:

- **Fences**: within the APZ are constructed from non-combustible materials (e.g. iron, brick, limestone, metal post and wire). It is recommended that solid or slatted non-combustible perimeter fences are used.
- **Objects**: within 10 metres of a building, combustible objects must not be located close to the vulnerable parts of the building i.e. windows and doors.
- **Fine Fuel load**: combustible dead vegetation matter less than 6 millimetres in thickness reduced to and maintained at an average of two tonnes per hectare.
- **Trees** (> 5 metres in height): trunks at maturity should be a minimum distance of 6 metres from all elevations of the building, branches at maturity should not touch or overhang the building, lower branches should be removed to a height of 2 metres above the ground and or surface vegetation, canopy cover should be less than 15% with tree canopies at maturity well spread to at least 5 metres apart as to not form a continuous canopy (Figure 6).

- **Shrubs** (0.5 metres to 5 metres in height): should not be located under trees or within 3 metres of buildings, should not be planted in clumps greater than 5m2 in area, clumps of shrubs should be separated from each other and any exposed window or door by at least 10 metres. Shrubs greater than 5 metres in height are to be treated as trees.
- **Ground covers** (<0.5 metres in height): can be planted under trees but must be properly maintained to remove dead plant material and any parts within 2 metres of a structure, but 3 metres from windows or doors if greater than 100 millimetres in height. Ground covers greater than 0.5 metres in height are to be treated as shrubs.
- **Grass**: should be managed to maintain a height of 100 millimetres or less.

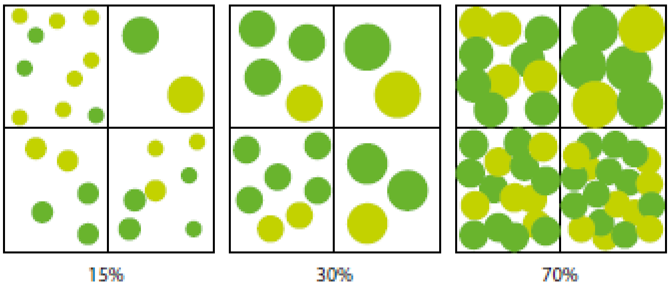


Figure 6: Tree canopy cover ranging from 15 to 70 percent at maturity (Source: WAPC, 2017)

As no proposed development will be subject to BAL-40 or BAL-FZ, it is considered that development will be sited to avoid areas of extreme bushfire risk.

4.3 Vehicular access

The subject site is afforded excellent access from the regional road network. The subject land is bounded by to the north by Victoria Road which provides strong east-west connectivity with Kelvin Road through the middle of the site. North-south links are provided by Bickley Road as well as the proposed internal road layout. These networks provide excellent access to and egress from the subject land.

The proposed local road network provides for at least two different access and egress routes to the majority of the proposed industrial areas. Although a cul-de-sac is identified at Kenwick Road, the affected lots have frontage to Kelvin Road which provides direct access onto the surrounding road network. Cul-de-sacs are also proposed at either ends of Victoria Ave. This will reduce the vehicular access for two lots north of the proposed new road and eight small lots at the south-western end of Victoria Ave. It is therefore proposed that emergency accessways are established between the southern cul-de-sac and Bickley Road and the northern cul-de-sac and Brentwood Road.

The cul-de-sacs will be constructed in accordance with the following requirements:

- Requirements in Table 3, Column 2;
- Maximum length: 200 metres (if public emergency access is provided between cul-de-sac heads maximum length can be increased to 600 metres provided no more than eight lots are serviced and the emergency access way is no more than 600 metres); and
- Turn-around area requirements, including a minimum 17.5 metre diameter head.

The emergency accessways will be constructed in accordance with the following requirements:

- Requirements in Table 3, Column 4;
- No further than 600 metres from a public road;
- Provided as right of way or public access easement in gross to ensure accessibility to the public and fire services during an emergency; and
- Must be signposted.

Any future road or transport infrastructure in an area subject to bushfire risk above BAL-LOW will be designed and constructed to meet the requirements of the *Guidelines for Planning in Bushfire Prone Areas* (Version 1.3 WAPC, 2017) Appendix Four, Table 4, as replicated in Table 3 below.

Table 3: Vehicular access technical requirements (WAPC, 2017)

Technical Requirement	Public road	Cul-de-sac	Private driveway	Emergency access way	Fire service access routes
Minimum trafficable surface (m)	6	6	4	6	6
Horizontal clearance (m)	6	6	6	6	6
Vertical clearance (m)	4	N/A	4.5	4.5	4.5
Maximum grade over <50m	1 in 10	1 in 10	1 in 10	1 in 10	1 in 10
Minimum weight capacity (t)	15	15	15	15	15
Maximum cross fall	1 in 33	1 in 33	1 in 33	1 in 33	1 in 33
Curves minimum inner radius (m)	8.5	8.5	8.5	8.5	8.5
Additional specialist requirements					

Due to the length of some of the lots, long private driveways may be needed to access the whole lot. It is noted that private driveways longer than 50m should be avoided in bushfire prone areas; however, where a lot is affected by BAL-12.5 or above, the following criteria should be met:

- Requirements in Table 4, Column 3;
- Required where a house site is more than 50 metres from a public road;
- Passing bays: every 200 metres with a minimum length of 20 metres and a minimum width of two metres (i.e. the combined width of the passing bay and constructed private driveway to be a minimum six metres);
- Turn-around areas designed to accommodate type 3.4 fire appliances and to enable them to turn around safely every 500 metres (i.e. kerb to kerb 17.5 metres) and within 50 metres of a house;
- Any bridges or culverts are able to support a minimum weight capacity of 15 tonnes; and
- All-weather surface (i.e. compacted gravel, limestone or sealed)

4.4 Water

The subject land is currently serviced by a reticulated water supply, together with fire hydrants, in accordance with the specifications of the Water Corporation and Department of Fire and Emergency Services (DFES).

New development will be required to meet the fire safety requirements of the Building Code of Australia, which include but are not limited to connection to adequate and reliable water supplies with access to an appropriately located fire hydrant.

Contractors or others carrying out building or other works at the site must not cover hydrants and/or the markings indicating their location. In the event activities occur that do result in hydrants or markings being covered, damaged, or removed, it will be the responsibility of the relevant contractor to rectify the situation.

5 ASSESSMENT AGAINST THE BUSHFIRE PROTECTION CRITERIA

The subject land contains and is adjacent to an area of bushfire risk. A suite of bushfire risk mitigation and management measures have been identified to reduce bushfire risk to the proposed development which, on completion, will achieve the objectives of SPP3.7. These measures are previously outlined in Section 3 and depicted in Figure 7.

The bushfire risk mitigation strategies proposed comply with the acceptable solutions for each of the Bushfire Protection Criteria detailed in *Guidelines for Planning in Bushfire Prone Areas* (2017). They are summarised in Table 4.

5.1 Compliance Table

Table 4: Bushfire protection criteria assessment

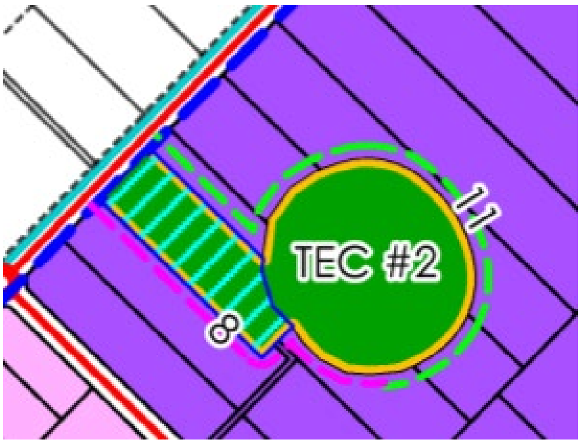
Element	Acceptable solution	Compliance	
1. Location	A1.1 Development location	☑	No development will be permitted in areas subject to BAL-40 or BAL-FZ.
2. Siting and design of development	A2.2 Asset Protection Zone	☑	Firebreak and APZ established to ensure no development will be subject to BAL-40 or BAL-FZ.
3. Vehicular Access	A3.1 Two access routes	☑	Short and long term public access is provided which ensures a minimum 2 access routes are provided at all times.
	A3.2 Public road	☑	All public roads will meet the requirements of Table 4 of Appendix 4 of the Guidelines for Planning in Bushfire Prone Areas (WAPC, 2017)
	A3.3 Cul-de-sac	☑	Two points of access provided to lots on the cul-de-sac. In addition, the design will be consistent with the requirements of Table 3.
	A3.4 Battle-axe	☑	Battle-ax lots are not recommended to be included in this area. Should future subdivision of areas subject to BAL-12.4 allow battle-axe lots, they will be designed to meet the requirements in Table 3..
	A3.5 Private driveway longer than 50m	☑	Any private driveways greater than 50m in length in areas subject to BAL 12.5 or above should be designed to meet requirements in Table 3.
	A3.6 Emergency access way	☑	Will be established at either ends of Victoria Ave, connecting it with Bickley Road and Brentwood Road to the requirements of Table 3, Column 4.
	A3.7 Fire service access routes	☑	The existing road network provides appropriate fire service access routes.
	A3.8 Firebreak widths	☑	Firebreaks around each area of public open space (wetlands to be retained and revegetated) to be 6m.
4. Water	A4.1 Reticulated areas	☑	The development has access to reticulated water and fire hydrants which meet Water Corporation and DFES specifications. Any new development

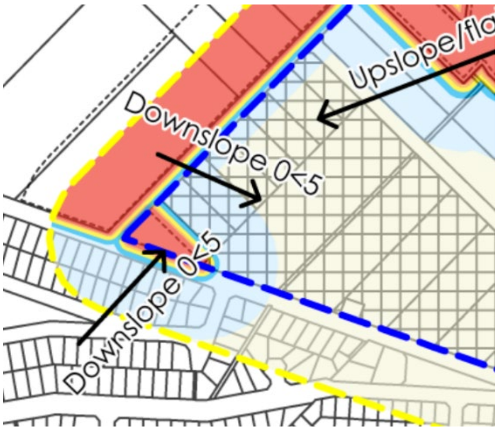
Element	Acceptable solution	Compliance	
			will be required to meet the requirements of the Building Code of Australia.
	A4.2 Non-reticulated areas	☑	N/A
	A4.3 Individual lots within non-reticulated areas	☑	N/A

5.2 Bushfire management strategies

Appropriate asset protection zones (APZ) will be established through this bushfire management plan on any lots adjacent to areas of public open space to ensure no development occurs in an area subject to BAL-FZ or BAL-40. The APZ is a defendable space within which firefighting operations can be undertaken to defend a building or structure. Activities and uses within the APZ will be maintained to the standards stated in section 4.2 by the landowner. The minimum widths of the APZ are shown in Figure 7 (and enlarged below) and are as follows:

- Three lots in the south east of the precinct on Bickey Rd – 8m to adjacent grassland;
- Lot adjacent to revegetated buffer north of Bush Forever site 53, Clifford Rd Bushland – 8m to edge of firebreak;
- Lots downslope of TEC#1 – 9m to edge of firebreak;
- Lots upslope of TEC#1 – 7m to edge of firebreak.
- Lots downslope of TEC#2 and nominal drainage basin– 11m to edge of firebreak; and
- Lots upslope of TEC#2 and nominal drainage basin– 8m to edge of firebreak.



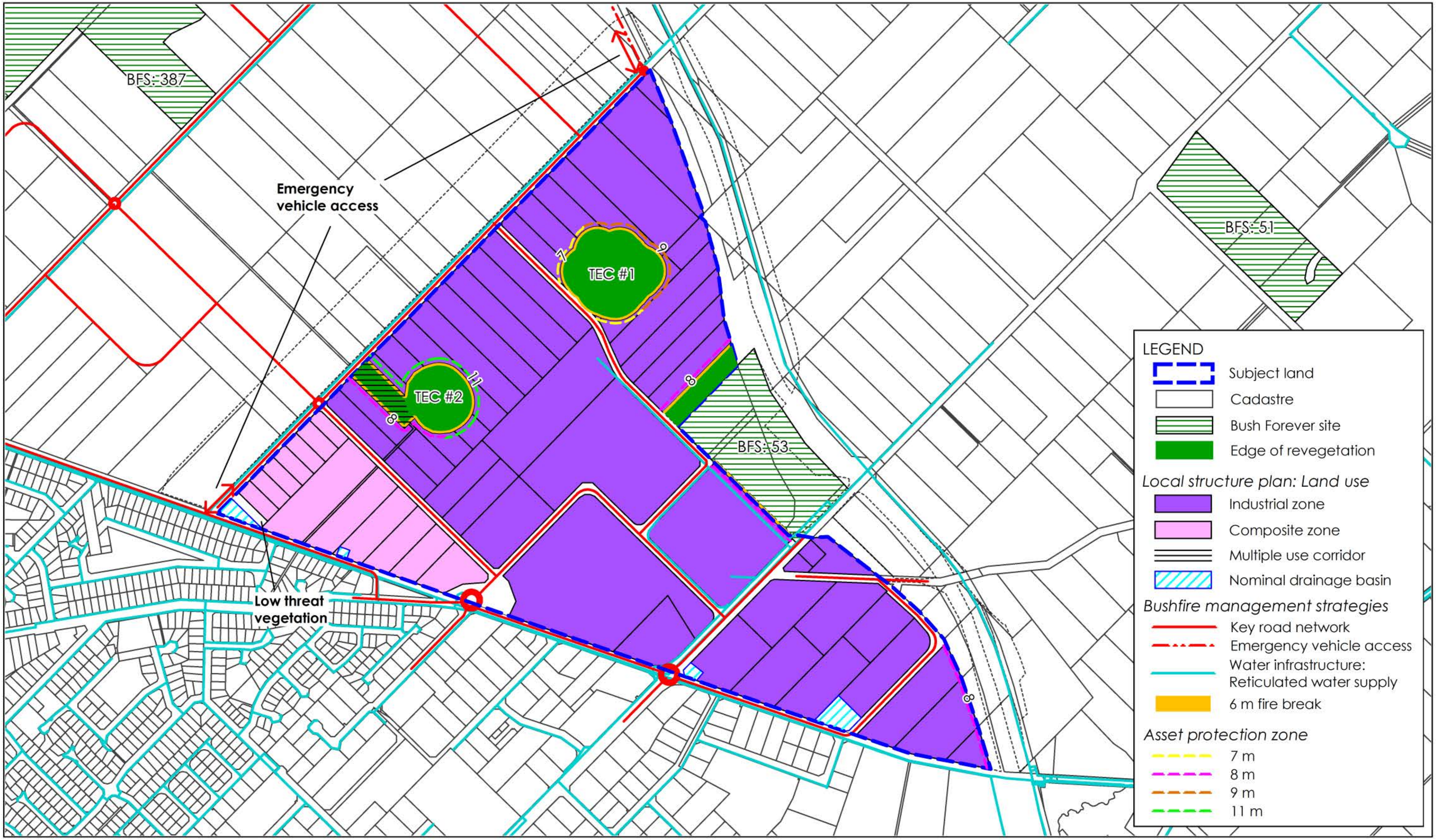


Eight lots within the area indicated as Composite Zone are affected by BAL-12.5. The Composite Zone provides for a residence to be located within the lot and it is intended that it is located within the front 35m. Any residential building affected by bushfire risk will need to be constructed to meet the requirements of *AS 3959:2009 Construction of buildings in bushfire prone areas*. However, due to the likelihood of removal of the vegetation to the north of Victoria Rd to permit future Industrial development and a lack of certainty regarding classification of the vegetation in the drainage basin, it is recommended that a BAL assessment is completed for any future Class 1-3 or 10 buildings in the area indicated as being affected by bushfire risk within the Composite Zone.

The remainder of the proposed development is for industrial use. There is no requirement for additional mitigation and/or construction methodologies to manage bushfire risk in accordance with *AS 3959: Construction of buildings in bushfire prone areas*. However, consideration should be given to the control of land use such that high risk land uses are not located within areas other than those that are assessed as BAL-LOW.

Any development located within areas other than BAL-LOW should by supported by a Risk Management Plan for any flammable on-site hazards. It is also recommended, due to the very important natural values and ecological processes that are associated with the areas of vegetation within and adjacent to the subject land, that the risk management plans outline measures to reduce the risk of activities on-site resulting in any fire risk to the vegetation.

City of Gosnells - Maddington Kenwick Strategic Employment Area, Precinct 1 Bushfire Management Plan
Figure 7 - Bushfire management strategies



Data source: Landgate, MRWA, DPLH, Created by:AT Projection: MGA: zone 50.

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6 RESPONSIBILITIES FOR IMPLEMENTATION AND MANAGEMENT OF THE BUSHFIRE MEASURES

The following management measures are recommended to support the proposed development and may be implemented as part of any future subdivision and/or development, or as an ongoing role of landowners. The measures aim to mitigate the inherent bushfire risk to life, property and the environment and achieve a suitable and effective bushfire management outcome for the site.

Implementation of this Plan will commence immediately and will be the responsibility of the landowners and the City of Gosnells. Likely tasks that will be involved with implementation of this plan are described in Table 5 and 6.

Although implementation of the following management measures is considered to mitigate bushfire risk, there is a need for individual landowners to protect their property in line with this bushfire management plan noting that, despite any management measures outlined in the bushfire management plan, during a bushfire event, fire appliances may not be available to protect each asset.

Table 5: Responsibilities of landowners

No.	Implementation Action	Development
1	Construct the emergency accessways and any roads, cul-de-sacs and private driveways to the standards stated in the BMP.	☐
2	Maintain vegetation that constitutes a fire hazard consistent with the requirements of the City of Gosnells Annual Fire Hazard Reduction Notice	☐
3	Maintain Asset Protection Zones on lots adjacent to regionally significant bushland (POS) to the requirements of this BMP.	☐
4	Any development located within areas other than BAL-LOW should by supported by a Risk Management Plan for any flammable on-site hazards, minimising risk of fire to adjacent bushland	☐

Table 6: Responsibilities of the City as part of ongoing operations and future decision-making

No.	Implementation Action	Ongoing
5	Maintain 6m firebreaks around areas of POS consistent with the City's Firebreaks Notice upon acquisition of land.	☐
6	Maintain the land around the drainage basin on corner Bickley and Victoria roads in a state of 'low threat vegetation.'	☐
7	Enforce the requirements of the City of Gosnells Annual Fire Hazard Reduction Notice	☐
8	Consider control of development such that high risk uses as defined in SPP 3.7 are not located within areas other than those that are assessed as BAL-LOW.	☐

No.	Implementation Action	Ongoing
9	Ensure design and construction of the emergency accessways and any cul-de-sac, battle axe access and private driveways meet requirements in the Guidelines and this Bushfire Management Plan	☐
10	Any further subdivision to require a notification, pursuant to Section 165 of the *Planning and Development Act 2005*, on the titles of lots subject to the requirements of this Bushfire Management Plan (those above BAL-LOW)	☐

6.1 Certification by Bushfire Consultant

I, Shelley Shepherd, certify that at the time of inspection, the BAL contours contained within this BMP are correct. Implementation of actions 1 – 10 should be undertaken as part of any future subdivision or development approvals process, and the ongoing management of land by landowners and the City of Gosnells.

Signature: Shepherd Date: 21 February 2019

ATTACHMENT 1: CITY OF GOSNELLS ANNUAL FIRE HAZARD REDUCTION NOTICE

Annual Fire Hazard Reduction Notice
Bush Fires Act 1954 Section 33(1)

To prevent bush fires and to minimise the spread of a bush fire, all owners and occupiers of land within the City's district are required to comply with the requirements of this Annual Fire Hazard Reduction Notice.

For the purposes of this Notice, flammable matter includes, but is not limited to, vegetation (except for living trees, shrubs, plants and lawns under cultivation), prunings, cardboard, wood, paper, general rubbish and any other combustible material.

1. Owners or occupiers of land zoned 'General Rural' or 'Special Rural'

On or before 30 November each year, all owners or occupiers of land zoned 'General Rural' or 'Special Rural' under the City of Gosnells Town Planning Scheme No. 6 are required to:

a. Clear and maintain the land free of all flammable matter to a height no greater than 10cm; or

b. Maintain a mineral earth firebreak immediately inside all external boundaries of each lot on the land and maintain a mineral earth firebreak within 20m of all haystacks and stockpiled flammable matter.

Mineral earth firebreaks must be continuous (no dead ends) and maintained to a minimum standard of 3m wide by 4m high (vertical clearance) so as to provide unimpeded access for emergency vehicles. Driveways must also be maintained to these standards.

Firebreaks are intended to provide safe access on your property for emergency vehicles and to ensure fire does not travel under the vehicles or underfoot.

Note: The firebreaks and requirements set out above must be maintained up to and including 30 April in the following year.

2. Owners or occupiers of all other land, which is not zoned 'General Rural' or 'Special Rural'

At all times throughout the year, all owners or occupiers of land zoned other than 'General Rural' or 'Special Rural' under the Scheme are required to clear and maintain the land free of all flammable matter to a height no greater than 10cm.

Permission needed to vary requirements

If, due to the topography or other constraints of your land, you are unable to adhere to the requirements set out in this Notice, you may apply in writing to the City for permission to provide firebreaks in alternative locations or take alternative measures.

Unless and until permission in writing is granted by the City, you shall comply with the requirements of this Notice.

All land owners

Further to the above minimum requirements, the landowner may receive a separate written notice, sent to the address shown on the City of Gosnells rates record, requiring additional works which may be considered necessary by an Authorised Officer of the City.

Penalty for non-compliance

Failing to comply with the requirements of this Notice is an offence under the Bush Fires Act 1954 (Act), which carries a penalty of up to $5,000. In addition, where the owner or occupier of the land fails to comply with a Notice given pursuant to Section 33(1), the City may enter the land to carry out the work required to comply with the Notice and also recover any costs and expenses incurred in carrying out that work from the owner or occupier of the land.

Client: City of Gosnells

Report	Version	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
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Final draft	V2	SSh	HBr	Electronic	4 October 2018
Final draft	V3	SSh	Hbr	Electronic	21 February 2019
Final draft	V4	SSh	AT	Electronic	17 April 2019

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Appendix M Cultural Heritage Assessment Report

ACHM
AUSTRALIAN CULTURAL
HERITAGE MANAGEMENT

Cultural Heritage Assessment Report

Final Report for the Aboriginal Heritage Impact Assessment of the City of Gosnells MKSEA Planning Scheme Oct 2018.

Whadjak Noongar Heritage Site Investigation and Survey.

By: Nigel Tonkin

Date: 27 October 2018

Client Name: City of Gosnells
Client Contact: Clayton Windass
Address: PO Box 662
Gosnells WA
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Final Report for the Aboriginal Heritage Impact Assessment of the City of Gosnells MKSEA Planning Scheme Oct 2018.

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By: Nigel Tonkin

Date: 27 October 2018

Client Name: City of Gosnells
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Address: PO Box 662
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6990
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Document Control Information

Document information
Client: City of Gosnells Client Contact: Clayton Windass Title: Final Report for the Aboriginal Heritage Impact Assessment of the City of Gosnells MKSEA Planning Scheme Oct 2018. Subtitle: Whadjak Noongar Heritage Site Investigation and Survey. Our Ref: P18-0172 Date: 27 October 2018

Version	Date	Details
1.0	22/11/2018	For Client

Recipient Name	Organisation	Hardcopy	Electronic	Transmission Method	Purpose	Date
Clayton Windass	City of Gosnells		X	email	Report	

Author, Reviewer and Approver details				
Prepared by:	Nigel Tonkin	Date: 23/10/2018	Signature:	
Reviewed by:	Dr Shaun Canning	Date: 26/11/2018	Signature:	
Approved by:		Date:	Signature:	

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The professional advice and opinions contained in this document are those of the consultants, Australian Cultural Heritage Management (Victoria) Pty Ltd, and do not represent the opinions and policies of any third party.

The professional advice and opinions contained in this document do not constitute legal advice.

Spatial Data

Spatial data captured by Australian Cultural Heritage Management (Victoria) Pty Ltd in this document for any newly recorded sites has been obtained by using hand held or differential GPS units using the GDA94 co-ordinate system.

Abbreviations

Term	Meaning
ACHM	Australian Cultural Heritage Management
ACMC	Aboriginal Cultural Material Committee
AHA	*Aboriginal Heritage Act 1972* (WA)
AHIS	Aboriginal Heritage Inquiry System
CCW	Conservation Category Wetland
DPLH	Western Australian Department of Planning, Land and Heritage
GIS	Geographic Information System
GPS	Global Positioning System
MKSEA	Maddington Kenwick Strategic Employment Area
SWALSC	South West Aboriginal Land and Sea Council
TEC	Threatened Ecological Community
WA	Western Australia

Acknowledgements

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- Cindy Nelson (Whadjak Noongar Representative)
- Clayton Windass (City of Gosnells Representative)
- Dianne Wynne (Whadjak Noongar Representative)
- Doreen Nelson (Whadjak Noongar Representative)
- Glenys Yarran (Whadjak Noongar Representative)
- Jessica Landers (Whadjak Noongar Representative)
- Marian Collard (Whadjak Noongar Representative)
- Marlene Warrell (Whadjak Noongar Representative)
- Noel Morich (Whadjak Noongar Representative)
- Patricia Morich (Whadjak Noongar Representative)
- Reg Yarran (Whadjak Noongar Representative)
- Rick Malin (City of Gosnells Representative)
- Sophie Williams (Whadjak Noongar Care Taker)
- Stan Headland Jnr (Whadjak Noongar Representative)
- Stan Headland Snr (Whadjak Noongar Representative)
- Violet Pickett (Whadjak Noongar Representative)
- Wayne van Lieven (City of Gosnells Representative)

Executive Summary

Australian Cultural Heritage Management (Victoria) Pty Ltd (ACHM) have been engaged by the City of Gosnells to undertake the Aboriginal Cultural Heritage Impact Assessment of the City of Gosnells proposed Maddington Kenwick Strategic Employment Area (MKSEA). The Maddington Kenwick Strategic Employment Area (MKSEA) is an area bound by Bickley Road, Roe Highway and Tonkin Highway is currently being investigated for future industrial development (see Map 1-1). The aim of the proposed development is to determine if future industrial development can occur whilst ensuring the protection of key environmental characteristics of the area. The area has been and continues to be subject to various planning studies to determine its suitability of industrial development.

This Report documents the results of the Cultural Heritage Impact Investigation of the 6 designated sites within the proposed MKSEA impact areas, which was conducted 22 - 24 Oct 2018.

The work area lies wholly within the Whadjak Noongar Native Title area in the City of Gosnells MKSEA Precincts.

It should also be noted that prior to the commencement and in some instances during, that all permissions to enter target areas located on privately owned property was sought and obtained by the city of Gosnells prior to any entry. These permissions also informed of the survey target methodology.

As a result of the Cultural Heritage Impact Assessment:

- Taking into consideration the extensive historical development and land use within the proposed MKSEA project footprint, only those places where remnant vegetation i.e. Conservation Category Wetland (CCW) and Threatened Ecological Community (TEC) areas were deemed suitable for investigation and subsequently inspected (notwithstanding access restrictions) (see Map 8-1) due to the higher potential for in-situ cultural material in its original depositional context.
- Lots #110, #107, #195, #142, # 501, # 190, #279, #130, #137, #139, #71 and #78 were visited over the course of the fieldwork.
- 6 sites listed in the scope of works within Maddington Kenwick Strategic Employment Area (MKSEA) were revisited. These sites include (DPLH Place Id); Wattle Grove, Perth (3312) - or part thereof; Boundary Road, Wattle Grove (3624); Brentwood Road NW (4341); Brentwood road Quarry (4342); Brentwood Road Swamp (4343); and Yule Brook Farm 02 02 (24785).
- Of the six (6) visited locations, two (2) sites - Boundary road, Wattle Grove (3624 and Yule Brook Farm 02 02 (24785) could not be inspected in detail and due to access constraints or restrictions and subsequently were viewed from a short distance ~50m or less.
- Of the revisited sites, three (3) were found to be heavily disturbed by historical land use activities and therefore could no longer be recorded and assessed in detail as heritage sites under the AHA 72.
- Czerwinski 2009 Table 6: pg15 reports that all 3 artefacts were previously collected and therefore DPLH Id 3312 may be considered no longer a site under Section 5 of the AHA 72.
- One site - Edward/Grove Streets (4340) was not visited due to time constraints. Furthermore, the survey team were advised by the City of Gosnells representatives that this site was subject to an evaluation/inspection by another heritage consultancy which had been commissioned by the current landowner and no results were available at the time of drafting this report.
- The 3A Precinct and City of Kalamunda Precinct were not visited over the course of the Survey as no Conservation Category Wetland (CCW) and Threatened Ecological Community (TEC) areas are present in these areas furthermore time constraints restricted target location options.

ACHM, in consultation with the Whadjak Noongar Traditional Owners, recommends the following:

- For those locations - Brentwood Road NW (DPLH Id 4341); Brentwood Road, Quarry (DPLH Id 4342); Brentwood Road Swamp (DPLH Id 4343); that have been re-assessed as no longer likely to constitute an archaeological sites under section 5 of the AHA 72, the *Whadjak Noongar* representatives requested that further investigation is undertaken to provide understanding regarding any approval processes may have been undertaken prior to any ground disturbance activities.
- Boundary Road, Wattle Grove (DPLH Id 3624) further investigation is required to determine the condition and intactness of the site.

- If the access is granted by the land owner and the opportunity to visit this location become available that the Yule Brook Farm 02 02 (24785) site is investigated to determine the condition and intactness of the site.
- Should ground disturbing activity be proposed within the immediate vicinity of any previously identified site, *Whadjak Noongar* Traditional Owners are afforded the opportunity to have two representatives monitor earthworks at the following locations; Boundary Road, Wattle Grove (DPLH Id 3624); Brentwood Road NW (4341); Brentwood road Quarry (4342); Brentwood Road Swamp (4343); and Yule Brook Farm 02 02 (24785).
- *Whadjak Noongar* Traditional Owners requested an opportunity to undertake further discussion and consultation with the City of Gosnells regarding the future management and employment opportunities (such as conservation land managers, rangers as well as the establishment of potential tourism ventures) with regards to the area of land listed as the Bush Forever Precinct.
- The *Whadjak Noongar* representatives have requested further opportunity to have a suitably qualified anthropologist to conduct further ethnographic consultation re the Yule Brook Stream, as this water way was presented as a place of importance to past lifeways and daily life. It was considered that two days at accessible locations along the Yule Brook with Whadjak Noongar elders would be sufficient.
- Any proposed impacts to the newly recorded archaeological sites, and any other previously recorded sites, may breach section 17 of the AHA. It is recommended that any earthworks should avoid any damage or disturbance to these areas
- In the Rezoning MKSEA precincts that the street names are amended or replaced Whadjak Noongar names and places.

In addition to the archaeological recommendations provided in this report, Whadjak Noongar may have additional recommendations relating to the management and mitigation of these sites. Further consultation and engagement with Whadjak Noongar regarding proposed impacts and mitigation strategies should be conducted.

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1 MKSEA Location and Background

Australian Cultural Heritage Management (Victoria) Pty Ltd (ACHM) have been engaged by the City of Gosnells to undertake the Aboriginal Cultural Heritage Impact Assessment of the City of Gosnells proposed Maddington Kenwick Strategic Employment Area (MKSEA). The Maddington Kenwick Strategic Employment Area (MKSEA) is an area bound by Bickley Road, Roe Highway and Tonkin Highway is currently being investigated for future industrial development (see Map 8-1). The aim of the proposed development is to determine if future industrial development can occur whilst ensuring the protection of key environmental characteristics of the area. The area has been and continues to be subject to various planning studies to determine its suitability of industrial development.

1.1 Project Participation

- Cindy Nelson (Whadjak Noongar Representative 24 Oct)
- Clayton Windass (City of Gosnells Representative 22-24 Oct)
- Dianne Wynne (Whadjak Noongar Representative 23-24 Oct)
- Glenys Yarran (Whadjak Noongar Representative 22 & 24 Oct)
- Jessica Landers (Whadjak Noongar Representative 23-24 Oct)
- Marian Collard (Whadjak Noongar Representative 22-24 Oct)
- Nigel Tonkin (ACHM Archaeologist 22-24 Oct)
- Noel Morich (Whadjak Noongar Representative22-24 Oct)
- Rick Malin (City of Gosnells Representative 22-24 Oct)
- Stan Headland Snr (Whadjak Noongar Representative24 Oct)
- Violet Pickett (Whadjak Noongar Representative 22-24 Oct)
- Wayne van Lieven (City of Gosnells Representative 22-24 Oct)
- Doreen Nelson (Whadjak Noongar Representative 22-23 Oct)
- Patricia Morich (Whadjak Noongar Representative 23 Oct)
- Reg Yarran (Whadjak Noongar Representative 22-23 Oct)
- Stan Headland Jnr (Whadjak Noongar Representative 22-23 Oct)
- Marlene Warrell (Whadjak Noongar Representative22 Oct)
- Sophie Williams (Whadjak Noongar / Cared for Marian Collard 22-23 Oct)

2 Aboriginal heritage Protection Legislation

2.1 Aboriginal Heritage Act 1972 (WA)

The Minister for Aboriginal Affairs is responsible for the administration of the Western Australian Aboriginal Heritage Act 1972 (AHA). Under section 17 of the AHA, it is an offence to disturb any Aboriginal site. If a development is likely to impact a site, the consent of the Minister is required under section 18 of the AHA. The Minister receives a recommendation from the Aboriginal Cultural Material Committee (ACMC) before giving consent. S/he considers its recommendations and the general interests of the community when deciding. The Minister may also impose conditions on her/his approval.

The AHA was enacted to protect and preserve Aboriginal heritage. This includes any places or objects of past or present significance to Aboriginal people. It also provides for fines and jail sentences for breaches.

Section 15 of the AHA outlines the obligations relating to the reporting of an archaeological find.

Section 5 of the AHA provides the following definitions regarding Aboriginal sites:

> *a) Any place of importance or significance where people of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of Aboriginal people, past or present;*
>
> *b) Any sacred, ritual or ceremonial site, which is of importance and special significance to people of Aboriginal descent;*
>
> *c) Any place which, in the opinion of the committee, is or was associated with Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the State; and*
>
> *d) Any place where objects to which this Act applies are traditionally stored, or to which, under the provisions of the Act, such objects have been taken or removed.*

Any place determined to be a site under section 5, is then evaluated under section 39 of the AHA. Sections 39 (2) & (3) state:

(2) In evaluating the importance of places and objects the committee shall have regard to -

> *(a) Any existing use or significance attributed under relevant Aboriginal custom;*
>
> *(b) Any former or reputed use or significance which may be attributed on the basis of tradition, historical association, or Aboriginal sentiment;*
>
> *(c) Any potential anthropological, archaeological or ethnographical interest; and*
>
> *(d) Aesthetic values.*

(3) Associated sacred beliefs, and ritual or ceremonial usage, in so far as such matters can be ascertained, shall be regarded as the primary considerations to be taken into account in the evaluation of any place or object for the purposes of this Act.

2.2 DPLH Heritage Information Submission Form

The DPLH has developed a standard Heritage Information Site Recording Form (HISF), which is intended to capture sufficient relevant information to enable a decision on the applicability of the AHA to an Aboriginal place. The HISF requires information including the location of the place, the type of site with evidence and justification as to why the place is considered an Aboriginal site, a discussion of why and to whom the place is significant and important, and the condition of the site.

3 Methodology

3.1 Searches for Previously Recorded Sites

Prior to the site recording trip commencing, a search of the Aboriginal Heritage Information System and Aboriginal Heritage Sites Register maintained by the DPLH in Perth was conducted to identify any previously recorded Aboriginal sites that intersect with the immediately surrounding area. The DPLH Site Register is a record of previously recorded Aboriginal sites and heritage surveys within WA and is a mechanism whereby a proponent can identify previously reported Aboriginal sites on a parcel of land.

A similar search was also undertaken of the ACHM Corporate Archives.

4 Archaeological Recording Methods

It should also be noted that prior to the commencement and in some instances during, that all permissions to enter investigation/survey target areas located on privately owned property was sought and obtained by the City of Gosnells prior to any entry. These permissions also informed of the survey target methodology

The site recording was conducted between the 22 - 24 October 2018, with a team consisting of one ACHM archaeologists, between six and eight Whadjak Noongar representatives and Three Gosnells City representatives. The Gosnells City representatives provided logistical support and advice. Geographic Information System (GIS) data was uploaded into hand held Garmin GPS Map 64st unit for orientation in the field and to provide previously defined boundaries for the sites. Hard copy maps illustrating the boundaries of sites were also utilised in the field to inform team members of locations to be visited over the course of the trip.

The previously recorded locations were revisited (see Map 8-1) and subjected to detailed inspections to assess the presence of enough cultural material and determine the level of recording which may be required to assess the sites archaeological significance.

Places that may be identified as sites were recorded to a level considered enough to make an informed assessment on the site's potential significance. Where required, GPS units are used to record newly defined polygon boundaries for each site, as well as individual site attributes such as high-density artefact concentrations, individual grindstones, or topographic features.

ACHM archaeologists record the environmental setting for each archaeological site. This included collecting data on landforms, terrain, aspect, slope, orientation of the site and its position on the slope. Vegetation, topography, surface geology (presence/absence of surface rock or roof fall, surface matrix), and soil types (e.g. sand, loam, clay, etc.) are observed. Also noted are site formation processes operating at each site, including natural and artificial taphonomic processes such as evidence of site disturbance, erosion and preservation issues. Ground surface visibility was assessed and is represented as an average percentage of ground surface visibility across the site (0-30% low, 30-70% moderate and 70-100% high).

The site’s proximity to ephemeral or permanent water sources, to prominent landscape features and to other Aboriginal sites is also recorded. If potential subsurface archaeological material was suspected, it is recorded as a Potential Archaeological Deposit (PAD). The taphonomic conditions relating to the formation of the potential archaeological deposit was also considered. Excavation of PADs proceeds only if there is a section 16 authorisation or section 18 consent under the AHA.

Digital photography is used to provide additional environmental context for each site; photos are taken across the site and the direction of each image is noted. Site plans are drawn in the field, these will be scanned and digitized and provided to the proponent in the final report.

Pink and black heritage tape is used to demarcate the boundary of each site to alert against possible incursion and to help relocate it for further heritage work.

At each location, discussions were held with the Traditional Owners concerning what future management strategies they requested for each site. This report presents information regarding which sites do/do not require salvaging, and what level of salvage is recommended; detailed information regarding recommendations for each site is included.

- For all Aboriginal sites the following general data is recorded and are presented in this report:
- Site ID
- Site Type
- Easting (GDA94 – Zone 50)
- Northing (GDA94 – Zone 50)
- Site Measurements
- Archaeological significance
- Proposed salvage methodology and future analysis recommendations
- Stone Artefact Assemblages and Knapping Sites

ACHM archaeologists and Whadjak Noongar representatives conducted a visual inspection of each artefact assemblage to establish the distribution of cultural materials. Types of materials at artefact sites that may be identified include stone, bone, shell, ochre, charcoal, wood, glass, metal and ceramic. Artefact raw material types were defined based on rock type, colour, texture, and grain size. Artefacts were considered within a technological reduction system and were classified as being either cores (or core fragments), flakes (or broken flakes), flaked pieces or retouched flakes. Broad trends of artefact types and raw material use are recorded for the sites. Digital photography is used to record a sample of the artefacts within each site.

The basis of the recording methodology involved two major variable site characteristics: (1) the physical extent and shape of the site and (2) the concentration (density variations) of the assemblage on the ground. Other variables included the terrain and ground visibility.

At those locations where site assessment and recording is to occur the team follow the guidelines as presented in the scope of works, for the stone artefacts, the following attributes are recorded:

- Observed % of Raw material/lithology
- Observed % of Artefact type, such as:
- Core: is an artefact from which flakes have been detached using a hammer stone. The core will have one or more negative flake scars where flakes have been detached. Core types include single platform, multiplatform, and bipolar forms.
- Flake: is the detached fragment created by fracturing rock and will have a number of diagnostic features on the ventral and dorsal surface. This includes a striking platform, ring crack, and bulb of percussion on the ventral surface; the dorsal surface will have either cortex, or negative flake scars - depending on the stage of removal from the core.
- Retouched Flake: is a flake that has been flaked again along one or more of its margins, with the aim of sharpening or serrating the edge.
- Flake Fragment: Whether the artefact is complete or broken (fragment), and if broken, whether it was a longitudinal or transverse break
- Any observed grinding stones are noted, and their location recorded
- Any observed retouched or formal tools are noted, and their location recorded
- General areas of artefact concentrations and densities are noted as well as the overall spatial distribution of knapped stone.

5 Results of the Survey

5.1 Project Location and Environment

The Heritage Site Investigation and Survey are is located within the City of Gosnells local Government precinct which is situated 17kms south east from the Perth CBD and is the 5th largest local government in Western Australia (see Map 8-1).

The project area lies in the Brixton and Yule brook catchment area and the greater portion (~90%+) of the Project area has been subject to land development activities of both an Industrial and Rural nature in the past. As the environmental (Flora, Fauna and Vegetation) of the MKSEA has been reviewed and reported in detail by Cardno BSD Pty Ltd (2005) and Tuass & Weston (2010) for the City of Gosnells previously and therefore will not be reiterated here. However, it should be noted that there are several small and localized areas in the MKSEA project area footprint in which remnant bushland was noted.

6 Previously Reported Sites in the MKSEA

6.1 Archaeological Background

Prior to the site recording trip commencing, a search of the Aboriginal Heritage Information System and Aboriginal Heritage Sites Register maintained by the DPLH in Perth was conducted to identify any previously recorded Aboriginal sites that intersect with the immediately surrounding area. The DPLH Site Register is a record of previously recorded Aboriginal sites and heritage surveys within WA and is a mechanism whereby a proponent can identify previously reported Aboriginal sites on a parcel of land.

A similar search was also undertaken of the ACHM Corporate Archives and the details of these searches are below in Table 6-1.

Table 6-1: Previously Identified Sites in the MKSEA

#	Site Name (DPLH Id)	Site Type	MKSEA Precinct	Central Coordinate Easting mE - Northing mN	Arch / Ethno
1	Wattle Grove, Perth. (3312)	Artefact Scatter	Overlaps 2 & 3A	403639mE - 6456649mN	Archaeological
2	Boundary Road, Wattle Grove (3264)	Artefact Scatter	2	403739mE - 6456299mN	Archaeological
3	Edward/Grove Streets (4340)	Artefact Scatter	3A	403339mE - 6457599mN	Archaeological
4	Brentwood Road, NW (4341)	Artefact Scatter	2	405189mE - 6457599mN	Archaeological
5	Brentwood Road, Quarry (4342)	Artefact Scatter	2	405489mE - 6457199mN	Archaeological
6	Brentwood Road, Swamp (4343)	Artefact Scatter	2	405489mE - 6457199mN	Archaeological
7	Yule Brook Farm 02 (24785)	Artefact Scatter	3A	403053mE - 6457085mN	Archaeological

As can be noted in the above table the predominate site type across the area is artefact scatters with all seven (7) sites containing knapped stone. A review of the above sites suggests that the most likely site type to be encountered is small low-density artefact scatters with limited likelihood of other site types such as culturally modified tree or grinding patch sites. Furthermore, the site review coupled with a landscape analysis also indicates a low likelihood to encounter archaeological sites taking into consideration most of the survey area has been subject to historical disturbance associated with land development and clearing of native / remanent habitat.

A full review of the previous sites identified within the MKSEA survey area is reported by Czwerinski (2009) and has been presented to the City of Gosnells. Therefore, a comprehensive background will not be reiterated here. In the course of the survey, those previously recorded sites where the boundary overlapped the survey area and may be subject to impact by the proposed works were reassessed. The details of any reassessment are presented in the results section below.

6.2 Ethnographic background

No Ethnographic sites have been previously identified in the MKSEA area.

However, as noted in Czerwinski 2009: pg 16-17 in the section titled, *4.1.1 Relevant Reports and Aboriginal Site Implications* recommendations taken from Gifford 2007 were presented regarding the *concerns for the future preservation and the registration of the Yule Brook as a site noting the historical disturbance of the creek itsel*f.

Furthermore, in the course of the investigation the Whadjak Representatives requested that the City of Gosnells engage additional Anthropological services (preferably a female practitioner) to conduct a more in-depth assessment with Whadjak Noongar Elders in relation to the Yule Brook as well as record the details of a Frog Dreaming story as told to Violet Pickett and her sisters (names not provided) by their father.

7 Heritage Investigation and Site Assessment Results

7.1 Precinct One (1)

Precinct 1 was visited on the 22 Oct 2018.

There are No previously recorded sites within Precinct One (1) and two (2) areas identified as either Conservation Category Wetland (CCW) or Threatened Ecological Community (TEC) -. Following a debriefing period, the team investigated these areas, Lot numbers #110 and #107. A detailed search of the Investigation/survey target areas in remaining remnant bushland in Precinct 1 resulted in NO previously recorded aboriginal heritage sites or new aboriginal heritage sites being identified.

