Rivermark Area 3 Local Structure Plan

Lot 9009 Cranwood Crescent & Eveline Road, Viveash

Prepared For Hesperia

May 2024 - Final for WAPC Approval | 21-742

element.

RIVERMARK
· VIVEASH ·

We acknowledge the Whadjuk people of the Noongar nation as Traditional Owners of the land on which we live and work.

We acknowledge and respect their enduring culture, their contribution to the life of this city, and Elders, past and present.

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Issue	Date	Status	Prepared by	Approved by	Graphics	File
1	27.05.22	Draft	Leigh Caddy	Matt Raymond	SA	D1
2	23.06.22	Final Draft	Leigh Caddy	Matt Raymond	SA	D2
3	24.06.22	Final 1	Leigh Caddy	Matt Raymond	SA	F1
4	04.07.22	Final 2	Leigh Caddy	Matt Raymond	SA	F2
5	11.07.22	Final 3	Leigh Caddy	Matt Raymond	SA	F3
6	03.03.23	Final 4	Claire Willey	Matt Raymond	SA	F4
7	06.05.23	Final 5	Claire Willey	Matt Raymond	SA	F5
8	03.04.24	Final 6 - For WAP Approval	Claire Willey	Matt Raymond	SA	F6
9	22.04.24	Final 6 - For WAP Approval	Claire Willey	Matt Raymond	SA	F7
10	14.05.24	Final 7	Claire Willey	Matt Raymond	SA	F8

CERTIFICATION OF APPROVED STRUCTURE PLAN

This Structure Plan is prepared under the provisions of the City of Swan Local Planning Scheme No. 17 and in accordance with the Planning and Development (Local Planning Schemes) Regulations 2015

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

18 July 2024

Signed for an on behalf of the Western Australian Planning Commission

……………………………………………………………………………

An officer of the Commission duly authorised by the Commission pursuant to section 24 of the *Planning and Development Act 2005* for that purpose, in the presence of:

Witness ……………………………

Date 19 July 2024

Date of Expiry 19 July 2034

Indigenous Heritage

While the site intersects with the boundaries of the Registered Heritage Sites; 'Turtle Swamp', 'Blackadder and Woodbridge Creek' and 'Jane Brook' and 'Bishop Road Camp', their physical location is not within the site, and therefore approval under the Act is not required. There are no known implications for Aboriginal Heritage associated with the Structure Plan. Hesperia has initiated discussions with the SWALSC during February 2020 and with the Whadjuk Working Group in April 2021.

More recently, Karrda and The Fulcrum Agency (TFA) have been engaged in developing a cultural narrative for Rivermark that is historically authentic and representative of Noongar culture today, linking the past to the present and paving the way for the future. Ongoing engagement and collaboration with the local elders has been established through Karrda and TFA and will remain through Rivermark's ongoing development.

Public Open Space

The proponent is committed to providing more than 10% public open space across the broader redevelopment area. Area 3, the subject of this Structure Plan, forms just part of the broader redevelopment site. The proponent is allocating substantial areas of public open space along the Swan River foreshore in the next stage (Area 4). This area of public open space does not include the existing Bush Forever area. This will be accessible to all to use. This will be subject to a future planning process, which includes advertising requirements by the City of Swan and final approval by the WAPC.

Health Considerations

The proposal will relocate the existing hardstand area (used for storing brick packs) to the north-east of Bassett Road. Moving brickwork activities and associated operational activities more than 1 kilometre from nearby residents will result in a positive outcome for the existing Viveash community.

Existing and Proposed Stormwater Management

The Department of Water and Environmental Regulation has endorsed a District Water Management Strategy (DWMS) for the entirety of the brickworks site, including Area 3, the subject of this Structure Plan. The Department of Biodiverstiy, Conservation and Attractions has previously advised the Western Australian Planning Commission it has no objection, in-principle, to the DWMS.

Area 3 is located in the catchment of Blackadder Creek. Water from the brickworks site is managed via a series of attenuation and sedimentation ponds which flow to a tributary of Blackadder Creek in all but major events which release to the Swan River. This tributary flows into a subdivision piped drainage system at Muriel St before meeting Blackadder Creek in the wetland area upstream of the Swan River.

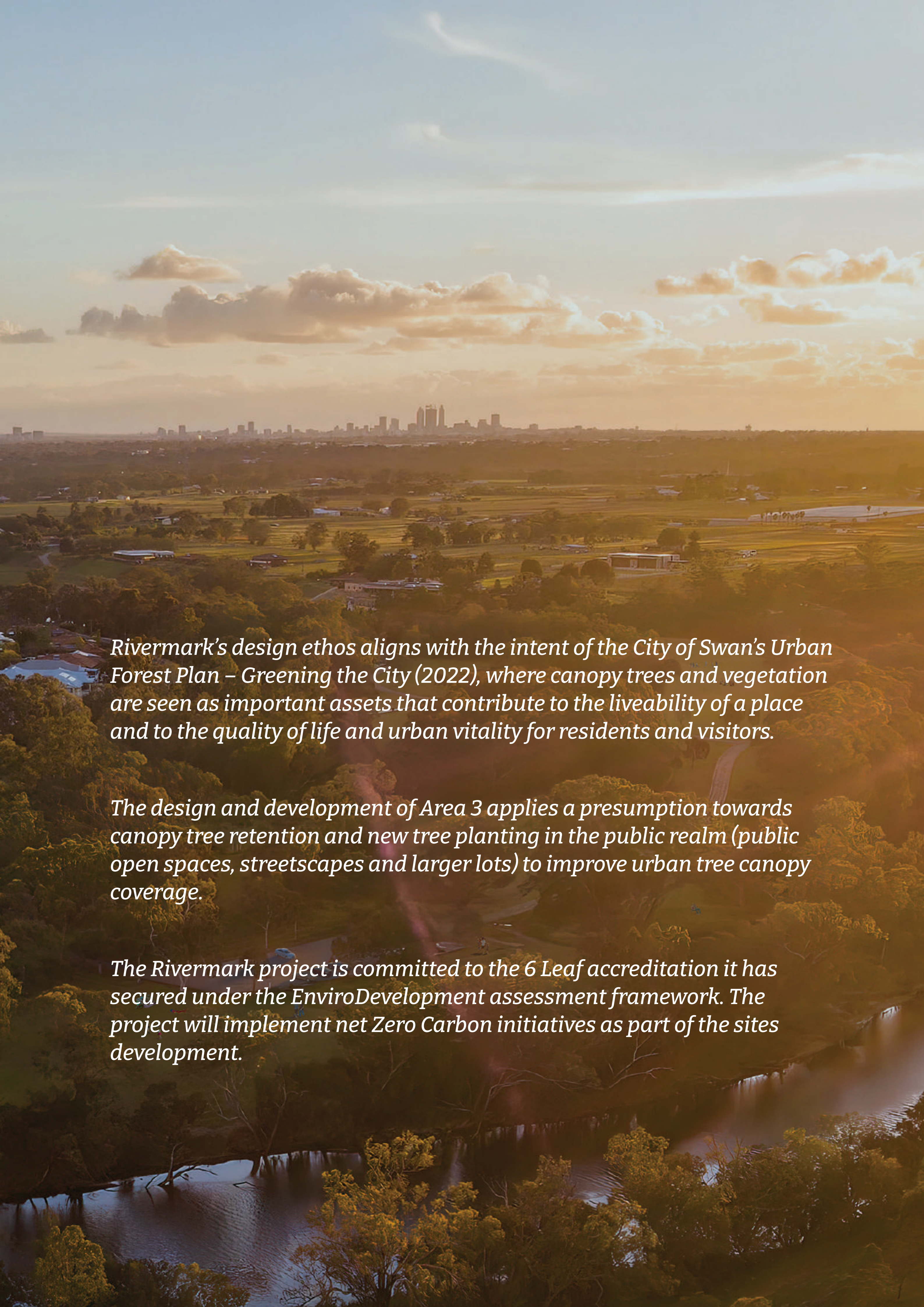
Recent modifications to the brickworks stormwater management system on Lot 9009 in 2020 are temporary staging measures to maintain existing flow paths and function during the transition process.

The DBCA acknowledges that the site currently relies on a pumped drainage system and that some site constraints, including existing inflow to the site from upstream council drainage systems, prevent development of a naturally flowing stormwater network. It is understood that some areas may continue to require a pumped system in order to ensure the water balance of the Threatened Ecological Community (TEC) and Blackadder Creek tributary is maintained. The DWMS demonstrates that the stormwater quality within the site is currently meeting DBCA and DWER's long-term nutrient targets for the Blackadder Creek and Swan River.

The current hydrological functions of the site will be managed through the application of the Better Urban Water Management Framework (implemented through the standard planning process), detailed in the Local Water Management Strategy (LWMS) prepared to support the proposed structure plan. The broad redevelopment of the brickworks site provides an opportunity to mitigate the impacts of a drying climate by making more water available to flow through the area surrounding the TEC and the Blackadder Creek tributary, and to capture stormwater for irrigation use.

The LWMS is also supported by a biophysical assessment of Blackadder Creek Tributary. Although the assessment concluded the LSP poses no risk of impacts to the Blackadder Creek Tributary and that existing setbacks to confirmed adjacent Threatened Ecological Community (TEC) are adequate, it also found there is an opportunity in redeveloping the LSP area, to improve the LSP's existing interface and relationship with the Blackadder Creek Tributary. The biophysical assessment recommends further investigating the definition and extent of a tributary foreshore, to be managed under a Foreshore Management Plan, prepared at the subdivision stage.

Further detail of the integration of stormwater within Public Open Space areas and any improvements to the Blackadder Creek Tributary area adjacent to Lot 9009 will be provided at the time of development. This will include the refinement of stormwater modelling, preparation of detailed landscape plans (species selection and treatments), and detailed engineering design drawings. Staging of stormwater changes will be detailed in the relevant Urban Water Management Plans (UWMP's) and implemented to ensure key hydrological performance criteria in relation to the receiving environment and key design objectives are maintained during the transition process.



Rivermark's design ethos aligns with the intent of the City of Swan's Urban Forest Plan – Greening the City (2022), where canopy trees and vegetation are seen as important assets that contribute to the liveability of a place and to the quality of life and urban vitality for residents and visitors.

The design and development of Area 3 applies a presumption towards canopy tree retention and new tree planting in the public realm (public open spaces, streetscapes and larger lots) to improve urban tree canopy coverage.

The Rivermark project is committed to the 6 Leaf accreditation it has secured under the EnviroDevelopment assessment framework. The project will implement net Zero Carbon initiatives as part of the sites development.

Project Team

Consultant	Discipline
Hesperia	Development Manager
element	Planning
Studio CFM	Urban design
Julie Harrold Architect	Estate Architect
Plan-e	Landscape design
Cardno/Stantec	Transport impact advice
TABEC	Civil engineering and servicing
Hyd2o	District water management plan
Emerge	Environmental Assessment Report (EAR)
Karrda and The Fulcrum Agency	Cultural heritage
Lloyd George Acoustics	Environmental noise assessment
Environmental Technologies & Analytics	Air quality assessment
MNG	Surveying
Clarity Communications	Communications
Philippa O'Brien	Cultural Interpretation
EnRisks	Human Health Risk Assessment

Table of Amendments

Amendment No.	Description of Amendment	Amendment Type	Date Approved by the WAPC

Executive Summary

The Structure Plan for Area 3 of the Rivermark residential project shall facilitate the proponent's aspirations to develop the now redundant former industrial land for future residential purposes The 10.02ha site represents the next stage of redevelopment of the former brickworks site. Approximately 152 lots are estimated to be accommodated as part of this next stage of the Rivermark project, ranging in density between R10 for 'Landscape' lots, up to R30 lots.

The majority of the Structure Plan area is cleared (used previously as hardstand by Midland Brick for storage and more recently temporary drainage storage). The site contains an existing hardstand area (previously used for storing brick pallets) and open storage ponds that currently discharges into a tributary of Blackadder Creek. The hardstand area is now redundant, with storage now moved to the north-east of Bassett Road.

Key Considerations

Recognising the Need for Tree Retention

It is recognised that there is a strip of trees along the bund adjacent to Cranwood Crescent. Whilst this bund and the vegetation was planted by Midland Brick as part of operational works, the proponent recognises a real opportunity to integrate the trees into the Structure Plan design and the subsequent detailed subdivision design stage. The key design principles of this are to:

- Maximise tree canopies across the site including along Cranwood Crescent on the earth bund and the planting of trees throughout the estate to encourage and support animal movement across the landscape and site.
- Integrate appropriate road networks to manage traffic movements and ensure the designs have consideration for existing trees to ensure they are protected.
- Ensure good east-west connectivity is provided to the existing community to gain direct access to the Jack Williamson Oval; along with connections to the future masterplanned community linking the Viveash community to a planned river hub and foreshore.
- Provide an appropriate mix of lot sizes and configurations, noting that a maximum dwelling yield will apply to the site, in accordance with the 20-25 ANEF noise contour.
- Create Local Development Plan provisions, in association with the City of Swan, to protect trees within private lots and ensure appropriate built form outcomes.

Providing Secondary Vehicle Access to Viveash Community

Secondary vehicle access will be delivered to the existing Viveash community with the construction of the Eveline Road linkage through to Cranwood Crescent. This will be in the next stage of works at Rivermark and will provide alternative access and connectivity to residents whilst reducing traffic at La Salle College, and a dependency on the existing road network. The Structure Plan integrates the proposed local road network into the extend Eveline Road linkage.

Improving the relationship to adjacent Threatened Ecological Communities (TEC's) and the Blackadder Creek Tributary

Whilst there are no TEC's in the Structure Plan area, flora and vegetation studies (Emerge, 2020) identified a TEC, and the Blackadder Creek Tributary, within the adjoining public reserve R29037. The reserve, which sits outside of the Structure Plan area, is owned by the State of WA and managed by the City of Swan.

Although the proposed Structure Plan development poses no risk of impacts to the Blackadder Creek Tributary and that existing setbacks to the TEC located outside of the area are adequate, there is an opportunity to define a foreshore and improve the Structure Plan's existing interface and relationship with the Blackadder Creek Tributary. The tributary foreshore will protect the waterway adjacent to the LSP area from potential development impacts and will be managed by a Foreshore Management Plan, currently being prepared in coordination with the DBCA.

The following is a summary of the proposed structure plan for Area 3.

Item	Data
Total area covered by the Structure Plan	10.02ha
Area of each land use proposed • Residential • Roads • Drainage	 7.13ha 2.65ha 0.24ha
Total estimated lot yield	152 lots estimated
Estimated number of dwellings	152 dwellings
Estimated residential density • Per site hectare	 14 dwellings per site hectare[1]
Estimated Population (average 2.6 people/household)	396 persons[2]

Note:

[1] Based on the residential zoned land (exclusive of roads and public open space) as per definition in Liveable Neighbourhoods

[2] Based on Australian Bureau of Statistics (2016) for Viveash relating to average people per household of 2.6.

Contents

Figures

Abbreviations

AHD – Australian Height Datum

ASS – Acid Sulphate Soils

BAL – Bushfire Attack Level

BMP – Bushfire Management Plan

DBCA – Department of Biodiversity, Conservation and Attractions

DFES – Department of Fire and Emergency Services

DPLH – Department of Planning, Lands and Heritage

DSI – Detailed Site Investigation

DWER – Department of Water and Environmental Regulation

ESA – Environmentally Sensitive Areas

GCC – Great Cocky Count

LDP – Local Development Plan

LN – Liveable Neighbourhoods

LPS17 – City of Swan Local Planning Scheme No.17

LSP – Local Structure Plan

PEC – Priority Ecological Communities

SPP – State Planning Policy

SRZ – Structural Root Zone

SWALSC – South West Aboriginal Land and Sea Council

TEC – Threatened Ecological Community

TPZ – Tree Protection Zone

WAPC – Western Australian Planning Commission

PART 1

1. Implementation

1.1 Structure Plan Area

The Local Structure Plan (LSP) applies to the land contained within the inner edge of the line denoting the structure plan boundary on the Local Structure Plan map (Plan 1). It covers an area of approximately 10.02 hectares.

1.2 Operation

The LSP comes into effect on the date the Western Australian Planning Commission (WAPC) approves the LSP, as set out on the Certification Page.

1.3 Staging

The LSP guides the future development of the land located south of Eveline Road for urban, primarily residential purposes. The LSP area is anticipated to be delivered in three stages through the subsequent subdivision process. The following works are required prior to the occupation of development on the site:

- Provision of all essential services; and
- Construction of Eveline Road.

1.4 Subdivision and Development Requirements

1.4.1 Land Use and Permissibility

Plan 1 outlines the land use zone and reserves applicable within the LSP area. Land use permissibility shall generally be in accordance with the LPS 17.

1.4.1.1 Land Use Restrictions

Kiln 11 is located approximately 200m north-east of the LSP area. The kiln has now been decommissioned. At the time of publication, the Licence is being amended to remove reference/inclusion of Kiln 11. This is being lodged with DWER for processing.

Whilst Kiln 11 is no longer operational, in accordance with Environmental Protection Authority's (EPA) support, a Restricted Use overlay was proposed to be introduced over the 'Residential Development' zone as part of Amendment No.209 to the City of Swan's Local Planning Scheme No.17 for Area 3. The introduction and content of the Restricted Use overlay will be addressed at the time that the Council considers submissions and makes its decision.

The EPA's advice on Amendment No.209 state that it expects the proposed Restricted Use text and map be included regardless of whether Kiln 11 is decommissioned prior to gazettal of the amendment, as other elements of the brickworks such as the clay shed may remain in operation. This will restrict and condition the development of sensitive land uses while there are still operating brickworks elements.

1.4.2 Residential Density

1.4.2.1 Dwelling Target

The LSP is expected to provide approximately 152 lots, subject to subsequent detailed subdivision design.

1.4.2.2 Residential Density

a. The maximum number of residential lots permitted in this structure plan area shall not exceed the average dwelling yield achievable at the R20 Residential Density Code. This requirement applies to areas affected by the 20 and above ANEF aircraft noise exposure levels (at commencement this applies to the entire structure planning area). This is to enable small pockets of housing diversity whilst having regard to the density requirements of the State Planning Policy 5.1 Land Use Planning in Vicinity of Perth Airport.

b. Density is to be consistent with the R-Codes shown on Plan 1. A density schedule summary shall be provided with each stage of subdivision to demonstrate that the residential density cap of R20 is being compiled with for the entire residential area of the Structure Plan.

1.4.3 Other Controls

Design Element	Provisions
Landscape Lot Requirements	The objective of the Landscape Lots area is to retain significant urban tree canopy and provide a soft landscape interface with existing residences on Cranwood Crescent. The Indicative Tree Protection Plan as shown in Figure 1 identifies trees for retention within the R10 Landscape Lots. Figure 1 indicatively illustrates how reasonable efforts will be taken to retain the identified trees by the preparation of a Local Development Plan to provide deeper setbacks and coordination of driveways to avoid tree removal. Figure 2 indicatively illustrates a cross-section of what is proposed. The following will be implemented: 1. A landscape plan is to be implemented as a condition of subdivision, detailing how the landscape setback area will be landscaped with a planting schedule confirming the species, numbers and planting size, and how the proposal complies with the approved Bushfire Management Plan. Where removal is proposed the plan is to consider the location of new trees and a planting schedule confirming the species, planting size and number of trees to be planted at a rate of 2 new trees to 1 replace where proposed (or at a rate of 3 new trees to one replaced if done retrospectively). 2. As part of (1) above an arborist report will: • confirm the health and structure of the proposed retained trees and identify any trees not possible to retain; and • confirm trees Structural Root Zones (SRZ) and Tree Protection Zones (TPZ) in accordance with Australian Standards. 3. Landscape Lots are to be restricted to a Residential Density Code that avoids further subdivision potential. The Structure Plan Map identifies R10 as a suitable density code, which requires an average lot size of 1000sqm. 4. A Local Development Plan(s) is required for all landscape lots as a condition of subdivision, which is to: • Ensure retention of trees as identified on the Indicative Tree Retention Plan below and building envelope setback controls are implemented as set out in the figure below and the approved plan of subdivision. Setback controls within the landscape setback area shall also regulate garages, carports, outbuildings, and other non-habitable structures. • Mechanisms to limit and/or coordinate crossovers and driveways in the front, landscape setback area. • Mechanisms to provide adequate canopy and deep soil areas to protect trees identified for retention and proposed). 5. Tree retention and careful construction management practices and plans (to Australian Standard AS 4970) are required at the subdivision clearance or development stage to ensure civil works can remove the redundant bund without tree disturbance. 6. At the discretion of the WAPC, on the advice of the local government, the subdivider can be conditioned to construct vehicular crossover and driveway to minimise disturbances and/or prepare additional legal instruments to control their encroachments into the landscape setback area.
Public Open Space (Jack Williamson Oval)	The requirement for 10% public open space provision is satisfied via satisfactory arrangements in accordance with an agreement between the subdivider and the City of Swan to facilitate the rehabilitation and redevelopment of the under-utilised and degraded Jack Williamson Oval and surrounds, located immediately east of the Structure Plan. Suitable agreement shall be put in place between the proponent and the City of Swan, to the satisfaction of the Western Australian Planning Commission, to ensure conformance.
Foreshore Management Plan	A foreshore management plan is to be prepared in consultation with DBCA and the City of Swan to ensure stormwater conveyance, bushfire management, landscaping, development interface and subdivision Threatened Ecological Community (TEC) (Corymbia calophylla Xanthorrea preissii woodlands and shrublands). The foreshore management plan should improve the local hydrology of the environmental assets referred to above, with satisfactory arrangements being made for the implementation of the approved plan at subdivision stage. Further investigation is required to locate the abutting TEC along the Structure Plan's eastern and south-eastern boundaries, along with the extent of any required foreshore area to the satisfaction of the DBCA and the City of Swan. This will be conveyed in the foreshore management plan. Foreshore improvement works and best practice water and construction planning will protect the offsite environmental features and maintain or improve the local hydrology. The likely scope of the foreshore works will include: Fencing, Demarcation on map of TEC areas, vegetation retention, rehabilitation areas (weed control and planting), Drainage infrastructure footprint impact, Pathways, Signage, evidence of consultation and in-principle agreements with third party approvals.

Design Element	Provisions
Dewatering of the existing clay basins	• Any dewatering of the existing clay basins should not affect the water quality and quantity of the Blackadder Creek Tributary and the TECs. In this regard no dewatering effluent is to enter the River, either directly or indirectly (via the stormwater system), unless approved by the Department of Biodiversity, Conservation and Attractions. • In the event it is proposed to dewater effluent either directly or indirectly (eg. via the stormwater system) to the Blackadder Creek Tributary and river, a dewatering management plan, demonstrating that the dewatering effluent discharge standards contained within the Department of Biodiversity, Conservation will be required.
Bushfire Management	The Bushfire Management Plan (BMP) identifies the LSP area is bushfire prone, with future lots being subject to low to moderate bushfire risk. A future BMP shall be prepared as part of the subdivision process and will detail the development design response to ensure habitable development achieves a Bushfire Attack Level (BAL) rating of BAL-29 or less, including: • Development within 100m of classified vegetation will require a BAL assessment to be completed as part of the subdivision and certified prior to dwelling construction. The BAL assessment will inform the requirement for increased construction standards in accordance with AS3959 which will be implemented via the building licence process. • The indicative BAL assessment undertaken as part of the existing BMP, indicates building footprints within lots will be subject to a BAL rating of BAL-29 or less. Future subdivision and development will require roads to be support two access routes, hydrants to be constructed and public open space to be implemented and maintained to a low threat standard in accordance with clause 2.2.3.2(f) of AS 3959. • A notification, pursuant to Section 165 of the Planning and Development Act 2005 is to be placed on the certificate(s) of title of the proposed lot(s) with a Bushfire Attack Level (BAL) rating of 12.5 or above, advising of the existence of a hazard or other factor not part of the EAR. Notice of this notification is to be included on the diagram or plan survey (deposited plan). The notification is to state as follows: "This land is within a bushfire prone area as designated by an Order made by the Fire and Emergency Services Commissioner and may be subject to a Bushfire Management Plan. Additional planning and building requirements may apply to development on this land." • For actions identified at subdivision stage, Jack Williamson Oval to be implemented and maintained to a low threat standard in accordance with *clause 2.2.3.2(f) of AS 3959*. • In accordance with the Bushfire Management Plan that a landscaped area within Jack Williamson Oval adjacent the eastern perimeter Access Street is to be landscaped in consultation with the City of Swan to allow for this area to be maintained at a low threat standard by the City of Swan in accordance with clause 2.2.3.2(f) of AS 3959. • A landscape plan to be undertaken for the Landscape lots as a condition of subdivision to be implemented as part of subdivision works which identifies trees for protection and landscaping to occur to allow for the classification of 'low threat vegetation' in consultation with the City of Swan.
Industrial Noise and Emission Mitigation Requirements	**Brick Works Noise** In addition to the provision of Restricted Use provisions created under Local Scheme Amendment No.209, noise and industrial emission impacts are to be managed in the LSP area by: 1. A notification, pursuant to Section 165 of the Planning and Development Act 2005 is to be placed on the certificates of title of all residential lots advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification is to state as follows: *"This lot is in close proximity to existing masonry and bricks works and may be adversely affected by virtue of gaseous, odour, noise and/or dust emissions from the facility."* 2. The preparation of a Noise Management Plan outlining the recommended type and specification of physical noise barrier to achieve acceptable noise levels at surrounding sensitive land uses to be approved by City of Swan in consultation with Department of Water and Environmental Regulation. This is to be undertaken and at the first stage of subdivision in this Structure Plan area. The noise management measures may be located on Lot 9009, to the north of Evelyn Road, providing an interface with the Structure Plan area. 3. Local Development Plan, as appropriate, are to impose built form controls applicable to proposed residential lots, as identified in the requirements and recommendations of approved Noise Management Plan.

Design Element	Provisions
Aircraft Noise Mitigation Requirements	A notification, pursuant to Section 165 of the Planning and Development Act 2005 is to be placed on the certificates of title of the proposed lots advising the lot is affected, or may in the future be affected by aircraft noise. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The wording of this notification is to be consistent with the wording specified in WAPC Model Subdivision Conditions or State Planning Policy 5.1. Additionally any specific Restricted Use provisions or condition of subdivision must also be complied with, where applicable.

1.4.4 Other Requirements

1.4.4.1 Subdivision Conditions

As part of any subdivision application, the WAPC will include as conditions of approval:

- Satisfactory arrangements being made in the form of a legal agreement between the City of Swan and the proponent for the rehabilitation and redevelopment of Jack Williamson Oval and surrounds to the satisfaction of the WAPC.
- The Jack Williamson rehabilitation works shall include a requirement for the proponent to plant a minimum of 100 trees and suitable maintenance arrangements being made with the City of Swan.
- The requirements for Restrictive Covenants to be entered into and placed on the certificate of title(s) for protection of mature trees on the proposed R10 lots and any other lots as applicable.

The following information may be required either to support a future development or subdivision application or, imposed as a condition of subdivision or development, to the satisfaction of the relevant authority:

- **Acid Sulfate Soil**

  Acid Sulfate Soil self-assessment and preparation of an Acid Sulfate Soil and Dewatering Management Plan.

- **Urban Water Management Plan**

  A Urban Water Management Plan generally in accordance with the District Water Management Strategy and Local Water Management Strategy.

  The Urban Water Management Plan should implement the environmental management framework for ground water and surface water within the site as set out under the DWMS and LWMS. It should also address the two proximate offsite environmental features located east and south-east of the LSP area in two local reserves, Jack Williamson Oval and Eveline Road Reserve, managed by the City of Swan.

  The UWMP should and reflect the updated modelling and recommendations of the LWMS including the Biophysical Assessment of the Blackadder Creek Tributary and the Threatened Ecological Community (TEC) (Corymbia calophylla – Xanthorrea preissii woodlands and shrublands located outside and abutting the LSP's eastern and south-eastern boundaries.

  The drainage system route identified in the UWMP is to follow the internal developable areas, comply with Aboriginal Cultural Heritage requirements and not directly overflow into TEC areas.

- **Threatened Ecological Community (TEC) (Corymbia calophylla – Xanthorrea preissii woodlands and shrublands Assessment.**

  Further investigation is required to locate the abutting TEC along the LSP's eastern and south-eastern boundaries, along with the extent of any required foreshore area. The investigation is designed to protect the identified nearby environmental features from potential development impacts.

- **Aboriginal Cultural Heritage Management Plan**

  Drainage and other works proposed in the adjoining reserve with the Blackadder Creek will be required to address Aboriginal Cultural Heritage requirements including consultation and potentially the preparation of a Tier 3 assessment and Aboriginal Cultural Heritage Management Plan.

- **Operational Policy 2.4 School Sites**

  In response to the WAPC Operational Policy 2.4 School Sites which commenced on 22 December 2022, the landowner will continue to liaise with the Department of Education to ensure the community's future educational needs are met.

1.4.5 Local Development Plans

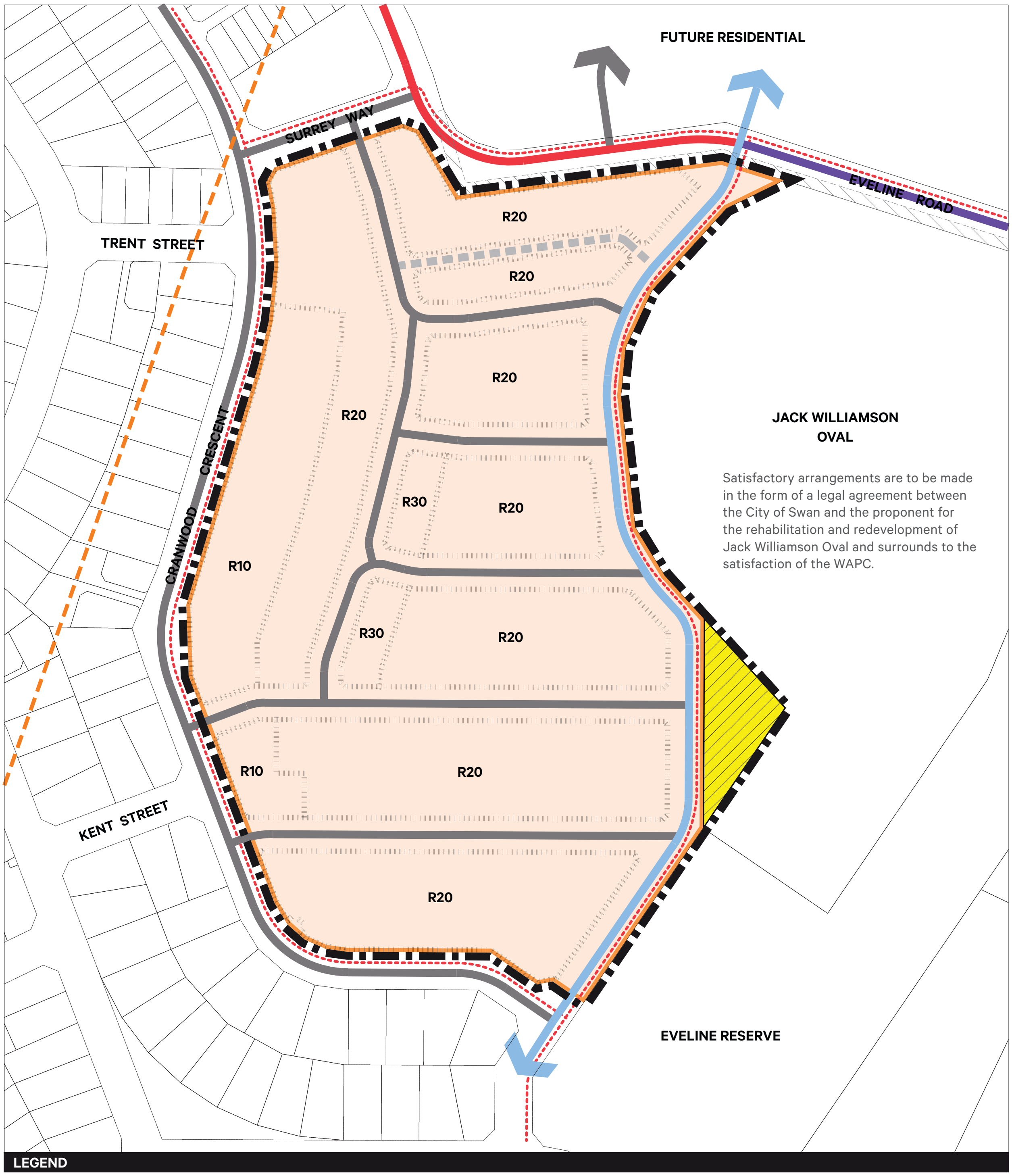
Local Development Plans (LDP) may be prepared for any area within the LSP which requires specific built form controls (specifically variations to R-Code provisions relating to setbacks, private open space, boundary walls, fencing and site requirements), as a condition of subdivision and shall be prepared and implemented pursuant to the provisions of LPS 17 and the *Planning & Development (Local Planning Schemes) Regulations 2015* (the Regulations). LDPs may address the following elements:

- Vehicle access and egress;
- Building orientation;
- Garaging;
- Setbacks;
- Open space;
- Tree retention and protection;
- Built form controls including street interface, and noise insulation measures as identified by the Noise Management Plan, as appropriate;
- Landscape lot requirements as identified in 1.4.3 Other Controls; and
- Setbacks and building controls for BAL-40 and BAL-FZ exclusion areas.

The LDP shall:

- ensure residential development meets community expectations regarding appearance, use and density;
- ensure designs respond to the natural and built features of the local context;
- ensure adequate provision of sunlight and natural ventilation for buildings and to limit the impacts of building bulk; and
- ensure open space (private and communal) is provided on site that is landscaped to enhance streetscapes, provides privacy, sunlight, and recreational opportunities.

Plan 1 – Structure Plan



LEGEND

Local Structure Plan Boundary

LOCAL SCHEME ZONES

Residential Development

LOCAL SCHEME RESERVES

Public Purposes - Drainage

NEIGHBOURHOOD AND KEY ACCESS STREETS

Neighbourhood Connector A

Neighbourhood Connector B

Access Street C

LOCAL ACCESS STREETS (Indicative and subject to change)

Access Street D

Laneway

OTHER

Gas Pipeline Easement

ANEF 20-25

R20 Residential Density

Shared Path

Draft Local Development Plan

LOCAL DEVELOPMENT PLAN - RIVERMARK AREA 3 SUBDIVISION (STAGES 1 & 2)

DRAFT

RESIDENTIAL DESIGN CODE VARIATIONS

Residential R20

The development standards applicable to R20 under *State Planning Policy 7.3 - Residential Design Codes Volume 1* (R-Codes) apply to lots designated a density code of R20 in this LDP with the exception of:

1. **Garages (Lots 121 - 132 and Lots 134 - 139)**
   A variation to Clause 5.2.1 Setbacks of garages and carports, Deemed-to-comply C1.3 applies to these lots. The variation requires garages or carports be setback 0.5m from the boundary.

Residential R20 - R30

The development standards applicable to R-MD-R30 under the *City of Swan Local Planning Policy: Variation to deemed-to-comply requirements of the R-Codes Medium Density Single House Development Standards* (POL-LP-011) apply to lots designated Residential R20-R30 in this LDP.

Tree Protection Provisions

Retained trees, as shown on the LDP map are identified indicatively. Tree retention and new tree planting is to support the protection of significant biodiversity values, the consolidation of fauna habitat and ecological linkages and the achievement of an urban canopy coverage across Area 3.

Best practice shall be implemented during subdivision and development stages to retain the trees identified on the LDP map. Factors that may mitigate retention include natural attrition, unintended impacts of servicing requirements, bushfire risk management, public safety and subdivision design or development requirements.

An Arborist Report shall be prepared to confirm tree Structure Root Zones (SRZ) and Tree Protection Zones (TPZ) in accordance with Australian Standards.

General

Minor variations to the requirements of this LDP may be approved by the City of Swan.
Unless otherwise defined on this LDP, all development shall be in accordance with the City of Swan Local Planning Scheme No.17.

Bushfire Planning Provisions

Residential Dwellings are not to be sited outside of the Bal-29 area as identified on this LDP.

DEVELOPMENT PROVISIONS

1. Quiet House Design
   The lots are situated in the vicinity of Perth Airport and may experience aircraft noise nuisance.
   Noise exposure levels are likely to increase in the future. It is suggested that landowners consider incorporating the following noise insulation in the construction of dwellings in accordance with the approved Noise Management Plan to reduce aircraft noise, however this is not mandatory:
   a) All external glazing to be minimum 6mm thick;
   b) External windows to habitable rooms be fixed or awning style;
   c) External sliding doors, bi-fold doors or similar to be fitted with acoustic seals; and
   d) Timber entry door or timber door to habitable rooms to be minimum 35mm thick, solid timber core with full perimeter acoustic seals.

2. Crossovers and Garages
   a) Designated crossover and garage locations apply to Lots as shown on the LDP map.
   b) On Lots with an indicative building envelope shown, the garage is to be located within the building envelope area.
   c) Garages on neighbouring lots are to be co-located where possible to promote visual diversity.

3. Other
   a) Affected lots are to orientate dwellings towards the Orientation Frontage as shown on the LDP map.
   b) Building envelopes as shown are indicative and will be further influenced by site-specific considerations and planning controls.

SUMMARY OF AMENDMENTS

No	Summary of Amendment	Date Endorsed
A		
B		

ENDORSEMENT PANEL

element.
the art and science of place

HESPERIA

Indicative Tree Protection Plan

Figure 1:	**Indicative Tree Retention Plan**	
Project:	Area 3 Rivermark	
Client:	Hesperia Pty Ltd	

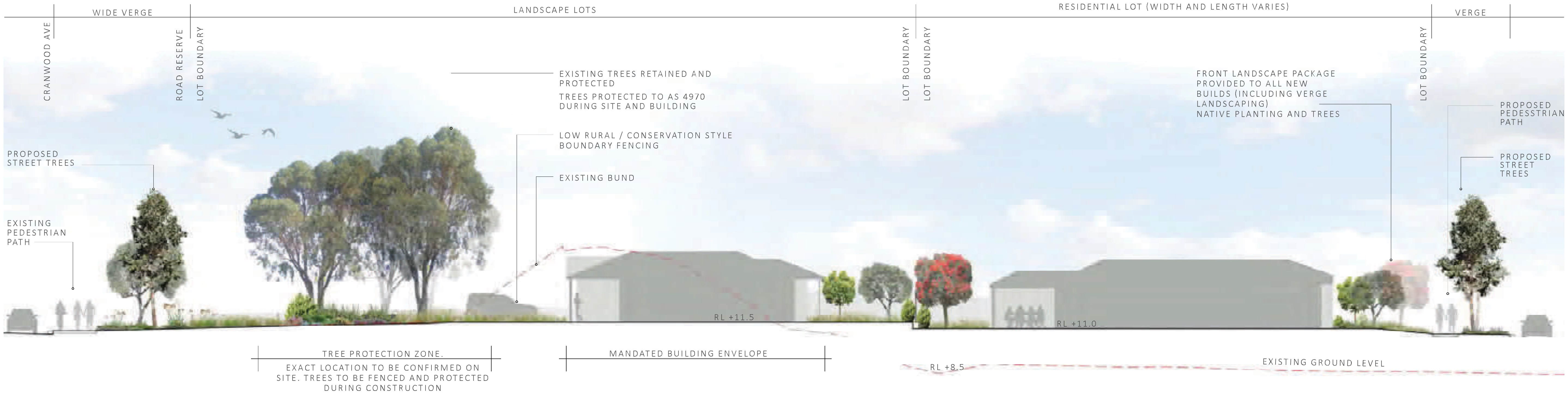
Plan Number:
EP19-105(54)--F354a
Drawn: GAR
Date: 28/02/2024
Checked: SPL
Approved: TB
Date: 28/02/2024

N

0 40 80
Metres
Scale: 1:2,000@A3
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Proposed Landscape Lot Interface



SECTION AA - (WESTERN INTERFACE)

Figure 3 Western

KEY PLAN

NOTE: PLAN AND SECTIONS ARE CONCEPTUAL TO PROVIDE THE INTENT RELATING TO RETAINED TREES AND BUILDING ENVELOPES. PLAN IS SUBJECT TO A FUTURE APPROVAL PROCESS.

RIVERMARK - LANDSCAPE INTERFACE

LANDSCAPE SECTION REVIEW

OCTOBER 2023

JOB NO. 2105504 C4.101 REV B

0 2.5 5 10 15 20m

PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au

Figure 1. Context Plan

PART 2

2. Explanatory Section

2.1 Introduction and Purpose

This report provides the planning rationale for the 'Rivermark Area 3 Local Structure Plan' (the 'LSP'). The LSP covers one land parcel comprised of approximately 10.02 hectares. The proponent of this LSP is Hesperia Projects on behalf of the landowner, Lot 9009 Middle Swan Pty Ltd.

This report explains and provides detailed planning justification in support of the LSP which applies to the south-western portion of the wider Midland Brick site, known as Area 3, located on Lot 9009 (DP 405292), Cranwood Crescent, Viveash.

2.2 Location and Context

The subject site is situated approximately 16 kilometres from the Perth Central Business District, 1.5 kilometres from the Midland City Centre and 8km to Perth Airport. The land is positioned in close proximity (a 1 km radius) of the regional movement corridors of Reid Highway and Great Northern Highway and regional open space along the Swan River and within a 2 kilometre radius of a range of education (La Salle College, North Metropolitan TAFE) and other regional level recreational facilities (Midland Sports Complex, Speed Dome, Swan Regional Recreation Park, Ray Marshal Park).

Refer to Figure 1 – Context Plan.

The LSP boundary is framed by existing Cranwood Crescent to the south and west, the new Eveline Road and Surrey Street (formerly York Street) to the north, and the Jack Williamson Oval to the east. These edges establish a clearly delineated development cell for future residential subdivision and development. Due to its defined edges and the established surrounding residential context, the LSP for Area 3 does not prejudice the future planning for the broader the brickworks site north of Eveline Road.

Refer to Figure 2 – Aerial Plan

Figure 2. Aerial Plan

The LSP shall facilitate the proponent's aspirations to develop the now redundant 'General Industrial' zone land for future Residential housing. The subject land has remained inconsistent with the MRS zoning of 'Urban' since 1964 when this zoning was gazetted. To date the City of Swan's Local Planning Scheme No.17 (LPS17) has remained inconsistent with the Metropolitan Region Scheme zoning of 'Urban' and retained a 'General-Industrial' zoning to date. A separate local scheme amendment has been progressed to rezone the site from 'General Industrial' to a 'Residential Development' zone.

The subject site contains an existing hardstand area (previously used for the storage brick pallets) and open storage ponds that currently discharges into a tributary of Blackadder Creek. The hardstand area is now redundant, with storage now moved to the north-east of Bassett Road.

2.3 Requirement for a Structure Plan

A Structure Plan is generally required to be prepared and approved prior to subdivision and development of the land where identified under a local planning scheme and in accordance with the *Planning & Development (Local Planning Schemes) Regulations 2015*.

A Structure Plan is required in line with the 'Residential Development' zone under the City of Swan LPS17. The LSP is informed by a comprehensive review of town planning, environmental, and engineering considerations and has been prepared in accordance with the provisions of the Planning and Development (Local Planning Schemes) Regulations 2015 Schedule 2 Part 4 'Structure Plans'.

The LSP has been prepared on behalf of the proponent following preliminary discussions held with key stakeholders, including the City of Swan.

Regeneration of a scarred landscape:
The proposed redevelopment of the brick works will heal the existing predominately hardstand landscape into a stunning residential community which reconnects people to the river, new local amenities, and establishes networks of new tree lined avenues between parklands.

Existing Site Condition

2.4 Site Details

The subject site is Lot 9009 Cranwood Crescent, Viveash The site covers an area of 10.02 ha and has an irregular shape that follows the alignment of Cranwood Crescent to the west and south and Jack Williamson Oval and Eveline Road to the east/north-east.

In August 2020, the WAPC approved a 60 lot subdivision (WAPC Ref 158848) located to the north-west of the subject site. Known as Areas 1 and 2, the residential subdivision also incorporated the northern most portion of Lot 9009 including the extension of Eveline Road. At the time of print the Eveline Road reserve extension had not been created, so the existing boundary of Lot 9009 remains.

The brickworks site has been largely cleared and modified for the purpose of industrial manufacture of bricks and masonry products. The majority of the subject site is relatively level with an elevation of 9.0 to 10.0m AHD, with the exception of the western bund. The existing levels outside of the bund are generally consistent with Cranwood Crescent. The current use and appearance of Lot 9009 replicates the condition of the brickworks land but also includes additional man-made features, such as:

- Large modified flat hardstand areas used for the storage of bricks.
- A vegetated soil bund that varies between 14m and 16m AHD along the western boundary. The bund was originally established to manage visual, acoustic and dust relief to the brickworks operations. The vegetation is planted and comprises mostly regrowth. Now that the brick works operations have been relocated, the bund is no longer required.
- A combination open / pipe drain on the eastern side of the bund which accommodates minor stormwater event flows from the northern storage ponds and connects it to a series of storage ponds that ultimately discharges into a tributary of Blackadder Creek. The pipes and southern storage ponds (a temporary drainage basin) on Lot 9009 form part of a stormwater management system introduced in 2020 to attenuate stormwater and avoid it from being discharged into the Swan River.

2.4.1 Site Tenure

The subject site is owned by Lot 9009 Middle Swan Pty Ltd. The following table summarises the property details.

Lot	Volume / Folio	Plan / Diagram	Area (Ha)	Landowner
9000	2905 / 766	P405292	Title Area: 11.4315 ha Structure Plan Area: 10.02ha	Lot 9009 Middle Swan Pty Ltd

Lot 9009 is subject to encumbrances, including an easement (B929287) registered to the WA State Energy Commission, now Alinta Gas, for the purpose of laying, constructing gas pipelines and other apparatus. The easement is located outside of the proposed rezoning area, running west following the existing alignment of Eveline Road and dog legs north connecting with the intersection of Surrey Way. Lot 9009 is also burdened by the following encumbrances:

- Memorial (M562964) relating to the Contaminated Sites Act 2003
- Various (12) Restrictive Covenants

2.5 Surrounding Land Uses

North

Lot 72 (No. 72) Eveline Road, Middle Swan is located to the north-east. This land, together with Lot 9007 Great Northern Highway formed the original Midland Brick brickworks site, which was established in the 1950s on what was then rural land. For over 70 years the brickworks site which was owned up until recently and is still operated by Midland Bricks, has been used for brickmaking.

In the 1960s, the land located adjacent to Cranwood Crescent was subdivided into 49 residential lots and a network of internal residential roads, including Lot 167 Surrey Way, however the lots were not physically created.

As part of the broader redevelopment strategy for the brickworks site, which includes retaining the operational capacity of the brickworks on a consolidated and rationalised footprint, and following the recent sale of the land to the landowner, the Midland Brick operations will contract to the east, concentrating on Lots 9007 and 111.

The western portion of the brickworks site, Lot 9009 and Lot 72 Eveline Road, Viveash will become available for urban renewal in line with the recent 2021 MRS 'Urban' rezoning request (currently under WAPC assessment) and recent 2020 subdivision approval for Areas 1 and 2.

The current MRS amendment proposal will facilitate the future transformation of the area north of Eveline Road into a vibrant and diverse residential community with landscaped public parkland including land along the Swan River foreshore.

In 2020 the WAPC approved a 60 lot residential subdivision over portions of Lot 72, Lot 23 and Lot 9009, including some of the land previously the subject of the 1960s subdivision. The 2020 approval created the internal subdivision roads known York Street (recently changed to Surrey Street) and Somerset Street (recently changed to Eveline Road) which also forms the north-west boundary to the subject site.

East

The existing Jack Williamson Oval (formally Reserve R29036 vested in the City of Swan) and the associated vegetated corridor Reg Bond Reserve, Reserve 29037, forms the eastern and south-eastern boundary respectively. A small portion of the Jack Williamson reserve is currently being used by a volunteer bicycle repair group, with other small areas utilised for unsealed hardstand overflow storage by the City of Swan. The site was previously used by a local football club however due to geo-technical challenges affecting the quality of the playing surface and unstable club room foundations, the club relocated. Further to the south-east is La Salle College and the former Swan District Hospital which is planned to be redeveloped for a residential aged care, a local recreation reserve, and potentially residential at an R20 density.

West / South

The land follows the crescent shape of Cranwood Crescent which forms the western and southern site boundary. The established residential suburb of Viveash is located to the west of Cranwood Crescent predominantly comprising single residential lots with a density of R20 or split density R20/R35.

2.5.1 Existing Use

The subject site contains an existing hardstand area (previously used for the storage brick pallets) and open storage ponds that currently discharges into a tributary of Blackadder Creek. The hardstand area is now redundant, with storage now moved to the north-east of Bassett Road. This has resulted in relocating trucks and associated operational noise over 1km away to the north-east.

The pipes and southern storage ponds (which are temporary drainage basins) form part of a stormwater management system introduced in 2020 to attenuate stormwater and avoid it from being discharged into the Swan River.

A vegetated soil bund that varies between 14m and 16m AHD along the western boundary, near Cranwood Crescent, is planted vegetation and comprises mostly regrowth.

RIVERMARK

· VIVEASH ·

Parks and Conservation

1 Reg Bond Reserve
2 Jack Williamson Park
3 Ray Marshall Park
4 Woodbridge Riverside Park
5 Blackadder Creek
6 Swan Regional Recreation Park
7 Speed Dome
8 Midland Sports Complex
9 Jack Mann Oval
10 Middle Swan Reserve

Dining and Wineries

23 Sandalford Wines
24 Mandoon Estate
25 Homestead Brewery
26 Riverbank Estate Winery
27 Bolt Coffee Roasters
28 New Ritual Cafe
29 The Colony of Midland
30 Crooked Spire Coffee & Art House
31 Syd & Phyllis

Education

11 La Salle College
12 Governor Sterling Senior High School
13 Woodbridge Primary School
14 Guildford Grammar School
15 Midvale Primary School
16 North Metropolitan TAFE Midland
17 Swan Christian College
18 Caversham Primary School

Health Care

32 North Street Medical Centre
33 Masonic Aged Care Facility
34 Swan Medical Group
35 St Andrews Medical Group - Midland
36 HealthState Midland
37 Talem Medical Group
38 St John of God Midland Public and Private Hospitals
39 Midland Medical Specialists

Shopping and Fresh Produce

19 Midland Gate Shopping Centre
20 Centrepoint Shopping Centre
21 Gilbert Fresh Market
22 Midland Home Shopping Centre

Transport

40 Midland Station
41 Woodbridge Station
42 East Guildford Station
43 Local Bus Stop - 297, 310, 311, 335

Map Key

- Parks and Conservation
- Education
- Swan Valley Wine Region
- Bus Stop
- Train Station
- Hospital
- Bus Route
- Train Line
- Principle Shared Path

Local Amenities Plan

2.6 Coordinated Redevelopment Framework for the Brickworks Site (North of Eveline Road)

After more than 70 years of brick works operations, the proponent is pursuing an opportunity to strengthen the brickwork's long-term sustainability by improving operational efficiencies. Following the recent sale of the land to the landowner, a broader redevelopment framework has been developed for the original brickworks site. The strategic framework involves two core strategies, including:

- Retaining the operational capacity of the brickworks (Lot 9007 and Lot 72) on a consolidated and rationalised footprint to be concentrated on Lot 9007 Great Northern Highway and Lot 111 (Cement Masonry Paver operations).
- Opening up the western portion of the brickworks site for renewal and transformation into a vibrant and diverse residential community with landscaped public parkland including land along the Swan River foreshore.

The proponent has leased portions of the brickworks site to BGC. A general summary of the lease arrangements is provided below and on *Figure 3*:

- The existing brickworks site area subject of this LSP (Area 3) is no longer used for industrial purposes.
- BGC access has now reverted to the Clay Shed lease area (Area C), the Masonry Facility area (Lot 111) and the kiln 9 and 10 lease area (Area B1 and B2). That is, the only brickwork related activity south of Bassett Road will be the Clay Shed.
- The current Clay Shed lease is for a period between 5 and 10 years. Kiln 11 has ceased operations.
- The Masonry Facility is a standalone title and is envisaged to operate into the long term.
- The Kiln 9 and 10 lease area is for a period between 5 and 15 years.

Refer to Figure 3 – Lease Arrangements

The redevelopment of the broader brickworks site is to be realised through a series of separate and orderly development processes, some of which have already commenced. These include:

Phase 1: A 60 lot-subdivision (WAPC Ref 155848) approved in August 2020 over Lot 23 and 72 Eveline Road, Middle Swan and Lot 9009 Cranwood Crescent. The approval partially replaces the unconstructed subdivision approval from the 1960s. Titles for Area 1 residential lots have been released.

Phase 2: A request was lodged with the WAPC in 2020 to rezone portions of Lots 9002 and 72 Eveline Road from 'Industrial' to 'Urban' under the Metropolitan Region Scheme (MRS). In September 2021, following pre-referral feedback, an updated MRS amendment report was lodged with the WAPC. WAPC's initiation of the MRS amendment is anticipated to occur by mid-2024.

Phase 3: A proposed future amendment to LPS 17 to rezone Lots 9002 and 72 Eveline Road (land to the north of Eveline Road) from' Private Clubs & Institutions' and 'General Industry' to a suitable residential zone. This amendment is likely to be processed concurrently with the currently active MRS amendment during 2024 (this will be subject to a future planning process, which includes advertising requirements by the City of Swan and final approval by the WAPC).

Phase 4: The preparation of a local structure plan over Lots 9002 and 72, for the land located to the north of Eveline Road, in line with the provisions of a suitable residential zone under LPS 17. The preparation of the structure plan is likely to be processed concurrently or in close succession with the proposed MRS amendment in mid-2024 and would:

- Coordinate the development of future residential areas via a comprehensive plan for the land area north of Eveline Road that guides subsequent subdivision for residential lots, public open space and a regional reservation along the foreshore.
- Provide for predominantly residential development as well as compatible services, consistent with the needs of an integrated neighbourhood, and planned so as to minimise adverse impacts on amenity.
- Account for the need to protect the amenity and on-going use of adjacent property owners and provide for future residential amenity.

Phase 5: Subsequent subdivision applications for Lot 9002 and Lot 72 Eveline Road, north of Eveline Road, in line with the approved structure plan, to follow from 2024-2025.

The staged coordination of the redevelopment of the brickworks site is depicted in Figure 4 – Staged and Co-Ordinated Redevelopment Framework Plan. The proposed Area 3 structure plan, the subject of this report, will be progressed independent of the above mentioned phases.