7.2 Precinct Two (2)

Precinct 2 was visited on the 23 & 24 Oct 2018.

There are 5 previously recorded sites within Precinct Two (2) and six (6) areas identified as either Conservation Category Wetland (CCW) or Threatened Ecological Community (TEC). Following debriefing period, the team investigated these areas. A detailed search of the Investigation/survey target areas in remaining remnant bushland in Precinct 2 resulted in the identification of 1 Isolated Artefact (see Figure 7-1) which was collected by Stan Headland Jnr for safe keeping. There were NO new aboriginal heritage sites identified in the target investigation areas.

Figure 7-1: Isolated Artefact - Quartz Flake held by Stan Headland Jnr.

A total 5 previously recorded sites were identified within or overlapping the MKSEA Precinct Two Inspection/Survey areas and all of these were subject to detailed investigation.

7.2.1 Wattle Grove, Perth DPLH Id 3312 - Artefact Scatter

This site is a small artefact Scatter consisting of 3 Quartz Flakes and was initially recorded in 1973 by Hallam (1986). This site has a large Polygon that overlaps a portion of Precinct 2, Precinct 3A & 3B, Bush Forever allotment of land as well as a large area outside the MKSEA footprint. Furthermore, this site boundary covers the Boundary Road, Wattle Grove site (details below). Czerwinski 2009 Table 6: pg15 reports that all 3 artefacts were previously collected and therefore DPLH Id 3312 may be considered no longer a site under Section 5 of the AHA 72.

7.2.2 Boundary Road, Wattle Grove DPLH Id 3624 - Artefact Scatter

This site is a small artefact Scatter consisting of 3 artefacts 1x Quartz Flake, 1 x Dolerite Flake and 1 x Glass was initially recorded in 1970 by Hallam (1986). This site has a small circular boundary that is situated in its entirety in Precinct 2, within the MKSEA footprint. Czerwinski (2009:15) reports that all 3 artefacts represent a contact assemblage and is listed as a registered Aboriginal heritage site. Upon visiting the recorded site location central coordinate, the team found the area to be heavily disturbed by pastoral activities as a number of horses were observed grazing at the site location. Furthermore, the area had formed a natural wetland in was in a large part underwater. The team were not able to investigate the area in which the site central coordinate was located as winter rains had in undated the site location and it was therefore inaccessible. Further investigation is required to determine the presence of cultural materials, condition and intactness of site. However, given the evident disturbance it is unlikely that any cultural materials present would be in their original depositional context and the site integrity is very poor.

Figure 7-2: Boundary Road, Wattle Grove DPLH Id 3624; located in wetland left half of Image behind trees.

7.2.3 Brentwood Road, NW DPLH Id 4341

This site is a small artefact Scatter consisting of ~50 artefacts, 49 x Quartz and 1 x Chert which was initially recorded in 1973 by Stranger (no date). This site has a small circular boundary that is situated almost in its entirety (~90%) in Precinct 2, within the MKSEA footprint. Czerwinski 2009 Table 6: pg15 reports from Strawbridge 1988: 56) " **There are also many sites that have been disturbed by development……these sites cannot be or do not require further assessment** ". It is also noted in Czerwinski 2009: 13 that;

> *Currently (2009) there is insufficient information for the ACMC to determine if this is an Aboriginal site" but there is potential for this to be determined to be an Aboriginal site. More information is required by the ACMC to determine the sites status*.

Upon visiting the recorded site location central coordinate, the team found the area to be heavily disturbed by historical clearing activities as building rubble was found at this location. Furthermore, the area to the SW of the central coordinate was built up with significant earthworks in place (see Figure 7-3 and Figure 7-4 below). The remaining site area in which remnant bushland was identified was inspected in detail with no cultural material identified. Given the evident disturbance it is unlikely that any cultural materials present would be in their original depositional context and the site integrity is very poor. Therefore, it is considered that it is unlikely that Brentwood Road, Quarry DPLH Id 4342 would constitute an aboriginal Heritage site under section 5 of the AHA 72.

Figure 7-3: Brentwood Road NW DPLH Id 4341 Central Coordinate Location view NNW

Figure 7-4: Brentwood Road NW DPLH Id 4341 SW portion of site view SE

Brentwood Road, Quarry DPLH Id 4342

This site is a small to moderate sized artefact Scatter/Quarry consisting of ~48 artefacts, 40 x Quartz, 7 x Fossilized Chert, and 1 x Chert which was initially recorded in 1973 by Stranger (no date). This site has a small circular boundary that is situated half in half out (~50%) of Precinct 2, within the MKSEA footprint. It is notable that that approximately half of the site area is situated across the Tonkin Hwy at the location where a culvert drain is located (see Figure 7-5). Czerwinski 2009 Table 6: pg15 reports from Strawbridge (1988: 56) "*There are also a large number of sites that have been disturbed by development…. these sites cannot be or do not require further assessment".*

Upon visiting the recorded site location central coordinate, the team found the area to be heavily disturbed, and within 12m of the Culvert Drainage exit point that runs underneath the Tonkin HWY. General visibility at the site location was poor around the central coordinate at <10%. However further to southern and eastern portions of the site were access was granted by the current land owners' visibility was mildly increased at 10-20%. Nevertheless, given the evident extensive disturbance it is probable that any cultural materials present would not be in their original depositional context and the site integrity is very poor. Therefore, it is considered that it is unlikely that Brentwood Road, Quarry DPLH Id 4342 would constitute an aboriginal Heritage site under section 5 of the AHA 72.

Figure 7-5: Brentwood Road, Quarry DPLH Id 4342 site with Tonkin HWY - View SE.

7.2.4 Brentwood Road, Swamp DPLH Id 4343

This site is a small to moderate sized artefact Scatter consisting of ~42 artefacts, 32 x Quartz and 10 x Fossilized Chert, which was initially recorded in 1973 by Stranger (no date). This site has a small circular boundary that is situated half in half out (~50%) of Precinct 2, within the MKSEA footprint. It is notable that that approximately half of the site area is situated across the Tonkin Hwy at the location where a culvert drain is located. Czerwinski 2009 Table 6: pg15 reports from Strawbridge (1988: 56) "*Indications of early occupation. This site requires further examination prior to disturbance by development".*

Of note, both this site and Brentwood Road, Quarry DPLH Id 4342 are listed on the DPLH AHIS and site cards at the same location at 405489mE - 6457199mN.

Upon visiting the recorded site location central coordinate, the team found the area to be heavily disturbed, and within 12m of the Culvert Drainage exit point that runs underneath the Tonkin HWY (see Figure 7-6). General visibility at the site location was poor around the central coordinate at <10%. However further to southern and eastern portions of the site were access was granted by the current land owners' visibility was mildly increased at 10-20%. Nevertheless, given the evident extensive disturbance it is unlikely that any cultural materials present would be in their original depositional context and the site integrity is very poor. Therefore, it is considered that it is unlikely that Brentwood Road, Swamp DPLH Id 4343 would constitute an aboriginal Heritage site under section 5 of the AHA 72.

Figure 7-6: Brentwood Road, Swamp DPLH Id 4343 site with Tonkin HWY - View SE

7.3 Precinct Three (3) B

Precinct 3B was visited on the 24 Oct 2018.

There are No previously recorded sites within Precinct 3B and two (2) areas identified as either Conservation Category Wetland (CCW) or Threatened Ecological Community (TEC). Following debriefing period the team investigated these areas including several accessible points along the Yule Brook. A detailed search of the Investigation/survey target areas in remaining remnant bushland in Precinct 3B resulted in NO previously recorded aboriginal heritage sites or new aboriginal heritage sites being identified. Visited Lot#71 and #8 before walking the edge of the Yule Brook which was very densely vegetated resulting in <5% visibility along both banks.

Figure 7-7: Survey Team visiting Yule Brook at rear of Lot#71 - View SW

7.4 Precinct Three (3) A

Precinct 3A was not visited in the course of the Heritage Impact Assessment. However, two (2) previously recorded sites were noted in the Precinct 3A MKSEA footprint.

7.4.1 Yule Brook Farm 02 DPLH Id 24785

This site is a small artefact Scatter consisting of 24 artefacts all Quartz was initially recorded in 2007 by Hook (2007). This site has a small circular boundary that is situated in its entirety in Precinct 3A, within the MKSEA footprint. Czerwinski 2009 Table 6: pg15 reports (from Hook 2007: 33) that *If the water corporation intend to conduct excavation works in this area that shovel test pitting occurs at YB07-01* This site is listed on the DPLH AHIS as a lodged Aboriginal heritage site.

Access was not granted to visit the property on which the site was recorded and therefore the team were not able to investigate the area in which the site central coordinate was located as winter rains had lush grasses cover the site location and visibility was very low. Further investigation is required to determine the presence of cultural materials, condition and intactness of site. However, given the evident disturbance it is unlikely that any cultural materials present would be in their original depositional context and the site integrity is very poor.

Figure 7-8: Yule Brook Farm 02 DPLH Id 24785 view NE

7.4.2 Edward/Grove Streets DPLH Id 4340

This site was not visited in the course of the survey due to time constraints and that the land owner had commissioned a heritage investigation through another heritage consultancy. The results of that survey were not available at the time of drafting this report.

8 Summary of Results

Australian Cultural Heritage Management (Victoria) Pty Ltd (ACHM) have been engaged by the City of Gosnells to undertake the Aboriginal Cultural Heritage Impact Assessment of the City of Gosnells proposed Maddington Kenwick Strategic Employment Area (MKSEA). The Maddington Kenwick Strategic Employment Area (MKSEA) is an area bound by Bickley Road, Roe Highway and Tonkin Highway is currently being investigated for future industrial development (see Map 1-1). The aim of the proposed development is to determine if future industrial development can occur whilst ensuring the protection of key environmental characteristics of the area. The area has been and continues to be subject to various planning studies to determine its suitability of industrial development.

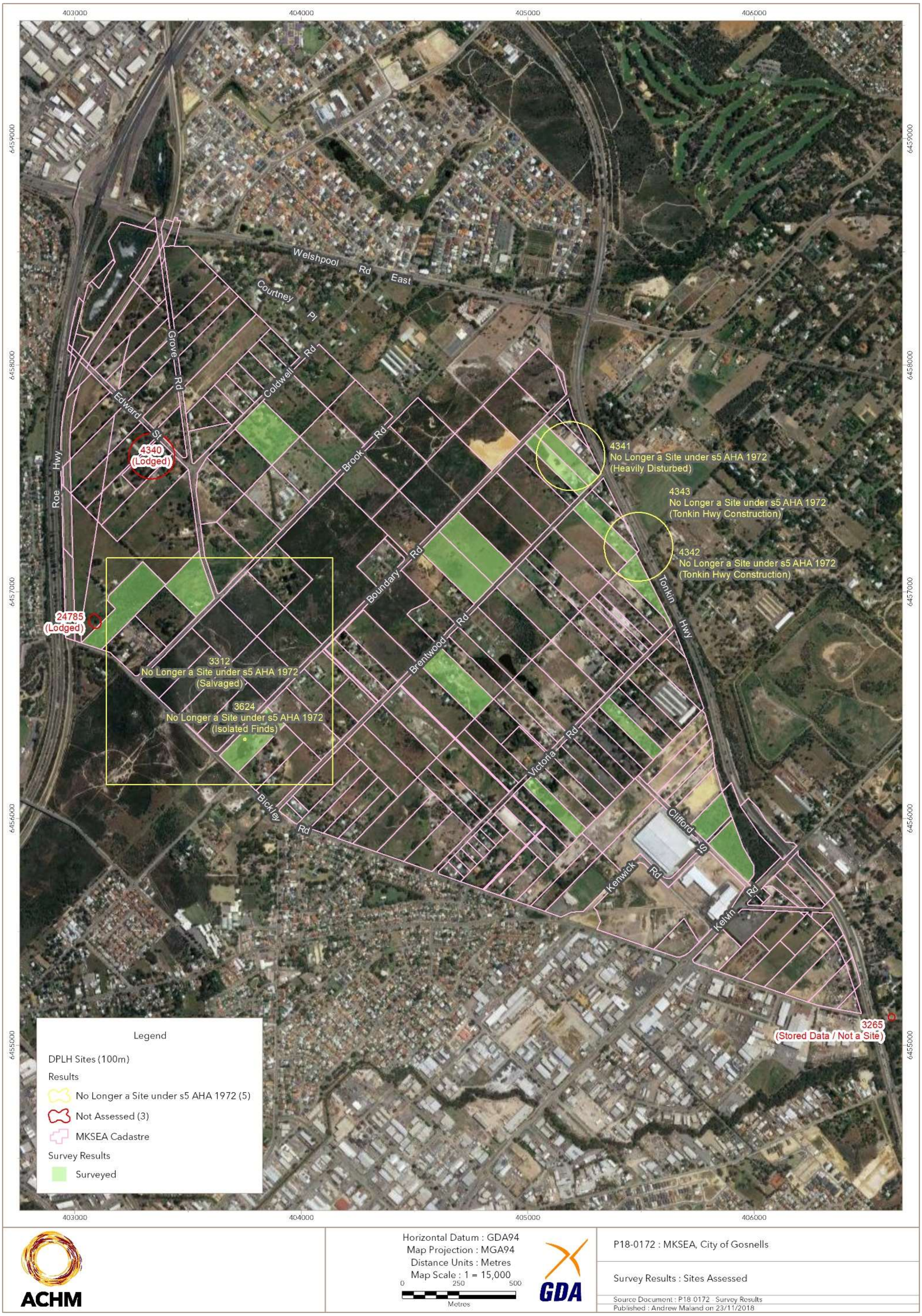
This Report documents the results of the Cultural Heritage Impact Investigation of the 6 designated sites within the proposed MKSEA impact areas, which was conducted 22 - 24 Oct 2018.

The work area lies wholly within the Whadjak Noongar Native Title area in the City of Gosnells planned MKSEA Precincts.

It should also be noted that prior to the commencement and in some instances during, that all permissions to enter target areas located on privately owned property was sought and obtained by the city of Gosnells prior to any entry. These permissions also informed of the survey target methodology.

As a result of the Cultural Heritage Impact Assessment:

- Taking into consideration the extensive historical development and land use within the proposed MKSEA project footprint, only those places where remnant vegetation i.e. Conservation Category Wetland (CCW) and Threatened Ecological Community (TEC) areas were deemed suitable for investigation and subsequently inspected (notwithstanding access restrictions) (see Map 8-1) due to the higher potential for in-situ cultural material in its original depositional context.
- Lots #110, #107, #195, #142, # 501, # 190, #279, #130, #137, #139 (?), #71 and #78 were visited over the course of the fieldwork.
- 6 sites listed in the scope of works within Maddington Kenwick Strategic Employment Area (MKSEA) were revisited. These sites include (DPLH Place Id); Wattle Grove, Perth (3312) - or part thereof; Boundary Road, Wattle Grove (3624); Brentwood Road NW (4341); Brentwood road Quarry (4342); Brentwood Road Swamp (4343); and Yule Brook Farm 02 02 (24785).
- Of the six (6) visited locations, two (2) sites - Boundary road, Wattle Grove (3624 and Yule Brook Farm 02 02 (24785) could not be inspected in detail and due to access constraints or restrictions and subsequently were viewed from a short distance ~50m or less.
- Of the revisited sites, three (3) (see Map 8-1) were found to be heavily disturbed by historical land use activities and therefore could no longer be recorded and assessed in detail as heritage sites under the AHA 72.
- Czerwinski (2009:15) reports that all 3 artefacts were previously collected and therefore DPLH Id 3312 may be considered no longer a site under Section 5 of the AHA 72.
- 1 site - Edward/Grove Streets (4340) was not visited due to time constraints. Furthermore, the survey team were advised by the City of Gosnells representatives that this site was subject to an evaluation/inspection by another Heritage Consultancy which had been commissioned by the current landowner and no results were available at the time of drafting this report.
- The 3A Precinct and City of Kalamunda Precinct were not visited over the course of the Survey as no Conservation Category Wetland (CCW) and Threatened Ecological Community (TEC) areas are present in these areas furthermore time constraints restricted target location options.



Map 8-1: Survey Results.

9 Recommendations

- For those locations - Brentwood Road NW (DPLH Id 4341); Brentwood Road, Quarry (DPLH Id 4342); Brentwood Road Swamp (DPLH Id 4343); that have been re-assessed as no longer likely to constitute an archaeological sites under section 5 of the AHA 72, the Whadjak Noongar representatives requested that further investigation is undertaken to provide understanding regarding any approval processes may have been undertaken prior to any ground disturbance activities.
- Boundary Road, Wattle Grove (DPLH Id 3624) further investigation is required to determine the condition and intactness of the site.
- If the access is granted by the land owner and the opportunity to visit this location become available that the Yule Brook Farm 02 02 (24785) site is investigated to determine the condition and intactness of the site.
- Should ground disturbing activity be proposed within the immediate vicinity of any previously identified site, Whadjak Noongar Traditional Owners are afforded the opportunity to have two representatives monitor earthworks at the following locations; Boundary Road, Wattle Grove (DPLH Id 3624); Brentwood Road NW (4341); Brentwood road Quarry (4342); Brentwood Road Swamp (4343); and Yule Brook Farm 02 02 (24785).
- Whadjak Noongar Traditional Owners requested an opportunity to undertake further discussion and consultation with the City of Gosnells regarding the future management and employment opportunities (such as conservation land managers, rangers as well as the establishment of potential tourism ventures) with regards to the area of land listed as the Bush Forever Precinct.
- The Whadjak Noongar representatives have requested further opportunity to have a suitably qualified anthropologist to conduct further ethnographic consultation re the Yule Brook Stream, as this water way was presented as a place of importance to past lifeways and daily life. It was considered that two days at accessible locations along the Yule Brook with Whadjak Noongar elders would be sufficient.
- Any proposed impacts to the newly recorded archaeological sites, and any other previously recorded sites, may breach section 17 of the AHA. It is recommended that any earthworks should avoid any damage or disturbance to these areas
- In the Rezoning MKSEA precincts that the street names are amended or replaced Whadjak Noongar names and places.

In addition to the archaeological recommendations provided in this report, Whadjak Noongar may have additional recommendations relating to the management and mitigation of these sites. Further consultation and engagement with Whadjak Noongar regarding proposed impacts and mitigation strategies should be conducted.

11 Bibliography

Aboriginal Heritage Act 1972

Cardno BSD Pty, 2005: *Maddington - Kenwick Strategic Industrial Area; Environmental Review Flora, Vegetation, Fauna and Wetlands*

Czwerinski, P., 2009: *Preliminary Investigation of Aboriginal Heritage - City of Gosnells Maddington Kenwick Strategic Employment Area (MKSEA).*

Gifford, P. 2007: *Results of an Aboriginal Cultural Heritage Survey of the Yule Brook Flow Reduction Dam Site, Kenwick.* DPLH Report Number 22955

Hallam, S. 1986: *Australian Research Grants Scheme: final Report on the Project the Swan River Coastal Plain, Western Australia.* DPLH Report Number 104379

Hook, F. 2007: *The Report of an Indigenous Archaeological Assessment of the Proposed Yule Brook Flow Reduction Dam Site, Kenwick.* DPLH Report Number 22955

Strawbridge, L. 1988 *Aboriginal Sites in the Perth Metropolitan Area: A Management Scheme, June 1987, Revised 1988 [Centre for Prehistory, University of Western Australia].* DPLH Report Number 104505

Tauss, C. & Weston, A. S., 2010: *A Survey of Rural Lands in the Vicinity of the Greater Brixton Street Wetlands; The Flora, Vegetation and Wetlands of the Maddington-Kenwick Strategic Employment Area.*

12 Glossary

Absolute Dating: Is the process of determining a specific date for an archaeological or paleontological site or artefact. Some archaeologists prefer the terms chronometric or calendar dating, as use of the word "absolute" implies a certainty and precision that is rarely possible in archaeology. See also relative dating.

Adze: A stone tool made on flakes with steep flaking along the lateral margins and hafted for use as a wood working tool.

Alluvial Terrace: A terraced embankment of loose material adjacent to the sides of a river valley.

Amorphous: Showing no definite crystalline structure.

Angle Of Applied Force: The angle at which the force of flaking is applied to a core.

Angular fragment: A piece of stone that is blocky or angular.

Anisotropic: Having some physical properties which vary in different directions.

Anvil: A portable stone, used as a base for working stone tools. Anvils most frequently have a small circular depression in the centre which is the impact damage from where cores were held while being struck by a hammer stone. An anvil may be a multi-functional tool also used as a grindstone and hammer stone.

Archaeological Context: The situation or circumstances in which a particular item or group of items is found.

Archaeological site types: The archaeological site types encountered in Australia can be divided into three main groups:

Historical archaeological site: An archaeological site formed since the European settlement containing physical evidence of past human activity (for example a structure, landscape or artefact scatter).

Aboriginal contact site: A site with a historical context such as an Aboriginal mission station or provisioning point, or a site that shows evidence of Aboriginal use of non-traditional Aboriginal materials and technologies (e.g. metal or ceramic artefacts).

Aboriginal prehistoric archaeological site: A site that contains physical evidence of past Aboriginal activity, formed or used by Aboriginal people before European settlement.

These sites may be:

Artefact scatters	Scarred Trees
Isolated artefacts	Mounds
Rock shelters	Rock art
Burial Structures	Hearths
Shell middens	Quarries
Ethnographic Items	Grinding Patches

Archaeology: The study of the past through the systematic recovery and analysis of material culture. Archaeology relies heavily upon science and cognate disciplines to provide interpretations of the past life ways of the peoples under investigation.

Artefact: any movable object that has been utilised modified or manufactured by humans.

Artefact scatter: A surface scatter of cultural material. Aboriginal artefact scatters are often defined as being the occurrence of five or more items of cultural material within an area of about 10m x 10m.

Australian Height Datum: The datum used to determine elevations in Australia. The AHD is based on the mean coastal sea level being zero metres AHD.

Australian Small Tool Tradition: Stone tool assemblages found across Australia, with the exception of Tasmania, dating between 8000 BP to European contact. The tool types include hafted implements (e.g. Bondi points), bifacial and unifacial points, geometric microliths, and blades. The assemblage is named for its distinct lack of larger ‘core tools’ which characterised earlier assemblages.

Axe: A stone-headed axe or hatchet or the stone head alone, characteristically containing two ground surfaces which meet at a bevel.

Backed Artefact: Backed artefacts are flakes retouched until they have one or more steep and relatively thick surfaces that are covered with negative scars. Since the backing retouch was accomplished with a bipolar and/or anvil-rested knapping technique, these retouched surfaces typically show negative scars originating from two directions, a pattern that is sometimes described as "double backing". Backed pieces are a feature of the ‘Australian small tool tradition’, dating from about 8000 BP in southern Australia.

Bearing: An angle measured clockwise from a north line of 0° to a given surveyed line.

Bevelled Edge: An edge which has had its angle altered.

Biface: A flaked stone artefact which has flake scars on both ventral and dorsal surfaces.

Bipolar: Technique of knapping where a core is rested on an anvil and force applied to the core at an angle close to 90o in the direction of the core's contact with the anvil.

Blade: A flake at least twice as long as it is wide.

Blaze: A mark carved in a tree trunk at about breast height. This type of mark was traditionally used by explorers or surveyors to indicate a route of passage in a certain direction, or a particular camp location.

Bulb of Percussion: Is a convex protuberance located at the proximal end of the ventral surface of a flake, immediately below the ring crack.

Bulbar Scar: The negative scar on a core that results from the bulb of percussion on the extracted flake.

Burial site: Usually a sub-surface pit containing human remains and sometimes associated artefacts. Human burials can also occur above the ground surface within rock shelters or on tree platform burials.

Burin: A stone implement roughly rectangular in shape with a corner flaked to act as a point for piercing holes.

Cadastral: From the Latin, a cadastre is a comprehensive register of the real property of a country, and commonly includes details of the ownership, the tenure, the precise location (some can include GPS coordinates), the dimensions (and area), the cultivations if rural and the value of individual parcels of land.

Chert: Is a fine-grained silica-rich microcrystalline, cryptocrystalline or microfibrous sedimentary rock that may contain small fossils. It varies greatly in colour (from white to black), but most often manifests as gray, brown, greyish brown and light green to rusty red. Its colour is an expression of trace elements present in the rock, and both red and green are most often related to traces of iron (in its oxidized and reduced forms respectively).

Cleavage Plane: A plane of weakness or preferred fracture in a rock.

Composite: An artefact made up of two or more parts joined together.

Conchoidal Fracture: describes the way that brittle materials break when they do not follow any natural planes of separation. Materials that break in this way include flint and other fine-grained minerals, as well as most amorphous solids, such as obsidian and other types of glass. Conchoidal fractures often result in a curved breakage surface that resembles the rippling, gradual curves of a mussel shell; the word "conchoid" is derived from the word for this animal. A swelling appears at the point of impact called the bulb of percussion. Shock waves emanating outwards from this point leave their mark on the stone as ripples. Other conchoidal features include small fissures emanating from the bulb of percussion.

Conjoin: A physical link between artefacts broken in antiquity. A conjoin set refers to a number of artefacts which can be been refitted together.

Contours: Lines joining points of equal height on a topographic map. Contour lines that are relatively close together depict an area of steep terrain on the earth's surface; whereas lines depicted a distance apart represent flat areas on the earth’s surface.

Core: An artefact from which flakes have been detached using a hammer stone. Core types include single platform, multi-platform, and bipolar forms.

Cortex: Weathered outer surface of rock, usually chemically altered.

Crazing: Production of visible surface cracks by uncontrolled heating of rock.

Crown land: Technically belonging to the reigning sovereign, is a class of public land, provided for the enjoyment and benefit of the people.

Crushing: Abrasion, small fracturing and the formation of ring cracks, usually along an artefacts edge.

Cryptocrystalline: Rock in which the crystal structure is too fine for clear resolution with an optical microscope.

Cultural significance: Cultural significance means aesthetic, historic, scientific, social or spiritual value for past, present or future generations (Australia ICOMOS Burra Charter Article 1.2).

Cultural Materials: The products of human behaviour, such as stone artefacts or food debris.

Datum: In surveying and geodesy, a datum is a reference point or surface against which position measurements are made, and an associated model of the shape of the earth for computing positions. Horizontal datum’s are used for describing a point on the earth's surface, in latitude and longitude or another coordinate system. Vertical datum’s are used to measure elevations or underwater depths. The previous datum used in Australia was known as the Australian Geodetic Datum (AGD). However, this was restricted because it was defined to best fit the shape of the earth in the Australian region only. The change in datum’s had a major consequence to all coordinates. Both latitudes/longitudes and eastings/northings were shifted by approximately 200 metres in a north-easterly direction.

Debitage: The term debitage refers to the totality of waste material produced during lithic reduction and the production of chipped stone tools. This assemblage includes, but is not limited to, different kinds of lithic flakes, shatter, and production errors and rejects.

Decortication: Removal of cortex from a stone artefact.

Dendrochronology: Is the method of scientific dating based on the analysis of tree-ring growth patterns.

Denticulated: Describes a stone tool which has one edge worked into a series of notches giving a toothed or serrated cutting edge.

Discard: The movement of an object from its systemic context to an archaeological context.

Distal: The end of a flake opposite the bulb; the area of a flake containing its termination.

Direct Freehand Knapping: A method of holding the material to be flaked in the unsupported hand and directing the hammer stone with the other hand.

Dorsal Surface: The face of a flake which was the core surface prior to flake removal and may therefore retain negative flake scars or cortex.

Edge ground implement: A tool, such as an axe or adze which has been flaked to a rough shape and then ground against another stone to produce a sharp edge.

Edge modification: Irregular small flake scarring along one or more margins of a flake, flaked piece or core, which is the result of utilisation/retouch or natural edge damage. Edge damage refers to the removal of small flakes from the edge of an artefact.

Elevation: The height above mean sea level.

Eraillure Flake: A flake formed between the bulb of force and the bulbar scar. Sometimes the eraillure flake adheres to the core in the bulbar scar. The eraillure flake leaves no scar on the core, but always leaves a scar on the ventral surface of the flake. The eraillure flake is convex / concave (like a meniscus lens), has no distinct features on the "dorsal face", but may contain compression rings on the bulbar face.

Ethno-archaeology: The study of human behaviour and of the material culture of living societies in order to learn how items enter the archaeological record, thus allowing the formation of hypotheses as to how items of material culture entered the archaeological record in pre-history.

Ethnographic Site: Often overlooked in cultural heritage management, an ethnographic site is one which has particular spiritual or ritual significance to a particular group of people. They are more commonly referred to as ‘dreaming sites’ in Australia, and most appropriately recorded by someone with anthropological qualifications.

Excavation: The systematic recovery of archaeological data through the exposure of buried sites and artefacts. Excavation is a destructive process, and hence it is accompanied by comprehensive recording of every aspect.

Excavation Report: Once an excavation has finished, a report outlining the reasons, aims, methods used and findings from the excavation as well as some conclusions drawn from interpreting the artefacts.

Faceted Platform: A platform which is created by the removal of a number of flake scars.

Feather Termination: A termination of the fracture plane that occurs gradually (i.e. there are no sharp bends in the plane), producing a thin, low angled distal margin.

Feature: In excavations, a feature is something that a human made in the past that has not been or cannot be moved. Examples of this would be a house floor or a hearth (fire pit). When archaeologists are excavating, they often come across features.

Flake: A piece of stone removed from a core during the process of knapping by the application of external force, which characteristically shows traces of the processes of removal: concentric fracture ripples and a bulb of percussion. Flakes with a length: breadth ratio of 2:1 or more are usually referred to as blades. In some cases flakes are the result of shaping a block of stone into a tool of some kind. When removed from a prepared core, however, they were usually used as blanks for making tools. Primary flakes (also called decortication flakes) are large, thick flakes struck off a core when removing the cortex and preparing it for working. Secondary flakes (also called reduction flakes) are large flakes struck off a piece to reduce its size or thickness. Tertiary flakes are small flakes struck off when shaping the detail of a piece to make a specific tool. Retouching flakes are tiny, extremely thin flakes pinched or pushed off a piece to finish it, to fine-shape part of the surface, sharpen it, or resharpen it. Notching flakes are produced when putting hafting notches in stone tools.

Force: The quantity of energy exerted by a moving body; power exerted; energy exerted to move another body from a state of inertia.

Formal tool: an artefact that has been shaped by flaking, including retouch, or grinding to a predetermined form for use as a tool. Formal tools include scrapers, backed pieces, adzes and axes.

Fracture: Irregular surface produced by breaking a mineral across rather than along cleavage planes.

GDA94: Geocentric Datum of Australia. A spatial reference system which is universally implemented across Australia. The Geocentric Datum of Australia (GDA) is a coordinate reference system that best fits the shape of the earth as a whole. It has an origin that coincides with the centre of mass of the earth, hence the term 'geocentric'

Geodesy: The science and mathematical calculations of the shape and size of the Earth.

Geographic coordinates: a geographic coordinate system enables every location on the earth to be specified, using mainly a spherical coordinate system. There are three coordinates: latitude, longitude and geodesic height.

Geographic Information Systems: Is any system for capturing, storing, analysing, managing and presenting data and associated attributes which are spatially referenced to Earth. GIS is a system or tool or computer based methodology to collect, store, manipulate, retrieve and analyse spatially (georeferenced) data.

Geometric microlith: A small tool that has been fashioned from breaking apart a microblade. The piece is then retouched or backed and a small tool formed.

Gilgai soils: Soils with an undulating surface, presenting as a pattern of mounds and depressions. Gilgai soils contain swelling clays, which shrink and swell with alternate drying and wetting cycles. They display strong cracks when dry. Elements of the soil circulate and move during the shrink-swell process.

Global Positioning System: GPS is a satellite based navigation system originally developed by the United State's Department of Defence. A GPS receiver calculates a position by measuring distances to four or more satellites of a possible 24. These always orbit the Earth .

Grain: A description of the size of particles or crystals in rocks or sand. Coarse grained rocks have particles or crystals which are large (1mm or more), and fine grained rocks have particles which are small (0.1mm or less).

Greywacke: Hard fine-grained rock of variable composition containing some quartz and feldspar but mostly very fine particles of rock fragments.

Graticule: A network of crossing lines on a map representing parallels of latitude and meridians of longitude as defined by the projection.

Grid: The division of an archaeological site into small squares that denote different areas of excavation, making it easier to measure and document the site.

Grid coordinates: A point on a map given as an easting and northing reading. The values are given in metres.

Grindstone: The abrasive stone used to abrade another artefact or to processes food. Upper and lower grind stones used to grind plants for food and medicine and/or ochre for painting. A hammer stone sometimes doubles as a hammer stone and/or anvil.

Hammer stone: a piece of stone, often a creek/river pebble/cobble, which has been used to detach flakes from a core by percussion. During flaking, the edges of the hammer stone become ‘bruised’ or crushed by impact with the core. Hammer stones may also be used in the manufacture of petroglyphs.

Hand-Held: Description of the method used to immobilize the rock during knapping, it which it is held in one hand and struck by a hammer stone held in the other hand.

Hardness: Resistance of material to permanent deformation.

Hearth: Usually a sub-surface feature found eroding from a river or creek bank or a sand dune – it indicates a place where Aboriginal people cooked food. The remains of hearth are usually identifiable by the presence of charcoal and sometimes clay balls (like brick fragments) and hearth stones. Remains of burnt bone or shell are sometimes preserved with a hearth.

Heat treatment: The thermal alteration of stone (including silcrete) by stone workers to improve its flaking qualities.

Heritage: The word 'heritage' is commonly used to refer to our cultural inheritance from the past that is the evidence of human activity from Aboriginal peoples through successive periods of later migration, up to the present day. Heritage can be used to cover natural environment as well, for example the Natural Heritage Charter. Cultural heritage can be defined as those things and places associated with human activity. The definition is very broad, and includes Indigenous and historic values, places and objects, and associated values, traditions, knowledge and cultures.

Heritage Place: A place that has aesthetic, historic, scientific or social values for past, present or future generations – ‘this definition encompasses all cultural places with any potential present or future value as defined above’. Heritage place can be subdivided into Aboriginal place and historical place, for the purposes of this document.

Hinge Termination: A fracture plane that turns sharply toward the free surface of the core immediately prior to the termination of the fracture. The bend of the ventral surface is rounded and should not be confused with a step termination.

Historic place: A place that has some significance or noted association in history.

Homogeneous: Uniform structure and property throughout the material.

Hunter-gatherer: A member of a society who gains their subsistence in the wild on food obtained by hunting and foraging.

Hydrology: Is the study of the movement, distribution, and quality of water throughout the Earth.

ICOMOS (International Council on Monuments and Sites): ICOMOS is a nongovernment professional organisation closely linked to UNESCO, with national committees in some 100 countries with the headquarters in France. ICOMOS promotes expertise in the conservation of cultural heritage. It was formed in 1965, and has a responsibility to advise UNESCO in the assessment of sites proposed for the World Heritage List. Australia ICOMOS was formed in 1976. Its fifteen member executive committee is responsible for carrying out national programmes and participating in decisions of ICOMOS.

Incipient Crack: A crack or line of weakness in the rock.

Inclusion: An impurity or foreign body in the stone that reduces the homogeneity of the rock.

Indirect Percussion: Punch technique.

Interpretation: The process of explaining the meaning or use of an artefact.

Inward Force: Force applied to the platform, and directed into the body of the core.

Isolated artefact: The occurrence of less than five items of cultural material within an area of about 100 sq. metres. It/they can be evidence of a short-lived (or one-off) activity location, the result of an artefact being lost or discarded during travel, or evidence of an artefact scatter that is otherwise obscured by poor ground visibility.

Knapper: A person who creates stone artefacts by striking rocks and causing them to fracture.

Knapping Floor: The debris left on one spot and resulting from the reduction of one block of raw material. A knapping location is a site comprised of one or more knapping floors.

Koori: Koori is an Aboriginal term used to describe Indigenous people from Victoria and southern New South Wales.

Lateral Margins: The margins of a flake either side of the percussion axis.

Latitude: The angular distance along a meridian measured from the Equator, either north or south.

Layer: The layer is the level in which archaeologists dig. All excavation sites have different numbers of layers. Archaeologists try to work out when they are moving to a new layer by cultural or man-made clues like floors, but sometimes they will go by changes in soil colour or soil type.

Longitude: The angular distance measured from a reference meridian, Greenwich, either east or west.

Longitudinal Cross Section: The cross-section of a flake along its percussion axis.

Magnetic north: The direction from a point on the earth's surface to the north magnetic pole. The difference between magnetic north and true north is referred to as magnetic declination.

Maintenance: The process of keeping an artefact in a particular state or condition. An edge which is being used is maintained by flaking off blunted portions. A core is maintained by keeping its characteristics within the limits required for certain types of flaking.

Manufacture: The process of making an artefact.

Manuport: Foreign fragment, chunk or lump of stone that shows no clear sings of flaking but is out of geological context and must have been transported to the site by people.

Map scale: The relationship between a distance on a map and the corresponding distance on the earth's surface.

Margin: Edge between the ventral and dorsal surfaces of a flake.

Material culture: A term that refers to the physical objects created by a culture. This could include the buildings, tools and other artefacts created by the members of a society.

Mercator projection: A conformal cylindrical projection tangential to the Equator. Rhumb lines on this projection are represented as straight lines.

Meridian: A straight line connecting the North and South Poles and traversing points of equal longitude.

MGA94: The Universal Transverse Mercator coordinates of eastings, northings, and zones generated from GDA94 are called Map Grid of Australia 1994 coordinates.

Microblade: A very small narrow blade.

Microcrystalline: Rocks in which the crystals are very small but visible in an optical microscope.

Microwear: Microscopic use-wear.

Moiety: A moiety is a half. Tribes were composed of two moieties (halves) and each clan belonged to one of the moieties.

Mound: These sites, often appearing as raised areas of darker soil, are found most commonly in the volcanic plains of western Victoria or on higher ground near bodies of water. The majority were probably formed by a slow buildup of debris resulting from earth-oven cooking: although some may have been formed by the collapse of sod or turf structures. It has also been suggested some were deliberately constructed as hut foundations.

Morphology: The topographical characteristics of the exterior of an artefact.

Mosaic: A number of continuous aerial photographs overlapped and joined together by way of 'best fit' to form a single non-rectified image.

Negative Bulb of Force: The concave surface left after a flake has been removed. See Bulbar Scar.

Notched: Serration or series of alternating noses and concavities.

Obtrusiveness: How visible a site is within a particular landscape. Some site types are more conspicuous than others. A surface stone artefact scatter is generally not obtrusive, but a scarred tree will be.

Overhang: The lip on a core or retouched flake, caused by the platform being undercut by the bulb on the flake removed.

Overhang Removal: The act of brushing or tapping the platform edge in order to remove the overhang in a series of small flakes.

Overlays: The Victorian Planning Provisions establish a number of different Overlays to show the type of use and development allowed in a municipality. Heritage Overlays will list places of defensible cultural heritage significance.

Patina: An alteration of rock surfaces by molecular or chemical change (but not by attrition, hence not to be confused with sand blasting).

Pebble/cobble: Natural stone fragments of any shape. Pebbles are 2-60 mm in size and cobbles are 60-200 mm in size.

Percussion: The act of hitting a core with a hammer stone to strike off flakes.

Percussion Flaking: The process of detaching flakes by striking with a percussor.

Percussion Length: The distance along the ventral surface from the ring crack to the flake termination.

Place: Place means a site, area, land, landscape, building or other works, group of buildings or other works, and may include components, contents, spaces and views. (Australia ICOMOS Burra Charter Article 1.1)

Plane of Fracture: The fracture path which produces the ventral surface of a flake.

Planning scheme: The legal instrument that sets out the provisions for land use, development, and protection in Victoria. Every municipality in Victoria has a planning scheme.

Platform: Any surface to which a fabricator is applied when knapping.

Platform Angle: 1. The angle between the platform and core face on a core. 2. The angle between the platform and dorsal surface on a flake. 3. The angle between the platform and flaked surface on a retouched flake.

Platform Preparation: Alteration of the portion of the platform which receives the fabricator by grinding, polishing or flaking. Removal of small flake scars on the dorsal edge of a flake, opposite the bulb of percussion. These overhang removal scars are produced to prevent a platform from shattering.

Platform removal flake: A flake which contains a platform on the dorsal surface.

Point of force application: The area of the platform in contact with the indenter during knapping. Also known as point of contact.

Positive Bulb of Force: Bulb of force.

Post-depositional processes: The natural or cultural processes which may differentially impact upon archaeological sediments after they deposited.

Potlids: A concave-convex or plano-convex fragment of stone. Potlids never have a ringcrack or any other feature relating to the input of external force. They often have a central protuberance which indicates an internal initiation to the fracture. Potlids are the result of differential expansion of heated rock.

Pre-contact: Before contact with non-Aboriginal people.

Post-contact: After contact with non-Aboriginal people.

Pressure Flaking: The process of detaching flakes by a pressing force. Also Static Loading.

Primary decortication: The first removal of cortex from a core, creating a primary decortication flake. The flake will have a dorsal surface covered entirely by cortex.

Procurement: Obtaining raw materials.

Provenance: The location of an artefact or feature both vertically and horizontally in the site. Archaeologists record the provenance of artefacts and features in their field books and on the artefact bag. Provenance is important because it gives archaeologists the history and context of an object, i.e., exactly where it was found on the site.

Punch: An object which is placed on a core or retouched flake and receives the blow from the percussor.

Quarry: A place where humans obtained stone or ochre for artefact manufacture. A place where stone or ochre is exposed and has been extracted by Aboriginal people. The rock types most commonly quarried for artefact manufacture in Victoria include silcrete, quartz, quartzite, chert and fine-grained volcanics such as greenstone.

Quartz: A form of silica.

Quartzite: Sandstone in which the quartz sand grains are completely cemented together by secondary quartz deposited from solution.

Radiocarbon Dating: Also called carbon dating and C-14 dating. It is used to work out the approximate age of an artefact by measuring the amount of carbon 14 it contains. This dating technique is not perfect. It can only be used on organic remains (typically wood or charcoal). Also radiocarbon is only accurate to ±50 years, and cannot accurately date objects more than 50,000 years old.

Redirecting Flake: A flake which uses an old platform as a dorsal ridge to direct the fracture plane.

Redirection: Rotation of a core and initiation of flaking from a new platform situated at right angles to a previous platform. It produces a redirecting flake.

Reduction: Process of breaking down stone by either flaking or grinding.

Reduction Sequence: A description of the order in which reduction occurs within one block of stone.

Rejuvenate: The process of flaking in such a way that further reduction is possible or is easier. This usually involves removing unwanted features, such as step terminations, or making unsuitable characteristics more favourable, for example changing the platform angle. A Rejuvenation flake is a flake that has been knapped from a core solely for the purpose of preparing a new platform and making it easier to get flakes off a core, as it reduces that angle between platform and core surface.

Relative Dating: A general method of dating objects, which uses their relation to other objects. For example, artefacts found in lower layer are typically older than artefacts in higher layer.

Relic: Deposit, object or material evidence of human past.

Replica: A copy of a prehistoric artefact made by a modern investigator for research purposes.

Replicative Systems Analysis: A method of analysing prehistoric artefacts by creating exact replicas of all the manufacturing debris.

Reserves: The word 'reserve' derives from the land being reserved for a particular public use. Crown land retained in public ownership, but not reserved is termed unreserved Crown land.

Resharpening: The process of making a blunt edge sharper by grinding or flaking.

Retouched Flake: A flake that has subsequently been re-flaked. A flake, flaked piece or core with intentional secondary flaking along one or more edges.

Retouching: The act of knapping a flake into a retouched flake.

Ridge: The intersection of two surfaces, often at the junction of two negative scars.

Ring Crack: A circular pattern of micro-fissures penetrating into the artefact around the Point of Force Application and initiating the fracture. It appears on the ventral surface usually as a semi-circular protuberance on the edge of the platform.

Rock art: Paintings, engravings and shallow relief work on natural rock surfaces. Paintings were often produced by mineral pigments, such as ochre, combined with clay and usually mixed with water to form a paste or liquid that was applied to an unprepared rock surface.

Run: A large area of land in which squatters could pasture their stock without a lot of fencing necessary. Employed shepherds looked after various areas of the runs. Runs became consolidated pastoral holdings. Many of the runs were about 25 sq miles in area and later became parishes.

Sand: Quartz grains with only a small content of other materials. Grain size 2.00 mm to 0.05 mm.

Sandstone: A sedimentary rock composed of sand, and with only a small amount of other material, which has been consolidated by argillaceous or calcareous bonding of grains.

Sahul: This is the name given to the continent when Australia and New Guinea were a single landmass during the Pleistocene era. During this period, sea levels were approximately 150 metres lower than present levels.

Scar: The feature left on an artefact by the removal of a flake. Includes negative bulb, negative ring crack and negative termination.

Scarred tree: Scars on trees may be the result of removal of strips of bark by Aborigines e.g. for the manufacture of utensils, canoes or for shelter; or resulting from small notches chopped into the bark to provide hand and toe holds for hunting possums and koalas. Some scars may be the result of non-Aboriginal activity, such as surveyors' marks.

Scraper: A flake, flaked piece or core with systematic retouch on one or more margins.

Screen: A screen is used by an archaeologist to sift excavated soil in search of small artefacts like nails, ceramic fragments, and organic material like seeds, shell, and bone. Can be either manual (hand held) or mechanical.

Secondary Decortication: The removal of cortex from a core after the primary decortication flake. A secondary decortication flake is one that has both cortex and flake scars on the dorsal surface.

Selection: Runs were subdivided into selections for farming, agriculture and grazing homesteads. After a period of yearly rental payments, the selector could often obtain freehold ownership.

Shell midden: A surface scatter and/or deposit comprised mainly of shell, sometimes containing stone artefacts, charcoal, bone and manuports. These site types are normally found in association with coastlines, rivers, creeks and swamps – wherever coastal, riverine or estuarine shellfish resources were accessed and exploited.

Sieve: See Screen.

Significance: Significance is a term used to describe an item's heritage value. Values might include natural, Indigenous, aesthetic, historic, scientific or social importance.

Silica: Silicon dioxide.

Silcrete: A silicified sediment.

Siliceous: Having high silica content.

Site: An area designated for archaeological exploration by excavation and/or survey usually due to the presence of a concentration of cultural material.

Step Termination: A fracture plane that turns sharply towards the free surface of the core immediately prior to the termination of the fracture. The bend of the ventral surface is sharp, often a right angle.

Stratification: Over time, debris and soil accumulate in layers (strata). Colour, texture, and contents may change with each layer. Archaeologists try to explain how each layer was added--if it occurred naturally, deliberately (garbage), or from the collapse of structures-and they record it in detailed drawings so others can follow. Stratigraphy refers to the interpretation of the layers in archaeological deposits. Usually, the artefacts found on top are the youngest (most recent), while those on the bottom are the oldest.

Structures (Aboriginal): Can refer to a number of different site types, grouped here only because of their relative rarity and their status as built structures. Most structures tend to be made of locally available rock, such as rock arrangements (ceremonial and domestic), fish traps, dams and cairns, or of earth, such as mounds or some fish traps.

Surface Site: A site where artefacts are found on the ground surface.

Taphonomy: The study of the depositional and preservation processes which produce archaeological or paleontological material.

Termination: The point at which the fracture plain reaches the surface of a core and detaches a flake.

Tertiary Flake: A flake without cortex.

Theodolite: Instrument used by a surveyor for measuring horizontal and vertical angles.

Thermal Treatment: Alteration of siliceous materials by controlled exposure to heat.

Thickness: Measurement of the distance between the dorsal and ventral surfaces of a flake.

Thumbnail scraper: A convex edged scraper that is small, generally the size of a thumbnail.

Tool: Any object that is used.

Topographic map: A detailed representation of cultural, hydrographic relief and vegetation features. These are depicted on a map on a designated projection and at a designated scale.

Transverse Cross Section: The cross section of a flake at 90^{o} to the length.

Transverse Mercator projection: A projection similar to the Mercator projection, but has the cylinder tangent at a particular meridian rather than at the equator.

True north: The direction to the Earth's geographic North Pole.

Tula: A flake with a prominent bulb, large platform and platform/ventral surface angle of about 130o, which is retouched at the distal end. Not to be confused with a Tula Adze.

Tula Adze: A composite tool observed ethnographically, consisting of a stone artefact (often a Tula), a wooden handle and resin.

Unidirectional Core: Core from which flakes were removed from one platform surface and in only one direction.

Unifacial: Artefact flaked on only one side.

Unit: Archaeologists lay out a grid over a site to divide it into units, which may vary in size, and then figure out which units will be dug. Archaeologists dig one unit at a time. Keeping track of specific measurements between artefacts and features gives archaeologists the ability to draw an overall map looking down on the site (called a floor plan), to get the bigger picture of the site.

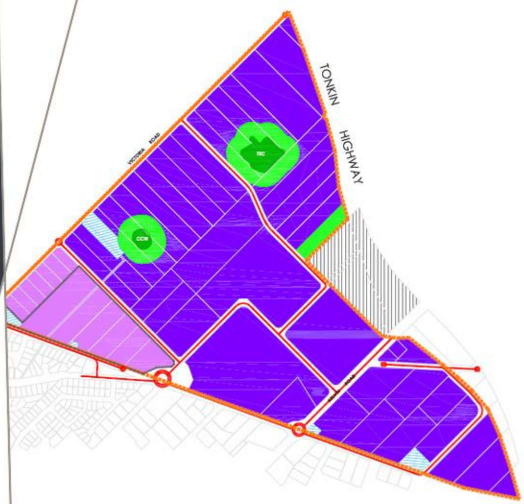
Use-wear: Damage to the edges or working surfaces of tools sustained in use.

Ventral Surface: The surface of a flake created when it is removed and identified mainly by the presence of a ring crack.

Visibility: The degree to which the surface of the ground can be seen. This may be influenced by natural processes such as wind erosion or the character of the native vegetation, and by land-use practices, such as ploughing or grading. Visibility is generally expressed in terms of the percentage of the ground surface visible for a project area.

Appendix N Transport Impact Assessment

MKSEA Precinct 1 Structure Plan Transport Impact Assessment



MKSEA Traffic Study

CW10300000

Prepared for
City of Gosnells

12 April 2019

Cardno®

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A	05/10/2018	Rev A	Raymond Rachmat	RJC
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D	12/04/2019	Rev D – Figure Update	James Dracup	RJC

Executive Summary

Cardno was commissioned by the City of Gosnells to prepare a Transport Impact Assessment for the proposed Maddington Kenwick Strategic Employment Area (MKSEA) Precinct 1 (P1).

This report has been prepared in accordance with the Western Australian Planning Commission (WAPC) *Transport Impact Assessment Guidelines Volume 2 – Planning Schemes, Structure Plans & Activity Centre Plans (2016).* Specifically, this report aims to assess the operations of the proposed development internally, its connections to the adjacent road network, with a focus on the traffic operations, access arrangements and road reservation widths within the area and will support the detailed structure planning for the locality.

The following conclusions have been made in regards to the MKSEA P1 Structure Plan as part of this assessment:

> The proposed Structure Plan, containing a gross area of approximately 108 hectares of Industrial, Composite Industrial and Natural Reserve land will provide employment opportunities and support the economic growth in the area.

> The land uses within the proposed Structure Plan will generate an estimated 1,413 trips in the AM peak period (7-9AM), 1,162 trips in the PM peak period (4-6PM) and approximately 8,400 daily trips.

> The intersection of Tonkin Highway / Kelvin Road is shown to not operate satisfactorily during the existing AM and PM peak periods, with several movements shown to operate at LOS E. By 2021 this is expected to deteriorate further, with several movements shown to operate at LOS F, thus indicating that the intersection is likely operating above capacity at this time. The grade-separated interchange (assumed to be operational by 2031) is shown to substantially improve the intersection performance due to the grade-separation as the volumes on the Tonkin Highway mainlines do not contribute to delays on the interchange.

> The intersection of Kelvin Road / Bickley Road is shown to operate satisfactorily for both the Existing and 2021 scenario. For the 2031 scenario, with a LoS of A for all movements. This is expected to decrease to a LoS of B for the 2031 +10% MKSEA traffic scenario.

> The intersection of Bickley Road / P1 Access Road is shown to operate satisfactorily for all modelled scenarios.

> All internal intersections within P1 are proposed to be designed to accommodate up to class 4 RAVs.

> The proposed road cross-sections will allow for the provision of pedestrian facilities within P1, as well as a 3.5m wide shared path on the western side of Kelvin Road.

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Appendices

Tables

Figures

1 Introduction

1.1 Introduction

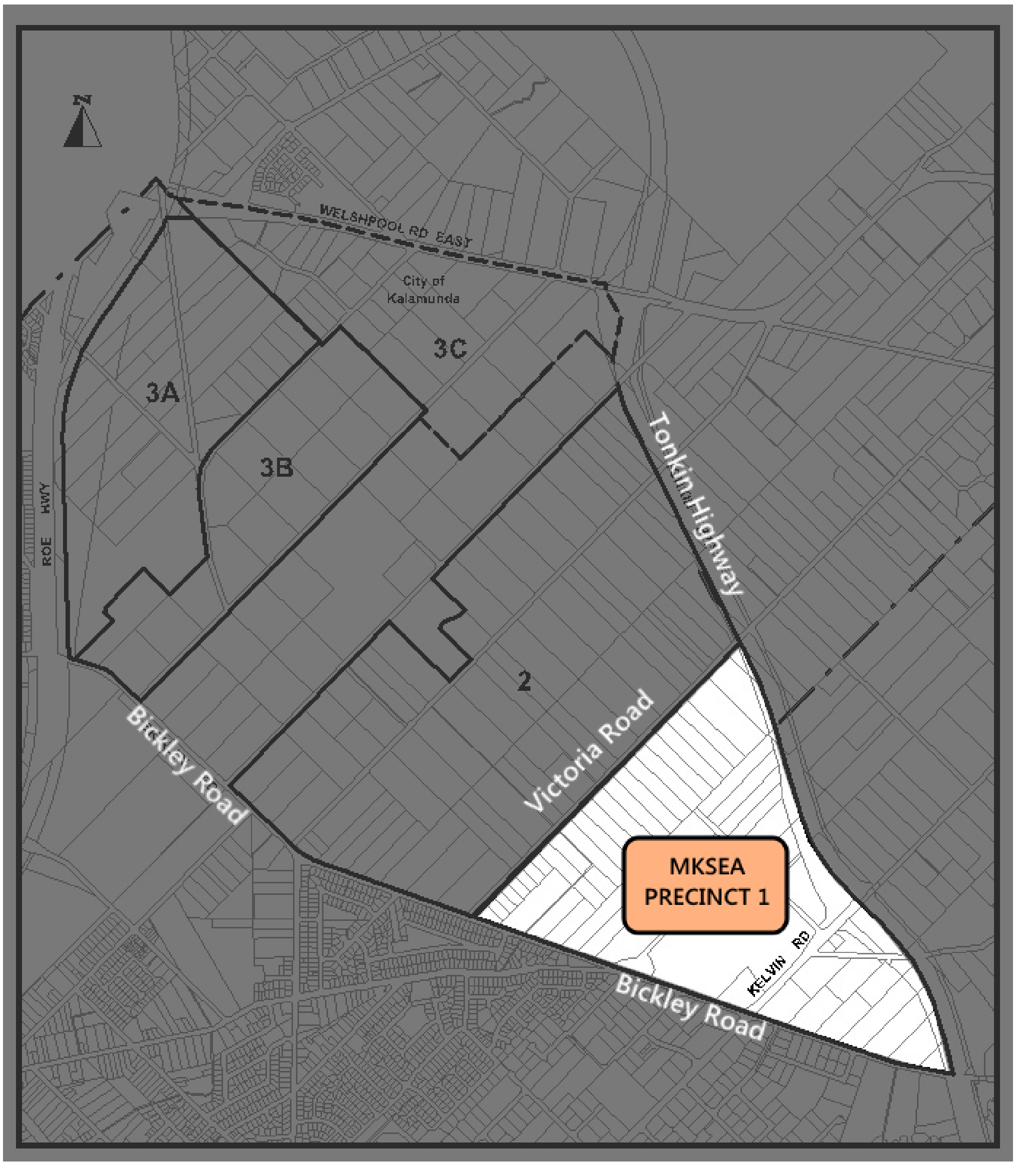
Cardno was commissioned by the City of Gosnells to prepare a Transport Impact Assessment for the proposed Maddington Kenwick Strategic Employment Area (MKSEA) Precinct 1 (P1).

This report has been prepared in accordance with the Western Australian Planning Commission (WAPC) *Transport Impact Assessment Guidelines Volume 2 – Planning Schemes, Structure Plans & Activity Centre Plans (2016).* Specifically, this report aims to assess the operations of the proposed development internally, its connections to the adjacent road network, with a focus on the traffic operations, access arrangements and road reservation widths within the area and will support the detailed structure planning for the locality.

1.2 Site Location and Description

P1 is located at Maddington, City of Gosnells and covers a gross area of approximately 108 hectares (ha), which will be developed a as mixture of combined industrial and light industrial land. Precinct 1 area is approximately bounded by Victoria Road, Tonkin Highway, and Bickley Road as indicated on **Figure 1-1**.

Figure 1-1 Location of MKSEA Precinct 1



2 Structure Plan Proposal

2.1 Proposed Land Uses

The Structure Plan area for MKSEA P1 is shown in **Figure 2-1.**

The proposed structure plan will comprise mostly of industrial, with some composite light industrial areas. The Structure plan yields are summarised in **Table 2-1.**

Figure 2-1 Proposed Land Uses for MKSEA Precinct 1 Structure Plan

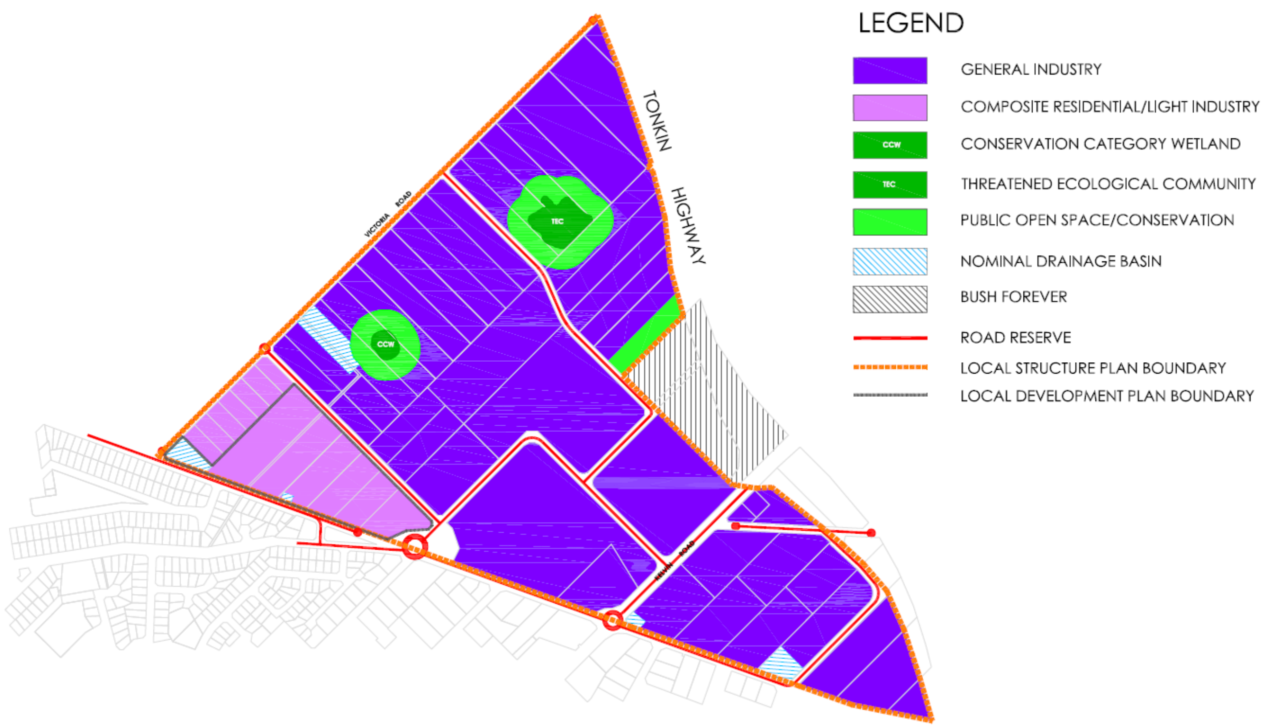


Table 2-1 Proposed Land Uses for MKSEA Precinct 1

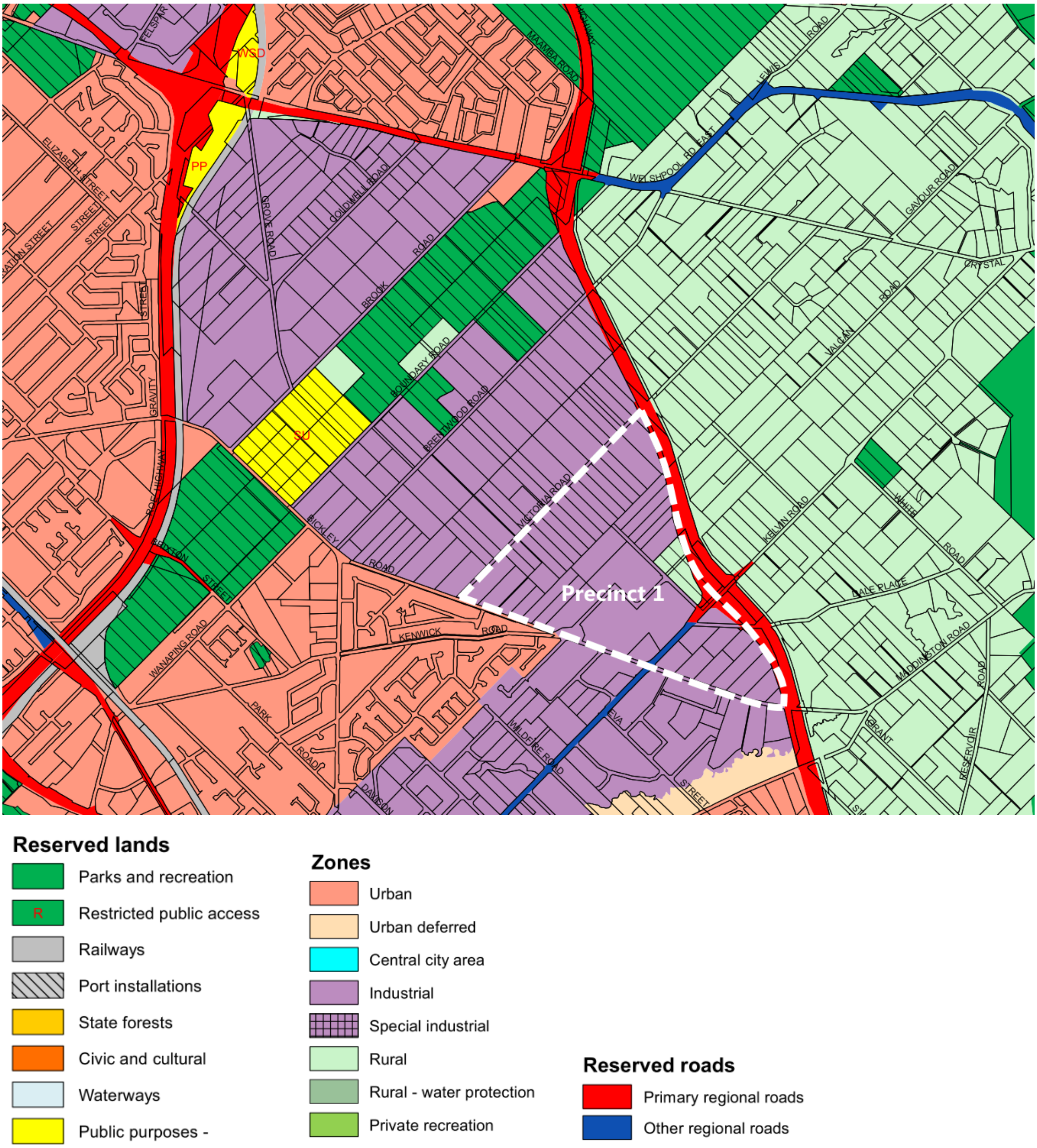
Land Use	Gross Developable Area (ha)
Industrial	98.08 ha
Composite Industrial	5.45 ha
Drainage	0.96 ha
CCW and TEC	1.541 ha
POS/Conservation Buffers	6.00 ha
Multiple Use Corridor	0.95 ha
TOTAL	112.969 ha

3 Existing Situation

3.1 Existing Land Uses

As shown in **Figure 3-1,** the land within the structure plan area is currently zoned as ‘Industrial’ in the Metropolitan Region Scheme (MRS). Areas north of the Structure Plan are also zoned primarily as ‘Industrial’. Areas outside of MKSEA are primarily ‘Urban’ and ‘Rural’.

Figure 3-1 Existing Zoning within and adjacent to Structure Plan Area



3.2 Existing Road Network

The existing road network surrounding the SP is shown in **Figure 3-2**. Road classifications are defined in the Main Roads Functional Hierarchy as follows:

> **Primary Distributors (light blue):** Form the regional and inter-regional grid of MRWA traffic routes and carry large volumes of fast-moving traffic. Some are strategic freight routes, and all are National or State roads. They are managed by Main Roads.

> **Regional Distributors (red):** Roads that are not Primary Distributors, but which link significant destinations and are designed for efficient movement of people and goods within and beyond regional areas. They are managed by Local Government.

> **District Distributor A (green):** These carry traffic between industrial, commercial, and residential areas and connect to Primary Distributors. These are likely to be truck routes and provide only limited access to adjoining property. They are managed by Local Government.

> **District Distributor B (dark blue):** Perform a similar function to “District Distributor A” but with reduced capacity due to flow restrictions from access to and roadside parking alongside adjoining property. These are often older roads with traffic demand in excess of that originally intended. District Distributor A and B roads run between land-use cells and not through them, forming a grid that would ideally be around 1.5 kilometres apart. They are managed by Local Government.

> **Local Distributors (orange):** Carry traffic within a cell and link District Distributors at the boundary to access roads. The route of the Local Distributor discourages through traffic so that the cell formed by the grid of District Distributors only carries traffic belonging to or serving the area. These roads should accommodate buses but discourage trucks. They are managed by Local government.

> **Access Roads (grey):** Provide access to abutting properties with amenity, safety and aesthetic aspects having priority over the vehicle movement function. These roads are bicycle and pedestrian friendly. They are managed by Local government.

Figure 3-2 Existing Road Network

The following discusses the characteristics of the road network within and surrounding the Structure Plan:

> **Tonkin Highway** is classified as *Primary Distributor* with a posted speed of 100 km/h. It forms a part of RAV 7 network (north of Welshpool Road East).

> **Bickley Road** is classified as *Local Distributor* west of Kenwick Road and *Distributor B* east of Kenwick Road. It has a posted speed limit of 50km/h west of Kenwick Road and 60km/h east of Kenwick Road.

> **Victoria Road** is a two-way, single carriageway road classified as an *Access Road* with a posted speed of 50 km/h.

> **Kelvin Road** is a two-way, dual carriageway road classified as a *Distributor A* with a posted speed of 70 km/h. There is currently a footpath on the western side of the road. The road intersects with Tonkin Highway to the north and Bickley Road to the south.

> **Clifford Street** is a two-way, single carriageway road classified as an *Access Road* with a posted speed of 50 km/h.

> **Kenwick Road** is a two-way, single carriageway road classified as an *Access Road* with a posted speed of 50 km/h.

3.3 Existing Traffic Volumes

Existing weekday traffic volumes were obtained from traffic surveys conducted in May 2018. These traffic volumes are summarised in **Table 3-1.**

Table 3-1 Existing Weekday Traffic Volumes

Location	Year	Weekday Traffic Volumes (two-way)	
		AM Peak	PM Peak (4pm-5pm)
Tonkin Highway (west of Kelvin Road)	2018	3,292	4,198
Kelvin Road (south of Tonkin Highway)	2018	1,266	1,509
Bickley Road (west of Kelvin Road)	2018	608	675

3.4 Existing Pedestrian/Cycle Network

As the Structure Plan area is mostly vacant, there is currently very limited pedestrian and cycling infrastructure within the Structure Plan. Refer to **Figure 3-3** for pedestrian and cycling facilities in the surrounding area.

Figure 3-3 Existing Pedestrian/Cycling Infrastructure

Source: Department of Transport 2016

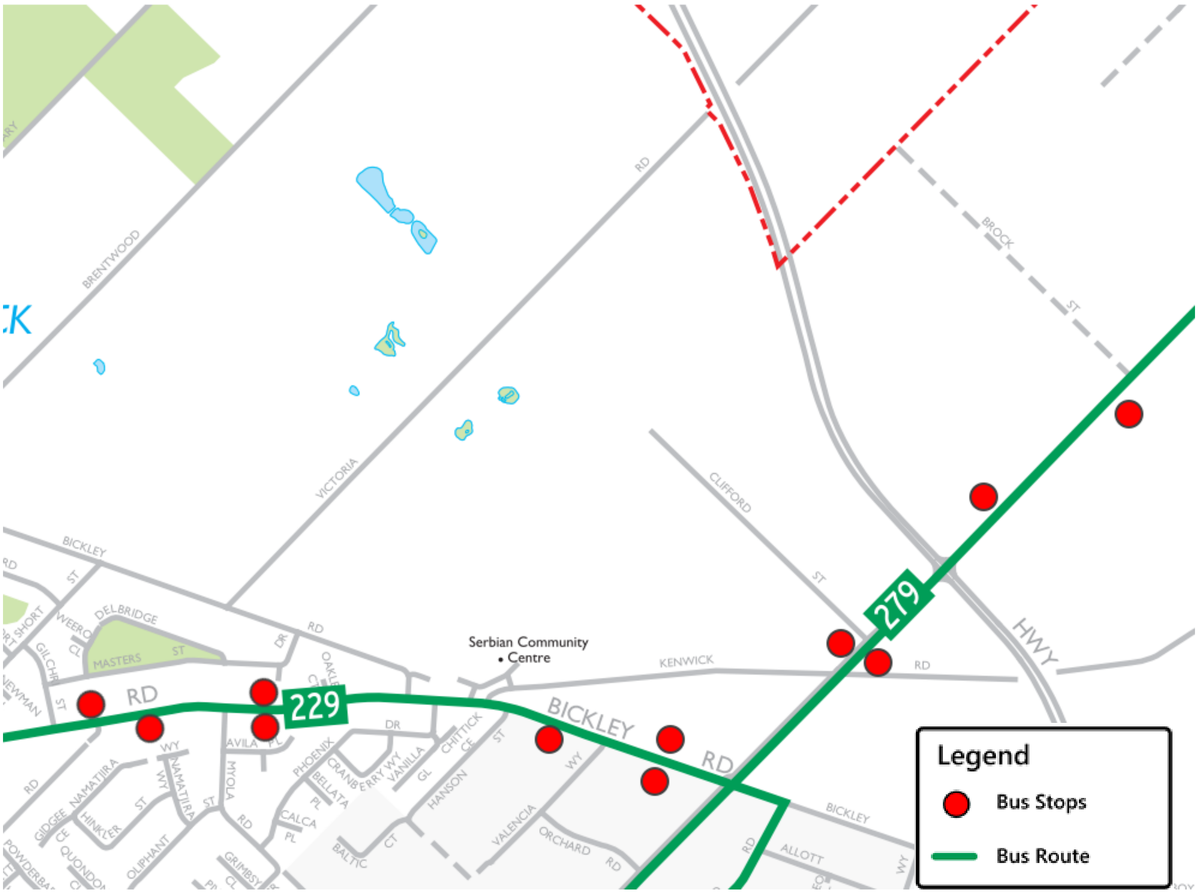
3.5 Existing Public Transport Service

Refer to **Figure 3-4** for existing public transport routes and stops within and surrounding the Structure Plan. The nearest bus routes are Route 279 running along Kelvin Road and Route 229 long Bickley Road. Refer to **Table 3-2** for service frequency of the bus routes.

Table 3-2 Bus Routes

Route No.	Route Description	Service Frequency	
		Weekdays	Saturday
279	Maddington – Kalamunda Bus Station	Only 2 to 3 services in the AM and PM peak. Operates on school days only	No Service
229	Carousel Shopping Centre – Maddington Station	Every 15 to 30 minutes during peak periods Every 60 minutes during off-peak periods	Every 60 minutes

Figure 3-4 Existing Public Transport Routes



4 Proposed Internal Transport Networks

4.1 Changes to Existing Internal Road Network

Changes to the existing internal road network as part of the Structure Plan are as follows:

> Kenwick Road (between Bickley Road and Kelvin Road) has recently been realigned and is now connected to Kelvin Road as a left-in, left-out only intersection;

> Kenwick Road and Bickley Road intersection has recently been realigned and modified to a roundabout

> Kenwick Road (east of Kelvin Road) will be closed on both ends and a new road constructed that will connect this section of Kenwick Road to Bickley Road.

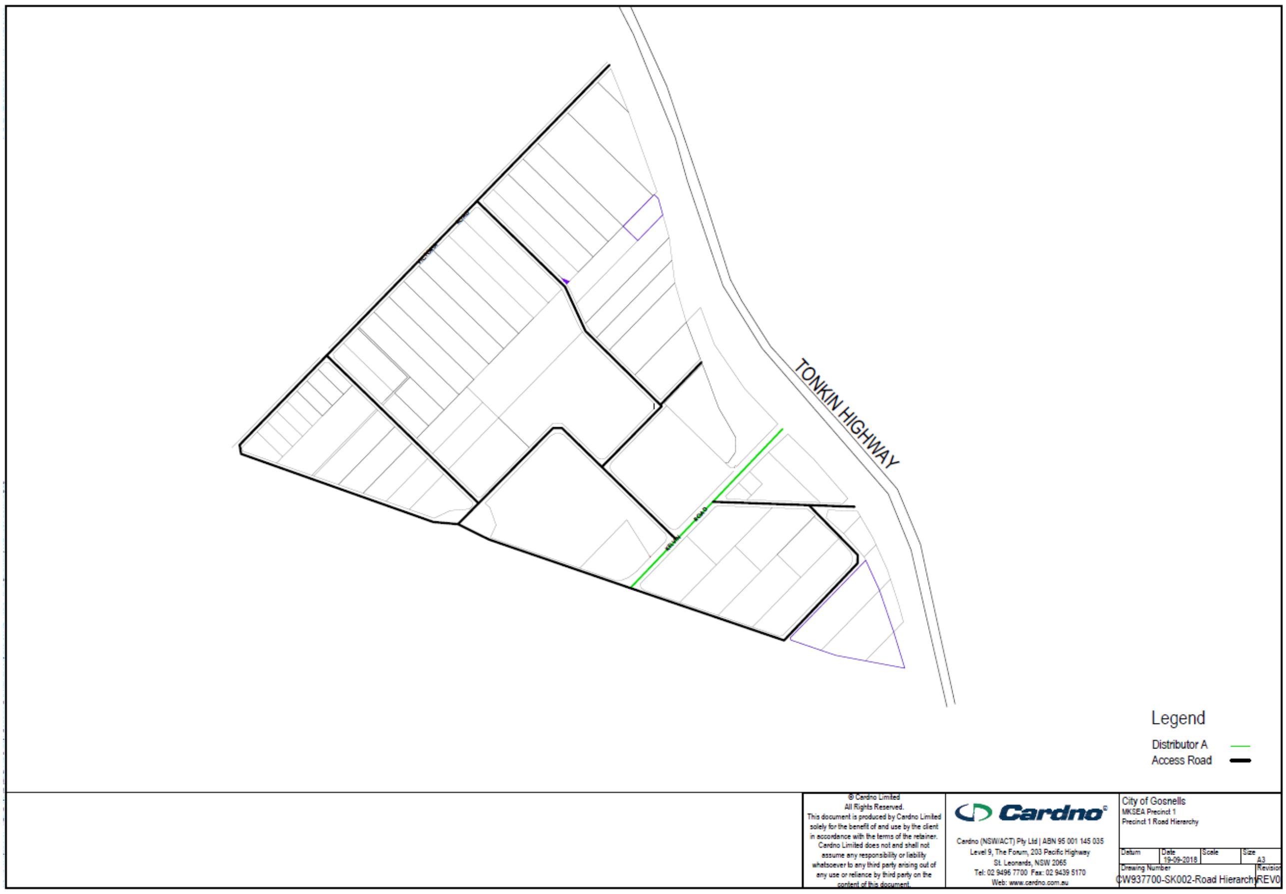
> Bickley Road (Belmont Road intersection) is set to be closed off and Bickley road terminated as a cul-de-sac.

> Victoria Road is set to be terminated at the Bickley Road intersection. As a result Victoria Road with end in a cul-de-sac.

4.2 Internal Road Network

The proposed internal road network is shown in **Figure 4-1.** With the exception of Kelvin Road, all roads within the Structure Plan area will be categorised as an Access Street and will have a speed limit of 50km/h. Kelvin Road is proposed to remain as a Distributor A with a posted speed limit of 70 km/h (as per existing).

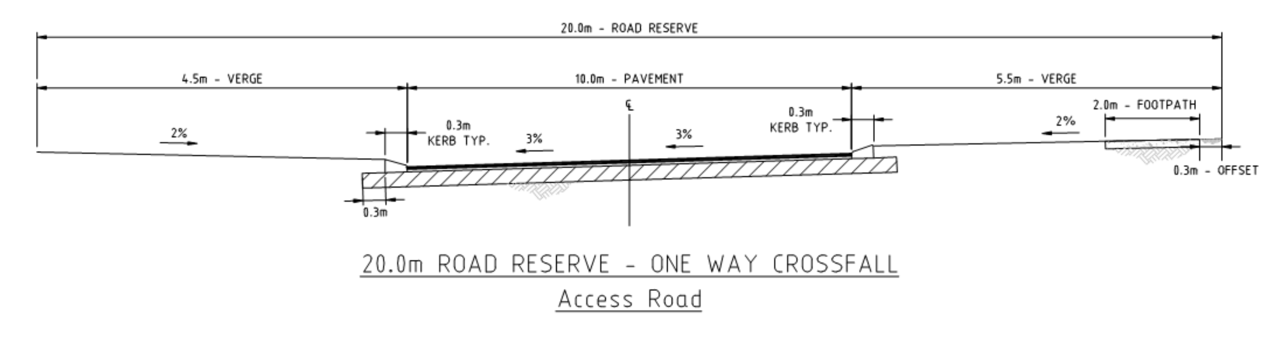
Figure 4-1 Proposed Internal Road Hierarchy



4.2.1 Road Reserve Width and Cross-Section

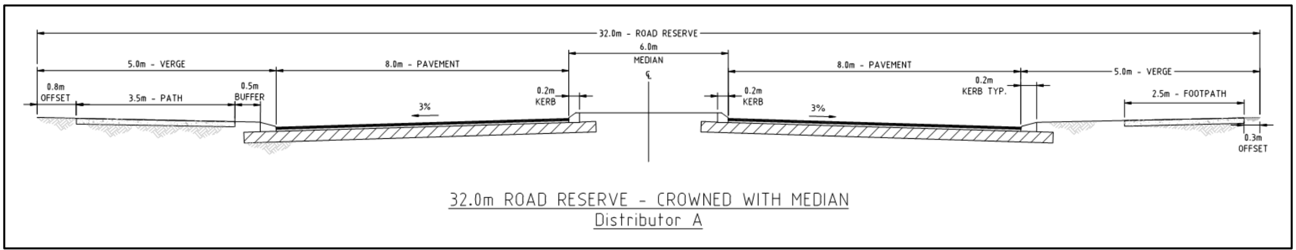
As per Development Control Policy 4.1: Industrial Subdivision, the proposed road reserve width for the Local Roads within the Structure Plan is 20m wide, with road pavement width of 10m from kerb to kerb (refer **Figure 4-2**).

Figure 4-2 Proposed Cross-Section for Local Roads



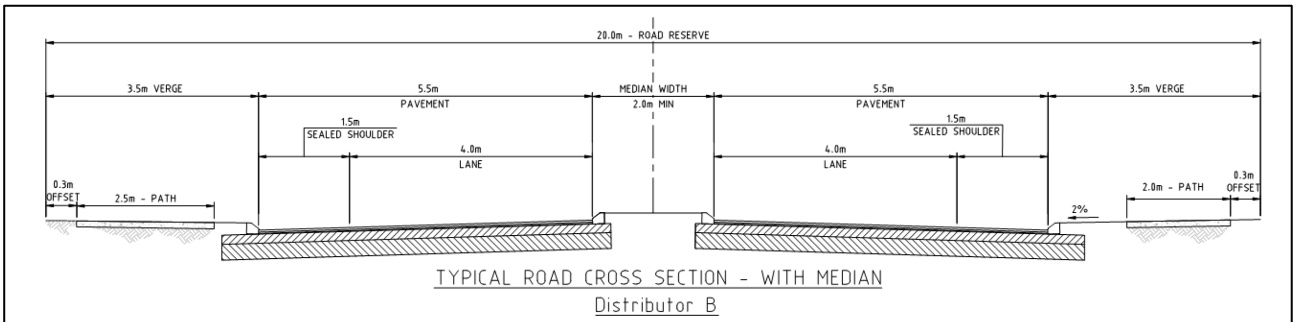
The proposed cross-section for the Distributor A Road (Kelvin Road) is shown in **Figure 4-3** and is similar to the existing cross-section, with the exception of a 3.5m shared path on the western side of the road (consistent with the Department of Transport strategic cycle network for the Perth metropolitan area).

Figure 4-3 Proposed Cross-Section for Distributor A Road (Kelvin Road)



The proposed cross-section for the Distributor B Road (Bickley Road) is shown in **Figure 4-4**. This is to consist of a 5.5m kerb to kerb width, with a 4.0m roadway and 1.5m cycle lane. Total road reserve width is 20m with a minimum 2.0m wide median and 2.5m path on the northern side. Due to paths bordering the roadway either side, street lighting and underground services will need to be managed accordingly as this results in a maximum 1.2m easement width (with a 2.0m path). This may result in an overall road reserve widening.

Figure 4-4 Proposed Cross-Section for Distributor B Road (Bickley Road)



The above cross-sections are included in A3 format in **Appendix A**.

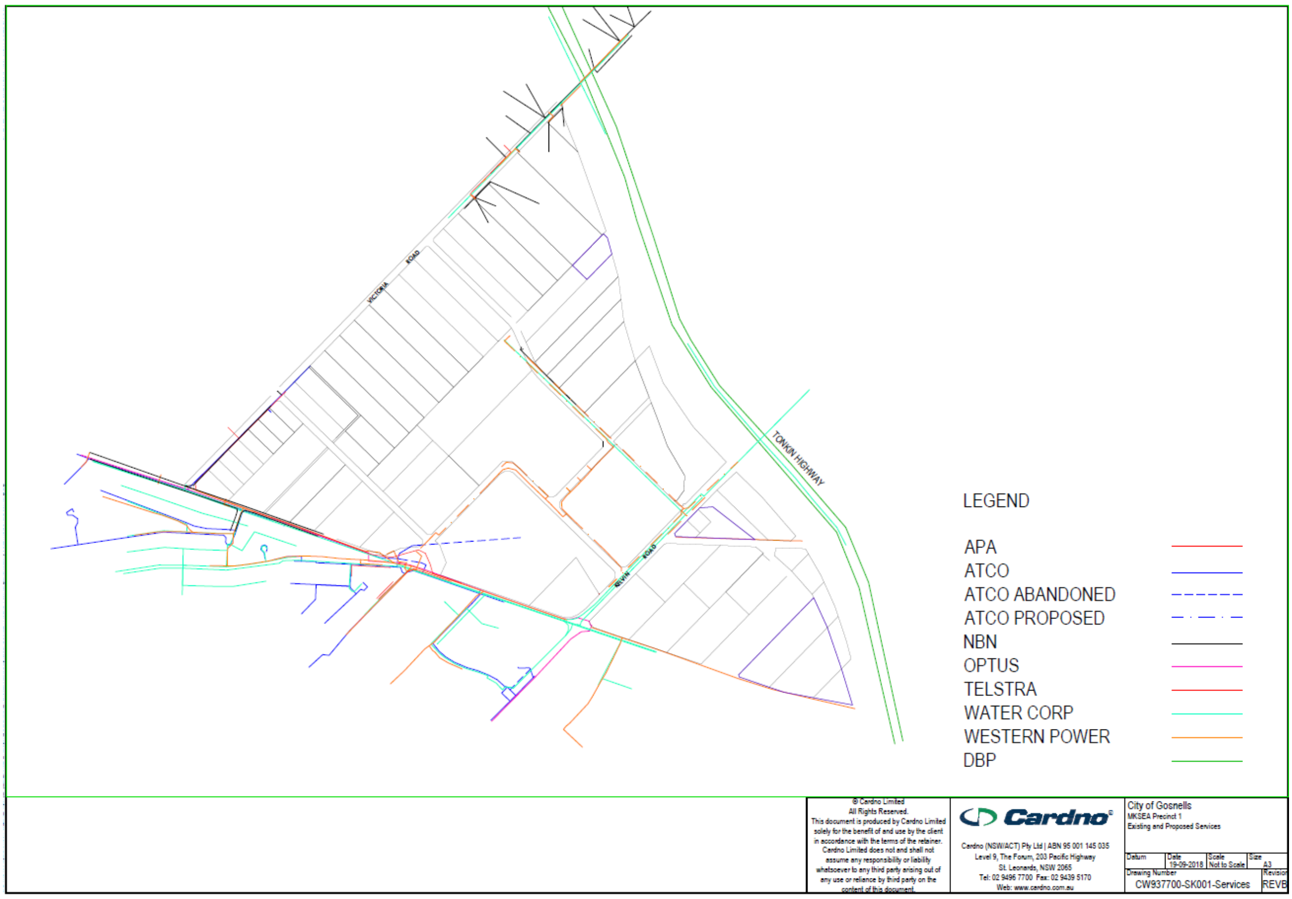
4.2.2 Intersection Control

All intersections within the Structure Plan will be in the form of priority intersections and roundabouts. No traffic signals are proposed within the Structure Plan. It is noted that all internal intersections are to be designed to accommodate up to class 4 Restricted Access Vehicles (RAV4)

4.3 Existing Utilities

While not a requirement under the WAPC Transport Assessment Guidelines, Cardno have prepared a schematic sketch of existing and proposed utilities within MKSEA P1. The schematic sketch is shown in **Figure 4-5** and is based on Dial-Before-You-Dig (DBYD) information sourced by Cardno for this project. It is noted that while this sketch is schematic only, the detailed DBYD data that was used to develop this sketch can be made available upon request.

Figure 4-5 Schematic Sketch of Existing and Proposed Utilities within MKSEA P1



4.4 Structure Plan Area Access Arrangements

Access to the Structure Plan area is via the following intersections:

> Bickley Road (priority controlled, full movements)
> Kenwick Road, Bickley Road and Hanson Street (roundabout)
> Kenwick Road and Kelvin Road (priority controlled, left-in, left-out only)
> Kelvin Road and Bickley Road (roundabout)

4.5 Pedestrian/Cycle Network

It is proposed that all local roads include 2.0m wide paths, to be constructed on one side of every street within the Structure Plan area. Pedestrian and cycling crossing at intersections will be provided via kerb ramps. Where medians or roundabout splitter island exists, pedestrian refuge will be provided.

Kelvin Road is proposed to include a 3.5m shared path on the western side of the road, which is consistent with the Department of Transport strategic cycle network for the Perth metropolitan area.

4.6 Public Transport Network

No changes to the existing public transport networks are proposed as part of the MKSEA P1 Structure Plan.

5 Changes to External Transport Networks

5.1 External Road Network

Planned road network changes are as follows:

- **Tonkin Highway and Kelvin Road Intersection**

  This intersection has recently been upgraded with additional through lanes and extension of turning pockets. Cycle lanes along Tonkin Highway have also been upgraded.

  In the long term, Tonkin Highway / Kelvin Road will become a grade separated interchange. While federal funding for this project in the 2018-19 Commonwealth Budget (along with grade-separation at the intersections of Tonkin Highway with Welshpool Road East and Hale Road) (https://www.mediastatements.wa.gov.au/Pages/McGowan/2018/04/Joint-media-statement-Major-jobs-and-infrastructure-boost-for-Western-Australia.aspx), this funding will need to be matched by the WA State Government before the project can be delivered. There is currently no timeframe for the delivery of this project, but for the purpose of this assessment it has been assumed that this interchange will be constructed between 2021 and 2031.

- **Tonkin Highway and Welshpool Road East Intersection**

  Similar to the intersection of Tonkin Highway / Kelvin Road, the intersection of Tonkin Highway / Welshpool Road East is also planned to become a grade-separated interchange in the long term. It is likely that this interchange will be constructed around the same time as the grade-separated interchange of Tonkin highway / Kelvin Road.

- **Grove Road and Welshpool Road East Intersection**

  Grove Road will be extended north and be connected to form a 4-way signalised intersection with Welshpool Road East and Hale Road.

- **Coldwell Road and Welshpool Road East Intersection**

  This intersection is proposed to be converted into a signalised intersection if/when RAV7 vehicles are permitted to use Coldwell Road.

5.2 Pedestrian/Cycling Network

The adjacent cycle network is currently under review by the WA Department of Transport.

5.3 Public Transport Network

Correspondence with the Public Transport Authority confirms that there will be no changes to the bus route network in the vicinity of the Structure Plan area.