Refer to Figure 4 – Staged and Co-Ordinated Redevelopment Framework Plan

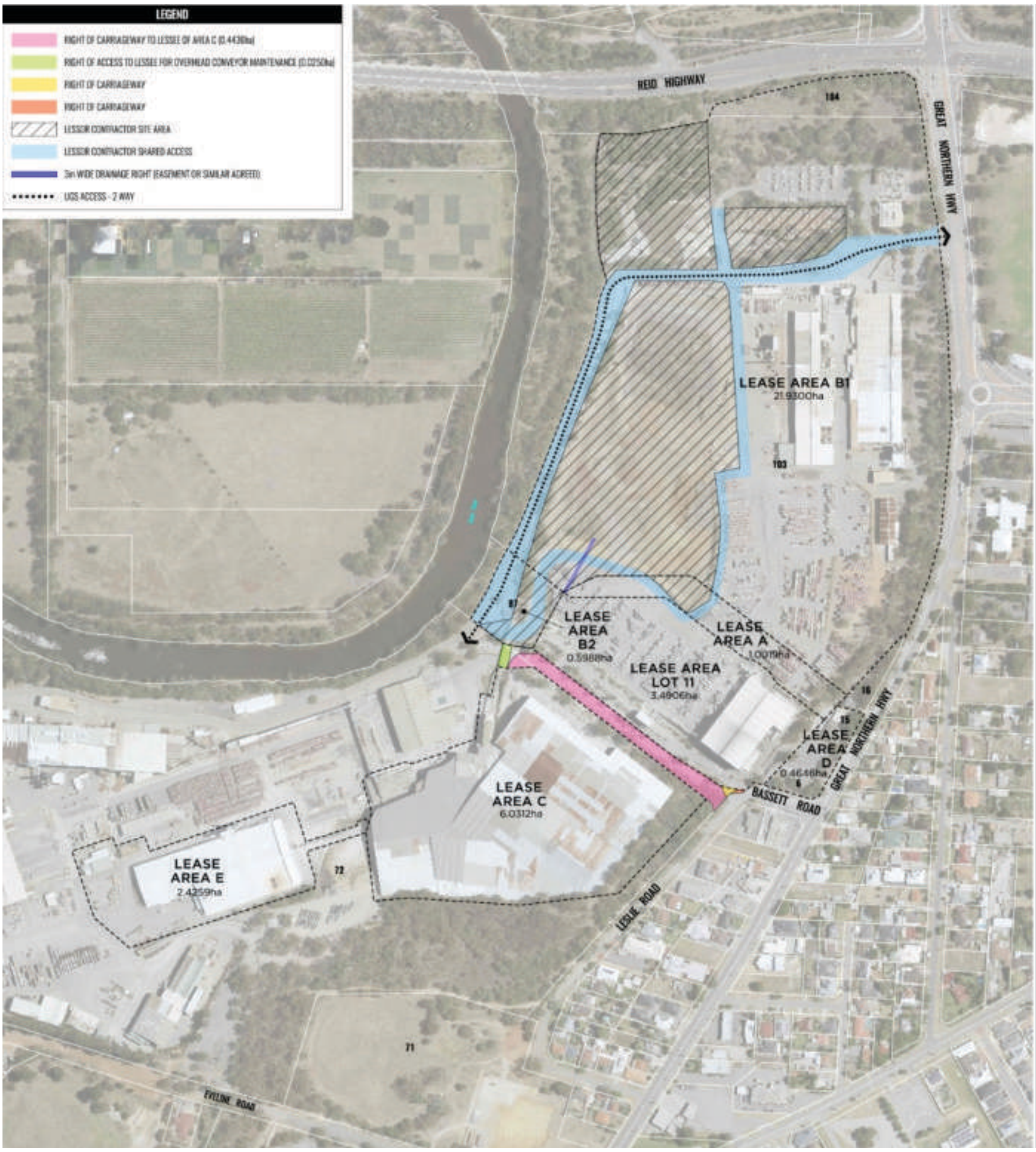
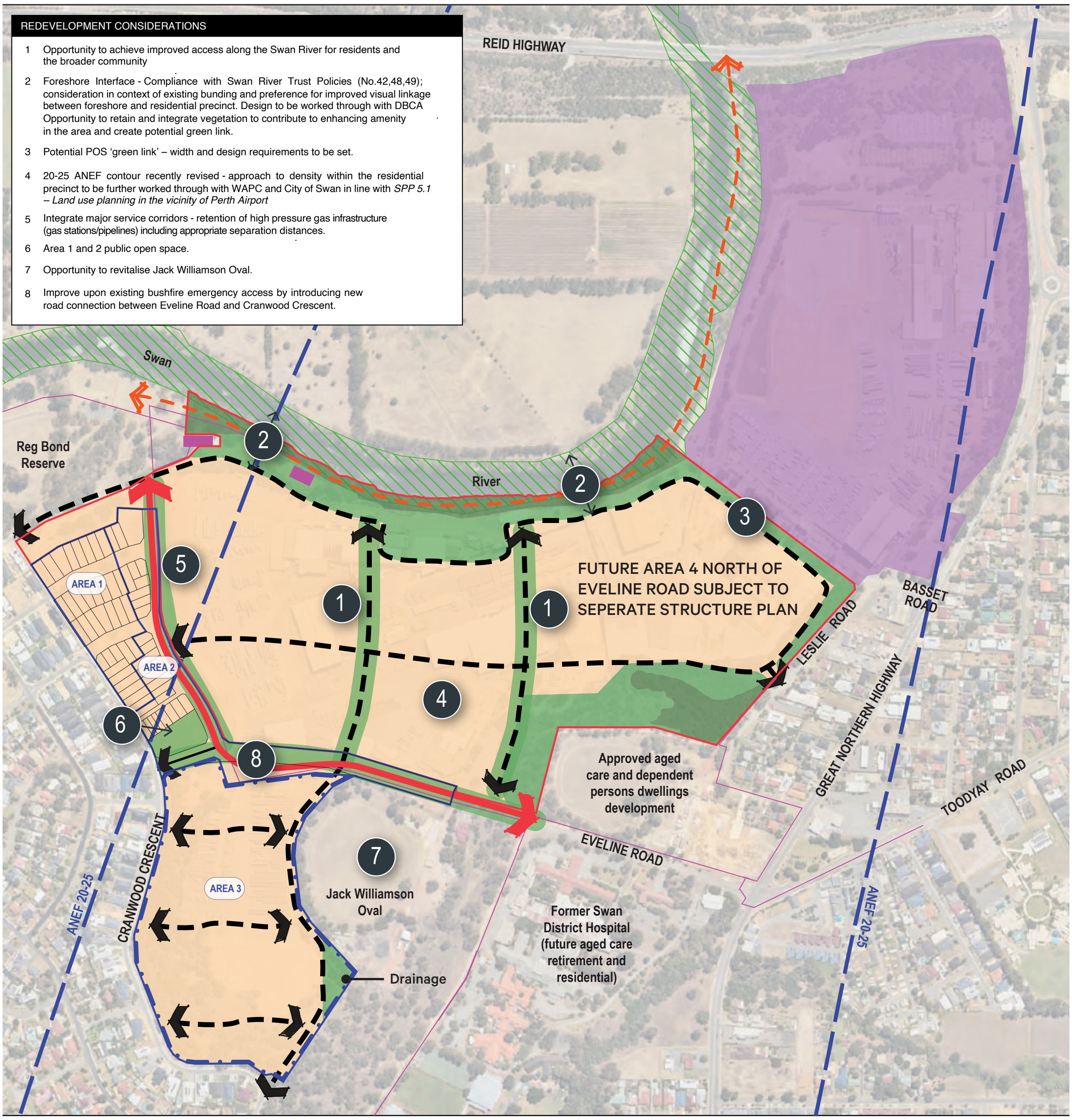


Figure 3. Lease Arrangements



KEY

- Subject site
- Stage area
- Area subject of future structure plan
- Consolidated brickworks site
- Residential precinct
- Future foreshore / vegetation to be retained
- Potential open space / corridors
- Bush Forever
- 20-25 ANEF Contour
- Existing gas station/pipeline
- Neighbourhood connector road (WAPC approval ref: 158848)
- Indicative access roads
- Potential dual use path

source: landgate

Figure 4. Staged and Co-Ordinated Redevelopment Framework Plan

2.7 Prescribed Premises Licence and Ministerial Statements

The brickworks operates under DWER Part V EP Licence L4511/1967/13. The historical expansion of the Midland Brick operations was also assessed under Part IV of the EP Act, and approved subject to a number of conditions (Ministerial Statements 322 and 1124). This structure plan proposal area is currently located within the boundary of Ministerial Statement 1124. On 30 August 2021 DWER issued an amendment to the Licence which removed Kilns 7 and 8 located near the northern boundary of Lot 103 (for their permanent decommissioning). In addition, Kiln 11 has now been decommissioned.

2.8 Subject Site

This section demonstrates there are no significant constraints to urban development which cannot be adequately addressed. A Site Considerations plan is provided in Figure 5.

Refer to Figure 5 – Site Considerations

2.8.1 Landforms and Topography

A detailed topographic survey for the site was completed by MNG on 11 July 2019, indicating the current surface elevation varies from approximately:

- 16.75 metres relative to the Australian Height Datum (AHD) at the top of the western bund along the western boundary of the site.
- 8.5m AHD in the central portion of the site in the vicinity of the brick storage area.
- 9.25m AHD along the north boundary of the site.
- 15.0m AHD at the top of the western bund along the south-eastern boundary of the site.
- 7.0m AHD at the base of the southern storage ponds in the south portion of the site.

The western bund and southern storage ponds resulted in relatively steep soil batters along the alignment of these features, particularly the western bund. The bund is up to approximately 5 metres (m) in height relative to the ground surface in the adjacent suburb of Viveash and is located along the western, southern and south-east site boundary. Shallow excavations have been undertaken to construct the southern storage ponds.

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

Detailed soil mapping DMIRS (2018) shows that the site is underlain by the soil Mgs1-pebbly silt soil type, described as 'strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin'.

The regional mapping shows land to the south, east and north of the site is likely to comprise pebbly silt (soil unit MGS1) similar to that mapped for the site. Regional mapping shows land to the north of the site (along the general alignment of the Swan River) is likely to comprise clayey silt.

The site is not known to contain any restricted landforms or unique geological features. A review of DWER mapping also indicates that the site is not identified within an area of ASS risk.

Refer to Figure 6 – Existing Contours

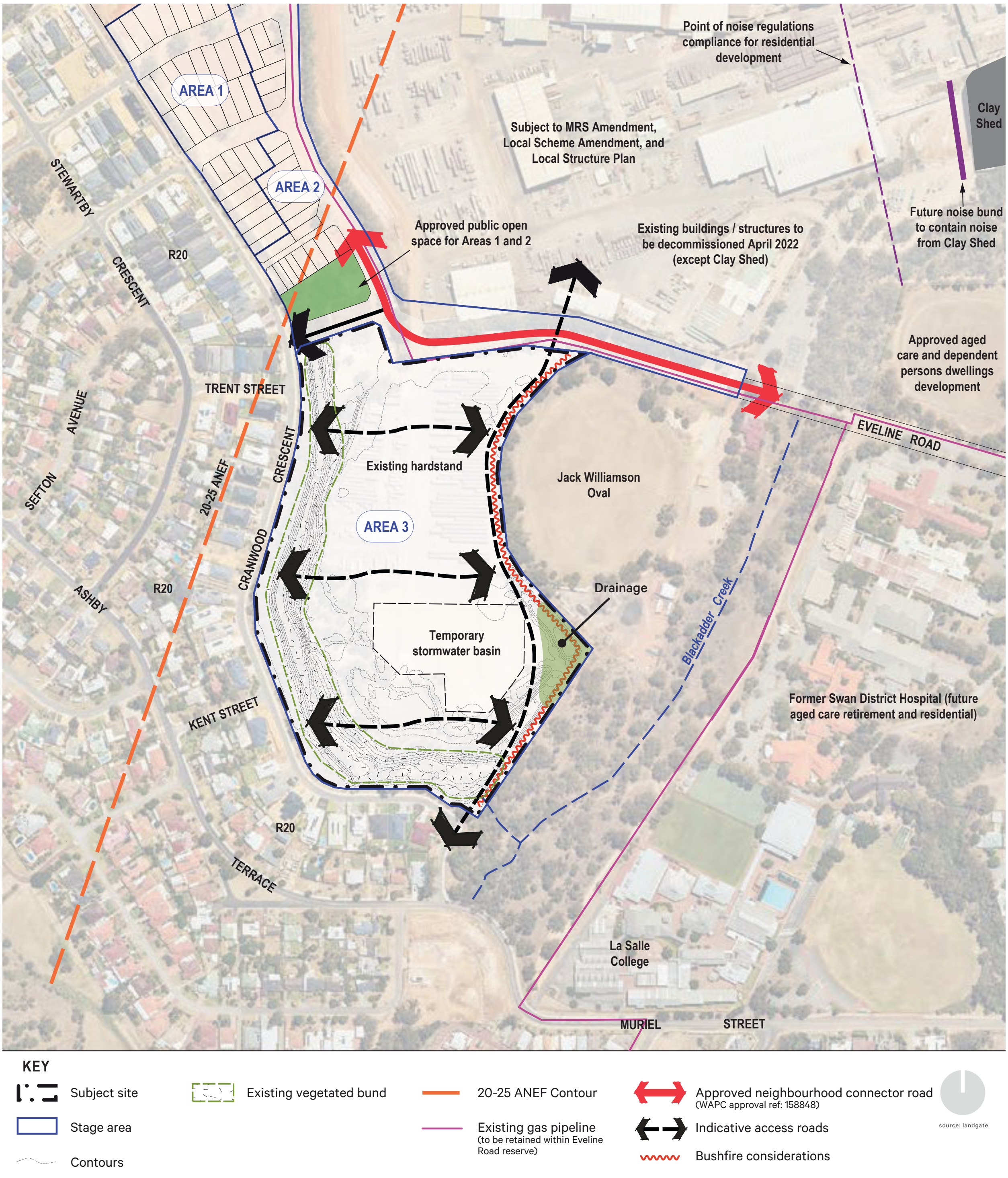


Figure 5. Site Considerations

Figure 6. Existing Contours (Source: Hyd2o, 2022)

2.9 Environmental Considerations

The site has been subject to historical disturbance and modification given past vegetation clearing, and agricultural and brick-making activities. It does not include any Bush Forever sites, Environmentally Sensitive Areas (ESAs) or Local Natural Areas. An Environmental Assessment Report was prepared to support the proposed structure plan. A summary of the key points is provided below.

Refer to Appendix A - Environmental Assessment Report

2.9.1 Flora and Vegetation

A review of publicly available aerial imagery indicates the majority of the site was cleared of native vegetation prior to 1953, likely for grazing and subsequently for brick making, with the exception of the patch of remnant vegetation within the western portion of the site adjoining the oval (Landgate 2021).

Clay quarrying within the site occurred between circa 1965 to circa 1981, after which the clay pits were decommissioned, filled and utilised as hardstand areas for brick storage since circa 1987. The south western storage ponds were constructed circa 2000. Some additional tree planting has occurred since the initial clearing along Eveline Road to the north of the site and surrounding the perimeter of Jack Williamson's oval.

A detailed flora and vegetation assessment was undertaken by Emerge Associates (2020) over the broader Midland Brick landholdings, encompassing the site. The assessment indicated the site has been subject to long-term disturbance and modification, and as such is dominated by planted non-endemic vegetation with scattered occurrences of remnant native trees and native regrowth. Vegetation is limited to the western portion of the site representative of two plant communities, extending over 4.56 ha in 'degraded' condition. The majority of this area comprises planted non-endemic vegetation associated with the western noise bund, with occasional remnant native trees. The remaining 5.40 ha comprises hardstand areas and stormwater storage ponds in 'completely degraded' condition.

Refer to Figure 7 – Plant Communities and Figure 8 – Vegetation Condition.

2.9.2 Threatened Ecological Communities

The flora and vegetation survey undertaken by Emerge Associates (2020) determined that all plant communities within the site have been subject to a high level of historical disturbance through vegetation clearing and industrial land uses and are present in a 'degraded' or 'completely degraded' condition. The survey concluded that the plant communities within the site have been altered, are no longer intact and do not represent a listed community. Therefore, no Threatened or Priority Ecological Communities (TECs or PEC's) occur within the site. Further investigation is required to locate the abutting TEC along the LSP's eastern and south-eastern boundaries, along with the extent of any required foreshore area. The investigation is designed to protect the identified nearby environmental features from potential development impacts.

2.9.3 Significant Flora

No threatened or priority flora species were identified within the site during the field surveys, nor has any suitable habitat been identified for these species within the site. Rather, the flora and vegetation assessment recorded a high weed coverage within disturbed areas synonymous with a degraded condition.

Should bulk earthworks or any other works be commenced within the site that requires clearing of native vegetation before subdivision approvals are obtained, a clearing permit pursuant to Part V of the EP Act will be required. Subdivision approval and associated authorised subdivision works will otherwise provide an exemption from the requirements for a clearing permit.

Plant community	Description	Area (ha)
Ec	Woodland to tall shrubland of various planted species, particularly *Eucalyptus camaldulensis*, with scattered *E. rudis* over shrubland *Genista linifolia* and *Melaleuca viminea* over closed non-native grassland with occasional scattered *Rytidosperma setaceum*	4.54
Ew	Woodland *Eucalyptus wandoo* over open non-native grassland.	0.02
Non-native/cleared	Heavily disturbed areas comprising planted non-native trees and shrubs over non-native herbs and grasses, with occasional native shrubs and forbs.	5.40

Figure 7a. Plant Communities (Source: Emerge, 2022)

Figure 7b. Tree Locations (Source: Emerge, 2022)

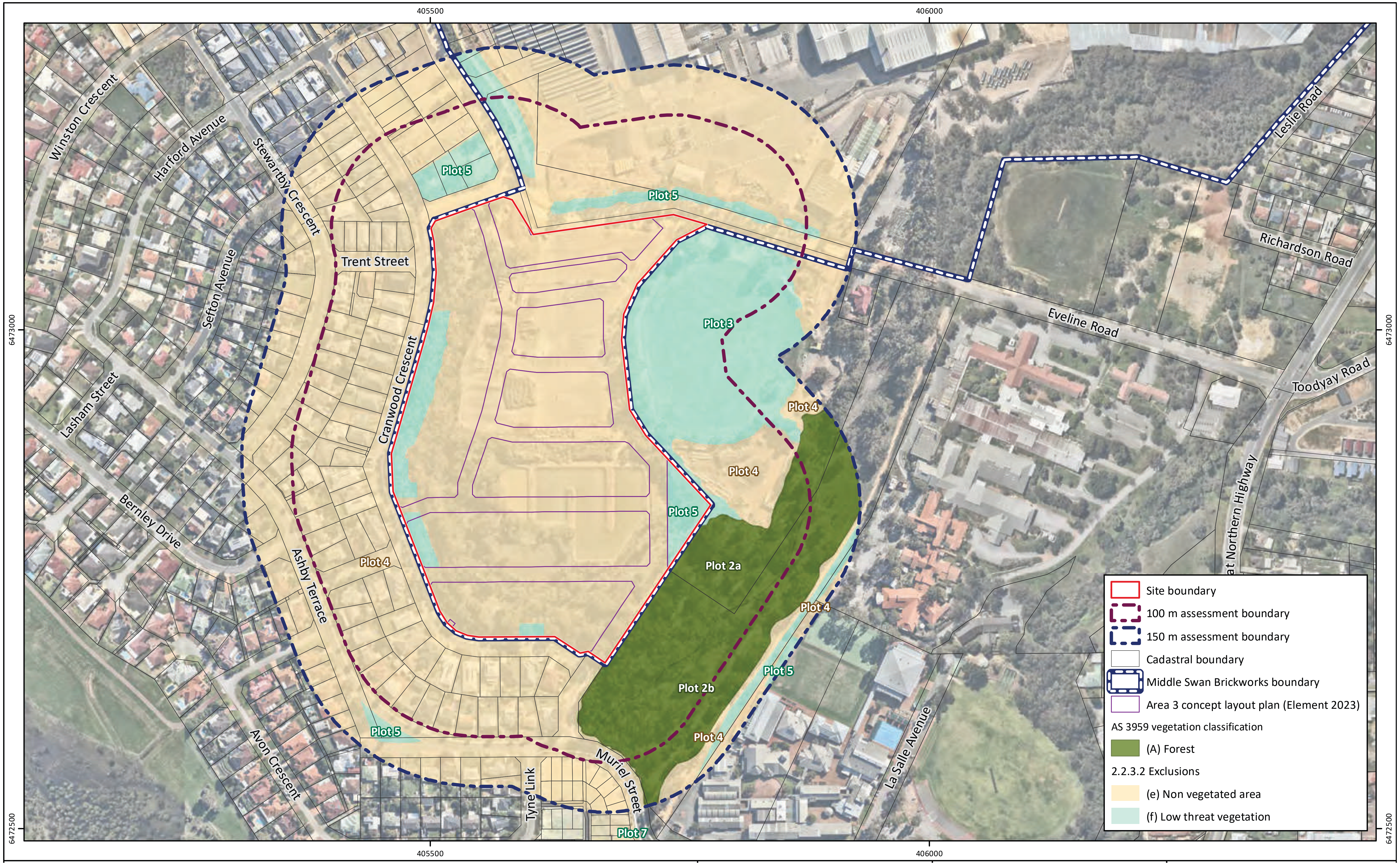


Figure 8. Vegetation Condition (Source: Emerge, 2022)

2.9.4 Fauna Habitat

Fauna habitat within the site is limited to scattered trees and small pockets of remnant vegetation which have been subject to significant historical disturbance. The site provides 0.02 ha of potential foraging habitat for black cockatoos as well as three potential black cockatoo habitat trees, none of which contain potentially suitable nesting hollows. Given the limited fauna values identified within the site, future residential development is unlikely to give rise to a significant adverse impact.

Breeding habitat

Trees of species known to support breeding of the black cockatoos within the known range of these species which either have a suitable nest hollow or are of a suitable diameter at breast height (DBH) > 500 mm (or > 300 mm for salmon gum and wandoo), are considered to represent potential breeding habitat trees. A total of 26 potential black cockatoo habitat trees were recorded in the site none of which contain potentially suitable nesting hollows, as shown in Figure 9.

There are no Carnaby's cockatoo confirmed breeding sites within a 6 km radius of the site. One breeding site is located within 12 km to the west of the site, associated with the Darling Scarp.

Roosting habitat

Patches of native and non-native trees within the site have the potential to provide roosting habitat for species of black cockatoo. No evidence of black cockatoo roosting, such as branch clippings, droppings and moulted feathers was observed within the site.

Records of black cockatoo roosting sites across south-west Western Australia are maintained by Birdlife Australia, utilising annual community surveys as part of the Great Cocky Count (GCC). Based on the most recently published 2019 GCC report, the site does not contain any confirmed black cockatoo roosting sites. A number of potential roost sites are mapped as occurring near the site; however, no birds have been recorded at most of these sites. The closest known roost site where birds have been recorded is located approximately 6 km west of the site. This roost site is associated with forest red-tailed black cockatoos.

However, that notwithstanding, the assessment identified three habitat trees, albeit without suitable nesting hollows, at the northern and southern ends of the western vegetated bund on Lot 9009. Consideration will be given to retaining these trees within future road reserves, and or future residential lot boundary setbacks subject to further detailed investigation, expert advice and having regard to mitigating factors.

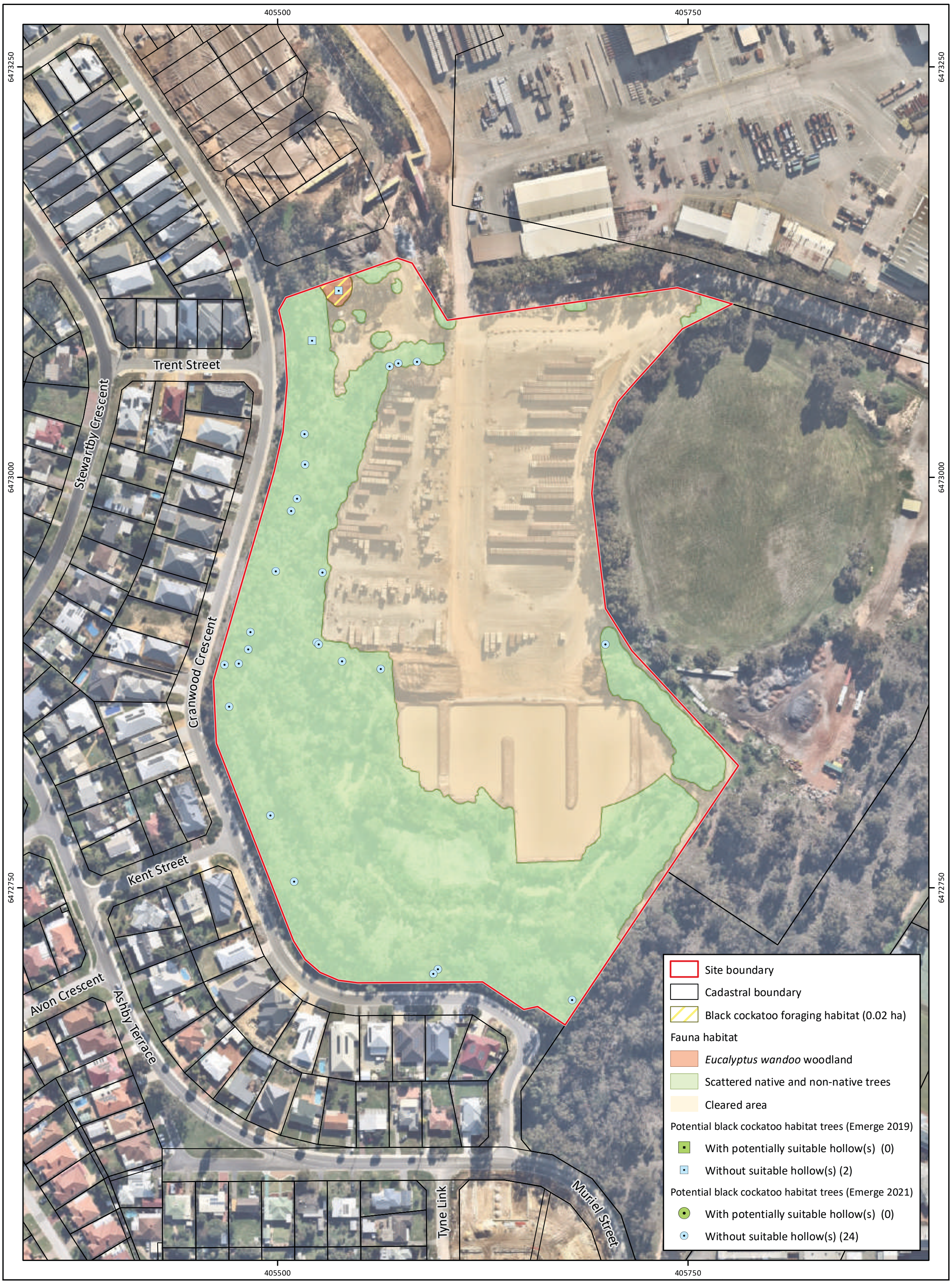


Figure 9. Fauna Habitat and Black Cockatoo Habitat Trees (Source: Emerge, 2022)

2.9.5 Wetland and Conservation

In 2022 in preparation of the LWMS for the LSP, Emerge undertook a biophysical assessment of Blackadder Creek Tributary. It found:

- There is no riparian vegetation or riparian wetlands that extend into the LSP area.
- The 1% AEP floodplain for the Blackadder Creek tributary does not extend into the LSP area.
- The landform and soils within the LSP area have been substantially modified given historic industrial brickworks uses.
- At its closest, the Blackadder Creek Tributary is situated 43m from the LSP area, extending to a separation of 91m at the south-eastern boundary.
- The Blackadder Creek tributary is located in a vegetated corridor that provides separation from the LSP area and the proposed change in land use.

Wetlands

A review of the Department of Biodiversity Conservation and Attractions (DBCA)'s Geomorphic Wetlands of the Swan Coastal Plain dataset indicates that no geomorphic wetlands are mapped as occurring within the site. The Swan River Estuary Conservation Category Wetland (CCW) (UFI 14 356) occurs approximately 450 m to the north of the site. One Multiple Use Wetland (MUW) has been identified to the north of the site extending over a large area (106.74 ha).

No other wetlands of conservation significance are mapped as occurring within 1 km of the site.

Surface Water features

No natural surface water features have been identified within the site; however, the Swan River is located directly approximately 450 m to the north of the site and a tributary of the Blackadder Creek which in turn is a tributary of Swan River is located to the south of the site. Due to clay soils onsite infiltration is limited and stormwater is currently managed through offsite discharge. The current stormwater system on site comprises various storage ponds for attenuation and settlement of stormwater and a series of outlets to the Swan River and Blackadder Creek tributary.

A series of stormwater settlement ponds are located within the south-western portion of the site to treat stormwater before it is discharged to Blackadder Creek. Surface water is intermittently present in the southern storage ponds, predominantly during winter. The stormwater settlement ponds are part of the stormwater infrastructure present across the entire Midland Brick landholding extending further to the north of the site to manage stormwater collection, storage and disposal.

2.9.6 Groundwater and Stormwater Management

Groundwater

Groundwater is hydraulically connected with the Swan River and expected to flow towards the river, generally in a northerly direction. Perth Groundwater Atlas (2004) indicates that the groundwater levels beneath the site ranges from 1m to 2m AHD, with groundwater flow generally in a westerly direction towards the Swan River. Groundwater levels in the Atlas are representative of typical end of summer groundwater levels and are subject to variation due to the influence of rainfall, temperature, tides, local drainage and the seasons.

Based on the existing data, Consultant Hydrologist, hyd2o have calculated the estimated average annual maximum groundwater levels (AAMGL) for the brickworks landholding and site which are shown below. Hyd2o also noted that perching of groundwater appears to be occurring at some bores due to their proximity to existing stormwater attenuation areas.

Surface Water

No surface water features have been identified within the site; however, the Swan River is located to the north and north-west, and a tributary of the Blackadder Creek which in turn is a tributary of Swan River is located to the south of the site. Stormwater is currently treated within the site and discharged to the Swan River via the Blackadder Creek. During extreme events, stormwater can overly flow directly to the river.

The Swan River 1% Annual Exceedance Probability (AEP) levels adjacent to brickworks range from 5.7 mAHD near the downstream boundary to 6.0 m AHD at the northern boundary. These levels have been recently updated by DWER based on an updated flood study of the Swan River (BMT WBM Pty Ltd, 2017). These levels supersede previous estimates and are approximately 1m lower than those of the previous 1985 flood study.

With respect to the Blackadder Creek Tributary, the 1% AEP level value at the confluence of the Blackadder Creek and the Blackadder Creek Tributary near Area 3 is shown as 6.43 m AHD.

Existing Stormwater Management

Due to the presence of clay soils, infiltration is limited and stormwater is managed through offsite discharge. The brickworks landholding's current stormwater system comprises various storage ponds for attenuation and settlement of stormwater and a series of outlets to the Swan River and Blackadder Creek tributary.

The majority of stormwater from the brickworks landholding (outside Area 3) flows to an existing sump, via a 1.8-hectare open water body, where it is then pumped to the storage ponds in the north west of the site and brickworks landholding. Water then flows south along the western boundary of the site, entering a further series of storage ponds (located within the southern portion of Area 3) and ultimately discharging to a tributary of Blackadder Creek, in the southwest corner of the site and landholding. Major events have an outlet to the Swan River.

Identified Actions At Subdivision Stage:

The LWMS provides for the environmental management framework for ground water and surface water within the site. It is anticipated that future subdivision will be conditioned to require the preparation of an Urban Water Management Plan.

Although the biophysical assessment of Blackadder Creek Tributary concluded the LSP poses no risk of impacts to the tributary and that existing setbacks to the confirmed adjacent Threatened Ecological Community (TEC) are adequate, it did identify an opportunity to improve the LSP's existing interface and relationship with the Blackadder Creek Tributary. The assessment recommends further investigating the definition and extent of a tributary foreshore, to be managed under a Foreshore Management Plan, prepared at the subdivision stage.

2.9.7 Bushfire Management

Whilst the site is identified as bushfire prone by the Map of Bush Fire Prone Areas (OBRM 2020) and a Bushfire Management Plan has been prepared to support the proposed structure plan, future subdivision and development is capable of satisfying the requirements of SPP 3.7 and the associated guidelines.

Refer to Appendix B - Bushfire Management Plan.

The BMP has considered the proposed development of the site and includes an assessment of vegetation within and surrounding the site to determine applicable bushfire hazards. The proposed eastern drainage area is to be managed to a 'low threat' standard (classified as Grassland). External to the site, the vegetation classified as 'forest' to the east of the site will remain a bushfire risk to future urban development. The proponent has entered into an agreement with the City of Swan that will result in the Jack Williamson Oval to be upgraded and achieve a low threat in accordance with clause 2.2.3.2 (f) of AS 3959. This will be managed by the City of Swan.

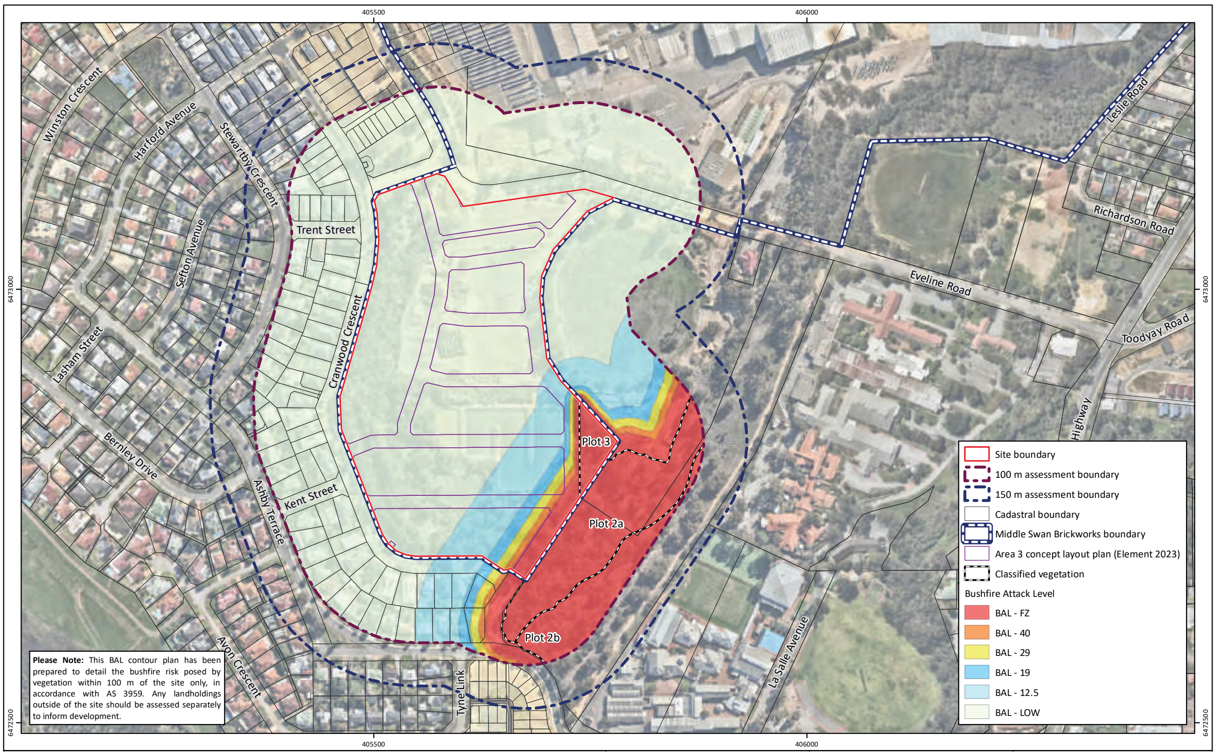


Figure 10. Bushfire Attack Level Contour Plan (Source: Emerge, 2022)

It has determined that the retention of these vegetated areas surrounding the site can be accommodated whilst still satisfying the requirements of SPP 3.7 and the Guidelines.

The site is suitably sized to accommodate the minimum separation distances required to achieve BAL-29 or less for future habitable buildings from classified vegetation within and surrounding the site through the provision of public roads and if required the setback area within residential lots. The retention of trees within future residential lots will be managed to a low threat standard by future land owners. There are no constraints to meeting the bushfire compliance criteria outlined in the Guidelines for Planning in Bushfire Prone Areas version 1.3 (WAPC and DFES 2017).

Identified Actions At Subdivision Stage:

The Bushfire Management Plan prepared by Emerge Associates is to be updated, approved and relevant bushfire protection measures therein implemented during subdivisional works to address the following:

- Development within 100m of classified vegetation will require a BAL assessment to be completed as part of the subdivision and certified prior to dwelling construction. The BAL assessment will inform the requirement for increased construction standards in accordance with AS3959 which will be implemented via the building licence process.
- The indicative BAL assessment undertaken as part of the existing BMP, indicates building footprints within lots will be subject to a BAL rating of BAL-29 or less. Future subdivision and development will require roads to be support two access routes, hydrants to be constructed and Jack Williamson Oval to be implemented and maintained to a low threat standard in accordance with clause 2.2.3.2(f) of AS 3959.
- A notification, pursuant to Section 165 of the Planning and Development Act 2005 is to be placed on the certificate(s) of title of the proposed lot(s) with a Bushfire Attack Level (BAL) rating of 12.5 or above, advising of the existence of a hazard or other factor not part of the EAR. Notice of this notification is to be included on the diagram or plan survey (deposited plan). The notification is to state as follows: “This land is within a bushfire prone area as designated by an Order made by the Fire and Emergency Services Commissioner and may be subject to a Bushfire Management Plan. Additional planning and building requirements may apply to development on this land.”
- In accordance with the Bushfire Management Plan that a landscaped area within Jack Williamson Oval adjacent the eastern perimeter Access Street is to be landscaped in consultation with the City of Swan to allow for this area to be maintained at a low threat standard by the City of Swan in accordance with clause 2.2.3.2(f) of AS 3959.
- A landscape plan to be undertaken for the Landscape lots as a condition of subdivision to be implemented as part of subdivision works which identifies trees for protection and landscaping to occur to allow for the classification of ‘low threat vegetation’ in consultation with the City of Swan.

2.9.8 Acoustic Considerations - Brick Works

The Noise Management Plan undertaken to support the structure plan investigated the impacts from the consolidated brickworks operations, and aircraft and traffic noise, on the proposed residential land use in Area 3.

For the brickworks operations, the influencing factor applicable at noise sensitive premises varies depending upon their proximity to commercial and industrial zoned land within a 450 metre radius. The industrial noise assessment concluded that noise emissions to Area 3 will comply with the Environmental Protection (Noise) Regulations 1997 at all times. This is on the basis of:

- the only operations existing south of Bassett Road is the Clay Shed;
- the Clay Shed does not operate during the night, with the exception of the conveyor transfer of materials from the Clay Shed (bins) to kilns 9 and 10; and
- a temporary noise wall shall be included on the west side of the Clay Shed and at the nearest future residences to act as noise barriers.

Before the Clay Shed is demolished, a 5-metre high wall will be constructed abutting the south side of the masonry lot to act as a noise barrier.

Refer to Figure 11 – Acoustic Considerations Noise Contour Plot: Day/Evening Period (Temporary Retention of Clay Shed For 5-10 years)

Refer to Appendix C – Noise Management Plan.

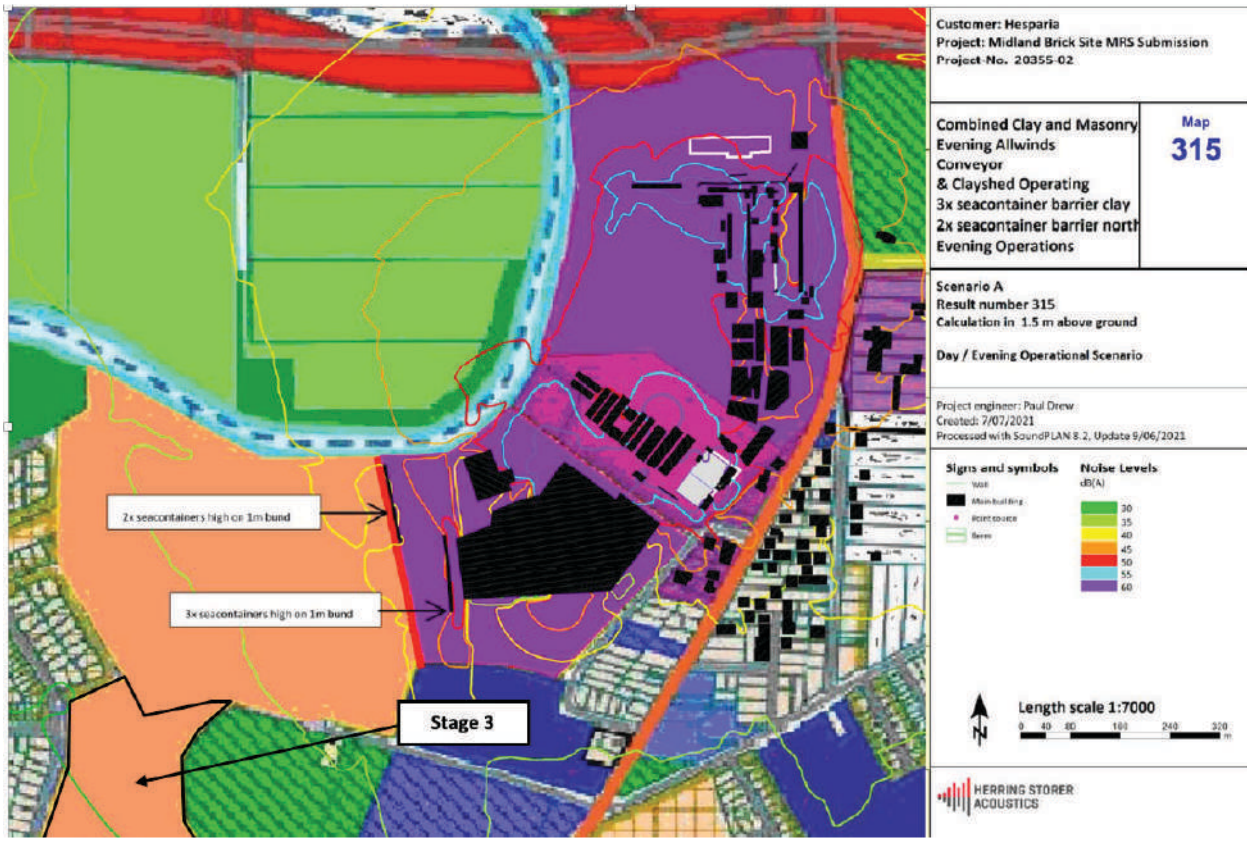


Figure 11. Acoustic Considerations Noise Contour Plot: Day/Evening Period (Temporary Retention of Clay Shed For 5-10 years) (Source: Herring Stores Acoustics, 2021)

Identified Actions At Subdivision Stage:

To manage noise impacts to the proposed area, the following is proposed to be implemented:

A notification, pursuant to Section 165 of the Planning and Development Act 2005 is to be placed on the certificates of title of all residential lots advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification is to state as follows:

> *"This lot is in close proximity to existing masonry and bricks works and may be adversely affected by virtue of gaseous, odour, noise and/or dust emissions from that facility."*

The preparation of a Noise Management Plan outlining the recommended type and specification of physical noise barrier to achieve acceptable noise levels at surrounding sensitive land uses.

2.9.9 Aircraft Noise

The entirety of Area 3 falls within 20 ANEF. The ANEF contours are associated with the future parallel runway. Since SPP 5.1 allows residential development to occur within the ANEF 20-25 contour, subject to the implementation of appropriate noise control measure.

SPP 5.1 stipulates that residential development within the 20-25 ANEF contour is conditionally acceptable and recommends a maximum residential density for R20, with a limited number of exceptions for higher density such as where there is a demonstrated strategic need. In this regard, the dwelling yield for the site complies with the maximum R20 density requirement.

Noise insulation is not mandatory for residential development. Some areas however, may experience peak aircraft noise levels in excess of the Indoor Design Levels specified in AS2021, and noise insulation is recommended in such cases.

Closure of windows and other openings to habitable rooms can significantly reduce the intrusion of aircraft noise. This will normally require forced ventilation, and may also necessitate some form of active cooling, such as refrigerative air conditioning. The operational management of buildings however, is outside the ambit of this policy, and will therefore be subject only to advice.

A 'notice on title' advising of the potential for noise nuisance is to be required as a condition of any subdivision or planning approval within this noise exposure zone.

Identified Actions At Subdivision Stage:

To manage noise impacts to the proposed area, the following is proposed to be implemented:

A notification, pursuant to Section 165 of the Planning and Development Act 2005 is to be placed on the certificates of title of the proposed lots advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification is to state as follows:

> *"This lot is situated in the vicinity of Perth Airport, and is currently affected, or may in the future, be affected by aircraft noise. Noise exposure levels are likely to increase in the future as a result of increases in numbers of aircraft using the airport, changes in aircraft type or other operational changes. Further information about aircraft noise, including development restrictions and noise insulation requirements for noise affected properties, are available on request from the relevant local government offices."*

The preparation of a Noise Management Plan may also consider potential noise attenuation measures for future development related to aircraft noise.

2.9.10 Air Quality Considerations

The Midland Brick operations are classed as a Prescribed Premises pursuant to Part V Division 3 of the *Environmental Protection Act 1986*, whereby all works and activities must only be carried under licence.

There is a current licence ref: L4511/1967/13 revised 30/08/2021 which includes a reduction in licenced operational areas scaled back north eastwards, the closest operational building would be approximately 280m away and the closest open operational area approximately 790m away.

An Air Quality Assessment was undertaken to support the broader redevelopment of the brickworks site in order to understand the potential impacts from the consolidated brickworks' operations, predominately existing Kilns 9 and 10, on the proposed residential land use. Separate but related to the structure plan for Area 3, operations at the brickworks site have already been reduced (with the decommissioning of Kilns 7, 8 and 11). Brickworks operations will further reduce and contract to a consolidated area located to the north of the site (north of Bassett Road) where Kilns 9 and 10 would continue to operate.

A Human Health Risk Assessment (HHRA) has been prepared in support of the MRS amendment to understand the potential risks to human health for the future residential use of the site. This assessment has specifically reviewed the air quality monitoring undertaken by Environmental Technologies and Analytics as part of the Air Quality Impact Assessment (ETA 2020) as these relate to the health of future residents at the site, particularly air emissions from the ongoing operation of Kilns 9 and 10 located to the north of Bassett Road.

The assessment results indicate engineering of these kilns and the flue gas treatment system (for each kiln) means that there are no situations where emissions to air could occur, even during upset, start-up or shutdown conditions, that are higher than the emissions scenarios evaluated in the air quality modelling.

The maximum concentrations predicted on the site, as a result of ongoing operation of Kilns 9 and 10, have been reviewed against guidelines that are protective of human health (for all residents), odour and vegetation effects. There are no exceedances of any of these guidelines. Hence there are no air quality impacts (derived from the brick works operations) that would be of concern to the health of future residents at the site.

2.9.11 Site Contamination

Whilst contaminated site investigations have been conducted over the broader brickworks site, investigations have particularly focused on Lot 72, which is classified as 'Possibly contaminated – investigation required' due to localised areas of elevated petroleum hydrocarbon concentrations in soil and groundwater. Lot 9009 has not been identified as presenting a contamination risk or requirement for remediation. A Detailed Site Investigation (DSI) identified potential sources of contamination largely associated with the four southern storage ponds and the western bund due to the potential for uncontrolled fill. The DSI indicated very limited impacts are present within the site from current and historical land uses and recommended a site classification under the Contaminated Sites Act 2003 of 'Not Contaminated' was appropriate.

Identified Actions At Subdivision Stage:

There will be no requirement for remediation given the results of detailed investigations did not report contamination from the current and historical land uses within the site. If evidence of contamination is encountered as part of future ground disturbing activities, any sources of contamination will need to be completed prior to the issue of titles to the satisfaction of the WAPC on advice from DWER.

2.9.12 Acid Sulfate Soils

Acid Sulphate Soil (ASS) is the common name given to naturally occurring soil and sediment containing iron sulfides. These naturally occurring iron sulfides are generally found in a layer of waterlogged soil or sediment and are benign in their natural state. When disturbed and exposed to air, however, they oxidise and produce sulfuric acid, iron precipitates, and concentrations of dissolved heavy metals such as aluminium, iron and arsenic. Release of acid and metals as a result of the disturbance of ASS can cause significant harm to the environment and infrastructure.

The WAPC's Bulletin 64 (WAPC, 2003) ASS risk mapping indicates that the area is classified as no known risk. The environmental assessment has confirmed that the majority of the site is not identified as having any known risk of Acid Sulfate Soils (ASS).

If ASS is to be disturbed, a suitably qualified environmental consultant will be engaged to conduct an investigation of the area and if necessary, prepare an ASS Management Plan. The ASS Management Plan will detail the actions to minimise and mitigate potential adverse environmental effects during the works.

2.10 Heritage

Indigenous Heritage

While the site intersects with the boundaries of the Registered Heritage Sites; 'Turtle Swamp', 'Blackadder and Woodbridge Creek' and 'Jane Brook' and 'Bishop Road Camp', their physical location is not within the site, and therefore approval under the Act is not required. There are no known implications for Aboriginal Heritage associated with Area 3.

The proponent has initiated discussions with the SWALSC during February 2020 and with the Whadjuk Working Group in April 2021. More recently, Karrda and The Fulcrum Agency (TFA) have been engaged in developing a cultural narrative for Rivermark that is historically authentic and representative of Noongar culture today, linking the past to the present and paving the way for the future. Ongoing engagement and collaboration with the local elders has been established through Karrda and TFA and will remain through Rivermark's ongoing development.

Opportunities have been identified as part of this engagement with the Whadjuk Elders including cultural verge gardens across the Rivermark project.

Refer to Figure 12 – Known Heritage Sites (Emerge, 2021)

Non Indigenous Heritage

A search of the Heritage Council of Western Australia State Register confirms that Area 3 contains no buildings or landmarks considered to be of European heritage significance. Despite this, an interpretation plan shall be prepared as part of the broader areas redevelopment to document and integrate historical themes and materials as the main area of the brick works operations in Area 4 is relocated.

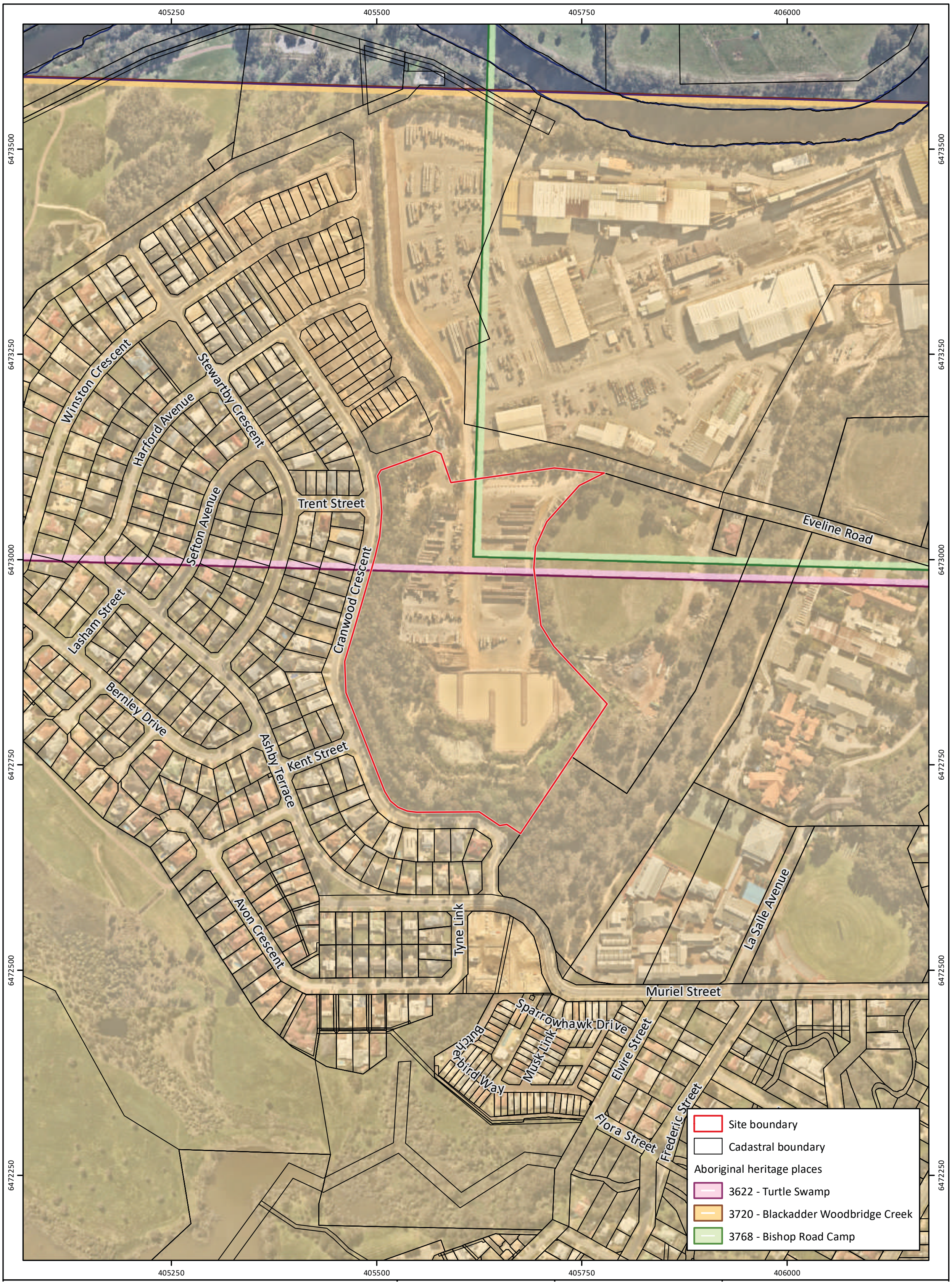


Figure 12. Known Heritage Sites (Source: Emerge, 2021)

2.11 Pre-lodgement Consultations

Extensive agency led consultation has occurred in association with the broader brickworks site, particularly in support of the current Metropolitan Region Scheme amendment (pre-referral process), and intended Local Structure Plan pertaining to Lots 23 and 72 Eveline Road, Viveash. Noting the complexities associated with the existing land use, zoning and environmental values, broad consultation has occurred with the following agencies:

- City of Swan.
- Department of Planning Lands and Heritage (DPLH).
- Department of Water and Environmental Regulation (DWER).
- Department of Biodiversity, Conservation and Attractions (Rivers and Estuaries Branch) (DBCA).
- Environmental Protection Authority (EPA).
- APA Group.
- Perth Airport.
- South West Aboriginal Land and Sea Council (SWALSC).

Preliminary pre-lodgement consultation specific to Lot 9009 has occurred as part of the pre-lodgement consultation on the overall redevelopment of the brickworks site as well as through informal, site-specific discussions with the DPLH and the City of Swan.

Given the relatively self-contained and unconstrained nature and ready serviceability of the site, the proposed structure plan is consistent with the MRS 'Urban' zoning and does not prejudice strategic planning or coordinated planning outcomes for the wider area.

3. Key Planning Framework

3.1 State Planning Framework

3.1.1 Metropolitan Region Scheme

The subject site is already appropriately zoned 'Urban' under the MRS for residential redevelopment.

Refer to Figure 13 – Existing MRS Zoning Plan

3.1.2 Perth and Peel@3.5 Million and North East Sub-Regional Planning Framework

The Perth and Peel @ 3.5 Million document provides strategic guidance to government agencies and local governments on land use, land supply, land development, environmental protection, infrastructure investment and the delivery of physical and community/social infrastructure for the Perth and Peel regions. The document seeks to meet the targets identified under Directions 2031 and the State Planning Strategy 2050. The suite of documents also includes four subregional planning frameworks for the Central, North-West, North-East and South Metropolitan Peel sub-regions. The four sub-regional planning frameworks detail where future homes and employment should be located, and where important environmental assets should be avoided and protected.

The subject site is situated within the North East Sub-Regional Planning Framework and is identified for Urban consistent with the current MRS zoning. The Framework advocates for a consolidated urban form that focuses residential development in areas with existing infrastructure which minimises environmental impacts to creates sustainable communities that are attractive places to live and work.

The Framework contains strategic priorities which seeks to provide development of under-utilised urban land that can be serviced with the required infrastructure and that is located in proximity to activity centres, transit corridors and/or areas of high amenity. In this regard the proposed structure plan will allow for residential development to occur in close proximity to existing rail, road and urban infrastructure in accordance with the general intent of Perth and Peel@3.5 Million and the associated North-East Sub-regional Planning Framework. A number of the Framework's key principles are relevant, including:

- Develop a consolidated urban form that limits the identification of new greenfield areas to where they provide a logical extension to the urban form, and that places a greater emphasis on urban infill and increased residential density.
- Facilitate increasing the number of people living close to where they work with the identification of suitable sites for employment within the sub-region, with a focus on attracting strategic economic and employment land use to the sub-region.
- Maximise the use of and add value to existing infrastructure including transport, community/social and service infrastructure where there is a concentration of urban and employment opportunities.
- Avoid, protect and mitigate impacts on environmental attributes (with an emphasis on avoiding and protecting) when allocating proposed land uses, or address impacts through an improved conservation estate where those impacts cannot be avoided or mitigated.

Urban infill areas form a key component of the Framework in providing opportunities for more efficient use of urban land and infrastructure, with improved access to public transport, community and commercial facilities, while minimising environmental impacts.

The proposed structure plan of Lot 9009 for residential purposes will contribute to satisfying forecast housing needs in the City of Swan and wider North-East Sub Region (an infill development target of an additional 30,800 dwellings within the City of Swan by 2050).