6 Integration with Surrounding Area

6.1 Surrounding Attractors / Generators

Major generators within 800m of the Structure Plan is the residential area south of Bickley Road and the rural residential north of Tonkin Highway.

Major attractors within 800m of the Structure Plan area are the industrial area along Kelvin Road, south of Bickley Road.

6.2 Proposed Changes to Surrounding Land Uses

Development within the entire MKSEA area will occur subject to the Citys planning policies and economic activity.

6.3 Travel Desire Lines Between the Structure Plan and Surrounding Land Uses

The main travel desire lines between the Structure Plan and the surrounds will be largely based on the connectivity of the internal road network to the major highways and freeways, as a result it is expected that traffic will utilise Kelvin Road and Bickley Road, where traffic can either go north to access Tonkin Highway, or south towards Albany Highway.

It is expected that the existing road network will be able to cater for the travel desire lines between the Structure Plan area and the surrounding land uses. This is supported by the recent upgrade to the Bickley Road/Hanson Street/Kenwick Road roundabout and existing intersections along Kelvin Road (refer to **Section 4.4** for access arrangement to the Structure Plan area).

7 Analysis of Transport Network

7.1 Assessment Years and Time Periods

As the ultimate development of MKSEA is expected to generate a substantial amount of traffic, and to account for the changes to both the internal and external road networks, Cardno developed a number of mesoscopic traffic models in the Aimsun transport modelling suite. In addition to the calibrated existing (base) models, Cardno developed the following future year mesoscopic models for the purpose of intersection and network analysis:

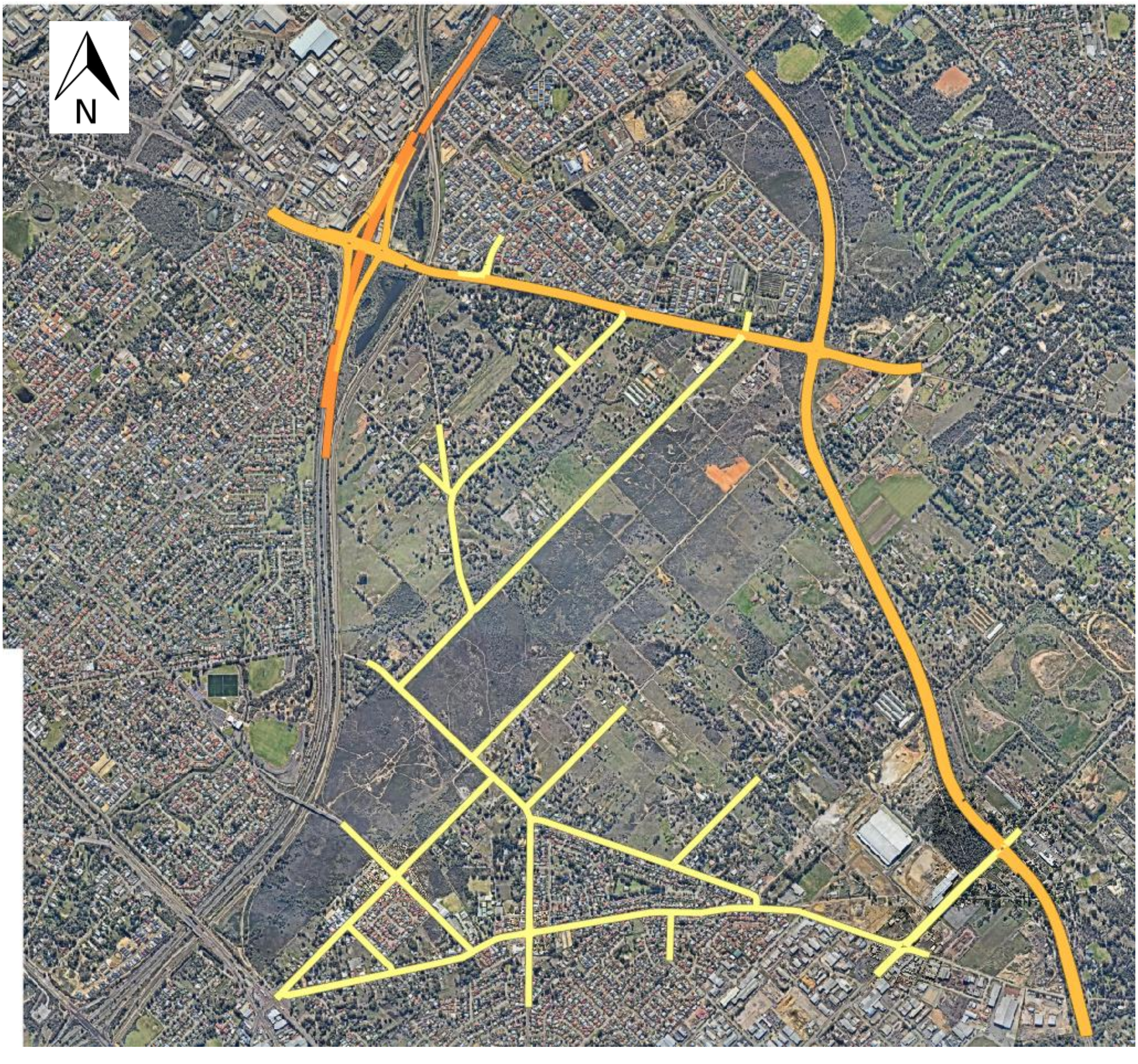
> 2021 – AM and PM peak hours, to represent the interim development of MKSEA;

> 2031 – AM and PM peak hours, to represent the ultimate development of MKSEA;

The extent of the model area is shown in **Figure 7-1** and encompasses the entire MKSEA, as well as the surrounding regional roads.

The base model calibration and validation report is included in **Appendix B** for reference.

Figure 7-1 Extent of Model Coverage



7.2 Traffic Generation Estimation

The MKSEA land use assumptions (in terms of expected employment numbers) for the Interim and Ultimate scenario years were provided by the City and are summarised in **Table 7-1**.

Table 7-1 MKSEA Development Yields

Development Area	Area Developed for Interim Scenario	Employee Forecast for Interim Scenario	Area Developed for Ultimate Scenario	Employee Forecast Ultimate Scenario
Precinct 1	60%	729	100%	1,215
Precinct 2	20%	285	100%	1,423
Precinct 3B	20%	101	100%	503
Precinct 3A	60%	470	100%	784
Precinct 3C	20%	85	100%	427
Total	**-**	**1,670**	**-**	**4,353**

The above MKSEA land use assumptions were provided to Main Roads Western Australia (MRWA), where they were used as input to the Regional Operations Model 24 (ROM24) and the resulting sub-area matrices for each scenario year provided to Cardno and used to develop the Interim and Ultimate MKSEA mesoscopic transport models.

A summary of the resulting trip generation for each precinct is included in **Table 7-2**.

Table 7-2 Summary of MKSEA Development Traffic for Interim and Ultimate Scenarios

Development Area	Interim (2021)			Ultimate (2031)		
	AM (7-9AM)	PM (4-6PM)	Daily*	AM (7-9AM)	PM (4-6PM)	Daily*
Precinct 1	808	705	4,905	1,413	1,162	8,359
Precinct 2	372	317	2,298	1,661	1,405	9,997
Precinct 3B	148	121	840	567	485	3,494
Precinct 3A	530	449	3,150	924	775	5,496
Precinct 3C	124	107	711	528	446	3,178
Total	**1,982**	**1,699**	**11,904**	**5,093**	**4,273**	**30,524**

* Daily volumes not included for purpose of assessment

7.3 Traffic Distribution

The MKSEA P1 traffic distribution was based on the traffic distribution from ROM24 outputs. The traffic distribution is shown in **Figure 7-2** and **Figure 7-3** for the AM peak period and in **Figure 7-4** and **Figure 7-5** for the PM peak period.

Figure 7-2 MKSEA P1 AM Peak Hour Traffic Distribution (Inbound)

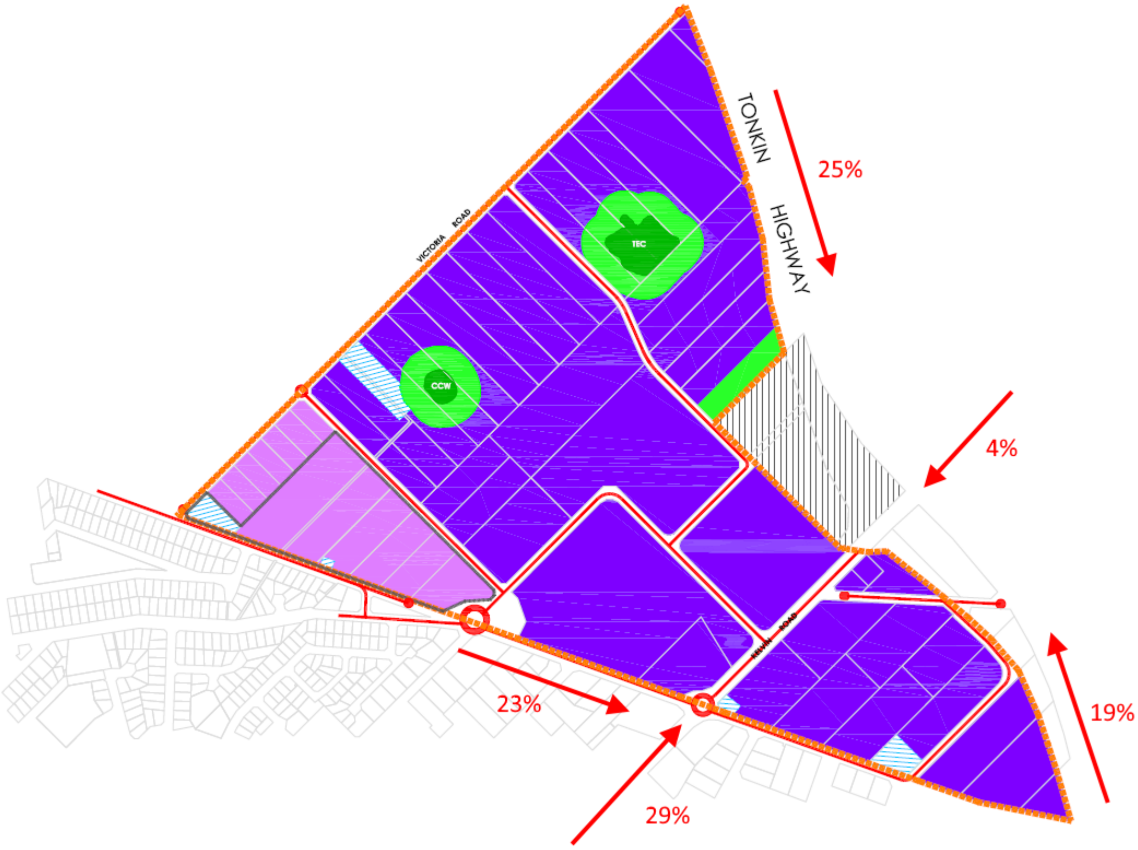


Figure 7-3 MKSEA P1 AM Peak Hour Traffic Distribution (Outbound)

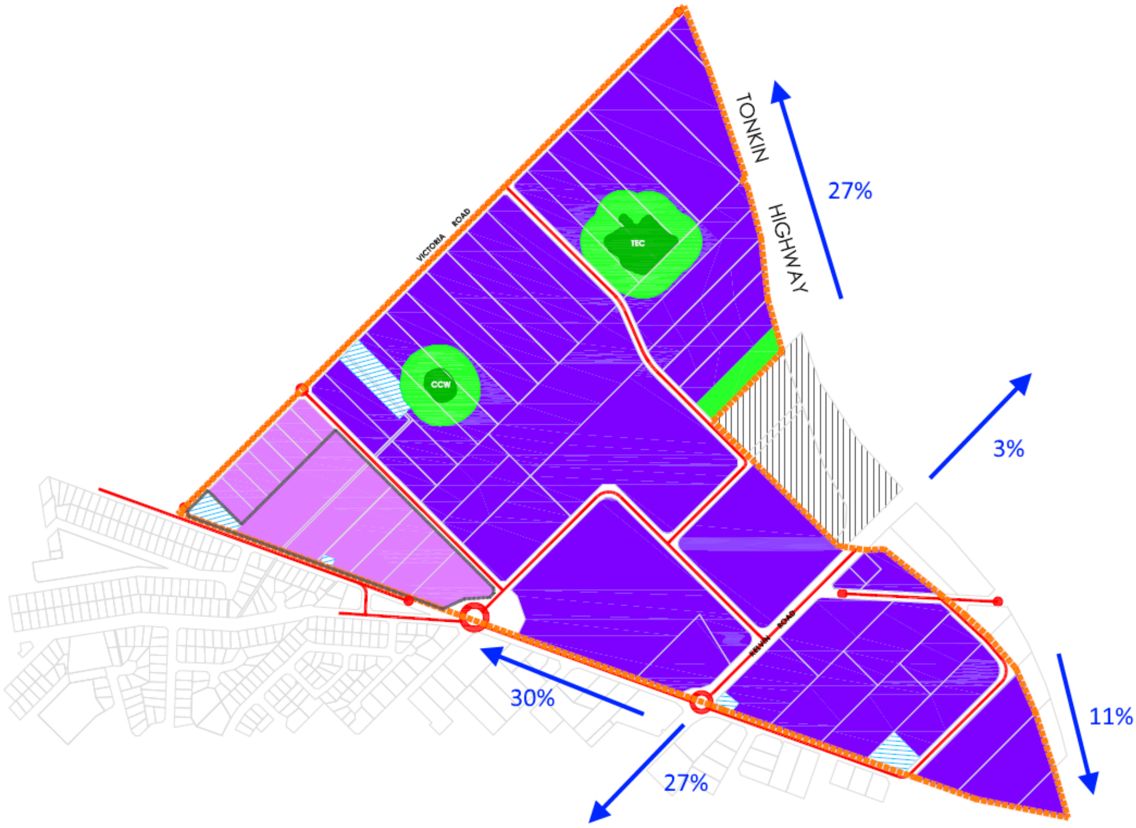


Figure 7-4 MKSEA P1 PM Peak Hour Traffic Distribution (Inbound)

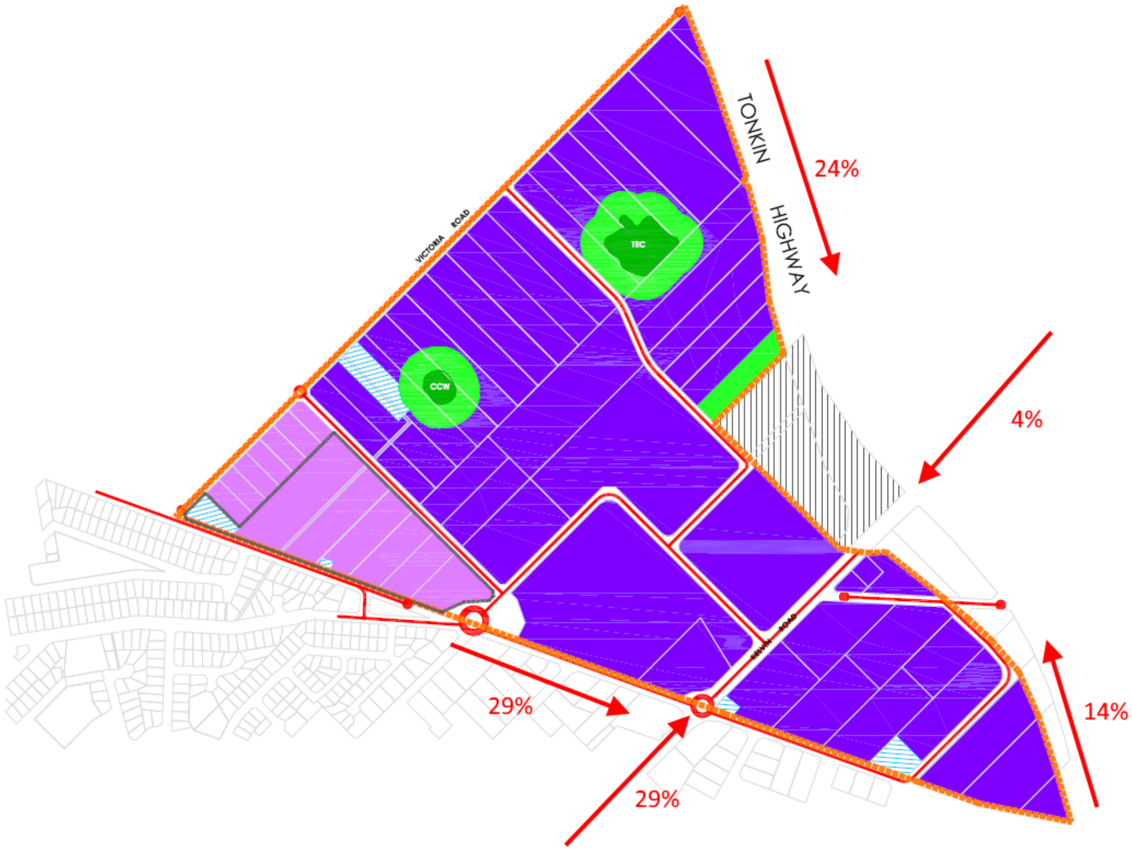
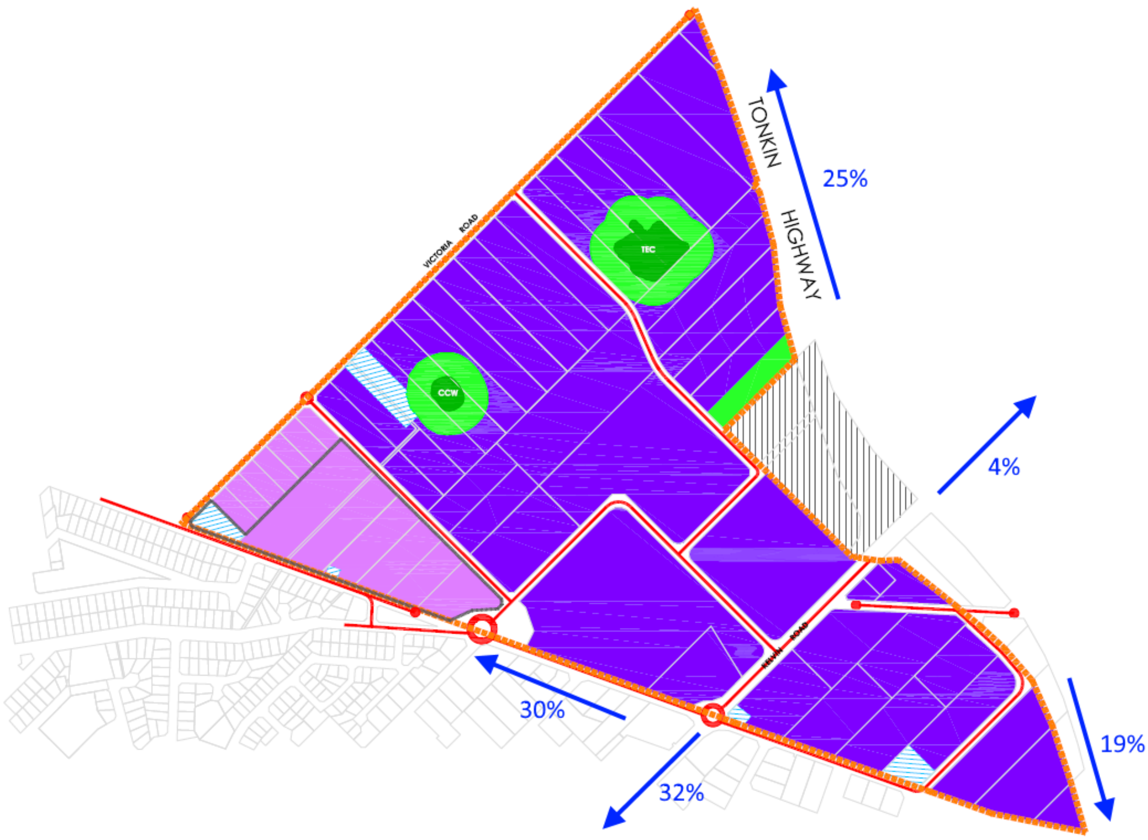


Figure 7-5 MKSEA P1 PM Peak Hour Traffic Distribution (Outbound)



7.4 Background Traffic Flows

The existing (base) peak period traffic flows are shown in **Figure 7-6** and **Figure 7-7** for the AM and PM peak periods respectively. It is noted that these figures display the average hourly vehicle flow of traffic over the 2-hour model periods and not the total vehicle count over the 2-hour model periods.

Figure 7-6 MKSEA Precinct 1 - Existing AM Peak Period Traffic Flows

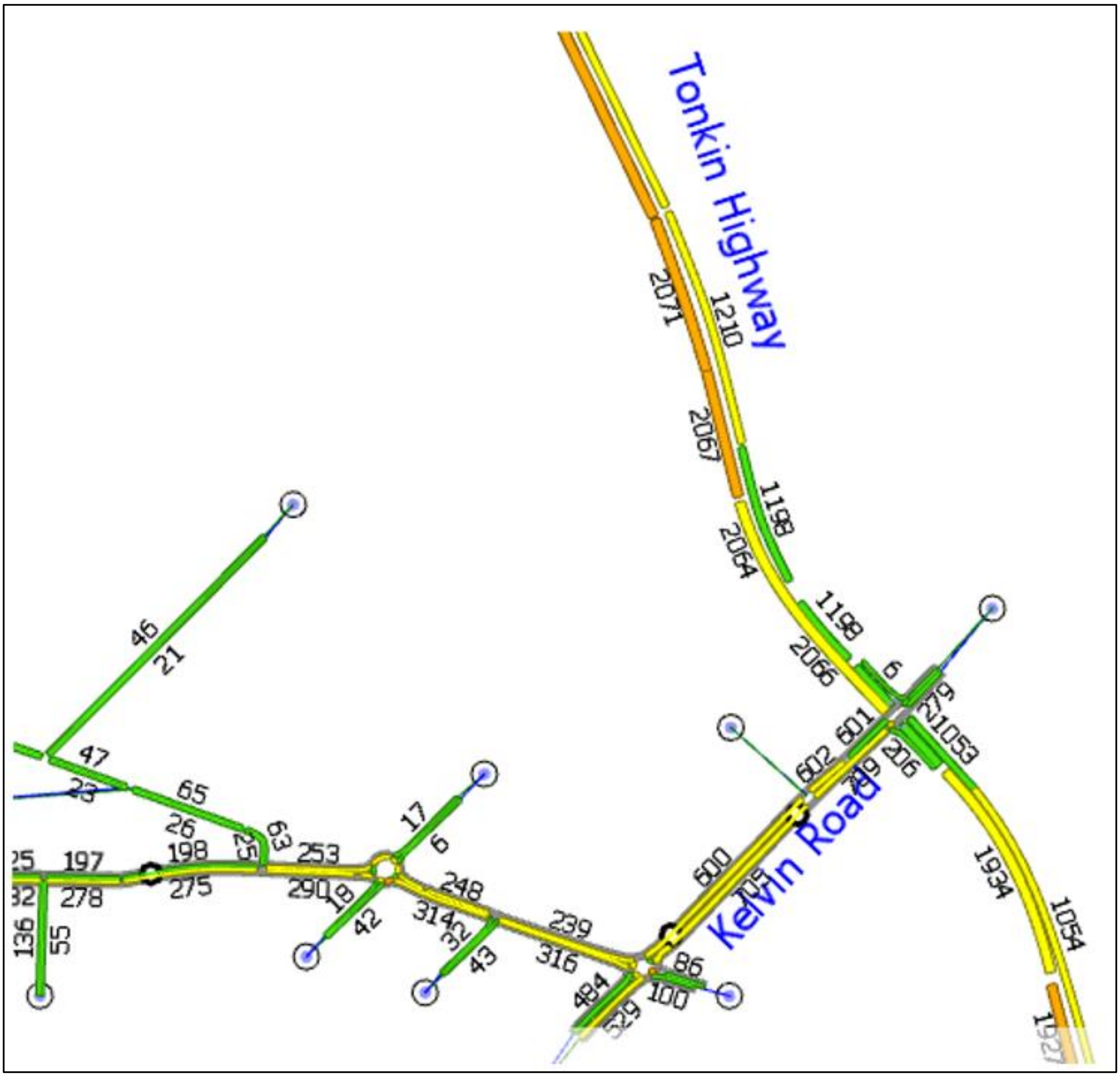
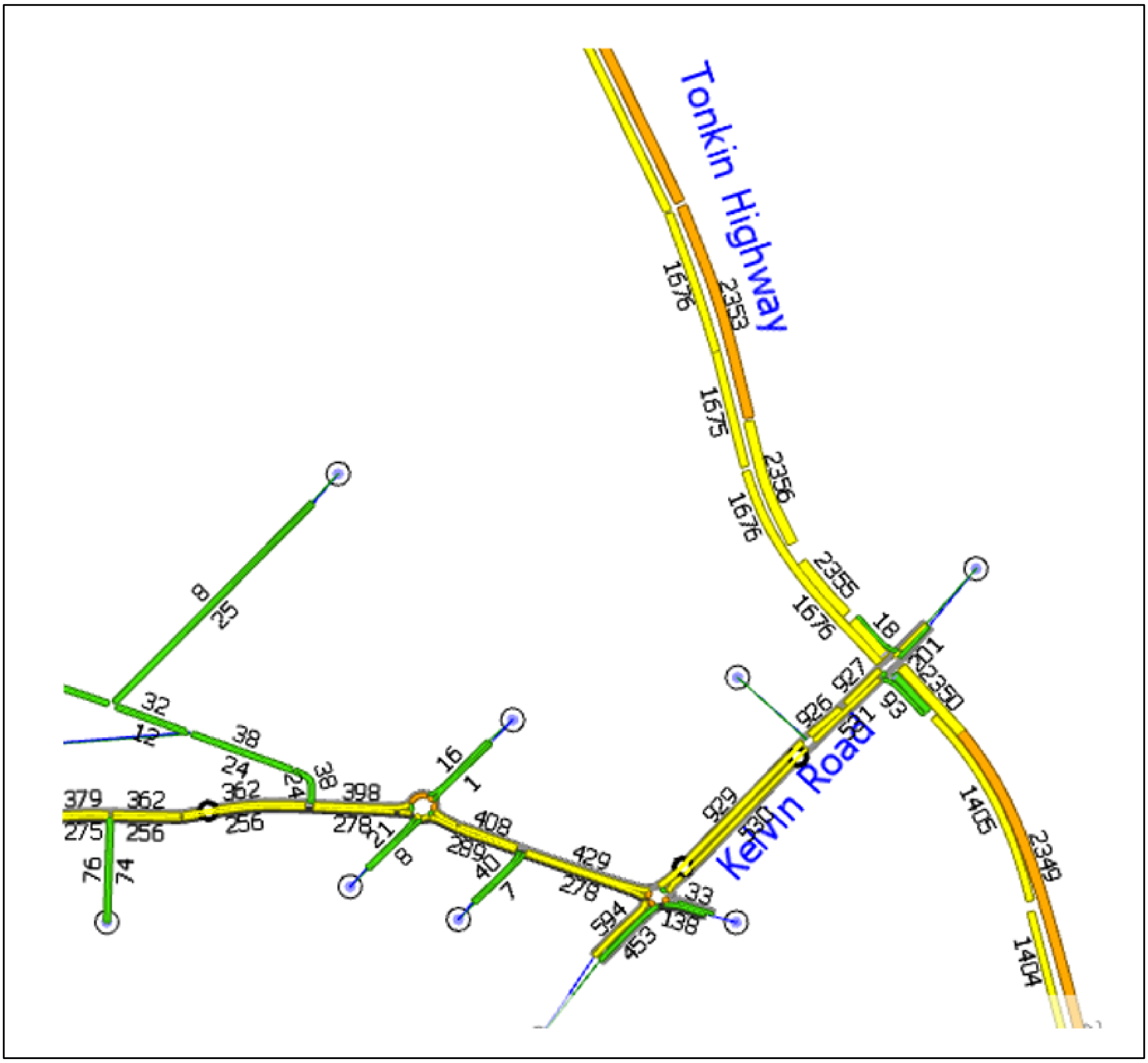


Figure 7-7 MKSEA Precinct 1 - Existing PM Peak Period Traffic Flows



7.5 Total Traffic Flow

7.5.1 2021 Traffic Flows

The traffic flows are shown in **Figure 7-8** and **Figure 7-9** for the 2021 AM and PM peak periods respectively.

Figure 7-8 MKSEA Precinct 1 - 2021 AM Peak Period Traffic Flows

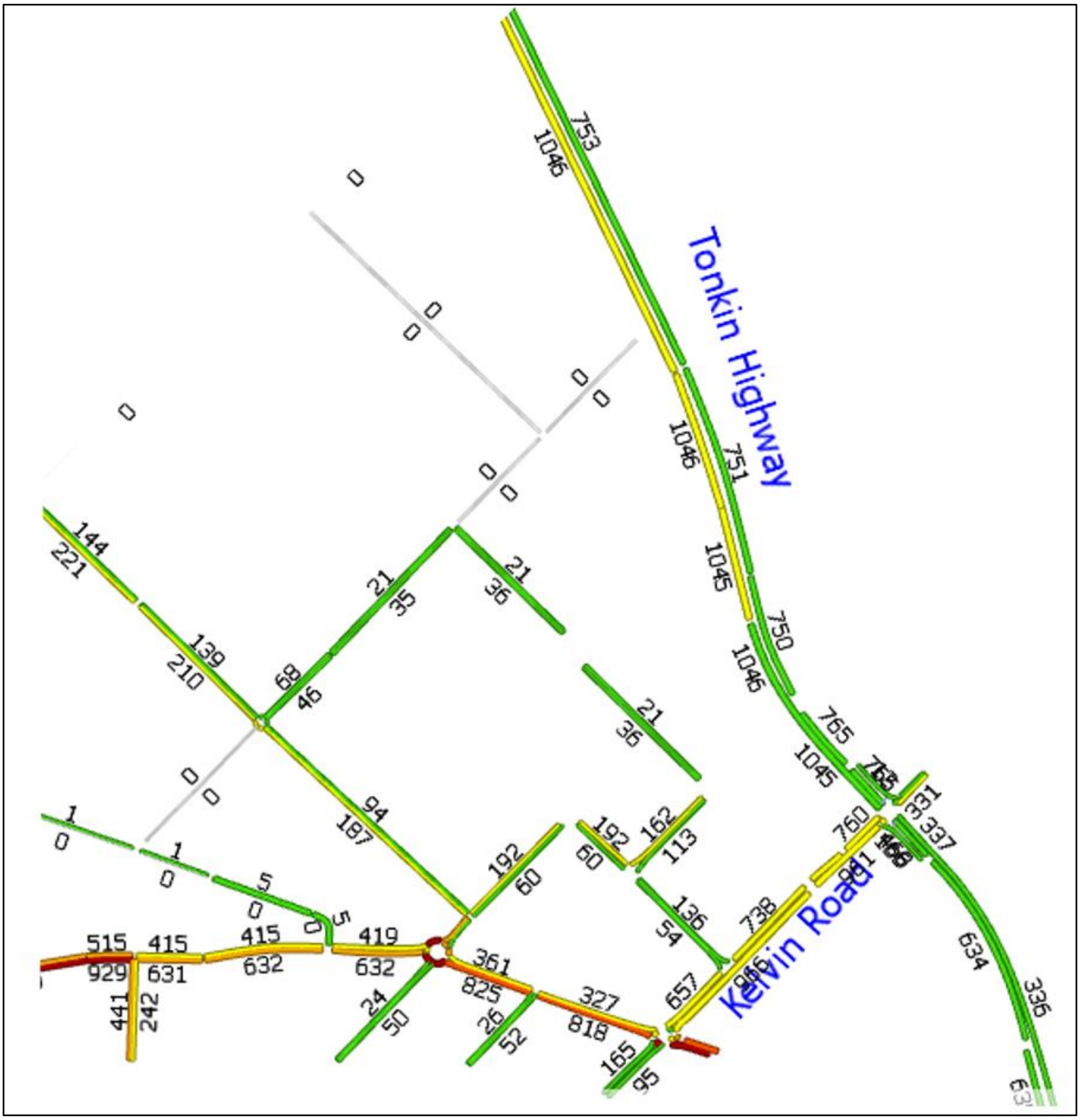
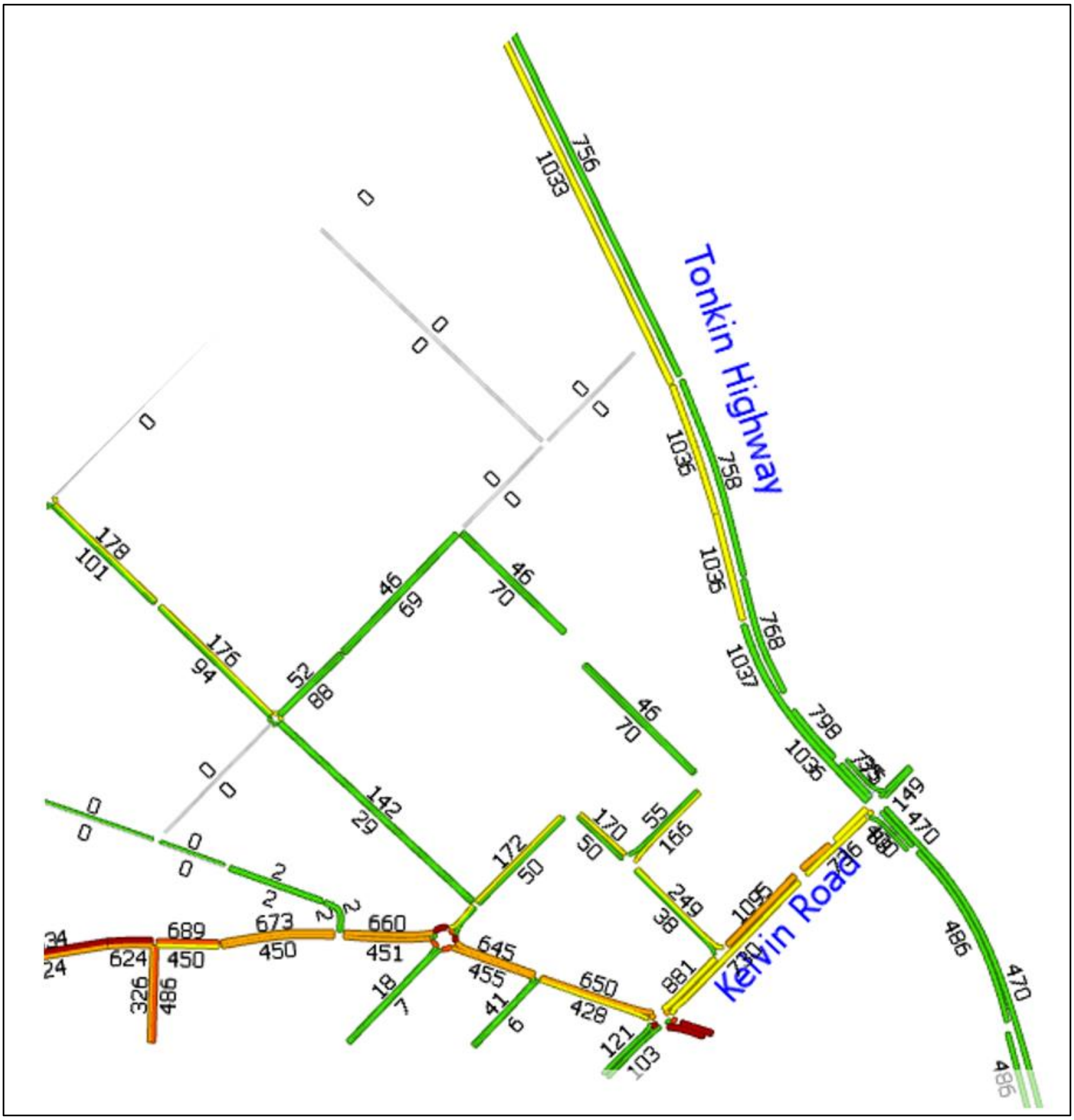


Figure 7-9 MKSEA Precinct 1 - 2021 PM Peak Period Traffic Flows



7.5.2 2031 Traffic Flows

The traffic flows are shown in **Figure 7-10** and **Figure 7-11** for the 2031 AM and PM peak periods respectively.

Figure 7-10 MKSEA Precinct 1 - 2031 AM Peak Period Traffic Flows

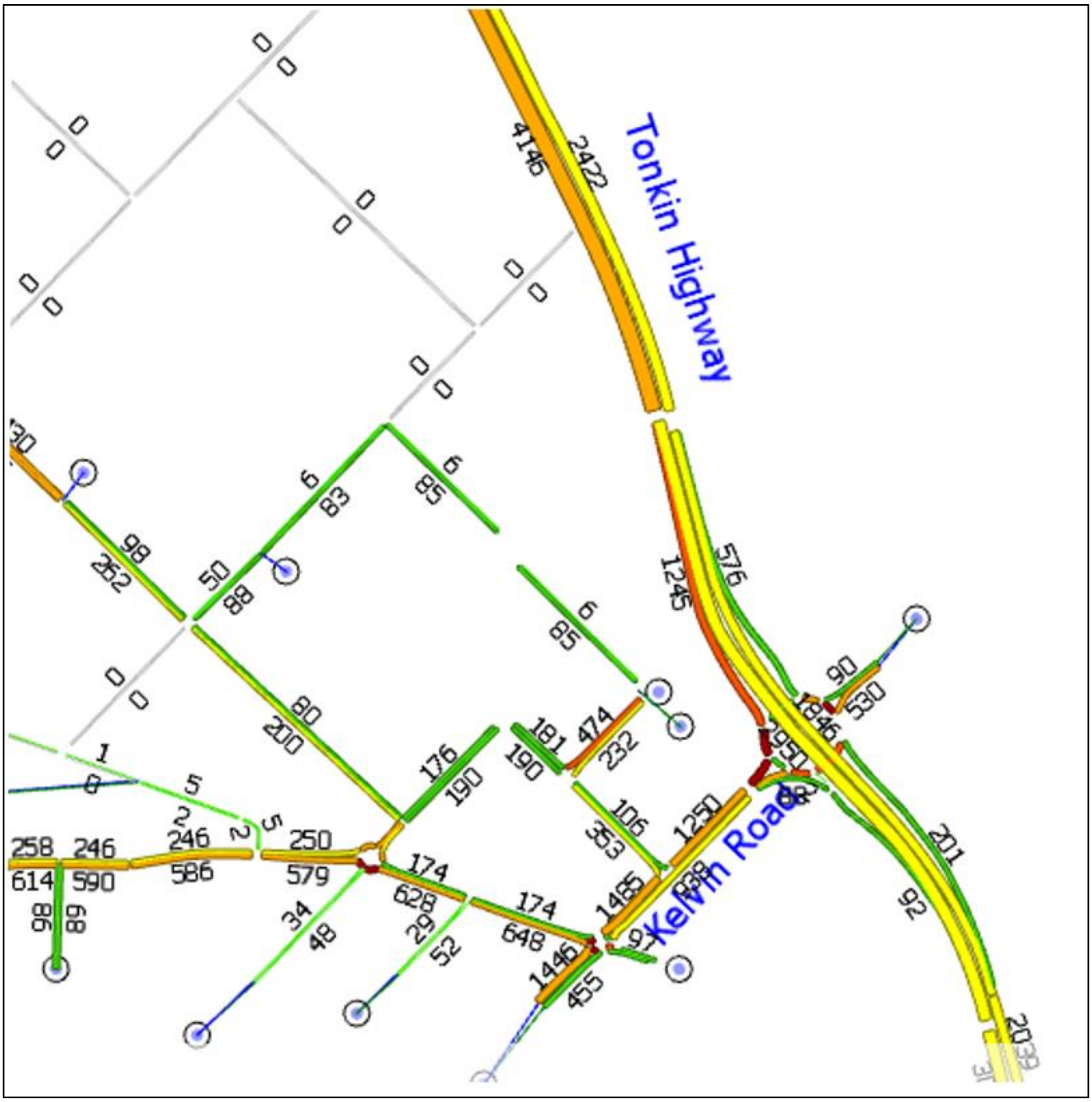
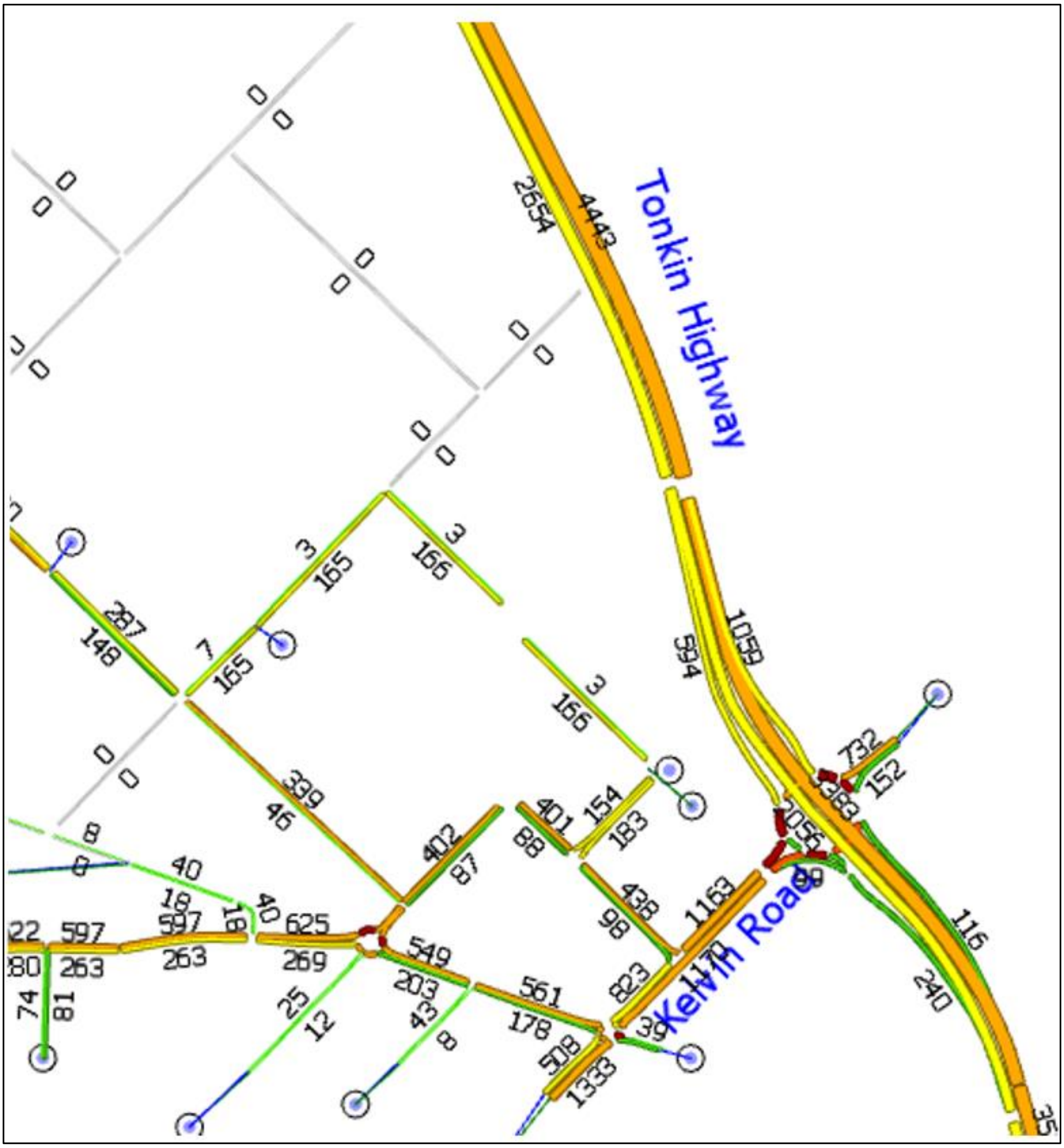


Figure 7-11 MKSEA Precinct 1 - 2031 PM Peak Period Traffic Flows



7.6 Model Results

The intersection delays and Level Of Service (LOS) were extracted from the model for the intersection of Tonkin Highway / Kelvin Road and Kelvin Road / Bickley Road intersections for all scenarios, as well as for the proposed new roundabout on Bickley Road to access MKSEA P1 for the 2021 and 2031 scenarios.

7.6.1 Existing Scenario

The existing intersection performance summary for the intersection of Tonkin Highway / Kelvin Road is shown in **Table 7-3** and suggests that the intersection is not operating satisfactorily during either of the peak periods, with several movements operating at LOS E.

Table 7-3 Intersection Delays and Level of Service for Intersection of Tonkin Highway / Kelvin Road – Existing Scenario

Intersection	Approach	Turn	LOS		Weighted Intersection Delay		Intersection LOS	
			AM	PM	AM	PM	AM	PM
Tonkin Highway / Kelvin Road	South-West (Kelvin Road)	Left	D	D	56	47	E	D
		Through	E	E				
		Right	E	F				
	South-East (Tonkin Highway)	Left	A	A				
		Through	E	D				
		Right	E	E				
	North-West (Tonkin Highway)	Left	A	D				
		Through	D	E				
		Right	E	D				
	North-East (Kelvin Road)	Left	D	D				
		Through	E	E				
		Right	E	D				

The existing intersection performance summary for the intersection of Kelvin Road / Bickley Road is shown in **Table 7-4** and suggests that the intersection is operating satisfactorily during the both peak periods.

Table 7-4 Intersection Delays and Level of Service for Intersection of Kelvin Road / Bickley Road – Existing Scenario

Intersection	Approach	Turn	LOS		Weighted Intersection Delay		Intersection LOS	
			AM	PM	AM	PM	AM	PM
Kelvin Road / Bickley Road	West (Bickley Road)	Left	A	A	3	3	A	A
		Through						
		Right						
	East (Bickley Road)	Left	A	A				
		Through						
		Right						
	North (Kelvin Road)	Left	A	A				
		Through						
		Right						
	South (Kelvin Road)	Left	A	A				
		Through						
		Right						

7.6.2 2021 Scenario

The 2021 intersection performance summary for the intersection of Tonkin Highway / Kelvin Road is shown in **Table 7-5** and suggests that the intersection is not operating satisfactorily during neither of the peak periods, with several movements deteriorating to LOS F as a combination of the MKSEA P1 development and increased traffic demands on Tonkin Highway.

Table 7-5 Intersection Delays and Level of Service for Intersection of Tonkin Highway / Kelvin Road – 2021 Scenario

Intersection	Approach	Turn	LOS		Weighted Intersection Delay		Intersection LOS	
			AM	PM	AM	PM	AM	PM
Tonkin Highway / Kelvin Road	South-West (Kelvin Road)	Left	D	D	62	53	E	D
		Through	E	F				
		Right	E	F				
	South-East (Tonkin Highway)	Left	B	A				
		Through	E	D				
		Right	F	E				
	North-West (Tonkin Highway)	Left	A	A				
		Through	D	D				
		Right	E	E				
	North-East (Kelvin Road)	Left	D	D				
		Through	E	E				
		Right	E	F				

The 2021 intersection performance summary for the intersection of Kelvin Road / Bickley Road is shown in **Table 7-6** and suggests that while the LOS has deteriorated slightly for the western intersection approach (Bickley Road) the intersection is still considered to operate satisfactorily during the both peak periods.

Table 7-6 Intersection Delays and Level of Service for Intersection of Kelvin Road / Bickley Road – 2021 Scenario

Intersection	Approach	Turn	LOS		Weighted Intersection Delay		Intersection LOS	
			AM	PM	AM	PM	AM	PM
Kelvin Road / Bickley Road	West (Bickley Road)	Left	A	A	7	8	A	A
		Through						
		Right						
	East (Bickley Road)	Left	A	A				
		Through						
		Right						
	North (Kelvin Road)	Left	A	A				
		Through						
		Right						
	South (Kelvin Road)	Left	A	A				
		Through						
		Right						

The 2021 intersection performance summary for the intersection of Bickley Road / P1 Access Road / Hanson Road is shown in **Table 7-7** and suggests that the intersection is operating satisfactorily during the both peak periods.

Table 7-7 Intersection Delays and Level of Service for Intersection of Bickley Road / Hanson Road / P1 Access Road – 2021 Scenario

Intersection	Approach	Turn	LOS		Weighted Intersection Delay		Intersection LOS	
			AM	PM	AM			
Bickley Road / P1 Access Road / Hanson Road	West (Bickley Road)	Left	A	A	1	1	A	A
		Through						
		Right						
	East (Bickley Road)	Left	A	A				
		Through						
		Right						
	North (P1 Access Road)	Left	A	A				
		Through						
		Right						
	South (Hanson Road)	Left						
		Through						
		Right						

7.6.3 2031 Scenario

The 2031 intersection performance summary for the grade-separated interchange of Tonkin Highway / Kelvin Road is shown in **Table 7-8** and suggests that the intersection performance will be substantially improved during both the peak periods as a result of the grade-separation as the volumes on the Tonkin Highway mainlines do not contribute to delays on the interchange.

Table 7-8 Intersection Delays and Level of Service for Tonkin Highway / Kelvin Road Grade-Separated Interchange – 2031 Scenario

Intersection	Approach	Turn	LOS		Weighted Intersection Delay		Intersection LOS	
			AM	PM	AM	PM	AM	PM
Tonkin Highway / Kelvin Road	South-West (Kelvin Road)	Left	A	A	2	4	A	A
		Through						
		Right						
	South-East (Tonkin Highway)*	Left	A	A				
		Right						
	North-West (Tonkin Highway)*	Left	A	A				
		Right						
	North-East (Kelvin Road)	Left	A	A				
		Through						
		Right						

* traffic volumes on the Tonkin Highway mainline have been excluded from this summary as they do not contribute any delays on the interchange.

The 2031 intersection performance summary for the intersection of Kelvin Road / Bickley Road is shown in **Table 7-9** and suggests that the LOS has deteriorated to LOS E for the western intersection approach (Bickley Road) during the PM peak period due to a combination of traffic from MKSEA P1 utilising this roundabout to go south on Kelvin Road, as well as an increase in volumes on the northern and southern approaches (Kelvin Road).

Table 7-9 Intersection Delays and Level of Service for Intersection of Kelvin Road / Bickley Road – 2031 Scenario

Intersection	Approach	Turn	LOS		Weighted Intersection Delay		Intersection LOS	
			AM	PM	AM	PM	AM	PM
Kelvin Road / Bickley Road	West (Bickley Road)	Left	B	A	9	9	A	A
		Through						
		Right						
	East (Bickley Road)	Left	A	B				
		Through						
		Right						
	North (Kelvin Road)	Left	A	A				
		Through						
		Right						
	South (Kelvin Road)	Left	A	A				
		Through						
		Right						

The 2031 intersection performance summary for the intersection of Bickley Road / P1 Access Road / Hanson Road is shown in **Table 7-10** and suggests that the intersection is operating satisfactorily during the both peak periods.

Table 7-10 Intersection Delays and Level of Service for Intersection of Bickley Road / Hanson Road / P1 Access Road – 2031 Scenario

Intersection	Approach	Turn	LOS		Weighted Intersection Delay		Intersection LOS	
			AM	PM	AM			
Bickley Road / P1 Access Road / Hanson Road	West (Bickley Road)	Left	A	A	1	2	A	A
		Through						
		Right						
	East (Bickley Road)	Left	A	A				
		Through						
		Right						
	North (P1 Access Road)	Left	A	A				
		Through						
		Right						
	South (Hanson Road)	Left						
		Through						
		Right						

7.6.4 2031 Scenario – Sensitivity Analysis

The primary land use in MKSEA P1 structure plan area is proposed to be Industrial, which can cover a wide variety of specific development types. Sensitivity analysis was therefore undertaken for the 2031 scenario where the MKSEA traffic volumes were increased by 10% to account for potential higher-than-expected traffic generating developments and to identify potential intersection and network impacts from the additional traffic.

The 2031 intersection performance summary for the grade-separated interchange of Tonkin Highway / Kelvin Road is shown in **Table 7-11** and suggests no change to the intersection delays as a result of the additional MKSEA traffic.

Table 7-11 Intersection Delays and Level of Service for Tonkin Highway / Kelvin Road Grade-Separated Interchange – 2031 Scenario (+10% MKSEA Traffic)

Intersection	Approach	Turn	LOS		Weighted Intersection Delay		Intersection LOS	
			AM	PM	AM	PM	AM	PM
Tonkin Highway / Kelvin Road	South-West (Kelvin Road)	Left	A	A	2	4	A	A
		Through						
		Right						
	South-East (Tonkin Highway)*	Left	A	A				
		Right						
	North-West (Tonkin Highway)*	Left	A	A				
		Right						
	North-East (Kelvin Road)	Left	A	A				
		Through						
		Right						

* traffic volumes on the Tonkin Highway mainline have been excluded from this summary as they do not contribute any delays on the interchange.

The 2031 intersection performance summary for the intersection of Kelvin Road / Bickley Road is shown in **Table 7-12** and suggests that the LOS deteriorates to a maximum level of B for both the eastern and western approach (Kelvin Road) during the PM peak period as a result of the additional MKSEA development generated traffic.

Table 7-12 Intersection Delays and Level of Service for Intersection of Kelvin Road / Bickley Road – 2031 Scenario (+10% MKSEA Traffic)

Intersection	Approach	Turn	LOS		Weighted Intersection Delay		Intersection LOS	
			AM	PM	AM	PM	AM	PM
Kelvin Road / Bickley Road	West (Bickley Road)	Left	B	B	10	32	A	A
		Through						
		Right						
	East (Bickley Road)	Left	A	B				
		Through						
		Right						
	North (Kelvin Road)	Left	A	A				
		Through						
		Right						
	South (Kelvin Road)	Left	A	A				
		Through						
		Right						

The 2031 intersection performance summary for the intersection of Bickley Road / P1 Access Road / Hanson Road is shown in **Table 7-10** and suggests only minor increases to the intersection delays as a result of the additional MKSEA traffic.

Table 7-13 Intersection Delays and Level of Service for Intersection of Bickley Road / Hanson Road / P1 Access Road – 2031 Scenario

Intersection	Approach	Turn	LOS		Weighted Intersection Delay		Intersection LOS	
			AM	PM	AM			
Bickley Road / P1 Access Road / Hanson Road	West (Bickley Road)	Left	A	A	2	4	A	A
		Through						
		Right						
	East (Bickley Road)	Left	A	A				
		Through						
		Right						
	North (P1 Access Road)	Left	A	A				
		Through						
		Right						
	South (Hanson Road)	Left						
		Through						
		Right						

7.7 Access to Frontage Properties

Any access to properties / lots along Kelvin Road will be limited to left-in, left-out movements only.

7.8 Access to Public Transport

No changes to existing bus stops are proposed as part of the MKSEA P1 structure plan.

8 Summary and Conclusions

This report has been prepared in accordance with the Western Australian Planning Commission (WAPC) *Transport Impact Assessment Guidelines Volume 2 – Planning Schemes, Structure Plans & Activity Centre Plans (2016) and will* support the detailed structure planning for the locality.

The following conclusions have been made in regards to the MKSEA P1 Structure Plan as part of this assessment:

> The proposed Structure Plan, containing a gross area of approximately 108 hectares of Industrial, Composite Industrial and Natural Reserve land will provide employment opportunities and support the economic growth in the area.

> The land uses within the proposed Structure Plan will generate an estimated 1,413 trips in the AM peak period (7-9AM), 1,162 trips in the PM peak period (4-6PM) and approximately 8,400 daily trips.

> The intersection of Tonkin Highway / Kelvin Road is shown to not operate satisfactorily during the existing AM and PM peak periods, with several movements shown to operate at LOS E. By 2021 this is expected to deteriorate further, with several movements shown to operate at LOS F, thus indicating that the intersection is likely operating above capacity at this time. The grade-separated interchange (assumed to be operational by 2031) is shown to substantially improve the intersection performance due to the grade-separation as the volumes on the Tonkin Highway mainlines do not contribute to delays on the interchange.

> The intersection of Kelvin Road / Bickley Road is shown to operate satisfactorily for both the Existing and 2021 scenario. This LoS is projected to be maintained into 2031

> The intersection of Bickley Road / P1 Access Road is shown to operate satisfactorily for all modelled scenarios.

> All internal intersections within P1 are proposed to be designed to accommodate up to class 4 RAVs.

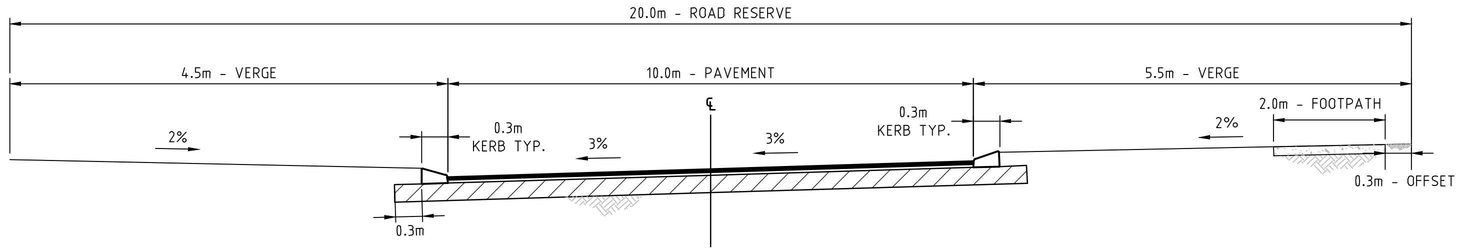
> The proposed road cross-sections will allow for the provision of pedestrian facilities within P1, as well as a 3.5m wide shared path on the western side of Kelvin Road.

APPENDIX

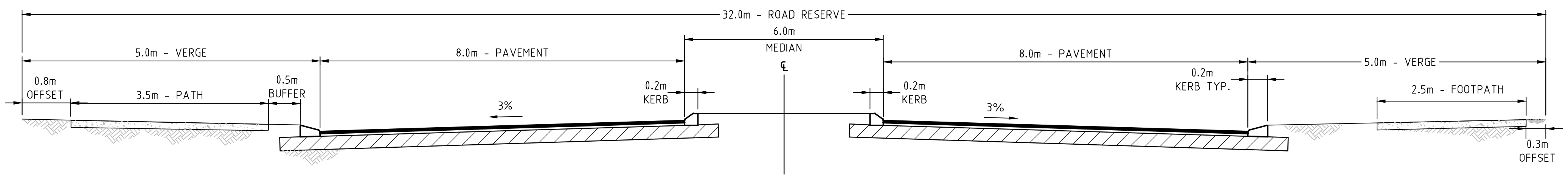
A

PROPOSED INTERNAL ROAD CROSS-SECTIONS (A3)

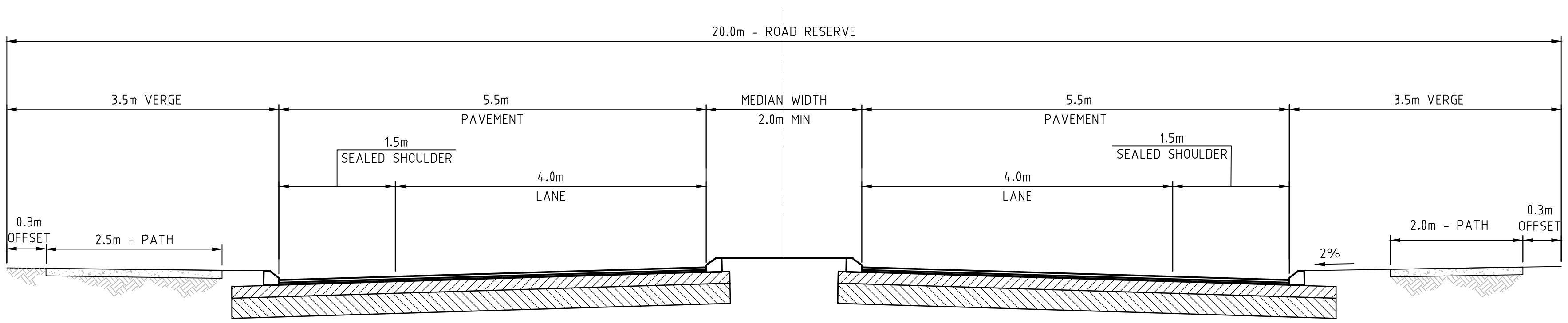
DATE PLOTTED: 8 March 2019 11:07 AM BY : JAMES DRACUP



20.0m ROAD RESERVE - ONE WAY CROSSFALL
Access Road



32.0m ROAD RESERVE - CROWNED WITH MEDIAN
Distributor A



TYPICAL ROAD CROSS SECTION - WITH MEDIAN
Distributor B

Cardno
Cardno (NSW/ACT) Pty Ltd | ABN 95 001 145 035
Level 9, The Forum, 203 Pacific Highway
St. Leonards, NSW 2065
Tel: 02 9496 7700 Fax: 02 9439 5170
Web: www.cardno.com.au

City of Gosnells
MKSEA Precinct 1
Precinct 1 Road Cross Sections

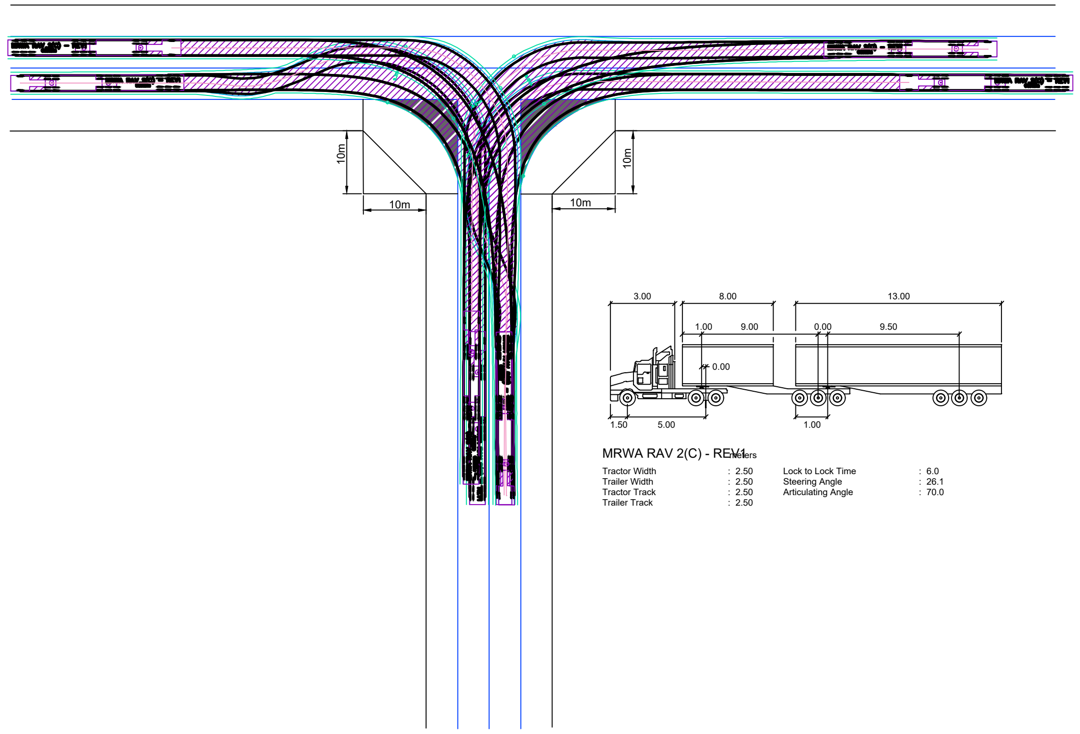
Datum	Date	Scale	Size
	06-02-2019		A3

Drawing Number	Revision
CW937700-SK003-Cross Sections	REVD

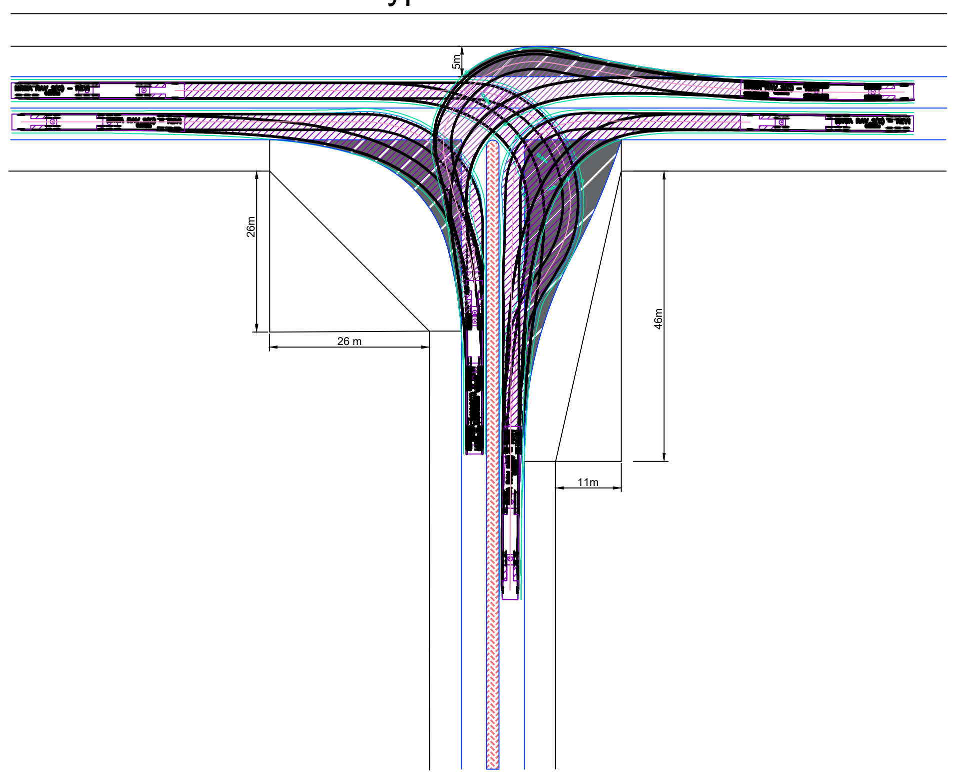
XREFs:
CAD File: Y:\CW937700_Linc_Property_Pty_Ltd_MKSEA_Transport_Asessment\5_Technical\Traffic\Graphics\CAD\MKSEA Precinct 1 servicing and hierarchy\Road Hierarch and Servicing REVB.dwg

DATE PLOTTED: 8 March 2019 12:11 PM BY : JAMES DRACUP

Type A RAV 4



Type B RAV 4



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City of Gosnells
MKSEA RAV Intersection Layouts

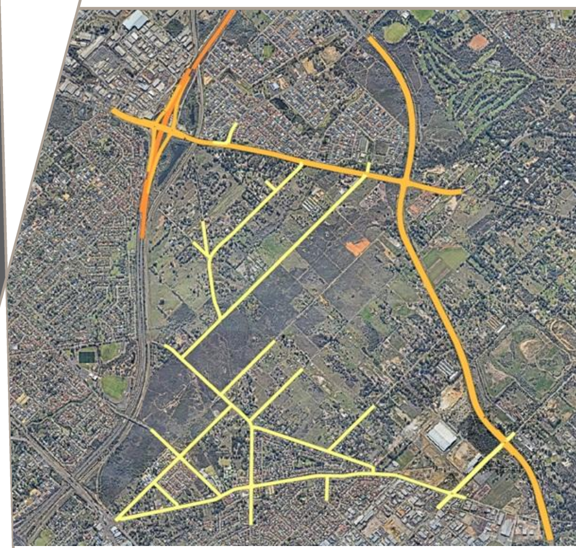
Datum	Date	Scale	Size
	20/11/2018		A3

Drawing Number	Revision
CW103000-SK003	C

APPENDIX

B

MKSEA BASE MODEL CALIBRATION AND VALIDATION



Base Model Calibration and Validation Report

MKSEA Transport Assessments

Prepared for
City of Gosnells

7 September 2018

Contact Information

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Document Information

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Document Type	RP
Document Sequence	002
Date	7 September 2018
Revision Number	Rev A

Author(s):

Andreas Wang
Team Leader – Transport Modelling

Approved By:

Ray Cook
Manager Traffic and Transport

Document History

Revision	Date	Description of Revision	Prepared by:	Reviewed by:
Rev A	7/9/2018	Rev A	AW	RC

Executive Summary

Cardno has been engaged by City of Gosnells to develop a number of traffic models for the Maddington Kenwick Strategic Employment Area (MKSEA).

This report outlines the processes and data sources used for the development of the MKSEA model, as well as the calibration and validation results of the base year models. Two modelling periods have been selected to represent the study area. The AM 7:00 – 9:00 and PM 16:00 – 18:00 peak hour models are intended to describe peak MKSEA demand periods.

Rigorous calibration and validation processes have been undertaken for these models to ensure that they reflect observed travel behaviours. The models have been assessed under the calibration and validation criteria defined by the MRWA Operational Modelling Guidelines.

As a result of this analysis, it has been concluded that these models reflect the existing traffic conditions and can be used as the base for the future transport models, including the impact of the proposed MKSEA. This calibration report has been prepared for approval by the City. Once approved, Cardno will develop future year models based on a traffic growth scenario derived from information provided by the City of Gosnells and distributed in accordance with ROM24 outputs for the 2021 and 2031 scenario years.

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Appendices

Tables

Figures

1 Introduction

1.1 Background

Cardno has been engaged by City of Gosnells (City) to develop a mesoscopic Transport Model for the Maddington Kenwick Strategic Employment Area (MKSEA) utilising the Aimsun transport modelling suite.

The following Aimsun models will be developed as part of the study:

> Existing – AM and PM peak period models;

> 2021 – AM and PM peak hour models to represent the interim development phase of MKSEA;

> 2031 – AM and PM peak hour models to represent the ultimate development phase of MKSEA;

The models prepared as part of this study will assist the City to gain an understanding of the future road network requirements to ultimately support the development of the industrial area. This information will further be used to inform structure planning to guide detailed land use planning and development.

This report outlines the development process of MKSEA base year models detailing their calibration and validation in accordance with the guidelines set forth by the Main Roads Western Australia (MRWA) in the *Operational Modelling Guidelines*.

Once this report has been approved by the City, Cardno will develop future year models based on a traffic growth scenario derived from information provided by the City of Gosnells and distributed in accordance with ROM24 outputs for the 2021 and 2031 scenario years.

1.2 Study Area

The study area is shown in **Figure 1-1** and **Figure 1-2** and encompasses roads within both City of Gosnells and City of Kalamunda.

Figure 1-1 Extent of Model

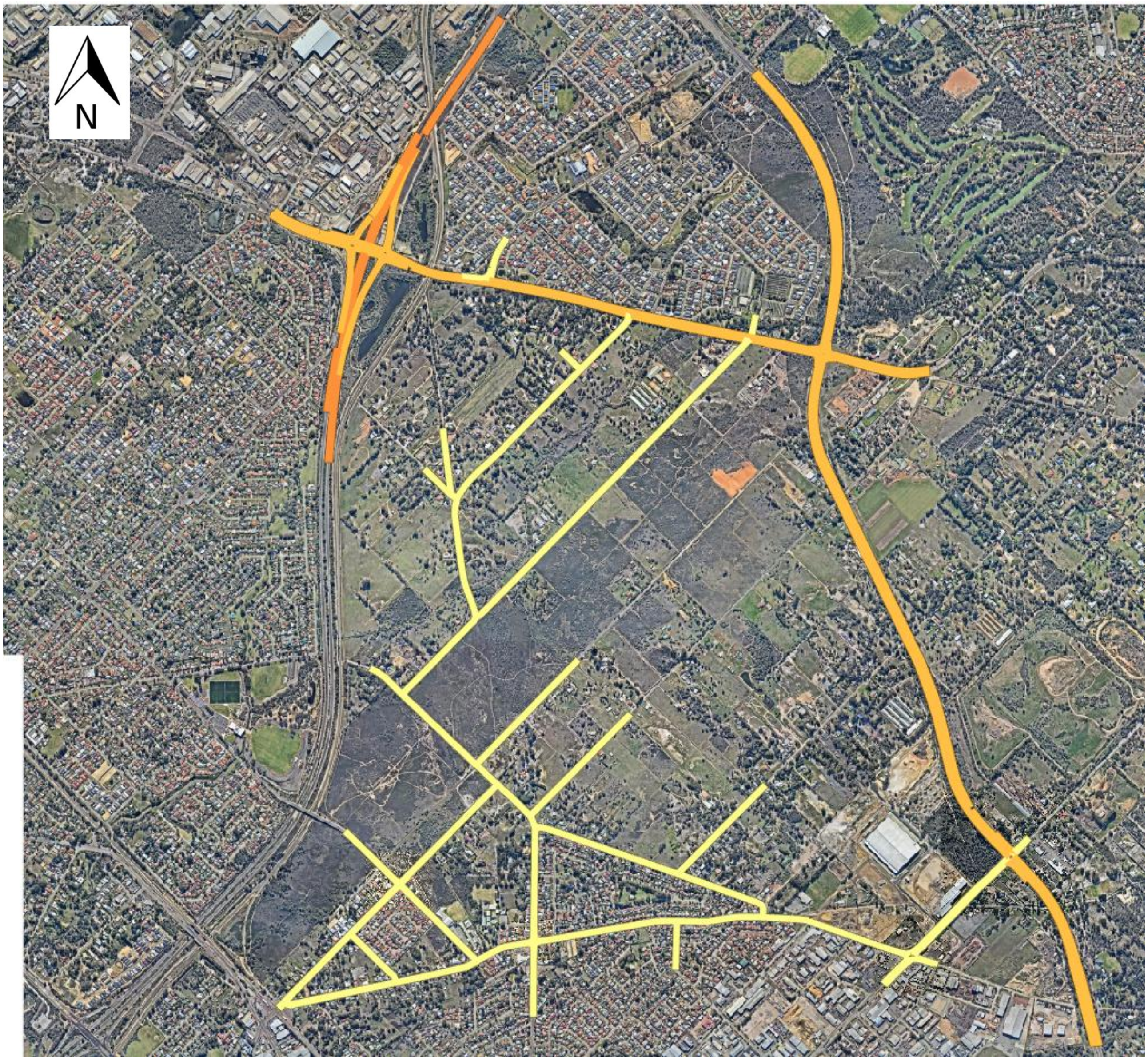
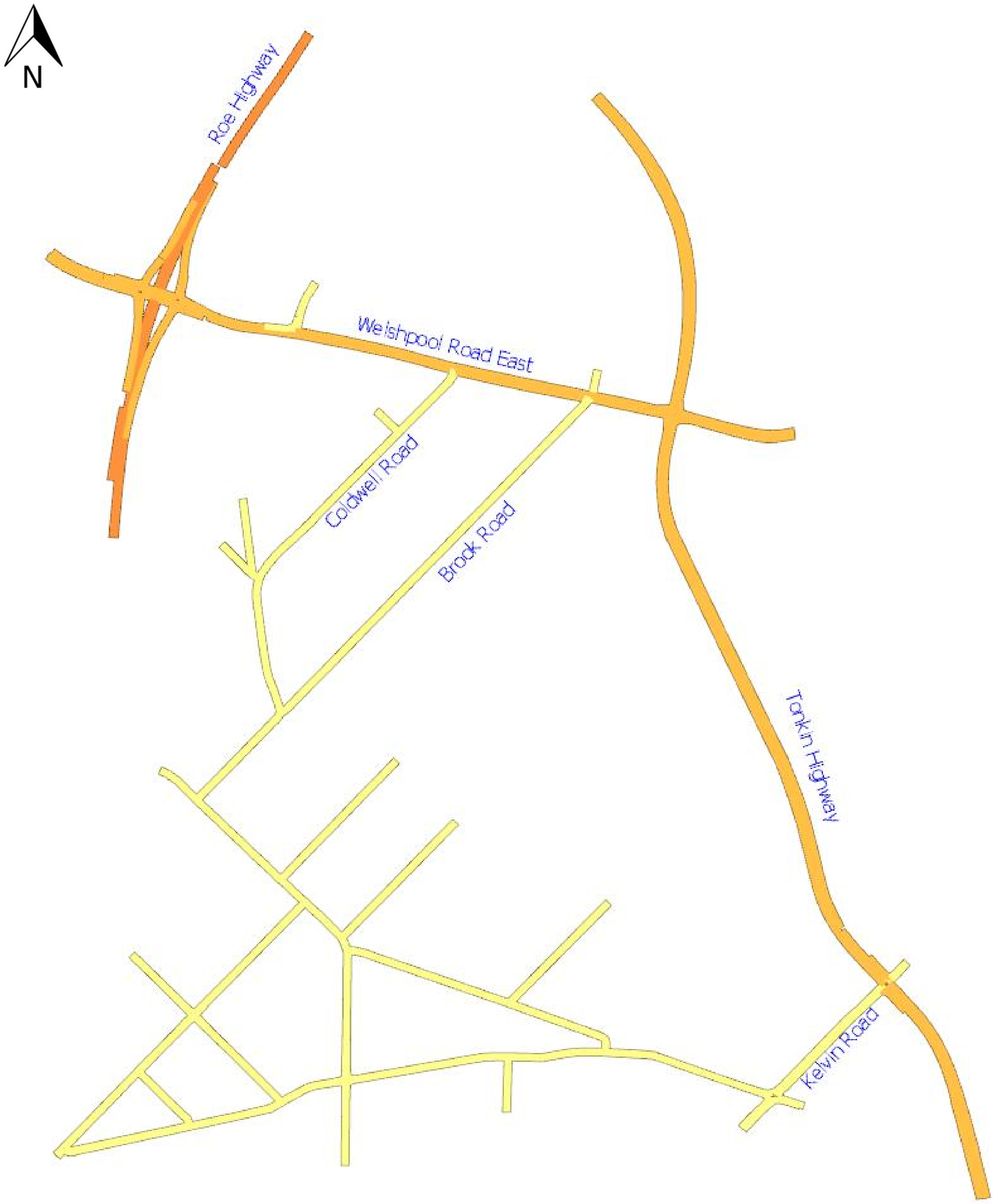


Figure 1-2 Study Area – Key Roads



1.3 Data Sources

Table 1-1 below outlines the various data sources and assumptions which form the basis of MKSEA transport model.

Table 1-1 Data Sources

Data	Source
Existing traffic volumes (un-calibrated)	Regional Operations Model (ROM24)
Traffic calibration data	Traffic Counts, Cardno, May 2018
Existing residential dwellings (per zone)	Australian Bureau of Statistics (ABS) 2011 Census
Signalised intersection phase timing	Main Roads Western Australia (MRWA)
Current land uses	Department of Planning (DOP) and NearMaps
Future land uses	DOP and City of Gosnells
Intersection geometry	Visual site inspections, supplemented with NearMaps imagery
Model validation and calibration criteria	MRWA Operational Modelling Guidelines
Aimsun model parameters and default values	MRWA Operational Modelling Guidelines
Network Speed and Road Hierarchy	Road Information Mapping System, MRWA

1.3.2 Intersection Surveys

In order to ensure the modelled traffic conditions were reflective of existing observed traffic conditions, classified traffic movement surveys were undertaken at 15 key intersections within the MKSEA study area as shown in **Figure 1-3** and listed in **Table 1-2**. The intersection surveys were undertaken in May 2018 and covered the AM peak period between 07:00 – 9:00 and the PM peak period between 16:00 – 18:00.

Figure 1-3 Locations of Intersection Traffic Survey for MKSEA Model

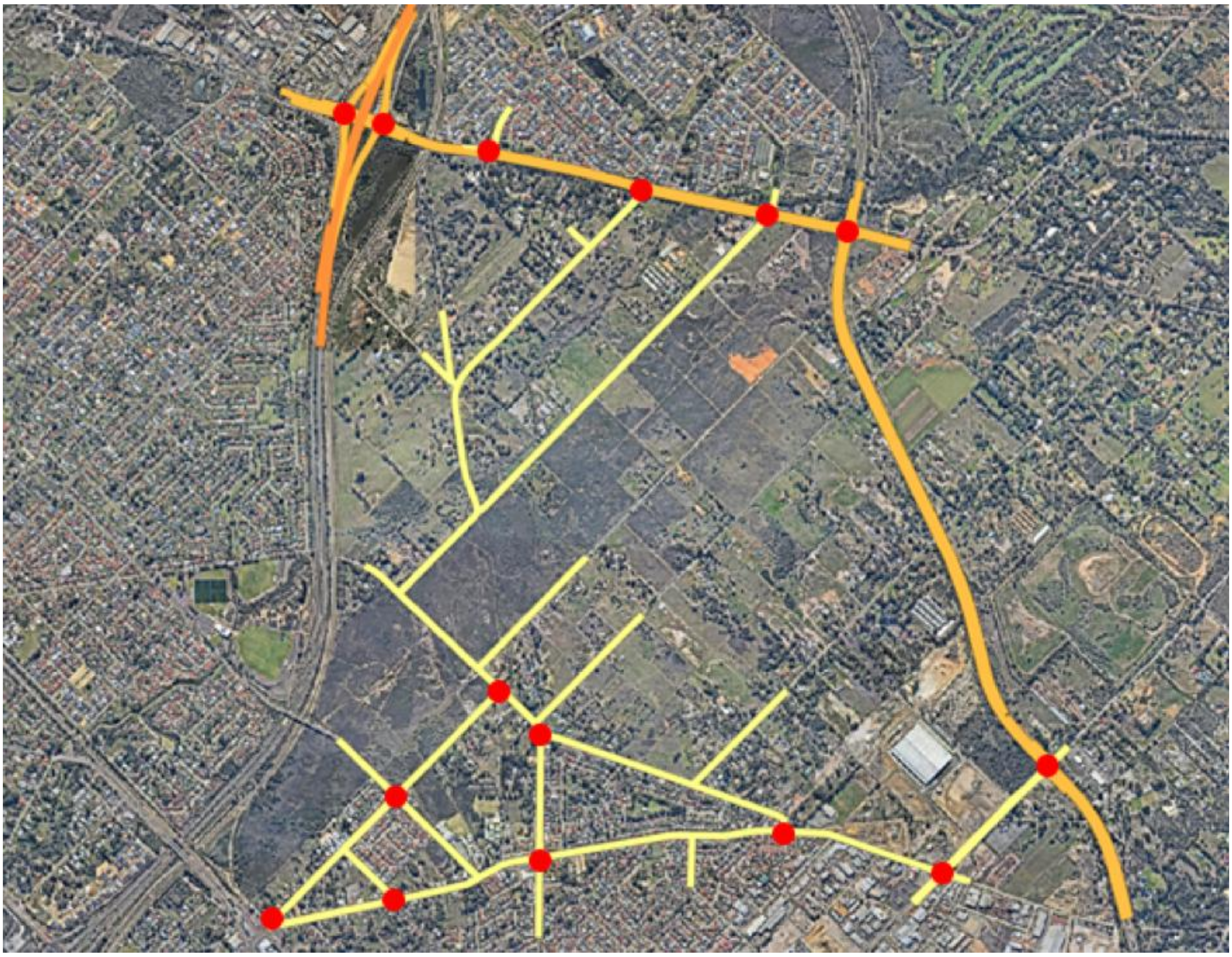


Table 1-2 Summary of Intersection Traffic Surveys

Intersection ID	Intersection
Intersection 1	Bickley Rd & Kelvin Rd
Intersection 2	Bickley Rd & Kenwick Rd
Intersection 3	Bickley Rd & Belmont Rd
Intersection 4	Belmont Rd & Kenwick Rd
Intersection 5	Kenwick Rd & Park Rd
Intersection 6	Brixton St & Wanaping Rd
Intersection 8	Bickley Rd & Wanaping Rd
Intersection 9	Kelvin Rd & Tonkin Hwy
Intersection 10	Tonkin Hwy & Welshpool Rd E
Intersection 11	Orrong Rd & Roe Hwy
Intersection 12	Welshpool Rd East & Roe Hwy
Intersection 13	Welshpool Rd East & Hale Rd
Intersection 14	Welshpool Rd East & Coldwell Rd
Intersection 15	Welshpool Rd East & Brook Rd & Bruce Rd

2 Model Assumptions

2.1 Modelling Platform

The MKSEA transport model was developed using Aimsun v8.2.3 R54491.

2.2 Time Periods

Two peak hour periods were assessed in this study: Weekday AM and PM. The modelled peak hour periods were determined from the obtained traffic survey data, with separate model scenarios developed for each peak period. For each peak period, a ‘warm-up’ period of 15 minutes was added before the modelled peak period, with overall modelled periods as follows:

- Weekday AM
  - Warm-up: 06:45 to 07:00
  - AM peak period 07:00 to 09:00
- Weekday PM
  - Warm-up: 15:45 to 16:00
  - PM peak period 16:00 to 18:00

2.3 Vehicle Types

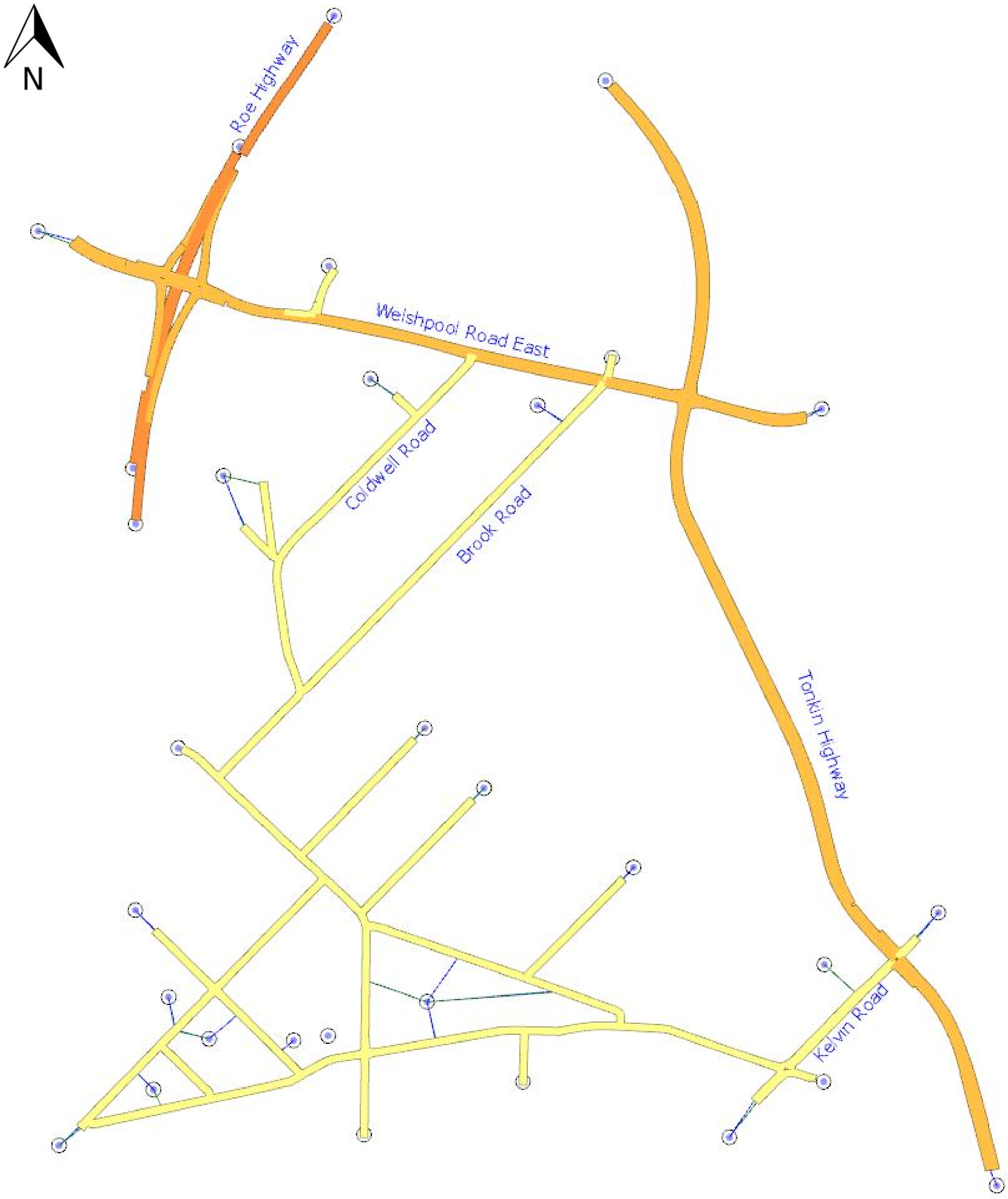
The following vehicles types were incorporated in the models to reflect the typical vehicle types within the study area:

- Light vehicles (Austroads class 1), with vehicle parameters based on Table 6-3 of the MRWA Operational Modelling Guidelines;
- Trucks (Austroads classes 2-5) with vehicle parameters based on Table 6-5 of the MRWA Operational Modelling Guidelines;
- Semi-trailers (Austroads classes 6-9) with vehicle parameters based on Table 6-6 of the MRWA Operational Modelling Guidelines;
- B-doubles (Austroads class 10) with vehicle parameters based on Table 6-7 of the MRWA Operational Modelling Guidelines;
- B-triples (Austroads class 11) with vehicle parameters based on Table 6-8 of the MRWA Operational Modelling Guidelines; and
- Buses (modelled separately using fixed routes and timetables rather than demand matrices) with vehicle parameters based on Table 6-4 of the MRWA Operational Modelling Guidelines

2.4 Traffic Zones and Disaggregation

The zone system for the entire model is shown in **Figure 2-1**.

Figure 2-1 MKSEA Zone System



As the model "prior matrices" were based on ROM24, disaggregation of the ROM24 zones was required in order to increase the resolution of the model in the study area and provide a more realistic network loading. In these cases, zones were split using a method that tracks the process of zone splitting to enable aggregation of zones according to TfNSW Mesoscopic Network Representation, AIMSUN Network Coding Guidelines, Version 1, October 2016. The disaggregation of the ROM24 zones resulted in approximately an additional 13 internal model zones. A summary of all disaggregated zones is shown in **Table 2-1**.