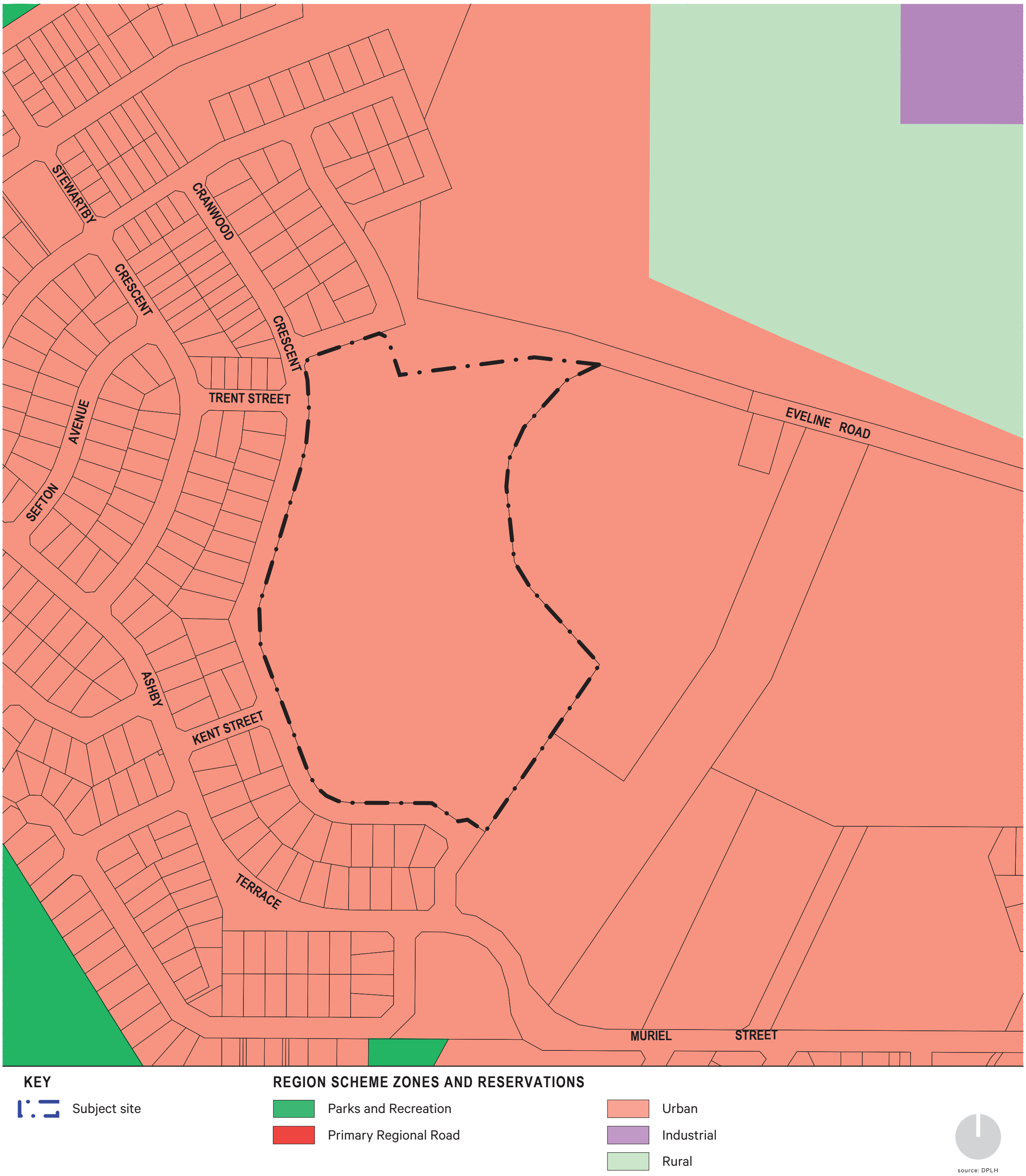


Figure 13. Existing MRS Zoning Plan

3.2 State Planning Policies

3.2.1 Liveable Neighbourhoods

Liveable Neighbourhoods (LN) was prepared by the WAPC to implement the objectives of the State Planning Strategy and deliver the strategies and actions of metropolitan spatial frameworks. LN is an operational policy that guides structure planning (regional, district and local), subdivision and development for new urban areas, including greenfield and large brownfield (urban infill) sites. LN seeks to promote the design of walkable neighbourhoods; places that offer community and a sense of place; mixed uses and active streets; accessible and sustainable parks; energy efficient design; and a variety of lot sizes and housing types.

At a higher strategic level, the proposal will not prejudice nor preclude the attainment of Liveable Neighbourhoods design objectives which will be delivered through detailed subdivision design. To this end, we note the capacity of future development to:

- Facilitate appropriate linkages into the existing road, pedestrian and cycle networks, encouraging walkability and reducing the reliance on vehicular traffic.
- Take advantage of its interface to the proposed upgraded Jack Williamson Oval by orienting and designing new dwellings to interface with public open spaces and improving the opportunity for passive surveillance and interaction with the public realm.
- Facilitate landscaped linkages to the Swan River and regional open space.
- Prioritise the retention of the existing urban canopy particularly within the existing road reserve.
- Leverage from existing service connections, with augmentation where necessary.
- Appropriately support the urban water management strategy for the site.
- Provide sustainable housing that optimises solar orientation for internal and external spaces and natural ventilation and reduces reliance on mechanical passive cooling and heating.

Future lot dimensions will be designed to be rectangular in shape wherever possible in order to develop high quality housing and built form outcomes that conform with the Residential Design Codes of Western Australia.

3.2.2 State Planning Policy No. 2.8 – Bushland Policy for the Perth Metropolitan Region

State Planning Policy 2.8: Bushland Policy for the Perth Metropolitan Region (SPP 2.8) aims to provide a policy and implementation framework that will ensure bushland protection and management issues are addressed and integrated with broader land use planning and decision-making.

The policy predominantly deals with two distinct subjects, Bush Forever areas and local bushland areas. In general, the policy does not prevent development where consistent with policy measures and other planning and environmental considerations.

No Bush Forever sites occur within Lot 9009. The site is well separated from the boundary of Bush Forever Site 302 located within the boundary of the Swan River foreshore. There are no local bushland areas found within Lot 9009.

3.2.3 State Planning Policy No. 3 – Urban Growth and Settlement

SPP 3.0 sets out the principles and considerations that guide the development of new urban growth and settlements. It focuses on consolidation in areas with good access to employment, services and transportation, minimised environmental impact and efficient use of suitable land and infrastructure.

The proposed structure plan demonstrates it is consistent with SPP 3.0 as it will realise residential consolidation and intensification within an area of under-utilised urban land that has immediate access to transport, services and employment. All essential services can be readily and efficiently connected from immediate surrounding areas.

3.2.4 State Planning Policy 3.4 Natural Hazards and Disasters (SPP 3.4)

SPP 3.4 identifies the need for the planning of urban areas to consider natural hazards including flooding, bush fire, landslides, earthquakes, cyclonic activity, coastal erosion, severe storms, storm surge and tsunamis. Of relevance to this structure plan is flooding and the risk of bushfire.

The Swan River 1% Annual Exceedance Probability (AEP) levels adjacent to the site range from 5.5 metres AHD at the downstream end to 6.0 metres AHD at the northern boundary. The site is predominately located outside of the river's 1% AEP floodplain with only a minor area within the site classified as floodway and flood fringe. Development levels will be such that all residential lots will have suitable clearance above the 1% AEP flood levels of the Swan River and Blackadder Creek.

In relation to bush fire risk, it has been determined that whilst the site is identified as bushfire prone by the Map of Bush Fire Prone Areas (OBRM 2019), a Bushfire Management Plan has been prepared to in support of Lot 9009 which demonstrates that bushfire risk does not preclude the approval of the proposed structure plan. Refer to section below for further commentary.

3.2.5 State Planning Policy 3.7 Planning in Bushfire Prone Areas

SPP 3.7 seeks to guide the implementation of effective risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure. It applies to all higher order strategic planning documents, strategic planning proposals, subdivision and development applications located in designated bushfire prone areas (unless exemptions apply). The accompanying Guidelines for Planning in Bushfire Prone Areas provide supporting information to assist in the interpretation of the objectives and policy measures outlined in SPP 3.7. They provide advice on how bushfire risk is to be addressed when planning, designing or assessing a planning proposal within a designated bushfire prone area.

The site is identified within a 'bushfire prone area' on the state-wide Map of Bush Fire Prone Areas as prepared by the Office of Bushfire Risk Management (OBRM 2019). A Bushfire Management Plan has been prepared in support of Lot 9009 which demonstrates that bushfire risk does not preclude the approval of the proposed structure plan. Bushfire hazards can be suitably managed through the provision of appropriate setbacks to achieve a bushfire attack level (BAL) of BAL-29 or less, and constructing dwellings in accordance with Australian Standard 3959-2019 Construction of buildings in bushfire prone areas. Appropriate mitigation measures for bushfire can be resolved in further detail at the time of subdivision.

Refer to Appendix B – Bushfire Management Plan

3.2.6 Draft State Planning Policy No. 4.1 – State Industrial Buffer Policy, EPA Guidance: Separation distances between industrial and sensitive land uses

Draft SPP 4.1 provides guidance for considering proposals to rezone land for sensitive uses in the vicinity of, various industry types, including brick manufacturing. The EPA *Guidance Statement No. 3 – Separation Distances Between Industrial Sensitive Land Uses* is incorporated into SPP 4.1 as a planning consideration.

The objectives of SPP 4.1 are to:

- protect existing and proposed industry, and infrastructure facilities from encroachment by incompatible land uses that would adversely affect efficient operations;
- avoid land use conflict between existing and proposed industry/ infrastructure facilities and sensitive land uses; and
- promote compatible land uses in areas impacted by existing and proposed industry and infrastructure facilities.

In particular, the following principles of SPP 4.1 are relevant to this proposal in the context of mechanisms to prevent land use conflict:

> *5.2.2 (a) New sensitive land uses should not be considered on land impacted by existing or proposed industrial land uses and/or infrastructure facilities.*

In addition to draft SPP 4.1, the EPA's Environmental Protection Guidance Statement No.3 Separation Distances Between Industrial and Sensitive Land Uses provides advice on which land uses require separation, and recommends the appropriate separation distances. The guidance outlines the EPA's expectations on the application of separation distances for schemes and scheme amendments during the environmental impact assessment process.

As a general principle, land use conflict should be considered at each stage of the planning framework, increasing in detail at each level, from the MRS amendment down to the structure plan, detailed subdivision design and building stages. The future noise and air quality emissions of the consolidated brickworks are well understood in the context of the staged eastward contraction of the brickworks to Lots 9007 Great Northern Highway. Acoustic and air quality considerations associated with the brickworks have been comprehensively reviewed in environmental studies:

- A Noise Impact Assessment undertaken to verify the capacity for future residential use of the subject site considered the impacts from the consolidated brickworks' operations, and aircraft and traffic noise, on the proposed final land use (Refer to Appendix C).
- Air quality impacts, the environmental study found that 'typical operations' emissions from the consolidated brickworks will comply with all relevant assessment criteria for the broader redevelopment of the brickworks site for residential purposes.

3.2.7 State Planning Policy No. 5.1 – Land Use Planning in the Vicinity of Perth Airport

The subject site is located within the aircraft noise ANEF 20-25 contour, as defined under the Perth Airport Master Plan 2020. SPP 5.1 allows residential development to occur within the ANEF 20-25 contour subject to the implementation of appropriate noise control measures. Noise insulation is not mandatory for residential development within the 20-25 ANEF. However, some areas may experience, currently or in the future, maximum aircraft noise levels in excess of the Indoor Design Sound Levels specified in AS2021, and noise insulation is recommended in such cases. SPP 5.1 stipulates that residential development within the 20-25 ANEF contour is conditionally acceptable and recommends a maximum residential density for R20, however does provide for a limited number of exceptions for higher density such as where there is a demonstrated strategic need.

Hesperia has commenced a dialogue with Perth Airport to better understand the ANEF contour modelling applied to the broader brickworks redevelopment site. This is being undertaken so that specific site design solutions and a variety of lot product can be appropriately tailored across the site without compromising the intent of the ANEF mapping as shown in the Master Plan 2020. The current SPP 5.1 approach to maintaining an R20 average and minimum lot size within the 20-25 ANEF contour does not consider alternative solutions, including innovative approaches to noise insulation, and design layout solutions for smaller lot product. This more progressive approach would enable a greater diversity of housing product and price points being provided to the community.

The local scheme amendment (209) and structure plan for Area 3 incorporates a maximum density which is in-keeping with the SPP 5.1 recommended maximum residential density.

Refer to Figure 14 - Extract of Master Plan 2020, Perth Airport, ANEF mapping.

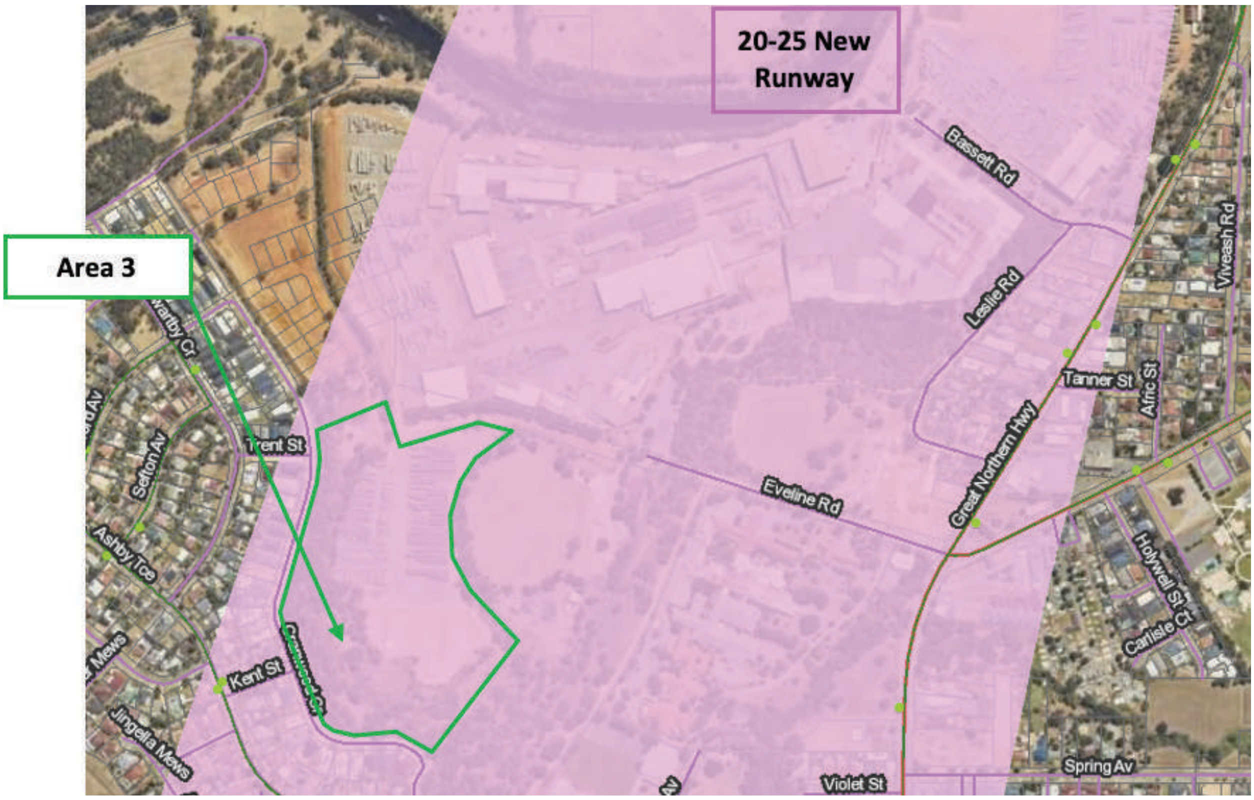


Figure 14. Extract of Master Plan 2020, Perth Airport, ANEF mapping

3.2.8 WAPC DC Policy 2.3 Public Open Space in Residential Areas

DC 2.3 seeks to ensure that residential development is supported by adequate public open space which contributes to the amenity of a place. Amongst other matters, DC 2.3 typically requires the provision of 10 percent of the gross subdivisible area to be provided as public open space, corresponding to the requirements of Liveable Neighbourhoods. This land is to be ceded by the subdivider 'free of cost' to the Crown as a Reserve for Recreation.

The broader public open space contribution being provided across the brickworks redevelopment area will exceed the 10% requirement once the site is completed. This will be subject to a future planning process, which includes advertising requirements by the City of Swan and final approval by the WAPC.

Figure 15 spatially represents the broader supply of public open space in the Viveash and Middle Swan area once Rivermark is completed. Figure 15 demonstrates that the public open space catchment areas will deliver an efficient network of accessible open spaces within a suitable radius. The network will provide for a variety of open space types and functions, enhancing local environment values and improving existing underutilised or currently inaccessible assets. The efficient provision and resourcing of open spaces in accordance with the overall concept plan avoids piecemeal micro POS solutions in the form of pocket parks. In the context of the overall POS strategy, micro POS solutions are financially and environmentally inefficient and challenged by limited utility, surveillance and enjoyment.

The project area responds to the EnviroDevelopment criteria for 'Healthy and Active Communities'. This requires developments to 'provide a number of parks throughout the neighbourhood(s), catering for a range of uses and people of varying ages and abilities'. This will be achieved in accordance with WAPC's Liveable Neighbourhoods by the provision of:

- the rejuvenated Jack Williamson Oval, in association with the City of Swan.
- a new neighbourhood park proposed adjacent to the Swan River (Area 4).
- a local Conservation park which will conserve existing TEC (Area 4).
- a local park along Cranwood Crescent (Area 1).
- a local park adjacent to Jack Williamson Oval (Area 3).

Each of these open space areas will be linked by a network of pedestrian pathways, and a new Principal Shared Path along the future foreshore reserve, to connect Reg Bond Reserve up to Middle Swan Reserve.

Council has resolved to upgrade the Jack Williamson Oval in partnership with the proponent (refer to Section 4 of this report).

3.2.9 Operational Policy 2.4 School Sites

The WAPC Operational Policy 2.4 School Sites commenced on 22 December 2022. It outlines the general requirements for school sites in order to meet the existing and future community needs.

This policy guides the strategic planning for government and non-government school sites in existing and proposed urban areas. It applies to the preparation of structure plans (district, local and precinct) and subdivisions where residential development is proposed, and development applications in close proximity to school sites.

The policy requires early liaison with the Department of Education, including when a structure plan is being formulated or amended, and prior to advertising of proposals.

Structure plans proposing residential development should be supported by formal comment from the Department of Education regarding:

- the location and suitability of all government school sites; and
- acknowledging the proposed dwelling numbers anticipated within a structure plan area.

In general, the policy requires the provision of one 4ha government (public) school site for every 1,500 dwellings (and 5ha where associated facilities used for community purposes are included on the site). However, the WAPC may accept alternative primary school site provisioning, for example based on the capacity of surrounding schools, and demographic projections. Non-government schools are to be provided at an average ratio of 1 non-government to 3 government primary schools.

Clause 3.9 of the policy sets out the development contributions for Government (public) primary schools. Generally pro rata development contributions, at a rate of 1/1500th of the value of a 4ha primary school site and up to a maximum of $4,500 per lot, will be conditioned on any residential subdivision (other than aged/dependent persons) creating an additional five lots, or more, where it is located within:

- the Metropolitan Region Scheme area or
- the Peel Region Scheme area or
- the Greater Bunbury Region Scheme area or
- an approved structure plan area within the State.

Subdividers/landowners who have either all, or a portion of a primary school site, within their subdivision application are required to cede the school site land or relevant portion, to the Crown at the time of subdivision.

Subdivider/landowners who do not have any portion of the primary school site within their subdivision application are required to pay the full pro rata contribution in cash to the Department of Education.

The proponents of this Structure Plan undertook preliminary consultation with the Department of Education in relation to the future development of Lots 23 and 72 (now Lot 9009) Eveline Road, which includes the proposed structure plan area, Area 3 and future redevelopment area, Area 4.

Formal Department of Education advice provided in 2020 and consistent with the operational school sites policy confirmed that the broader redevelopment area would likely yield 500 additional dwellings. It was envisaged that a public primary school would be required to support student population growth in the broader redevelopment area and relieve demand on local primary schools Midvale Primary School and Woodbridge Primary School.

It is intended that the Department of Education's response will be further explored through the formal referral of the Area 3 Local Structure Plan and that provision of a public primary school site will revisited in the preparation and lodgement of the Area 4 Local Structure Plan.

3.3 Local Planning Framework

3.3.1 City of Swan Local Planning Scheme 17

Under the City of Swan's Local Planning Scheme No.17 (LPS17), Lot 9009 is zoned 'General Industrial'. Clause 6 of LPS17 establishes two special control areas affecting the subject site. These are Aircraft Noise Exposure and Flood Prone Areas.

Amendment No.209 to LPS17 rezoned Lot 9009 to 'Residential Development' and included restricted use provisions applicable to density restrictions and noise compliance.

The proposed structure plan will enable the delivery of a range of lot and housing product to the market. Guided by the core principles incorporated into the redevelopment framework along with the vision for Area 3, the structure plan will foster local amenity and enhance the unique character of the site's parkland and riverine location. In particular, the proposal will ensure the future delivery of a high quality, safe and sustainable residential neighbourhood by:

- Take advantage of its interface to Jack Williamson Oval by orienting and designing new dwellings to interface with public open spaces and improving the opportunity for passive surveillance and interaction with the public realm.
- Improve pedestrian and cycle accessibility from the existing Viveash community to the Jack Williamson Oval.
- Facilitate landscaped linkages from Area 3 up through Areas 1 and 2 along Eveline Road to the Swan River and regional open space.
- Prioritise the opportunity to support environmental values and retain the existing tree canopy.
- Provide a sustainable housing that optimises solar orientation for internal and external spaces and natural ventilation and reduces reliance on mechanical passive cooling and heating.

3.3.2 POL-LP-1-12 Local Planning Policy 12 – Public Open Space and Community Buildings

LPP 12 sets out the City's expectations for the provision of open space in order to meet the City's growing population and diverse community needs. It contains the requirements for open space provision that must be addressed in Structure Plans including:

- City's Open Space and Community Building Principles
- Six (6) core benchmark and criteria for the provision of open space
- Four (4) Place Measures
- Timing (thresholds) of provision

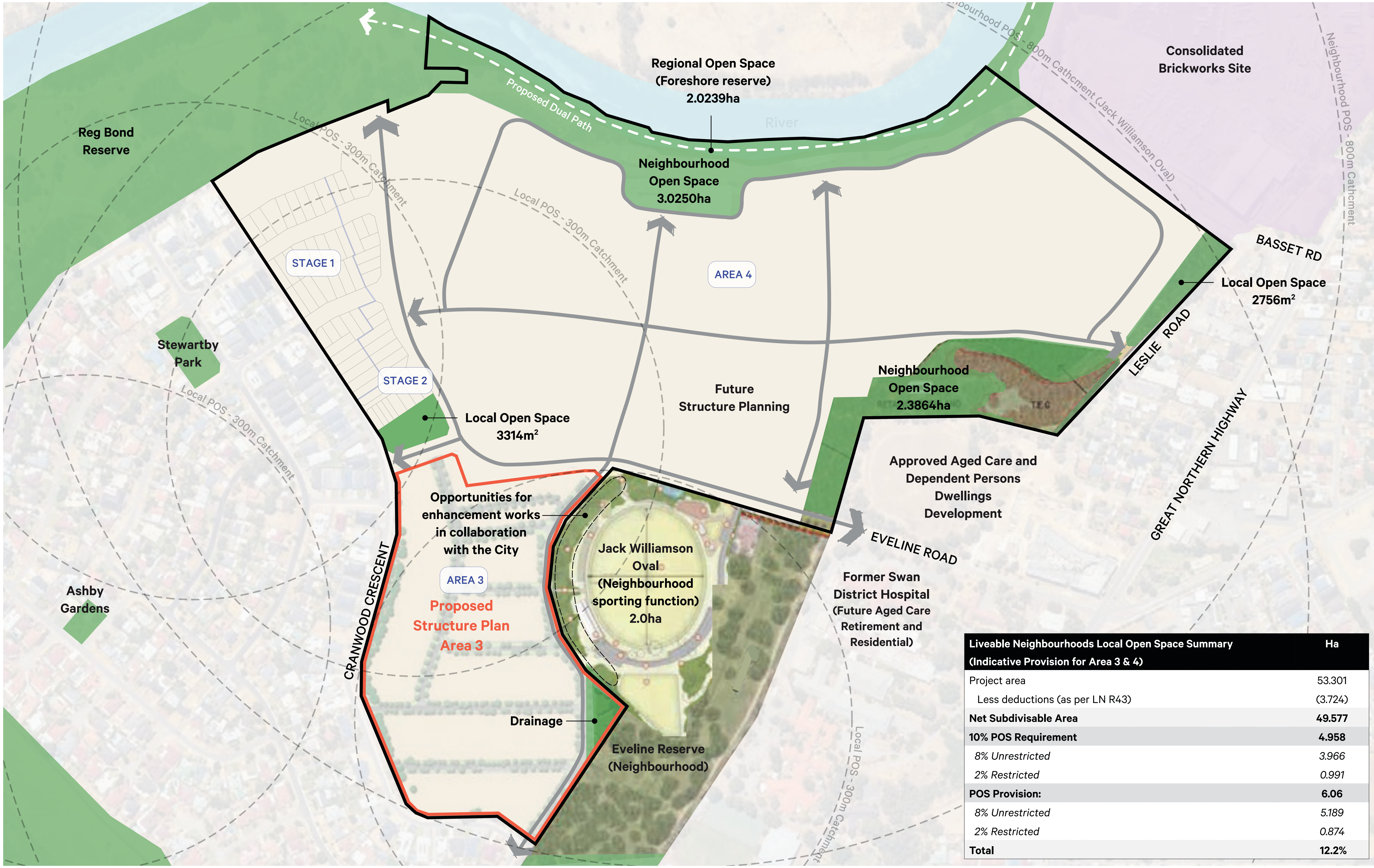
In summary, where the overall development of the former Midland Brick site is considered in totality, a variety of local, neighbourhood and regional POS will be provided. The size, catchment and function of POS in the Midland Brick redevelopment is consistent with the City's Standard Provision under LPP 12.

The POS strategy for the broader Midland Brick redevelopment also responds directly to the City's open space principles and benchmark criteria. Consideration of the total POS provision is necessary from a sustainability, financial, quality and enjoyment and functional perspective. In particular, it avoids the repetitious provision of superfluous pocket parks which will be financially and environmentally costly to maintain, superseded by larger and more diverse hierarchical areas of POS containing higher order functions and targeted facilities.

The overall amount of POS to be provided over the broader redevelopment area exceeds the Liveable Neighbourhoods 10% requirement, with less than 2% provided as restricted open space for drainage or environmental values. This will be subject to a future planning process, which includes advertising requirements by the City of Swan and final approval by the WAPC.

Refer to Figure 15 Distribution of Public Open Space Across Rivermark Project.

Specific responses to the open space policy requirements are addressed below.



Liveable Neighbourhoods Local Open Space Summary (Indicative Provision for Area 3 & 4)	Ha
Project area	53.301
Less deductions (as per LN R43)	(3.724)
Net Subdivisable Area	**49.577**
10% POS Requirement	**4.958**
8% Unrestricted	*3.966*
2% Restricted	*0.991*
POS Provision:	**6.06**
8% Unrestricted	*5.189*
2% Restricted	*0.874*
Total	**12.2%**

Figure 15. Distribution of Public Open Space Across Rivermark Project

Open Space and Community Building Principles

Sustainability	Area 3 contributes to the overall POS strategy for the Midland Brick redevelopment area, which results in spatially and typologically diverse POS (local, neighbourhood and regional POS) being accessible to the future residential catchment. Overall, the POS strategy for the broader Rivermark residential estate exceeds the Liveable Neighbourhood 10% (maximum 2% restricted POS) requirement. This will be subject to a future planning process, which includes advertising requirements by the City of Swan and final approval by the WAPC. The overall POS strategy ensures a balance between social, environmental and economic needs. It integrates and incorporates areas of environmental values and existing POS assets including Jack Williamson Oval, Neighbourhood (Sporting) POS. It also avoids the incidental provision of piecemeal pocket parks that are costly to maintain and superfluous to the higher utility and enjoyment of facilities provided in consolidated POS areas. The landscape concept design is committed to appropriate resource use, energy efficiency and implementation of both water sensitive urban design and environmentally sustainable design.
Quality and Enjoyment	The proposed open space strategy will enhance the existing physical quality and appearance of the Swan River foreshore and together with the City of Swan, the Jack Williamson Oval western interface. These contributions, together with the provision of new local and neighbourhood POS, restore the areas parkland and riverine identity, delivering an engaging natural environment for the existing and future community to enjoy. The global strategy will result in a positive impact on community health.
Diversity, Flexibility and Innovation	The diverse typologies and spatially located areas of POS will enable a variety of outdoor experiences and opportunities. The proposed integration with existing Jack Williamson Oval reflects an innovative partnership and opportunity for collaboration to restore an underutilised asset to the community.
Access and Equity	The POS strategy provides a range of open spaces of different sizes and types that will be accessible to the future community in accordance with the City's Standards of Provision. Residents in and around the former Midland Brick site will benefit from the equitable distribution of local, neighbourhood and regional POS. The different areas of POS will be designed with age appropriate and diverse facilities that help to establish the sense of place.
Financial Responsibility	The POS strategy has been designed in recognition of the City's burden for long term maintenance of public funds and assets. The coordinated strategy for POS provision considers the global provision of interconnected and diverse typologies of POS that are well distributed amongst the future catchment. It avoids the provision of incidental pocket parks and micro level POS provision which are financially inefficient, have lower utility and result in reduced enjoyment and use. The POS strategy across the Midland Brick redevelopment achieve a balance between community benefit and lifecycle cost, ensuring resources are spent efficiently from design through to ultimate operation.
Integration	The strategy delivers an integrated system of POS. The strategy connects future communities in Area 3 and 4 to the foreshore via street lined streetscapes and the collaborative partnership approach to upgrading Jack Williamson Oval. The strategy also integrates drainage and natural environmental values into the POS network and linkages between a variety of park amenities, functional spaces and vegetation types.
Consultation and Collaboration	The integration with Jack Williamson Oval demonstrates the strategy's commitment to community and stakeholder engagement. Together, the strategy aspires to deliver a shared, high utility outcome for the future community and City of Swan.
Safety	The overall POS strategy will ensure the delivery of well located, appropriately sized and accessible and diverse POS areas. The robust strategy for the overall redevelopment area, which includes integration with Jack Williamson Oval, age appropriate design and implementation of CPTED principles, and multi-purpose and functional open spaces will ensure a high level of future use and enjoyment, passive surveillance and perceived safety.

Benchmarks and criteria for POS provision

Hierarchy	The POS strategy for the Midland Brick redevelopment features the incorporation of a full hierarchy of POS areas. The strategy will restore underutilised and underdeveloped foreshore and neighbourhood sporting POS spaces. It will also enhance and integrate areas of environmental values and include WSUD (drainage) facilities. The strategy will deliver a continuation of regional level foreshore parkland, joint improvements to the existing Jack Williamson Oval which is a neighbourhood sporting open space. Additional neighbourhood level open space incorporating TECs and local biodiversity values will be complemented by local parks in Stages 1 and 2. The POS Provision Plan demonstrates the accessibility of the POS network to future catchments.
Function	The POS strategy clearly identifies the diverse function and catchment of each area of POS within the Midland Brick redevelopment. Detailed design will consolidate the conceptual provision plan ensuring that spaces are designed for their commensurate purposes.
Use	As guided by the overall POS strategy, the provision of each POS area can be identified by function and catchment. The consideration of future uses within the functional hierarchy and POS network will inform detailed design and ensure equitable access for the future community.
Length of stay	The POS strategy provides for diverse POS typologies. Areas of open space are connected as a network and adequately sized and distributed to cater for the future catchment needs. The efficient provision and resourcing of open spaces in accordance with the overall strategy avoids piecemeal POS solutions that are otherwise financially and environmentally inefficient and challenged by limited utility, enjoyment and length of stay.

City's Standards of Provision: Open Space and Community Buildings

LPP12 sets out the set out detailed frameworks for open spaces. The following summary table articulates the provision of open space in light of the City's expectations set out under Table 1 of LPP12. It demonstrates the LSP Area 3 will achieve an appropriate balance for sporting, recreational, nature, kick-about and play purposes. The POS strategy will deliver appropriately sized POS areas that are accessible and equitably distributed with the corresponding local catchments.

	Function Required							POS Proposed		
	Recreation	Sport	Nature	Kickabout	Play Space	Description	Size	POS	Size Proposed	Catchment
Local	✓		✓	✓	✓	Small parklands servicing recreation needs of the immediate surrounding area.	0.4-1ha	Stages 1& 2: Area 4: Nearby: Blackadder Creek	3,341m² 2,675m²	>400m

	Function Required							POS Proposed		
	Recreation	Sport	Nature	Kickabout	Play Space	Description	Size	POS	Size Proposed	Catchment
Neighbourhood	✓		✓	✓	✓	Serves as the recreational and social focus. Play space has a specific age category and suite of age appropriate play opportunities.	1-5ha	Proposed upgrades to the western edge of Jack Williamson Oval to be determined in consultation with City of Swan – refer to Landscape Concept Design Area 4: Foreshore POS Area 4: TEC POS Eveline Reserve Nearby: Ray Marshall Park Woodbridge Riverside Park	0.86ha 2.324ha 2.39ha	800m
Neighbourhood Sport	✓	✓	✓	✓	✓	Preferred at district sized areas and based on local demand	1-5ha (senior size and 2.9ha turf)	Jack Williamson Oval Nearby: Jack Mann Oval	2.0ha	800m
District	✓	✓	✓	✓	✓	Principally provides organised formal sport and recreation for multiple surrounding neighbourhoods. Provides play opportunities for a wide age range including accessible play opportunities.	5-20ha Sport >15ha Min 4.8 flat turf Equivalent to x2 AFL sized ovals	Nearby: Midland Sports Complex		2km

	Function Required							POS Proposed		
	Recreation	Sport	Nature	Kickabout	Play Space	Description	Size	POS	Size Proposed	Catchment
Regional	✓	✓	✓	✓	✓	The largest provision of open space for organised sport, recreation, conservation and environmental features. Serves residents and wider region. Provides highest quality and quantity of facilities	Function dependent Sport >20ha	Area 4: Continuation of Reg Bond Reserve Nearby: Swan Regional Recreation Park	2.024ha	Majority Drive

Threshold for Provision:

The POS strategy ensures the provision of local and neighbourhood open space facilities in a timely manner for new residents. In accordance with the policy provisions, the local and neighbourhood open spaces intended to be utilised by future residents will be in the design phase when 30 per cent of the forecast catchment lots have been created.

Additional Growth Area requirements

Where residential lots abut public open space, a footpath (or an alternative design treatment encouraging passive surveillance) will be provided near the common boundary on the open space.

3.3.3 City of Swan Local Planning Strategy

The City's Local Planning Strategy (LPS) sets out the broad direction for the future growth and development of the City for the next 10-15 years, and provides the strategic basis for the review of the local planning scheme and its amendments. The LPS was adopted by Council at its Ordinary Council Meeting on August 28, 2019 and endorsed by the Western Australian Planning Commission (WAPC) in August 2000. The document identifies a number of strategies and actions relevant to this proposal:

- 3.1.1 Promote the protection of biodiversity through scheme provisions.
- 3.1.4 Ensure an acceptable level of environmental performance for industry and/or separation from sensitive land uses.
- 3.2.3 Promote housing diversity to address sustainability principles such as reducing car dependence and to address housing affordability issues.
- 3.4.1 Promote Midland as a Strategic Metropolitan Centre and the major economic hub of the North-East sub-region.
- 3.8.4 Promote liveable and safe environments throughout the City.
- 3.10.4 Identify alternative and sustainable sources of water where groundwater is not available to meet the non-potable water needs of urban expansion including irrigation or public open space.

3.3.4 City of Swan Urban Housing Strategy

The 2012 Urban Housing Strategy was developed in response to the State Government's "Directions 2031 and Beyond" report which outlines a potential doubling of the population and an additional 35,510 dwellings within the City of Swan by 2031. The anticipated number of new dwellings could be accommodated in the City's expanding urban growth areas as greenfield development, however, increasing the opportunities for infill development within the City's established areas will provide much needed housing options for residents who prefer to live in these areas. Whilst not included in the infill mapping at that time, the structure plan remains in alignment with the infill objectives of the strategy. The density of approximately R20 dwellings per gross urban hectare will contribute to meeting the forecast housing needs of the City of Swan and wider North-east sub-region, where an infill development target of an additional 30,800 dwellings is specified for the City of Swan by the year 2050. This aligns with recent report findings by UDIA which projects that demand for housing will outstrip within 3 years.

3.3.5 City of Swan Sustainable Environmental Strategy and Sustainable Environment Policy

The City resolved to develop an Environmental Management System as a tool to coordinate the wide range of environmental activity within the City into a cohesive approach that achieves environmental objectives. These objectives are derived from the environmental objectives and high level strategies of the City of Swan Strategic Plan (2008–2012) and are further defined in the City's Sustainable Environment Policy.

The implementation section of the Sustainable Environment Strategy is divided into seven focus areas including Biodiversity Retention, Water Quality and Water Efficiency. The respective goals for these areas include:

- The City of Swan will work internally and with partners within our community to:
  - Monitor and improve efficiency in the use (direct and indirect) of natural resources such as ground and potable water and non-renewable energy sources and materials.
  - Support and implement the development of sustainable alternatives for the supply of water and energy.
- The City of Swan will work internally and with partners within our community to:
  - Preserve and protect the ecology and biodiversity of our natural ecosystems.
  - Implement 'best practice' in the management of ground and surface water quality and quantity.
  - Prevent and / or manage contamination of developed land and other inappropriate land management practices.

Whilst the majority of the site has been scarred by substantial hardstand and large industrial sheds from the brickworks operations, the structure plan documentation identifies opportunities to protect and enhance the existing environmental features of the site. The supporting design framework which accompanies this structure plan proposal supports environmental values and opportunities for tree canopy retention and planting.

Redevelopment of this industrial area to a residential use will enable environmental improvements to on-site drainage management and water quality, decreasing industrial runoff water leaving the site. Future development facilitated by the structure plan will be sustainable, underpinned by the Local Water Management Strategy and subsequent Urban Water Management Plan.

3.3.6 City of Swan Biodiversity Strategy

The 2016 Biodiversity Strategy provides a plan for the future with a number of recommendations for biodiversity and is a key document in guiding natural resource management over the next decade. It sets out a vision for biodiversity in the City of Swan including "to protect and manage a network of natural areas within the City of Swan that support the diversity of local indigenous biodiversity (plants, animal, fungi and microorganisms) in our region for the future." It sets out protection, retention and management goals including:

- The goal to formalise the long term preservation of local natural aeras. This may be achieved through reservation, conservation covenant or inclusion in a conservation purpose zoning.
- The goal is to use a variety of processes available to ensure retention of natural areas to ensure its continued existence and viability.
- Active management of local natural areas largely involves the control of threats to biodiversity values but may also include rehabilitation and revegetation tasks.

Fauna habitat within the site is limited to scattered trees and small pockets of remnant vegetation which have been subject to significant historical disturbance. The site provides 0.02 ha of potential foraging habitat for black cockatoos as well as three potential black cockatoo habitat trees, none of which contain potentially suitable nesting hollows. The three habitat trees without suitable nesting hollows are located along the western vegetated bund on Lot 9009. Consideration has been given to retain these trees within future road reserves and private large landscape lots along Cranwood Crescent during future detailed subdivision design. Whilst impacts to native fauna will be minimal given the limited habitat value within the site the proposed structure plan does not preclude the preservation of these potential habitat trees.

Subject to mitigating factors, the proposed structure plan supports opportunities for the retention of habitat trees and foraging habitat. It also supports potential opportunities for the retention of existing trees within the new road network, public open space and in the future large landscape residential lots to be located along Cranwood Crescent. Furthermore, new tree planting opportunities will be integrated in line with the landscape master plan.

3.3.7 City of Swan Urban Forest Plan - Greening the City (2022)

The plan recognises that trees provide an important role in urban areas due to their ability to absorb carbon, purify the air that we breathe, cool outdoor spaces particularly in heat-absorbing paved areas and in providing amenity, liveability, habitat for biodiversity and in supporting mental wellbeing for our community.

The Urban Forest Plan (the Plan) represents an integrated approach to supporting and enhancing our urban forest within the City's operations and in the wider community. The following underlying principles, supported by objectives and strategies, form the foundation of the Plan, guiding the effective delivery of actions and quality of outcomes:

- A good quality urban forest contributes towards many social, environmental and economic benefits and outcomes for the City along with residents and visitors.
- The urban forest with its comprising tree canopy and green spaces should be protected, preserved and enhanced to achieve the wide range of benefits.
- The City of Swan has a responsibility to ensure the tree canopy and green spaces are protected, managed and monitored to secure quality urban forestry outcomes into the future.

The Rivermark project aligns to the City's Urban Forest Plan's abovementioned principles, Rivermark's Area 3 seeks to deliver actions and quality outcomes as identified in the table below:

	Rivermark Project Design Response	How It Will Be Implemented
1.	Retention of trees along the existing earth bund adjacent to Cranwood Crescent. The provision of large 'landscape' residential lots (800-1000sqm) hugging the eastern side of Cranwood Crescent.	The proponent will collaborate with the City's officers to design and implement Local Development Plans at the detailed subdivision stage to define building footprints and crossover locations to protect trees within private lots.
2.	Design roads and verges to meander around existing trees being retained, providing unique visual punctuations in the streetscape.	Detailed design and alignment of the new internal roads will be placed to facilitate the protection of existing trees within verges.
3.	Improve upon the existing brick works hardstand areas and drainage ponds to maximise new street tree planting opportunities which will achieve substantial new urban canopy areas.	Design verges and crossover spacings to maximise new tree plantings in accordance with the City's Tree Guidelines.
4.	Facilitate, in collaboration with the City, the rejuvenation and delivery of a new Jack Williamson Oval to the benefit of the broader Viveash community.	Progress design options with the City, to consider: • Oval remediation and returfing, • New dog park and passive recreational space, • Amenities (e.g. nature play, bbq settings, drinking fountains). • Retention of existing trees and provide additional tree plantings around the periphery of the oval.
5.	Maximise tree retention and introduce new plantings as part of the extension of Eveline Road.	Protection of existing trees as part of Eveline Road extension design – design now complete. Integrate new street tree plantings along this major boulevard to achieve substantial canopy areas.
6.	Retain existing trees and plant additional trees around the proposed drainage area.	Opportunity to physically integrate the tree plantings as part of the broader rejuvenation of the adjoining oval design works.

3.3.8 2021-2031 City of Swan Strategic Community Plan

The City's Strategic Community Plan is the City's principal strategy and planning document and sets out the vision, aspirations and objectives for the Swan community over the next 10 years.

The City's vision is for One City, diverse people, cultures and places. A sustainable, thriving City of diverse people and places enjoying a great quality of life, health and wellbeing. The key themes are:

- Sustainable growth: We are committed to economic growth and diversity balanced with natural environment and heritage to ensure the City provides local services, industry access, local employment and diverse places to live.
- Caring for our environment: The City is committed to caring for and protecting the environment and our history and heritage. The community is proud of the City's beautiful natural environment, its bushland, open spaces, the Swan Valley and Swan River with its natural and diverse beauty.

The structure plan will establish a new chapter for the brickworks site, one that references the local built form character and significant environmental values of the parkland and riverine.

Figure 16. Concept Plan

4. Structure Plan

4.1 Vision

Rivermark reimagines its connection to nature through the next sequence in the continuing story of this place. It will provide new homes, a new neighbourhood and community. It will create spaces for people to make new memories in a beautiful natural setting, with houses on and linked into the river environs.

The new neighbourhood will feature fresh, modern and innovative houses that are sensitive to the local environment and character. Future homes will be identifiable by their variety and sophisticated palette of textured materials, contrasts of shade and pattern and earthy riverine colour scheme. Future homes will reference traditional design elements readily identifiable in Midland's historic homes and in the surrounding industrial heritage of the brickworks. The future landscape will comprise a continuous ribbon of green linkages, weaving the creek and river together and threaded through the streets as a constant reminder of place.

4.2 Land Uses

The structure plan provides for the following land uses:

- Residential; and
- Drainage.

4.3 Design Overview

Broadly, the project's guiding design ethos focuses on four key principles as illustrated in the figure below.

4.3.1 Site Responsive Design - Tree Retention & Planting

The proposed structure plan design framework seeks to protect and enhance environmental values by optimising tree retention. This is being addressed by the following initiatives:

- Expert advice has been sought to identify opportunities to retain significant trees within the existing Cranwood Crescent road reserve, the new road network accounting for Tree Protection Zones, Structural Root Zones and tree canopy.
- Detailed investigations are being undertaken by the design team to determine finished earthworked levels to tie into the eastern side of Cranwood Crescent down to Jack Williamson Oval and identify trees that can be practically retained once the existing bund along Cranwood Crescent is modified. These trees will be retained within larger 'Landscape' lots, providing unique lifestyle lots where established trees shall provide valued shade and amenity to the locality. Refer to Figure 17: Concept Layout of Landscape Residential Lots Retaining Existing Trees.
- New local road reserves are being configured to incorporate as many existing trees as possible within the verges.
- New residential lots shall be required to protect existing trees within their front and rear building setbacks as part of future Local Development Plan (s), this will include designating crossovers to avoid potential conflicts.
- Retention of existing trees along the site's eastern interface to the Jack Williamson Oval, subject to any mitigating factors faced.

Substantial tree planting shall also be undertaken as part of the future redevelopment of the existing scarred brickworks landscape to achieve significant tree canopy areas as the site develops.

Refer to Figure 16 - Concept Plan

4.3.2 Rehabilitation and Enhancement of Jack Williamson Oval

The proponent, in collaboration with the City of Swan, is exploring opportunities to integrate Jack Williamson Oval to the benefit of the broader Viveash community. These investigations are considering:

- Oval remediation and returfing,
- New dog park and passive recreational space,
- Amenities (e.g. nature play, bbq settings, drinking fountains).

The proposal will retain existing trees and provide additional tree plantings around the periphery of the oval.

4.3.3 Reconnecting the Community to Jack Williamson Oval

In accordance with Figure 15, opportunities are being explored for further integration between the public realm, the interface to the surrounding road network and the Jack Williamson Oval. This is intended to provide east-west pedestrian connections, enabling the existing Viveash community to gain direct access to the existing Jack Williamson Oval. This is intended to ensure dwellings will have direct access to the local parks in Area 2 and Area 3 (300m catchments), aswell as the neighbourhood open space facilities at Jack Williamson Oval (800m catchment).

4.3.4 Environmental Smarts

Rivermark boasts a 6 Leaf accreditation under the EnviroDevelopment assessment framework, with net Zero Carbon initiatives being integrated as part of the sites development. The project will encourage the design and construction of homes which are efficient in energy and water use, oriented to maximise natural light and ventilation, comfortable and economical. Houses will optimise passive design above the dependence on mechanical heating and cooling, delivering economic and environmental gains for the future community.

New cycle and pedestrian/dog walking networks will be created, providing direct connectivity to a planned dog park at Jack Williamson Oval. Alternative circuits will be provided leading to the north, up to the river and existing Reg Bond Reserve, and a future dual use path network hugging the riverside for enjoyable natural recreational exercise.

Residential Yield and Densities

The conceptual subdivision design provides for a residential density of R10 to R30 across the subject site, comprising single dwelling lots in a mix of large 'Landscape' lots (800sqm-1,300sqm) and small conventional and cottage lots. Based on this density, an indicative yield shows that the structure plan area will yield of in the order of 152 dwellings.

The range of lot areas is the result of implementing site responsive design solutions to retain an existing earth bund and associated trees located along the eastern edge of Cranwood Crescent. The retention of this bund and trees requires sufficient space to ensure Tree Protection Zones, Structural Root Zones and tree canopy are accommodated and protected as part of the larger lot product; referred to as Landscape lots. Detailed engineering design work will be undertaken as part of the subdivision application, in association with arborist, to determine earthwork solutions and separation areas around trees.

The final lot yield and design will be determined as part of a detailed subdivision application at the subsequent stage of planning.

Table 6 provides an overview of development statistics based on the concept plan. The concept plan provides a point of reference to demonstrate the capability of the proposed structure plan design over the subject site.

The initial estimated 152 single lots in Table 6 is based on an estimated residential housing composition as shown below:

Table 6 – Estimated dwelling yield and lot typology

Housing Typology	Estimated Dwelling Yield	Percentage
Single Dwelling (R20) Low Density – Min 350sqm – Average 450sqm	128	84%
Single Dwelling (R30) Medium Density – Min 260sqm – Average 300sqm	13	8.5%
Single Dwelling (R10) Landscape Lots Low Density – Min 875sqm – Average 1000sqm	11	7.5%
Total Yield	**152**	**100%**

Table 7 – Development Statistics (based on the Concept Plan)

	Site Outcomes
Total Structure Plan Area	10.02 ha
Estimate ultimate number of single/grouped dwellings	152 dwellings
Estimated number dwellings per site hectare[1]	21.29 dwellings per site hectare
Estimated number dwellings per gross hectare	14 dwellings per site hectare
[1]Liveable Neighbourhoods definition of site hectare is the area available for residential development excluding roads, non-residential uses, public open space and drainage areas.	

5. Proposed Movement Network

5.1 Road Network

Changes to the internal road network are summarised as follows:

- Three access street connections to Cranwood Crescent.
- New north-south street connection (adjacent to Jack Williamson Oval) between Eveline Road extension and Cranwood Crescent.
- All intersections within the Site is expected to be priority controlled. Further details regarding road reserve widths, hierarchies, will be provided at the subdivision stage, generally in accordance with Liveable Neighbourhoods.

Refer to Figure 17: Proposed Movement Network

5.2 Pedestrian and Cycle Networks

Footpaths shall be provided on at least one side of every street within the site. A shared path shall be provided along the north-south road adjacent to the Jack Williamson Oval, connecting Eveline Road and Cranwood Crescent. The City of Swan have indicated that there will be no changes to the pedestrian network surrounding the proposed site, other than works related to the approved subdivision to the north. A shared path will be constructed along the Eveline Road extension during November 22 to June 23.

Footpaths will be determined in consultation with the City of Swan as part of the detailed design phases of the subdivision works. It is understood that the City of Swan has no plans to add or upgrade the cycling network in the vicinity of Area 3, however the Department of Transport (DoT) has long term plans for continuous shared path networks along both sides of the Swan River. Area 3 will connect into the Long Term Cycling Network via Cranwood Crescent and Eveline Road down to the existing network on Great Northern Highway and upto the network along Reg Bond Reserve.

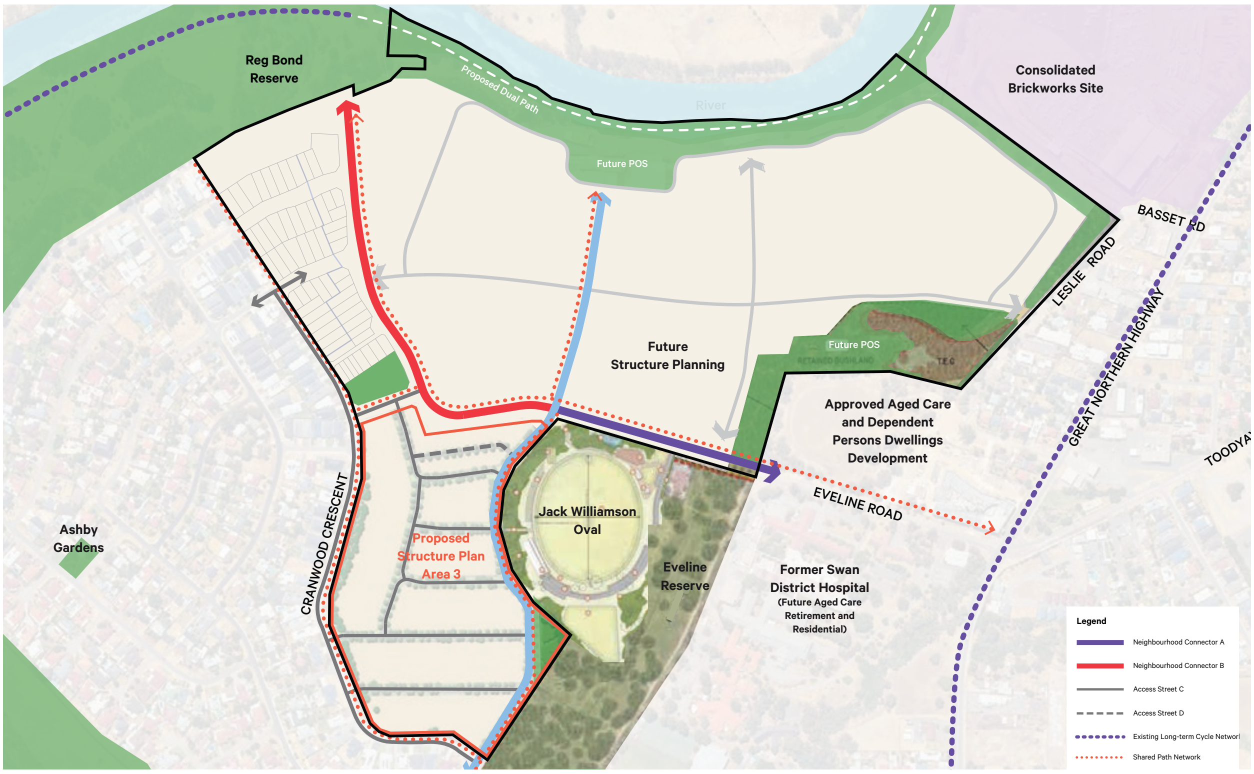


Figure 17. Proposed Movement Network

5.3 Traffic Generation

The proposed development of Area 3 (the subject of this structure plan) consists of 152 dwellings. This is envisaged to form part of a broader redevelopment area consisting a total of 650 residential dwellings. Area 3 is estimated to generate 118 trips in the AM Peak Hour, 155 trips in the PM Peak Hour, and 1,464 daily trips.

The Eveline Road extension (to be constructed by the second quarter of 2023) will provide improved connectivity for the site and the existing Viveash suburb and present the possibility for bus services to be routed through or adjacent to the site and Viveash, therefore improving public transport access. Having regard to the broader redevelopment assessment, the report concluded that by 2031 some intersections will require upgrades; in some cases regardless of the broader redevelopment of the brickworks site:

SIDRA analysis results show that the intersection of Great Northern Highway/Reid Highway/Roe Highway would perform poorly in 2031. This is caused by the background traffic growth and will perform poorly regardless of whether the broader redevelopment area is included. Main Roads WA is planning to grade separate the intersection within 10 years as part of the Eastlink WA project which would significantly increase the capacity. As such, it is expected that this intersection would performed adequately when the grade separation is completed

SIDRA analysis results show that the intersection of Great Northern Highway/Toodyay Road/Eveline Road generally operates satisfactorily, however during the AM Peak in 2031, the right turn from Eveline Road should be improved. The recommended mitigation measure is to amend the signal phasing and construct a left turn slip lane with splitter island for the Toodyay Road approach in order to reduce the amount of opposing traffic for the right turn from Eveline Road. This mitigation measure results in satisfactory performance in all scenarios.

SIDRA analysis results for Great Northern Highway/Morrison Road/Keane Street intersection indicates that the intersection is likely to require upgrades prior to 2031 to accommodate background traffic growth. A recommended mitigation measure is to modify the lane allocations and phasing to allow a dual right turn from Great Northern Highway into Morrison Road (west). This mitigation measure results in satisfactory performance in all scenarios.

Morrison Road/Frederic Street SIDRA results show that some delays are expected on Frederic Street in the year 2031. Providing a short left turn lane in Frederic Street results in satisfactory level of service for Frederic Street and improved right turn and left turn performance.

Overall, the proposed Area 3 development can be catered for by the surrounding road network.

Refer to Appendix D - Transport Impact Assessment

6. Water Management

6.1 Local Water Management Strategy

The proposed structure plan will ultimately result in the replacement of existing industrial hardstand with residential lots, roads, adjacent to existing developed areas of Viveash, Jack Williamson Oval, and the Blackadder Creek Tributary.

From a stormwater management perspective, the development will seek to provide improvements in local water management and interaction with adjacent watercourses and seek to improve existing water quality management outcomes as the area transitions from its current industrial use.

In order to support the proposed structure plan, a Local Water Management Strategy (LWMS) has been prepared. The LWMS (February 2024) considers stormwater management in the context of the whole of the brickworks site. It provides a comprehensive overall assessment of the existing water management system and its performance. It also demonstrates how the existing system will be modified to improve water sensitive urban design outcomes as a result of the proposed residential land use change. The LWMS includes key design principles and criteria in line with the proposed residential use of Lot 9009.

Refer to Table 8 – LWMS design principles and criteria.

Table 8 – LWMS design principles and criteria

Strategy Elements	Method & Approach
Water Use Sustainability	
Water Efficiency	Promotion of 6 star building standards (water efficient fixtures and fittings). Use of water-wise plantings in POS and landscape rehabilitation areas. Maximise infiltration of residential stormwater runoff.
Water Supply	Construction: Temporary DWER groundwater licence and use of brickworks stormwater Lots: Water Corporation IWSS and rainwater tanks (optional). POS: Groundwater irrigation. Retained industrial outside of LSP area to continue with Water Corporation IWSS and stormwater harvesting via Clay Basin/Swale storage for dust suppression.
Wastewater	Water Corporation reticulated sewerage.
Stormwater	
Design and Management Principals	Habitable development levels have suitable clearance above the 1% AEP flood level of the Swan River (5.7-6.0 mAHD) and Blackadder Creek (5.46 mAHD at Muriel St). Water quality to be managed through biofiltration treatment of runoff generated by first 15mm of rainfall prior to discharge to Blackadder Creek tributary. Maintain the overall water balance at Muriel St and maintain the peak discharge at the existing southern outlet of the Midland Brick site to existing flows. For the remaining industrial area and its upstream external catchment, continue to provide a flow path and operation consistent with existing practice.
Lot Scale Measures	Soakwells sized to retain and infiltrate first 15 mm rainfall on lots within sand fill. Rainwater tanks (optional). Water-wise landscaping to retain stormwater and minimise runoff
Street Scale Measures	Biofiltration as specified in POS, with additional areas identified at UWMP scale as necessary if required Piped drainage, with opportunities for localised swales in road reserves to be reviewed at UWMP stage. GPT's

Strategy Elements	Method & Approach
Estate Scale Measures	Water quality treatment areas for treatment of runoff from first 15mm rainfall via biolfitration. Estimated area and volume required of 0.076 ha and 227 m3, based on assumed 0.3m depth. Flood management storage areas within POS areas to attenuate flows in accordance with agency requirements. Post development groundwater, surface water, and system performance monitoring and annual reporting.
Groundwater	
Fill & Subsoil	Use of imported fill, with subsoil to be implemented to control perched water levels within the imported fill.
Acid Sulphate Soils	Development area has no known risk of ASS.
Implementation	
Process	Predevelopment groundwater and surface water monitoring program complete. Future stages of planning consistent with BUWM including preparation of UWMP's. Staging of stormwater changes to be detailed in the relevant UWMP's and implemented to ensure key hydrological performance criteria for the receiving environment are maintained during the transitional process.