Table 2-1 Internal Zone Disaggregation Comparison

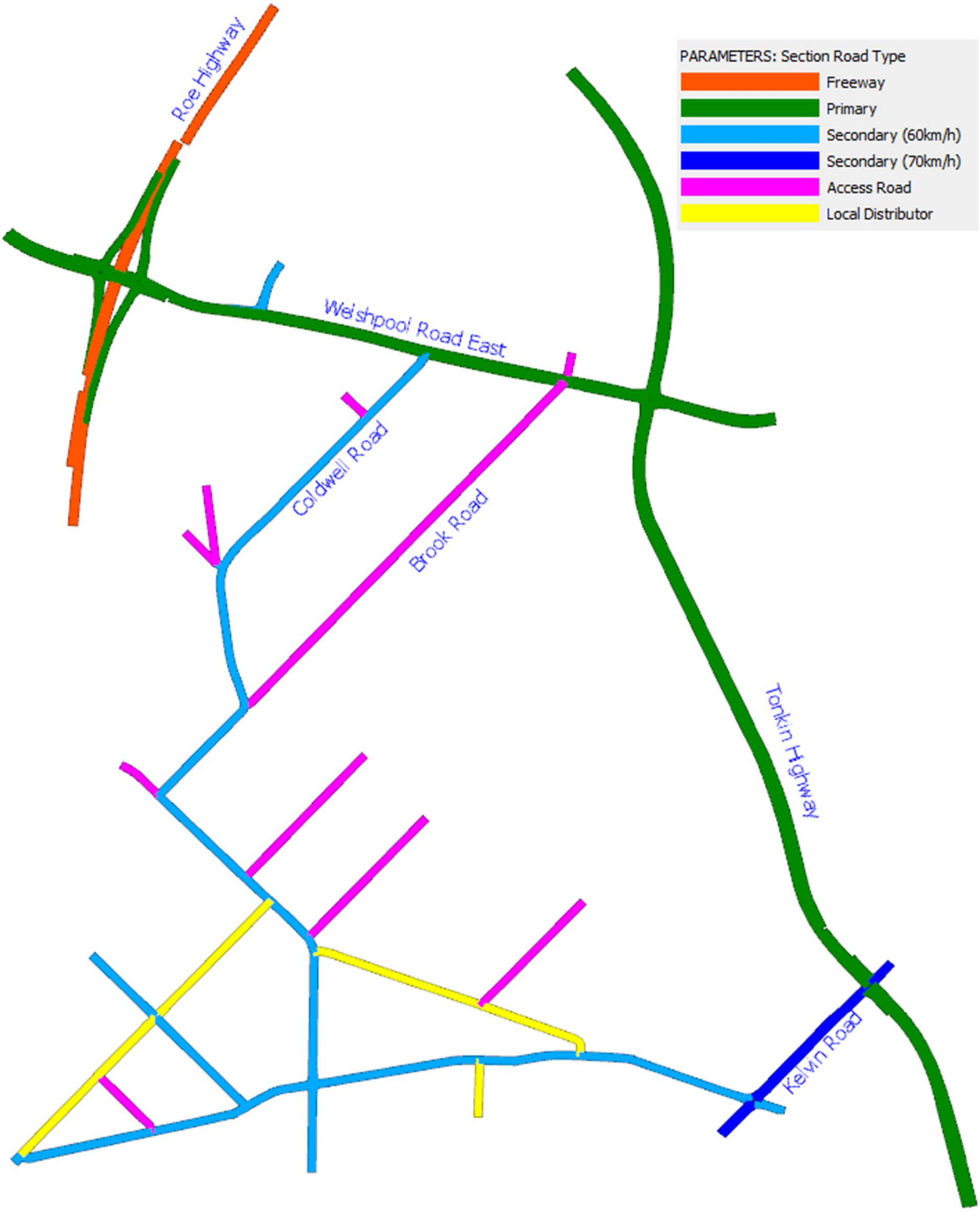
ROM24 Sub-Area Zones	MKSEA Zones
1	1-1
	1-2
	1-3
2	2-1
	2-2
	2-3
	2-4
	2-5
	2-6
	2-7
	2-8
3	3-1
	3-2
	3-3
	3-4
	3-5

2.5 Road Types

The model road types and associated typical parameters adopted within the MKSEA are shown in **Figure 2-2** and includes the following road types:

- **Primary Roads (100km/h)**
  - Maximum speed: 100km/h
  - Capacity (per lane): 2100 PCUs/h
- **Primary Roads (80km/h)**
  - Maximum speed: 80km/h
  - Capacity (per lane): 1500 PCUs/h
- **Secondary (70km/h)**
  - Maximum speed: 70 km/h
  - Capacity (per lane): 900 PCUs/h
- **Secondary (60km/h)**
  - Maximum speed: 60 km/h
  - Capacity (per lane): 900 PCUs/h
- **Access Road (50km/h)**
  - Maximum speed: 50 km/h
  - Capacity (per lane): 400 PCUs/h
- **Local Distributor (50km/h)**
  - Maximum speed: 50 km/h
  - Capacity (per lane): 400 PCUs/h

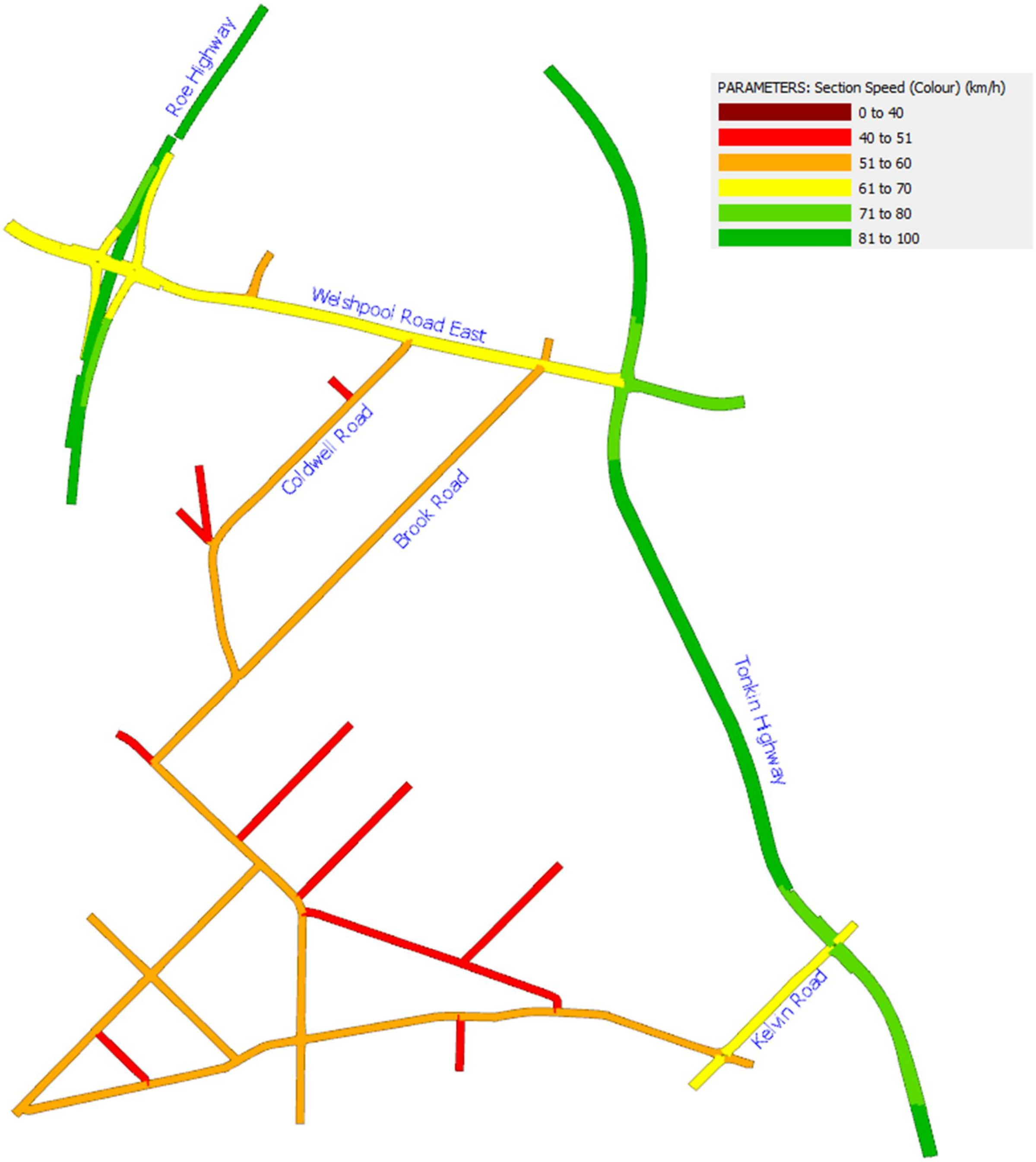
Figure 2-2 Road Types



2.6 Speed Profiles

The posted speed limits for the roads are summarised in **Figure 2-3**.

Figure 2-3 Road Speeds



2.7 Traffic Signals

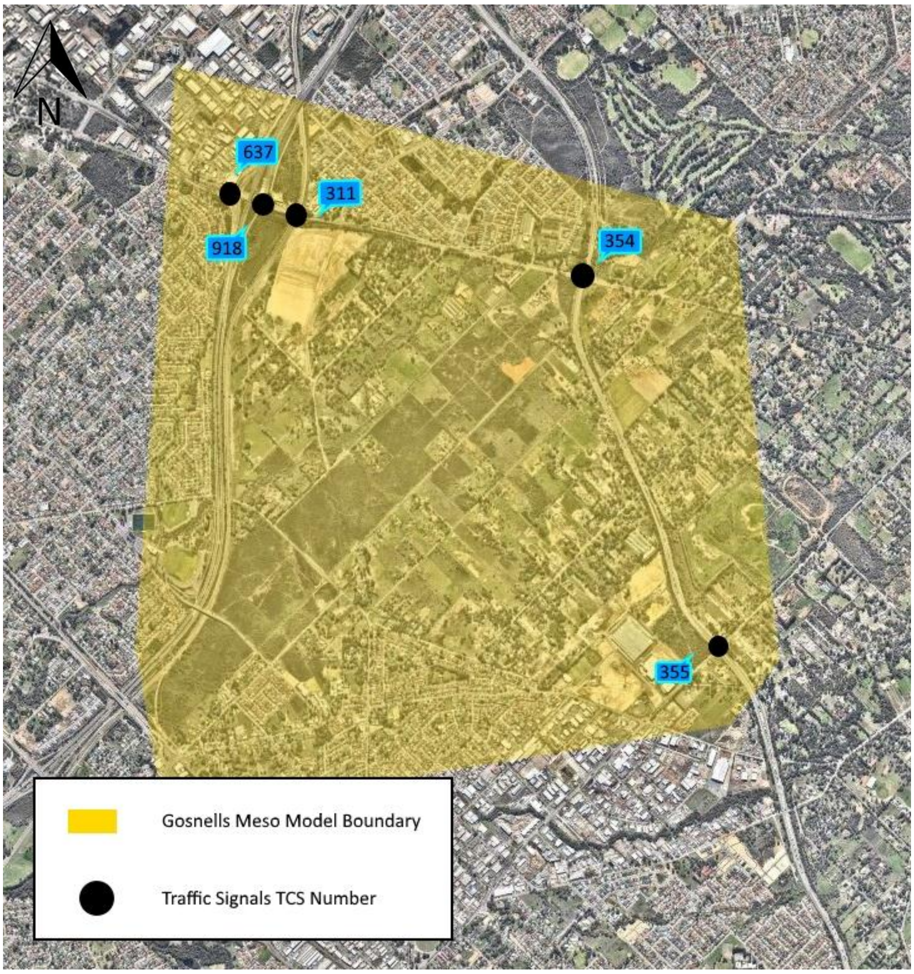
A total of 5 signalised intersections are located within the MKSEA study area as shown in **Figure 2-4** and summarised in **Table 2-2**.

Cardno requested MRWA signal information in the form of SCATS operation and signalling information collected on the same day as the traffic surveys used to develop traffic models. This data was provided as SCATS plots and HIST files.

Table 2-2 TCS ID and Signalised Intersection Descriptions

TCS	Intersection
637	Orrong Road & Roe Hwy
918	Roe Hwy & Welshpool Rd East
311	Hale Rd & Welshpool Rd East
354	Tonkin Hwy & Welshpool Rd East
355	Tonkin Highway & Kelvin Rd

Figure 2-4 Traffic Signals within MKSEA Boundary



2.8 Public Transport

The existing bus stops and services have been added to the model. The public transport routes and headways were based on bus route time tables available on the Transperth website (as per July 2018). The existing bus routes are shown in **Figure 2-5**.

The following bus routes were included in the MKSEA:

> 229 Maddington to Cannington

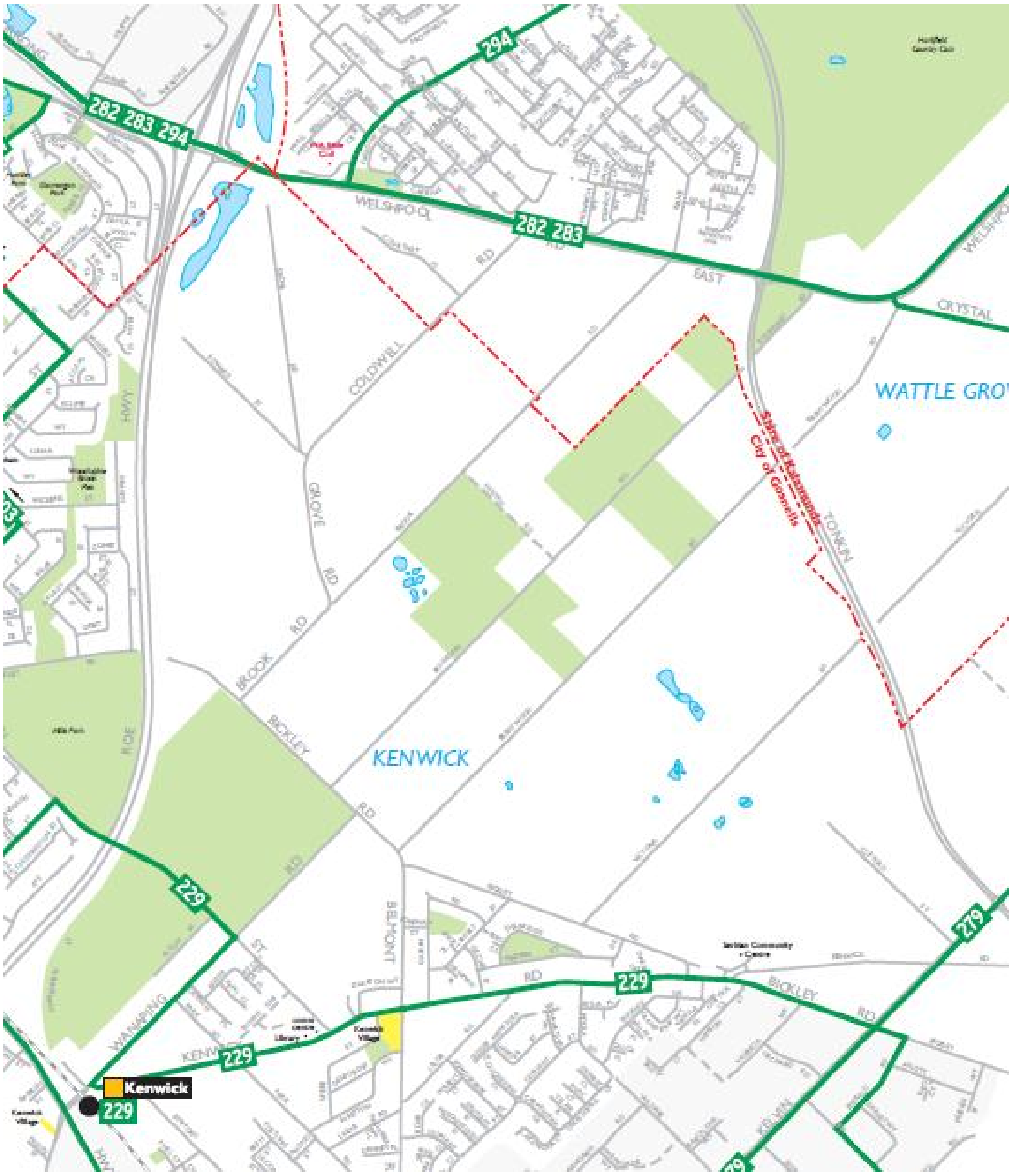
> 279 Kalamunda to Maddington

> 282 Elizabeth Quay to Kalamunda

> 283 Elizabeth Quay to Kalamunda

> 294 Cannington to Midland

Figure 2-5 Existing Bus Routes



Source: Transperth

2.9 Assignment Type

The MKSEA model was developed using the following combinations of assignment and simulation techniques in a three-step process:

> Static equilibrium (MACRO) assignment using static traffic model.
> Dynamic User Equilibrium (DUE) assignment using mesoscopic simulator.
> Stochastic assignment using mesoscopic simulator.

The route choice parameters used in the simulation consist of the following:

> Route choice calculation cycle interval every 15 minutes
> Relative Gap set as 3%
> Attractiveness weight set as 2
> Gradient based for the Dynamic User Equilibrium (DUE) runs
> C-Logit Model for the Stochastic Route Choice (SRC) replications.

The demand matrices went through several iterations to check that demands assigned represented the surveyed turning volumes at key intersections.

2.10 Demand Assumptions / Adjustment

The methodology for the development of the trip demand matrices for each of the modelled periods is detailed below.

> GMA Static Assignment: Demand matrices for the study area were extracted from ROM24 for base year to provide strategic traffic demand and patterns.
> Static Assignment Adjustment: Further development and demand estimation was undertaken using static equilibrium assignment. This was used to calibrate the initial traffic demand (derived from two-hour sub-area cordon matrices and initially constant over time in two hour modelled period) across the entire network and provide a starting point for more detailed mesoscopic simulation.
> Manual Adjustment: Matrices were then restructured to fit the mesoscopic model zone system. This consists of analysis of turning movement counts on a network wide basis and link total comparisons between surveyed intersections. Where necessary minor adjustments were made to balance trip totals between intersections for the base year.
> Departure Time Adjustment: Traffic demand release profiles were applied to dispense traffic demands in defined time intervals over the model periods. These profiles were developed based on the traffic survey data which was collated in 15 minute intervals (refer to Traffic Profile section for traffic demand release percentages of the two-hour trip demand matrices).
> Dynamic Traffic Assignment Adjustment: The resulting sliced trip demand matrices from the departure adjustment process were applied to the model and an iterative loop of testing and matrix refinement undertaken to achieve an appropriate level of model calibration.

2.11 Traffic Profiles

As stated in the previous section the model covers the weekday AM and PM peak periods including a warmup period (i.e. 15 minutes) to generate sufficient demand on the network at the start of each analysis period.

Figure 2-6 and **Figure 2-7** present the AM and PM network traffic demand profiles respectively.

Figure 2-6 AM Network Traffic Demand

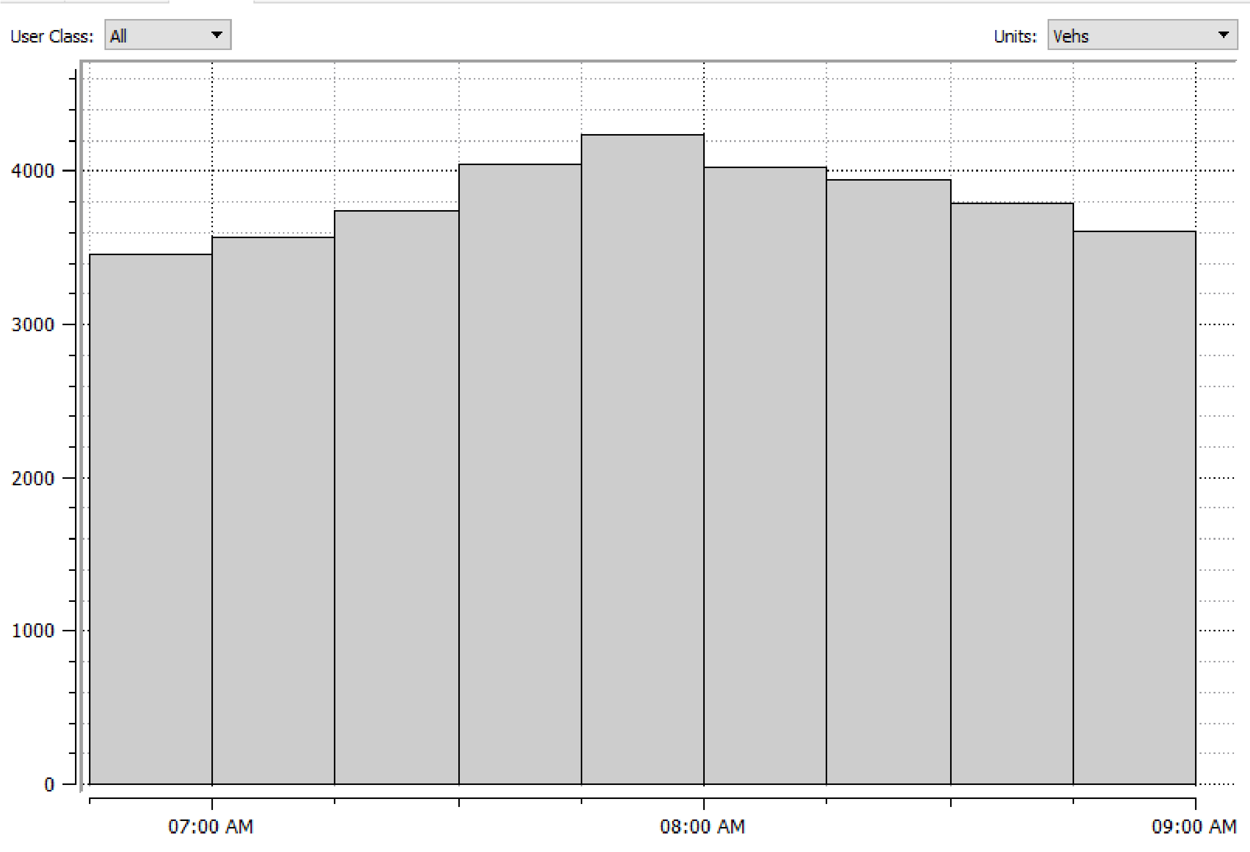
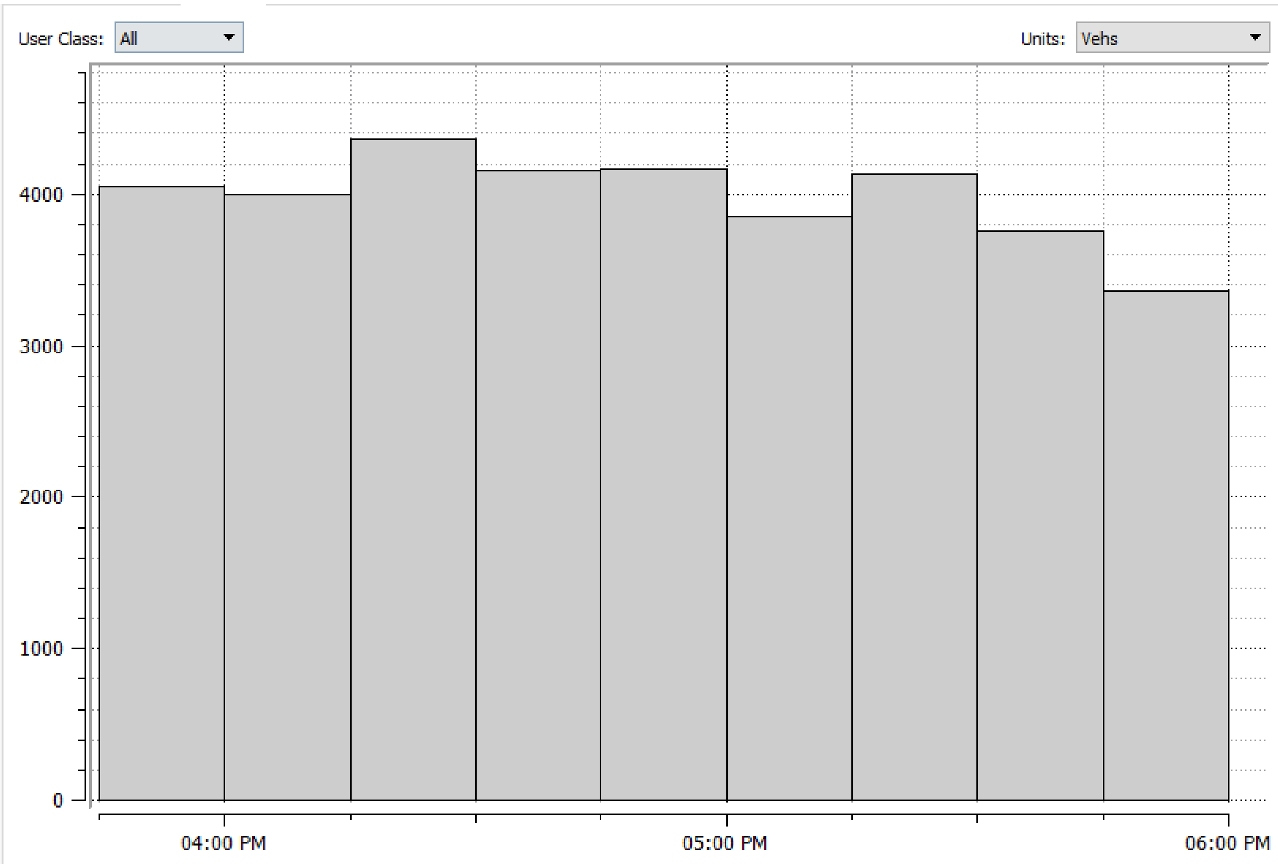


Figure 2-7 PM Network Traffic Demand



2.12 Behaviour Parameters

A number of modelling parameters have been calibrated reflecting localised driver behaviour. Specifically, in the mesoscopic simulation the reaction time and give way factors have been adjusted to the following values:

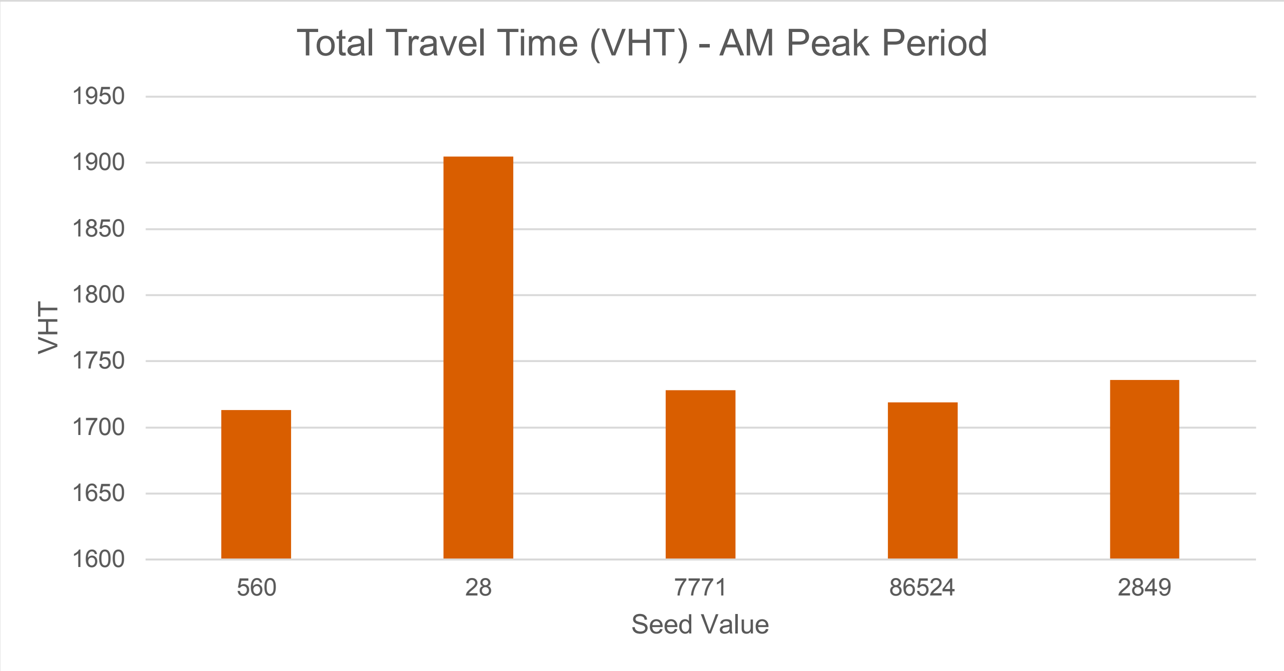
> Car reaction time 1.35 seconds general and 1.60 seconds at traffic lights
> Heavy vehicle reaction time 1.35 seconds general and 1.70 seconds at traffic lights
> Simulation Step 0.45 seconds
> Give-way time factor: 1.00
> Initial safety margin: 3.00 seconds
> Final safety margin: 1.00 seconds.

At merge locations on Tonkin Highway, the Reaction Time Factor was increased to 1.25 in order to account for realistic merge behaviour, and resulting delays, at these locations.

3 Model Stability

The stochasticity of a micro-simulation model can cause instability in the model, which can undermine the reliability of the model to forecast future traffic conditions. Thus, it is important to develop a base model that is stable and has an appropriate degree of accuracy for future options assessment. To determine the stability of a model, a total of 5 seed values and the default time-step value in Aimsun are initially used. The VHT statistics were used as a basis to determine the model stability. It was found that during the AM peak period for seed value 28, the network VHT statistics were substantially higher compared to the other seed values. This was found to be due to the northbound queue length on Tonkin Highway at the intersection of Tonkin Highway / Welshpool Road East extending to the intersection of Tonkin Highway / Kelvin Road. As this was not considered realistic or supported by observed data, the results from this seed value was excluded from the reported results.

Figure 3-1 VHT Statistics for Seed Values for AM Peak Period



The average total travel time is illustrated in **Figure 3-2** and **Figure 3-3**.

Figure 3-2 Average AM Vehicle Hours Travelled

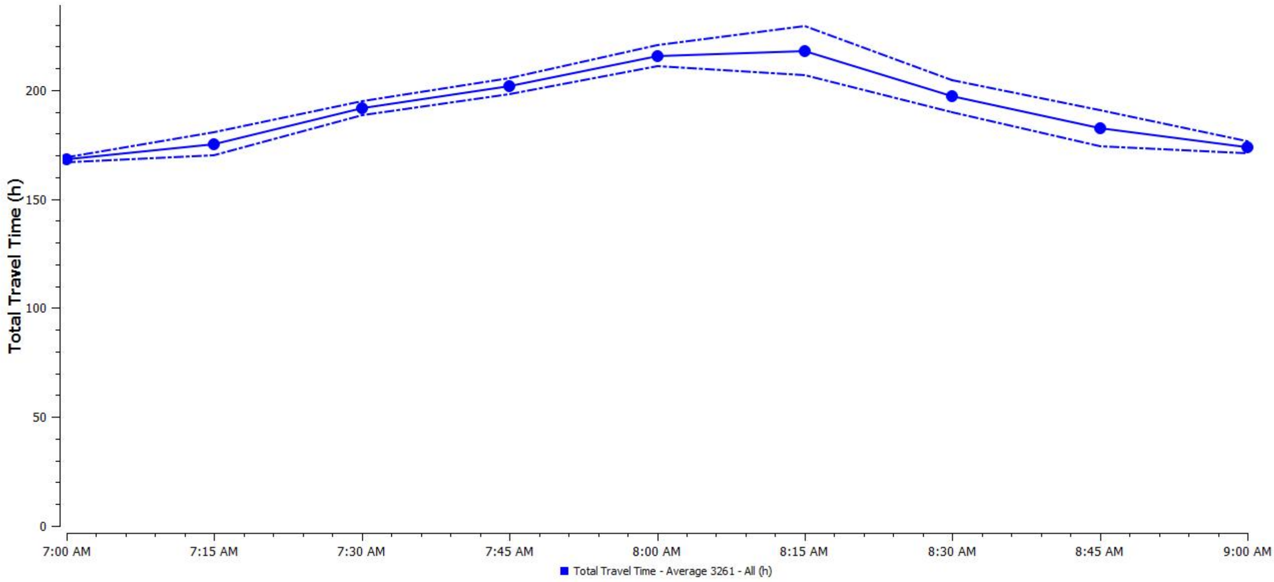
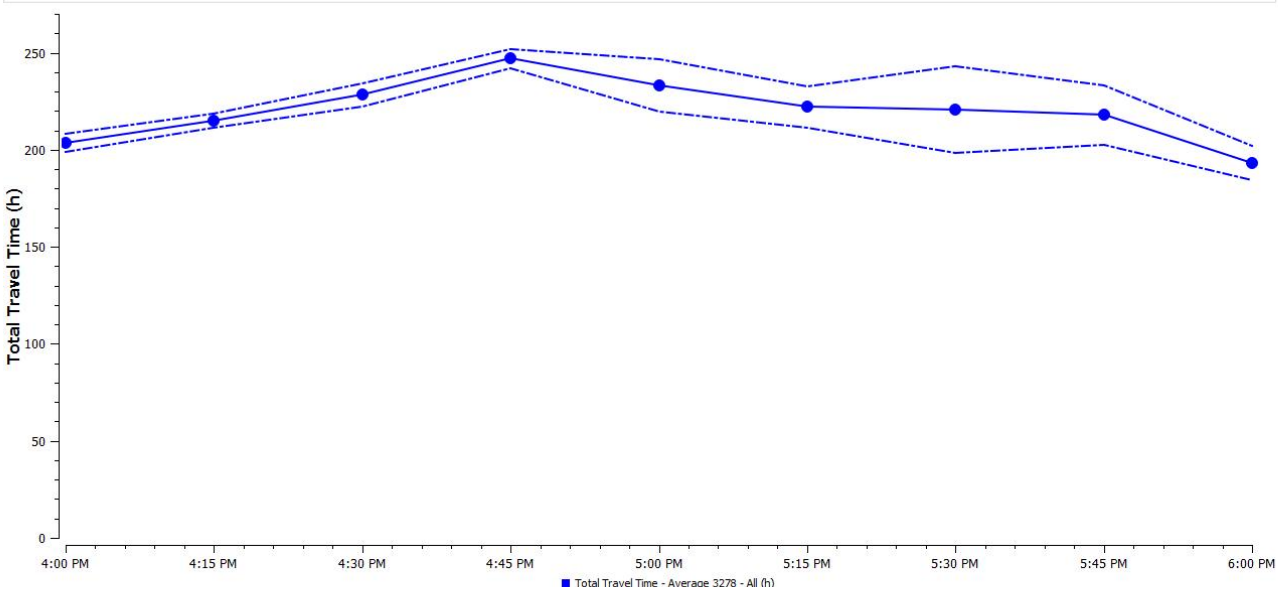


Figure 3-3 Average PM Vehicle Hours Travelled



The resulting model performance is summarised by the total vehicle hours travelled comparisons above. The general network statistics for both periods show a substantial low level of variability in the peak hours of both the AM and PM peaks. Overall, the analysis of the model runs demonstrates the modelled network and output results are stable.

4 Model Calibration and Validation

4.1 Calibration and Validation Criteria

This section sets out the key calibration statistics from the preparation of the base (existing conditions) model. The calibration of a base model is important to ensure a robust base from which to test options and provide statistical comparisons of existing layouts against options.

Calibration for this model has been based on the following:

> Model Convergence: Assessing the relative gap between iterations is a measure of how close the assignment is to the “optimal” equilibrium assignment

> Turn Counts: Comparing observed and modelled turning movements for general traffic over the modelled peak hour periods.

The MKSEA Mesoscopic base model turn counts calibration has been undertaken in two stages:

> Calibration of the static assignment parameters iteratively alongside demand adjustment to ensure that the adjustment is undertaken using valid static assignment routing

> Calibration of the traffic signals, microsimulation and DUE assignment parameters.

For the purpose of this study, the model developed is considered to be a Category 3 model as defined in MRWA Operational Modelling Guidelines (section 2.11.2.1). These types of models are defined to have the following characteristics:

> *Large area networks including multiple long corridors with various routes between origin and destination zones, and use dynamic traffic assignment.*

> *Models in this category are generally used in transport network planning, assessment of traffic management and road schemes.*

4.2 Category 3 Model Calibration and Validation Requirements

> 90% of turn and link flow comparisons with GEH less than 10.

> 80% of turn and link flow comparisons with GEH less than 5.

> Regression of modelled and observed counts to show R^2 and slope greater than 0.9 for each hour.

4.2.1 Base Model Validation Criteria

Validation of the base model was undertaken on the basis of travel time along key routes within the study area. Current guidelines for travel time validation recommend a target of modelled travel times being within 15% or 1 minute of the observed travel times, whichever is larger.

4.2.2 Convergence

The MKSEA model was been developed using the combination of static simulation, dynamic user equilibrium (DUE) assignment and stochastic traffic assignment.

4.3 Calibration Results

The model was calibrated to the criteria listed in **Section 4.1** of this report by comparing the turn flows modelled with observed counts and the GEH statistics.

The GEH (named after its inventor, Geoffrey E. Havers) is a statistic used to determine the measure of fit between observed and modelled traffic flows and is defined as:

$$GEH = \sqrt{\frac{2 * (Observed - Modelled)^2}{(Observed + Modelled)}}$$

A GEH value of five or less is generally considered a good correlation while a GEH value of ten or greater requires further explanation. While not required under the MRWA Operational Modelling Guidelines, the statistics for GEH < 3 has also been included in the tables, with an aim to achieve a minimum of 50% of the turn flow comparisons to have a GEH < 3.

The GEH statistics is summarised by time period and vehicle type from **Table 4-1** to **Table 4-12**, while detailed GEH statistics for each turn count are included in **Appendix B**.

Table 4-1 Summary of GEH Statistics for Weekday 7-8 AM Peak Hour Scenario - Cars

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	89	80%	✓
Number of Turning Counts with GEH < 5	108	96%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-2 Summary of GEH Statistics for Weekday 8-9 AM Peak Hour Scenario - Cars

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	85	76%	✓
Number of Turning Counts with GEH < 5	105	94%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-3 Summary of GEH Statistics for Weekday 7-8 AM Peak Hour Scenario - Trucks

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	108	96%	✓
Number of Turning Counts with GEH < 5	111	99%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-4 Summary of GEH Statistics for Weekday 8-9 AM Peak Hour Scenario - Trucks

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	109	97%	✓
Number of Turning Counts with GEH < 5	112	100%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-5 Summary of GEH Statistics for Weekday 7-8 AM Peak Hour Scenario – Semi-trailer

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	109	97%	✓
Number of Turning Counts with GEH < 5	112	100%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-6 Summary of GEH Statistics for Weekday 8-9 AM Peak Hour Scenario – Semi-trailer

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	109	97%	✓
Number of Turning Counts with GEH < 5	112	100%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-7 Summary of GEH Statistics for Weekday 7-8 AM Peak Hour Scenario – B-double

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	112	100%	✓
Number of Turning Counts with GEH < 5	112	100%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-8 Summary of GEH Statistics for Weekday 8-9 AM Peak Hour Scenario – B-double

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	112	100%	✓
Number of Turning Counts with GEH < 5	112	100%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-9 Summary of GEH Statistics for Weekday 4-5 PM Peak Hour Scenario - Cars

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	93	83%	✓
Number of Turning Counts with GEH < 5	103	92%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-10 Summary of GEH Statistics for Weekday 5-6 PM Peak Hour Scenario - Cars

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	83	74%	✓
Number of Turning Counts with GEH < 5	105	94%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-11 Summary of GEH Statistics for Weekday 4-5 PM Peak Hour Scenario - Trucks

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	108	96%	✓
Number of Turning Counts with GEH < 5	112	100%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-12 Summary of GEH Statistics for Weekday 5-6 PM Peak Hour Scenario - Trucks

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	104	93%	✓
Number of Turning Counts with GEH < 5	112	100%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-13 Summary of GEH Statistics for Weekday 4-5 PM Peak Hour Scenario – Semi-trailer

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	106	95%	✓
Number of Turning Counts with GEH < 5	112	100%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-14 Summary of GEH Statistics for Weekday 5-6 PM Peak Hour Scenario – Semi-trailer

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	112	100%	✓
Number of Turning Counts with GEH < 5	112	100%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-15 Summary of GEH Statistics for Weekday 4-5 PM Peak Hour Scenario – B-double

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	112	100%	✓
Number of Turning Counts with GEH < 5	112	100%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Table 4-16 Summary of GEH Statistics for Weekday 5-6 PM Peak Hour Scenario – B-double

AIMSUN Objects	Count	Percentage	Calibration
Total Counts	112	100%	✓
Number of Turning Counts with GEH < 3	112	100%	✓
Number of Turning Counts with GEH < 5	112	100%	✓
Number of Turning Counts with GEH < 10	112	100%	✓

Figure 4-1 Observed and Modelled Regression Graph for 7-8AM Peak Hour (Cars)

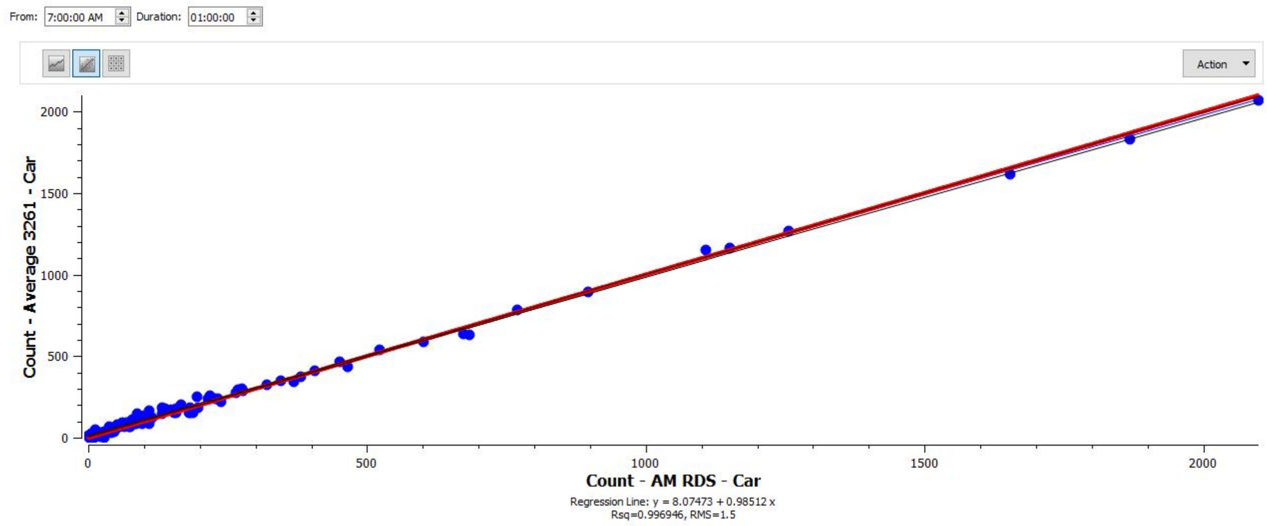


Figure 4-2 Observed and Modelled Regression Graph for 8-9AM Peak Hour (Cars)

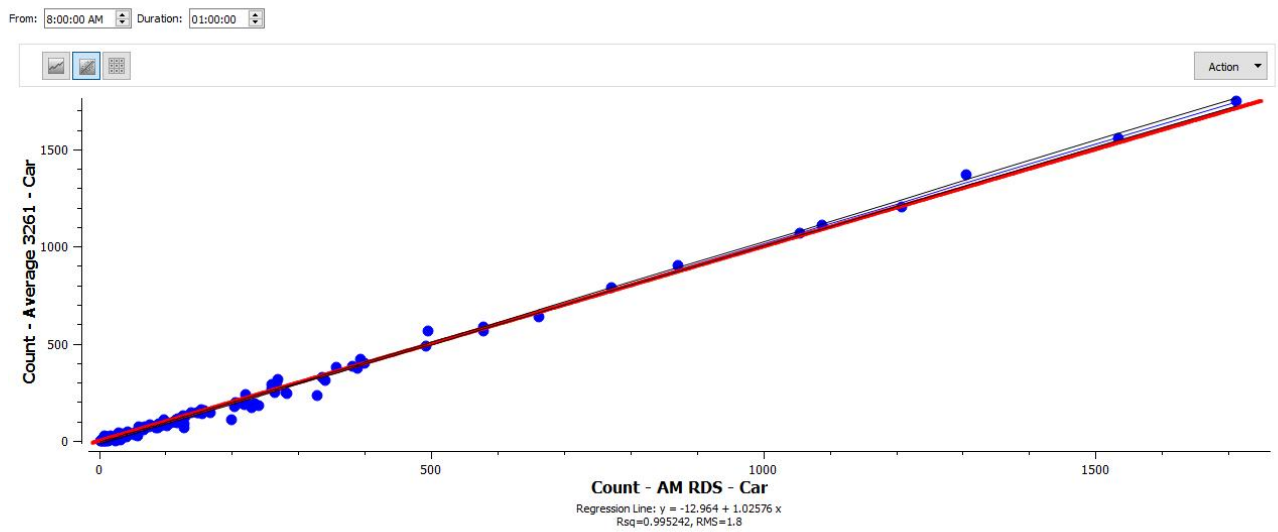


Figure 4-3 Observed and Modelled Regression Graph for 4-5PM Peak Hour (Cars)

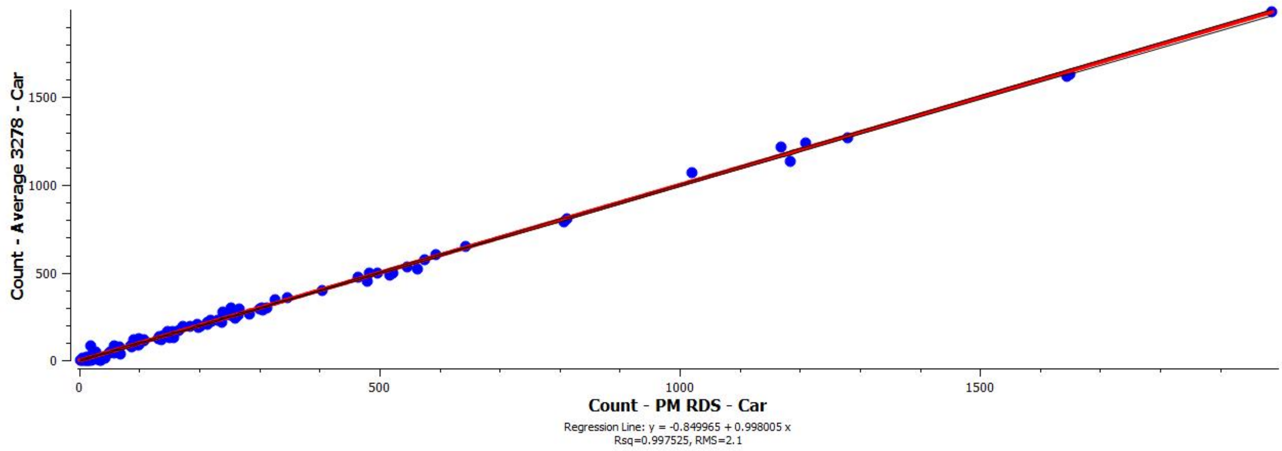
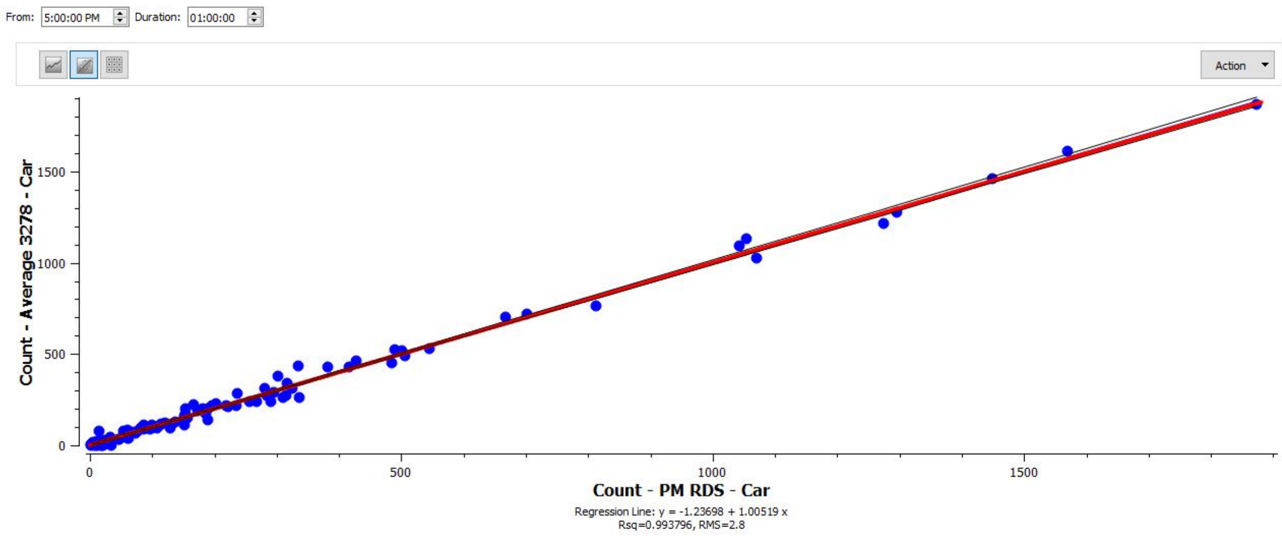


Figure 4-4 Observed and Modelled Regression Graph for 5-6PM Peak Hour (Cars)



4.4 Travel Time Validation

For the purpose of model validation, the MRWA Operational Modelling and Visualisation (OMV) team provided TomTom travel time data for a total of 6 routes along Tonkin Highway and Welshpool Road East, such that the modelled travel times could be compared to the observed travel times. The travel time routes are shown in **Figure 4-5** to **Figure 4-7**.

Figure 4-5 Tonkin Highway Travel Time Routes (Northbound and Southbound)

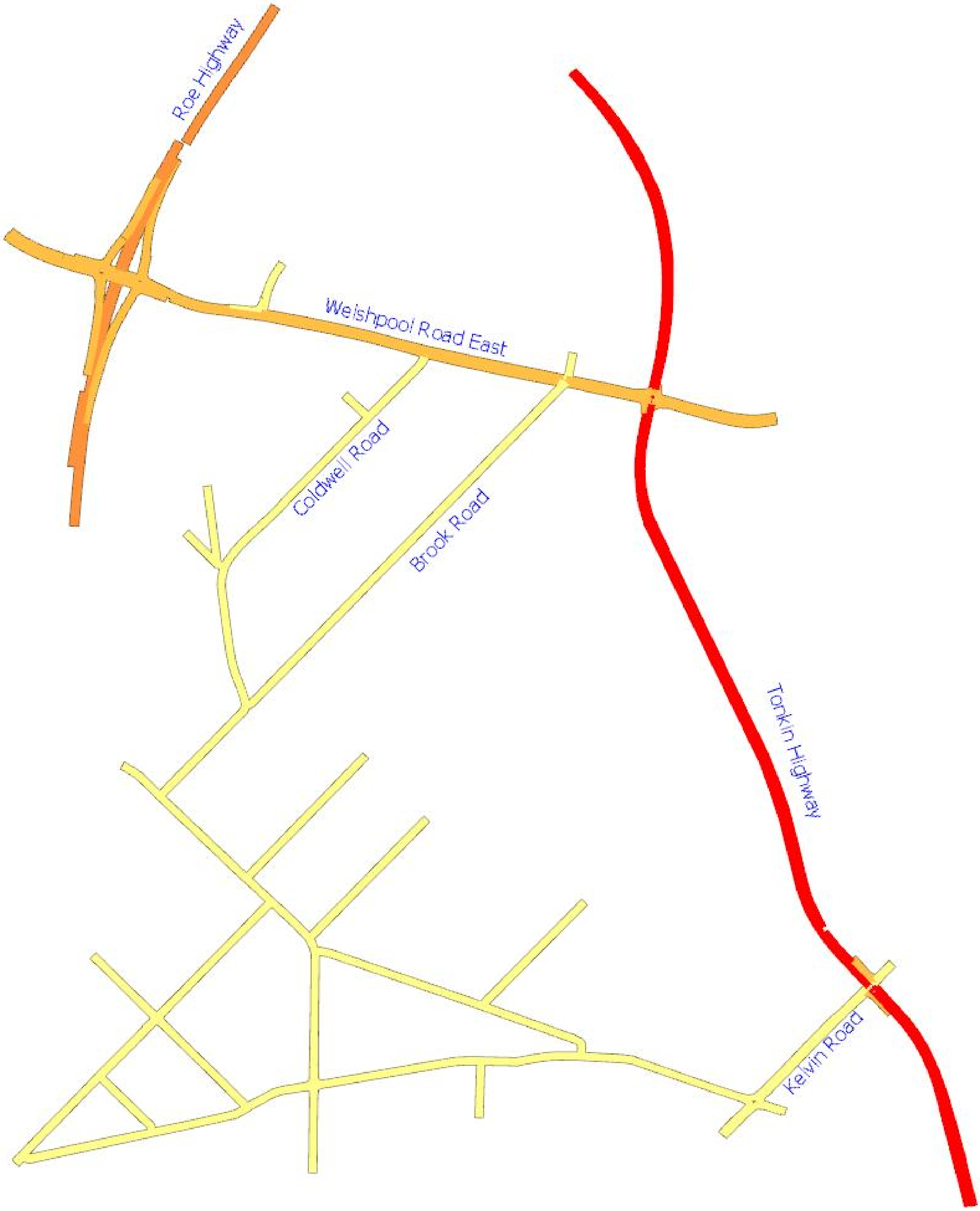


Figure 4-6 Welshpool Road East Travel Time Routes (Eastbound and Westbound)

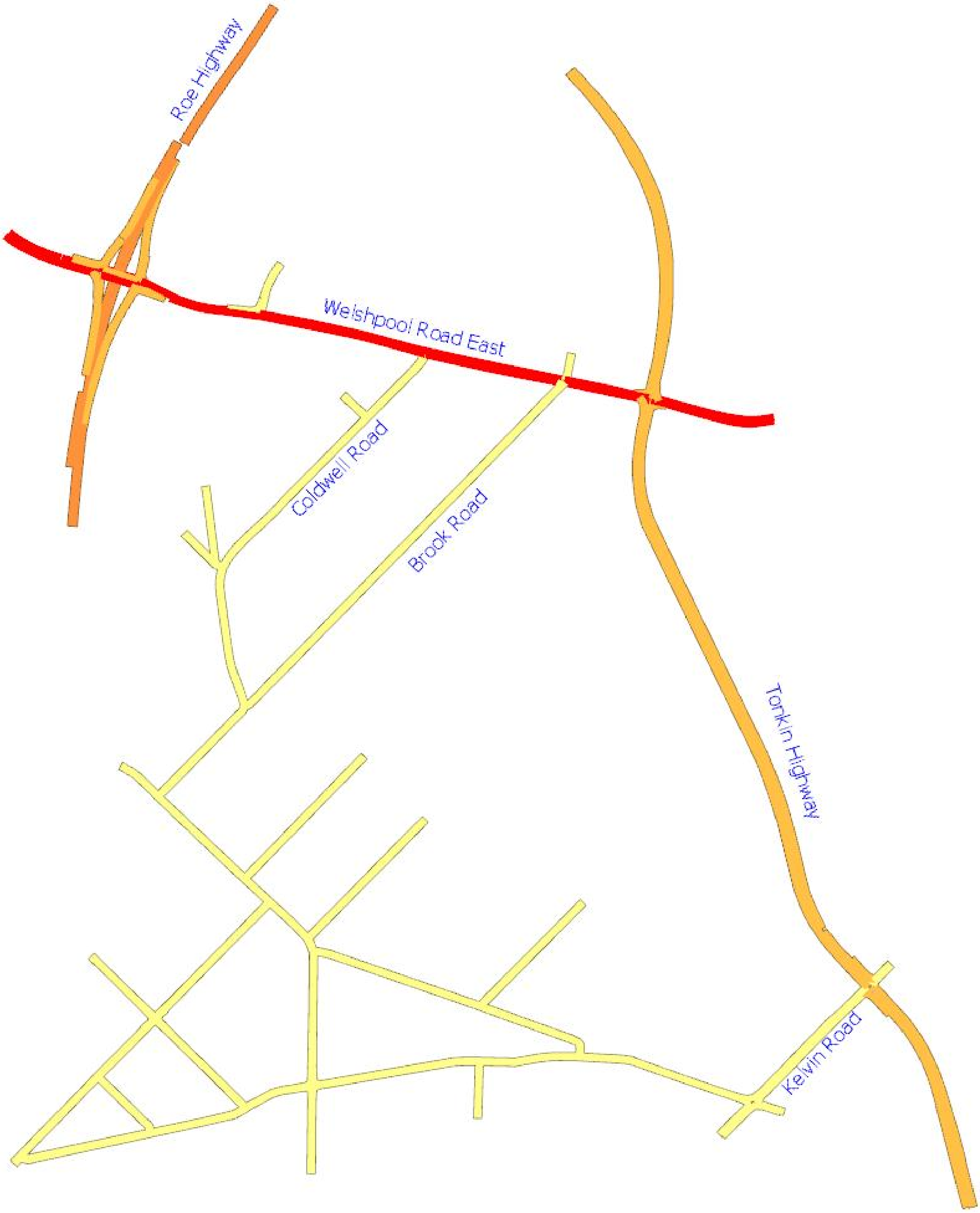


Figure 4-7 Tonkin Highway and Welshpool Road East Travel Time Routes (Northbound/Westbound and Eastbound/Southbound)

The MRWA Operational Modelling Guidelines set the travel time validation criteria for traffic models as the average modelled travel time to be within 15 per cent or one minute (whichever is greater) of average observed travel time for 85% of the travel time route (for a Category 3 model).

Table 4-17 below summarises the overall travel time validation results.

Table 4-17 Hume Highway / Motorway – Base AM Model – Travel Time Validation

Route ID	Route	Travel Direction	Time Period	Observed Average Travel Time (sec)	Modelled Average Travel Time (sec)	Difference (%)	Validation (<15%)
Route 1	Tonkin Highway and Welshpool Road East	Eastbound / Southbound	AM	526	443	19%	X
			PM	549	548	0%	✓
		Northbound / Westbound	AM	520	461	13%	✓
			PM	387	391	1%	✓
Route 2	Tonkin Highway	Southbound	AM	295	287	3%	✓
			PM	330	343	4%	✓
		Northbound	AM	326	344	5%	✓
			PM	235	234	0%	✓
Route 3	Welshpool Road East	Westbound	AM	381	334	14%	✓
			PM	326	412	21%	X
		Eastbound	AM	276	270	2%	✓
			PM	288	323	11%	✓

The travel time comparison shows that during both the AM and PM peak periods, the observed and modelled travel times for the critical directional routes are within acceptable thresholds. While the Tonkin Highway (southbound) and Welshpool Roast East (eastbound) route is outside of the thresholds during the AM peak period and the Welshpool Road East route is outside of the threshold during the PM peak periods, these route are not considered to be a critical route during their respective peak periods and therefore not considered to warrant further investigation.

5 Conclusions

The Base Weekday AM and PM models conform to Roads and Maritime Services Traffic Modelling Guidelines for traffic modelling. The modelling results show that the models have:

> 100% of the turning counts had a GEH of less than 10

> Travel time results for critical routes within 15% of average observed travel time.

It is concluded that the two peak base models appropriately reflect existing year conditions and provide a suitable basis for the development of present and long term infrastructure upgrades and subsequent performance assessment for the respective future year horizon.

The model calibration and validation statistics are consistent with the minimum requirements as set out in the MRWA *Operational Modelling Guidelines* and is therefore considered fit-for-purpose.

APPENDIX

A

DETAILED GEH TABLES

Car 7-8 AM

Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	83	86	3	3.61446	0.32636
			Left	68	77	9	13.2353	1.057
		South	Right/Through	320	346	26	8.125	1.42479
			Left	85	87	2	2.35294	0.21567
		East	Right/Through	73	51	-22	-30.137	2.794
			Left	13	14	1	7.69231	0.27217
		North	Right/Through	523	516	-7	-1.33843	0.30712
			Left	76	79	3	3.94737	0.34078
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	227	233	6	2.64317	0.39563
			Right	28	19	-9	-32.1429	1.85656
		North	Right	2	0	-2	-100	2
			Left	21	25	4	19.0476	0.83406
		West	Through	148	139	-9	-6.08108	0.75131
			Left	1	0	-1	-100	1.41421
Intersection 3	Bickley Rd & Belmont Rd	South	Right	7	9	2	28.5714	0.70711
			Through	180	147	-33	-18.3333	2.5808
		East	Left	11	6	-5	-45.4545	1.71499
			Right	27	34	7	25.9259	1.2675
		North	Through	77	74	-3	-3.8961	0.34526
			Left	77	59	-18	-23.3766	2.18282
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	37	74	37	100	4.96655
			Right/Through	268	288	20	7.46269	1.19952
		North	Right/Through	75	88	13	17.3333	1.44001
			Left	12	14	2	16.6667	0.5547
		West	Right/Through	195	208	13	6.66667	0.91581
			Left	8	19	11	137.5	2.99382
		South	Right/Through	153	142	-11	-7.18954	0.90573
			Left	182	182	0	0	0
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	14	14	inf	5.2915
			Through	167	211	44	26.3473	3.20053
		North	Left	2	6	4	200	2
			Right	5	0	-5	-100	3.16228
		West	Through	110	148	38	34.5455	3.34571
			Left	3	0	-3	-100	2.44949
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	219	226	7	3.19635	0.46928
			Left	78	98	20	25.641	2.13201
		South	Left	5	23	18	360	4.8107
			Right/Through	264	247	-17	-6.43939	1.06354
		East	Right/Through	74	110	36	48.6486	3.75326
			Left	2	8	6	300	2.68328
		North	Right/Through	138	149	11	7.97101	0.91826
			Left	22	11	-11	-50	2.70801

Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	215	253	38	17.6744	2.48414
			Right	2	0	-2	-100	2
		East	Through	100	121	21	21	1.99774
			Left	6	0	-6	-100	3.4641
		West	Right	132	172	40	30.303	3.24443
			Through	87	145	58	66.6667	5.38516
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	48	56	8	16.6667	1.1094
			Right	12	34	22	183.333	4.58732
		North	Right	54	85	31	57.4074	3.71851
			Through	85	92	7	8.23529	0.74409
		South	Left	22	31	9	40.9091	1.74831
			Through	183	163	-20	-10.929	1.52057
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	51	46	-5	-9.80392	0.71796
			Through	2099	2067	-32	-1.52454	0.70114
			Left	197	194	-3	-1.52284	0.21456
		East	Right	10	13	3	30	0.88465
			Through	132	124	-8	-6.06061	0.70711
			Left	86	84	-2	-2.32558	0.21693
		North	Right	278	281	3	1.07914	0.17945
			Through	769	803	34	4.42133	1.21274
			Left	21	4	-17	-80.9524	4.80833
		West	Right	52	75	23	44.2308	2.8863
			Through	61	92	31	50.8197	3.5443
			Left	276	296	20	7.24638	1.18262
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	83	82	-1	-1.20482	0.1101
			Through	1654	1685	31	1.87424	0.7587
			Left	683	627	-56	-8.19912	2.1881
		East	Right	238	216	-22	-9.2437	1.46019
			Through	602	581	-21	-3.48837	0.86346
			Left	64	86	22	34.375	2.54034
		North	Right	26	17	-9	-34.6154	1.94099
			Through	897	888	-9	-1.00334	0.30126
			Left	114	118	4	3.50877	0.37139
		West	Right	111	105	-6	-5.40541	0.57735
			Through	218	243	25	11.4679	1.64666
			Left	28	39	11	39.2857	1.90051
Intersection 11	Orrong Rd & Roe Hwy	East	Through	1868	1841	-27	-1.4454	0.62698
			Right	17	21	4	23.5294	0.91766
		South	Left	672	647	-25	-3.72024	0.97349
			Right	83	82	-1	-1.20482	0.1101
		West	Left	158	157	-1	-0.632911	0.07968
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	157	182	25	15.9236	1.92024
			Through	451	465	14	3.10421	0.65418
		North	Left	23	24	1	4.34783	0.20628
			Right	465	435	-30	-6.45161	1.41421
		East	Left	233	248	15	6.43777	0.96724

Intersection 13	Welshpool Rd E & Hale Rd	West	Left	82	114	32	39.0244	3.23249
			Through	381	375	-6	-1.5748	0.30861
		East	Through	1256	1310	54	4.29936	1.50758
			Right	41	58	17	41.4634	2.41627
		North	Right	406	425	19	4.6798	0.93211
			Left	55	71	16	29.0909	2.01581
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	5	5	0	0	0
			Through	1151	1187	36	3.12772	1.05292
		West	Right	97	96	-1	-1.03093	0.1018
			Through	345	343	-2	-0.57971	0.10783
		South	Right	9	2	-7	-77.7778	2.98481
			Left	187	170	-17	-9.09091	1.27242
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	9	1	-8	-88.8889	3.57771
			Right	46	37	-9	-19.5652	1.39707
			Through	10	0	-10	-100	4.47214
		East	Through	1108	1133	25	2.25632	0.74685
			Left	109	80	-29	-26.6055	2.9832
			Right	11	0	-11	-100	4.69042
		North	Right	21	32	11	52.381	2.13683
			Through	29	0	-29	-100	7.61577
			Left	41	30	-11	-26.8293	1.8462
		West	Right	5	0	-5	-100	3.16228
			Through	368	333	-35	-9.51087	1.86949
			Left	2	11	9	450	3.53009

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Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	119	109	-10	-8.40336	0.936586
			Left	118	88	-30	-25.4237	2.95599
		South	Right/Through	336	353	17	5.05952	0.915913
			Left	76	90	14	18.4211	1.5367
		East	Right/Through	89	49	-40	-44.9438	4.81543
			Left	14	13	-1	-7.14286	0.272166
		North	Right/Through	578	572	-6	-1.03806	0.250217
			Left	69	79	10	14.4928	1.16248
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	264	272	8	3.0303	0.488678
			Right	29	17	-12	-41.3793	2.50217
		North	Right	4	0	-4	-100	2.82843
			Left	31	31	0	0	0
		West	Through	204	168	-36	-17.6471	2.63965
			Left	5	0	-5	-100	3.16228
Intersection 3	Bickley Rd & Belmont Rd	South	Right	8	8	0	0	0
			Through	168	159	-9	-5.35714	0.703856
		East	Left	13	5	-8	-61.5385	2.66667

			Right	34	20	-14	-41.1765	2.6943
		North	Through	128	108	-20	-15.625	1.84115
			Left	128	69	-59	-46.0938	5.94475
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	60	79	19	31.6667	2.27909
			Right/Through	341	320	-21	-6.15836	1.15514
		North	Right/Through	199	120	-79	-39.6985	6.25528
			Left	32	10	-22	-68.75	4.80079
		West	Right/Through	281	228	-53	-18.8612	3.32225
			Left	9	24	15	166.667	3.69274
		South	Right/Through	150	149	-1	-0.666667	0.0817861
			Left	219	181	-38	-17.3516	2.68701
Intersection 5	Kenwick Rd & Park Rd	East	Right	7	10	3	42.8571	1.02899
			Through	220	207	-13	-5.90909	0.889702
		North	Left	4	0	-4	-100	2.82843
			Right	5	0	-5	-100	3.16228
		West	Through	229	155	-74	-32.3144	5.34049
			Left	11	0	-11	-100	4.69042
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	329	228	-101	-30.6991	6.05214
			Left	98	105	7	7.14286	0.694808
		South	Left	59	25	-34	-57.6271	5.24631
			Right/Through	260	269	9	3.46154	0.553388
		East	Right/Through	108	77	-31	-28.7037	3.22323
			Left	32	6	-26	-81.25	5.96481
		North	Right/Through	240	146	-94	-39.1667	6.76627
			Left	33	12	-21	-63.6364	4.42719
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	283	251	-32	-11.3074	1.95837
			Right	2	0	-2	-100	2
		East	Through	155	138	-17	-10.9677	1.40453
			Left	7	0	-7	-100	3.74166
		West	Right	235	174	-61	-25.9574	4.26563
			Through	138	139	1	0.724638	0.0849719
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	60	51	-9	-15	1.20808
			Right	29	33	4	13.7931	0.718421
		North	Right	93	63	-30	-32.2581	3.39683
			Through	116	140	24	20.6897	2.12132
		South	Left	42	21	-21	-50	3.74166
			Through	159	159	0	0	0
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	75	68	-7	-9.33333	0.827837
			Through	1535	1591	56	3.64821	1.41647
			Left	205	220	15	7.31707	1.02899
		East	Right	11	16	5	45.4545	1.36083
			Through	154	158	4	2.5974	0.320256
			Left	101	112	11	10.8911	1.0659
		North	Right	267	283	16	5.99251	0.964836
			Through	772	798	26	3.36788	0.92798
			Left	16	4	-12	-75	3.79473

		West	Right	85	88	3	3.52941	0.322562
			Through	88	110	22	25	2.21108
			Left	269	293	24	8.92193	1.43172
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	96	91	-5	-5.20833	0.517088
			Through	1306	1380	74	5.66616	2.01927
			Left	495	546	51	10.303	2.23542
		East	Right	220	234	14	6.36364	0.929213
			Through	579	575	-4	-0.690846	0.166522
			Left	102	76	-26	-25.4902	2.75599
		North	Right	34	21	-13	-38.2353	2.479
			Through	872	905	33	3.7844	1.1071
			Left	127	136	9	7.08661	0.784837
		West	Right	129	124	-5	-3.87597	0.444554
			Through	260	286	26	10	1.57359
			Left	43	36	-7	-16.2791	1.11378
Intersection 11	Orrong Rd & Roe Hwy	East	Through	1712	1805	93	5.43224	2.21775
			Right	17	29	12	70.5882	2.50217
		South	Left	662	683	21	3.17221	0.809791
			Right	96	91	-5	-5.20833	0.517088
		West	Left	158	170	12	7.59494	0.937043
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	216	207	-9	-4.16667	0.618853
			Through	492	477	-15	-3.04878	0.681466
		North	Left	36	29	-7	-19.4444	1.22788
			Right	357	380	23	6.44258	1.19814
		East	Left	264	240	-24	-9.09091	1.51186
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	123	100	-23	-18.6992	2.17816
			Through	393	408	15	3.81679	0.749532
		East	Through	1208	1205	-3	-0.248344	0.0863689
			Right	68	53	-15	-22.0588	1.92847
		North	Right	400	427	27	6.75	1.32778
			Left	86	67	-19	-22.093	2.17232
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	8	8	0	0	0
			Through	1089	1096	7	0.642792	0.211781
		West	Right	113	109	-4	-3.53982	0.379663
			Through	381	369	-12	-3.14961	0.619677
		South	Right	5	0	-5	-100	3.16228
			Left	148	166	18	12.1622	1.43656
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	9	2	-7	-77.7778	2.98481
			Right	54	32	-22	-40.7407	3.35497
			Through	10	0	-10	-100	4.47214
		East	Through	1055	1067	12	1.13744	0.368403
			Left	90	89	-1	-1.11111	0.105703
			Right	25	0	-25	-100	7.07107
		North	Right	29	32	3	10.3448	0.543214
			Through	15	0	-15	-100	5.47723
			Left	54	43	-11	-20.3704	1.57951

		West	Right	10	4	-6	-60	2.26779
			Through	389	362	-27	-6.94087	1.39335
			Left	11	8	-3	-27.2727	0.973329

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Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	141	129	-12	-8.51064	1.0328
			Left	260	224	-36	-13.8462	2.31417
		South	Right/Through	564	530	-34	-6.02837	1.45374
			Left	58	90	32	55.1724	3.71992
		East	Right/Through	158	134	-24	-15.1899	1.98625
			Left	20	0	-20	-100	6.32456
		North	Right/Through	465	429	-36	-7.74194	1.70274
			Left	24	14	-10	-41.6667	2.29416
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	260	255	-5	-1.92308	0.311588
			Right	23	11	-12	-52.1739	2.91043
		North	Right	2	0	-2	-100	2
			Left	40	34	-6	-15	0.986394
		West	Through	347	320	-27	-7.78098	1.47848
			Left	2	0	-2	-100	2
Intersection 3	Bickley Rd & Belmont Rd	South	Right	11	4	-7	-63.6364	2.55604
			Through	137	119	-18	-13.1387	1.59099
		East	Left	9	1	-8	-88.8889	3.57771
			Right	23	12	-11	-47.8261	2.6295
		North	Through	305	279	-26	-8.52459	1.52153
			Left	43	18	-25	-58.1395	4.52679
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	66	99	33	50	3.63318
			Right/Through	238	255	17	7.14286	1.08278
		North	Right/Through	251	241	-10	-3.98406	0.637577
			Left	49	37	-12	-24.4898	1.82998
		West	Right/Through	594	596	2	0.3367	0.081992
			Left	21	19	-2	-9.52381	0.447214
		South	Right/Through	184	217	33	17.9348	2.33054
			Left	134	133	-1	-0.746269	0.0865485
Intersection 5	Kenwick Rd & Park Rd	East	Right	5	19	14	280	4.04145
			Through	201	199	-2	-0.995025	0.141421
		North	Left	4	12	8	200	2.82843
			Right	6	0	-6	-100	3.4641
		West	Through	239	275	36	15.0628	2.24562
			Left	9	0	-9	-100	4.24264
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	64	87	23	35.9375	2.647
			Left	105	146	41	39.0476	3.65984
		South	Left	13	23	10	76.9231	2.35702
			Right/Through	214	210	-4	-1.86916	0.274721
		East	Right/Through	99	103	4	4.0404	0.398015

			Left	5	0	-5	-100	3.16228
		North	Right/Through	517	470	-47	-9.09091	2.1157
			Left	58	60	2	3.44828	0.260378
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	230	232	2	0.869565	0.13159
			Right	10	0	-10	-100	4.47214
		East	Through	147	138	-9	-6.12245	0.753937
			Left	16	0	-16	-100	5.65685
		West	Right	326	317	-9	-2.76074	0.50194
			Through	155	158	3	1.93548	0.239808
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	88	77	-11	-12.5	1.21106
			Right	29	8	-21	-72.4138	4.8824
		North	Right	94	93	-1	-1.06383	0.103418
			Through	312	282	-30	-9.61538	1.74078
		South	Left	13	11	-2	-15.3846	0.57735
			Through	150	136	-14	-9.33333	1.17074
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	107	99	-8	-7.47664	0.788263
			Through	1168	1211	43	3.68151	1.24677
			Left	97	74	-23	-23.7113	2.4874
		East	Right	36	0	-36	-100	8.48528
			Through	98	107	9	9.18367	0.888957
			Left	86	83	-3	-3.48837	0.326357
		North	Right	253	266	13	5.13834	0.807002
			Through	1986	2013	27	1.35952	0.603814
			Left	13	1	-12	-92.3077	4.53557
		West	Right	283	238	-45	-15.9011	2.7881
			Through	199	210	11	5.52764	0.769212
			Left	479	457	-22	-4.5929	1.01695
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	304	312	8	2.63158	0.455842
			Through	1280	1285	5	0.390625	0.139618
			Left	300	276	-24	-8	1.41421
		East	Right	132	139	7	5.30303	0.601351
			Through	265	262	-3	-1.13208	0.184812
			Left	172	196	24	13.9535	1.7693
		North	Right	17	12	-5	-29.4118	1.31306
			Through	1649	1635	-14	-0.848999	0.345495
			Left	196	233	37	18.8776	2.52632
		West	Right	483	498	15	3.10559	0.677285
			Through	644	690	46	7.14286	1.78113
			Left	28	45	17	60.7143	2.81386
Intersection 11	Orrong Rd & Roe Hwy	East	Through	812	827	15	1.84729	0.523982
			Right	20	26	6	30	1.25109
		South	Left	218	222	4	1.83486	0.26968
			Right	304	312	8	2.63158	0.455842
		West	Left	405	421	16	3.95062	0.787309
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	807	794	-13	-1.6109	0.459476
			Through	1645	1601	-44	-2.67477	1.09218

		North	Left	107	118	11	10.2804	1.03709
			Right	213	212	-1	-0.469484	0.0685994
		East	Left	166	159	-7	-4.21687	0.549125
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	497	494	-3	-0.603622	0.134772
			Through	1209	1230	21	1.73697	0.601351
		East	Through	576	570	-6	-1.04167	0.250654
			Right	99	93	-6	-6.06061	0.612372
		North	Right	220	237	17	7.72727	1.12462
			Left	91	157	66	72.5275	5.92697
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	11	4	-7	-63.6364	2.55604
			Through	546	505	-41	-7.50916	1.78854
		West	Right	267	301	34	12.7341	2.01753
			Through	1021	1102	81	7.9334	2.48614
		South	Right	19	13	-6	-31.5789	1.5
			Left	136	153	17	12.5	1.41421
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	30	5	-25	-83.3333	5.97614
			Right	51	60	9	17.6471	1.20808
			Through	17	0	-17	-100	5.83095
		East	Through	523	490	-33	-6.30975	1.4663
			Left	68	40	-28	-41.1765	3.81032
			Right	26	17	-9	-34.6154	1.94099
		North	Right	6	16	10	166.667	3.01511
			Through	14	0	-14	-100	5.2915
			Left	19	15	-4	-21.0526	0.970143
		West	Right	12	0	-12	-100	4.89898
			Through	1184	1098	-86	-7.26351	2.54598
			Left	34	0	-34	-100	8.24621

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Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	114	127	13	11.4035	1.18427
			Left	196	212	16	8.16327	1.12022
		South	Right/Through	381	447	66	17.3228	3.24372
			Left	69	69	0	0	0
		East	Right/Through	86	111	25	29.0698	2.51896
			Left	12	0	-12	-100	4.89898
		North	Right/Through	335	352	17	5.07463	0.917245
			Left	21	13	-8	-38.0952	1.94029
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	167	190	23	13.7725	1.72151
			Right	26	15	-11	-42.3077	2.42949
		North	Right	1	0	-1	-100	1.41421
			Left	21	39	18	85.7143	3.28634
		West	Through	280	301	21	7.5	1.2321

			Left	1	0	-1	-100	1.41421
Intersection 3	Bickley Rd & Belmont Rd	South	Right	6	4	-2	-33.3333	0.894427
			Through	130	109	-21	-16.1538	1.92104
		East	Left	11	2	-9	-81.8182	3.53009
			Right	19	14	-5	-26.3158	1.23091
		North	Through	310	280	-30	-9.67742	1.74667
			Left	26	31	5	19.2308	0.936586
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	60	69	9	15	1.12063
			Right/Through	153	194	41	26.7974	3.11268
		North	Right/Through	267	239	-28	-10.4869	1.76034
			Left	47	46	-1	-2.12766	0.146647
		West	Right/Through	501	536	35	6.98603	1.53707
			Left	13	23	10	76.9231	2.35702
		South	Right/Through	186	180	-6	-3.22581	0.443533
			Left	137	127	-10	-7.29927	0.870388
Intersection 5	Kenwick Rd & Park Rd	East	Right	3	20	17	566.667	5.01303
			Through	153	172	19	12.4183	1.49048
		North	Left	6	3	-3	-50	1.41421
			Right	10	0	-10	-100	4.47214
		West	Through	256	250	-6	-2.34375	0.377217
			Left	2	0	-2	-100	2
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	57	71	14	24.5614	1.75
			Left	108	132	24	22.2222	2.19089
		South	Left	12	19	7	58.3333	1.778
			Right/Through	189	166	-23	-12.1693	1.72635
		East	Right/Through	152	85	-67	-44.0789	6.15482
			Left	2	0	-2	-100	2
		North	Right/Through	416	418	2	0.480769	0.0979404
			Left	60	59	-1	-1.66667	0.129641
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	181	188	7	3.8674	0.515347
			Right	2	0	-2	-100	2
		East	Through	189	131	-58	-30.6878	4.5853
			Left	17	0	-17	-100	5.83095
		West	Right	325	273	-52	-16	3.00724
			Through	156	142	-14	-8.97436	1.14692
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	74	63	-11	-14.8649	1.32907
			Right	26	16	-10	-38.4615	2.18218
		North	Right	129	75	-54	-41.8605	5.3468
			Through	315	301	-14	-4.44444	0.797724
		South	Left	22	9	-13	-59.0909	3.302
			Through	131	121	-10	-7.63359	0.890871
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	99	111	12	12.1212	1.17108
			Through	1071	1111	40	3.73483	1.21101
			Left	53	74	21	39.6226	2.63531
		East	Right	12	0	-12	-100	4.89898
			Through	82	78	-4	-4.87805	0.447214

			Left	76	70	-6	-7.89474	0.702247
		North	Right	237	220	-17	-7.173	1.12462
			Through	1874	1854	-20	-1.06724	0.463241
			Left	10	3	-7	-70	2.74563
		West	Right	203	218	15	7.38916	1.03387
			Through	151	166	15	9.93377	1.19145
			Left	301	395	94	31.2292	5.03893
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	296	306	10	3.37838	0.57639
			Through	1042	1098	56	5.37428	1.71197
			Left	284	301	17	5.98592	0.993999
		East	Right	121	124	3	2.47934	0.271052
			Through	291	259	-32	-10.9966	1.92967
			Left	173	160	-13	-7.51445	1.00748
		North	Right	24	21	-3	-12.5	0.632456
			Through	1449	1401	-48	-3.31263	1.27155
			Left	218	178	-40	-18.3486	2.84268
		West	Right	490	497	7	1.42857	0.315104
			Through	668	688	20	2.99401	0.768095
			Left	32	51	19	59.375	2.94937
Intersection 11	Orrong Rd & Roe Hwy	East	Through	812	789	-23	-2.83251	0.812919
			Right	19	20	1	5.26316	0.226455
		South	Left	235	237	2	0.851064	0.130189
			Right	296	306	10	3.37838	0.57639
		West	Left	316	343	27	8.5443	1.48743
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	701	718	17	2.42511	0.638223
			Through	1570	1686	116	7.38854	2.87495
		North	Left	112	129	17	15.1786	1.54866
			Right	187	200	13	6.95187	0.934551
		East	Left	151	136	-15	-9.93377	1.25218
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	484	513	29	5.99174	1.29887
			Through	1296	1324	28	2.16049	0.773611
		East	Through	545	543	-2	-0.366972	0.0857493
			Right	87	84	-3	-3.44828	0.324443
		North	Right	222	218	-4	-1.8018	0.26968
			Left	100	111	11	11	1.07094
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	7	2	-5	-71.4286	2.35702
			Through	505	519	14	2.77228	0.618718
		West	Right	336	297	-39	-11.6071	2.19219
			Through	1054	1124	70	6.64137	2.12121
		South	Right	15	25	10	66.6667	2.23607
			Left	121	113	-8	-6.61157	0.7396
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	19	3	-16	-84.2105	4.82418
			Right	62	59	-3	-4.83871	0.385695
			Through	21	0	-21	-100	6.48074
		East	Through	427	497	70	16.3934	3.25669
			Left	46	46	0	0	0

			Right	26	29	3	11.5385	0.572078
		North	Right	4	18	14	350	4.22116
			Through	20	0	-20	-100	6.32456
			Left	23	15	-8	-34.7826	1.83533
		West	Right	12	0	-12	-100	4.89898
			Through	1274	1169	-105	-8.24176	3.00429
			Left	35	0	-35	-100	8.3666

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Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	12	5	-7	-58.3333	2.40098
			Left	12	11	-1	-8.33333	0.294884
		South	Right/Through	51	60	9	17.6471	1.20808
			Left	5	20	15	300	4.24264
		East	Right/Through	14	16	2	14.2857	0.516398
			Left	14	3	-11	-78.5714	3.77297
		North	Right/Through	39	61	22	56.4103	3.11127
			Left	7	7	0	0	0
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	23	31	8	34.7826	1.5396
			Right	3	5	2	66.6667	1
		North	Right	0	0	0	0	0
			Left	6	1	-5	-83.3333	2.67261
		West	Through	15	16	1	6.66667	0.254
			Left	1	0	-1	-100	1.41421
Intersection 3	Bickley Rd & Belmont Rd	South	Right	0	0	0	0	0
			Through	19	20	1	5.26316	0.226455
		East	Left	2	3	1	50	0.632456
			Right	2	4	2	100	1.1547
		North	Through	17	19	2	11.7647	0.471405
			Left	17	1	-16	-94.1176	5.33333
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	3	13	10	333.333	3.53553
			Right/Through	25	31	6	24	1.13389
		North	Right/Through	11	21	10	90.9091	2.5
			Left	6	3	-3	-50	1.41421
		West	Right/Through	21	11	-10	-47.619	2.5
			Left	1	4	3	300	1.89737
		South	Right/Through	18	18	0	0	0
			Left	12	11	-1	-8.33333	0.294884
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	19	19	0	0	0
		North	Left	0	0	0	0	0
			Right	1	0	-1	-100	1.41421
		West	Through	16	10	-6	-37.5	1.6641
			Left	0	0	0	0	0
		West	Right/Through	15	5	-10	-66.6667	3.16228

Intersection 6	Brixton St & Wanaping Rd		Left	6	11	5	83.3333	1.71499
		South	Left	0	3	3	inf	2.44949
			Right/Through	15	26	11	73.3333	2.42949
		East	Right/Through	4	5	1	25	0.471405
			Left	0	0	0	0	0
		North	Right/Through	12	10	-2	-16.6667	0.603023
			Left	1	0	-1	-100	1.41421
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	18	22	4	22.2222	0.894427
			Right	2	0	-2	-100	2
		East	Through	0	13	13	inf	5.09902
			Left	0	0	0	0	0
		West	Right	14	15	1	7.14286	0.262613
			Through	6	6	0	0	0
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	2	0	-2	-100	2
			Right	1	0	-1	-100	1.41421
		North	Right	3	5	2	66.6667	1
			Through	14	17	3	21.4286	0.762001
		South	Left	1	0	-1	-100	1.41421
			Through	20	20	0	0	0
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	1	11	10	1000	4.08248
			Through	101	84	-17	-16.8317	1.76758
			Left	22	22	0	0	0
		East	Right	3	6	3	100	1.41421
			Through	10	11	1	10	0.308607
			Left	5	9	4	80	1.51186
		North	Right	27	35	8	29.6296	1.43684
			Through	89	83	-6	-6.74157	0.646997
			Left	6	0	-6	-100	3.4641
		West	Right	16	17	1	6.25	0.246183
			Through	5	8	3	60	1.1767
			Left	55	62	7	12.7273	0.915209
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	2	12	10	500	3.77964
			Through	97	92	-5	-5.15464	0.514344
			Left	36	41	5	13.8889	0.805823
		East	Right	9	10	1	11.1111	0.324443
			Through	22	17	-5	-22.7273	1.13228
			Left	4	11	7	175	2.55604
		North	Right	2	4	2	100	1.1547
			Through	99	87	-12	-12.1212	1.24434
			Left	13	13	0	0	0
		West	Right	16	21	5	31.25	1.16248
			Through	12	26	14	116.667	3.21182
			Left	3	3	0	0	0
Intersection 11	Orrong Rd & Roe Hwy	East	Through	84	94	10	11.9048	1.06
			Right	6	11	5	83.3333	1.71499
		South	Left	37	39	2	5.40541	0.324443

			Right	2	12	10	500	3.77964
		West	Left	31	43	12	38.7097	1.97279
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	62	80	18	29.0323	2.13621
			Through	47	70	23	48.9362	3.00711
		North	Left	4	14	10	250	3.33333
			Right	25	29	4	16	0.7698
		East	Left	9	12	3	33.3333	0.92582
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	9	16	7	77.7778	1.9799
			Through	42	68	26	61.9048	3.50584
		East	Through	59	68	9	15.2542	1.12942
			Right	0	7	7	inf	3.74166
		North	Right	15	19	4	26.6667	0.970143
			Left	5	4	-1	-20	0.471405
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	2	0	-2	-100	2
			Through	44	59	15	34.0909	2.0902
		West	Right	15	23	8	53.3333	1.83533
			Through	31	48	17	54.8387	2.70489
		South	Right	5	0	-5	-100	3.16228
			Left	16	16	0	0	0
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	2	0	-2	-100	2
			Right	0	3	3	inf	2.44949
			Through	0	0	0	0	0
		East	Through	61	55	-6	-9.83607	0.787839
			Left	1	6	5	500	2.67261
			Right	0	0	0	0	0
		North	Right	0	3	3	inf	2.44949
			Through	1	0	-1	-100	1.41421
			Left	0	1	1	inf	1.41421
		West	Right	0	0	0	0	0
			Through	36	48	12	33.3333	1.85164
			Left	0	0	0	0	0

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Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	12	20	8	66.6667	2
			Left	13	8	-5	-38.4615	1.54303
		South	Right/Through	68	66	-2	-2.94118	0.244339
			Left	8	11	3	37.5	0.973329
		East	Right/Through	26	19	-7	-26.9231	1.47573
			Left	8	1	-7	-87.5	3.29983
		North	Right/Through	57	48	-9	-15.7895	1.24212
			Left	8	3	-5	-62.5	2.13201
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	33	25	-8	-24.2424	1.48556
			Right	3	0	-3	-100	2.44949