The strategy also outlines the broad terms of the proposed stormwater management system being:

- For Blackadder Creek tributary, the stormwater management area will be required to provide stormwater storage to attenuate flows to existing levels for events up to the 1% AEP. This storage area will be integrated within the designated drainage area, with opportunities for smaller scale distributed storage considered at UWMP stage.
- For the existing brickworks site and its external contributing local authority catchment, the strategy will be to continue to provide a functioning stormwater management system in accordance with existing environmental requirements. This will require the continued use of a pumped stormwater management system. Additional staging works will be required in due course, including relocation of the existing southern storage area once development proceeds.
- Staging of stormwater works will be required to maintain a functioning stormwater management system for the existing brickworks and external council drainage system which drains into brickworks throughout the development transition period.

The LWMS is also supported by a biophysical assessment of Blackadder Creek Tributary. Although the assessment concluded the LSP poses no risk of impacts to the Blackadder Creek Tributary and that existing setbacks to confirmed adjacent Threatened Ecological Community (TEC) are adequate, it also found there is an opportunity in redeveloping the LSP area, to improve the LSP's existing interface and relationship with the Blackadder Creek Tributary. The biophysical assessment recommends further investigating the definition and extent of a tributary foreshore, to be managed under a Foreshore Management Plan, prepared at the subdivision stage.

The LWMS suggests the foreshore be defined to:

- Include the full extent of the land included in the public reserve that includes the Blackadder Creek tributary and the outermost extent of 1% AEP flooding, but no further separations to the public reserve given the proposed public road reserve interfaces under the LSP.
- Manage stormwater flows from the LSP area, in terms of location, rates and volumes, to take into consideration the location of known TEC occurrences.
- Manage the public reserve incorporating the Blackadder Creek tributary to maintain and ideally enhance the waterway, vegetation and fauna habitat values, and to ensure that the implementation of the LSP does not require any impact to the public reserve (including for stormwater conveyance and bushfire management purposes).

The current hydrological functions of the site will be managed through the application of the Better Urban Water Management Framework (implemented through the standard planning process), detailed in the LWMS prepared to support the structure plan (Hyd2o Hydrology 2021). The broad redevelopment of the brickworks site provides the opportunity to mitigate the impacts of a drying climate by making more water available to flow through the catchment surrounding the TEC and the Blackadder Creek tributary, and to capture stormwater for irrigation use.

Refer Appendix E – Local Water Management Strategy (Revised February 2024).

6.2 Urban Water Management Plan

Consistent with processes defined in WAPC (2008), Urban Water Management Plans (UWMPs) will be developed and submitted to support the subsequent subdivision application. Preparation of the UWMP will be the responsibility of the developer. UWMPs will address:

- Demonstrated compliance with LWMS criteria and objectives to the satisfaction of the City of Swan, DBCA and DWER.
- Agreed/approved measures to achieve water conservation and efficiencies of water use.
- Detailed stormwater management design.
- Management of groundwater levels including proposed cut/fill levels.
- Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, expected performance and agreed ongoing management arrangements.
- Management of subdivisional works including development of a strategy for sediment control during construction.
- Implementation plan including roles, responsibilities, funding and maintenance arrangements.
- Specific monitoring and reporting to be undertaken for each UWMP area consistent with the monitoring program defined in the LWMS.
- Contingency plans (where necessary).
- Opportunities for more drainage (eg swales, biofilters) to provide a more desirable interface with the Blackadder Creek foreshore/bush land adjacent.

Further detail of any improvements to the Blackadder Creek Tributary area adjacent to Lot 9009 will be provided at the time of development. This will include the refinement of stormwater modelling, preparation of detailed landscape plans (species selection and treatments), and detailed engineering design drawings.

Staging of stormwater changes will be detailed in the relevant UWMP's and implemented to ensure key hydrological performance criteria in relation to the receiving environment and key design objectives are maintained during the transition process.

7. Infrastructure Coordination and Servicing

An engineering infrastructure report has been prepared by TABEC Civil Engineering consultants (Refer to Appendix F) to demonstrate Area 3's capability to be serviced. The engineering servicing review concludes that there are no engineering or servicing constraints to the redevelopment of the site for residential purposes. Significant planning has already been undertaken by the relevant authorities to support existing developments within the vicinity of the site, including the recent release of Areas 1 and 2 residential lots. The report makes the additional comments in respect of the below services.

Refer to Appendix F – Engineering Infrastructure Report.

7.1 Water Supply

Existing Water Corporation infrastructure in the vicinity of the site includes a 250mm diameter main in Eveline Road, 100mm diameter main in Cranwood Crescent and a 200mm diameter main traversing the site between Eveline Road and Cranwood Crescent, just north of Trent Street. The existing brickworks water and fire supply network within the site is intended to be removed in a progressive manner as part of the proposed staged demolition works.

The extension of the existing water mains surrounding the site will provide the internal reticulation network. An internal water reticulation network will be constructed within the site to provide a service to all lots in accordance with the Water Corporation requirements. Standard Water Corporation water headworks are applicable in this area.

7.2 Power Supply

There is currently capacity within Western Power's broader network to service the development with their network mapping tool indicating that there is in excess of 25MVa capacity in the area which is serviced from Hadfields WP-009 substation.

In this instance, it is also noteworthy that the reduction in area and capacity of the brick making facilities will free up capacity in the existing network. Street lighting will also be required as part of the development in accordance with Western Power and City of Swan guidelines.

7.3 Wastewater

The proposed development is within the Water Corporation license area and all lots created will be connected to the Water Corporation sewer. The site sits within Eden Hill Sewer District 024. Based on a review of existing sewer infrastructure, it is likely that lots directly abutting Cranwood Crescent will connect to the existing sewer in Cranwood Crescent. However, as Cranwood Crescent sewer is relatively shallow, it is likely that the majority of Area 3 will need to outfall to the existing network near the intersection of Ashby Terrace and Kent Street.

From a development perspective, providing the site with a reticulated sewer system will be achieved through the orderly development of the site. Wastewater infrastructure will be designed and constructed in accordance with Water Corporation standards and requirements. Standard Water Corporation wastewater headworks are applicable in this area.

7.4 Telecommunications

Area 3 is within the NBN fibre to the node fixed line footprint and therefore can be serviced.

The NBN network is located adjacent to the site, within the existing residential subdivision in Cranwood Crescent and provides a connection point for an NBN compliant pit and pipe network to be extended within the proposed development. The site would enter into an agreement with NBN (or other service provider). NBN is required to recover part of the cost of deploying the NBN network infrastructure by applying a Developer contribution charge per premises.

7.5 Gas

ATCO Gas have a steel high-pressure gas pipeline within and in near proximity to the site, along with a PRS located north of the site near Swan River shoreline.

Unlike the Parmelia 'single user' supply, the ATCO Gas infrastructure forms part of a broader network. The pipes traverse the site through the future development and along Eveline Road and Leslie Street.

The Concept Layout Plan and subsequent conceptual earthworks modelling has taken into consideration the existing ATCO Gas steel high-pressure pipeline such that it can remain in situ. However, it is an ATCO requirement that no sensitive land uses such as aged care, child care etc. are located immediately adjacent to any HP gas pipes located within future road reserves. The proponent has elected against servicing future residential development with a reticulated gas supply, and shall commit to 100% of estate being powered by renewable energy.

8. Site Works and Earthworks

Siteworks to support residential urban development will generally comprise the clearing of existing vegetation, stripping of topsoil, earthworking of the existing ground surface, compaction to areas of existing fill and import of a sand topping to facilitate the proposed form of development.

Given the existing soils within the site consist of material unsuitable for residential development in its current state and the geotechnical requirement for imported sand fill, limited vegetation will be able to be retained during site preparation. However, some of the more significant trees have been identified through planning investigations and environmental studies and the conceptual earthworks design accounts, as much as is practicable, for the retention of significant trees.

Future roads and services are being designed to minimise the impact on the retained trees. Future detailed design at the subdivision stage will inform specific tree retention.

Development of Area 3 will require removal of all brick and clay stock on site as well as the demolition of existing pavements and services prior to undertaking site earthworks, servicing and roadworks to produce the desired development form. Following demolition of existing infrastructure, earthworking will take place to provide for a desired development form while addressing the engineering constraints of the site.

The clayey subgrade surface will be earthworked and shaped, before the sand is placed, to ensure no ponding of perched water occurs. Following the subgrade works, a layer of clean sand fill will be imported and placed above the clayey material to achieve the proposed finished levels and desired site classification. Earthworking of the site is also required to ensure the positive drainage of the allotments to the road and drainage reserves for disposal.

The Douglas Partners geotechnical review recommends that there is a minimum depth zone of at least 1.2m of compacted clay fill that sits below the sand topping layer. Therefore, areas where there is less than 1.2m of clay filling required below the sand layer will need to be over-excavated and recompacted. Where the excavated material has brick or other deleterious inclusions, a screening and crushing process will be required to downsize material to less than 50mm to ensure there are no voids in the future structural fill matrix.

The imported material used for filling should be a free drainage clean sand material having a fines content less than 5% and permeability greater than 5m/day to avoid the imported material having a negative impact on site drainage.

Once an appropriate level of site preparation is undertaken to address the geotechnical risk from the existing fill, compaction of the clayey subgrade and depending on the thickness of the proposed sand fill layer over the clayey soils, it is expected that the post development site classification will be 'A' or 'S', in accordance with AS2870.

It is anticipated that the final levels across the site will be dictated by either the fill required for improvement of the AS2870 site classification, or the minimum level required to ensure adequate separation from the Guildford formation and groundwater levels. Additionally, final levels will need to accommodate interface levels with the adjacent developments and existing infrastructure. Furthermore, finished floor levels for the buildings will need to be at least 500mm above the estimated 1% average exceedance probability (AEP) flood levels.

In accordance with current market expectations flat residential allotments will generally be created. Due to the proposed earthworks strategy, stepping between allotments is likely to be achieved with the minimal use of retaining.

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Appendix A

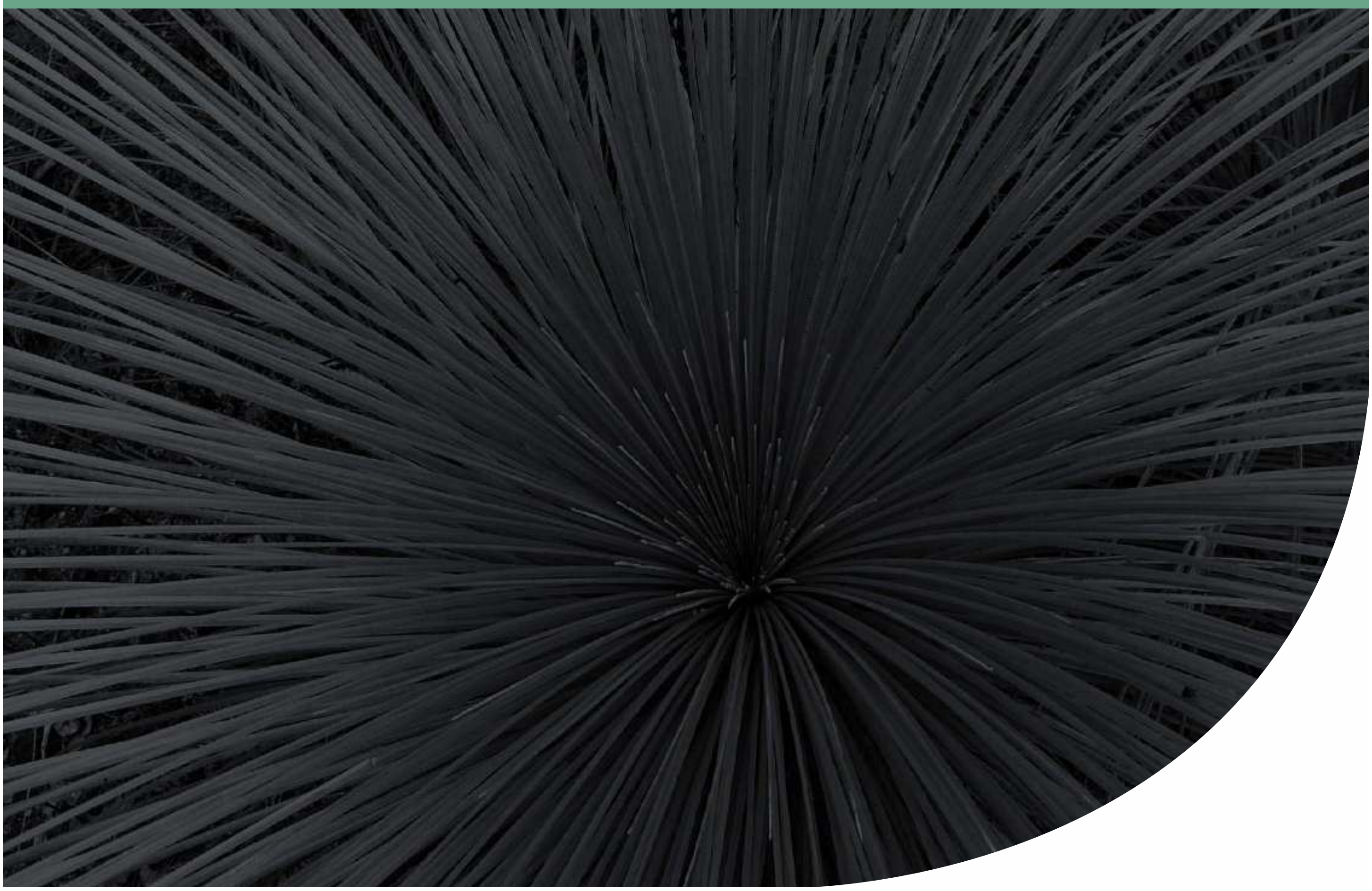
Environmental Assessment Report (Emerge Associates)

Environmental Assessment Report

Area 3 Middle Swan Brickworks Local Planning Scheme Amendment

Project No: EP19-105(44)

Prepared for Hesperia Pty Ltd
April 2022



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Version	Date	Author		Reviewer	
1	September 2021	Bianca Bertelli	BRB	Jason Hick	JDH
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	Report updated in response to comments received.				
B	April 2022	Bianca Bertelli	BRB	Jason Hick	JDH
	Report updated to incorporate updated local structure plan.				

Executive Summary

This *Environmental Assessment Report* (EAR) has been prepared on behalf of Hesperia Pty Ltd ('the proponent') to support a Local Planning Scheme (LPS) amendment to rezone Lot 9000 Cranwood Crescent, Viveash (the site) from 'General Industrial' to 'Residential (R20)' under the City of Swan (CoS) LPS No.17. The proposed LPS amendment is to facilitate future residential development following the decommissioning of Middle Swan Brickworks land uses within the site. This EAR provides an assessment of the environmental issues associated with the proposed change in zoning/land use, an indicates how these issues could be resolved.

A Local Structure Plan has been prepared for the proposed 'Residential' (R20) area which provides a framework for how the structure and layout of development should be progressed for the site. Following the LPS amendment, residential development will be delivered through subdivision approvals and development applications, in a staged manor, in general alignment with the Local Structure Plan.

The site currently supports existing industrial uses associated with the Midland Brickworks which are in the process of being decommissioned. The Midland Brick operations are currently licenced under the Part V of the *Environmental Protection Act 1986* (EP Act) (L4511/1967/13), and the site is currently within the prescribed premise boundary of this licence. The historical expansion of the Midland Brick operations was also assessed under Part IV of the EP Act, and approved subject to a number of conditions (Ministerial Statement (MS) 322 and MS 1124). The site is contained within the boundary of MS 1124. An application was made in December 2020 to have Kilns 7 and 8 removed from the current Part V Licence which was granted by DWER in August 2021. In addition, Kiln 11 will be decommissioned and removed from the Part V Licence in April 2022.

The site is approximately 10 hectares (ha) in area and located within the CoS, approximately 17 km north-east from the Perth Central Business District. The site comprises existing brickworks infrastructure including stormwater storage ponds and hardstand areas and remnant native vegetation. It is bound by Eveline Road to the north, the Midland Brickworks operational areas to the north-east, Jack Williamson Park and La Salle College to the east and Cranwood Crescent and Ashby Gardens residential estate to the south and west.

The relevant environmental attributes and values of the site are summarised as follows:

- The general locality surrounding the site is characterised by a mixture of existing residential neighbourhoods and industrial landuses associated the existing Midland Brick Brickworks.
- Topography across the site varies between 16.75 metres relative to the Australian Height Datum (mAHD) along the western bund to 7.0 mAHD at the base of the stormwater storage ponds within the southern portion of the site.
- Soil types beneath the site generally comprises silts on a flat to gently undulating plain. The shallow soil profile is likely to have moderate to high permeability.
- The site is not mapped as having any known risk of Acid Sulfate Soils (ASS).
- A review of historical images available from 1953 onwards (Landgate 2021), indicates the majority of the site was cleared of native vegetation prior to 1953, likely for grazing and

subsequently for brick making, with the exception of a patch of remnant vegetation within the southern portion of the site adjoining Jack Williamson's oval. Some additional tree planting has occurred since the initial clearing along Eveline Road to the north of the site, on the western bund and surrounding the perimeter of Jack Williamson's oval. Portions of the site have been utilised as hardstand areas for brick storage since circa 1987.

- A detailed flora and vegetation assessment was undertaken by Emerge Associates (2020f) over the broader Midland Brick landholdings, encompassing the site. The assessment indicated the site has been subject to long-term disturbance and modification, and as such is dominated by planted non-endemic vegetation with scattered occurrences of remnant native trees and native regrowth. Vegetation is limited to the western portion of the site representative of two plant communities, extending over 4.56 ha in 'degraded' condition. The majority of this area comprises planted non-endemic vegetation associated with the western noise bund, with occasional remnant native trees. The remaining 5.40 ha comprises hardstand areas and stormwater storage ponds in 'completely degraded' condition.
- Given the vegetation within the site has been subject to a high level of historical disturbance through vegetation clearing and industrial land uses and is present in a 'degraded' or 'completely degraded' condition, the vegetation is no longer intact and does not represent a listed community. Therefore, no Threatened or Priority Ecological Communities (TECs or PEC's) occur within the site (Emerge Associates 2020f).
- No threatened or priority flora species were identified within the site during the field survey, nor has any suitable habitat been identified for these species within the site.
- A level 1 Fauna and Targeted Black Cockatoo Assessment undertaken by Emerge Associates (2021e) over the broader Midland Brick landholdings, encompassing the site. Fauna habitat within the site is limited to scattered trees and small pockets of remnant vegetation which have been subject to significant historical disturbance. The site provides 0.02 ha of potential foraging habitat for black cockatoos as well as 26 potential black cockatoo habitat trees, none of which contain potentially suitable nesting hollows.
- No natural surface water features have been identified within the site. However, the Swan River is located directly approximately 450 m to the north of the site and a tributary of the Blackadder Creek which in turn is a tributary of Swan River is located to the south of the site. The site is located outside the 1% AEP floodplain of the adjacent Swan River. A series of stormwater settlement ponds are located within the south-western portion of the site to treat stormwater before it is discharged to Blackadder Creek. The stormwater settlement ponds are part of the stormwater infrastructure present across the entire Midland Brick landholding extending further to the north of the site to manage stormwater collection, storage and disposal.
- The site is identified within the mapped boundary of three Registered Aboriginal Heritage Sites; 'Turtle Swamp', 'Blackadder and Woodbridge Creek' and 'Bishop Road Camp'. A Registered Site inquiry of the broader Midland Brickworks, which encompasses the site was submitted to DPLH on 7 May 2019. DPLH confirmed that while the site intersects with the boundaries of the above listed Registered Heritage Sites; their physical locations are not within the site, and therefore approval under AHA is not required in relation to these sites
- There are no registered non-Indigenous heritage sites located within, or in proximity to the site.

- The site is identified as bushfire prone by the Map of Bush Fire Prone Areas (OBRM 2020). A Bushfire Management Plan has been prepared to support the LPS amendment. It has determined that the proposed LPS amendment can be implemented whilst still satisfying the requirements of SPP 3.7 and the associated Guidelines.
- Several contaminated site investigations have been undertaken across the site due to the previous industrial land uses. A Detailed Site Investigation (DSI) identified potential sources of contamination largely associated with the four southern storage ponds (given the potential presence of residual metals, hydrocarbons and pesticides in the base of the ponds) and the western bund due to the potential presence of uncontrolled fill (Emerge Associates 2021b). Elevated levels of Zinc and Biogenic Organic Compounds (BOCs) (i.e. non-petrogenic) hydrocarbons were reported within the soil sediment from the storage ponds, however these exceedances were not considered to present any risk to ecological receptors post development. Soil samples collected from the western bund and general area did not report concentrations of potential contaminants exceeding any human health assessment level. The DSI indicated very limited impacts are present within the site from current and historical land uses and recommended a site classification under the *Contaminated Sites Act 2003* of '*Not contaminated'* was appropriate.
- The future residential development will be bound to the north-east by the consolidated brickworks operations, and as such is likely that industrial noise will be a key consideration. The entirety of the site is subject to the predicted Australian Noise Exposure Forecast (ANEF) 20 to 25 contour for Perth Airport. A Noise Assessment was undertaken by Lloyd George Acoustics (2021) to support the LPS amendment and investigated the industrial noise impacts to future residential areas assuming Kilns 7, 8 and 11 are demolished and kilns 9 and 10 are retained to the northeast of the site where brickmaking operations are proposed to be consolidated. It is considered that the brickworks operations can achieve compliance with the *Environmental Protection (Noise) Regulations 1997* at all times through noise mitigation measures including triple stacked shipping containers on the west side of the Clay Shed and double stacked shipping containers at the nearest future residences to act as noise barriers. With regards to aircraft noise, outdoor noise levels over 80 dB LAmax can be expected in the future. *State Planning Policy 5.1: Land Use Planning in the Vicinity of Perth Airport* (SPP 5.1) (WAPC 2004) does not mandate any noise insulation where residences are located within the 20-25 ANEF contour but does require notifications on lot title. A Noise Management Plan may be prepared at the subdivision stage to investigate any design solutions required.
- A Human Health Risk Assessment was undertaken by Environmental Risk Sciences (2021) to understand the potential impacts from the consolidated brickworks' operations, predominately existing Kilns 9 and 10, on the proposed residential land use. The assessment found that for typical and maximum allowable operations, predicted ground level concentrations of all potential pollutants comply with all relevant assessment criteria for urban land uses.

Based on the environmental values or attributes identified, this EAR provides an environmental management framework to be implemented across the site for future subdivision and development, including:

- **Flora and vegetation**: Due to the degraded nature of the site, no significant flora or vegetation values have been identified within the site that require specific spatial responses through the Local Structure Plan. Detailed investigations and expert advice will be sought to identify opportunities to retain native vegetation, and in particular mature trees, potentially within areas of POS, road reserves and future residential lot boundary setbacks. Where clearing of vegetation is proposed, a clearing permit will need to be attained pursuant to *Part V of the Environmental Protection Act 1986*, unless a valid exemption applies.
- **Native fauna**: Impacts to native fauna will be minimal given the limited habitat value within the site. Reasonable efforts will be made to retain the identified black cockatoo habitat trees and foraging habitat, subject to mitigating factors such as worthiness of Retention assessment, natural attrition, unavoidable or unintended impacts from servicing requirements, managing bushfire risk, public safety and subdivision design or development requirements.
- **Hydrology - Surface water:** The current hydrological functions of the site will be managed through the application of the *Better Urban Water Management Framework* (implemented through the standard planning process), detailed in the Local Water Management Strategy (LWMS) prepared to support the LPS amendment (Hyd2o Hydrology 2021). Stormwater management requirements as outlined within the LWMS will be implemented through an Urban Water Management Plan (UWMP) for each stage of future subdivision.
- **Land use considerations – air quality impacts**: The Human Health Risk Assessment (Environmental Risk Sciences 2021) reviewed the emissions to air from the ongoing operation of Kilns 9 and 10. The maximum concentrations predicted as a result of ongoing operation of Kilns 9 and 10, have been reviewed against guidelines that are protective of human health (for all residents), odour and vegetation effects. There are no exceedances of any of these guidelines. Hence there are no air quality impacts (derived from the brick works operations) that would be of concern to the health of future residents at the site.
- **Land use considerations – acoustic impacts:** The Noise Impact Assessment (Lloyd George Acoustics 2021) concludes that the site will comply with the *Environmental Protection (Noise) Regulations 1997* at all times given no brick work operations shall occur south of Bassett Road other than the Clay Shed, and triple stacked shipping containers are included on the west side of the Clay Shed and double stacked shipping containers at the nearest future residences to act as noise barriers. Specific mitigation measures can be resolved in further detail at the time of subdivision and documented in a Noise Management Plan.
- **Bushfire management**: To respond to the known bushfire hazards within and surrounding the site, future development will be in accordance with the currently prepared BMP (Emerge Associates 2021a). This assumed that public open space (POS) within the site will be classified as ‘low threat’ and Jack Williamsons Park to the east will remain a bushfire hazard external to the site, classified as Forest (Class A) and Grassland (Class G) vegetation based on the future growth. Bushfire hazards can be suitably managed through the provision of appropriate setbacks to achieve a bushfire attack level (BAL) of BAL-29 or less and constructing dwellings in accordance with *Australian Standard 3959-2019 Construction of buildings in bushfire prone*

areas. Appropriate mitigation measures for bushfire can be resolved in further detail at the time of subdivision, as part of a BAL Assessment.

The EAR has found that the proposed urban development can be suitably managed through the planning process, with a low likelihood of significant adverse environmental impacts. As such there are no significant environmental issues or constraints within the site to the extent that it would preclude the site from being rezoned to from 'General Industrial' to 'Residential (R20)' under the City of Swan (CoS) LPS No.17 under the CoS LPS.

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List of Abbreviations

Table A1: Abbreviations – General terms

General terms	
AASS	Actual Acid Sulfate Soil
AHD	Australian Height Datum
ASS	Acid Sulfate Soil
CCW	Conservation Category Wetland
DBH	Diameter at Breast Height
DWMS	District Water Management Strategy
EAR	Environmental Assessment Report
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
PEC	Priority Ecological Community
PDWSA	Public Drinking Water Source Area
REW	Resource Enhancement Wetland
TEC	Threatened Ecological Community
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	
CoS	City of Swan
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity Conservation and Attractions
DoEE	Department of Environment and Energy (now known as the Department of Agriculture, Water and the Environment)
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
MRS	Metropolitan Region Scheme
LPS	Local Planning Scheme

1 Introduction

1.1 Background

Hesperia Pty Ltd (the proponent) is seeking to lodge a Local Planning Scheme amendment to rezone Lot 9000 Cranwood Crescent, Viveash (the site) from 'General Industrial' to 'Residential (R20)' under the City of Swan (CoS) Local Planning Scheme (LPS) No.17. The proposed LPS amendment is to facilitate future residential development following the decommissioning of a portion of the Middle Swan Brickworks land uses within the site. A Local Structure Plan has been prepared for the proposed 'Residential' (R20) area which provides an outline for how the structure and layout of development should be progressed for the site, as shown in **Appendix A**.

The site is approximately 10 hectares (ha) in area and located within the CoS, approximately 17 km north-east from Perth Central Business District. The site comprises existing brickworks infrastructure, stormwater settlement ponds, hardstand areas and areas of remnant native vegetation. It is bound by the Cranwood Crescent residential development (WAPC subdivision approval reference #158848) and Eveline Road to the north, the Midland Brickworks operational areas to the north-east, Jack Williamson Park and La Salle College to the east and Cranwood Crescent and Ashby Gardens residential estate to the south and west. The site is currently zoned 'Urban' the Metropolitan Region Scheme (MRS) and 'Industrial' under the CoS LPS No.17, as shown in **Plate 1** below.

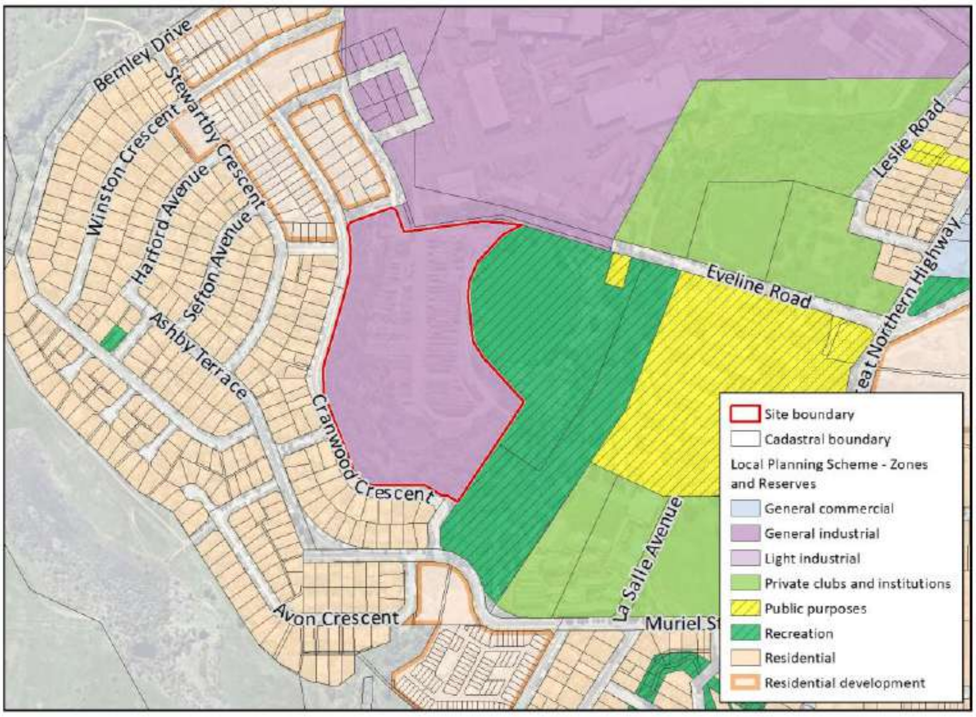

Plate 1: City of Swan LPS 17 zones and reserves within and surrounding the site (DPLH 2018)

1.2 Purpose of this report

Emerge Associates was engaged by Hesperia Pty Ltd (Hesperia) to prepare an Environmental Assessment Report (EAR) to support the submission of an amendment to CoS LPS No.17 to rezone the site from 'General Industrial' to 'Residential (R20)', to ensure the site is consistent with the current 'Urban' MRS zoning and facilitate future residential development. This EAR provides an assessment of the potential considerations associated with the proposed change in zoning/land use and indicates how these could be resolved.

A Local Structure Plan has been prepared by Element (2022) (**Appendix A**) to support and guide future residential development within the site. Following the LPS amendment, residential development will be delivered through subdivision approvals and development applications, in a staged manor, in general alignment with the Local Structure Plan layout.

The Environmental Assessment Report (EAR) is the principal supporting environmental document for the LPS amendment process, providing a synthesis of information regarding the environmental values and attributes of the site. This EAR:

- identifies and assesses the existing environmental values and attributes of the site (**Section 2**)
- discusses the land use planning context and the proposed LPS amendment (**Section 3**)
- discusses how the Local Structure Plan design responds to the existing environment and outlines the proposed future environmental management requirements (**Section 4**)
- describes how the environmental management approach can be implemented (**Section 5**)

1.3 Assessment scope

To inform the EAR, Emerge Associates was engaged by Hesperia to undertake a range of environmental investigations and assessments across the site as summarised in **Table 1** below.

The EAR has incorporated the outcomes of these investigations and assessments to provide an overarching environmental assessment. It documents the existing environmental attributes and values and ensures that significant ones can be accommodated as part of the LPS amendment, and at future stages of development.

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

Component	Purpose	Relevant EAR section/s
Level 1 Fauna and Targeted Black Cockatoo Assessment	To assess and document the existing terrestrial vertebrate and avian fauna habitat values and known species occurrences within the site.	**Section 2.2.4** *Technical Memorandum - Fauna Assessment Part Lots 23 Winston Crescent, Lot 9000 Cranwood Crescent and 73 Eveline Road, Middle Swan (Emerge Associates 2022) provided* in **Appendix B**
Detailed Flora and Vegetation Assessment	To assess and document the existing flora and vegetation values within the site.	**Section 2.2.1** *Technical Memorandum - Flora and Vegetation Assessment Part Lots 23 Winston Crescent, Lot 9000 Cranwood Crescent and 73 Eveline Road, Middle Swan (Emerge Associates 2020),* provided in **Appendix C**
Detailed Site Investigation	To assess the contamination status of the site and to identify any potential risk to human health or the environment, and to determine the suitability of the site for the intended residential land use and identify any requirement for remediation necessary to facilitate the intended residential land use.	**Section 2.6.2** *Detailed Site Investigation – Midland Brick Stage 2 Subdivision (Emerge Associates 2021b)*

In addition to this EAR, the following documents have been prepared or commissioned to support the LPS amendment:

- Bushfire Management Plan (BMP) (Emerge Associates 2021a)
- Noise Assessment (Lloyd George Acoustics 2021) (attached as **Appendix D**)
- Human Health Risk Assessment (Environmental Risk Sciences 2021) (attached as **Appendix E**)
- Local Water Management Strategy (LWMS) (Hyd2o Hydrology 2021) (attached as **Appendix F**)

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 the site and are discussed in further detail below.

2.1 Landform and soils

2.1.1 Topography

A detailed topographic survey for the site was completed by MNG on 11 July 2019, indicating the current surface elevation varies from approximately:

- 16.75 metres relative to the Australian Height Datum (mAHD) at the top of the western bund along the western boundary of the site.
- 8.5 mAHD in the central portion of the site in the vicinity of the brick storage area.
- 9.25 mAHD along the north boundary of the site.
- 15.0 mAHD at the top of the western bund along the south-eastern boundary of the site.
- 7.0 mAHD at the base of the southern storage ponds in the south portion of the site.

The western bund and southern storage ponds resulted in relatively steep soil batters along the alignment of these features, particularly the western bund. The western bund is up to approximately 5 metres (m) in height relative to the ground surface in the adjacent suburb of Viveash and is located along the western, southern and south-east site boundary. Shallow excavations have been undertaken to construct the southern storage ponds. Topographic contours are shown in **Figure 2**.

2.1.2 Landform, soils and geology

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

Examination of broad scale soil mapping places the site in the Pinjarra Plain within the Swan complex, which occurs along watercourses. The site is very close to the Guildford complex which also lies on the Pinjarra Plain and comprises clays and silts on a flat to gently undulating plain (Churchward and McArthur 1980).

Detailed soil mapping DMIRS (2018) shows that the site is underlain by the soil Mgs1-pebbly silt soil type, described as 'strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin', as shown in **Figure 2.**

The regional mapping shows land to the south, east and north of the site is likely to comprise pebbly silt (soil unit MGS1) similar to that mapped for the site. Regional mapping shows land to the north of the site (along the general alignment of the Swan River) is likely to comprise clayey silt.

The site is not known to contain any restricted landforms or unique geological features.

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 and/or anoxic conditions and do not present any risk to the environment. However, when oxidised, ASS can pose issues through the production of sulphuric acid, which can present a range of risks for the surrounding environment, infrastructure and human health.

The Department of Water and Environmental Regulation (DWER) provides broad-scale mapping indicating areas of potential ASS risk (DWER 2019). A review of the DWER mapping indicates that the site is not identified within an area of ASS risk.

2.2 Biodiversity and natural area assets

2.2.1 Flora and vegetation

2.2.1.1 Regional context

Native vegetation within the site can be classified based on regional vegetation associations. Heddle *et al.* (1980) mapping shows the site as comprising the 'Swan complex', which is described as 'fringing woodland of *Eucalyptus rudis* and *Melaleuca rhaphiophylla* with localised occurrence of low open forest of *Casuarina obesa* and *Melaleuca cuticularis*'. This complex was determined to have 13.84% of its pre-European extent remaining in 2013, of which 0.56% is under formal protection (PBP 2013).

2.2.1.2 Site specific investigations

A detailed flora and vegetation assessment was undertaken over the broader Midland Brick landholdings, encompassing the site on 18 September and 8 October 2019. During the survey an assessment was made on the type, condition and values of vegetation across the site, and weed mapping was also undertaken. The technical memo, Emerge Associates (2020) (**Appendix B**), details the flora and vegetation results recorded within the broader survey area and has been summarised with relevance to the site below.

2.2.1.3 Plant communities

Based on the findings from the flora and vegetation survey, a total 5.40 ha comprises hardstand areas and sedimentation ponds associated with the existing brickworks infrastructure, which constitutes over half of the site (54.21%). Vegetation is limited to the western portion of the site representative of two plant communities, extending over 4.56 ha. The majority of this area comprises planted non-endemic vegetation associated with the western noise bund, with occasional remnant native trees. The plant communities identified within the site are described in **Table 2** and shown in **Figure 3**.

Table 2: Plant communities present within the site

Plant community	Description	Area (ha)
Ec	Woodland to tall shrubland of various planted species, particularly *Eucalyptus camaldulensis*, with scattered *E. rudis* over shrubland *Genista linifolia* and *Melaleuca viminea* over closed non-native grassland with occasional scattered *Rytidosperma setaceum*	4.54
Ew	Woodland *Eucalyptus wandoo* over open non-native grassland.	0.02
Non-native/cleared	Heavily disturbed areas comprising planted non-native trees and shrubs over non-native herbs and grasses, with occasional native shrubs and forbs.	5.40

2.2.1.4 Vegetation condition

The condition of the vegetation across the site was determined to range from 'completely degraded' (5.40 ha) to 'degraded' (4.56 ha). The site has been subject to long-term disturbance and modification, and as such is dominated by non-native vegetation. Where native vegetation does occur, it was determined to have been altered from its natural state and were assessed to be in 'degraded' condition. As such, no plant communities within the site representative of intact native vegetation. The extent of vegetation by condition category is shown in **Figure 4.**

2.2.1.5 Threatened and Priority Ecological Communities

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'.

Within Western Australia, listed TECs are provided statutory protection through the Biodiversity Conservation Act 2016 (BC Act). While no TECs are currently listed for protection under the BC Act, they will likely be listed at a future date. In the interim, the Minister for Environment has listed ecological communities as threatened through a non-statutory process if the community is presumed to be totally destroyed or at risk of becoming totally destroyed. The WA Minister for Environment has endorsed 69 ecological communities as threatened through this non-statutory process.

An ecological community under consideration for listing as a TEC in Western Australia, but which does not yet meet survey criteria or has not been adequately defined, or which is rare but not currently threatened, is referred to as a 'Priority Ecological Community' (PEC). Whilst PECs are not afforded statutory protection in Western Australia, they are also considered during the environmental approval processes.

Known locations of TECs and PECs within 5-10 km of the site were searched for using the publicly available *Protected Matters Search Tool* (DoEE 2019), the weed and native flora dataset and DBCA's threatened and priority ecological communities databases (reference no. 17-01019EC). These search results identified 10 TECs and two PECs as occurring or potentially occurring within a 5-10 km radius of the site.

Based on geomorphology, soils and regional vegetation patterns, three TECs were considered to potentially occur in the broader survey area and also within the site:

- '*Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain' TEC which is listed as 'endangered' under the EPBC Act and recognised as 'critically endangered' in Western Australia.
- '*Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain' TEC which is listed as 'endangered' under the EPBC Act and recognised as 'critically endangered' in Western Australia.
- 'Clay pans of the Swan Coastal Plain' TEC which is which is listed as 'critically endangered' under the EPBC Act and recognised as 'vulnerable' or 'endangered' in Western Australia, depending on the vegetation type.

The flora and vegetation survey undertaken by Emerge Associates (2020f) determined that all plant communities within the site were subject to a high level of historical disturbance through vegetation clearing and industrial land uses and are present in a 'degraded' or 'completely degraded' condition. The survey concluded that the plant communities within the site have been altered, are no longer intact. Therefore, no TECs or PECs occur within the site.

2.2.1.6 Significant 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 the EPBC Act. At a State level, plant species may also be classed as 'threatened' under the BC Act. Species which are potentially rare or threatened; meet the criteria for near threatened; or have recently been removed from the threatened species list are classed as 'priority' flora species. However, priority flora species are not afforded statutory protection.

The desktop flora assessment using the *Protected Matters Search Tool*, *NatureMap* and DBCA's threatened and priority flora database identified many threatened and priority flora species as having potential to occur in the site, based on landscape and soil mapping. The field survey determined that most of the site does not provide suitable habitat due to the high level of historical disturbance with the exception of the south eastern patch of remnant native vegetation.

No threatened or priority flora species were identified within the site, despite two surveys undertaken within spring, which is the main flowering period for most plants on the Swan Coastal Plain. As the spring survey timing was suitable to search for threatened and priority flora species identified as potentially occurring in the site, no threatened and priority flora are considered to occur in the site (Emerge Associates 2020).

2.2.1.7 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 state *Biosecurity and Agriculture Management Act 2007* (BAM Act), indicating that it warrants special management to limit its spread. At a National level, the Australian government has compiled a list of 32 Weeds of National Significance (WoNS) (DoEE 2019c).

As part of the flora and vegetation assessment (Emerge Associates 2020), mapping of weed species was undertaken within the site. A high weed coverage was recorded within disturbed areas (**Er**) synonymous with a 'degraded' condition. **Chrysanthemoides monilifera subsp. monilifera* (boneseed), was recorded within the site, this species listed as a declared pest (C3) pursuant to the BAM Act and as a weed of national significance (WoNS).

No other declared pests or WONS were recorded within the site.

2.2.2 Bush Forever

The Government of Western Australia's *Bush Forever Policy* (Government of WA 2000) 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 vegetation complexes by targeting a minimum of 10% of each for protection. Bush Forever sites are representative of regional ecosystems and habitat and have a key role in the conservation of Perth's biodiversity.

No Bush Forever Sites are located within the site. Bush Forever Site 302 'Swan River and Jane Brook, Ashfield to Upper Swan' is located approximately 430 m to the north of the site which extends further to the east and west of the site, associated with the Swan River.

2.2.3 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 values such as significant wetlands, threatened flora, threatened communities and *Bush Forever* sites. 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, which includes 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).

No ESA's occur within the site. One large ESA is located to the north of the site following the general orientation of the Swan River watercourse. The ESA appears to be associated with the Conservation Category Wetland (CCW) 'Swan River Estuary' (UFI 14,356) which extends over 53.96 ha to the north, east and west of the site.

2.2.4 Local Natural Areas

From 2001 to 2014, the WALGA sponsored *Local Biodiversity Program* (LBP) promoted and enabled long-term conservation of natural areas in regions of Western Australia subject to rapid development. Through this time, the LBP provided Local Governments with expert and technical advice, data, and mapping to inform biodiversity planning and management. The LBP supported the preparation of Local Biodiversity Strategies (LBS), such as the one adopted by the City of Swan in 2016.

One of the goals of the City's LBS is to protect Local Natural Areas that contain vegetation in 'good' or better condition. The term 'natural area' is used to describe any physical area that contains native species or ecological communities in a relatively natural state and hence contain biodiversity. The term Local Natural Area defines natural areas that exist outside: Bush Forever Sites (Swan Coastal Plain), the Department of Parks and Wildlife Managed Estate and Regional Parks.

The strip of vegetation located to the south-east of the site is mapped as a Local Natural Area (refer to **Figure 5**). This vegetation is also part of the 'Swan' vegetation complex which has less than 8% of its pre-European extent remaining within the City of Swan and forms part of a 'Protection Goal' within the City's *Local Biodiversity Strategy* (City of Swan 2015).

2.2.5 Terrestrial fauna

2.2.5.1 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. At a state level, fauna species may also be classed as 'threatened' under the *Biodiversity Conservation Act 2016* (BC Act). In addition to this, DBCA maintains a list of priority fauna species which, while not considered threatened under the BC Act and therefore not protected directly, elicit some concern over their long-term survival.

A search was conducted for threatened and priority fauna that may occur or have been recorded within a 10 km radius of the site using the *Protected Matters Search Tool* (DoEE 2019a) and *NatureMap* (DBCA 2019).

Based on these desktop results and taking into account the habitat requirements of individual fauna species, the following eleven fauna species of conservation significance were considered 'likely' or 'possible' to occur within the site:

- *Apus pacificus* (Pacific swift)
- *Botaurus poiciloptilus* (Australasian bittern)
- *Calyptorhynchus banksii naso* (forest red-tailed black cockatoo)
- *Calyptorhynchus baudinii* (Baudin's cockatoo)
- *Calyptorhynchus latirostris* (Carnaby's cockatoo)
- *Falco peregrinus* (peregrine falcon)
- *Oxyura australis* (blue-billed duck)
- *Plegadis falcinellus (*glossy ibis)
- *Isoodon fusciventer* (quenda)
- *Ctenotus delli (*Dell's skink)
- *Westralunio carteri* (Carter's freshwater mussel).

No conservation significant species were directly or indirectly (from secondary evidence) recorded during the field survey of the wider brickworks that encompasses the site (Emerge Associates 2022). The likelihood that the site would provide important habitat for these species is low, given the surrounding industrial area and the scattered native and non-native trees and shrubs in 'degraded' condition which support low fauna habitat values.

2.2.5.2 Site specific surveys and investigations

A level 1 Fauna and Targeted Black Cockatoo Assessment undertaken over over the broader Midland Brick landholdings, on 18 September, 8 October and 24 October 2019. Ecologists from Emerge also visited portions of the site on multiple dates in September 2021 to undertake a tree survey, which included recording of *Eucalyptus rudis* (flooded gum) trees with DBH ≥50 cm as black cockatoo habitat trees. Flooded gums were not recorded during the 2019 survey.

A technical memorandum (Emerge Associates 2022) (**Appendix C**), details the fauna values recorded within the broader survey area and has been summarised with relevance to the site below. The three threatened species of black cockatoo, listed above, were assessed and are collectively referred to as 'black cockatoos'.

2.2.5.3 Fauna Habitat

As part of the fauna assessment, fauna habitats were described according to the dominant flora species and vegetation type present. The assessment determined that historical disturbance has significantly compromised habitat values within the site. While a large portion of the site comprises sealed areas associated with the existing brickworks infrastructure, a total of three fauna habitats were identified, listed and described in **Table 3** and shown in **Figure 6.**

The three fauna habitats identified; Eucalyptus wandoo woodland, cleared area and scattered native and non-native trees and shrubs which comprises cleared areas, non-native vegetation and weeds were determined to support low fauna values.

Table 3: Fauna habitats identified within the site.

Fauna habitat classification	Description	Area (ha)
Eucalyptus wandoo woodland	Woodland *Eucalyptus wandoo* over open non-native grassland.	0.02
Scattered native and non-native trees and shrubs	Woodland to tall shrubland of various planted species, particularly *Eucalyptus camaldulensis*, with scattered *E. rudis* over scattered native and non-native shrubs over non-native grassland with occasional native species. Where this habitat occurs in lower lying areas it was partially saturated with standing water.	4.60
Cleared area	Heavily disturbed areas comprising planted non-native trees and shrubs over non-native herbs and grasses, with occasional native shrubs and forbs.	5.34

2.2.5.4 Black cockatoo habitat

Foraging habitat

Foraging habitat within the site is generally limited and patchily distributed throughout the site. The areas mapped as potential foraging habitat within the site primarily relate to vegetation containing wandoo trees extending over 0.02 ha, as shown in **Figure 6**. It is not considered that the site provides quality foraging habitat for black cockatoos, given its limited extent within an industrial setting and presence of extensive areas of higher quality foraging habitat for all three species of black cockatoo near the site within the Darling Scarp.

Breeding habitat

Trees of species known to support breeding of the black cockatoos within the known range of these species which either have a suitable nest hollow or are of a suitable diameter at breast height (DBH) $\geq$ 500 mm (or $\geq$ 300 mm for salmon gum and wandoo), are considered to represent potential breeding habitat trees. A total of 26 potential black cockatoo habitat trees were recorded in the site none of which contain potentially suitable nesting hollows, as shown in **Figure 6**.

There are no Carnaby's cockatoo confirmed breeding sites within a 6 km radius of the site. One breeding site is located within 12 km to the west of the site, associated with the Darling Scarp.

Roosting habitat

Patches of native and non-native trees within the site have the potential to provide roosting habitat for species of black cockatoo. No evidence of black cockatoo roosting, such as branch clippings, droppings and moulted feathers was observed within the site.

Records of black cockatoo roosting sites across south-west Western Australia are maintained by Birdlife Australia, utilising annual community surveys as part of the *Great Cocky Count* (GCC). Based on the most recently published 2019 GCC report, the site does not contain any confirmed black cockatoo roosting sites. A number of potential roost sites are mapped as occurring near the site; however, no birds have been recorded at most of these sites. The closest known roost site where birds have been recorded is located approximately 6 km west of the site. This roost site is associated with forest red-tailed black cockatoos.

2.3 Hydrology

2.3.1 Groundwater

Information on the regional groundwater conditions obtained from the *Water Information Reporting* (DWER 2019a) indicates the groundwater beneath the site is a multi-layered system comprised of the following:

- Perth – Superficial Swan aquifer
- Perth – Leederville (confined) aquifer
- Perth – Yarragadee North (confined) aquifer.

The Perth - Superficial Swan aquifer is considered to be the primary aquifer of interest in relation to investigation as it is the aquifer most likely impacted by any site contamination via transport of surface contaminants.

Characteristics of the superficial aquifer in the vicinity of the site according to the *Perth Groundwater Map* (DWER 2019b) indicates regional groundwater flow direction in the vicinity of the site is expected to be generally in a north-westerly direction toward the Swan River.

Emerge Associates (2019a) completed a groundwater investigation that comprised the installation of 10 groundwater monitoring wells across the Midland Brick landholding including two wells within the site (EMW03 and EMW04). Groundwater levels in monitoring wells were measured in February 2019. The groundwater levels measured were:

- 1.14 mAHD, corresponding to a depth of approximately 10.2 mBGL in the north portion of the site (groundwater monitoring well ref EMW03).
- 2.01 mAHD, corresponding to a depth of approximately 7.7 mBGL in the south portion of the site (groundwater monitoring well ref EMW04).

2.3.2 Surface water

No natural surface water features have been identified within the site; however, the Swan River is located directly approximately 450 m to the north of the site and a tributary of the Blackadder Creek which in turn is a tributary of Swan River is located to the south of the site. The site is located outside the 1% AEP floodplain of the adjacent Swan River.

Due to clay soils onsite infiltration is limited and stormwater is currently managed through offsite discharge. The current stormwater system on site comprises various storage ponds for attenuation and settlement of stormwater and a series of outlets to the Swan River and Blackadder Creek tributary.

A series of stormwater settlement ponds are located within the south-western portion of the site to treat stormwater before it is discharged to Blackadder Creek. Surface water is intermittently present in the southern storage ponds, predominantly during winter. The stormwater settlement ponds are part of the stormwater infrastructure present across the entire Midland Brick landholding extending further to the north of the site to manage stormwater collection, storage and disposal.

Surface water runoff for the majority of the Midland Brick landholding is directed to a stormwater sump located in the northern portion of Lot 72. Stormwater is pumped from the stormwater sump to a series of stormwater settlement ponds (SP1.1 to SP1.4) located to the north of the site. Upon exiting SP1.4, the water is directed through a drainage channel to the southern storage ponds situated within the south-western portion of the site. The southern storage ponds allow infiltration to groundwater or, in times of high flow, surface water overflow into a drain fitted with a hydrocarbon trap that discharges to Blackadder Creek and ultimately flows to the Swan River (a distance of approximate 3 km). The nearest downgradient surface water receptor is the Swan River.

A Local Water Management Strategy (LWMS) has been prepared by (Hyd2o Hydrology 2021) to support the LPS amendment. The existing hydrological regime for the site is discussed in detail within the LWMS and due to its complexity is broadly summarised in **Section 4.3**.

2.3.3 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).

The Department of Biodiversity Conservation and Attractions (DBCA) maintains the *Geomorphic Wetlands of the Swan Coastal Plain* database, which categorises individual wetlands into specific management categories based on their attributes and management objectives.

A review of the *Geomorphic Wetlands of the Swan Coastal Plain dataset* (DBCA 2014) indicates that no geomorphic wetlands are mapped as occurring within the site. The Swan River Estuary Conservation Category Wetland (CCW) (UFI 14 356) occurs approximately 450 m to the north of the site. One Multiple Use Wetland (MUW) has been identified to the north of the site extending over a large area (106.74 ha). No other wetlands of conservation significance are mapped as occurring within 1 km of the site.

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* by the Department of Planning Lands and Heritage (DPLH) and contains information on Registered Aboriginal Heritage 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 (DAA 2015) was undertaken. The results of this search indicated that the site is identified within the mapped boundary of three Registered Aboriginal Heritage Site, listed in **Table 4** below and illustrated on **Figure 7.**

Table 4: Aboriginal Heritage Sites

Site ID	Site name	
3622	Turtle Swamp	Hunting Place
3720	Blackadder and Woodbridge Creek	Mythological
3768	Bishop Road Camp	Camp

A Registered Site inquiry of the broader Midland Brickworks, which encompasses the site was submitted to DPLH on 7 May 2019 to determine if the site intersects with the known location of the above-listed registered Aboriginal Heritage sites. DPLH confirmed that while the site intersects with the boundaries of the Registered Heritage Sites; 'Turtle Swamp', 'Blackadder and Woodbridge Creek' and 'Bishop Road Camp', their physical locations is not within the site, and therefore approval under AHA is not required in relation to these sites.

2.4.2 Non-Indigenous heritage

A desktop search of the Australian Heritage Database (Department of the Environment 2019), the State Heritage Office database (Heritage Council 2019) and the City of Swan Local Government Inventory indicated there are no registered heritage sites located within, or in proximity to the site.

2.5 Bushfire

The site is identified within a 'bushfire prone area' on the state-wide *Map of Bush Fire Prone Areas* as prepared by the Office of Bushfire Risk Management (OBRM 2019), as shown in **Plate 2**. Strategic planning proposals require a bushfire hazard level assessment under the *Guidelines for Planning in Bushfire Prone Areas Version 1.3* (the Guidelines) (WAPC and DFES 2017).

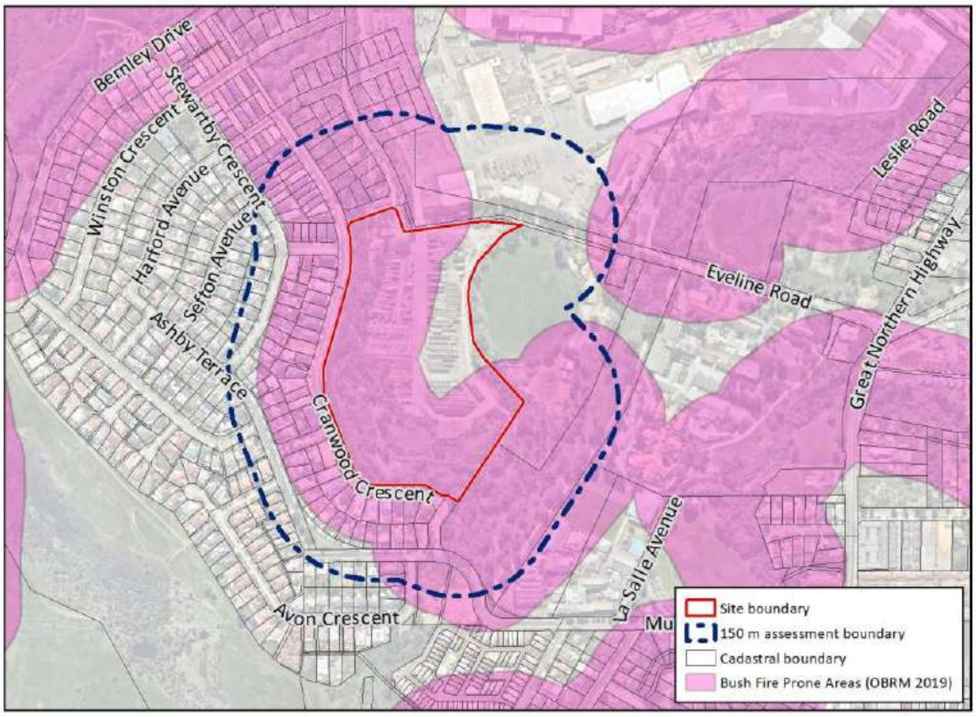

Plate 2: Areas within and surrounding the site identified as 'bushfire prone areas' (as indicated in purple) under the state-wide Map of Bush Fire Prone Areas (OBRM 2020).

A Bushfire Management Plan (BMP) (Emerge Associates 2021) has been prepared to support the LPS amendment which includes an assessment of vegetation within and surrounding the site to determine applicable bushfire hazards, in accordance with *Australian Standard 3959:2018 Construction of buildings in bushfire-prone areas (AS 3959),* and an assessment of the bushfire protection criteria outlined in the Guidelines.