		North	Right	0	0	0	0	0
			Left	1	2	1	100	0.816497
		West	Through	23	26	3	13.0435	0.606092
			Left	0	0	0	0	0
Intersection 3	Bickley Rd & Belmont Rd	South	Right	0	0	0	0	0
			Through	26	32	6	23.0769	1.11417
		East	Left	1	0	-1	-100	1.41421
			Right	2	1	-1	-50	0.816497
		North	Through	21	15	-6	-28.5714	1.41421
			Left	21	0	-21	-100	6.48074
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	7	14	7	100	2.16025
			Right/Through	27	29	2	7.40741	0.377964
		North	Right/Through	17	17	0	0	0
			Left	6	0	-6	-100	3.4641
		West	Right/Through	16	28	12	75	2.55841
			Left	0	0	0	0	0
		South	Right/Through	24	31	7	29.1667	1.33485
			Left	4	6	2	50	0.894427
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	14	15	1	7.14286	0.262613
		North	Left	0	4	4	inf	2.82843
			Right	0	0	0	0	0
		West	Through	12	26	14	116.667	3.21182
			Left	0	0	0	0	0
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	23	11	-12	-52.1739	2.91043
			Left	3	9	6	200	2.44949
		South	Left	2	3	1	50	0.632456
			Right/Through	3	27	24	800	6.19677
		East	Right/Through	7	3	-4	-57.1429	1.78885
			Left	0	0	0	0	0
		North	Right/Through	12	15	3	25	0.816497
			Left	1	4	3	300	1.89737
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	12	16	4	33.3333	1.06904
			Right	2	0	-2	-100	2
		East	Through	10	12	2	20	0.603023
			Left	1	0	-1	-100	1.41421
		West	Right	11	28	17	154.545	3.84974
			Through	8	19	11	137.5	2.99382
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	3	7	4	133.333	1.78885
			Right	1	3	2	200	1.41421
		North	Right	4	2	-2	-50	1.1547
			Through	19	15	-4	-21.0526	0.970143
		South	Left	3	1	-2	-66.6667	1.41421
			Through	22	32	10	45.4545	1.9245
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	7	11	4	57.1429	1.33333
			Through	90	88	-2	-2.22222	0.212

			Left	17	17	0	0	0
		East	Right	0	3	3	inf	2.44949
			Through	11	9	-2	-18.1818	0.632456
			Left	3	17	14	466.667	4.42719
		North	Right	40	25	-15	-37.5	2.63117
			Through	89	105	16	17.9775	1.62455
			Left	9	0	-9	-100	4.24264
		West	Right	19	13	-6	-31.5789	1.5
			Through	7	9	2	28.5714	0.707107
			Left	69	71	2	2.89855	0.239046
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	10	9	-1	-10	0.324443
			Through	116	117	1	0.862069	0.0926482
			Left	47	37	-10	-21.2766	1.54303
		East	Right	6	20	14	233.333	3.8829
			Through	27	17	-10	-37.037	2.13201
			Left	9	12	3	33.3333	0.92582
		North	Right	6	0	-6	-100	3.4641
			Through	98	99	1	1.02041	0.100759
			Left	8	9	1	12.5	0.342997
		West	Right	30	18	-12	-40	2.44949
			Through	18	25	7	38.8889	1.50966
			Left	4	7	3	75	1.2792
Intersection 11	Orrong Rd & Roe Hwy	East	Through	105	94	-11	-10.4762	1.10276
			Right	4	12	8	200	2.82843
		South	Left	69	47	-22	-31.8841	2.88874
			Right	10	9	-1	-10	0.324443
		West	Left	35	27	-8	-22.8571	1.43684
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	92	79	-13	-14.1304	1.40592
			Through	58	52	-6	-10.3448	0.80904
		North	Left	4	7	3	75	1.2792
			Right	26	31	5	19.2308	0.936586
		East	Left	6	11	5	83.3333	1.71499
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	7	14	7	100	2.16025
			Through	55	45	-10	-18.1818	1.41421
		East	Through	78	72	-6	-7.69231	0.69282
			Right	1	12	11	1100	4.31455
		North	Right	11	14	3	27.2727	0.848528
			Left	1	4	3	300	1.89737
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	1	0	-1	-100	1.41421
			Through	54	56	2	3.7037	0.26968
		West	Right	17	14	-3	-17.6471	0.762001
			Through	39	35	-4	-10.2564	0.657596
		South	Right	3	0	-3	-100	2.44949
			Left	23	30	7	30.4348	1.3598
		South	Left	1	0	-1	-100	1.41421

Intersection 15	Welshpool Road East & Brook Road & Bruce Rd		Right	0	7	7	inf	3.74166
			Through	0	0	0	0	0
		East	Through	60	54	-6	-10	0.794719
			Left	2	1	-1	-50	0.816497
			Right	0	0	0	0	0
		North	Right	1	2	1	100	0.816497
			Through	0	0	0	0	0
			Left	1	7	6	600	3
		West	Right	1	0	-1	-100	1.41421
			Through	52	33	-19	-36.5385	2.91447
			Left	1	2	1	100	0.816497

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Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	17	8	-9	-52.9412	2.54558
			Left	6	17	11	183.333	3.24372
		South	Right/Through	26	24	-2	-7.69231	0.4
			Left	3	10	7	233.333	2.74563
		East	Right/Through	11	16	5	45.4545	1.36083
			Left	3	0	-3	-100	2.44949
		North	Right/Through	28	25	-3	-10.7143	0.582772
			Left	4	2	-2	-50	1.1547
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	9	10	1	11.1111	0.324443
			Right	1	2	1	100	0.816497
		North	Right	0	0	0	0	0
			Left	6	7	1	16.6667	0.392232
		West	Through	18	17	-1	-5.55556	0.239046
			Left	0	0	0	0	0
Intersection 3	Bickley Rd & Belmont Rd	South	Right	0	0	0	0	0
			Through	7	11	4	57.1429	1.33333
		East	Left	0	0	0	0	0
			Right	0	2	2	inf	2
		North	Through	20	20	0	0	0
			Left	7	7	0	0	0
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	1	6	5	500	2.67261
			Right/Through	7	12	5	71.4286	1.62221
		North	Right/Through	15	17	2	13.3333	0.5
			Left	8	3	-5	-62.5	2.13201
		West	Right/Through	11	13	2	18.1818	0.57735
			Left	0	1	1	inf	1.41421
		South	Right/Through	8	20	12	150	3.20713
			Left	0	4	4	inf	2.82843
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	4	5	1	25	0.471405

		North	Left	0	0	0	0	0
			Right	0	0	0	0	0
		West	Through	5	6	1	20	0.426401
			Left	0	0	0	0	0
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	6	9	3	50	1.09545
			Left	2	10	8	400	3.26599
		South	Left	0	0	0	0	0
			Right/Through	0	8	8	inf	4
		East	Right/Through	6	5	-1	-16.6667	0.426401
			Left	0	0	0	0	0
		North	Right/Through	8	15	7	87.5	2.06419
			Left	3	8	5	166.667	2.13201
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	4	6	2	50	0.894427
			Right	2	0	-2	-100	2
		East	Through	6	6	0	0	0
			Left	3	0	-3	-100	2.44949
		West	Right	6	12	6	100	2
			Through	5	13	8	160	2.66667
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	4	3	-1	-25	0.534522
			Right	2	5	3	150	1.60357
		North	Right	6	3	-3	-50	1.41421
			Through	25	22	-3	-12	0.618853
		South	Left	0	2	2	inf	2
			Through	7	10	3	42.8571	1.02899
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	6	10	4	66.6667	1.41421
			Through	66	50	-16	-24.2424	2.1009
			Left	3	1	-2	-66.6667	1.41421
		East	Right	0	0	0	0	0
			Through	2	2	0	0	0
			Left	3	7	4	133.333	1.78885
		North	Right	23	24	1	4.34783	0.206284
			Through	66	64	-2	-3.0303	0.248069
			Left	2	0	-2	-100	2
		West	Right	12	16	4	33.3333	1.06904
			Through	4	3	-1	-25	0.534522
			Left	23	33	10	43.4783	1.88982
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	6	12	6	100	2
			Through	65	60	-5	-7.69231	0.632456
			Left	14	8	-6	-42.8571	1.80907
		East	Right	8	7	-1	-12.5	0.365148
			Through	13	12	-1	-7.69231	0.282843
			Left	9	17	8	88.8889	2.2188
		North	Right	2	2	0	0	0
			Through	71	61	-10	-14.0845	1.23091
			Left	8	18	10	125	2.7735
		West	Right	9	11	2	22.2222	0.632456

			Through	17	24	7	41.1765	1.54604
			Left	3	0	-3	-100	2.44949
Intersection 11	Orrong Rd & Roe Hwy	East	Through	42	26	-16	-38.0952	2.74398
			Right	4	2	-2	-50	1.1547
		South	Left	41	24	-17	-41.4634	2.982
			Right	6	12	6	100	2
		West	Left	21	37	16	76.1905	2.97113
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	30	16	-14	-46.6667	2.9192
			Through	59	55	-4	-6.77966	0.529813
		North	Left	5	6	1	20	0.426401
			Right	18	13	-5	-27.7778	1.27
		East	Left	7	9	2	28.5714	0.707107
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	10	18	8	80	2.13809
			Through	52	44	-8	-15.3846	1.1547
		East	Through	31	20	-11	-35.4839	2.17832
			Right	4	5	1	25	0.471405
		North	Right	2	5	3	150	1.60357
			Left	8	9	1	12.5	0.342997
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	0	0	0	0	0
			Through	31	22	-9	-29.0323	1.74831
		West	Right	23	23	0	0	0
			Through	37	31	-6	-16.2162	1.02899
		South	Right	0	0	0	0	0
			Left	5	3	-2	-40	1
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	0	0	0	0	0
			Right	0	2	2	inf	2
			Through	1	0	-1	-100	1.41421
		East	Through	28	20	-8	-28.5714	1.63299
			Left	0	2	2	inf	2
			Right	1	0	-1	-100	1.41421
		North	Right	0	2	2	inf	2
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	29	31	2	6.89655	0.365148
			Left	0	0	0	0	0

Truck 5-6 PM

Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	9	3	-6	-66.6667	2.44949
			Left	5	7	2	40	0.816497
		South	Right/Through	20	28	8	40	1.63299
			Left	2	5	3	150	1.60357
		East	Right/Through	8	6	-2	-25	0.755929

			Left	1	0	-1	-100	1.41421
		North	Right/Through	14	16	2	14.2857	0.516398
			Left	7	0	-7	-100	3.74166
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	4	6	2	50	0.894427
			Right	2	1	-1	-50	0.816497
		North	Right	0	0	0	0	0
			Left	4	3	-1	-25	0.534522
		West	Through	12	7	-5	-41.6667	1.62221
			Left	0	0	0	0	0
Intersection 3	Bickley Rd & Belmont Rd	South	Right	1	0	-1	-100	1.41421
			Through	5	4	-1	-20	0.471405
		East	Left	0	0	0	0	0
			Right	1	2	1	100	0.816497
		North	Through	12	15	3	25	0.816497
			Left	2	3	1	50	0.632456
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	0	5	5	inf	3.16228
			Right/Through	4	6	2	50	0.894427
		North	Right/Through	8	14	6	75	1.80907
			Left	4	1	-3	-75	1.89737
		West	Right/Through	10	18	8	80	2.13809
			Left	4	0	-4	-100	2.82843
		South	Right/Through	3	6	3	100	1.41421
			Left	0	2	2	inf	2
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	2	0	-2	-100	2
		North	Left	0	0	0	0	0
			Right	0	0	0	0	0
		West	Through	14	17	3	21.4286	0.762001
			Left	0	0	0	0	0
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	0	11	11	inf	4.69042
			Left	5	5	0	0	0
		South	Left	1	2	1	100	0.816497
			Right/Through	0	9	9	inf	4.24264
		East	Right/Through	3	1	-2	-66.6667	1.41421
			Left	0	0	0	0	0
		North	Right/Through	5	8	3	60	1.1767
			Left	0	4	4	inf	2.82843
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	0	0	0	0	0
			Right	2	0	-2	-100	2
		East	Through	2	5	3	150	1.60357
			Left	3	0	-3	-100	2.44949
		West	Right	9	23	14	155.556	3.5
			Through	3	12	9	300	3.28634
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	0	3	3	inf	2.44949
			Right	0	3	3	inf	2.44949
		North	Right	1	1	0	0	0

			Through	17	16	-1	-5.88235	0.246183
		South	Left	0	0	0	0	0
			Through	5	6	1	20	0.426401
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	1	8	7	700	3.29983
			Through	35	45	10	28.5714	1.58114
			Left	3	0	-3	-100	2.44949
		East	Right	0	0	0	0	0
			Through	1	5	4	400	2.3094
			Left	1	10	9	900	3.83761
		North	Right	12	11	-1	-8.33333	0.294884
			Through	37	57	20	54.0541	2.9173
			Left	1	0	-1	-100	1.41421
		West	Right	5	12	7	140	2.40098
			Through	5	4	-1	-20	0.471405
			Left	19	31	12	63.1579	2.4
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	5	9	4	80	1.51186
			Through	49	52	3	6.12245	0.422159
			Left	7	13	6	85.7143	1.89737
		East	Right	6	7	1	16.6667	0.392232
			Through	3	8	5	166.667	2.13201
			Left	2	13	11	550	4.01663
		North	Right	2	2	0	0	0
			Through	33	46	13	39.3939	2.06845
			Left	9	13	4	44.4444	1.20605
		West	Right	9	11	2	22.2222	0.632456
			Through	11	10	-1	-9.09091	0.308607
			Left	0	0	0	0	0
Intersection 11	Orrong Rd & Roe Hwy	East	Through	38	26	-12	-31.5789	2.12132
			Right	0	2	2	inf	2
		South	Left	17	24	7	41.1765	1.54604
			Right	5	9	4	80	1.51186
		West	Left	7	14	7	100	2.16025
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	13	19	6	46.1538	1.5
			Through	46	38	-8	-17.3913	1.23443
		North	Left	5	5	0	0	0
			Right	8	8	0	0	0
		East	Left	9	12	3	33.3333	0.92582
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	10	13	3	30	0.884652
			Through	38	31	-7	-18.4211	1.19176
		East	Through	25	22	-3	-12	0.618853
			Right	2	1	-1	-50	0.816497
		North	Right	8	11	3	37.5	0.973329
			Left	1	3	2	200	1.41421
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	0	1	1	inf	1.41421
			Through	22	18	-4	-18.1818	0.894427
		West	Right	15	15	0	0	0

			Through	23	19	-4	-17.3913	0.872872
		South	Right	0	2	2	inf	2
			Left	4	5	1	25	0.471405
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	0	0	0	0	0
			Right	0	1	1	inf	1.41421
			Through	0	0	0	0	0
		East	Through	14	19	5	35.7143	1.23091
			Left	0	3	3	inf	2.44949
			Right	1	1	0	0	0
		North	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	10	20	10	100	2.58199
			Left	0	2	2	inf	2

Semi-trailer 7-8 AM

Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	2	0	-2	-100	2
			Left	1	0	-1	-100	1.41421
		South	Right/Through	13	17	4	30.7692	1.0328
			Left	2	0	-2	-100	2
		East	Right/Through	7	3	-4	-57.1429	1.78885
			Left	1	0	-1	-100	1.41421
		North	Right/Through	13	14	1	7.69231	0.272166
			Left	1	0	-1	-100	1.41421
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	5	0	-5	-100	3.16228
			Right	2	0	-2	-100	2
		North	Right	0	0	0	0	0
			Left	1	0	-1	-100	1.41421
		West	Through	5	0	-5	-100	3.16228
			Left	0	0	0	0	0
Intersection 3	Bickley Rd & Belmont Rd	South	Right	0	0	0	0	0
			Through	3	0	-3	-100	2.44949
		East	Left	1	0	-1	-100	1.41421
			Right	4	0	-4	-100	2.82843
		North	Through	1	0	-1	-100	1.41421
			Left	1	0	-1	-100	1.41421
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	1	0	-1	-100	1.41421
			Right/Through	5	0	-5	-100	3.16228
		North	Right/Through	1	0	-1	-100	1.41421
			Left	2	0	-2	-100	2
		West	Right/Through	4	0	-4	-100	2.82843
			Left	0	0	0	0	0

		South	Right/Through	3	0	-3	-100	2.44949
			Left	0	0	0	0	0
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	2	0	-2	-100	2
		North	Left	0	0	0	0	0
			Right	0	0	0	0	0
		West	Through	2	0	-2	-100	2
			Left	0	0	0	0	0
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	4	0	-4	-100	2.82843
			Left	1	0	-1	-100	1.41421
		South	Left	0	0	0	0	0
			Right/Through	2	3	1	50	0.632456
		East	Right/Through	2	0	-2	-100	2
			Left	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	2	0	-2	-100	2
			Right	1	0	-1	-100	1.41421
		East	Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	3	0	-3	-100	2.44949
			Through	1	0	-1	-100	1.41421
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	0	3	3	inf	2.44949
			Right	1	0	-1	-100	1.41421
		North	Right	2	0	-2	-100	2
			Through	2	0	-2	-100	2
		South	Left	0	0	0	0	0
			Through	7	0	-7	-100	3.74166
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	1	0	-1	-100	1.41421
			Through	41	41	0	0	0
			Left	2	4	2	100	1.1547
		East	Right	7	10	3	42.8571	1.02899
			Through	4	1	-3	-75	1.89737
			Left	1	0	-1	-100	1.41421
		North	Right	9	9	0	0	0
			Through	46	36	-10	-21.7391	1.56174
			Left	1	8	7	700	3.29983
		West	Right	0	3	3	inf	2.44949
			Through	0	0	0	0	0
			Left	18	12	-6	-33.3333	1.54919
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	0	0	0	0	0
			Through	47	51	4	8.51064	0.571429
			Left	15	11	-4	-26.6667	1.1094
		East	Right	8	3	-5	-62.5	2.13201
			Through	2	5	3	150	1.60357
			Left	0	0	0	0	0

		North	Right	1	0	-1	-100	1.41421
			Through	49	47	-2	-4.08163	0.288675
			Left	4	5	1	25	0.471405
		West	Right	7	8	1	14.2857	0.365148
			Through	5	4	-1	-20	0.471405
			Left	0	0	0	0	0
Intersection 11	Orrong Rd & Roe Hwy	East	Through	21	20	-1	-4.7619	0.220863
			Right	0	0	0	0	0
		South	Left	26	28	2	7.69231	0.3849
			Right	0	0	0	0	0
		West	Left	15	10	-5	-33.3333	1.41421
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	32	40	8	25	1.33333
			Through	6	5	-1	-16.6667	0.426401
		North	Left	0	1	1	inf	1.41421
			Right	5	11	6	120	2.12132
		East	Left	3	3	0	0	0
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	2	0	-2	-100	2
			Through	4	6	2	50	0.894427
		East	Through	20	16	-4	-20	0.942809
			Right	0	0	0	0	0
		North	Right	2	0	-2	-100	2
			Left	0	0	0	0	0
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	1	0	-1	-100	1.41421
			Through	21	16	-5	-23.8095	1.16248
		West	Right	0	0	0	0	0
			Through	4	6	2	50	0.894427
		South	Right	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	0	0	0	0	0
			Right	2	3	1	50	0.632456
			Through	0	0	0	0	0
		East	Through	15	16	1	6.66667	0.254
			Left	3	0	-3	-100	2.44949
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	10	8	-2	-20	0.666667
			Left	0	0	0	0	0

Semi-trailer 8-9 AM

Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	4	0	-4	-100	2.82843
			Left	1	0	-1	-100	1.41421
		South	Right/Through	14	14	0	0	0
			Left	5	0	-5	-100	3.16228
		East	Right/Through	5	5	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	8	15	7	87.5	2.06419
			Left	3	2	-1	-33.3333	0.632456
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	9	0	-9	-100	4.24264
			Right	1	0	-1	-100	1.41421
		North	Right	0	0	0	0	0
			Left	4	0	-4	-100	2.82843
		West	Through	4	0	-4	-100	2.82843
			Left	0	0	0	0	0
Intersection 3	Bickley Rd & Belmont Rd	South	Right	0	0	0	0	0
			Through	4	0	-4	-100	2.82843
		East	Left	0	0	0	0	0
			Right	0	0	0	0	0
		North	Through	1	0	-1	-100	1.41421
			Left	1	0	-1	-100	1.41421
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	1	0	-1	-100	1.41421
			Right/Through	5	0	-5	-100	3.16228
		North	Right/Through	1	0	-1	-100	1.41421
			Left	2	0	-2	-100	2
		West	Right/Through	1	0	-1	-100	1.41421
			Left	0	0	0	0	0
		South	Right/Through	3	0	-3	-100	2.44949
			Left	0	0	0	0	0
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	5	0	-5	-100	3.16228
		North	Left	0	0	0	0	0
			Right	0	0	0	0	0
		West	Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	5	2	-3	-60	1.60357
			Left	0	0	0	0	0
		South	Left	0	0	0	0	0
			Right/Through	1	1	0	0	0
		East	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	1	0	-1	-100	1.41421

Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	5	0	-5	-100	3.16228
			Right	0	0	0	0	0
		East	Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	1	0	-1	-100	1.41421
			Through	0	0	0	0	0
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	1	3	2	200	1.41421
			Right	2	0	-2	-100	2
		North	Right	0	0	0	0	0
			Through	2	0	-2	-100	2
		South	Left	0	0	0	0	0
			Through	5	0	-5	-100	3.16228
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	0	3	3	inf	2.44949
			Through	42	45	3	7.14286	0.454859
			Left	1	4	3	300	1.89737
		East	Right	9	8	-1	-11.1111	0.342997
			Through	2	0	-2	-100	2
			Left	0	1	1	inf	1.41421
		North	Right	12	13	1	8.33333	0.282843
			Through	18	26	8	44.4444	1.70561
			Left	8	3	-5	-62.5	2.13201
		West	Right	7	0	-7	-100	3.74166
			Through	0	0	0	0	0
			Left	11	20	9	81.8182	2.286
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	0	0	0	0	0
			Through	60	64	4	6.66667	0.508001
			Left	12	14	2	16.6667	0.5547
		East	Right	3	4	1	33.3333	0.534522
			Through	1	5	4	400	2.3094
			Left	0	0	0	0	0
		North	Right	1	2	1	100	0.816497
			Through	36	40	4	11.1111	0.648886
			Left	3	3	0	0	0
		West	Right	4	3	-1	-25	0.534522
			Through	5	5	0	0	0
			Left	0	0	0	0	0
Intersection 11	Orrong Rd & Roe Hwy	East	Through	30	20	-10	-33.3333	2
			Right	0	0	0	0	0
		South	Left	32	31	-1	-3.125	0.178174
			Right	0	0	0	0	0
		West	Left	20	10	-10	-50	2.58199
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	32	38	6	18.75	1.01419
			Through	10	3	-7	-70	2.74563
		North	Left	1	2	1	100	0.816497
			Right	12	5	-7	-58.3333	2.40098
		East	Left	4	8	4	100	1.63299

Intersection 13	Welshpool Rd E & Hale Rd	West	Left	2	0	-2	-100	2
			Through	9	5	-4	-44.4444	1.51186
		East	Through	17	20	3	17.6471	0.697486
			Right	0	0	0	0	0
		North	Right	2	0	-2	-100	2
			Left	0	0	0	0	0
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	1	0	-1	-100	1.41421
			Through	14	20	6	42.8571	1.45521
		West	Right	3	0	-3	-100	2.44949
			Through	6	5	-1	-16.6667	0.426401
		South	Right	0	0	0	0	0
			Left	2	0	-2	-100	2
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	0	0	0	0	0
			Right	2	3	1	50	0.632456
			Through	0	0	0	0	0
		East	Through	16	20	4	25	0.942809
			Left	0	1	1	inf	1.41421
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	7	5	-2	-28.5714	0.816497
			Left	0	0	0	0	0

Semi-trailer 4-5 PM

Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	4	0	-4	-100	2.82843
			Left	0	1	1	inf	1.41421
		South	Right/Through	12	8	-4	-33.3333	1.26491
			Left	0	0	0	0	0
		East	Right/Through	1	0	-1	-100	1.41421
			Left	1	0	-1	-100	1.41421
		North	Right/Through	8	9	1	12.5	0.342997
			Left	3	5	2	66.6667	1
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	1	0	-1	-100	1.41421
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Left	2	1	-1	-50	0.816497
		West	Through	10	0	-10	-100	4.47214
			Left	0	0	0	0	0
Intersection 3	Bickley Rd & Belmont Rd	South	Right	0	0	0	0	0
			Through	0	0	0	0	0
		East	Left	0	0	0	0	0

			Right	0	0	0	0	0
		North	Through	9	0	-9	-100	4.24264
			Left	6	1	-5	-83.3333	2.67261
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	0	0	0	0	0
			Right/Through	1	0	-1	-100	1.41421
		North	Right/Through	0	0	0	0	0
			Left	9	0	-9	-100	4.24264
		West	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		South	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	0	0	0	0	0
		North	Left	0	0	0	0	0
			Right	0	0	0	0	0
		West	Through	1	0	-1	-100	1.41421
			Left	0	0	0	0	0
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	2	0	-2	-100	2
			Left	0	0	0	0	0
		South	Left	0	0	0	0	0
			Right/Through	1	0	-1	-100	1.41421
		East	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	0	0	0	0	0
			Right	0	0	0	0	0
		East	Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	1	0	-1	-100	1.41421
			Through	2	0	-2	-100	2
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	0	0	0	0	0
			Right	1	0	-1	-100	1.41421
		North	Right	0	0	0	0	0
			Through	12	1	-11	-91.6667	4.31455
		South	Left	0	0	0	0	0
			Through	0	0	0	0	0
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	0	0	0	0	0
			Through	22	21	-1	-4.54545	0.215666
			Left	2	6	4	200	2
		East	Right	1	1	0	0	0
			Through	3	0	-3	-100	2.44949
			Left	0	0	0	0	0
		North	Right	11	8	-3	-27.2727	0.973329
			Through	22	26	4	18.1818	0.816497
			Left	1	3	2	200	1.41421

		West	Right	8	4	-4	-50	1.63299
			Through	0	0	0	0	0
			Left	6	1	-5	-83.3333	2.67261
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	4	1	-3	-75	1.89737
			Through	25	19	-6	-24	1.2792
			Left	6	2	-4	-66.6667	2
		East	Right	1	1	0	0	0
			Through	0	0	0	0	0
			Left	1	5	4	400	2.3094
		North	Right	0	0	0	0	0
			Through	25	24	-1	-4	0.202031
			Left	2	2	0	0	0
		West	Right	5	8	3	60	1.1767
			Through	0	1	1	inf	1.41421
			Left	0	0	0	0	0
Intersection 11	Orrong Rd & Roe Hwy	East	Through	13	5	-8	-61.5385	2.66667
			Right	1	1	0	0	0
		South	Left	12	12	0	0	0
			Right	4	1	-3	-75	1.89737
		West	Left	3	0	-3	-100	2.44949
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	11	4	-7	-63.6364	2.55604
			Through	9	7	-2	-22.2222	0.707107
		North	Left	3	4	1	33.3333	0.534522
			Right	2	4	2	100	1.1547
		East	Left	2	0	-2	-100	2
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	0	0	0	0	0
			Through	14	11	-3	-21.4286	0.848528
		East	Through	13	2	-11	-84.6154	4.01663
			Right	0	0	0	0	0
		North	Right	1	0	-1	-100	1.41421
			Left	0	0	0	0	0
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	0	0	0	0	0
			Through	13	2	-11	-84.6154	4.01663
		West	Right	4	1	-3	-75	1.89737
			Through	10	12	2	20	0.603023
		South	Right	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	2	0	-2	-100	2
			Right	0	0	0	0	0
			Through	0	0	0	0	0
		East	Through	6	2	-4	-66.6667	2
			Left	0	0	0	0	0
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0

		West	Right	2	4	2	100	1.1547
			Through	7	8	1	14.2857	0.365148
			Left	0	0	0	0	0

Semi-trailer 5-6 PM

Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		South	Right/Through	7	8	1	14.2857	0.365148
			Left	1	0	-1	-100	1.41421
		East	Right/Through	1	0	-1	-100	1.41421
			Left	0	0	0	0	0
		North	Right/Through	6	13	7	116.667	2.2711
			Left	4	2	-2	-50	1.1547
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	0	0	0	0	0
			Right	2	0	-2	-100	2
		North	Right	0	0	0	0	0
			Left	1	0	-1	-100	1.41421
		West	Through	2	0	-2	-100	2
			Left	0	0	0	0	0
Intersection 3	Bickley Rd & Belmont Rd	South	Right	0	0	0	0	0
			Through	0	0	0	0	0
		East	Left	1	0	-1	-100	1.41421
			Right	0	0	0	0	0
		North	Through	1	0	-1	-100	1.41421
			Left	2	0	-2	-100	2
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	0	0	0	0	0
			Right/Through	0	0	0	0	0
		North	Right/Through	3	0	-3	-100	2.44949
			Left	0	0	0	0	0
		West	Right/Through	2	0	-2	-100	2
			Left	0	0	0	0	0
		South	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	1	0	-1	-100	1.41421
		North	Left	0	0	0	0	0
			Right	0	0	0	0	0
		West	Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		South	Left	0	0	0	0	0
			Right/Through	0	0	0	0	0

		East	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	1	0	-1	-100	1.41421
			Right	0	0	0	0	0
		East	Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	2	0	-2	-100	2
			Through	0	0	0	0	0
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	0	0	0	0	0
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	3	0	-3	-100	2.44949
		South	Left	0	0	0	0	0
			Through	0	0	0	0	0
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	0	0	0	0	0
			Through	14	17	3	21.4286	0.762001
			Left	6	3	-3	-50	1.41421
		East	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right	6	13	7	116.667	2.2711
			Through	16	10	-6	-37.5	1.6641
			Left	1	0	-1	-100	1.41421
		West	Right	4	4	0	0	0
			Through	1	0	-1	-100	1.41421
			Left	1	2	1	100	0.816497
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	1	2	1	100	0.816497
			Through	15	19	4	26.6667	0.970143
			Left	0	2	2	inf	2
		East	Right	1	1	0	0	0
			Through	2	0	-2	-100	2
			Left	3	2	-1	-33.3333	0.632456
		North	Right	1	0	-1	-100	1.41421
			Through	17	18	1	5.88235	0.239046
			Left	1	2	1	100	0.816497
		West	Right	3	2	-1	-33.3333	0.632456
			Through	2	3	1	50	0.632456
			Left	0	0	0	0	0
Intersection 11	Orrong Rd & Roe Hwy	East	Through	4	5	1	25	0.471405
			Right	1	0	-1	-100	1.41421
		South	Left	6	2	-4	-66.6667	2
			Right	1	2	1	100	0.816497
		West	Left	4	1	-3	-75	1.89737
		West	Right	3	10	7	233.333	2.74563

Intersection 12	Welshpool Rd E & Roe Hwy		Through	4	6	2	50	0.894427
		North	Left	2	2	0	0	0
			Right	4	3	-1	-25	0.534522
		East	Left	2	0	-2	-100	2
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	0	0	0	0	0
			Through	9	8	-1	-11.1111	0.342997
		East	Through	5	3	-2	-40	1
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	0	0	0	0	0
			Through	4	2	-2	-50	1.1547
		West	Right	2	1	-1	-50	0.816497
			Through	7	7	0	0	0
		South	Right	0	0	0	0	0
			Left	1	1	0	0	0
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	1	0	-1	-100	1.41421
			Right	0	0	0	0	0
			Through	0	0	0	0	0
		East	Through	3	2	-1	-33.3333	0.632456
			Left	0	0	0	0	0
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	2	2	0	0	0
			Through	1	5	4	400	2.3094
			Left	0	0	0	0	0

B-double 7-8 AM

Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	1	0	-1	-100	1.41421
			Left	0	0	0	0	0
		South	Right/Through	1	0	-1	-100	1.41421
			Left	0	0	0	0	0
		East	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	3	0	-3	-100	2.44949
			Left	0	6	6	inf	3.4641
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	0	0	0	0	0
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Left	1	0	-1	-100	1.41421
		West	Through	0	0	0	0	0

			Left	0	0	0	0	0
Intersection 3	Bickley Rd & Belmont Rd	South	Right	0	0	0	0	0
			Through	0	0	0	0	0
		East	Left	0	0	0	0	0
			Right	0	0	0	0	0
		North	Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	0	0	0	0	0
			Right/Through	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		South	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	0	0	0	0	0
		North	Left	0	0	0	0	0
			Right	0	0	0	0	0
		West	Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		South	Left	0	0	0	0	0
			Right/Through	0	0	0	0	0
		East	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	0	0	0	0	0
			Right	0	0	0	0	0
		East	Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	0	0	0	0	0
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	0	0	0	0	0
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	0	0	0	0	0
		South	Left	0	0	0	0	0
			Through	0	0	0	0	0
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	0	0	0	0	0
			Through	14	11	-3	-21.4286	0.848528
			Left	0	0	0	0	0
		East	Right	0	0	0	0	0
			Through	0	0	0	0	0

			Left	0	0	0	0	0
		North	Right	3	6	3	100	1.41421
			Through	14	15	1	7.14286	0.262613
			Left	0	0	0	0	0
		West	Right	2	1	-1	-50	0.816497
			Through	0	0	0	0	0
			Left	1	0	-1	-100	1.41421
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	0	1	1	inf	1.41421
			Through	8	6	-2	-25	0.755929
			Left	5	5	0	0	0
		East	Right	1	0	-1	-100	1.41421
			Through	2	5	3	150	1.60357
			Left	0	0	0	0	0
		North	Right	1	0	-1	-100	1.41421
			Through	14	13	-1	-7.14286	0.272166
			Left	1	0	-1	-100	1.41421
		West	Right	3	8	5	166.667	2.13201
			Through	1	0	-1	-100	1.41421
			Left	0	0	0	0	0
Intersection 11	Orrong Rd & Roe Hwy	East	Through	2	9	7	350	2.98481
			Right	0	0	0	0	0
		South	Left	5	6	1	20	0.426401
			Right	0	1	1	inf	1.41421
		West	Left	5	0	-5	-100	3.16228
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	6	5	-1	-16.6667	0.426401
			Through	3	11	8	266.667	3.02372
		North	Left	0	0	0	0	0
			Right	1	3	2	200	1.41421
		East	Left	1	4	3	300	1.89737
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	0	0	0	0	0
			Through	3	11	8	266.667	3.02372
		East	Through	2	11	9	450	3.53009
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	0	0	0	0	0
			Through	2	11	9	450	3.53009
		West	Right	0	3	3	inf	2.44949
			Through	3	8	5	166.667	2.13201
		South	Right	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	0	1	1	inf	1.41421
			Right	0	0	0	0	0
			Through	0	0	0	0	0
		East	Through	4	10	6	150	2.26779
			Left	1	0	-1	-100	1.41421

			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	4	8	4	100	1.63299
			Left	0	0	0	0	0

B-double 8-9 AM

Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	1	0	-1	-100	1.41421
			Left	0	0	0	0	0
		South	Right/Through	1	2	1	100	0.816497
			Left	0	0	0	0	0
		East	Right/Through	1	1	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	1	1	0	0	0
			Left	3	5	2	66.6667	1
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	0	0	0	0	0
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Left	0	0	0	0	0
		West	Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 3	Bickley Rd & Belmont Rd	South	Right	0	0	0	0	0
			Through	0	0	0	0	0
		East	Left	0	0	0	0	0
			Right	0	0	0	0	0
		North	Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	0	0	0	0	0
			Right/Through	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		South	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	0	0	0	0	0
		North	Left	0	0	0	0	0
			Right	0	0	0	0	0
		West	Through	0	0	0	0	0
			Left	0	0	0	0	0

Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		South	Left	0	0	0	0	0
			Right/Through	0	0	0	0	0
		East	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	0	0	0	0	0
			Right	0	0	0	0	0
		East	Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	0	0	0	0	0
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	0	0	0	0	0
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	0	0	0	0	0
		South	Left	0	0	0	0	0
			Through	1	0	-1	-100	1.41421
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	0	0	0	0	0
			Through	10	9	-1	-10	0.324443
			Left	0	0	0	0	0
		East	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right	0	6	6	inf	3.4641
			Through	13	13	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	2	3	1	50	0.632456
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	1	4	3	300	1.89737
			Through	9	5	-4	-44.4444	1.51186
			Left	2	8	6	300	2.68328
		East	Right	0	0	0	0	0
			Through	2	5	3	150	1.60357
			Left	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	15	13	-2	-13.3333	0.534522
			Left	0	0	0	0	0
		West	Right	3	4	1	33.3333	0.534522
			Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 11	Orrong Rd & Roe Hwy	East	Through	8	10	2	25	0.666667
			Right	0	0	0	0	0

		South	Left	8	11	3	37.5	0.973329
			Right	1	4	3	300	1.89737
		West	Left	2	1	-1	-50	0.816497
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	4	7	3	75	1.2792
			Through	6	8	2	33.3333	0.755929
		North	Left	0	0	0	0	0
			Right	4	3	-1	-25	0.534522
		East	Left	2	2	0	0	0
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	0	0	0	0	0
			Through	6	8	2	33.3333	0.755929
		East	Through	6	8	2	33.3333	0.755929
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	0	0	0	0	0
			Through	5	8	3	60	1.1767
		West	Right	0	0	0	0	0
			Through	6	8	2	33.3333	0.755929
		South	Right	0	0	0	0	0
			Left	1	0	-1	-100	1.41421
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	0	0	0	0	0
			Right	1	0	-1	-100	1.41421
			Through	0	0	0	0	0
		East	Through	6	8	2	33.3333	0.755929
			Left	1	5	4	400	2.3094
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	4	4	inf	2.82843
			Through	7	4	-3	-42.8571	1.2792
			Left	0	0	0	0	0

B-double 4-5 PM

Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	4	7	3	75	1.2792
			Left	0	5	5	inf	3.16228
		South	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		East	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	0	0	0	0	0

			Left	5	0	-5	-100	3.162 28
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	0	5	5	inf	3.162 28
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Left	0	0	0	0	0
		West	Through	0	5	5	inf	3.162 28
			Left	0	0	0	0	0
Intersection 3	Bickley Rd & Belmont Rd	South	Right	0	0	0	0	0
			Through	0	0	0	0	0
		East	Left	0	0	0	0	0
			Right	0	0	0	0	0
		North	Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 4	Belmont Rd & Kenwick Rd	East	Left	0	0	0	0	0
			Right/Through	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		South	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	0	0	0	0	0
		North	Left	0	0	0	0	0
			Right	0	0	0	0	0
		West	Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		South	Left	0	0	0	0	0
			Right/Through	0	0	0	0	0
		East	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	1	0	-1	-100	1.414 21
			Right	0	0	0	0	0
		East	Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	0	0	0	0	0
Intersection 8	Bickley Rd &	West	Left	0	0	0	0	0
			Right	0	0	0	0	0

	Wanaping Rd	North	Right	0	0	0	0	0
			Through	0	0	0	0	0
		South	Left	0	5	5	inf	3.16228
			Through	0	0	0	0	0
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	Count - B-double - PM RDS	Count - B-double - Result 2622	Absolute Difference	Relative Difference (%)	GEH
			Through	0	0	0	0	0
			Left	0	5	5	inf	3.16228
		East	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	11	3	-8	-72.7273	3.02372
		North	Right	6	2	-4	-66.6667	2
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	3	0	-3	-100	2.44949
			Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	4	2	-2	-50	1.1547
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		East	Right	1	0	-1	-100	1.41421
			Through	12	2	-10	-83.3333	3.77964
			Left	1	0	-1	-100	1.41421
		North	Right	0	0	0	0	0
			Through	2	2	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 11	Orrong Rd & Roe Hwy	East	Through	1	0	-1	-100	1.41421
			Right	0	0	0	0	0
		South	Left	0	0	0	0	0
			Right	4	2	-2	-50	1.1547
		West	Left	1	0	-1	-100	1.41421
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	13	2	-11	-84.6154	4.01663
			Through	0	0	0	0	0
		North	Left	2	4	2	100	1.1547
			Right	5	8	3	60	1.1767
		East	Left	3	0	-3	-100	2.44949
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	0	0	0	0	0
			Through	0	0	0	0	0
		East	Through	0	0	0	0	0
			Right	1	5	4	400	2.3094

		North	Right	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	2	0	-2	-100	2
			Through	0	0	0	0	0
		West	Right	1	5	4	400	2.3094
			Through	0	0	0	0	0
		South	Right	1	0	-1	-100	1.41421
			Left	0	0	0	0	0
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	0	0	0	0	0
			Right	0	0	0	0	0
			Through	1	0	-1	-100	1.41421
		East	Through	0	0	0	0	0
			Left	7	5	-2	-28.5714	0.816497
			Right	1	5	4	400	2.3094
		North	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	7	0	-7	-100	3.74166

B-double 5-6 PM

Intersection ID	Intersection	Direction	Movement	Survey Count	Model Flow	Absolute Difference	Relative Difference (%)	GEH
Intersection 1	Bickley Rd & Kelvin Rd	West	Right/Through	0	1	1	inf	1.41421
			Left	0	0	0	0	0
		South	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		East	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	3	0	-3	-100	2.44949
			Left	1	0	-1	-100	1.41421
Intersection 2	Bickley Rd & Kenwick Rd	East	Through	0	0	0	0	0
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Left	0	1	1	inf	1.41421
		West	Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 3	Bickley Rd & Belmont Rd	South	Right	0	0	0	0	0
			Through	0	0	0	0	0
		East	Left	0	0	0	0	0
			Right	0	0	0	0	0
		North	Through	0	0	0	0	0
			Left	0	1	1	inf	1.41421

Intersection 4	Belmont Rd & Kenwick Rd	East	Left	0	0	0	0	0
			Right/Through	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		South	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 5	Kenwick Rd & Park Rd	East	Right	0	0	0	0	0
			Through	0	0	0	0	0
		North	Left	0	0	0	0	0
			Right	0	0	0	0	0
		West	Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 6	Brixton St & Wanaping Rd	West	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		South	Left	0	0	0	0	0
			Right/Through	0	0	0	0	0
		East	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right/Through	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 7	Kenwick Rd & Wanaping Rd	South	Left	0	0	0	0	0
			Right	0	0	0	0	0
		East	Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	0	0	0	0	0
Intersection 8	Bickley Rd & Wanaping Rd	West	Left	0	0	0	0	0
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	0	1	1	inf	1.41421
		South	Left	0	0	0	0	0
			Through	0	0	0	0	0
Intersection 9	Kelvin Rd & Tonkin Hwy	South	Right	0	0	0	0	0
			Through	9	9	0	0	0
			Left	0	0	0	0	0
		East	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		North	Right	2	0	-2	-100	2
			Through	4	5	1	25	0.471405
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	2	5	3	150	1.60357

Intersection 10	Tonkin Hwy & Welshpool Rd	South	Right	1	0	-1	-100	1.41421
			Through	6	0	-6	-100	3.4641
			Left	4	14	10	250	3.33333
		East	Right	0	0	0	0	0
			Through	1	0	-1	-100	1.41421
			Left	0	0	0	0	0
		North	Right	1	1	0	0	0
			Through	6	5	-1	-16.6667	0.426401
			Left	0	0	0	0	0
		West	Right	1	0	-1	-100	1.41421
			Through	0	2	2	inf	2
			Left	0	0	0	0	0
Intersection 11	Orrong Rd & Roe Hwy	East	Through	5	10	5	100	1.82574
			Right	0	0	0	0	0
		South	Left	4	11	7	175	2.55604
			Right	1	0	-1	-100	1.41421
		West	Left	9	1	-8	-88.8889	3.57771
Intersection 12	Welshpool Rd E & Roe Hwy	West	Right	6	3	-3	-50	1.41421
			Through	0	0	0	0	0
		North	Left	0	2	2	inf	2
			Right	2	0	-2	-100	2
		East	Left	1	0	-1	-100	1.41421
Intersection 13	Welshpool Rd E & Hale Rd	West	Left	0	0	0	0	0
			Through	2	2	0	0	0
		East	Through	2	10	8	400	3.26599
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 14	Welshpool Rd E & Coldwell Rd	East	Left	0	0	0	0	0
			Through	2	10	8	400	3.26599
		West	Right	0	0	0	0	0
			Through	3	2	-1	-33.3333	0.632456
		South	Right	0	0	0	0	0
			Left	0	0	0	0	0
Intersection 15	Welshpool Road East & Brook Road & Bruce Rd	South	Left	0	0	0	0	0
			Right	2	0	-2	-100	2
			Through	0	0	0	0	0
		East	Through	5	10	5	100	1.82574
			Left	1	5	4	400	2.3094
			Right	0	0	0	0	0
		North	Right	0	0	0	0	0
			Through	0	0	0	0	0
			Left	0	0	0	0	0
		West	Right	0	0	0	0	0
			Through	8	2	-6	-75	2.68328
			Left	0	0	0	0	0

About Cardno

Cardno is a professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD].

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