2.6 Other land use considerations

2.6.1 Historic and existing land uses

A review of publicly available aerial imagery indicates the majority of the site was cleared of native vegetation prior to 1953, likely for grazing and subsequently for brick making, with the exception of the patch of remnant vegetation within the western portion of the site adjoining the oval (Landgate 2021). Clay quarrying within the site occurred between circa 1965 to circa 1981, after which the clay pits were decommissioned, filled and utilised as hardstand areas for brick storage since circa 1987. The southwestern storage ponds were constructed circa 2000. Some additional tree planting has occurred since the initial clearing along Eveline Road to the north of the site and surrounding the perimeter of Jack Williamson's oval.

The Midland Brick operations are currently licenced under the Part V of the *Environmental Protection Act 1986* (EP Act) (L4511/1967/13), and the site is currently within the prescribed premise boundary of this licence. The overall subdivision development over the broader Midland Brick landholdings will occur in stages stage along with the contraction of the brickworks footprint.

The 'Stage 1' residential subdivision approval (WAPC Ref No: 158848), which falls outside the LPS amendment boundary, to the north, has initiated an alteration to the brickworks' EP Act Part V Licence premise boundary and Part IV proposal boundary, as shown in Ministerial Statement 1124, and remove the ability to operate the already decommissioned brickworks' Kilns 7 and 8 (refer to **Figure 1**). In addition, Kiln 11 will be decommissioned and removed from the Part V Licence in April 2022.

The historical expansion of the Midland Brick operations was also assessed under Part IV of the EP Act, and approved subject to a number of conditions (Ministerial Statement (MS) 322 and MS 1124). The site is contained within the proposal boundary of MS 1124. As urban development progresses across the site the premise boundary will be amended using the EP Act's Part V Licence amendment process, and likewise the proposal boundary of MS 1124 will be amended using the EP Act's Section 45C process.

2.6.2 Potential site contamination

Several contaminated site investigations have been undertaken across the site, which identified potential sources of contamination from current and historical land uses. A Preliminary Site Investigation (PSI) considering the entire Midland Brickworks landholding was completed by Emerge Associates (2019b). The PSI identified that the site is not currently classified pursuant to the *Contaminated Sites Act 2003* (the CS Act). However, the south-western storage ponds were identified as a potential area of concern (PAoC), given the potential presence of residual metals, hydrocarbons and pesticides in the base of the ponds as a result of the temporary storage and transfer of stormwater from the Midland Brick landholding. In addition, areas of the site subject to filling activities including the western bund were identified as PAoCs due to the potential presence of uncontrolled fill.

Subsequent to this, a Detailed Site Investigation (DSI) undertaken by Emerge Associates (2021b) to characterise soil, groundwater, sediment and surface water at the site to ascertain the contamination status of the site, and its suitability for the intended residential land use. Potential sources of contamination identified were largely associated with the four southern storage ponds, the western bund and fill present across the general area. The works undertaken as part of the DSI included the sampling of surface water and sediment within the four southern storage ponds, excavation of 37 test pits within the western bund and the installation and sampling of six groundwater monitoring wells within and surrounding the site.

The southern storage ponds water and sediment samples did not report any exceedance of the human health assessment levels. Concentrations of aluminium, iron and ammonia in surface water were reported below the assessment levels specific for the Swan River provided in DPaW (2017), therefore the surface water quality of the southern storage ponds was not considered to pose any risk to the Swan River. Sediment samples collected from southern storage pond 2 the reported elevated levels of Zinc and biogenic organic compounds (BOCs) (i.e. non-petrogenic) hydrocarbons, however it was not considered to require management given the hydrocarbons are biogenic in origin and the Zinc exceedance is not considered to present any risk to ecological receptors post development.

With regards to fill materials, no construction and demolition (C&D) waste or deleterious materials were observed in any location, although asbestos containing material (ACM) fragments were identified in one test pit located within the western bund. This isolated occurrence is not considered to pose a risk to human receptors at present or post-development on the basis that ACM were not identified in any other fill materials in the western bund and the fill material composition does not suggest a different source and post-development the fill will be placed at depth. Soil samples collected from the western bund and general area did not identify concentrations of potential contaminants exceeding any human health assessment level. An unexpected finds protocol should be implemented during excavation of the material to ensure any inadvertent occurrence of ACM which is encountered is identified and managed appropriately.

The DSI indicated very limited impacts are present within the site from current and historical land uses. The DSI recommended a site classification under the *Contaminated Sites Act 2003* of '*Not contaminated'* was appropriate.

2.6.3 Surrounding land uses

Land uses surrounding the site include:

- North: Cranwood Crescent residential development (WAPC subdivision approval reference #158848), Eveline Road and Midland Brickworks operational areas.
- East: Jack Williamson Park and La Salle College.
- South: Ashby Gardens residential estate.
- West: Cranwood Crescent and Ashby Gardens residential estate.

2.6.3.1 Acoustic Impacts

The entirety of the site is subject to the predicted Australian Noise Exposure Forecast (ANEF) 20 to 25 contour for Perth Airport. The ANEF system is a tool used to illustrate the impact of aircraft noise in an area using visual contours and provides guidance on the acceptability of new development sites within each ANEF zone. A Noise Assessment has been undertaken to support the LPS amendment to understand the potential impacts from the consolidated Midland Brick brickworks operations and aircraft noise on the proposed final land use (Lloyd George Acoustics 2021) provided in **Appendix D.** The results of the assessment are summarised below.

Industry Noise

The noise assessment considered three operational scenarios that are likely to occur until the clay brickworks are fully decommissioned:

A. **Full brickwork operations north of Bassett Road (i.e. Kilns 9 and 10 and Masonry Facilities) plus the Clay Shed operations.** The modelling included triple stacked shipping containers to the west of the Clay Shed and double stacked shipping containers adjacent to the closest future residential properties (as noise barriers).
B. **Full operations north of Bassett Road only (i.e. Kilns 9 and 10 and Masonry Facilities and no Clay Shed operations).** The modelling no longer includes the Clay Shed and conveyor (present in Scenario A) and includes a 5 m high noise wall along the southern side of the brickworks area (southern side of the masonry lot), however the modelling assumes the presence of a buffer to the west of Bassett Road
C. **Masonry Facility only, located immediately north of Bassett Road.** The modelling relates to only the masonry shed remaining operation on the brickworks site (not Kilns 9 and 10), with residential development up to Bassett Road. The noise barrier included in Scenario 2 remains in place

Noise sources (which included truck movements, crushing and screening, conveyors, Kilns 9 and 10) were identified and characterised for the three scenarios (A, B and C). The modelling incorporated noise mitigation measures relevant to each of these scenarios.

Based on the noise modelling, where the proposed residential development is staged along with the decommissioning of the brickworks operations as considered in Scenarios A, B and C, there would be no exceedance of the noise guidelines for industrial noise. Based on Scenario A (the scenario with the greatest propensity for impact), Area 3 will comply with the *Environmental Protection (Noise) Regulations 1997* at all times. Before the Clay Shed is demolished, a 5 metre high wall will be constructed abutting the south side of the masonry lot to act as a noise barrier. There are no noise impacts (derived from the operational brickworks) that would preclude the residential use of the site.

Aircraft Noise

With regards to aircraft noise, outdoor noise levels over 80 dB LAmax can be expected in the future. SPP 5.1 does not mandate any noise insulation where residences are located within the 20-25 ANEF contour but does require notifications on lot title.

2.6.3.2 Air Quality Impacts

Emissions to air from ongoing operations of the brickworks, specifically emissions from Kilns 9 and 10 which are located to the northeast of the site to be rezoned are of importance for the assessment of potential exposures by future residents living on the site (once developed).

A Human Health Risk Assessment has been undertaken by Environmental Risk Sciences (2021) to understand the potential impacts from the consolidated brickworks operations on the proposed final residential land use. The Human Health Risk Assessment reviewed the air quality modelling undertaken by Environmental Technologies and Analytics, as part of the An *Air Quality Impact Assessment* (ETA 2020), in particular the emissions to air from the ongoing operation of Kilns 9 and 10.

The results of the assessment indicate; the engineering of these kilns and the flue gas treatment system (for each kiln) means that there are no situations where emissions to air could occur, even during upset, start-up or shut-down conditions, that are higher than the emissions scenarios evaluated in the air quality modelling. The maximum concentrations predicted on the site, as a result of ongoing operation of Kilns 9 and 10, have been reviewed against guidelines that are protective of human health (for all residents), odour and vegetation effects. There are no exceedances of any of these guidelines. Hence there are no air quality impacts (derived from the brick works operations) that would be of concern to the health of future residents at the site.

3 Planning and Environmental Assessment Context

3.1 Existing zones and reservations

The site is currently zoned 'Urban' the Metropolitan Region Scheme (MRS) (**Plate 3**) and 'Industrial' under the CoS LPS No.17.

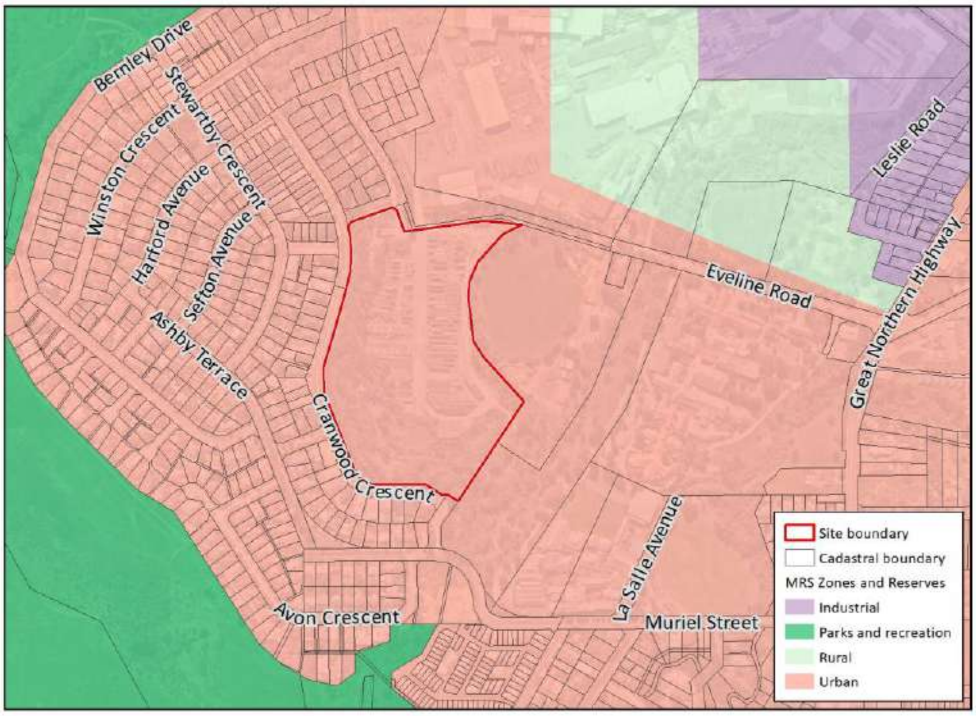

Plate 3: Metropolitan Region Scheme Zones and Reserves within and surrounding the site

3.2 Future land use planning processes

3.2.1 Local Planning Scheme amendment

This EAR supports a proposed amendment to the City of Swan's LPS 17 to rezone the site to 'Residential (R20) to ensure the site is consistent with the current 'Urban' MRS zoning.

The LPS 17 amendment will be referred to the EPA pursuant to Section 48A of the *Environmental Protection Act 1986* (EP Act), to determine if it is likely to result in significant environmental impacts and, therefore, require formal environmental assessment by the EPA.

3.2.2 Local Structure Plan

Element have prepared a Local Structure Plan for the site to support the proposed LPS amendment on behalf of Hesperia, as provided in **Appendix A**. The Local Structure Plan identifies the following land uses:

- residential development

- one public open space area
- an integrated local road network.

Given the degraded nature of the site associated with the current industrial land uses, there are limited environmental values identified which require specific spatial responses through the Local Structure Plan. Notwithstanding, opportunities to retain mature trees have been identified through the Local Structure Plan within areas of POS, road reserves and future residential lot boundary setbacks, as shown in **Figure 8**. Reasonable efforts will be made to retain the identified trees, including the three black cockatoo habitat trees and foraging habitat within the site. Potential tree retention will be subject to mitigating factors such as worthiness of retention assessment, natural attrition, unavoidable or unintended impacts from servicing requirements, managing bushfire risk, public safety and subdivision design or development requirements.

3.2.3. Subdivision and development

Subject to the amendment to LPS 17 and approval, residential development of the site will be progressed through subdivision. Once issued, subdivision approval/s would likely include a range of conditions, some of which may relate to environmental matters, which will need to be implemented as part of the subdivision and development process, before titles for subdivided lots are issued. These conditions are usually determined in accordance with *WAPC's Model Subdivision Conditions Schedule 2019* (WAPC and DPLH 2019) and include those relating to environmental considerations. Likely conditions will require:

- Preparation of a Noise Management Plan prior to development. The future Noise Management Plan(s) will demonstrate how development can adequately mitigate the noise impacts through the use of noise attenuation measures. These mitigation measures may include:
  - spatial separation between the consolidated brickworks and the future residential land use. This separation can be achieved by the inclusion of road reserves and/or the provision of a public open space buffer area; and/or
  - an acoustic barrier being incorporated between the consolidated brickworks and the residential receptors; and/or
  - engineering noise control measures to Kilns 9 and 10 within the consolidated brickworks
- Noise insulation in accordance with *AS2021 - 2015: Acoustics - Aircraft Noise Intrusion - Building Siting and Construction* shall be considered at each stage of subdivision release within the 20 - 25 ANEF contour to respond to site specific requirements.
- A notification is to be included on all titles and within sale contracts, to be signed and acknowledged by all purchasers which states as follows – "This land is subjected to aircraft noise at any time by the 24 hour a day, 7 day a week passenger and freight aircraft flight operations arriving and department Perth Airport. The frequency of aircraft movements and the size of aircraft are forecast to increase indefinitely into the future. It is the responsibility of landowners to noise attenuate their property to ensure their amenity, as Perth Airport will remain curfew free."
- Provision of a detailed Bushfire Attack Level assessment to support dwelling construction at development application stage, where applicable.

Other components of development may be progressed through development approval, for example forward bulk earthworks or other non-subdivisional works.

Future planning and development should also take into consideration the various environment-related CoS local planning policies. A summary of these policies and their relevance to the site is provided in **Table 5** below.

Table 5: Summary of relevant CoS Local Planning Policies

Local planning policy (LPP)	Summary of policy	Relevant to site (Y/N)	Summary of considerations
POL-C-061 Filling of Land	Notes that filling of land requires Development approval of council under LSP 17. Council will consider surface drainage changes, impacts to the environment, type and source of fill.	Y	The proponent will be required to submit a development application for any future filling of land, which must consider impacts to drainage and the existing environment.
POL-E92 Floodplain Management and Development	Consider risks of flooding and environmental impacts.	N	The proponent will be required to consider flood management and environmental conservation for any development within the Swan River floodplain.
POL-C-104 Environmental Planning	Clarifies the City's expectations for managing the environment through the planning process.	Y	Investigation and assessment of environmental values and preparation of environmental management plans.

3.3 Existing environmental approvals

3.3.1 Ministerial Statement 1124

Part IV of the EP Act regulates the operation of the brickworks site through the conditions attached to Ministerial Statement (MS) 1124. The proposal boundary that is the subject of MS 1124 encompasses the site. While the brickworks is operational within the site, compliance with the MS's conditions will be maintained. MS 1124 was published on 30 January 2020 and supersedes all the conditions and procedures of MS 322, which previously applied to the brickworks.

In accordance with the MS's Condition 5, a Decommissioning and Rehabilitation Plan will be prepared that will describe the processes and legislation that will ensure that the demolition of the brickworks' infrastructure within the site, will not give rise to any significant environmental impacts. Once approved, adherence with the plan's commitments will be documented in an annual compliance report, which will be submitted to the EPA.

Before any residential dwellings within the site are occupied, the MS's proposal boundary will be altered, in accordance with the EP Act's Section 45C process, to exclude Area 3.

3.3.2 Part V License L4511/1967/13

Part V of the EP Act regulates the emissions from the brickworks site through conditions attached to Licence L4511/1967/13. The premise boundary that is the subject of the Licence encompasses the majority of the site. While the brickworks is operational within the site, compliance with the Licence's conditions will be maintained.

The Licence limits the production capacity of the brickworks, and the emissions from the stacks of Kilns 7, 8, 9, 10 and 11. The Licence requires quarterly monitoring of stack emissions and continuous monitoring of ambient levels of hydrogen fluoride at two locations within the brickworks, one of which is within the site. The monitoring results will continue to be reported in an Annual Environmental Report.

The 'Stage 1' residential subdivision approval (WAPC Ref No: 158848), which falls outside the LPS amendment boundary, to the north, has initiated an alteration to the brickworks' EP Act Part V Licence premise boundary and Part IV proposal boundary. An application was made in December 2020 to have Kilns 7 and 8 removed from the current Part V Licence which was granted by DWER in August 2021. In addition, Kiln 11 will be decommissioned and removed from the Part V Licence in April 2022. The existing brickworks site area will remain active until April 2022, after which the only brickworks related activity occurring south of Bassett Road will be the Clay Shed (which will be leased for a period of 5 to 10 years).

Before any residential dwellings within the site are occupied, the premise boundary will be altered, in accordance with the EP Act's Section 59 process, to exclude the section of the site containing the dwellings.

3.4. Future environmental approvals

3.4.1 *Environmental Protection Act 1986* – Section 48

All amendments to local planning schemes are required to be referred to the EPA by the responsible authority pursuant Section 48A of the EP Act. The EPA then makes one of the following determinations on the initiated scheme amendment:

- **The proposed scheme amendment should not be assessed by the EPA**, on the basis that it is considered unlikely to result in significant environmental impacts. In making this determination, the EPA may choose to also provide informal advice in relation to how environmental factors are expected to be addressed as part of future stages of the planning and development process.
- **The proposed scheme amendment should be assessed by the EPA**, on the basis that it is considered likely to result in significant environmental impacts. An environmental impact assessment process is then undertaken and the Minister for Environment may then choose to issue a Ministerial Statement allowing the scheme to be implemented.
- **The proposed scheme amendment is by its nature incapable of being made environmentally acceptable.**

The CoS LPS 17 amendment would be referred to the EPA by the responsible authority (DPLH or CoS respectively).

3.4.2 *Environmental Protection Act 1986* – Section 38

Section 38 of the EP Act enables any person to refer a proposal likely to have a significant impact on the environment to the EPA, who then decide whether or not to assess the proposal.

Section 48I outlines that any proposal likely to have a significant impact on the environment, but which is within an area and for a land use that is subject to an assessed scheme (i.e. a scheme for which a determination has been made by the EPA under Section 48A), is not required to be referred to the EPA under Section 38 of the EP Act. Given the environmental impacts associated with implementation of urban subdivision and development works across the site would be considered by the EPA under Section 48A of the EP Act, it is not anticipated that the implementation of urban development works within the site would be referred under Section 38 of the EP Act. However, this only applies to proposed works which are consistent with those considered through the Section 48A process and where the potential environmental impacts were considered by the EPA. The EPA may choose to defer assessment of environmental factors to subsequent stages of the planning process, which would mean Section 48I would not apply in such instances.

3.4.3 Environment Protection and Biodiversity Conservation Act 1999

Any proposed action which is likely to result in significant impacts to Matters of National Environmental Significance (MNES) listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is required to be referred to the Commonwealth Department of Environment and Energy to determine whether it requires assessment and approval under the EPBC Act.

A limited area (0.02 ha) of foraging habitat suitable for Carnaby’s black cockatoo (CBC) Baudin’s black cockatoo (BBC), and Forest Red-tailed black cockatoo (FRTBC) occurs within the site, in addition to a total of 26 potential black cockatoo habitat trees, none of which contain potentially suitable nesting hollows. Given the limited fauna values identified within the site, the proposed urban development is unlikely to rise to a significant adverse impact. Therefore, a referral pursuant to the EPBC Act is not required.

4 Environmental Assessment and Management Strategies

This section outlines the spatial response of the Concept Design Plan to the environmental attributes and values associated with the site and the 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 the site, and/or applicable legislation and policy requirements are assessed.

In addition to environmental management considerations implemented through the statutory planning process (generally pursuant to Section 48A of the EP Act), the ongoing emissions from the brickworks will continue to be regulated under Part V of the EP Act.

4.1 Flora and vegetation

4.1.1 Policy framework, site context and 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

The site has been subject to long-term disturbance and modification, and as such is dominated by non-native vegetation. Native vegetation is limited to the western portion of the site representative of two plant communities, extending over 4.56 ha in 'degraded' condition. The remaining 5.40 ha comprises hardstand areas and sedimentation ponds in 'completely degraded' condition.

The extent of clearing of native vegetation will be determined at the future detailed planning stages when the detailed road and lot layout and finished site levels is known but it expected to involve the clearance of 4.56 ha of a mixture of remnant native vegetation and non-native endemic planted species within the site. Whilst clearing of primarily non-native trees, with occasional native vegetation will be required to enable future residential development in line with the proposed LPS amendment, this is primarily limited to isolated and disturbed patches of vegetation, the clearing of which is unlikely to cause a significant impact to flora and vegetation values.

4.1.2 Local Structure Plan Design considerations and future management requirements

Due to the degraded nature of the site, no significant flora or vegetation values have been identified within the site that require specific spatial responses through the Local Structure Plan. Detailed investigations and expert advice will be sought to identify opportunities to retain native vegetation, and in particular mature trees (refer to **Figure 8**), potentially within areas of POS, road reserves and future residential lot boundary setbacks.

Should bulk earthworks or any other works be commenced within the site that requires clearing of native vegetation before subdivision approvals are gained, a clearing permit pursuant to Part V of the EP Act will be required. Otherwise, subdivision approval and associated authorised subdivision works will provide an exemption from the requirements for a clearing permit.

4.2 Fauna

4.2.1 Policy framework, site context and 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. Any proposed action which is considered likely to result in a 'significant' impact upon these species, identified by the DAWE as Matters of National Environmental Significance (MNES), should be referred to them.

Fauna habitat within the site is limited to scattered trees and small pockets of remnant vegetation which have been subject to significant historical disturbance. The site provides 0.02 ha of potential foraging habitat for black cockatoos as well as 26 potential black cockatoo habitat trees, none of which contain potentially suitable nesting hollows. No signs of use by black cockatoos, such as chew marks, droppings or moulted feathers, were identified during the targeted survey. It is not considered that the site provides quality foraging habitat for black cockatoos, given its small extent within an industrial setting and presence of extensive areas of higher quality foraging habitat for all three species of black cockatoo near the site within the Darling Scarp.

4.2.2 Local Structure Plan Design considerations and future management requirements

Due to the cleared and degraded nature of the majority of vegetation within the site there are limited fauna habitat values associated with it. No conservation significant species were directly or indirectly (from secondary evidence) recorded during the fauna field survey of the site (Emerge Associates 2022). The likelihood that the site would provide important habitat for these species is low, given the surrounding industrial area and the entirety of the site comprises vegetation in 'degraded' or 'completely degraded' condition which support low fauna habitat values.

A limited extent (0.02 ha) of foraging habitat suitable for Carnaby's black cockatoo (CBC) Baudin's black cockatoo (BBC), and Forest Red-tailed black cockatoo (FRTBC) occurs within the site, in addition to a total of 26 potential black cockatoo habitat trees, none of which contain potentially suitable nesting hollows.

Reasonable efforts will be made to retain the identified trees, including the three black cockatoo habitat trees and foraging habitat within the site, subject to mitigating factors such as worthiness of retention assessment, natural attrition, unavoidable or unintended impacts from servicing requirements, managing bushfire risk, public safety and subdivision design or development requirements. Detailed investigations and expert advice will be sought to identify opportunities to the identified black cockatoo habitat trees, potentially within areas of POS, road reserves and future residential lot boundary setbacks. Refer to **Figure 8** showing potential trees for retention within the Local Structure Plan land use zones.

Given the limited fauna values identified within the site, the proposed urban development is unlikely to rise to a significant adverse impact. Therefore, a referral pursuant to the EPBC Act is not required.

4.3 Hydrology

4.3.1 Management objectives

In the context of environmental impact assessment, the EPA's objective for inland waters is *'to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected'.*

In addition, the *State Water Strategy for Western Australia* (Government of WA 2003) and *Better Urban Water Management* (WAPC 2008) endorses 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 that occurs outside of the site is the *Better Urban Water Management* criteria for ecological protection, which requires development to maintain or restore desirable environmental flows and/or hydrological cycles.

The principle management objectives for hydrology within the site is to ensure that the post-development environmental flows and/or hydrological cycles are maintained relative to pre-development conditions with regards to the Blackadder Creek tributary and the Swan River watercourse, and water quality is maintained and/or improved with the aim of maintaining and restoring ecological systems.

The *State Planning Policy 2.10 Swan-Canning River System* (SPP 2.10) (WAPC 2006) includes an objective to 'ensure that activities, land use and development maintain and enhance the health, amenity and landscape values of the river including its recreational and scenic values'. In relation to the Middle Swan area and relevant to this proposal, the SPP suggests that planning decisions in this area should:

- establish adequate protection measures for riparian vegetation on foreshores
- improve pedestrian and cycle access along the river
- ensure that subdivisions incorporate adequate foreshore reserves and building setbacks
- maintain foreshore protection and streamline habitat.

4.3.2 Local Structure Plan Design considerations and future management requirements

A Local Water Management Strategy (LWMS) has been prepared by (Hyd2o Hydrology 2021) (**Appendix F**) to support the LPS amendment, 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 overarching design principles are to maintain the existing hydrological regime within the Blackadder Creek Tributary and to address issues associated with a drying climate by providing an opportunity to direct additional flows to this system. The principal post development stormwater strategy is discussed in detail in the LWMS and summarised below.

Stormwater management at the site has been designed in accordance with *Better Urban Water Management* (WAPC, 2008), the City of Swan's principles for water quality and quantity management, DBCA and DWER requirements, and *Stormwater Management Manual for Western Australia* (DoW, 2007).

Post development annual stormwater discharge volumes and peak flows are typically required to be maintained relative to pre development conditions and water quality maintained and/or improved with the aim of maintaining and restoring ecological systems. These are the key guiding principles for the Blackadder Creek tributary.

In the case of extreme storm event flows to the Swan River, discussions with DWER and DBCA have indicated that the volume of post development flows to the river relative to its existing flows is not a major consideration. This is due to the timing of flows from the site and the river not being coincident; therefore, flows from the site are not considered a flood risk. Therefore, the issue with respect to the Swan River is in relation to more frequently occurring events, which to discharge to the river via Blackadder Creek. The key principle for all events is to ensure they receive appropriate levels of water quality treatment.

The proposed stormwater management system post development is summarised in Figure 2 within the LWMS, this shows catchment areas, flows paths, and key infrastructure details based on detailed modelling. The LWMS should be referred to for further detailed information regarding the groundwater and surface water strategy.

4.3.3 Future management requirements

The LWMS provides for the environmental management framework for groundwater and surface water within the site.

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) which states:

Prior to the commencement of subdivisional works, an urban water management plan is to be prepared and approved, in consultation with the Department of Water, consistent with any approved Local Water Management Strategy. (Local Government).

Generally, an UWMP will address the following considerations:

- The detailed drainage design.

- Imported fill specifications and requirements.
- Implementation of water conservation strategies.
- Non-structural water quality improvement measures.
- Management and maintenance requirements.
- Construction period management strategy.
- Monitoring and evaluation program.
- Status of groundwater abstraction license.

4.4 Bushfire management

4.4.1 Policy framework, site context and management objectives

State Planning Policy 3.7 Planning in Bushfire Prone Areas (WAPC 2015) stipulates that any development proposal which occurs partly or wholly within a bushfire prone area is required to be accompanied by a bushfire management plan. The preparation of the BMP is required to incorporate the following tasks:

- Classification of existing vegetation types within the site and surrounding 100 m, in accordance with *Australia Standard 3959-2018 Construction of buildings in bushfire-prone areas* (AS 3959) (Standards Australia 2018).
- Assessment of bushfire hazard levels within the site and surrounding 150 m, in accordance with the *Guidelines for Planning in Bushfire Prone Areas* (WAPC and DFES 2017).
- Assessment of effective slope under areas of classified vegetation.
- Completion of an indicative Bushfire Attack Level (BAL) assessment and preparation of an associated BAL contour plan.
- Assessment of the structure plan design against the bushfire protection criteria, in accordance with the *Guidelines for Planning in Bushfire Prone Areas* (WAPC and DFES 2017).

Policy objective 5.4 of SPP 3.7 specifies that development is required to:

'achieve an appropriate balance between bushfire risk management measures and biodiversity conservation values, environmental protection and biodiversity management and landscape amenity'.

This policy objective ensures that future development appropriately considers the bushfire risks, and provides appropriate separation from any identified risks without negatively impacting existing environmental values.

The BMP has considered the proposed development of the site in accordance with the Local Structure Plan (**Appendix A**). The majority of the vegetation within the site will be removed to facilitate future development, in order to achieve low threat classification in accordance with Section 2.2.3.2 of AS 3959. The eastern recreational POS area is assumed to be managed to a 'low threat' standard. External to the site, the vegetated area of Jack Williamson Park is expected to be revegetated to a 'Forest' classification.

The principal management objective for the bushfire risk to the site is to ensure that the risk to future dwellings is appropriately minimised without negatively impacting on environmental values within or surrounding the site. The site is suitably sized to accommodate the minimum separation distances required to achieve BAL-29 or less for future habitable buildings from classified vegetation within and surrounding the site through the provision of public roads, public open space. There are no constraints to meeting the bushfire compliance criteria outlined in the *Guidelines for Planning in Bushfire Prone Areas version 1.3* (WAPC and DFES 2017).

The anticipated environmental impacts of the proposed LPS amendment, as outlined in **Section 4** have specifically considered any bushfire management requirements. No further environmental impacts (such as clearing of vegetation) beyond those outlined in **Section 4** will be required in order to implement urban development across the site in alignment with the Local Structure Plan.

Further discussion in this regard is provided in the BMP that accompanies the LPS amendment (Emerge Associates 2021a).

4.4.2 Future bushfire management requirements

As outlined in the BMP (Emerge Associates 2021a), development within 100 m of classified vegetation will require a BAL assessment to be completed as part of subdivision and certified prior to dwelling construction. This BAL assessment will inform the requirement for increased construction standards in accordance with AS 3959, which will then be implemented through the building licence process. An indicative BAL assessment has been completed as part of the BMP and indicates that building footprints within lots will be subject to BAL ratings of BAL-29 or less.

As part of future subdivision and development, roads will be provided to support two access routes, hydrants will be constructed and public open space will typically be implemented and maintained as 'low threat' in accordance with Clause 2.2.3.2(f) of AS 3959.

Where public open space areas are landscaped (outside of conservation areas), these areas will be managed to a 'low threat' standard. Management of vegetation to a low threat standard includes:

- Irrigation of grass and garden beds (where required).
- Regular maintenance including removal of weeds and dead material.
- Low pruning of trees.
- Application of ground covers such as mulch or non-flammable materials.
- Regularly mowing/slashing of grass to less than 100mm in height.

4.5 Site contamination

4.5.1 Policy framework, site context and management objectives

The site has been operated as a brickworks for over 100 years and a number of contaminated site investigations over the site have identified a number of potential sources of contamination from current and historical land uses.

A Detailed Site Investigation (Emerge Associates 2021b) was undertaken over the site and identified potential sources of contamination largely associated with the four southern storage ponds (given the potential presence of residual metals, hydrocarbons and pesticides in the base of the ponds) and areas of the site subject to filling activities, including the western bund due to the potential presence of uncontrolled fill. The results of soil, groundwater, sediment and surface water reported elevated levels of zinc and biogenic organic compounds (BOCs) (i.e. non-petrogenic) hydrocarbons within the storage ponds, however these exceedances were not considered to present any risk to ecological receptors post development. Soil samples collected from the western bund and general area did not report concentrations of potential contaminants exceeding any human health assessment level.

The DSI indicated very limited impacts are present within the site from current and historical land uses and recommended a site classification under the *Contaminated Sites Act 2003* of '*Not contaminated'* was appropriate.

4.5.2 Future management requirements

There will be no requirement for remediation given detailed investigations did not report contamination from the current and historical land uses within the site. If evidence of contamination is encountered as part of future ground disturbing activities, any sources of contamination will need to be completed prior to the issuing of titles to the satisfaction of the WAPC on advice from the DWER.

4.6 Acoustic Impacts

4.6.1 Policy framework, site context and management objectives

The future residential development will be bound to the north-east by the consolidated brickworks operations, and as such industrial noise will need to be managed appropriately as outline in the Noise Management Plan (Lloyd George 2021) prepared to support the Area 3 LPS Amendment. Part V of the EP Act regulates the noise emissions from the brickworks site through *Environmental Protection (Noise) Regulations 1997*. While the brickworks is operational within the site, compliance with the Noise Regulations will be maintained.

The site is also located in proximity to Perth Airport. The relevant planning policy in Western Australia in relation to aircraft noise is *State Planning Policy 5.1: Land Use Planning in the Vicinity of Perth Airport; July 2015, Western Australian Planning Commission* (SPP 5.1) (WAPC 2004). The ANEF system is a tool used to illustrate the impact of aircraft noise in an area using visual contours and provides guidance on the acceptability of new development sites within each ANEF zone. The entirety of Area 3 falls within 20 ANEF, as shown in **Plate 4** below. This restricts the density of development to R20.

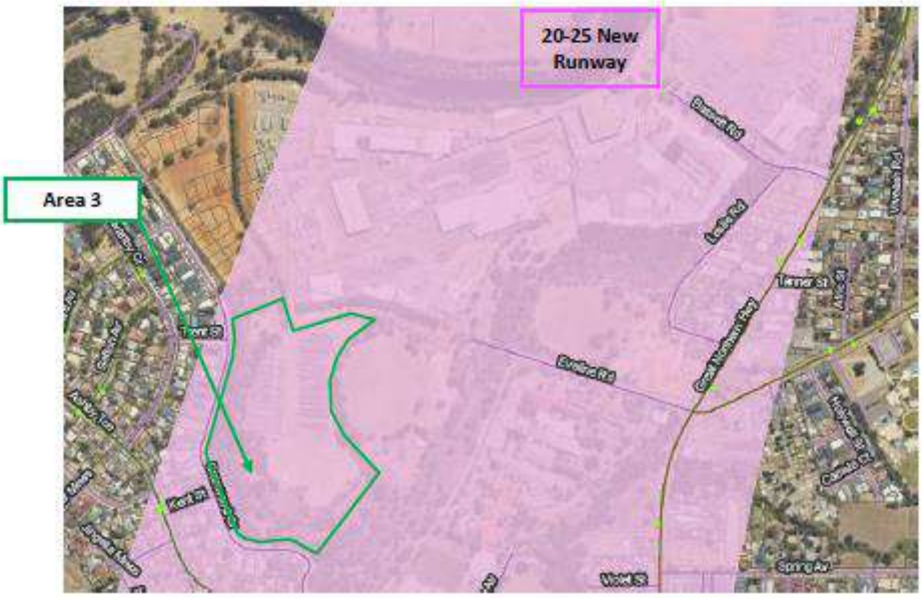

Plate 4: Site Locality in relation to ANF Contours

Noise insulation is not mandatory for residential development within the 20-25 ANEF. However, some areas may experience, currently or in the future, maximum aircraft noise levels in excess of the Indoor Design Sound Levels specified in *Australian Standard 2021:2015 Acoustics: Aircraft Noise Intrusion – Building Siting and Construction* (AS 2021:2015).

4.6.2 Future management requirements

A *Noise Impact Assessment* has been prepared by Lloyd George Acoustics (2021) (**Appendix D**) investigating the potential noise impacts from the industrial area and aircraft noise to support the preparation of the LPS amendment. With regards to aircraft noise, outdoor noise levels over 80 dB LAmax can be expected in the future. However, noise insulation is not mandatory under SPP 5.1 within the 20-25 ANEF contour for Perth Airport noise exposure zone.

The outcome of the industrial noise impact assessment is that noise to Area 3 can achieve compliance with the *Environmental Protection (Noise) Regulations 1997* at all times. This is on the basis of the following development measures:

- The only operations existing south of Bassett Road is the Clay Shed
- The Clay Shed does not operate during the night, with the exception of the conveyor transfer of materials from the Clay Shed (bins) to kilns 9 and 10
- Before the Clay Shed is demolished, a 5-metre high wall is constructed abutting the south side of the masonry lot to act as a noise barrier
- Triple stacked shipping containers are included on the west side of the Clay Shed and double stacked shipping containers at the nearest future residences to act as noise barriers.

The above measures can ensure the amenity of future residents will not be adversely impacted by operational noise from the brickworks are implemented.

Whilst not a specific recommendation through of the *Noise Impact Assessment* by (Lloyd George Acoustics 2021), the preparation of a Noise Management Plan may be required as part of future subdivision and development of the site, given the requirement for noise barriers, title notifications and construction standards to meet aircraft noise impacts. The future Noise Management Plan will demonstrate how development can adequately mitigate the noise impacts through the use of noise attenuation measures, as outlined above.

4.7 Air Quality

4.7.1 Policy framework, site context and management objectives

A Human Health Risk Assessment has been undertaken by Environmental Risk Sciences (2021) to understand the potential impacts from the consolidated brickworks operations on the proposed final residential land use. The Human Health Risk Assessment reviewed the air quality modelling undertaken by ETA (2020).

The assessment assumes that the Midland Brick will continue to operate Kilns 9 and 10, while Kilns 7, 8 and 11 will be decommissioned and then demolished (refer to **Figure 1**). The maximum allowable emission limits prescribed in the EP Act Part V licence for the Midland Brick operations were used as the basis to provide an estimate of the theoretical 'worst-case' operations for Kilns 9 and 10. This is a highly conservative approach, as the emissions from current and historical operation of these kilns are typically significantly below these limits.

The assessment compared the modelled air quality results to ambient air quality assessment criteria to determine the potential air quality impacts. The assessment criteria adopted for the study are consistent with the ambient air quality guideline values outlined in the following policy framework:

- *The National Environmental Protection Measure (NEPM) for Ambient Air Quality* (NEPC, 2015).
- *The Australian and New Zealand Environment Council* (ANZEC, 1990).
- *The New South Wales Environment Protection Authority (NSW EPA) statutory methods for modelling and assessing emissions of air pollutants from stationary sources in this state* (NSW EPA, 2017).
- The Department of Water and Environment Regulation (DWER)'s *Draft Air Emissions Guidelines.*

The assessment found that for typical and maximum allowable emission levels as currently authorised by brickworks' Part V Licence (L4511/1967/13), predicted ground level concentrations of potential pollutants comply with all relevant assessment criteria for the proposed land use beyond the consolidated brickworks' operations boundary (ETA 2020).

A summary of the findings of the assessment is provided below and discussed in further detail within the Human Health Risk Assessment (**Appendix E**) report:

- For typical operations of the two kilns (Kilns 9 and 10):
    - Predicted ground-level concentrations of HCl, HF, SO2, CO and particulate matter (as PM10 and PM2.5) comply with all relevant assessment criteria within the site.

  - Predicted ground-level concentrations of SO2 comply with the current and proposed NEPM Standards.
- For maximum allowable operations of the two kilns (Kilns 9 and 10), with a reduced HF limit:
  - Predicted ground-level concentrations of HCl, HF and SO2 comply with all relevant assessment criteria within site.
  - Predicted ground-level concentrations of SO2 comply with the current and proposed NEPM Standards.

The proposed future development of the site is unlikely to introduce land uses that would detrimentally impact air quality, or impact air quality differently to the typical residential development already present in the broader area.

4.7.2 Future management requirements

There are no exceedances of any of the ambient air quality guideline values, hence there are no air quality impacts (derived from the brick works operations) that would be of concern to the health of future residents at the site. There will be no requirement for the preparation of an air quality management plans given detailed investigations did not report impacts from the current and historical land uses within the site.

5 Implementation Framework

A summary of how the LPS amendment responds to the environmental values and attributes within the site is provided in **Table 6**. The table also outlines the proposed and potential future management measures required as part of the subdivision and development process.

Table 6: Environmental management framework implementation table

Factor	Local Planning Scheme amendment (completed)	Subdivision phase	Part of development works
Native vegetation	• Assessment of flora and vegetation values and preliminary consideration of potential retention opportunities	• Detailed analysis to inform the subdivision layout and consider tree retention opportunities. • Consideration of potential requirement for Clearing Permit unless a valid exemption applies.	• Consider opportunities to retain vegetation in road reserves, public open space or future residential lot boundary setbacks.
Native fauna	• Assessment of fauna habitat and preliminary consideration of potential retention opportunities.	• Detailed analysis to inform the subdivision layout to consider opportunities to retain potential habitat trees and foraging area.	• Consider opportunities to retain trees and foraging area in road reserves, public open space or future residential lot boundary setbacks.
Hydrology	• Preparation of a Local Water Management Strategy. • Provision of underground stormwater storage system to provide irrigation water. • POS areas to provide adequate stormwater biofiltration via system of swales.	• Preparation of Urban Water Management Plans.	• Implementation of the UWMP.
Heritage	• Preliminary desktop investigations into heritage sites.	• N/A	• As part of future ground disturbing activities, if Aboriginal artefacts or sites (not previously identified) are uncovered, works will cease and a suitably qualified expert be brought in to survey the potential site, Additional consent pursuant to the AH Act will then be sought if necessary.
Bushfire risk	• Preparation of a Bushfire Management Plan. • Provision of public open space and road reserves to accommodate appropriate setbacks. • Determining a spatial layout that reduces the bushfire hazard to future development.	• Complete detailed BAL assessment to support dwelling construction.	• Dwellings within 100 m of bushfire threat to demonstrate compliance with AS 3959.
Site contamination	• Determine potential contamination and that a	• N/A	• If evidence of contamination is encountered as part of ground

Factor	Local Planning Scheme amendment (completed)	Subdivision phase	Part of development works
	residential land use can be supported. • Determine any spatial land use implications.		disturbing activities, any sources of contamination will need to be completed prior to the issuing of titles to the satisfaction of the WAPC on advice from the DWER.
Noise	• Preparation of a Noise Impact Assessment • Determine noise implications from aircraft and consolidated brickworks and required spatial response.	• A noise management plan may be required as part of future subdivision and development of the site.	• Acoustic mitigation measures including: ○ The only operations existing south of Bassett Road is the Clay Shed ○ The Clay Shed does not operate during the night, with the exception of the conveyor transfer of materials from the Clay Shed (bins) to kilns 9 and 10 ○ Before the Clay Shed is demolished, a 5-metre high wall is constructed abutting the south side of the masonry lot to act as a noise barrier ○ Triple stacked shipping containers are included on the west side of the Clay Shed and double stacked shipping containers at the nearest future residences to act as noise barriers
Air Quality	• Preparation of an Air Quality Impact Assessment to understand potential impacts on future residents.	• N/A	N/A

6 Conclusion

This Environmental Assessment Report (EAR) has been prepared on behalf of Hesperia Pty Ltd ('the proponent') to support a Local Planning Scheme (LPS) amendment to rezone Lot 9000 Cranwood Crescent, Viveash (the site) from 'General Industrial' to 'Residential (R20)' under the City of Swan (CoS) LPS No.17. The proposed LPS amendment is to facilitate future residential development following the decommissioning of Middle Swan Brickworks land uses within the site. A Local Structure Plan has been prepared for the proposed 'Residential' (R20) area which provides a framework for how the structure and layout of development should be progressed for the site, provided in **Appendix A**.

The EAR provides a synthesis of information regarding the environmental values and attributes of the site, obtained from a range of sources such as local and regional reports, databases, mapping and site-specific investigations. The following documents provide support to this EAR:

- *Fauna Assessment - Part Lots 23 Winston Crescent, Lot 9000 Cranwood Crescent and 73 Eveline Road, Middle Swan* (Emerge Associates 2022)
- *Flora and Vegetation Assessment - Part Lots 23 Winston Crescent, Lot 9000 Cranwood Crescent and 73 Eveline Road, Middle Swan* (Emerge Associates 2020)
- *Detailed Site Investigation - Midland Brick Stage 2 Subdivision* (Emerge Associates 2021b)
- *Bushfire Management Plan - Area 3 Middle Swan Brickworks Local Planning Scheme Amendment* (Emerge Associates 2021a)
- *Noise Assessment Plan - Watermark Stage 3 Local Structure Plan* (Lloyd George Acoustics 2021)
- *Human Health Risk Assessment Midland Brick - Midland Brick MRS Rezoning* (Environmental Risk Sciences 2021)
- *Local Water Management Strategy – Watermark Area 3* (LWMS) (Hyd2o Hydrology 2021)

The environmental attributes and values identified within the site have been outlined in **Section 2** of this document and consideration of potential impacts on environmental values have been outlined within **Section 4**.

Given the degraded nature of the site associated with the current industrial land uses, there are limited environmental values identified which require specific spatial responses through the Local Structure Plan. Notwithstanding, the EAR provides a management framework for the relevant environmental attributes and values of the site identified within the site, including:

- **Flora and vegetation**: Due to the degraded nature of the site, no significant flora or vegetation values have been identified within the site that require specific spatial responses the Local Structure Plan. Detailed investigations and expert advice will be sought to identify opportunities to retain native vegetation, and in particular mature trees, potentially within areas of POS, road reserves and future residential lot boundary setbacks. Where clearing of vegetation is proposed, a clearing permit will need to be attained pursuant to Part V of the Environmental Protection Act 1986, unless a valid exemption applies.

- **Native fauna**: A limited extent (0.02 ha) of foraging habitat suitable for Carnaby's black cockatoo (CBC) Baudin's black cockatoo (BBC), and Forest Red-tailed black cockatoo (FRTBC) occurs within the site, in addition to a total of three potential black cockatoo habitat trees, none of which contain potentially suitable nesting hollows. Impacts to native fauna will be minimal given the limited habitat value within the site. Notwithstanding, reasonable efforts will be made to retain the 26 black cockatoo habitat trees and foraging habitat within the site, subject to mitigating factors such as worthiness of retention assessment, natural attrition, unavoidable or unintended impacts from servicing requirements, managing bushfire risk, public safety and subdivision design or development requirements. Detailed investigations and expert advice will be sought to identify potential retention areas within POS, road reserves and future residential lot boundary setbacks.
- **Hydrology - Surface water:** The current hydrological functions of the site will be managed through the application of the *Better Urban Water Management Framework* (implemented through the standard planning process), detailed in the Local Water Management Strategy (LWMS) prepared to support the LPS amendment (Hyd2o Hydrology 2021). Stormwater management requirements as outlined within the LWMS will be implemented through an Urban Water Management Plan (UWMP) for each stage of future subdivision.
- **Land use considerations – air quality impacts**: The results of the Human Health Risk Assessment (Environmental Risk Sciences 2021) indicated there will be no air quality impacts (derived from the brick works operations) that would be of concern to the health of future residents at the site.
- **Land use considerations – acoustic impacts:** The Noise Impact Assessment (Lloyd George Acoustics 2021) outlines a range of noise mitigation measures which will be applied as part of the future development of the site, such as noise barriers which can ensure that the future proposed urban land use will have an acceptable level of amenity. Specific mitigation measures can be resolved in further detail at the time of subdivision and documented in a Noise Management Plan.
- **Bushfire management**: Bushfire hazards can be suitably managed through the provision of appropriate setbacks to achieve a bushfire attack level (BAL) of BAL-29 or less and constructing dwellings in accordance with *Australian Standard 3959-2019 Construction of buildings in bushfire prone areas*. Appropriate mitigation measures for bushfire can be resolved in further detail at the time of subdivision through the preparation of a Bushfire Management Plan.

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

- Preparation of an Urban Water Management Plan to support each stage of subdivision.
- Preparation of a Bushfire Management Plan to support each stage of subdivision.
- The preparation of a Noise Management Plan as part of future subdivision and development of the site to oversee acoustic mitigation measures.

Overall, the EAR has found that the proposed urban development can be suitably managed through the planning process, with a low likelihood of significant adverse environmental impacts.

7 References

7.1 Legislation

Aboriginal Heritage Act 1972

Biodiversity Conservation Act 2016

Contaminated Sites Act 2003

Environmental Protection Act 1986

Environment Protection and Biodiversity Conservation Act 1999

Environmental Protection (Clearing of Native Vegetation) Regulations 2004

7.2 General references

City of Swan 2015, *Local Biodiversity Strategy*.

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Western Australian Planning Commission (WAPC) 2015, *State Planning Policy 3.7 Planning in Bushfire Prone Areas*, Perth.

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Western Australian Planning Commission and Department of Planning, Lands and Heritage (WAPC and DPLH) 2019, *Model Subdivision Conditions Schedule*, Perth.

7.3 Online references

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Department of Aboriginal Affairs (DAA) 2018, *Aboriginal Heritage Enquiry System*, viewed 13 September 2021, <http://maps.dia.wa.gov.au/AHIS2/>.

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Department of Parks and Wildlife (DPaW) 2013, *A visual guide to the Interim Biogeographic Regionalisation for Australia (IBRA) in WA*, viewed 13 September 2021, <http://florabase.dec.wa.gov.au/help/ibra/#map>.

Department of Parks and Wildlife (DPaW) 2015a, *Threatened Priority Flora Database*, viewed 13 September 2021, <http:// https://www2.landgate.wa.gov.au/bmvf/app/waatlas/>.

Department of Water (DoW) 2001, *Perth Groundwater Atlas (groundwater contours)*, viewed 13 September 2021, <http://atlases.water.wa.gov.au/idelve/gwa/>.

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Figures

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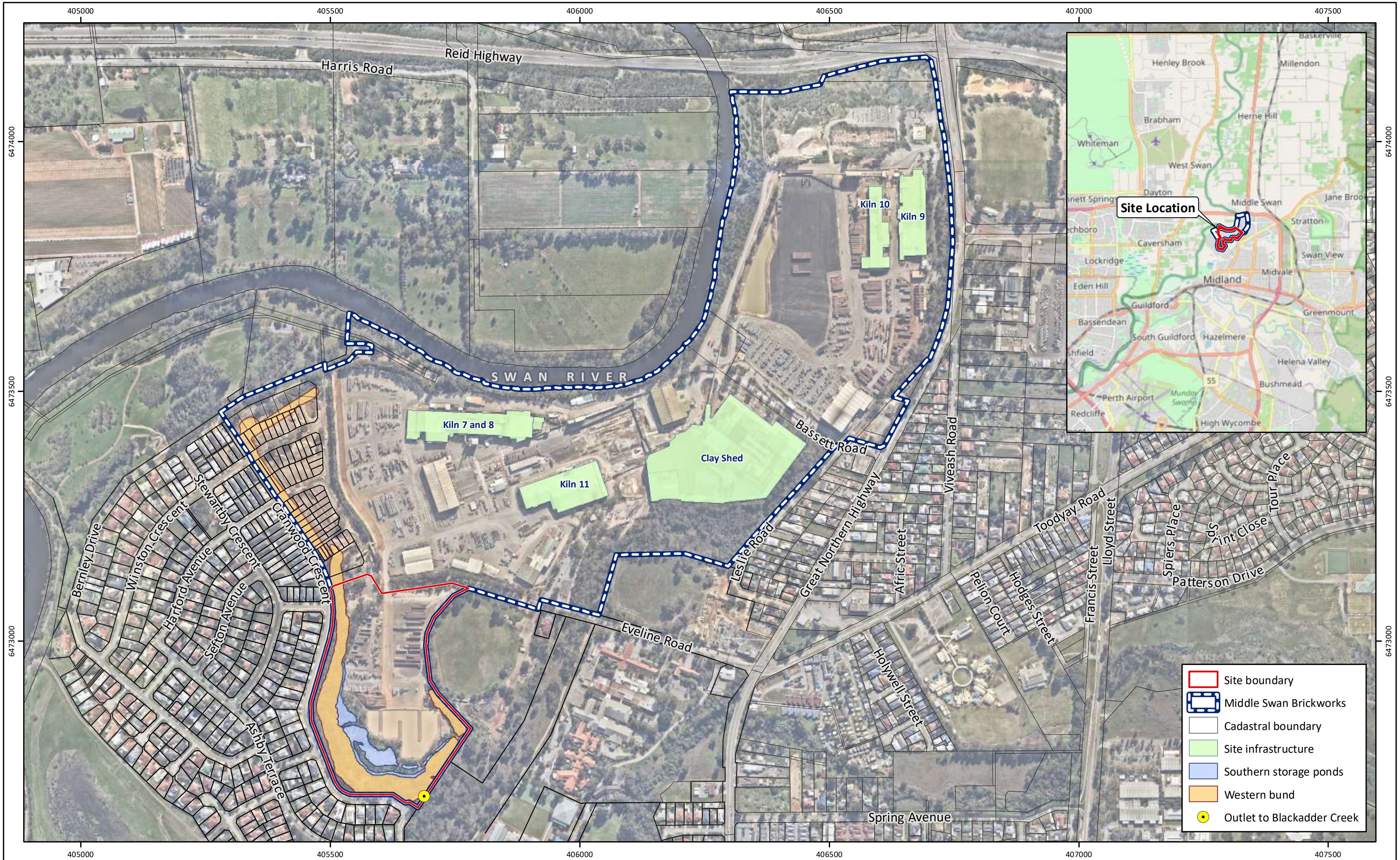

Figure 1: Site Location and Features

Project: Local Planning Scheme Amendment - Environmental Assessment Report
Area 3 Middle Swan Brickworks

Client: Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F246a

Drawn:	WJC
Date:	20/04/2022
Checked:	BRB
Approved:	JDH
Date:	20/04/2022

Scale: 1:10,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

Figure 2: **Soils and Topography**

Project:	Local Planning Scheme Amendment - Environmental Assessment Report Area 3 Middle Swan Brickworks
Client:	Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F247a
Drawn: WJC
Date: 20/04/2022
Checked: BRB
Approved: JDH
Date: 20/04/2022

N

0 50 100
Metres
Scale: 1:4,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Figure 3: Plant Communities

Project:	Local Planning Scheme Amendment - Environmental Assessment Report Area 3 Middle Swan Brickworks
Client:	Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F248a

Drawn:	WJC
Date:	20/04/2022
Checked:	BRB
Approved:	JDH
Date:	20/04/2022

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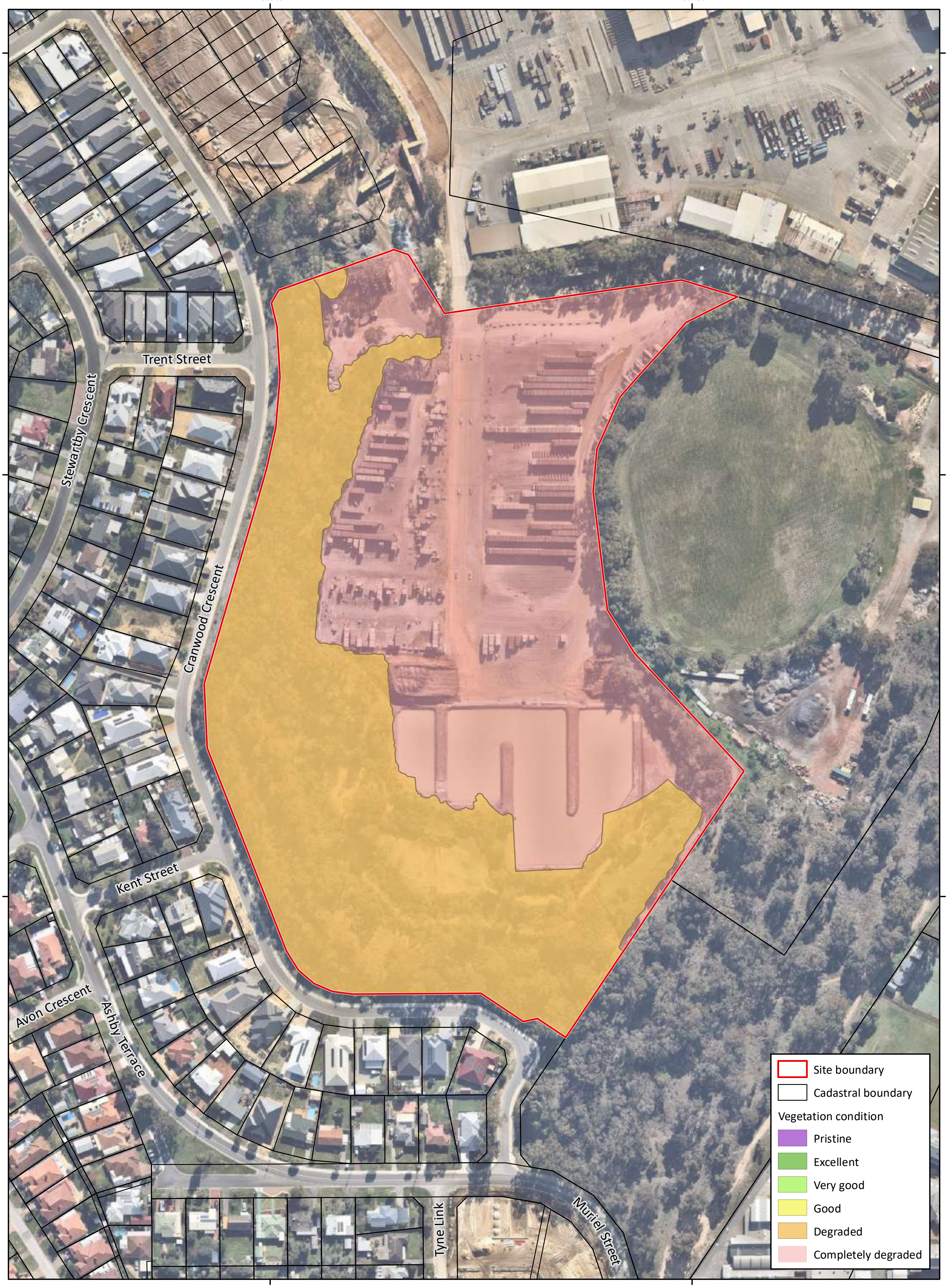

Figure 4: **Vegetation Condition**

Project: Local Planning Scheme Amendment - Environmental Assessment Report
Area 3 Middle Swan Brickworks

Client: Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F249a

Drawn:	ADB
Date:	03/09/2021
Checked:	BRB
Approved:	JDH
Date:	15/09/2021

N

0 20 40 60 80
Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

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Figure 5: Environmental Features

Project:	Local Planning Scheme Amendment - Environmental Assessment Report Area 3 Middle Swan Brickworks
Client:	Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F250a

Drawn:	WJC
Date:	20/04/2022
Checked:	BRB
Approved:	JDH
Date:	20/04/2022

N

0 20 40 60 80
Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Figure 6:	**Fauna Habitat and Black Cockatoo Habitat Trees**	**Plan Number:** **EP19-105(44)--F251a** Drawn: WJC Date: 20/04/2022 Checked: BRB Approved: JDH Date: 20/04/2022	0 20 40 60 80 Metres Scale: 1:3,000@A4 GDA 1994 MGA Zone 50
Project:	Local Planning Scheme Amendment - Environmental Assessment Report Area 3 Middle Swan Brickworks		
Client:	Hesperia Pty Ltd		

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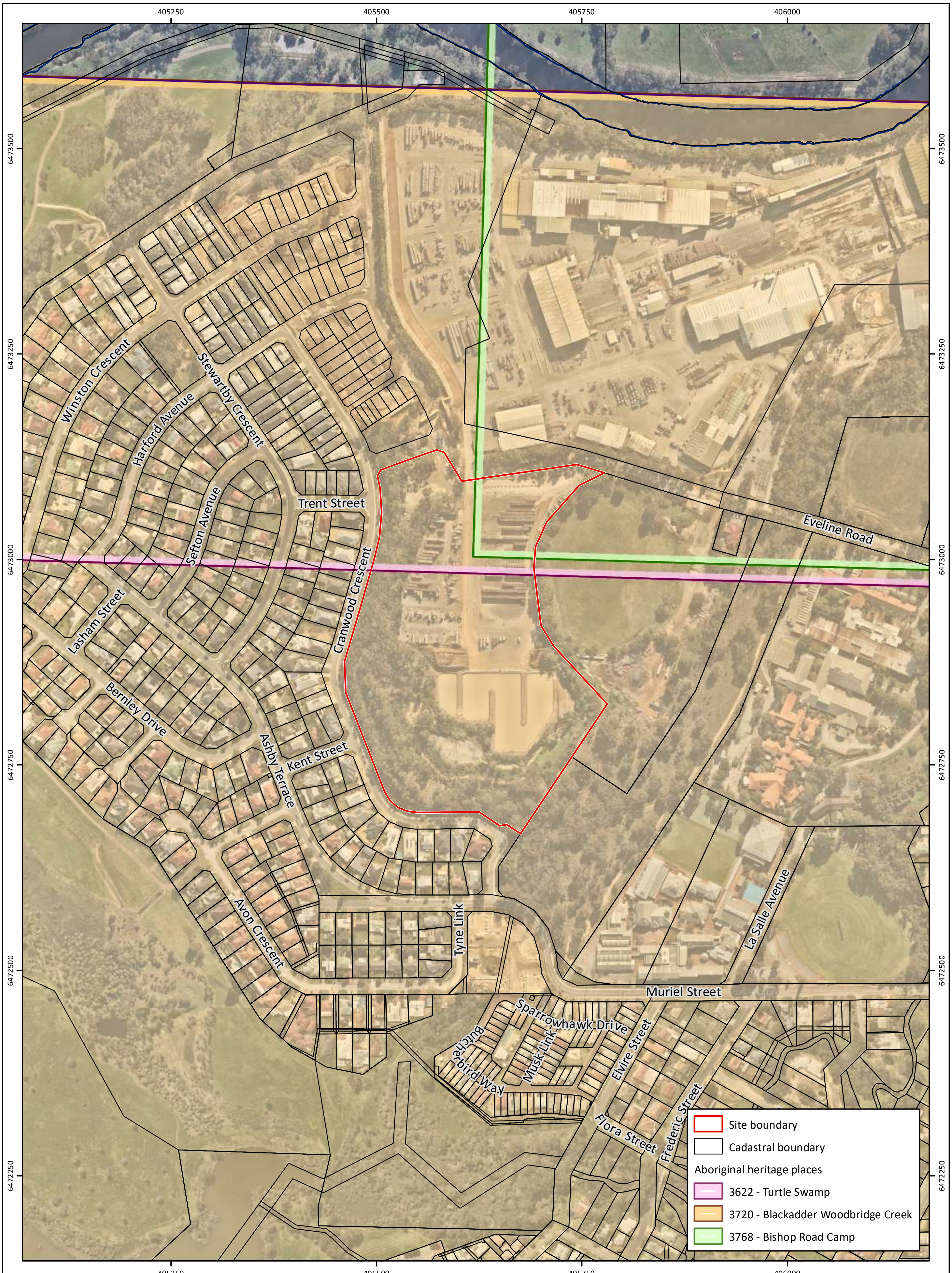

Figure 7:	**Aboriginal Heritage Sites**	**Plan Number:** **EP19-105(44)--F252a** Drawn: WJC Date: 20/04/2022 Checked: BRB Approved: JDH Date: 20/04/2022	0 50 100 150 Metres Scale: 1:6,000@A4 GDA 1994 MGA Zone 50
Project:	Local Planning Scheme Amendment - Environmental Assessment Report Area 3 Middle Swan Brickworks		
Client:	Hesperia Pty Ltd		

emerge ASSOCIATES

Figure 8: **Concept Layout Plan Response to Environmental Attributes**

Project: Local Planning Scheme Amendment - Environmental Assessment Report Area 3 Middle Swan Brickworks

Client: Hesperia Pty Ltd

Plan Number: EP19-105(44)--F253b
Drawn: WJC
Date: 20/04/2022
Checked: BRB
Approved: JDH
Date: 20/04/2022

Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

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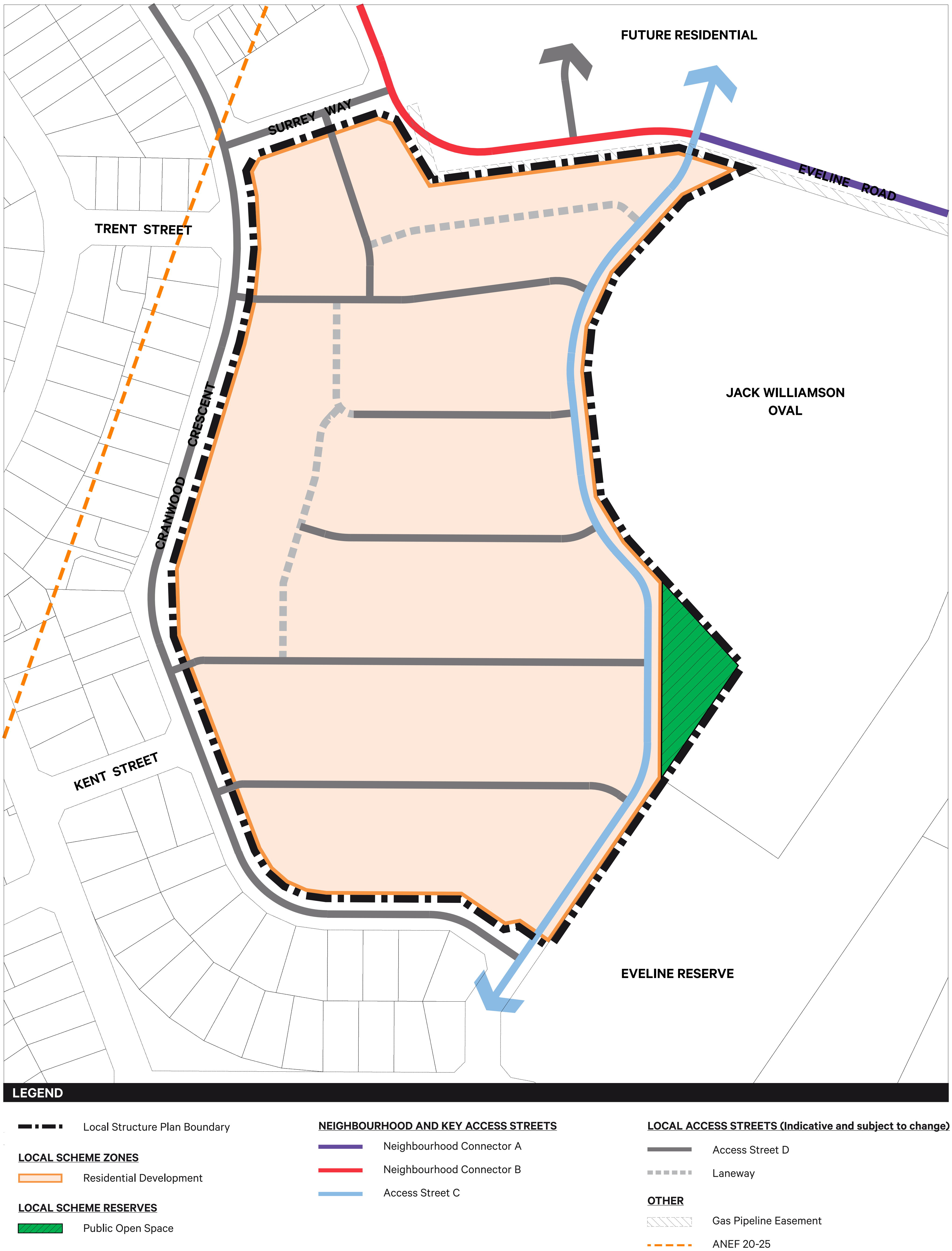
Appendix A

Area 3 Local Structure Plan (Element 2022)



Area 3 Local Structure Plan

Lot 9000 Eveline Road, Viveash

N

0 20 40m

Date: 13 April 2022 Scale: 1:2000 @ A3

File: 21-742 ST1 1 Staff: LC CW Checked: MR

Revision: A Description Date

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
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Appendix B

Technical Memorandum – Fauna Assessment, Part Middle Swan Brickworks, Middle Swan (Emerge Associates 2020)

TECHNICAL MEMORANDUM

Level 1 Fauna and Targeted Black Cockatoo Assessment
Part Middle Swan Brickworks, Middle Swan

PROJECT NUMBER	EP19-105(26)	**DOC. NUMBER**	EP19-105(26)—46A MS
PROJECT NAME	Part Middle Swan Brickworks, Middle Swan	**CLIENT**	Linc Property Pty Ltd
AUTHOR	MS	**REVIEWER**	RAW
VERSION	A	**DATE**	22/04/2022

1. INTRODUCTION

Hesperia Pty Ltd is progressing a Local Planning Scheme (LPS) amendment to rezone Lot 9000 Cranwood Crescent, Viveash (herein referred to as 'Area 3') from 'General Industrial' to 'Residential (R20)' under the City of Swan (CoS) LPS No.17. The proposed LPS amendment is to facilitate future residential development following the decommissioning of Middle Swan Brickworks land uses within Area 3. This report relates to the broader survey area encompassing all of Lot 72 Eveline Road, Lot 23 Winston Crescent, Lot 9000 Cranwood Crescent and multiple smaller undeveloped lots on Winston Crescent and Somerset Street in Middle Swan (herein referred to as the 'site'). The location of the site is shown in **Figure 1**.

The site is located approximately 17 kilometres (km) north-east of the Perth Central Business District within the City of Swan and is zoned 'industrial', urban and 'rural' under the Metropolitan Region Scheme (MRS) and 'general industrial' and 'local road' under the City of Swan's *Local Planning Scheme* (LPS) No. 17.

The site is approximately 47.18 ha in size and is bounded by the Swan River to the north, Bassett Road and industrial buildings to the east and residential housing and parklands to the south and south-east.

1.1. Purpose and scope of work

Emerge Associates (Emerge) were engaged to provide environmental consultancy services to support the LPS amendment for Area 3. The purpose of this assessment is to provide sufficient information on the fauna values within Area 3 and the broader site to inform this process. Emerge previously undertook a 'level 1' fauna survey and a targeted black cockatoo survey of the brickworks including the site in accordance with the Environmental Protection Authority's (EPA's) *Technical Guidance – Terrestrial fauna Surveys* (EPA 2016). A tree survey of a portion of the site was undertaken in 2021 (Emerge Associates 2021).

This technical memorandum details the fauna methodology and results recorded within the site during the Emerge Associates (2019) assessment which included the following tasks:

- Desktop review of background information regarding fauna species relevant to the site and surrounds.
- Compilation of a list of fauna species opportunistically recorded as part of the field survey.
- Identification of potential habitat for conservation significant fauna species and likelihood of occurrence.
- A targeted black cockatoo survey including identification and mapping of potential black cockatoo habitat values.

- Documentation of the desktop assessment, survey methodology and results into a technical memorandum.

2. ENVIRONMENTAL CONTEXT

2.1. Threatened fauna species

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

In Western Australia fauna species may also be classed as 'threatened' under the *Biodiversity Conservation Act 2016* (BC Act). It is an offence to 'take' or 'disturb' threatened fauna without Ministerial approval.

Threatened fauna species listed under the EPBC Act and/or BC Act are assigned a conservation status according to attributes such as population size and geographic distribution. Further information on threatened species and their categories is provided in **Appendix A**.

2.2. Priority fauna species

Fauna species that do not currently meet the criteria for listing as threatened but are potentially rare or threatened may be added to the Department of Biodiversity, Conservation and Attractions (DBCA) *Priority Fauna 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 priority species and their categories is provided in **Appendix A**.

2.3. Migratory fauna species

Migratory fauna species that migrate to Australia and its external territories or pass though or over Australian waters during their annual migrations warrant special protection under Commonwealth and State legislation. At a Commonwealth level, migratory fauna taxa may be listed as 'migratory' under *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Any action likely to have a significant impact on a taxon listed under the EPBC Act requires approval from the Commonwealth Minister for the Environment and Energy.

In Western Australia migratory fauna taxa may be listed as 'specially protected species' and classed as 'migratory' under the BC Act. Further information on migratory species is provided in **Appendix A**.

2.4. Pest fauna species

The term 'pest fauna' can refer to any animal that requires some form of action to reduce its effect on the economy, the environment, human health and amenity. Many non-native fauna species and some fauna species native to Australia but not Western Australia are considered to be pest fauna.

A particularly invasive or detrimental pest species may be listed as a 'declared pest' pursuant to Western Australia's *Biosecurity and Agriculture Management Act 2007* (BAM Act), indicating that it warrants special management to limit its spread. At a National level, pest fauna may be listed as

‘Established Pests and Diseases of National Significance’ (EPDNS) under the *Australian Pest Animal Strategy (2017-2027)* (DoA 2017). Further information on categories of declared pests is provided in **Appendix A.**

2.5. Black cockatoos

The Swan Coastal Plain is known to provide habitat for three threatened species of black cockatoo: *Calyptorhynchus baudinii* (Baudin’s cockatoo), *Calyptorhynchus latirostris* (Carnaby’s cockatoo) and *Calyptorhynchus banksii naso* (forest red-tailed black cockatoo) (collectively referred to herein as ‘black cockatoos’).

Important black cockatoo habitat comprises the following:

- Breeding habitat: Trees that contain hollows that are suitable for breeding by black cockatoos. These must generally be located within 7 km of food and water resources (Saunders 1990).
- Roosting habitat: Groups of large trees that are located within 6 km of water and food resources, with overlapping foraging ranges within 12 km (Shah 2006; Le Roux 2017).
- Foraging habitat: Vegetation that contains known foraging plant species for black cockatoos.

Broad-scale maps are available of the modelled distribution of Baudin’s cockatoo, Carnaby’s cockatoo and forest red-tailed black cockatoo (DSEWPaC 2011; DoEE 2016a, b). In terms of breeding, the modelling for Baudin’s cockatoo includes ‘known breeding areas’ and ‘predicted breeding range’, Carnaby’s cockatoo includes ‘breeding range’ and non-breeding range’ and forest red-tailed black cockatoo does not provide breeding range information.

In addition, the Department of Planning (DoP), in partnership with the Department of Conservation (DEC, not DBCA) and fauna experts, have identified and mapped Carnaby’s cockatoo habitat on the Swan Coastal Plain and Jarrah Forest regions to help identify areas of highest potential conflict between land-use planning and the conservation of important habitat (DEC 2011; Johnstone *et al.* 2011).

The dataset includes confirmed and potential Carnaby’s cockatoo breeding habitat, as well as confirmed and potential roosting habitat. Both confirmed and potential breeding sites are presented with a 12 km radius buffer. Potential foraging habitat is mapped based on regional vegetation mapping that may contain plant species known to be foraged upon by Carnaby’s cockatoo (Heddle *et al.* 1980; Havel and Mattiske 2000; DEC 2007; Strelein *et al.* 2009).

While these datasets only predict potential habitat for Carnaby’s cockatoo, the information is also largely applicable for Baudin’s cockatoo and forest red-tailed black cockatoo. Breeding sites that are suitable for Carnaby’s cockatoo may also be suitable for Baudin’s cockatoo and forest red-tailed cockatoo, if located within their distribution/breeding ranges. Similarly, many plant species that are foraged upon by Carnaby’s cockatoo are also consumed by Baudins’ cockatoo (e.g. *Banksia* spp. cones and *Corymbia calophylla* (marri) nuts) and forest red-tailed cockatoo (e.g. *Eucalyptus marginata* (jarrah) and marri nuts). However, the potential foraging habitat dataset likely overestimates available foraging habitat for forest red-tailed cockatoos, as it includes multiple plant species that are not consumed by this species (e.g. *Banksia* spp.).

Additionally, Birdlife Australia undertakes annual monitoring of black cockatoo roost sites as part of the ‘Great Cocky Count’. Information gathered from these monitoring events provides roost locations and black cockatoo use (Peck *et al.* 2017).

2.5.1. Distribution

The site is located within the known distribution range of all three species of black cockatoo (DSEWPaC 2011; DoEE 2016a, b).

2.5.2. Breeding habitat

The site is located within the modelled 'predicted breeding range' of Baudin's cockatoo and the 'breeding range' of Carnaby's cockatoo (DSEWPaC 2011; DoEE 2016a).

The site is located approximately 600 m west of a Carnaby's cockatoo confirmed breeding site 12 km buffer, which is associated with the Darling Scarp (DEC 2011). The entire site is also mapped as potential Carnaby's cockatoo breeding habitat (DEC 2011), as shown in **Figure 2**.

2.5.3. Roosting habitat

Multiple potential roost sites are mapped as occurring near the site (Peck *et al.* 2017). However, no birds have been recorded at most of these sites. The closest known roost site where birds have been recorded is located approximately 6 km west of the site and is associated with forest red-tailed black cockatoos. The location of roost sites near the site is shown in **Figure 2**.

2.5.4. Foraging habitat

The site is located within approximately 5 km of extensive areas of potential black cockatoo foraging habitat, which comprises remnant native vegetation of the Jarrah Forest region on the Darling Scarp. This vegetation is likely suitable for foraging by all three species of black cockatoo. Within the local area, multiple smaller pockets of vegetation are located in close proximity of the site as shown in **Figure 2**.

3. METHODS

3.1. Desktop assessment

3.1.1. Database searches

A search was conducted for threatened and priority fauna that may occur or have been recorded within a 10 km radius of the site using the *Protected Matters Search Tool* (DoEE 2019a) and *NatureMap* (DBCA 2019). DBCA's threatened and priority fauna database search was also requested and results were provided within a radius of 5 km (reference number FAUNA#6176).

A total number of species with potential to occur within the site was calculated by adding the total count of non-conservation significant species provided by *NatureMap* to the combined number of conservation significant species provided by *NatureMap* and *Protected Matters Search Tool*.

3.1.2. Likelihood of occurrence

Information on habitat preferences and distribution of threatened and priority vertebrate fauna species[1] identified to potentially occur within the site or wider area was reviewed. This was assessed against the general site conditions and fauna habitat types recorded during the field survey.

An assessment of the likelihood of occurrence of threatened and priority fauna species within the site was undertaken and each was assigned to one of the following categories:

- Recorded: The species in question was positively identified as being present within the site during the field survey or from recent literature records.
- Likely: Potentially suitable habitat for the species in question was identified during the field survey and the site lies within the known distribution of the species.
- Possible: Potentially suitable habitat for the species in question was identified but of marginal quality and/or extent and the site lies within or close to the known distribution of the species.
- Unlikely: The site lies outside of the known distribution of the species in question and/or no suitable habitat was identified within the site.

3.2. Field survey

An ecologist from Emerge visited the site on the 18 September, 8 October and 24 October 2019 to conduct the level 1 fauna and targeted black cockatoo field survey of the brickworks, which includes the site.

Ecologists from Emerge also visited portions of the site on multiple dates in September 2021 to undertake a tree survey, which included recording of black cockatoo habitat trees, as detailed in **Section 3.2.2**. The boundary of the tree survey area is shown in **Figure 4**.

3.2.1. Level 1 fauna

Transects were traversed across the site during the day and the characteristics of fauna habitat and presence of fauna species was recorded. Microhabitats such as logs, rocks and leaf litter were investigated and secondary evidence of species presence such as tracks, scats, skeletal remains, foraging evidence or calls was also noted.

A vertebrate fauna list was compiled and fauna habitat values were described, with particular reference to 'threatened' and 'priority' fauna[1] species with potential to occur within the site. Taxonomy and nomenclature for fauna species was taken from the *Western Australian Museum Checklist of the Terrestrial Vertebrate Fauna of Western Australia* (Western Australian Museum 2019). Literature listed in **Appendix A** represent the main publications used to identify fauna species and habitats within the site. Non-native species are denoted with asterisk (*) in text and raw data.

3.2.2. Targeted black cockatoo

The site and the brickworks were searched for potential black cockatoo breeding, roosting and foraging habitat. Black cockatoo 'habitat trees' were identified and individually tagged and assessed against attributes outlined in **Table 1** below.

A 'habitat tree' was defined as a native eucalypt that is typically known to support black cockatoo breeding such as marri, jarrah, blackbutt, tuart, wandoo, or salmon gum with a DBH ≥50 cm or DBH

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[1] Invertebrate taxa were not assessed and no evaluation of the potential for invertebrate taxa to occur within the site is provided.

≥30 cm for wandoo or salmon gum. As any tree that has a suitable hollow may provide breeding habitat for black cockatoos, other tree species were also considered to be habitat trees if they contained a suitable or potentially suitable hollow. In addition, the 2021 tree survey recorded *Eucalyptus rudis* (flooded gum) trees with DBH ≥50 cm as black cockatoo habitat trees. Flooded gums were not recorded during the 2019 survey, as detailed in **Table 2**.

Each habitat tree was assessed for hollows and each hollow was assessed to determine if it was suitable for breeding by black cockatoos.

For a hollow to be deemed potentially suitable, the following features were required to be met:

- opening diameter ≥10 cm (Groom 2010)
- branch/trunk high enough (approximately ≥3 m)
- branch/trunk large enough to accommodate a black cockatoo
- branch/trunk of suitable orientation (vertical or near-vertical).

Table 1: Attributes recorded for each black cockatoo habitat tree

Attribute	Description
Tag	Unique identifier on a metal tag was nailed to each habitat tree
Image	Individual photograph
GPS location	Location using a handheld GPS unit
Tree species	Species and common name
Diameter at breast height (DBH) (cm)	Measured using a diameter tape
Tree height (m)	Estimate of height
Hollow	Hollow(s) noted and photographed (where observed)
Hollow entrance	Estimate of entrance diameter and entry position (e.g. top-entry or side-entry).
Hollow orientation	Orientation of each hollow (vertical, near-vertical, non-vertical).
Signs of use of hollows	Observations of signs of use of hollows by black cockatoos or other species

A dusk roost survey was not undertaken. The site was assessed for the potential of providing roosting habitat for black cockatoos, and secondary evidence of roosting activity, such as branch clippings, droppings or moulted feathers was searched. Patches of large native and non-native trees were assumed to provide potential black cockatoo roosting habitat.

Potential black cockatoo foraging habitat was identified by comparing the literature on known foraging habitat resources against the vegetation within the site (Davies 1966; Saunders 1980; Johnstone and Storr 1998; Johnstone and Kirkby 1999; Groom 2011; Johnstone *et al.* 2011; DoEE 2012). Potential foraging habitat was then assessed for importance based on the presence of plant species known to be primary as a food source for black cockatoos, vegetation extent and regional context of the site. Secondary evidence of black cockatoo foraging, such as chewed marri nuts or banksia cones, within the site was searched and allocated to a species where possible.

Active searches were conducted for secondary evidence of breeding, roosting and foraging activity such as chew marks, branch clippings, droppings, moulted feathers and chewed marri nuts or banksia cones.

3.3. Mapping and data analysis

3.3.1. Fauna habitat

Fauna habitats were described according to the dominant flora species and vegetation type present, as determined from observations made during the field survey and information provided in the '*Detailed Flora and Vegetation Assessment*' (Emerge Associates 2020). The identified fauna habitats were mapped on aerial photography with the boundaries interpreted from aerial photography, previously identified plant communities (Emerge Associates 2020) and notes taken in the field.

Information on specific habitat requirements for conservation significant vertebrate fauna species with potential to occur within the site were compiled as part of the desktop assessment. This information was compared to the fauna habitats identified within the site to determine whether any conservation significant fauna species are considered to have potential to utilise the site.

3.3.2. Black cockatoo habitat

The location of potential black cockatoo habitat trees recorded in the site and information on hollows (if present) were mapped on aerial imagery. The data for each black cockatoo habitat tree was compiled in a table format.

Potential black cockatoo foraging habitat was mapped according to the fauna habitats recorded and notes taken in the field.

3.3.3. 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 – Terrestrial Fauna Surveys* (EPA 2016) is provided in **Table 2**.

Table 2: Evaluation of survey methodology against standard constraints outlined in EPA Technical Guidance – Terrestrial fauna Surveys.

Constraint	Degree of limitation	Details
Level of survey	No limitation	A level 1 survey (desktop study and field survey) in combination with level 2 (targeted) black cockatoo survey was considered adequate given the relatively low habitat values within the site and the generally good availability of fauna information for the region.
Scope	No limitation	The survey focused on vertebrate fauna and habitat values, with particular focus on conservation significant taxa with potential to occur within the site.
Proportion of fauna identified, recorded and/or collected.	No limitation	All observed vertebrate fauna were identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	No limitation	Adequate information was available from database searches.
The proportion of the task achieved and further work which might be needed.	No limitation	The task was achieved in its entirety.

Table 2: Evaluation of survey methodology against standard constraints outlined in EPA Technical Guidance – Terrestrial fauna Surveys (continued).

Constraint	Degree of limitation	Details
Experience level of personnel	Minor limitation	This fauna assessment was undertaken by a qualified, early career ecologist. The ecologist is experienced in conducting fauna surveys but is relatively new to Western Australia. Technical review was undertaken by a senior environmental consultant with 18 years' experience in environmental science in Western Australia.
Suitability of timing	No limitation	The survey was undertaken from the late morning until late afternoon, which is not typically the highest activity period for bird species. However, the weather conditions were optimal for identifying fauna species and survey timing is not considered to be of great importance for Level 1 assessments.
Completeness	No limitation	The desktop assessment, field survey components of the survey were completed. *Eucalyptus rudis* (flooded gum) trees were not recorded as habitat trees unless they contained a hollow that is suitable for breeding by black cockatoos. This is because they are not known to be favoured by black cockatoos for breeding and because they are less likely to form hollows of a suitable size for breeding by black cockatoos due to their typical bifurcated growth form and structure. Since the 2019 survey was completed the Department of Agriculture, Water and the Environment (DAWE) indicated that flooded gums should be included in habitat tree mapping, despite their low likelihood to form suitable hollows. Therefore, flooded gums were recorded and classified as habitat trees during the Emerge Associates (2021) tree survey. Therefore, it is possible that additional habitat trees without suitable hollow(s) (flooded gums) occur within the site, outside of the Emerge Associates (2021) tree survey boundary.
Spatial coverage and access	No limitation	Site coverage was comprehensive (track logged).
	No limitation	All parts of the site could be accessed as required.
Survey intensity	No limitation	The intensity of the survey was adequate given the size of the site and the relatively low habitat values present.
Influence of disturbance	No limitation	The site is highly modified due to historical disturbance. However, no recent disturbance was noted that may have affected outcomes of the survey.
Adequacy of resources	No limitation	All resources required to perform the survey were available.

4. RESULTS AND DISCUSSION

4.1. Fauna habitat

Historical disturbance has significantly compromised habitat values within the site. The majority of the site is devoid of native vegetation and comprises cleared areas, non-native vegetation and weeds.

The following five fauna habitats were identified within the site:

- **'*Corymbia calophylla* forest'**
- **'*Eucalyptus rudis* woodland'**
- **'*Eucalyptus wandoo* woodland'**
- **'scattered native and non-native trees and shrubs'**

- **'shrubland'**
- **'cleared area'.**

The highest natural fauna habitat values within the site are associated with ***Corymbia calophylla* forest**, ***Eucalyptus rudis* woodland** and **shrubland**. In particular, where the vegetation within these habitats remains in very good[2] or better condition, habitat includes cover of native trees and shrubs, dense ground cover and microhabitats such as logs, rocks and leaf litter. These habitats comprise a small portion of the site (1.78 ha/3.8%), with the remainder being ***Eucalyptus wandoo* woodland**, **scattered native and non-native trees and shrubs** and **cleared area** which were void of most or all native vegetation and supported low fauna habitat values.

A description and the area of each habitat is provided in **Table 3** and representative photographs of each are provided in **Plate 1** to **Plate 6.** The location of each habitat is shown on **Figure 3**.

Table 3: Fauna habitats identified within the site.

Fauna habitat classification	Description	Area (ha)
***Corymbia calophylla* forest**	Open forest *Corymbia calophylla* over shrubland *Hibbertia* sp. and *Xanthorrhoea preissii* over open sedgeland *Cyathochaeta avenacea* and *Mesomelaena tetragona* over open herbland *Agrostocrinum hirsutum* over open grassland *[3]*Eragrostis curvula* (**Plate 1**).	0.71
***Eucalyptus rudis* woodland**	Woodland *Eucalyptus rudis* over tall shrubland *Jacksonia sternbergiana* over shrubland *Billardiera heterophylla* and *Phyllanthus calycinus* and *Hakea* spp. over closed non-native grassland (**Plate 2**). This habitat type gently slopes towards a low-lying area in the west, where standing water was present and sedges covered the ground.	0.85
***Eucalyptus wandoo* woodland**	Woodland *Eucalyptus wandoo* over open non-native grassland (**Plate 3**)	0.02
Scattered native and non-native trees and shrubs	Woodland to tall shrubland of various planted species, particularly *Eucalyptus camaldulensis*, with scattered *E. rudis* over scattered native and non-native shrubs over non-native grassland with occasional native species (**Plate 4**). Where this habitat occurs in lower lying areas it was partially saturated with standing water.	11.49
Shrubland	Shrubland *Acacia pulchella* var. *pulchella, Hakea undulatum* and *Hypocalymma angustifolium* over sedgeland *Mesomelaena tetragona* over open grassland *Neurachne alopecuroidea* over herbland *Stylidium* spp. (**Plate 5**).	0.22
Cleared area	Heavily disturbed areas comprising planted non-native trees and shrubs over non-native herbs and grasses, with occasional native shrubs and forbs (**Plate 6**).	33.89

[2] As detailed in Emerge Associates (2020).
[3] '*' denotes non-native flora species

Plate 1: Corymbia calophylla forest.

Plate 2: Eucalyptus rudis woodland.

Plate 3: Eucalyptus wandoo woodland

Plate 4: Scattered native and non-native trees and shrubs.

Plate 5: Shrubland.

Plate 6: Cleared area.

4.2. Fauna

4.2.1. Desktop assessment

A total number of 598 fauna species were identified from database searches as occurring or potentially occurring within 10 km of the broader survey area[4] as listed in **Appendix B**.

This includes 30 threatened, 10 priority, 11 migratory fauna and two other specially protected species as listed in **Appendix C**.

4.2.2. Species inventory

A total of eight native and two introduced fauna species were directly or indirectly (from secondary evidence) recorded during the field survey of the brickworks, encompassing the site. No fauna species of conservation significance were recorded within the site.

A complete fauna species list is provided in **Appendix D**.

4.2.3. Conservation significant fauna

The native vegetation in the southern and south-eastern portion of the site would be the primary habitat within the site for conservation significant species. The remainder of the site provides limited habitat that would be suitable for common and widespread fauna species with non-specific habitat requirements.

Most of the threatened and priority fauna species identified in the desktop assessment are not considered to occur in the site due to lack of suitable habitat or because the site lies outside of the species known distribution range. A total of 11 conservation significant fauna species identified from database searches are considered to have the potential to utilise the site as shown in **Table 4**.

Table 4: Summary of conservation significant fauna species with have potential to occur within the site.

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		BC Act	EPBC Act		
Birds					
Apus pacificus	Pacific swift	MI	MI	Aerial, migratory species that is most often seen over inland plains and sometimes above open areas, foothills or in coastal areas. Sometimes occurs over settled areas, including towns, urban areas and cities (Johnstone and Storr 1998).	**Possible:** This aerial species may opportunistically occur in or fly over the site on commute or while searching for prey.

[4] Includes native and non-native species

Table 4: Summary of conservation significant fauna species with have potential to occur within the site (continued).

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		WA	EPBC Act		
Aves					
Botaurus poiciloptilus	Australasian bittern	EN	EN	In or over water, in tall reedbeds, sedges, rushes, cumbungi, lignum. Also occurs in ricefields, drains in tussocky paddocks and occasionally in saltmarshes and brackish wetlands.	**Possible:** This mobile species occurs in areas near the site and therefore could also occur in the site. However, habitat within the site is very marginal as dense reed vegetation is absent.
Calyptorhynchus banksii naso	Forest red-tailed black cockatoo	VU	VU	Eucalypt and Corymbia forests, often in hilly interior. More recently also observed in more open agricultural and suburban areas including Perth metropolitan area. Attracted to seeding Corymbia calophylla, Eucalyptus marginata, introduced Melia azedarach and Eucalyptus spp. trees (Johnstone and Storr 1998).	**Likely:** This species occurs in areas surrounding the site and potential foraging habitat is present within the site.
Calyptorhynchus baudinii	Baudin's cockatoo	EN	EN	Mainly eucalypt forests. Attracted to seeding Corymbia calophylla, Banksia spp., Hakea spp., and to fruiting apples and pears (Johnstone and Storr 1998).	**Likely:** This species occurs in areas surrounding the site and potential foraging habitat is present within the site.
Calyptorhynchus latirostris	Carnaby's cockatoo	EN	EN	Mainly proteaceous scrubs and heaths and adjacent eucalypt woodlands and forests; also plantations of Pinus spp. Attracted to seeding Banksia spp., Dryandra spp., Hakea spp., Eucalyptus spp., Corymbia calophylla, Grevillea spp., and Allocasuarina spp. (Johnstone and Storr 1998).	**Likely:** This species occurs in areas surrounding the site and potential foraging habitat is present within the site.

Table 4: Summary of conservation significant fauna species with have potential to occur within the site (continued).

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		WA	EPBC Act		
Aves					
Falco peregrinus	Peregrine falcon	S	-	Mainly found around cliffs along coasts, rivers, ranges and around wooded watercourses and lakes (Johnstone and Storr 1998).	**Possible**: This highly mobile species may opportunistically occur in or fly over the site on commute or while searching for prey.
Oxyura australis	Blue-billed duck	P4	-	Mainly deeper freshwater swamps and lakes; occasionally saltlakes and estuaries freshened by flood waters (Johnstone and Storr 1998a).	**Possible:** This mobile species occurs in areas near the site and therefore could also occur in the site.
Plegadis falcinellus	Glossy Ibis	MI	MI	Shallow and adjacent flats of freshwater lakes and swamps, also river pools, flooded samphire and sewage ponds.	**Possible:** This mobile species occurs in areas near the site and therefore could also occur in the site.
Mammals					
Isoodon fusciventer	Quenda	P4	-	Dense scrubby, often swampy, vegetation with dense cover up to one metre high (DEC 2012).	**Possible:** Some parts of the site provide adequate ground cover required by this species. However, they are limited in extent.
Reptiles					
Ctenotus delli	Dell's skink	P4	-	Jarrah and marri woodland with a shrub dominated understorey, sheltering in dense vegetation, inside grass trees and beneath rocks, sometimes in burrows (Nevill 2005).	**Possible**: Limited suitable habitat occurs within ***Corymbia calophylla* forest** and **shrubland**. However, this species has not been recorded within the wider area of the site for many years.

Table 4: Summary of conservation significant fauna species with have potential to occur within the site (continued).

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		WA	EPBC Act		
Moluscs					
Westralunio carteri	Carter's freshwater mussel	VU	VU	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).	**Possible:** May occur within or adjacent to the Swan River.

4.2.4. Declared pests

Two species, *Oryctolagus cuniculus* (rabbit) and *Trichoglossus moluccanus* (rainbow lorikeet) listed as a declared pest (C3) pursuant to the BAM Act, were identified within the site.

4.3. Black cockatoo habitat

4.3.1. Breeding habitat

A total of 43 black cockatoo habitat trees occur within the site. Four of these are stags (dead trees), eight are *Eucalyptus wandoo* (wandoo), 30 are *Eucalyptus rudis* (flooded gum) and one is a marri. Three of the habitat trees contain hollows.

Based on criteria outlined in **Section 3.2.2**, the three trees with hollows were classified as potentially suitable for BCs (tag numbers 462, 463 and 484) with the remainder of the habitat trees classed as containing no suitable hollow(s) as detailed in **Table 5**. The potentially suitable hollows were assessed from the ground only and so the internal dimensions of the hollows is unconfirmed. No signs of use by BCs, such as chew marks, droppings or moulted feathers, was recorded within any of the habitat trees in the site. An internal inspection of the potentially suitable hollows would be required to determine whether they are in fact suitable for breeding by black cockatoos.

Table 5: Habitat trees recorded within the site

Category	Emerge (2019)	Emerge (2021)	Total
With potentially suitable hollow(s)	3	0	3
Without suitable hollow(s)	5	35	40

The locations of habitat trees recorded within the site are shown in **Figure 4** and an inventory of the habitat trees recorded during the surveys is provided in **Appendix E**.

Note that flooded gum trees were only mapped as habitat trees in the Emerge Associates (2019) survey if they contained a suitable hollow for breeding by black cockatoos. All flooded gum trees that met the criteria outlined in **Section 3.3.2** (i.e. DBH ≥50 cm) were mapped as habitat trees in the Emerge Associates (2021) tree survey. Therefore, it is possible that additional flooded gums without suitable hollow(s) occur within the site, outside of the Emerge Associates (2021) tree survey boundary. However, these trees are considered to provide a lower likelihood of supporting black cockatoo breeding compared to other habitat tree species in the site, as detailed in **Table 2**.

4.3.2. Roosting habitat

Patches of native and non-native trees within the site have the potential to provide roosting habitat for BCs. No evidence of BC roosting, such as branch clippings, droppings and moulted feathers was observed within the site and no anecdotal records of BCs roosting within the site were reported by the brickworks staff.

4.3.3. Foraging habitat

The ***Corymbia calophylla* forest** habitat in the southern portion of the site comprises the primary area of potential foraging habitat for all three species of BCs. This area extends over 0.71 ha as shown in **Figure 4.**

Other species used by BCs for foraging, such as *Eucalyptus wandoo*, *Acacia saligna, Allocasuarina humilis, Casuarina obesa, Hakea* spp. and *Xanthorrhoea preissii*, are present within the site but are patchily distributed. The site also contains flooded gums and non-native eucalypt trees such as *Eucalyptus camaldulensis* (river red gum). While some evidence exists that these species are foraged upon by BCs, they are not considered a primary resource and consumption foraging upon the trees in the site, if it occurred, would likely be opportunistic. Therefore, the flooded gums and non-native eucalypt trees within the site were not mapped as foraging habitat.

5. CONCLUSIONS

Eight common and widespread native and two non-native fauna species were positively identified to occur within the brickworks which includes the site. Additionally, 11 species of conservation significance are considered to have potential to occur within the site. However, the likelihood that the site would provide important habitat for these species is low, as the majority of habitat within the site is in relatively poor condition and limited in extent. The site is likely to be primarily utilised by common and widespread native species without specific habitat requirements.

No black cockatoos were recorded within the site during the field survey and their presence was not reported by brickworks staff.

The site contains a total of 33 black cockatoo habitat trees comprising 30 without suitable hollow(s) and three with hollows that are potentially suitable for breeding by black cockatoos. An internal inspection of the potentially suitable hollows would be required to determine whether they are in fact suitable for breeding by black cockatoos. No evidence of black cockatoo roosting activity was observed within the site.

A patch of native vegetation in the southern portion of the site (0.71 ha) includes marri trees and provides potential foraging habitat for black cockatoos. Scattered native and non-native trees and shrubs within the site may also provide lower-quality foraging resource. Given the relatively small extent and presence of extensive areas of higher quality foraging habitat nearby, the site is considered unlikely to represent important foraging habitat for black cockatoos.

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Figures

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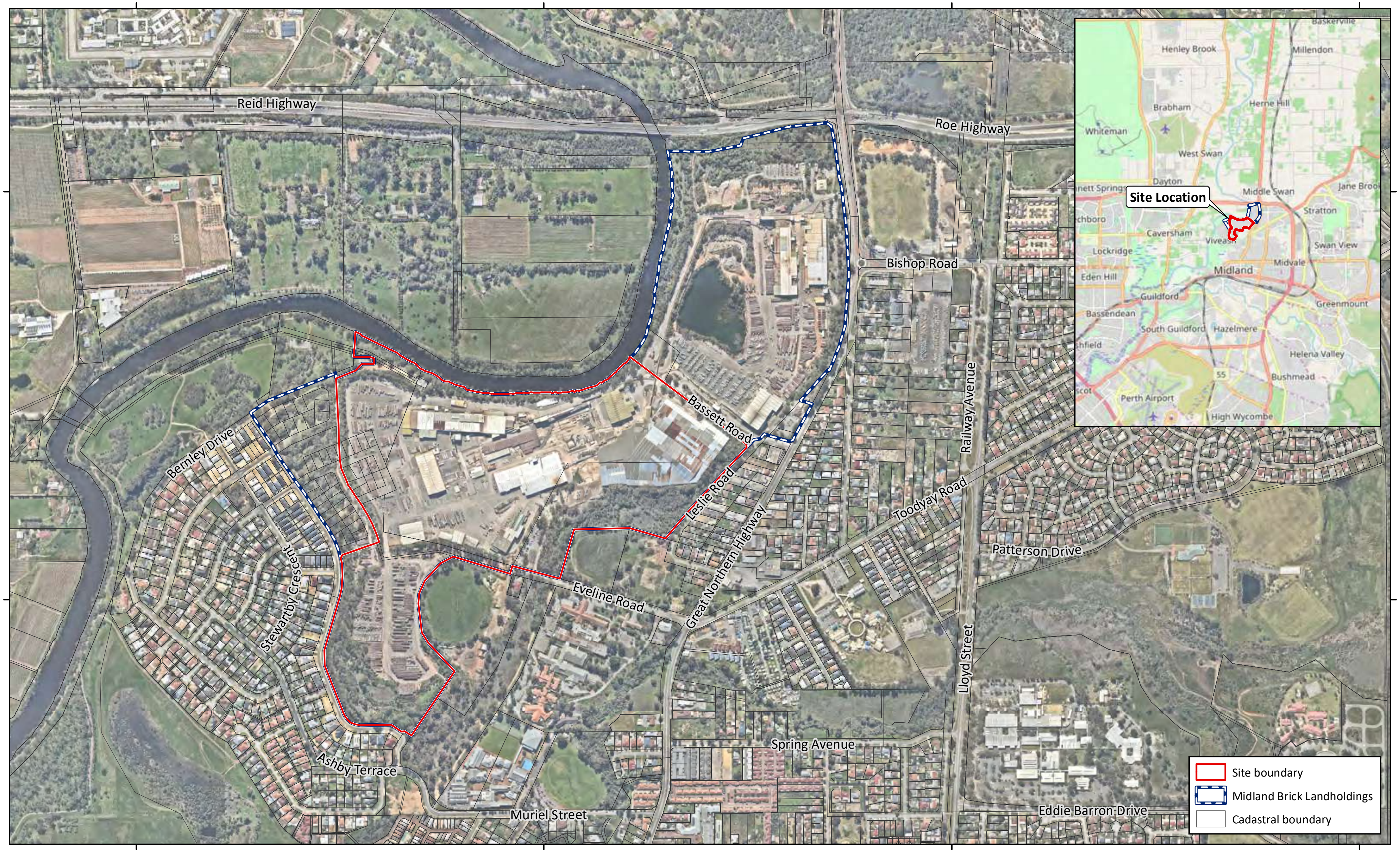


Figure 1: **Site Location**

Project:	Level 1 Fauna and Targeted Black Cockatoo Assessment Part Middle Swan Brickworks
Client:	Linc Property Pty Ltd

Plan Number:
EP19-105(26)--F160

Drawn:	GAR
Date:	25/03/2020
Checked:	RAW
Approved:	RAW
Date:	30/03/2020

N

0 200 400
Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

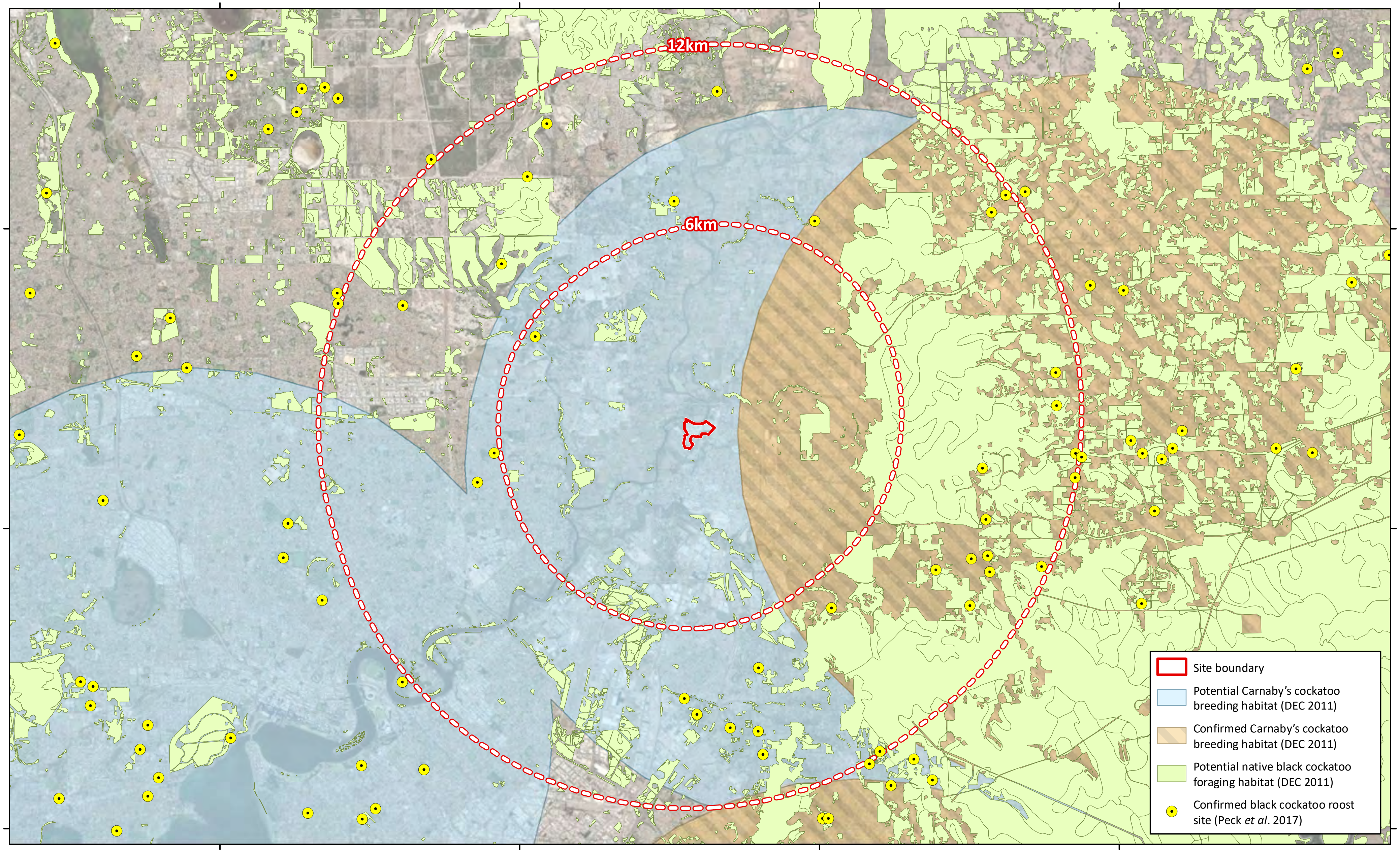


Figure 2: **Black Cockatoo Habitat Context**

Project: Level 1 Fauna and Targeted Black Cockatoo Assessment
Part Middle Swan Brickworks

Client: Linc Property Pty Ltd

Plan Number:
EP19-105(26)--F161
Drawn: GAR
Date: 25/03/2020
Checked: RAW
Approved: RAW
Date: 30/03/2020

N

0 2 4 6
Kilometres
Scale: 1:170,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

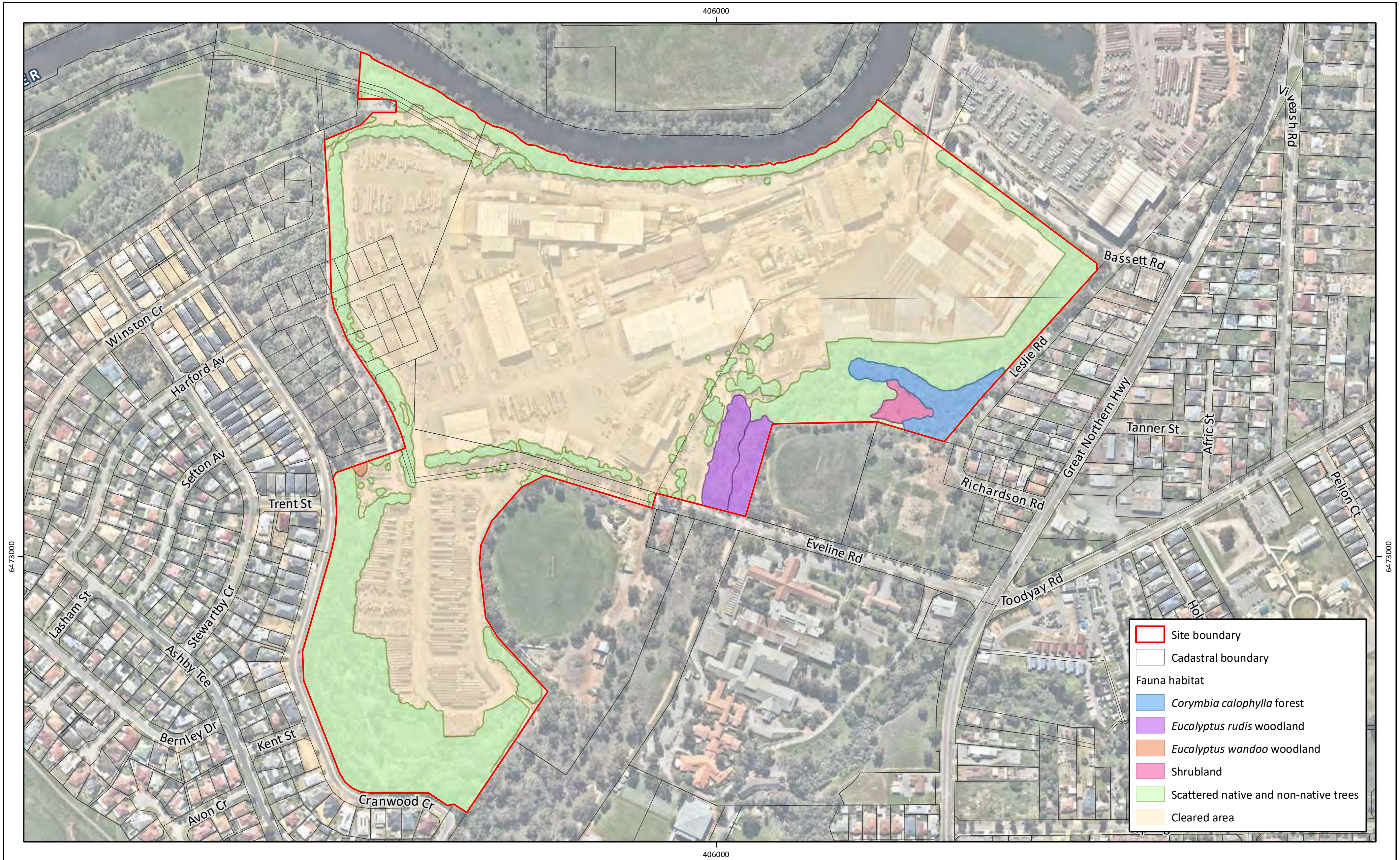


Figure 3: Fauna Habitat

Project: Level 1 Fauna and Targeted Black Cockatoo Assessment
Part Middle Swan Brickworks

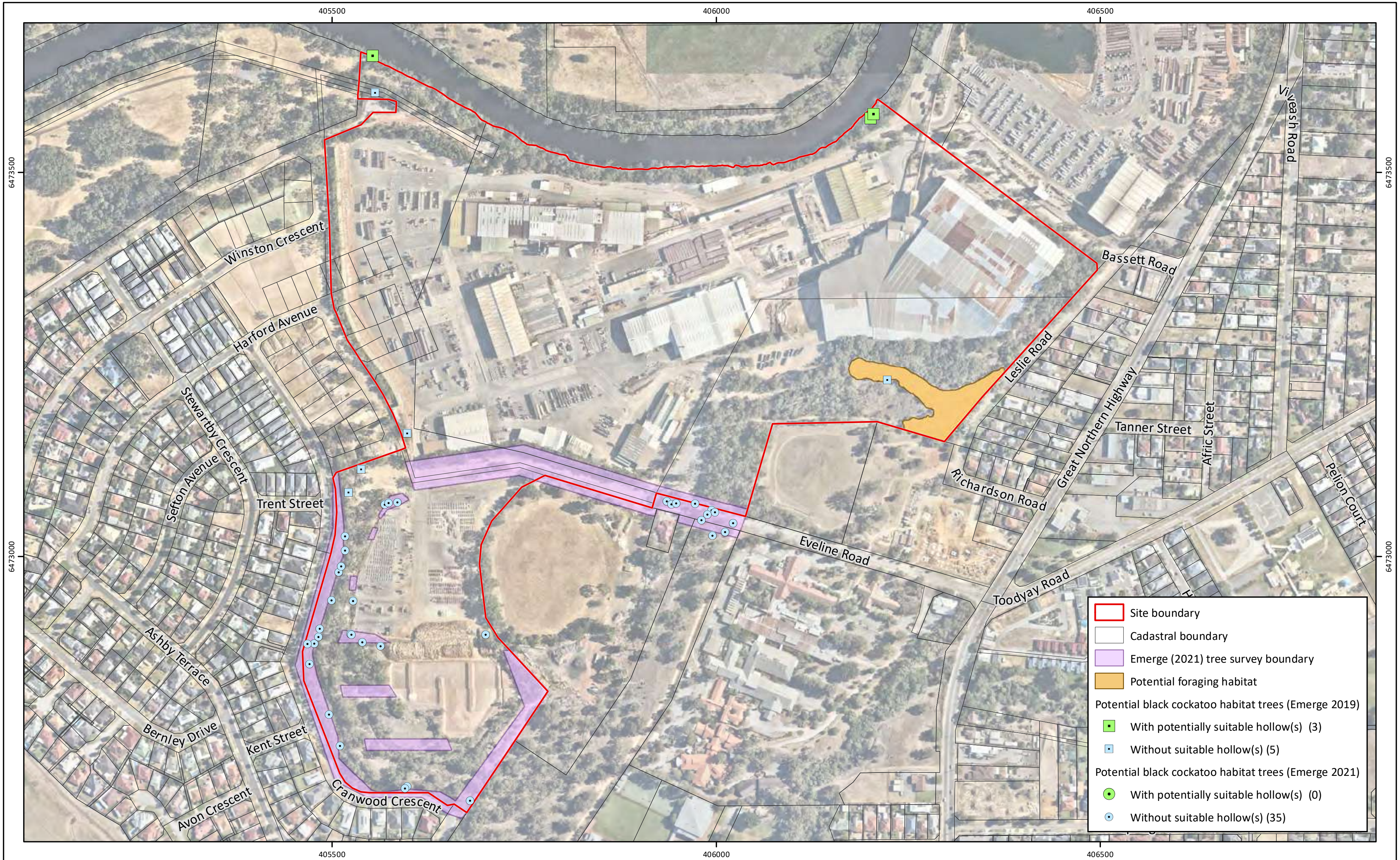
Client: Linc Property Pty Ltd

Plan Number:
EP19-105(26)--F162
Drawn: GAR
Date: 25/03/2020
Checked: RAW
Approved: RAW
Date: 30/03/2020

N

0 100 200
Metres
Scale: 1:6,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES



Scale: 1:6,500@A4

GDA 1994 MGA Zone 50

Figure 4: **Black Cockatoo Habitat**

Project: Level 1 Fauna and Targeted Black Cockatoo Assessment
Part Middle Swan Brickworks

Client: Linc Property Pty Ltd

Plan Number:
EP19-105(26)--F163a
Drawn: GAR
Date: 21/04/2022
Checked: MS
Approved: RAW
Date: 22/04/2022

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Appendix A

Additional Information

Conservation Significant Fauna

Threatened and priority fauna

Fauna species considered rare or under threat warrant special protection under Commonwealth and/or State legislation. At the Commonwealth level, fauna species can be listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Migratory birds may be recognised under international treaties including:

- *Japan Australia Migratory Bird Agreement 1981* (JAMBA)
- *China Australia Migratory Bird Agreement 1998* (CAMBA)
- *Republic of Korea-Australia Migratory Bird Agreement 2007* (ROKAMBA)
- *Bonn Convention 1979* (The Convention on the Conservation of Migratory Species of Wild Animals).

All migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as 'matters of national environmental significance' (MNES) under the EPBC Act. Fauna species considered 'threatened' pursuant to Schedule 1 of the EPBC Act are assigned categories as outlined in **Table 1**.

Table 1: Definitions of conservation significant fauna species pursuant to the EPBC Act

Conservation Code	Category
X	Threatened Fauna –Extinct There is no reasonable doubt that the last member of the species has died.
EW#	Threatened Fauna –Extinct in the Wild Taxa which are known only to survive in cultivation, captivity or as a naturalised population outside its past range, or taxa which have not been recorded in its known and/or expected habitat despite appropriate exhaustive surveys.
CR#	Threatened Fauna – Critically Endangered Taxa which are considered to be facing an extremely high risk of extinction in the wild.
EN#	Threatened Fauna – Endangered Taxa which are considered to be facing a very high risk of extinction in the wild.
VU#	Threatened Fauna – Vulnerable Taxa which are considered to be facing a high risk of extinction in the wild.
Migratory#	Migratory Fauna 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 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.
Ma	Marine Fauna Species in the list established under s248 of the EPBC Act

#matters of national environmental significance (MNES) under the EPBC Act

In Western Australia, fauna taxa may be classed as 'specially protected' under the *Biodiversity Conservation Act 2016* (BC Act) which is enforced by Department of Biodiversity Conservation and Attractions (DBCA). Specially protected fauna species are listed under Schedules 1 to 7 according to their conservation status. The definitions of these Schedules are provided in **Table 2**.

Table 2: Definitions of specially protected fauna schedules under the BC Act.

Conservation Code	Definition
CR	Schedule 1 – Critically Endangered Threatened species considered to be facing an extremely high risk of extinction in the wild.
EN	Schedule 2 – Endangered Threatened species considered to be facing a very high risk of extinction in the wild.
VU	Schedule 3 – Vulnerable Threatened species considered to be facing a high risk of extinction in the wild.
EX	Schedule 4 – Presumed extinct Species which have been adequately searched for and there is no reasonable doubt that the last individual has died.
MI	Schedule 5 – Migratory birds protected under an international agreement 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.
CD	Schedule 6 – Fauna of special conservation need as conservation dependent fauna Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened.
OS	Schedule 7 – Other specially protected fauna. Fauna otherwise in need of special protection to ensure their conservation.

Fauna species that may be threatened or near threatened but lack sufficient information to be legislatively listed may be added to the DBCA's *Priority Fauna List* (DBCA 2018). Priority fauna species are considered during State approval processes. Priority fauna categories and definitions are listed in **Table 3**.

Table 3: Definitions of priority fauna categories on DBCA's Priority Fauna List

Conservation Code	Category
P1	Priority 1 – Poorly known 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.
P2	Priority 2 – Poorly known 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.
P3	Priority 2 – Poorly known 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.
P4	(a) Priority 4 – Rare species 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) Priority 4 – Near Threatened Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Priority 4 – Other Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Pest fauna

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, pest fauna may be listed as 'Established Pests and Diseases of National Significance' (EPDNS) under the *Australian Pest Animal Strategy (2017-2027) (DoA 2017)*.

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

Category	Description
	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.

References

General references

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Department of Agriculture (DoA) 2017, *Australian Pest Animal Strategy (2017-2027)*, Canberra.

Literature

Table 1: Standard literature used for identifying fauna species and habitats.

Conservation Code	Category
Birds	Johnstone and Storr (1998b), Johnstone and Storr (1998a), Pizzey and Knight (2012), Slater *et al.* (2003)
Mammals	Menkhorst and Knight (2011), Triggs (2003)
Amphibia	Tyler and Doughty (2009), Bush *et al.* (2002)
Reptiles	Bush *et al.* (2002)

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Appendix B

NatureMap Database Results

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Guest user on 25/10/2019

Kingdom Animalia
Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 116° 00' 29'' E,31° 52' 17'' S
Buffer 10km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	24559	*Acanthagenys rufogularis (Spiny-cheeked Honeyeater)*			
2.		*Acanthaluteres brownii*			
3.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
4.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
5.	24262	*Acanthiza inornata (Western Thornbill)*			
6.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
7.		*Acariformes sp.*			
8.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
9.	24281	*Accipiter cirrocephalus subsp. cirrocephalus (Collared Sparrowhawk)*			
10.	25536	*Accipiter fasciatus (Brown Goshawk)*			
11.	24283	*Accipiter fasciatus subsp. didimus (Brown Goshawk)*			
12.	24282	*Accipiter fasciatus subsp. fasciatus (Brown Goshawk)*			
13.		*Acentrogobius bifrenatus*			
14.	25751	*Acridotheres tristis (Common Myna)*	Y		
15.	42368	*Acritoscincus trilineatus (Western Three-lined Skink)*			
16.		*Acroaspis olorina*			Y
17.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
18.	41323	*Actitis hypoleucos (Common Sandpiper)*		IA	
19.	25544	*Aegotheles cristatus (Australian Owlet-nightjar)*			
20.		*Aganippe cupulifex*			Y
21.		*Akamptogonus novarae*			
22.		*Aldrichetta forsteri*			
23.		*Allothereua maculata*			
24.		*Ambicodamus kochi*			
25.		*Amblyomma albolimbatum*			
26.		*Amblyomma fimbriatum*			
27.		*Amblyomma triguttatum*			
28.		*Amniataba caudavittata*			
29.		*Amphisopodidae sp.*			
30.		*Aname mainae*			
31.		*Aname tepperi*			
32.	24310	*Anas castanea (Chestnut Teal)*			
33.	24311	*Anas clypeata (Northern Shoveler)*			Y
34.	24312	*Anas gracilis (Grey Teal)*			
35.	24313	*Anas platyrhynchos (Mallard)*			
36.		*Anas platyrhynchos subsp. domesticus*			
37.	24315	*Anas rhynchotis (Australasian Shoveler)*			
38.	24316	*Anas superciliosa (Pacific Black Duck)*			
39.		*Ancylidae sp.*			
40.	47414	*Anhinga novaehollandiae (Australasian Darter)*			
41.	44629	*Anilios australis*			
42.	24506	*Anous tenuirostris subsp. melanops (Australian Lesser Noddy)*		T	
43.		*Anser anser*			
44.	25319	*Antaresia stimsoni subsp. orientalis (Stimson's Python)*			
45.	25241	*Antaresia stimsoni subsp. stimsoni (Stimson's Python)*			
46.	25449	*Antechinus flavipes (Yellow-footed Antechinus)*			
47.	24088	*Antechinus flavipes subsp. leucogaster (Yellow-footed Antechinus, Mardo)*			
48.	24561	*Anthochaera carunculata (Red Wattlebird)*			
49.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
50.	25670	*Anthus australis (Australian Pipit)*			
51.	24990	*Aprasia pulchella (Granite Worm-lizard)*			
52.	24991	*Aprasia repens (Sand-plain Worm-lizard)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
53.	25554	*Apus pacificus (Fork-tailed Swift, Pacific Swift)*		IA	
54.	24285	*Aquila audax (Wedge-tailed Eagle)*			
55.		*Arachnura higginsi*			
56.		*Araneus cyphoxis*			
57.		*Araneus eburneiventris*			
58.		*Araneus ginninderranus*			
59.		*Araneus senicaudatus*			
60.	25558	*Ardea ibis (Cattle Egret)*			
61.	25559	*Ardea intermedia (Intermediate Egret)*			
62.	41324	*Ardea modesta (great egret, white egret)*			
63.	24340	*Ardea novaehollandiae (White-faced Heron)*			
64.	24341	*Ardea pacifica (White-necked Heron)*			
65.		*Argiope protensa*			
66.		*Argiope trifasciata*			
67.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
68.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
69.	24356	*Artamus personatus (Masked Woodswallow)*			
70.		*Artoria flavimana*			
71.		*Artoria impedita*			
72.		*Artoria linnaei*			
73.		*Artoriopsis expolita*			
74.		*Asadipus kunderang*			
75.		*Atherinosoma wallacei*			
76.		*Austracantha minax*			
77.		*Australomimetus aurioculatus*			
78.		*Australomimetus ovidi*			
79.	48574	*Australotomurus morbidus (cemetery springtail, Guildford springtail)*		P3	
80.	33972	*Austromerope poultoni (earwigfly (southwest), scorpionfly)*			
81.	47713	*Austronomus australis (White-striped Free-tailed Bat)*			
82.	24318	*Aythya australis (Hardhead)*			
83.		*Backobourkia brounii*			
84.		*Backobourkia heroine*			
85.		*Badumna insignis*			
86.		*Baetidae sp.*			
87.		*Baiami volucripes*			
88.		*Ballarra longipalpus*			
89.		*Barnardius zonarius*			
90.	25452	*Bettongia penicillata (Woylie, Brush-tailed Bettong)*		T	
91.	24162	*Bettongia penicillata subsp. ogilbyi (Woylie, Brush-tailed Bettong)*		T	
92.		*Bigenditia zuytdorp*			
93.	24319	*Biziura lobata (Musk Duck)*			
94.		*Bostockia porosa*			
95.	24345	*Botaurus poiciloptilus (Australasian Bittern)*		T	
96.	42380	*Brachyurophis fasciolatus subsp. fasciolatus (Narrow-banded Shovel-nosed Snake)*			
97.	42381	*Brachyurophis semifasciatus (Southern Shovel-nosed Snake)*			
98.		*Brentidae sp.*			
99.	24359	*Burhinus grallarius (Bush Stone-curlew)*			
100.	25713	*Cacatua galerita (Sulphur-crested Cockatoo)*			
101.	24721	*Cacatua galerita subsp. galerita (Sulphur-crested Cockatoo)*	Y		
102.	24722	*Cacatua leadbeateri (Major Mitchell's Cockatoo)*			
103.	25714	*Cacatua pastinator (Western Long-billed Corella)*			
104.	24723	*Cacatua pastinator subsp. butleri (Butler's Corella)*			
105.	24724	*Cacatua pastinator subsp. pastinator (Muir's Corella, Muir's Corella (Western Corella SW WA))*		S	
106.	25715	*Cacatua roseicapilla (Galah)*			
107.	25716	*Cacatua sanguinea (Little Corella)*			
108.	24727	*Cacatua sanguinea subsp. westralensis (Little Corella)*			
109.		*Cacatua sulphurea subsp. galerita*			Y
110.	24729	*Cacatua tenuirostris (Eastern Long-billed Corella)*	Y		
111.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
112.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
113.		*Caenidae sp.*			
114.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
115.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black Cockatoo)*		T	
116.	24733	*Calyptorhynchus baudinii (Baudin's Cockatoo, White-tailed Long-billed Black Cockatoo)*		T	
117.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo, White-tailed Short-billed Black Cockatoo)*		T	
118.	48400	*Calyptorhynchus sp. (white-tailed black cockatoo)*		T	
119.		*Carabidae sp.*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
120.		*Carassius auratus*			
121.		*Carcharhinus leucas*			
122.	25625	*Carduelis carduelis (Goldfinch, European Goldfinch)*	Y		
123.	24480	*Carduelis carduelis subsp. britannica (Goldfinch)*	Y		
124.		*Ceinidae sp.*			
125.		*Celaenia excavata*			
126.		*Ceratopogonidae sp.*			
127.	24086	*Cercartetus concinnus (Western Pygmy-possum, Mundarda)*			
128.		*Cercophonius granulosus*			
129.		*Cercophonius sulcatus*			
130.		*Ceryerda cursitans*			
131.		*Cethegus fugax*			
132.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			
133.	24187	*Chalinolobus morio (Chocolate Wattled Bat)*			
134.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
135.	43380	*Chelodina colliei (South-western Snake-necked Turtle)*			
136.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
137.	47909	*Cheramoeca leucosterna (White-backed Swallow)*			
138.	33939	*Cherax cainii (Marron)*			
139.		*Cherax destructor*			
140.		*Cherax quinquecarinatus*			
141.		*Cherax sp.*			
142.		*Chironominae sp.*			
143.	24980	*Christinus marmoratus (Marbled Gecko)*			
144.		*Chroicocephalus novaehollandiae*			
145.	24431	*Chrysococcyx basalis (Horsfield's Bronze Cuckoo)*			
146.	25601	*Chrysococcyx lucidus (Shining Bronze Cuckoo)*			
147.	24432	*Chrysococcyx lucidus subsp. plagosus (Shining Bronze Cuckoo)*			
148.	24288	*Circus approximans (Swamp Harrier)*			
149.	24289	*Circus assimilis (Spotted Harrier)*			
150.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
151.		*Clynotis severus*			
152.		*Cnidoglanis macrocephalus*			
153.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
154.	24399	*Columba livia (Domestic Pigeon)*	Y		
155.	24361	*Coracina maxima (Ground Cuckoo-shrike)*			
156.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
157.		*Corduliidae sp.*			
158.		*Corixidae sp.*			
159.		*Cormocephalus aurantiipes*			
160.		*Cormocephalus rubriceps*			
161.		*Cormocephalus strigosus*			
162.		*Cormocephalus turneri*			
163.	24416	*Corvus bennetti (Little Crow)*			
164.	25592	*Corvus coronoides (Australian Raven)*			
165.	24420	*Cracticus nigrogularis (Pied Butcherbird)*			
166.	25595	*Cracticus tibicen (Australian Magpie)*			
167.	24422	*Cracticus tibicen subsp. dorsalis (White-backed Magpie)*			
168.	25596	*Cracticus torquatus (Grey Butcherbird)*			
169.	25456	*Crenadactylus ocellatus (Clawless Gecko)*			
170.	24918	*Crenadactylus ocellatus subsp. ocellatus (Clawless Gecko)*			
171.	25398	*Crinia georgiana (Quacking Frog)*			
172.	25399	*Crinia glauerti (Clicking Frog)*			
173.	25400	*Crinia insignifera (Squelching Froglet)*			
174.	25401	*Crinia pseudinsignifera (Bleating Froglet)*			
175.	30893	*Cryptoblepharus buchananii*			
176.	25020	*Cryptoblepharus plagiocephalus*			
177.	30899	*Ctenophorus adelaidensis (Southern Heath Dragon, Western Heath Dragon)*			
178.	24883	*Ctenophorus ornatus (Ornate Crevice-Dragon)*			
179.	25027	*Ctenotus australis*			
180.	25035	*Ctenotus delli (Dell's skink, Darling Range southwest Ctenotus)*		P4	
181.	25039	*Ctenotus fallens*			
182.	25040	*Ctenotus gemmula (Jewelled South-west Ctenotus (Swan Coastal Plain subpop P3), skink)*			
183.	25047	*Ctenotus impar*			
184.	25049	*Ctenotus labillardieri*			
185.		*Culicidae sp.*			
186.		*Curculionidae sp.*			
187.		*Cyanorhamphus auriceps*			Y
188.		*Cyclosa trilobata*			

NatureMap
Mapping Western Australia's biodiversity

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
189.	24322	*Cygnus atratus (Black Swan)*			
190.	24323	*Cygnus olor (Mute Swan)*	Y		
191.		*Cyrtophora parnasia*			
192.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
193.	30902	*Dacelo novaeguineae subsp. novaeguineae (Laughing Kookaburra)*	Y		
194.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
195.	24606	*Daphoenositta chrysoptera subsp. pileata (Varied Sittella, Black-capped Sitella)*			
196.	24092	*Dasyurus geoffroii (Chuditch, Western Quoll)*		T	
197.	25766	*Delma fraseri (Fraser's Legless Lizard)*			
198.	24999	*Delma grayii*			
199.	25296	*Demansia psammophis subsp. reticulata (Yellow-faced Whipsnake)*			
200.	24325	*Dendrocygna eytoni (Plumed Whistling Duck)*			
201.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
202.		*Dingosa serrata*			
203.		*Dinocambala ingens*			
204.	25469	*Diplodactylus granariensis*			
205.	24929	*Diplodactylus granariensis subsp. granariensis*			
206.	44654	*Diplodactylus lateroides (Speckled Stone Gecko)*			
207.	24939	*Diplodactylus polyophthalmus*			
208.	24940	*Diplodactylus pulcher*			
209.		*Dolichopodidae sp.*			
210.	24470	*Dromaius novaehollandiae (Emu)*			
211.		*Dugesiidae sp.*			
212.		*Dytiscidae sp.*			
213.	25251	*Echiopsis curta (Bardick)*			
214.	25096	*Egernia kingii (King's Skink)*			
215.	25100	*Egernia napoleonis*			
216.		*Egretta garzetta*			
217.		*Egretta novaehollandiae*			
218.		*Elanus axillaris*			
219.	24290	*Elanus caeruleus subsp. axillaris (Australian Black-shouldered Kite)*			
220.	25250	*Elapognathus coronatus (Crowned Snake)*			
221.	47937	*Elseyornis melanops (Black-fronted Dotterel)*			
222.		*Engraulis australis*			
223.		*Eodelena lapidicola*			
224.		*Eolophus roseicapillus*			
225.	25692	*Eopsaltria australis (Yellow Robin)*			
226.	24652	*Eopsaltria georgiana (White-breasted Robin)*			
227.	24567	*Epthianura albifrons (White-fronted Chat)*			
228.	24570	*Epthianura tricolor (Crimson Chat)*			
229.	24258	*Equus caballus (Horse)*	Y		
230.		*Erigone prominens*			
231.		*Eriophora biapicata*			
232.		*Eriophora pustulosa*			
233.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
234.		*Eucyrtops latior*			
235.	48579	*Euoplos inornatus (inornate trapdoor spider (northern Jarrah Forest))*		P3	
236.		*Eupograpta kottae*			
237.	24368	*Eurostopodus argus (Spotted Nightjar)*			
238.	25621	*Falco berigora (Brown Falcon)*			
239.	24471	*Falco berigora subsp. berigora (Brown Falcon)*			
240.	25622	*Falco cenchroides (Australian Kestrel, Nankeen Kestrel)*			
241.	24472	*Falco cenchroides subsp. cenchroides (Australian Kestrel, Nankeen Kestrel)*			
242.	25623	*Falco longipennis (Australian Hobby)*			
243.	24474	*Falco longipennis subsp. longipennis (Australian Hobby)*			
244.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
245.	24189	*Falsistrellus mackenziei (Western False Pipistrelle, Western Falsistrelle)*		P4	
246.		*Favonigobius sp.*			
247.	24041	*Felis catus (Cat)*	Y		
248.	25727	*Fulica atra (Eurasian Coot)*			
249.	24761	*Fulica atra subsp. australis (Eurasian Coot)*			
250.	34028	*Galaxias occidentalis (Western Minnow)*			
251.	25729	*Gallinula tenebrosa (Dusky Moorhen)*			
252.	24763	*Gallinula tenebrosa subsp. tenebrosa (Dusky Moorhen)*			
253.	25730	*Gallirallus philippensis (Buff-banded Rail)*			
254.		*Gea theridioides*			
255.	24959	*Gehyra variegata*			
256.	25404	*Geocrinia leai (Ticking Frog)*			
257.	24401	*Geopelia cuneata (Diamond Dove)*			
258.	34030	*Geotria australis (Pouched Lamprey)*		P3	

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
259.		*Gerres subfasciatus*			
260.	25530	*Gerygone fusca (Western Gerygone)*			
261.		*Glossiphoniidae sp.*			
262.	30918	*Glossopsitta concinna (Musk Lorikeet)*	Y		
263.	47962	*Glyciphila melanops (Tawny-crowned Honeyeater)*			
264.		*Gomphidae sp.*			
265.		*Gonorynchus greyi*			
266.		*Gracula religiosa*			
267.	24443	*Grallina cyanoleuca (Magpie-lark)*			
268.		*Gripopterygidae sp.*			
269.		*Gyrinidae sp.*			
270.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*			
271.	24295	*Haliastur sphenurus (Whistling Kite)*			
272.	24689	*Halobaena caerulea (Blue Petrel)*			
273.	24296	*Hamirostra isura (Square-tailed Kite)*			
274.	25408	*Heleioporus albopunctatus (Western Spotted Frog)*			
275.	25409	*Heleioporus barycragus (Hooting Frog)*			
276.	25410	*Heleioporus eyrei (Moaning Frog)*			
277.	25412	*Heleioporus psammophilus (Sand Frog)*			
278.		*Hemicloea sp.*			Y
279.		*Hemicloea sublimbata*			
280.		*Hemicorduliidae sp.*			
281.	25474	*Hemiergis initialis*			
282.	25115	*Hemiergis initialis subsp. initialis*			
283.	25119	*Hemiergis quadrilineata*			
284.		*Heurodes turritus*			
285.	47965	*Hieraaetus morphnoides (Little Eagle)*			
286.	25734	*Himantopus himantopus (Black-winged Stilt)*			
287.	24491	*Hirundo neoxena (Welcome Swallow)*			
288.		*Hoggicosa storri*			
289.		*Hogna crispipes*			
290.		*Hogna kuyani*			
291.		*Holasteron perth*			
292.		*Holconia westralia*			
293.		*Holocnemus pluchei*			
294.	24215	*Hydromys chrysogaster (Water-rat, Rakali)*		P4	
295.		*Hydrophilidae sp.*			
296.	48587	*Hydroprogne caspia (Caspian Tern)*		IA	
297.		*Hydroptilidae sp.*			
298.		*Hypoblemum sp.*			Y
299.		*Idiommata blackwalli*			
300.	48935	*Idiosoma sigillatum (Swan Coastal Plain shield-backed trapdoor spider)*		P3	
301.		*Isometroides vescus*			
302.	48588	*Isoodon fusciventer (Quenda, southwestern brown bandicoot)*		P4	
303.		*Isopeda leishmanni*			
304.		*Isopeda magna*			
305.		*Isopedella cana*			
306.		*Isopedella tindalei*			
307.	24347	*Ixobrychus flavicollis subsp. australis (Black Bittern (southwest subpop.), Australian Black Bittern)*		P2	
308.		*Karaops ellenae*			
309.	24367	*Lalage tricolor (White-winged Triller)*			
310.		*Lampona cylindrata*			
311.		*Lampona yanchep*			
312.		*Lamponella ainslie*			
313.	24511	*Larus novaehollandiae subsp. novaehollandiae (Silver Gull)*			
314.		*Latrodectus hasselti*			
315.		*Latrodectus hasseltii*			
316.		*Leptoceridae sp.*			
317.		*Leptophlebiidae sp.*			
318.	25131	*Lerista distinguenda*			
319.	25133	*Lerista elegans*			
320.	25148	*Lerista lineopunctulata*			
321.	25165	*Lerista praepedita*			
322.	25005	*Lialis burtonis*			
323.		*Libellulidae sp.*			
324.	25659	*Lichenostomus leucotis (White-eared Honeyeater)*			
325.	25661	*Lichmera indistincta (Brown Honeyeater)*			
326.	24582	*Lichmera indistincta subsp. indistincta (Brown Honeyeater)*			
327.		*Limnochares australica*			

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328.	25415	*Limnodynastes dorsalis (Western Banjo Frog)*			
329.	25378	*Litoria adelaidensis (Slender Tree Frog)*			
330.	25388	*Litoria moorei (Motorbike Frog)*			
331.		*Lophochroa leadbeateri*			
332.		*Lophoictinia isura*			
333.		*Lycosa ariadnae*			
334.		*Lycosa godeffroyi*			
335.		*Lymnaeidae sp.*			
336.	24132	*Macropus fuliginosus (Western Grey Kangaroo)*			
337.	24135	*Macropus robustus subsp. erubescens (Euro, Biggada)*			
338.	24168	*Macrotis lagotis (Bilby, Dalgyte, Ninu)*		T	
339.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
340.	25650	*Malurus elegans (Red-winged Fairy-wren)*			
341.	25651	*Malurus lamberti (Variegated Fairy-wren)*			
342.	25652	*Malurus leucopterus (White-winged Fairy-wren)*			
343.	24551	*Malurus pulcherrimus (Blue-breasted Fairy-wren)*			
344.	25654	*Malurus splendens (Splendid Fairy-wren)*			
345.	24552	*Malurus splendens subsp. splendens (Splendid Fairy-wren)*			
346.	24583	*Manorina flavigula (Yellow-throated Miner)*			
347.		*Maratus pavonis*			
348.		*Masasteron mas*			
349.	25758	*Megalurus gramineus (Little Grassbird)*			
350.		*Megapodagrionidae sp.*			
351.	47997	*Melanodryas cucullata (Hooded Robin)*			
352.	25663	*Melithreptus brevirostris (Brown-headed Honeyeater)*			
353.	24586	*Melithreptus brevirostris subsp. leucogenys (Brown-headed Honeyeater)*			
354.	24587	*Melithreptus chloropsis (Western White-naped Honeyeater)*			
355.	25184	*Menetia greyii*			
356.	24598	*Merops ornatus (Rainbow Bee-eater)*			
357.		*Microcarbo melanoleucos*			
358.	25693	*Microeca fascinans (Jacky Winter)*			
359.		*Missulena granulosa*			
360.		*Missulena hoggi*			
361.		*Missulena occatoria*			
362.		*Mituliodon tarantulinus*			
363.		*Monacanthus chinensis*			
364.	25240	*Morelia spilota subsp. imbricata (Carpet Python)*			
365.	25191	*Morethia lineoocellata*			
366.	25192	*Morethia obscura*			
367.	48005	*Mormopterus kitcheneri (South-western Free-tailed Bat)*			
368.		*Mugil cephalus*			
369.	24223	*Mus musculus (House Mouse)*	Y		
370.		*Myandra bicincta*			
371.	25610	*Myiagra inquieta (Restless Flycatcher)*			
372.	25420	*Myobatrachus gouldii (Turtle Frog)*			
373.		*Nannoperca vittata*			
374.		*Neatypus obliquus*			
375.	25248	*Neelaps bimaculatus (Black-naped Snake)*			
376.	25249	*Neelaps calonotos (Black-striped Snake, black-striped burrowing snake)*		P3	
377.		*Nematoda sp.*			
378.	25426	*Neobatrachus pelobatoides (Humming Frog)*			
379.	25686	*Neochmia temporalis (Red-browed Finch)*	Y		
380.	24738	*Neophema elegans (Elegant Parrot)*			
381.		*Neophema pulchella*			
382.		*Nephila edulis*			
383.		*Nicodamus mainae*			
384.	25747	*Ninox connivens (Barking Owl)*			
385.	48022	*Notamacropus irma (Western Brush Wallaby)*		P4	
386.	25252	*Notechis scutatus (Tiger Snake)*			
387.		*Notiasemus glauerti*			
388.		*Notsodipus muckera*			
389.		*Novakiella trituberculosa*			
390.		*Nunciella aspera*			
391.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
392.	24194	*Nyctophilus geoffroyi (Lesser Long-eared Bat)*			
393.	24742	*Nymphicus hollandicus (Cockatiel)*			
394.		*Occiperipatoides gilesii*			
395.		*Ocrisiona leucocomis*			
396.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
397.		*Oecobius navus*			

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398.		*Oligochaeta sp.*			
399.		*Ommatoiulus moreleti*			
400.		*Ommatoiulus moreletii*			
401.		*Oniscidae sp.*			
402.		*Opopaea sp.*			Y
403.		*Orphnaeus brevilabiatus*			
404.		*Orthocladiinae sp.*			
405.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
406.		*Ostearius melanopygius*			
407.	34016	*Ovis aries (Sheep)*			
408.		*Oxyopes gracilipes*			
409.		*Oxyopes punctatus*			
410.	24328	*Oxyura australis (Blue-billed Duck)*		P4	
411.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
412.	24624	*Pachycephala rufiventris subsp. rufiventris (Rufous Whistler)*			
413.	24693	*Pachyptila desolata (Antarctic Prion)*			
414.	48591	*Pandion cristatus (Osprey, Eastern Osprey)*		IA	
415.		*Papillogobius punctatus*			
416.		*Paralampona marangaroo*			
417.		*Paramelitidae sp.*			
418.		*Parastacidae sp.*			
419.	25253	*Parasuta gouldii*			
420.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
421.	24625	*Pardalotus punctatus subsp. punctatus (Spotted Pardalote)*			
422.	25682	*Pardalotus striatus (Striated Pardalote)*			
423.	24630	*Pardalotus striatus subsp. westraliensis (Striated Pardalote)*			
424.	25687	*Passer domesticus (House Sparrow)*	Y		
425.		*Pediana occidentalis*			
426.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
427.		*Pentasteron securifer*			
428.	48060	*Petrochelidon ariel (Fairy Martin)*			
429.	48061	*Petrochelidon nigricans (Tree Martin)*			
430.	48066	*Petroica boodang (Scarlet Robin)*			
431.	24659	*Petroica goodenovii (Red-capped Robin)*			
432.	25697	*Phalacrocorax carbo (Great Cormorant)*			
433.	25698	*Phalacrocorax melanoleucos (Little Pied Cormorant)*			
434.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
435.	25699	*Phalacrocorax varius (Pied Cormorant)*			
436.	24409	*Phaps chalcoptera (Common Bronzewing)*			
437.	25587	*Phaps elegans (Brush Bronzewing)*			
438.	48070	*Phascogale tapoatafa subsp. wambenger (South-western Brush-tailed Phascogale, Wambenger)*		S	
439.		*Pholcus phalangioides*			
440.		*Phryganoporus candidus*			
441.	48071	*Phylidonyris niger (White-cheeked Honeyeater)*			
442.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
443.		*Physidae sp.*			
444.		*Pinkfloydia harveii*			
445.		*Planorbidae sp.*			
446.	24841	*Platalea flavipes (Yellow-billed Spoonbill)*			
447.		*Platycephalus indicus*			
448.	25720	*Platycercus icterotis (Western Rosella)*			
449.	24747	*Platycercus spurius (Red-capped Parrot)*			
450.	25721	*Platycercus zonarius (Australian Ringneck, Ring-necked Parrot)*			
451.	24750	*Platycercus zonarius subsp. semitorquatus (Twenty-eight Parrot)*			
452.	24843	*Plegadis falcinellus (Glossy Ibis)*		IA	
453.	25007	*Pletholax gracilis subsp. gracilis (Keeled Legless Lizard)*			
454.	25703	*Podargus strigoides (Tawny Frogmouth)*			
455.	24679	*Podargus strigoides subsp. brachypterus (Tawny Frogmouth)*			
456.	25704	*Podiceps cristatus (Great Crested Grebe)*			
457.	24680	*Podiceps cristatus subsp. australis (Great Crested Grebe)*			
458.	25510	*Pogona minor (Dwarf Bearded Dragon)*			
459.	24907	*Pogona minor subsp. minor (Dwarf Bearded Dragon)*			
460.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
461.	25722	*Polytelis anthopeplus (Regent Parrot)*			
462.	24683	*Pomatostomus superciliosus (White-browed Babbler)*			
463.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
464.	24767	*Porphyrio porphyrio subsp. bellus (Purple Swamphen)*			
465.	24769	*Porzana fluminea (Australian Spotted Crake)*			
466.	25732	*Porzana pusilla (Baillon's Crake)*			

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467.	24771	*Porzana tabuensis (Spotless Crake)*			
468.	25261	*Pseudechis australis (Mulga Snake)*			
469.	25345	*Pseudemydura umbrina (Western Swamp Tortoise, Western Swamp Turtle)*		T	
470.	24166	*Pseudocheirus occidentalis (Western Ringtail Possum, ngwayir)*		T	
471.	25511	*Pseudonaja affinis (Dugite)*			
472.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
473.	42416	*Pseudonaja mengdeni (Western Brown Snake)*			
474.	25264	*Pseudonaja nuchalis (Gwardar, Northern Brown Snake)*			
475.	25433	*Pseudophryne guentheri (Crawling Toadlet)*			
476.	42344	*Purnella albifrons (White-fronted Honeyeater)*			
477.		*Purpureicephalus spurius*			
478.	25008	*Pygopus lepidopodus (Common Scaly Foot)*			
479.	24243	*Rattus fuscipes (Western Bush Rat)*			
480.	24245	*Rattus rattus (Black Rat)*	Y		
481.		*Raveniella cirrata*			
482.		*Raveniella peckorum*			
483.	24776	*Recurvirostra novaehollandiae (Red-necked Avocet)*			
484.		*Rhabdosargus sarba*			
485.	48096	*Rhipidura albiscapa (Grey Fantail)*			
486.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
487.	24454	*Rhipidura leucophrys subsp. leucophrys (Willie Wagtail)*			
488.		*Richardsonianidae sp.*			
489.		*Sandalodes joannae*			
490.		*Sandalodes superbus*			
491.		*Scirtidae sp.*			
492.		*Scobinichthys granulatus*			
493.		*Scolopendra laeta*			
494.		*Scytodes thoracica*			
495.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
496.		*Serinus canarius*			
497.		*Servaea melaina*			
498.		*Servaea spinibarbis*			
499.	25266	*Simoselaps bertholdi (Jan's Banded Snake)*			
500.		*Simuliidae sp.*			
501.		*Smeringopus natalensis*			
502.		*Smeringopus natalensis?*			Y
503.	30948	*Smicrornis brevirostris (Weebill)*			
504.	24645	*Stagonopleura oculata (Red-eared Firetail)*			
505.		*Steatoda capensis*			
506.		*Steatoda grossa*			
507.	24525	*Sterna fuscata subsp. nubilosa (Sooty Tern)*			
508.	24329	*Stictonetta naevosa (Freckled Duck)*			
509.		*Storena formosa*			
510.		*Storena sinuosa*			
511.		*Stratiomyidae sp.*			
512.	25597	*Strepera versicolor (Grey Currawong)*			
513.	25589	*Streptopelia chinensis (Spotted Turtle-Dove)*	Y		
514.	30951	*Streptopelia chinensis subsp. tigrina (Spotted Turtle-Dove)*	Y		
515.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
516.	25518	*Strophurus spinigerus*			
517.	24943	*Strophurus spinigerus subsp. inornatus*			
518.	24942	*Strophurus spinigerus subsp. spinigerus*			
519.		*Styloniscidae sp.*			
520.		*Supunna funerea*			
521.		*Supunna picta*			
522.	24259	*Sus scrofa (Pig)*	Y		
523.	33992	*Synemon gratiosa (Graceful Sunmoth)*		P4	
524.		*Synothele durokoppin*			
525.		*Synothele michaelseni*			
526.		*Synthemistidae sp.*			
527.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
528.	24682	*Tachybaptus novaehollandiae subsp. novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
529.	24207	*Tachyglossus aculeatus (Short-beaked Echidna)*			
530.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
531.		*Talitridae sp.*			
532.		*Tamopsis darlingtoniana*			
533.		*Tamopsis perthensis*			
534.		*Tanypodinae sp.*			
535.	24167	*Tarsipes rostratus (Honey Possum, Noolbenger)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
536.		*Tasmanicosa leuckartii*			
537.		*Tetragnatha demissa*			
538.		*Tetragnatha luteocincta*			Y
539.	48597	*Thalasseus bergii (Crested Tern)*		IA	
540.	48136	*Threskiornis moluccus (Australian White Ibis)*			
541.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
542.	25203	*Tiliqua occipitalis (Western Bluetongue)*			
543.	25519	*Tiliqua rugosa*			
544.	25204	*Tiliqua rugosa subsp. aspera*			
545.	25207	*Tiliqua rugosa subsp. rugosa*			
546.		*Tipulidae sp.*			
547.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
548.	24309	*Todiramphus sanctus subsp. sanctus (Sacred Kingfisher)*			
549.		*Trachycosmus sculptilis*			
550.		*Trachyspina mundaring*			
551.	48141	*Tribonyx ventralis (Black-tailed Native-hen)*			
552.		*Trichocyclus nullarbor*			
553.		*Trichoglossus chlorolepidotus*			
554.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
555.	24755	*Trichoglossus haematodus subsp. moluccanus (Rainbow Lorikeet)*	Y		
556.	24754	*Trichoglossus haematodus subsp. rubritorquis (Red-collared Lorikeet)*			
557.	25521	*Trichosurus vulpecula (Common Brushtail Possum)*			
558.	24158	*Trichosurus vulpecula subsp. vulpecula (Common Brushtail Possum)*			
559.		*Tridentiger trigonocephalus*			
560.	24806	*Tringa glareola (Wood Sandpiper)*		IA	
561.	24808	*Tringa nebularia (Common Greenshank, greenshank)*		IA	
562.	48147	*Turnix varius (Painted Button-quail)*			
563.	24851	*Turnix velox (Little Button-quail)*			
564.	25762	*Tyto alba (Barn Owl)*			
565.	24852	*Tyto alba subsp. delicatula (Barn Owl)*			
566.	24983	*Underwoodisaurus milii (Barking Gecko)*			
567.		*Urocampus carinirostris*			
568.		*Urodacus armatus*			
569.		*Urodacus novaehollandiae*			
570.		*Urodacus planimanus*			
571.	25577	*Vanellus miles (Masked Lapwing)*			
572.	24386	*Vanellus tricolor (Banded Lapwing)*			
573.	25218	*Varanus gouldii (Bungarra or Sand Monitor)*			
574.		*Varanus sp.*			
575.	25526	*Varanus tristis (Racehorse Monitor)*			
576.		*Venator immansueta*			
577.		*Venatrix pullastra*			
578.	24206	*Vespadelus regulus (Southern Forest Bat)*			
579.	24040	*Vulpes vulpes (Red Fox)*	Y		
580.	34113	*Westralunio carteri (Carter's Freshwater Mussel)*		T	
581.		*Withius piger*			
582.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			
583.		*unknown unknown*			Y

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
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.

Appendix C

Conservation Significant Species and Likelihood of Occurrence Assessment

Table C1: Likelihood of occurrence of conservation significant fauna species within the site.

Species	Common name	Level of significance		Habitat	Likelihood of occurrence
		WA	EPBC Act		
Aves					
Anous tenuirostris melanops	Australian lesser noddy	EN	VU	Very common in blue-water seas around the Abrolhos (endemic to this area, accidental occurrences on lower west coast of Australia) (Johnstone and Storr 1998).	Unlikely
Apus pacificus	Pacific swift	MI	MI	Aerial, migratory species that is most often seen over inland plains and sometimes above open areas, foothills or in coastal areas. Sometimes occurs over settled areas, including towns, urban areas and cities (Pizzey & Knight 2012).	Possible
Botaurus poiciloptilus	Australasian bittern	EN	EN	In or over water, in tall reedbeds, sedges, rushes, cumbungi, lignum. Also occurs in ricefields, drains in tussocky paddocks and occasionally in saltmarshes and brackish wetlands.	Possible
Cacatua pastinator pastinator	Muir's corella	S	-	Wheat and sheep farming country with remnant native forest.	Unlikely, locally extinct
Calidris acuminata	Sharp-tailed sandpiper	MI	MI	Occurs in tidal mudflats, saltmarshes and mangroves, as well as, shallow fresh,brackish or saline inland wetlands. It is also known from floodwaters, irrigated pastures and crops, sewage ponds, saltfields.	Unlikely
Calidris ferruginea	Curlew sandpiper	VU (MI)	CR (MI)	Mainly shallows of estuaries and near-coastal saltlakes (including saltwork ponds) and drying near-coastal freshwater lakes and swamps. Also beaches and near-coastal sewage ponds.	Unlikely
Calidris melanotos	Pectoral sandpiper	MI	MI	Mainly fresh waters (swamps, lagoons, river pools, irrigation channels and sewage ponds); also samphire flats around estuaries and saltlakes (Johnstone & Storr 1998).	Unlikely
Calyptorhynchus banksii naso	Forest red-tailed black cockatoo	VU	VU	Eucalypt and Corymbia forests, often in hilly interior. More recently also observed in more open agricultural and suburban areas including Perth metropolitan area. Attracted to seeding Corymbia calophylla, Eucalyptus marginata, introduced Melia azdarach and Eucalyptus spp. trees.	Likely

Table C1: Likelihood of occurrence of conservation significant fauna species within the site (continued).

Species	Common name	Level of significance		Habitat	Likelihood of occurrence
		WA	EPBC Act		
Aves					
Calyptorhynchus baudinii	Baudin's cockatoo	EN	EN	Mainly eucalypt forests. Attracted to seeding Corymbia calophylla, Banksia spp., Hakea spp., and to fruiting apples and pears (Johnstone and Storr 1998).	Likely
Calyptorhynchus latirostris	Carnaby's cockatoo	EN	EN	Mainly proteaceous scrubs and heaths and adjacent eucalypt woodlands and forests; also plantations of Pinus spp. Attracted to seeding Banksia spp., Dryandra spp., Hakea spp., Eucalyptus spp., Corymbia calophylla, Grevillea spp., and Allocasuarina spp. (Johnstone and Storr 1998).	Likely
Diomedea amsterdamensis	Amsterdam albatross	VU (MI)	EN (MI)	The Amsterdam albatross is a marine, pelagic seabird. It nests in open patchy vegetation (among tussocks, ferns or shrubs) near exposed ridges or hillocks (Weimerskirch et al. 1985). It sleeps and rests on ocean waters when not breeding (Marchant and Higgins 1990)	Unlikely
Diomedea epomophora	Southern royal albatross	VU (MI)	VU (MI)	Rare visitor to Western Australian seas; it breeds on subantarctic islands south of New Zealand (Johnstone and Storr 1998).	Unlikely
Diomedea exulans	Wandering albatross	VU (MI)	VU (MI)	Marine, pelagic and aerial species. It breeds on Macquarie Island and feeds in Australian portions of the Southern Ocean (DoE 2018).	Unlikely
Diomedea sanfordi	Northern royal albatross	EN	EN	Species is marine, pelagic and aerial. Habitat includes subantarctic, subtropical, and occasionally Antarctic waters (Marchant & Higgins 1990). Rare visitors to south Western Australian waters.	Unlikely
Falco peregrinus	Peregrine falcon	S	-	Mainly found around cliffs along coasts, rivers, ranges and around wooded watercourses and lakes (Johnstone and Storr 1998).	Possible
Leipoa ocellata	Mallefowl	VU	VU	Scrubs and thickets of Eucalyptus spp., Melaleuca lanceolata and Acacia linophylla; also other dense litter-forming shrublands. Attracted to fallen wheat in stubbles and along roads (Johnstone and Storr 1998).	Unlikely, locally extinct
Macronectes giganteus	Southern giant-petrel	MI	EN (MI)	Breeds on southern subantarctic and antarctic islands. May visit Western Australian waters from February to December (mostly June to September) (Johnstone and Storr 1998).	Unlikely

Table C1: Likelihood of occurrence of conservation significant fauna species within the site (continued).

Species	Common name	Level of significance		Habitat	Likelihood of occurrence
		WA	EPBC Act		
Aves					
Macronectes halli	Northern giant petrel	MI	VU (MI)	Breeds on subantarctic islands. May visit Western Australian water from February to September (Johnstone and Storr 1998).	Unlikely
Motacilla cinerea	Grey wagtail	MI	MI	Mainly banks and rocks in fast-running fresh water habitats: rivers, creeks, streams and around waterfalls, both in forest and open country; but occurs almost anywhere during migration.	Unlikely
Numenius madagascariensis	Eastern curlew	VU (MI)	CR (MI)	Mainly tidal mudflats; also reef flats, sandy beaches and rarely near-coastal lakes (including saltwork ponds) (Johnstone and Storr 1998).	Unlikely
Oxyura australis	Blue-billed duck	P4	-	Mainly deeper freshwater swamps and lakes; occasionally saltlakes and estuaries freshened by flood waters (Johnstone and Storr 1998a).	Possible
Pachyptila turtur subantarctica	Fairy prion	-	VU	Breeds on subantarctic islands and is presumed to frequent subtropical waters during non-breeding period (TSSC 2015).	Unlikely
Pandion haliaetus	Osprey	MI	MI	Coasts, estuaries, bays, inlets, islands, and surrounding waters; coral atolls, reefs, lagoons, rock cliffs, stacks (Pizzey & Knight 2012).	Unlikely
Plegadis falcinellus	Glossy Ibis	MI	MI	Shallow and adjacent flats of freshwater lakes and swamps, also river pools, flooded samphire and sewage ponds.	Possible
Rostratula australis	Australian painted snipe	EN	EN	Mainly shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans (Marchant and Higgins 1993).	Unlikely
Sterna bergii	Crested tern	MI	MI	Mainly blue-water seas (especially within 3 km of land), including southern estuaries in summer and autumn (when free of silt); also tidal creeks in north, but not penetrating far into larger estuaries.	Unlikely
Sterna caspia	Caspian tern	MI	MI	Mainly sheltered areas, estuaries (when not laden with silt) and tidal creeks; occasionally near-coastal saltlakes (including saltwork ponds) and brackish pools in lower courses of rivers; rarely fresh waters.	Unlikely
Sternula nereis nereis	Australian fairy tern	VU	VU	Sheltered blue-water seas close to land, estuaries (when free of silt) and near-coastal lakes (Johnstone and Storr 1998).	Unlikely

Table C1: Likelihood of occurrence of conservation significant fauna species within the site (continued).

Species	Common name	Level of significance		Habitat	Likelihood of occurrence
		WA	EPBC Act		
Aves					
Thalassarche cauta cauta	Shy albatross	VU (MI)	VU (MI)	Scarce visitor (late May to mid-October) to southwestern and western seas. Breeds on islands off Tasmania and south New Zealand (Johnstone and Storr 1998).	Unlikely
Thalassarche cauta steadi	White-capped albatross	VU (MI)	VU (MI)	Scarce visitor (late May to mid-October) to southwestern and western seas. Breeds on islands off Tasmania and south New Zealand (Johnstone and Storr 1998).	Unlikely
Thalassarche melanophris	Black-browed albatross	EN (MI)	VU (MI)	Seas of south and west coasts. Visitor to Western Australian mainland from January to early November (mostly May to September). Breeds on southern subantarctic and antarctic islands (Johnstone and Storr 1998).	Unlikely
Thalassarche melanophris impavida	Campbell albatross	VU (MI)	VU (MI)	Scarce visitor to south western and western seas. Breeds on Campbell island.	Unlikely
Tringa glareola	Wood sandpiper	MI	MI	Mainly shallow fresh waters (lagoons, swamps, claypans, river pools, dams, bore overflows and sewage ponds); occasionally brackish swamps, rarely saltlakes and estuaries.	Unlikely
Tringa hypoleucos	Common sandpiper	MI	MI	Edge of sheltered waters salt or fresh, e.g. estuaries, mangrove creeks, rocky coasts, near-coastal saltlakes (including saltwork ponds), river pools, lagoons, claypans, drying swamps, flood waters, dams and sewage ponds. Preferring situations wherelow perches are available (Johnstone & Storr 1998).	Unlikely
Tringa nebularia	Common greenshank	MI	MI	Shallow fresh waters (claypans, lagoons, swamps, river pools, dams and sewage ponds) and salt waters (estuaries, mangrove creeks, lakes, samphire flats, reef flats and saltwork ponds).	Unlikely

Table C1: Likelihood of occurrence of conservation significant fauna species within the site (continued).

Species	Common name	Level of significance		Habitat	Likelihood of occurrence
		WA	EPBC Act		
Agnatha					
Geotria australis	Pouched lamprey	P1	-	Marine, estuarine and coastal rivers and streams. Adults live in Southern Ocean and migrate upstream to spawn. Larvae live in muddy burrows in the upper reaches of streams (Bray and Gomon 2018).	Unlikely
Invertebrate					
Euoplos inornatus	Inornate trapdoor spider	P3	-	Unknown.	Not assessed
Hesperocolletes douglasi	Douglas's broad-headed bee	CR	CR	Banksia woodland vegetation (Pille Arnold 2019).	Unlikely
Idiosoma sigillatum	Swan Coastal Plain shield-backed trapdoor spider	P3	-	Unknown.	Not assessed
Synemon gratiosa	Graceful sunmoth	P4	-	Coastal heathland on Quindalup dunes where it is restricted to secondary sand dunes due to the abundance of the preferred host plant Lomandra maritima. Banksia woodland on Spearwood and Bassendean dunes, where the second known host plant L. hermaphrodita is widespread (DEC 2011).	Not assessed
Westralunio carteri	Carter's freshwater mussel	VU	VU	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).	Possible
Mammalia					
Bettongia penicillata ogilbyi	Woylie	CR	EN	Woodlands and adjacent heaths with a dense understorey of shrubs, particularly Gastrolobium spp. (TSSC 2018).	Unlikely, locally extinct
Dasyurus geoffroii	Chuditch	VU	VU	Wide range of habitats from woodlands, dry sclerophyll forests, riparian vegetation, beaches and deserts. Appears to utilise native vegetation along road sides in the wheatbelt (DEC 2012b).	Unlikely, locally extinct
Isoodon fusciventer	Quenda	P4	-	Dense scrubby, often swampy, vegetation with dense cover up to one metre high (DEC 2012).	Possible

Table C1: Likelihood of occurrence of conservation significant fauna species within the site (continued).

Species	Common name	Level of significance		Habitat	Likelihood of occurrence
		WA	EPBC Act		
Mammal					
Macrotis lagotis	Bilby	VU	VU	Open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises and hummock grassland (spinifex) growing on sandplains and dunes, drainage systems, salt lake systems and other alluvial areas (DBCA 2017a).	Unlikely, locally extinct
Notamacropus irma	Western brush wallaby	P4	-	Dry sclerophyll forest, Banksia spp. woodlands and shrublands, typically favouring dense low vegetation that provides dense cover (Christensen and Strahan 1983).	Unlikely
Phascogale tapoatafa wambenger	South-western brush-tailed phascogale	CD	-	Dry sclerophyll forests and open woodlands that contain hollow-bearing trees but a sparse ground cover (Triggs 2003).	Unlikely, no recent records
Pseudocheirus occidentalis	Western ringtail possum	CR	VU	On the Swan Coastal Plain in Agonis flexuosa woodlands and Agonis flexuosa/ Eucalyptus gomphocephala forests. Also Eucalyptus marginata forests (DBCA 2017b).	Unlikely, locally extinct
Setonix brachyurus	Quokka	VU	VU	On the mainland mostly dense streamside vegetation or shrubland and heath areas, particularly around swamps (Cronin 2007).	Unlikely, locally extinct
Falsistrellus mackenziei	Western false pipistrelle	P4	-	High rainfall forests dominated by jarrah, karri, marri, and tuart. Occupies hollow logs for breeding and resting (Van Dyck and Strahan 2008). Also known to utilise Banksia woodland on the Swan Coastal Plain (Hosken and O'Shea 1995).	Unlikely
Reptilia					
Ctenotus delli	Dell's skink	P4	-	Jarrah and marri woodland with a shrub dominated understorey, sheltering in dense vegetation, inside grass trees and beneath rocks, sometimes in burrows (Nevill 2005).	Possible
Neelaps calonotos	Black-striped snake	P3	-	Coastal and near-coastal dunes, sandplains supporting heathlands and Banksia spp. woodlands (Bush et al. 2002).	Unlikely
Pseudemydura umbrina	Western swamp tortoise	CR	CR	Clay based ephemeral swamps (Bush et al. 2002).	Unlikely

Appendix D

Species List

Fauna Species List - Middle Swan Brickworks

Note: * denotes introduced fauna species, DP=declared pest under the BAM Act

Class	Status	Species	Common name	Record type
Aves				
		Cacatua roseicapilla	Galah	Sight, call
		Corvus coronoides	Australian raven	Sight
		Cracticus tibicen	Australian magpie	Sight
		Grallina cyanoleuca	Magpie-lark	Sight
		Hirundo neoxena	Welcome swallow	Sight
		Platycercus zonarius	Australian ringneck	Sight, call
		Rhipidura leucophrys	Willie wagtail	Sight
	* DP	*Trichoglossus moluccanus*	Rainbow lorikeet	Sight
Mammalia				
	* DP	*Oryctolagus cuniculus*	Rabbit	Scat
Reptilia				
		Notechis scutatus	Tiger snake	

Appendix E

Black Cockatoo Habitat Tree Data

Black Cockatoo Habitat Tree Inventory - Middle Swan Brickworks

Tag No.	Easting	Northing	DBH (cm)	Species	Number of hollows	Number of hollows potentially suitable for BCs	Potential hollow 1 notes	Potential hollow 2 notes	General notes	Recorder
462	406201	6473570.5	71	Stag	2	2	Top-entry hollow that may have and entrance size ≥10cm.	Top-entry hollow hollow with an entrance size ≥10cm.	Hollows internal dimensions unconfirmed.	Emerge 2019
463	406205	6473575.8	88	Stag	2	1	Top-entry hollow that may have and entrance size ≥10cm.	Side-entry hollow, may have an entrance size ≥10cm. However, accomodating branch is too thin.	Hollows internal dimensions unconfirmed.	Emerge 2019
484	405552	6473651.6	60	Stag	1	1	Top-entry hollow that may have and entrance size ≥10cm.	-	Hollows internal dimensions unconfirmed.	Emerge 2019
337	405597	6473160.4	42	*Eucalyptus wandoo*	0	0	-	-	-	Emerge 2019
486	405556	6473603.9	72	Stag	0	0	-	-	-	Emerge 2019
490	405537	6473113.8	32	*Eucalyptus wandoo*	0	0	-	-	-	Emerge 2019
492	405521	6473083.3	33	*Eucalyptus wandoo*	0	0	-	-	-	Emerge 2019
499	406223	6473229.7	61	*Corymbia calophylla*	0	0	-	-	-	Emerge 2019
1701	405568	6473067.5	74	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1702	405574	6473069.5	74	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1703	405585	6473070.4	52	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1709	405527	6472942.2	51	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1712	405524	6472899.4	50	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1719	405525	6472898.2	54	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1723	405539	6472888.1	82	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1727	405563	6472883.3	68	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1740	405936	6473071.7	44	*Eucalyptus wandoo*	0	0	-	-	-	Emerge 2021
1741	405942	6473068.2	35	*Eucalyptus wandoo*	0	0	-	-	-	Emerge 2021

Black Cockatoo Habitat Tree Inventory - Middle Swan Brickworks

Tag No.	Easting	Northing	DBH (cm)	Species	Number of hollows	Number of hollows potentially suitable for BCs	Potential hollow 1 notes	Potential hollow 2 notes	General notes	Recorder
1742	405948	6473069.1	83	*Eucalyptus wandoo*	0	0	-	-	-	Emerge 2021
1743	405973	6473068.9	63	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1744	405994	6473060.3	72	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1745	405999	6473057.7	73	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1749	406022	6473043	66	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1750	406012	6473032	46	*Eucalyptus wandoo*	0	0	-	-	-	Emerge 2021
1751	405995	6473027.2	93	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1752	405989	6473054.9	52	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1753	405981	6473047.2	100	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1756	405700	6472898.1	70	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
332	405598	6472700.4	63	*Eucalyptus wandoo*	0	0	-	-	-	Emerge 2021
1592	405496	6472794.1	58	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
335	405477	6472886.6	60	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
338	405484	6472905.7	64	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
355	405499	6472942.9	56	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
359	405508	6472979.3	58	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
985	405595	6472697.7	58	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
989	405510	6472753.7	52	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
863	405482	6472895.1	52	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
876	405517	6473007.8	62	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1780	405679	6472681.7	65	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1798	405471	6472860.4	63	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
1800	405468	6472885.8	61	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
346	405512	6472987	52	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021
347	405517	6473026.3	56	*Eucalyptus rudis*	0	0	-	-	-	Emerge 2021

Appendix C

Technical Memorandum – Flora and Vegetation Assessment
Part Middle Swan Brickworks, Middle Swan
(Emerge Associates 2020)

TECHNICAL MEMORANDUM

Flora and Vegetation Assessment
Part Middle Swan Brickworks, Middle Swan

PROJECT NUMBER	EP19-105(07)	**DOC. NUMBER**	EP19-105(07)--044 RAW
PROJECT NAME	Middle Swan Brickworks Development Support	**CLIENT**	Linc Property Pty Ltd
AUTHOR	RAW	**REVIEWER**	TAA
VERSION	1	**DATE**	30/03/2020

1. INTRODUCTION

Linc Property Pty Ltd intends to develop the Middle Swan Brickworks for residential purposes. This report relates to the portion of the brickworks that will be subject to a *Local Structure Plan* (LSP) application, which comprises part or all of Lot 72 Eveline Road, Lot 23 Winston Crescent, Lot 9000 Cranwood Crescent and multiple smaller undeveloped lots on Winston Crescent and Somerset Street in Middle Swan (herein referred to as 'the site). The location of the site and the existing brickworks is shown in **Figure 1**.

The site is located approximately 17 kilometres (km) north east of the Perth Central Business District within the City of Swan and is zoned 'industrial', urban and 'rural' under the Metropolitan Region Scheme (MRS) and 'general industrial' and 'local road' under the City of Swan's *Local Planning Scheme* (LPS) No. 17.

The site is approximately 47.18 ha in size and is bound by the Swan River to the north, Bassett Road and industrial buildings to the east and residential housing and parklands to the south and south east.

1.1. Purpose and scope of work

Emerge Associates (Emerge) were engaged to provide environmental consultancy services to support the LSP application for the site. The purpose of this assessment is to provide sufficient information on the flora and vegetation values within the site to inform this process. Emerge previously undertook a flora and vegetation assessment of a wider area including the site to the standard required of a 'detailed' survey in accordance with the Environmental Protection Authority's (EPA's) *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016).

This technical memo details the flora and vegetation methodology and results recorded within the site during the Emerge Associates (2019) assessment which included the following tasks:

- Desktop review of relevant background information pertaining to the site and surrounds, including database searches for threatened 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.
- Documentation of the desktop assessment, survey methodology and results into a report.

2. PREVIOUS FLORA AND VEGETATION SURVEY

Emerge previously undertook a flora and vegetation assessment of the broader Middle Swan Brickworks, which includes the site, on 18 September and 8 October 2019 (Emerge Associates 2019).

3. ENVIRONMENTAL CONTEXT

3.1. Significant flora and vegetation

3.1.1. Threatened and priority flora

Certain flora taxa that are considered to be rare or under threat warrant special protection under Commonwealth and/or State legislation. At a Commonwealth level, flora taxa may be listed as 'threatened' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Threatened flora species listed under the EPBC Act are assigned a conservation status according to attributes such as population size and geographic distribution. Any action likely to have a significant impact on a taxon 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). It is an offence to 'take' or 'disturb' threatened flora listed under the BC Act without Ministerial approval.

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.**

3.1.2. 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 influenced by environmental factors such as soil type, position in the landscape, altitude, climate and water availability (DoEE 2019b). '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 EPBC Act. Similar to flora species, TECs listed under the EPBC Act are assigned a conservation status. 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.

Within Western Australia, State-listed TECs are statutorily protected through the BC Act and endorsed by the Minister for the Environment. While no TECs are currently listed for protection under the BC Act, it is likely they will be listed at a future date, requiring future Ministerial authorisation where a proposed development is likely to disturbed or modified an identified TEC. 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*.

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.**

4. METHODS

4.1. Desktop assessment

A search was conducted for threatened and priority flora that may occur or have been recorded within a 10 km radius of the site using the *Protected Matters Search Tool* (DoEE 2019a), *NatureMap* (DBCA 2019) and DBCA's threatened and priority flora database (reference no. 47-0919FL).

A search was also conducted for TECs and PECs that may occur or have been recorded within a 10 km radius of the site using the *Protected Matters Search Tool* (DoEE 2019a), the *weed and native flora dataset* (Keighery *et al.* 2012) and a five km buffer of the site using DBCA's threatened and priority ecological communities' databases (reference no. 17-01019EC). DBCA advised that a 5 km buffer was an appropriate size for the community database search.

Prior to undertaking the field survey, information on the habitat preferences of threatened and priority flora species and communities identified from database searches was reviewed. This was compared to existing environmental information available for the site, such as geomorphology, soils, regional vegetation and historic land use.

An assessment of the likelihood of occurrence of threatened and priority flora species and communities within the site was undertaken and each species was assigned to one of the following categories:

- Recorded: the species was recorded during the current field survey.
- Likely: the species has been previously recorded in the site.
- Possible: suitable habitat for the species may occur in the site.
- Unlikely: no suitable habitat for the species is present within the site.

4.2. Field surveys

A botanist from Emerge visited the site on 18 September and 8 October 2019 to conduct the flora and vegetation survey.

The site was traversed on foot and the composition and condition of vegetation was recorded.

Detailed sampling of the vegetation was undertaken using non-permanent 10 x 10 m quadrats and relevés. The quadrats were established using fence droppers bound by measuring tape. The relevés were completed over an equivalent 10 x 10 m area without the use of physical markers and were included to provide a more rapid sample of patches of vegetation in poorer condition and/or of smaller size.

Multiple samples were taken across the wider survey area, with three quadrats and one relevé located within the site. The remainder of the vegetation in the site was considered too disturbed to require formal sampling. Instead, notes about the vegetation type, vegetation structure and soils were recorded. A list of flora species observed within the site was collected. Photographs were taken throughout the field visit to show particular site conditions.

The site was assessed to determine whether suitable habitat was present for conservation significant species identified as potentially occurring within the site (refer **Section 4.1**) and whether the survey effort was appropriate to determine if they occur in the site.

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 to vegetation within the site and changes in vegetation condition were also noted and mapped across the site. The condition of the vegetation was assessed using methods from Keighery (1994).

Table 1:Vegetation condition scale applied during the field assessment

Condition category	Definition (Keighery 1994)
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
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
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.
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.
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.

4.3. Mapping and data analysis

4.3.1. Plant communities

The plant communities within the site were identified from the data collected during the field survey. The vegetation was 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 mapped on aerial photography from the notes taken in the field. Vegetation condition was mapped on aerial photography based on notes recorded during the field survey to define areas with differing condition.

4.3.2. Floristic community type

The identified plant communities were then compared to the regional 'floristic community type' (FCT) dataset *A floristic survey of the southern Swan Coastal Plain* by Gibson *et al.* (1994). The sample data (presence/absence) was reconciled with Gibson *et al*. (1994) by standardising the names of taxa with those used in the earlier study. This was necessary due to changes in nomenclature in the intervening period. Taxa that were only identified to genus level were excluded, while some infra-species that have been identified since 1994 were reduced to species level. The combined dataset was then imported into the statistical analysis package PRIMER v6 (Clarke and Gorley 2006). As data from a localised survey is often spatially correlated, data for each sample was compared to Gibson *et al.* (1994) separately. This removed the influence of spatial correlation when assigning a FCT. Classification was then undertaken using a group-average hierarchical clustering technique using the Bray-Curtis distance measure (as described above for plant community determination).

Where the sample tended to cluster with a grouping of different FCTs, samples were assessed separately to differentiate between FCTs. Ultimately the cluster analysis, as well as contextual information relating to the soils, landforms and known locations of FCTs within the region, was considered in the final determination of an FCT for vegetation within the site.

4.3.3. Threatened and priority ecological community

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 (where applicable):

- *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)
- *Approved Conservation Advice for Clay Pans of the Swan Coastal Plain* (DSEWPaC 2012).

4.4. 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 2**.

Table 2: 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 available was adequate to place the site and vegetation in context.
		The broader survey undertook a detailed review of environmental contextual information for the area adjacent to the site and the local area.
	No limitation	Regarding assignment of FCTs, the authoritative Gibson *et al.* (1994) dataset was derived from a necessarily limited sample of vegetation from largely publicly owned land which is now more than 20 years out of date. Consequently, it is unknown to what degree official FCTs are appropriate reference to biodiverse vegetation across the Swan Coastal Plain. Furthermore, Gibson *et al.* (1994) collected data in the spring main flowering period and in many cases sampled plots multiple times to provide a complete species list. This survey sampled the vegetation twice within the main flowering period and FCT assignment was conclusive for the majority of the higher quality vegetation in the site. FCT assignment was inconclusive for one plant community but an indicative FCT was able to be assigned.
Experience level of personnel	No limitation	The Emerge Associates (2019) flora and vegetation assessment and this technical memo were undertaken by a qualified botanist with over eight years of botanical experience in Western Australia. Technical review was undertaken by a senior environmental consultant with 16 years' experience in environmental science in Western Australia.
Suitability of timing	No limitation	The Emerge Associates (2019) survey was conducted in September and October and thus within the main flowering season. Adequate rainfall was recorded in the months preceding the site visit and many plant species were in flower and/or visible at the time of survey. The survey timing was considered adequate to allow the detection of species for which seasonal timing is critical (within areas of suitable habitat).
Temporal coverage	No limitation	Comprehensive flora and vegetation assessments can require multiple visits, at different times of year, and over multiple years, to enable observation of all species present. The site was visited two times in spring 2019. Therefore, according to the EPA guidelines this survey is considered to meet the requirements of a 'detailed' survey.
Spatial coverage and access	No limitation	Site coverage was comprehensive (track logged).
	No limitation	All parts of the site could be accessed as required.
Sampling intensity	No limitation	A total of 139 species were recorded, comprising 88 native and 51 non-native. The majority of the native species were recorded within intact native vegetation in the southern portion of the site, where sampling was undertaken. It was expected that the number of native species within the remainder of the site would be low due to the long-term history of disturbance. The samples were located within the highest quality vegetation and this data, combined with traverses across the site, were considered sufficient to prepare a near-comprehensive species inventory for the site.
Influence of disturbance	Minor limitation	Time since fire is greater than 60 years as interpreted form aerial imagery and therefore short-lived species more common after fire may not have been visible.
	No limitation	Historical ground disturbance was evident across much of the site. The disturbance history of the site was considered when undertaking the field survey.
Adequacy of resources	No limitation	All resources required to perform the survey were available.

5. RESULTS

The majority of the site has been subject to intensive historical disturbance and comprises a flat to undulating landscape with buildings, hardstand and brick stockpiles. The northern portion of the site slopes steeply down to the Swan River and supports a combination of native, non-native and planted vegetation. The southern portion of the site supports patches of high-quality native vegetation as well as some vegetation that has been subject to disturbance.

5.1. Flora

5.1.1. Desktop assessment

The database search results identified a total of 27 threatened and 47 priority flora species occurring or potentially occurring within a 10 km radius of the broader survey area, including the site. Information on these species including their habitat preferences is provided in **Appendix B.**

Based on existing information available for the site, 19 threatened flora species and 31 priority flora species were identified as having potential to occur within the broader survey area, as shown in **Table 3**. This list is also relevant to the site.

Table 3: Conservation significant flora species considered to have potential to occur in the site

Species	Level of significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Synaphea sp. Fairbridge Farm	T	CE	P	Low woodland on grey, clayey sand with lateritic pebbles (Pinjarra Plain) near winter wet flats.	Sep - Nov	Possible
Synaphea sp. Pinjarra Plain	T	CE	P	White grey clayey sand on edges of seasonally inundated low-lying areas.	Sep-Oct	Possible
Andersonia gracilis	T	E	P	Seasonally damp, black sandy clay flats near or on the margins of swamps.	Sep-Nov	Possible
Caladenia huegelii	T	E	P	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
Diuris purdiei	T	E	P	Sand to sandy clay soils in areas subject to winter inundation.	Sep-Oct, only after a fire	Possible
Drakaea elastica	T	E	P	Bare patches of sand within otherwise dense vegetation in low-lying areas alongside winter-wet swamps.	Sep-Oct (survey Jul-Aug)	Possible
Grevillea curviloba subsp. *incurva*	T	E	P	Sand, sandy loam. Winter-wet heath.	Aug-Sep.	Possible
Lepidosperma rostratum	T	E	P	Peaty sand and clay amongst low heath, in winter-wet swamps.	May-Jun (survey Jun-Aug)	Possible

Table 3: Conservation significant flora species considered to have potential to occur in the site (continued)

Species	Level of significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Macarthuria keigheryi	T	E	P	Low-lying winter-wet damp grey/white sands in open patches.	Sep-Dec/Feb-Mar	Possible
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 or gravel	Aug-Sep	Possible
Anigozanthos viridis subsp. *terraspectans*	T	V	P	Grey sand, clay loam. Winter-wet depressions.	Aug-Sep	Possible
Chamelaucium sp. Gingin	T	V	P	White yellow sand in low woodland.	Sep-Dec	Possible
Conospermum undulatum	T	V	P	Sand and sandy clay soils, on flat or gently sloping sites between the Swan and Canning Rivers	May-Oct	Possible
Diuris drummondii	T	V	P	In low-lying depressions in peaty and sandy clay swamps.	Nov-Jan	Possible

5.1.2. Species inventory

A total of 88 native and 51 non-native (weed) species were recorded within the site during the field survey, representing 46 families and 51 genera.

A complete species list is provided in **Appendix C**.

5.1.3. Threatened and priority flora

No threatened or priority flora were recorded in the site.

The survey timing was considered suitable to search for threatened and priority flora species identified as potentially occurring in the site (refer **Section 5.1.1**). Therefore, no threatened and priority flora species are considered to occur in the site.

5.1.4. Declared pests

Two species listed as a declared pests (C3) pursuant to the BAM Act, **Chrysanthemoides monilifera* subsp. *monilifera* (boneseed) and **Gomphocarpus fruticosus* (narrowleaf cottonbush), were recorded within the site. Boneseed was restricted to the central southern portion of the site within plant community **ErJsBh** (refer **Section 5.2.2**). Narrowleaf cottonbush was scattered throughout the site.

Boneseed is also listed as a weed of national significance (WoNS).

5.2. Vegetation

5.2.1. Desktop assessment

The database search results identified 10 TECs and two PECs occurring or potentially occurring within a 5-10 km radius of the broader survey area. This list is also relevant to the current site. Information on these communities is provided in **Appendix D**.

Based geomorphology, soils and regional vegetation patterns, three TECs were considered to potentially occur in the broader survey area and also within the site:

- '*Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain' TEC which is listed as 'endangered' under the EPBC Act and recognised as 'critically endangered' in Western Australia.
- '*Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain' TEC which is listed as 'endangered' under the EPBC Act and recognised as 'critically endangered' in Western Australia.
- 'Clay pans of the Swan Coastal Plain' TEC which is which is listed as 'critically endangered' under the EPBC Act and recognised as 'vulnerable' or 'endangered' in Western Australia, depending on the vegetation type.

5.2.2. Plant communities

Eight native plant communities and one non-native/cleared community were identified within the site.

The native vegetation in the site is primarily located in the southern, south eastern and northern portions of the site. The remainder of the site comprises buildings and hardstand associated with the current industrial uses of the site, as well as scattered native plants and bare ground.

The plant communities mapped in the site are described in **Table 4** and representative photos are provided in **Plate 1** to **Plate 9**. The extent of each plant community is shown in **Figure 2** and sample data is provided in **Appendix E**.

Table 4: Plant communities present within the banksia woodland in the site

Plant community	Description	Area (ha)
ApMtS	Shrubland *Acacia pulchella* var. *pulchella, Hakea undulatum* and *Hypocalymma angustifolium* over sedgeland *Mesomelaena tetragona* over open grassland *Neurachne alopecuroidea* over herbland *Stylidium* spp. (**Plate 1**).	0.22
Cc	Open forest *Corymbia calophylla* over shrubland *Hibbertia sp.* and *Xanthorrhoea preissii* over open sedgeland *Cyathochaeta avenacea* and *Mesomelaena tetragona* over open herbland *Agrostocrinum hirsutum* over open grassland **Eragrostis curvula* (**Plate 2**).	0.71
Ec	Woodland to tall shrubland of various planted species, particularly *Eucalyptus camaldulensis*, with scattered *E. rudis* over shrubland *Genista linifolia* and *Melaleuca viminea* over closed non-native grassland with occasional scattered *Rytidosperma setaceum* (**Plate 3**).	4.54
Er	Woodland to open forest *Eucalyptus rudis* over non-native shrubland (or absent) over closed non-native grassland (**Plate 4**).	2.88
ErBp	Open forest *Eucalyptus rudis* over closed sedgeland *Baumea preissii* (**Plate 5**).	0.47
ErCo	Woodland to open woodland *Eucalyptus rudis*, *Casuarina obesa*, **Eucalyptus* spp. and various non-native species over tall shrubland **Olea europaea* over non-native grassland and/or herbland (**Plate 6**).	1.67
ErJsBh	Woodland *Eucalyptus rudis* over tall shrubland *Jacksonia sternbergiana* over shrubland *Billardiera heterophylla* and *Phyllanthus calycinus* and *Hakea* spp. over closed non-native grassland (**Plate 7**).	0.38
Ew	Woodland *Eucalyptus wandoo* over open non-native grassland (**Plate 8**).	0.02
Non-native/cleared	Heavily disturbed areas comprising planted non-native trees and shrubs over non-native herbs and grasses, with occasional native shrubs and forbs (**Plate 9**).	36.29

Plate 1: Plant community ***ApMtS*** *in 'excellent' condition (Q3).*

*Plate 2: Plant community **Cc** in 'very good' condition.*

*Plate 3: Plant community **Ec** in 'degraded' condition.*

*Plate 4: Plant community **Er** in 'degraded' condition.*

*Plate 5: Plant community **ErBp** in 'excellent - very good' condition.*

*Plate 6: Plant community **ErCo** in 'degraded' condition.*

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

*Plate 8: Plant community **Ew** in 'degraded' condition.*

Plate 9: Non-native/cleared community in 'completely degraded' condition.

5.2.3. Vegetation condition

The most intact native vegetation is located in the southern portion of the site within plant communities **ApMtS**, **Cc** and **ErBp**. Plant community **ApMtS** was mapped as being in 'excellent' condition as its structure appears intact and weed cover is low. Plant community **Cc** was mapped as being in 'very good' condition its structure was mostly intact and grassy weeds are present at low to moderate cover. Plant community **ErBp** was mapped as being in an 'excellent – very good' condition as it showed evidence of potential disturbance to both structure and composition.

Plant community **ErJsBh** was mapped in 'good' condition as it was significantly altered and had relatively high weed cover while still containing a range of native species. Plant communities **Ec**, **Er ErCo** and **Ew** were mapped as being in 'degraded' condition as their structure had been significantly impacted by disturbance and weed cover was high.

The non-native/cleared area was mapped as being in 'completely degraded' condition as it comprises buildings and hardstand with some planted non-native trees and scattered native plants.

The extent of vegetation by condition category is detailed in **Table 5** and shown in **Figure 3.**

Table 5: Vegetation condition categories within the site

Condition category (Keighery (1994))	Size (ha)
Pristine	0
Excellent	0.22
Excellent – very good	0.47
Very good	0.71
Good	0.38
Degraded	9.11
Completely degraded	36.29

5.2.4. Floristic community type

Plant communities **ApMtS** and **Cc** were determined to represent FCT 3c '*Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands'. This FCT is listed as 'poorly reserved' and 'vulnerable' by Gibson *et al.* (1994). The one sample from **ApMtS** and the two samples from **Cc** grouped with Gibson *et al.* (1994) sites representing FCT 3c with 34-48% similarity (**Table 6**). The relevant portions of the cluster dendrograms showing Q1, Q2 and Q3 are provided in **Appendix F**.

Floristic analysis of Q4 within plant community **ErBp** was inconclusive, with weak similarity to Gibson *et al.* (1994) sites representing FCT 11 'wet forests and woodlands', FCT 13 'deeper wetlands on heavy soils' and FCT 15 'forests and woodlands of deep seasonal wetlands' with 11-16% similarity. FCT 11 and FCT 13 are both listed as 'well reserved' and 'low risk' and FCT 15 is listed as 'well reserved' and 'vulnerable' by Gibson *et al.* (1994).

Other plant communities in the site were considered too degraded and/or altered to assign to an FCT.

Table 6: Plant community and likely FCT represented within the site for each sample.

Plant community	Sample unit	Most similar Gibson *et al.* (1994) sites	Similarity (%)	Most likely floristic community type (FCT)	Reservation and conservation status (Gibson *et al.* 1994)
ApMtS	**Q1**	PEARCE-2 (FCT3c)	48	FCT 3c: *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands	Poorly reserved Vulnerable
Cc	**Q2**	DUCK-1 (FCT 3c) DUCK-2 (FCT 3c)	36		
	Q3	DUCK-1 (FCT 3c) DUCK-2 (FCT 3c)	34		
ErBp	**Q4**	CARAB-1 (FCT 15) AUSTB-3 (FCT 11) CAPEL-4 (FCT 13)	16 11 11	Inconclusive	-

5.2.5. Threatened and priority ecological communities

FCT 3c is directly linked to the TEC ‘SCP3c *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain’. This TEC, herein referred to as the SCP3c TEC, is ‘critically endangered’ in WA and ‘endangered’ under the EPBC Act. The entirety of plant communities **ApMtS** and **Cc** were considered to represent the TEC (0.93 ha in total), as shown in **Figure 4**.

No other TECs or PECs occur within the site.

5.2.6. Locally and regionally significant vegetation

Mature *Corymbia calophylla* (marri) and *Eucalyptus rudi*s (flooded gum) trees (diameter at breast height larger than 500 mm), including some with hollows, are present in the northern and central southern portions of the site. These trees have the potential to provide foraging, roosting and/or nesting habitat for threatened species of black cockatoo, along with other ecological services.

6. DISCUSSION

6.1. Threatened and priority flora

The desktop assessment identified that many threatened and priority flora species have potential to occur in the site based on landscape and soil mapping. The field survey determined that most of the site does not provide suitable habitat for such flora due to a high level of historical disturbance. However, the intact native vegetation in the south-eastern portion of the site was identified as having potential to provide habitat for threatened and priority flora species.

Two surveys were undertaken in vegetation in the southeastern portion of the site during spring, which is the main flowering period for most plants on the Swan Coastal Plain. The September and October timing of the surveys coincided with the known flowering periods of most of the perennial and annual flora species of conservation significance that were considered to have potential to occur in the site. As searches did not record these species they are considered unlikely to occur. Two annual species, *Hydrocotyle striata* and *Myriophyllum echinatum*, flower in November but no evidence, such as sterile specimens, was recorded in the October survey and hence they are also considered unlikely to occur.

6.2. Vegetation condition

Assigning vegetation condition categories was relatively straightforward for most of the site. A compound category of 'excellent – very good' was applied to plant community **ErBp**. The **ErBp** vegetation had lower native species diversity which is not uncommon in wetland ecosystems and was otherwise relatively intact. However, some signs of disturbance to the vegetation structure were evident and some weeds were present, particularly on the drier edges of the patch, making a compound rather than 'excellent' condition category most appropriate.

Plant communities **Ec** and **Er** were mapped as being in **'**degraded' condition as both had appropriate structure and native species in their canopy and understory layers at low densities. However, this label probably overstates the values of these areas of vegetation within the site as they are are highly modified and disturbed.

6.3. Floristic community type assignment

The FCT cluster analysis was conclusive for the samples within plant communities **ApMtS** and **Cc** but inconclusive for Q4 within plant community **ErBp**. Q4 showed similarity to FCTs 11, 13 and 15, which are all considered appropriate to the flora species recorded and the plant community location, soils and landform.

Native species diversity was low in **ErBp** but this is not unusual; Gibson *et al.* (1994) states that FCTs 11, 13 and 15 comprise deeper wetlands with low species richness. Further survey of the **ErBp** vegetation during other times of the year may record additional native species and provide more FCT conclusive results. However, the lack of identification of this species is only considered a minor limitation, particularly as the inferred FCTs are not associated with a PEC or TEC.

6.4. Threatened and priority ecological communities

The 'SCP3c *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain' TEC occurs on the heavy soils of the eastern side of the Swan Coastal Plain. As the name implies, the 'SCP3c *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain' TEC can comprise a woodland with a canopy of *Corymbia calophylla* (marri)/*Eucalyptus wandoo* (wandoo) or a shrubland. The site supports both forms of the TEC: plant community **ApMtS** represents the shruband form and plant community **Cc** represents the woodland form.

The eastern side of the Swan Coastal Plain has been subject to extensive clearing, with approximately 97% of vegetation cleared (DoEE 2017b). As such, FCT 3c vegetation is now very rare and no condition thresholds are applied to assessment of a patch of this TEC (DoEE 2017b).

The FCT 3c vegetation in the site represents a relatively undisturbed occurrence of the TEC, being in 'excellent' and 'very good' condition. Therefore, defining the boundaries of the TEC within the site was simple as the edge of the patch could be directly aligned with the edge of plant communities **ApMtS** and **Cc**.

No other TECs or PECs are considered to occur in the site.

7. CONCLUSIONS

The site has been subject to intensive historical disturbance, with approximately 36.29 ha (77%) mapped as being in 'completely degraded' condition. A further 9.11 ha (19%) of the site supports vegetation mapped as being in ‘degraded’ condition. The remaining 1.78 ha (4%) of the site supports vegetation mapped as being in ‘excellent’ to ‘good’ condition.

No threatened or priority flora species were recorded within the site. The intact vegetation in south eastern portion of the site has the highest potential to provide habitat for conservation significant flora species. The survey timing and effort were considered suitable to survey for threatened or priority flora species considered to have potential to occur within the site. Therefore, since they were not recorded no threatened or priority flora species are considered likely to occur in the site.

The site contains a 0.93 ha patch of the State and Commonwealth listed TEC ‘SCP3c *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain’. Mature trees within the site have the potential to provide foraging, roosting and/or nesting habitat for threatened species of black cockatoo, along with other ecological services.

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Figures

Figure 1: Site Location

Figure 2: Plant Communities

Figure 3: Vegetation Condition

Figure 4: Threatened Ecological Community

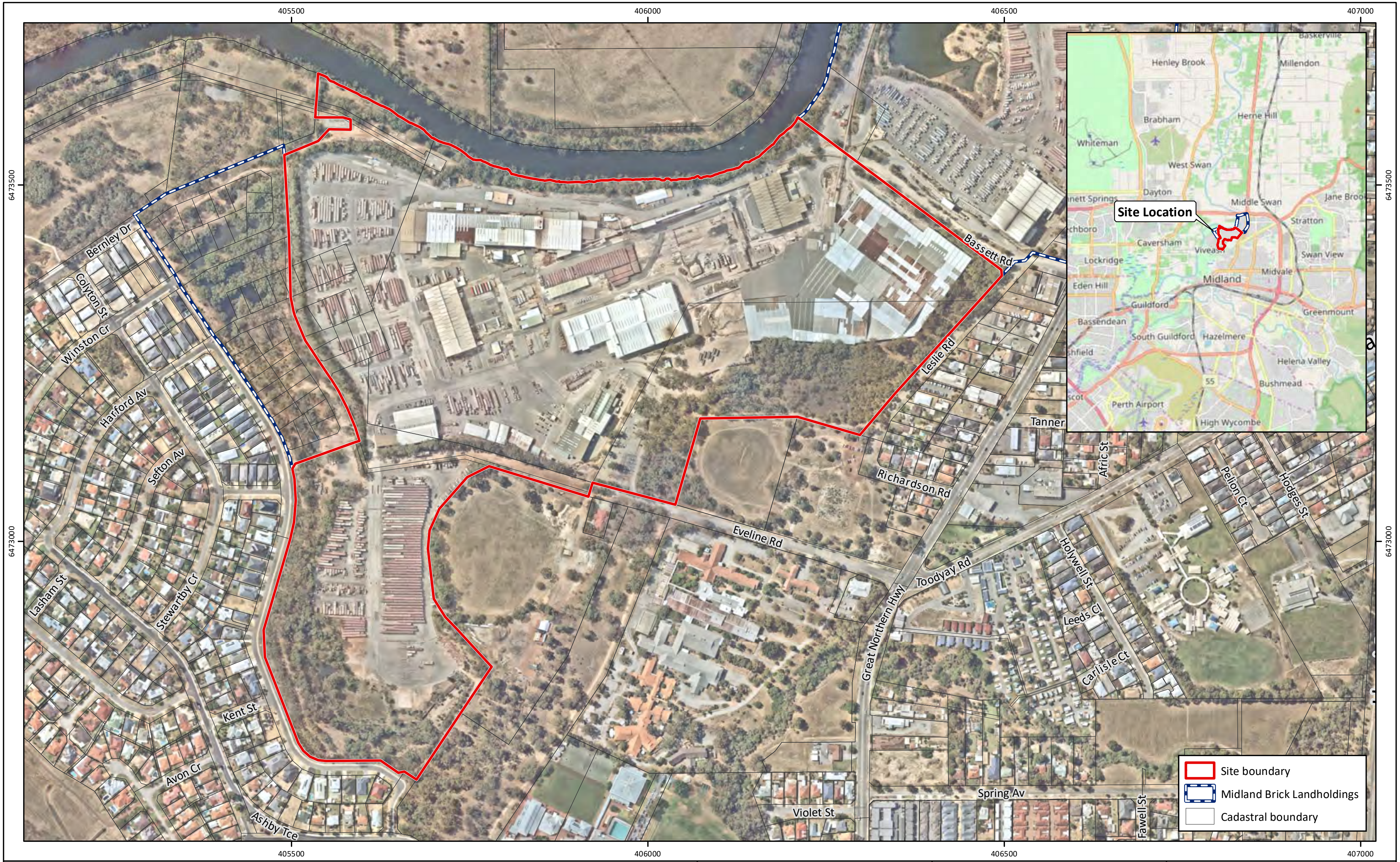

Figure 1: **Site Location**

Project: Flora and Vegetation Assessment
Part Middle Swan Brickworks, Middle Swan

Client: Linc Property Pty Ltd

Plan Number:
EP19-105(07)--F143
Drawn: AFF
Date: 24/03/2020
Checked: RAW
Approved: RAW
Date: 30/03/2020

N

0 100 200
Metres

Scale: 1:7,000@A4
GDA 1994 MGA Zone 50

emerge
ASSOCIATES

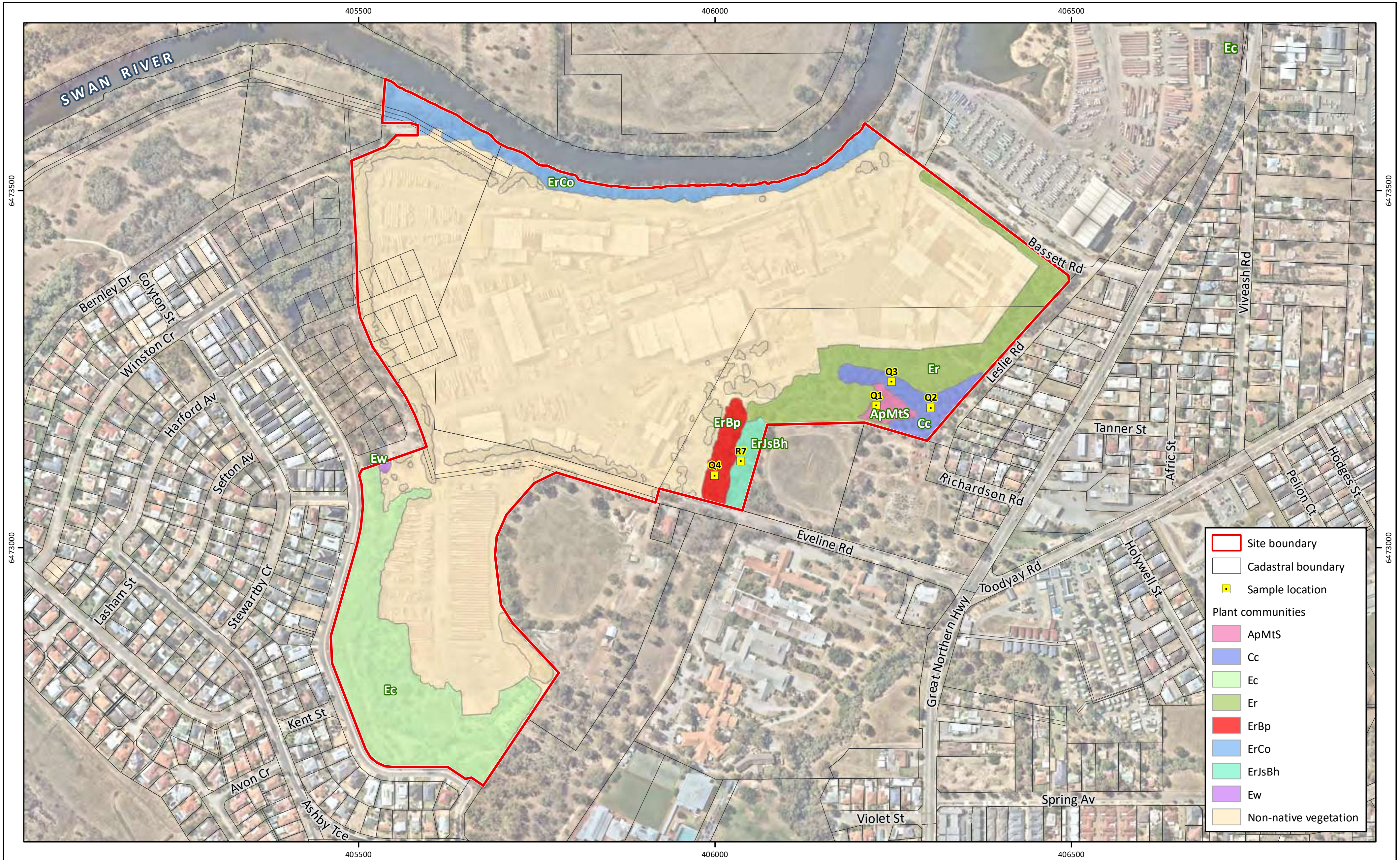

Figure 2: **Plant Communities**

Project: Flora and Vegetation Assessment
Part Middle Swan Brickworks, Middle Swan

Client: Linc Property Pty Ltd

Plan Number:
EP19-105(07)--F144
Drawn: AFF
Date: 24/03/2020
Checked: RAW
Approved: RAW
Date: 30/03/2020

N

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Metres
Scale: 1:7,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

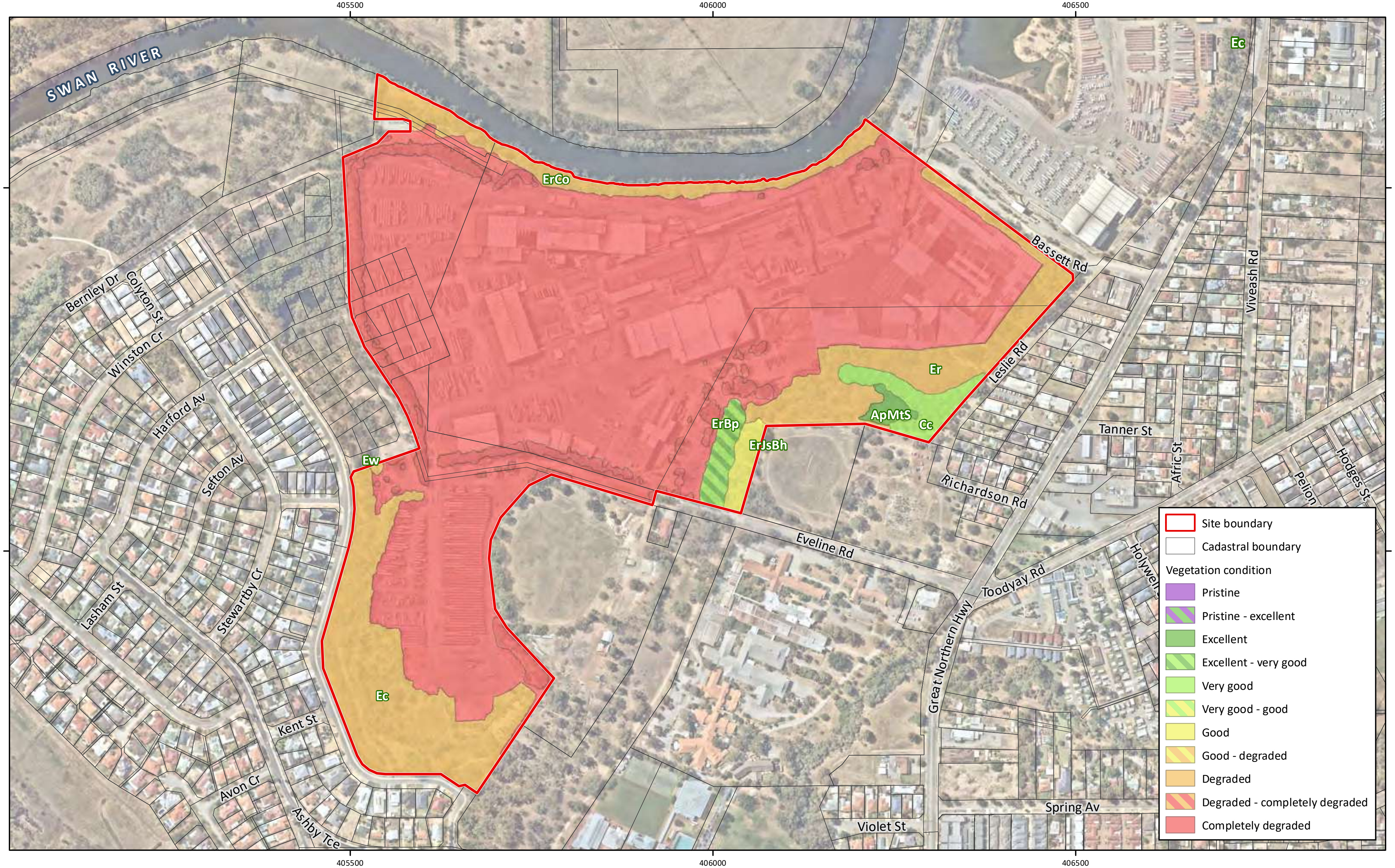

Figure 3: **Vegetation Condition**

Project: Flora and Vegetation Assessment
Part Middle Swan Brickworks, Middle Swan

Client: Linc Property Pty Ltd

Plan Number:
EP19-105(07)--F145
Drawn: AFF
Date: 24/03/2020
Checked: RAW
Approved: RAW
Date: 30/03/2020

N

0 100 200
Metres
Scale: 1:7,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

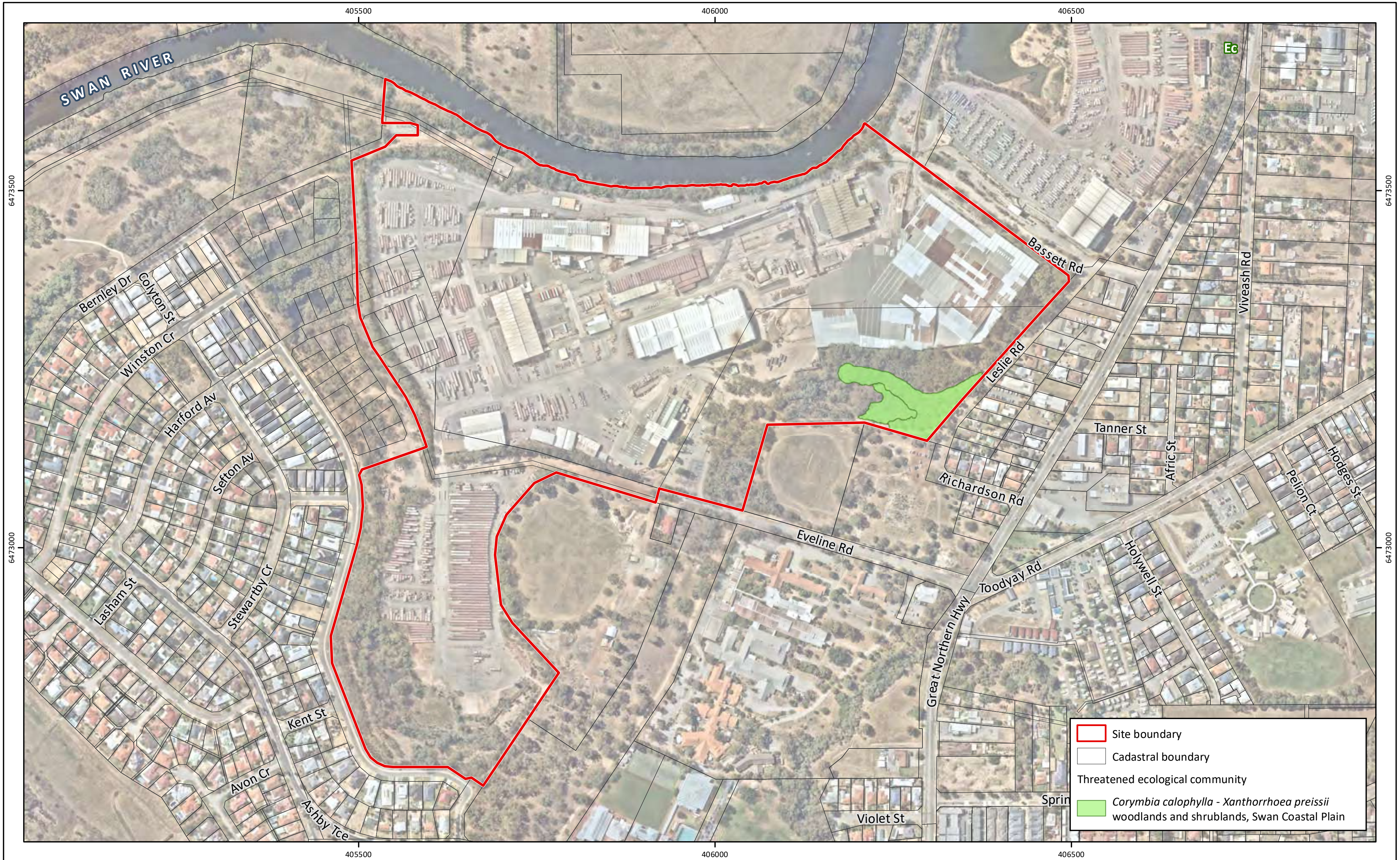

Figure 4: **Threatened Ecological Community**

Project: Flora and Vegetation Assessment
Part Middle Swan Brickworks, Middle Swan

Client: Linc Property Pty Ltd

Plan Number:
EP19-105(07)--F146
Drawn: AFF
Date: 24/03/2020
Checked: RAW
Approved: RAW
Date: 30/03/2020

N

0 100 200
Metres
Scale: 1:7,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix A

Additional 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. Ecological communities are listed under Section 27(1) and 33 of the BC Act. 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

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Appendix B

Conservation Significant Flora Species and Likelihood of Occurrence Assessment

Table Appendix B1: Conservation significant flora species known or likely to occur within 10 km of the site

Species	Level of significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Calectasia cyanea	T	CE	P	Heathland on white sand or laterite gravel over laterite.	Jun-Oct	Unlikely
Synaphea sp. Fairbridge Farm	T	CE	P	Low woodland on grey, clayey sand with lateritic pebbles (Pinjarra Plain) near winter wet flats.	Sep - Nov	Possible
Synaphea sp. Pinjarra Plain	T	CE	P	White grey clayey sand on edges of seasonally inundated low lying areas.	Sep-Oct	Possible
Andersonia gracilis	T	E	P	Seasonally damp, black sandy clay flats near or on the margins of swamps.	Sep-Nov	Possible
Caladenia huegelii	T	E	P	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	Open jarrah-marri woodland on shallow gravely soil over laterite, or open heathland over sandy loams with granite boulders.	Oct-Nov	Unlikely
Diplolaena andrewsii	T	E	P	Granite outcrops & hillsides.	Jul-Oct	Unlikely
Diuris purdiei	T	E	PG	Sand to sandy clay soils in areas subject to winter inundation.	Sep-Oct, only after a summer or early autumn fire	Possible
Drakaea elastica	T	E	PG	Bare patches of sand within otherwise dense vegetation in low-lying areas alongside winter-wet swamps.	Sep-Oct (survey Jul-Aug)	Possible
Eucalyptus x balanites	T	E	P	Light coloured sandy soils over laterite. Habitat consists of gently sloping heathlands; open mallee woodland over shrubland (Population 2) or heathland with emergent mallees (population 1)	Oct - Feb	Unlikely
Grevillea curviloba subsp. incurva	T	E	P	Sand, sandy loam. Winter-wet heath.	Aug-Sep.	Possible
Lepidosperma rostratum	T	E	P	Peaty sand and clay amongst low heath, in winter-wet swamps.	May-Jun (survey Jun-Aug)	Possible

Table Appendix B1: Conservation significant flora species known or likely to occur within 10 km of the site (continued)

Species	Level of significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Macarthuria keigheryi	T	E	P	Low-lying winter-wet damp gey/white sands in open patches.	Sep-Dec/Feb-Mar	Possible
Thelymitra dedmaniarum	T	E	PG	Red brown sandy loam with dolerite and granite outcrops.	Oct-Nov	Unlikely
Thelymitra stellata	T	E	PG	Sandy loam, clay or gravel over laterite or gravel.	Sep-Nov	Unlikely
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 or gravel	Aug-Sep	Possible
Acacia aphylla	T	V	P	Laterite and granite outcrops on hillsides.	Aug-Oct	Unlikely
Anigozanthos viridis subsp. terraspectans	T	V	P	Grey sand, clay loam. Winter-wet depressions.	Aug-Sep	Possible
Anthocercis gracilis	T	V	P	Steep granite slopes along the Darling Scarp in shallow, humis-rich sandy or loamy soils.	Sep-Oct, Apr	Unlikely
Chamelaucium sp. Gingin	T	V	P	White yellow sand in low woodland.	Sep-Dec	Possible
Conospermum undulatum	T	V	P	Sand and sandy clay soils, on flat or gently sloping sites between the Swan and Canning Rivers	May-Oct	Possible
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 sandly clay-loam in winter wet depressions or swamps. Often in shallow standing water.	Aug/Sep-early Oct	Possible
Drakaea micrantha	T	V	PG	Open sandy patches often adjacent to winter-wet swamps.	Sept- early 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

Species	Level of significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Bolboschoenus fluviatilis	P1	-	P	Floodplain with grey/brown wet sand.	Nov	Possible
Hydrocotyle striata	P1	-	A	Sand and clay in springs and creeklines.	Nov	Possible

Table Appendix B1: Conservation significant flora species known or likely to occur within 10 km of the site (continued)

Species	Level of significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Levenhookia preissii	P1	-	A	Grey or black, peaty sand. Swamps	Sep-Dec or Jan	Possible
Senecio gilbertii	P1	-	P	Peaty sand in swamps and on slopes.	Sep-Nov	Possible
Stachystemon sp. Keysbrook	P1	-	P	White grey sand.	Oct	Possible
Thelymitra magnifica	P1	-	PG	Gravelly soil on stony ridges.	Sep-Oct	Unlikely
Acacia benthamii	P2	-	P	Sand, typically on limestone breakaways	Aug - sept	Unlikely
Lepyrodia curvescens	P2	-	P	Sand, laterite. Seasonally inundated swampland.	Sep-Nov	Possible
Phyllangium palustre	P2	-	A	Winter-wet claypans, low-lying seasonal wetlands on clay	Oct-Nov	Possible
Acacia drummondii subsp. affinis	P3	-	P	Lateritic gravelly soils.	Jul-Aug	Unlikely
Acacia horridula	P3	-	P	Gravelly soils over granite, sand, rocky hillsides.	May-Aug	Unlikely
Acacia oncinophylla subsp. oncinophylla	P3	-	P	Granitic soils	Aug-Oct	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	Possible
Carex tereticaulis	P3	-	P	Black peaty sand.	Sep-Oct	Possible
Cyathochaeta teretifolia	P3	-	P	Grey sand, sandy clay in swamps and creek edges.	Oct-Jan	Possible
Eryngiumsp. Subdecumbens	P3	-	P	Claypans	Sep-Jan	Possible

Species	Level of significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Grevillea manglesii subsp. dissectifolia	P3	-	P	Gravelly loam, moist. Roadsides.	Jun, Sep or Nov	Unlikely
Halgania corymbosa	P3	-	P	Gravelly soils, soils over granite.	Aug-Nov	Possible
Isopogon drummondii	P3	-	P	Yellow/white sand	Feb-Jun	Possible
Lasiopetalum glutinosum subsp. glutinosum	P3	-	P	Brown clay loam on slopes	Sep-Dec	Possible

Table Appendix B1: Conservation significant flora species known or likely to occur within 10 km of the site (continued)

Species	Level of significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Meionectes tenuifolia	P3	-	P	Clay loam in seasonally wet areas.	Oct-Dec	Possible
Myriophyllum echinatum	P3	-	A	Clay in winter-wet flats.	Nov	Possible
Pithocarpa corymbulosa	P3	-	P	Gravelly or sandy loam, amongst granite outcrops.	Jan-Apr	Unlikely
Platysace ramosissima	P3	-	P	Sandy soils.	Oct-Nov	Possible
Schoenus capillifolius	P3	-	A	Brown mud in claypans	Oct-Nov	Possible
Schoenus sp. Waroona	P3	-	A	Clay or sandy clay. Winter-wet flats.	Oct-Nov	Possible
Sporobolus blakei	P3	-	P	Red sandy clay, loam. Creeks.	Mar or Jun to Jul	Possible
Tetratheca pilifera	P3	-	P	Gravelly soils.	Aug-Oct	Unlikely
Thysanotus anceps	P3	-	P	White or grey sand, lateritic gravel, laterite.	Oct-Dec	Unlikely
Verticordia serrata var. linearis	P3	-	P	White sand, gravel	Sep-Oct	Possible
Anigozanthos humilis subsp. chrysanthus	P4	-	P	Grey or yellow sand	Jul-Oct	Possible
Calothamnus accedens	P4	-	P	Sandy soils over laterite.	Sep-Jan	Possible
Darwinia pimelioides	P4	-	P	Loam, sandy loam on granite outcrops.	Sep-Oct	Unlikely
Drosera occidentalis	P4	-	P	Sand over clay, seasonally wet areas	Oct-Dec/Jan	Possible
Hydrocotyle lemnoides	P4	-	A	Swamps	Aug-Oct	Possible
Jacksonia sericea	P4	-	P	Calcareous and sandy soils on Swan Coastal Plain	Dec-Feb	Unlikely
Lasiopetalum bracteatum	P4	-	P	Sandy clay, clay, lateritic gravel along drainage lines, creeks, gullies, granite outcrops.	Aug-Nov	Possible
Ornduffia submersa	P4	-	A	Sandy clay in inundated wetland/creek.	Aug-Nov	Possible
Persoonia sulcata	P4	-	P	Lateritic or granitic soils.	Sep-Nov	Unlikely
Schoenus griffinianus	P4	-	P	White sand	Sep-Oct	Possible

Species	Level of significance		Life strategy	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

Table Appendix B1: Conservation significant flora species known or likely to occur within 10 km of the site (continued)

Species	Level of significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Stylidium longitubum	P4	-	A	Seasonal wetlands.	Oct-Dec	Possible
Stylidium striatum	P4	-	P	Brown clay over laterite on hill slopes.	Oct-Nov	Unlikely
Thysanotus glaucus	P4	-	P	White, grey or yellow sand, sandy gravel.	Oct-Mar	Possible
Verticordia lindleyi subsp. lindleyi	P4	-	P	Sand and sandy clay in winter wet areas.	May or Nov-Jan	Possible

Note: T=threatened, CE=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 potentially occur within the site are shaded green

Appendix C

Species List

Flora Species List - Part Middle Swan Brickworks

Note: * denotes introduced weed species, Pl=planted, DP=declared pest under the BAM Act, WoNS=weed of National significance

Family	Status	Species
Apiaceae		
		Xanthosia huegelii
Apocynaceae		
	*DP	*Gomphocarpus fruticosus*
Arecaceae		
	*	*Washingtonia filifera*
Asparagaceae		
		Lomandra caespitosa
		Lomandra micrantha subsp. micrantha
		Sowerbaea laxiflora
		Thysanotus gracilis
		Thysanotus manglesianus
		Thysanotus manglesianus/pattersonii
Asteraceae		
	*	*Arctotheca calendula*
	*	*Artemisia arborescens*
	*DP, WoNS	*Chrysanthemoides monilifera subsp. monilifera*
		Hypochaeris glabra
Boraginaceae		
	*	*Echium plantagineum*
		Heliotropium curassavicum
Casuarinaceae		
		Allocasuarina humilis
		Casuarina obesa
Centrolepidaceae		
		Centrolepis aristata
Chenopodiaceae		
	*	*Atriplex prostrata*
		Tecticornia sp.
Colchicaceae		
		Burchardia congesta
Cyperaceae		
		Baumea preissii
		Bolboschoenus caldwellii

Flora Species List - Part Middle Swan Brickworks

Note: * denotes introduced weed species, Pl=planted, DP=declared pest under the BAM Act, WoNS=weed of National significance

Family	Status	Species
		Carex appressa
	*	*Carex divisa*
		Cyathochaeta avenacea
		Cyperaceae sp.
	*	*Cyperus congestus*
		Cyperus gymnocaulos
		Eleocharis acuta
		Isolepis sp.
		Lepidosperma costale
		Lepidosperma leptostachyum
		Mesomelaena tetragona
		Tetraria octandra
Dilleniaceae		
		Hibbertia diamesogenos
		Hibbertia hypericoides
Droseraceae		
		Drosera glanduligera
		Drosera ?menziesii
Euphorbiaceae		
	*	*Ricinus communis*
Fabaceae		
		Acacia sp.
	*	*Acacia podalyriifolia*
		Acacia pulchella var. pulchella
		Acacia saligna
		Daviesia decurrens subsp. decurrens
		Gastrolobium nervosum
	*	*Genista linifolia*
		Gompholobium marginatum
		Jacksonia sternbergiana
		Kennedia prostrata
	*	*Lupinus angustifolius*
	*	*Trifolium subbiflorus*
	*	*Vachellia karroo*
	*	*Vicia sativa*
Goodeniaceae		
		Dampiera linearis
Haemodoraceae		
		Haemodorum laxum
		Tribonanthes longipetala

Flora Species List - Part Middle Swan Brickworks

Note: * denotes introduced weed species, Pl=planted, DP=declared pest under the BAM Act, WoNS=weed of National significance

Family	Status	Species
Haloragaceae		
		Gonocarpus cordiger
Hemerocallidaceae		
		Agrostocrinum hirsutum
		Caesia micrantha
		Tricoryne elatior
Iridaceae		
	*	*Babiana angustifolia*
	*	*Gladiolus caryophyllaceus*
	*	*Hesperantha falcata*
	*	*Patersonia occidentalis*
	*	*Watsonia marginata*
	*	*Watsonia meriana var. bulbillifera*
Juncaceae		
		Juncus kraussii
		Juncus pallidus
Juncaginaceae		
		Cycnogeton lineare
Lauraceae		
		Cassytha glabella
Loranthaceae		
		Amyema preissii
Malvaceae		
	*	*Lagunaria patersonia*
Moraceae		
	*	*Ficus sp.*
Myrtaceae		
		Babingtonia camphorosmae
		Callistemon phoeniceus
		Corymbia calophylla
	*Pl	*Eucalyptus sideroxylon*
	*Pl	*Eucalyptus camaldulensis*
	*Pl	*Eucalyptus cladocalyx*
	*Pl	*Eucalyptus lehmannii*
		Eucalyptus rudis
		Eucalyptus wandoo

Flora Species List - Part Middle Swan Brickworks

Note: * denotes introduced weed species, Pl=planted, DP=declared pest under the BAM Act, WoNS=weed of National significance

Family	Status	Species
		Hypocalymma angustifolium
		Kunzea micrantha
	*	*Lophostemon confertus*
		Verticordia densiflora var. densiflora
Oleaceae		
	*	*Olea europea*
Orchidaceae		
		Diuris sp.
		Microtis media
		Thelymitra ?macrophylla
		Thelymitra antennifera
		Thelymitra macrophylla
Orobanchaceae		
	*	*Parentucellia latifolia*
Oxalidaceae		
	*	*Oxalis glabra*
	*	*Oxalis pes-caprae*
	*	*Oxalis purpurea*
Papaveraceae		
	*	*Fumaria capreolata*
Phyllanthaceae		
		Phyllanthus calycinus
Pittosporaceae		
		Billardiera heterophylla
Plantaginaceae		
	*	*Plantago lanceolata*
Poaceae		
		Austrostipa elegantissima
		Austrostipa macalpinei
	*	*Avena barbata*
	*	*Briza maxima*
	*	*Bromus diandrus*
	*	*Cenchrus setaceus*
	*	*Cynodon dactylon*
	*	*Ehrharta calycina*
	*	*Ehrharta longiflora*
	*	*Eragrostis curvula*

Flora Species List - Part Middle Swan Brickworks

Note: * denotes introduced weed species, Pl=planted, DP=declared pest under the BAM Act, WoNS=weed of National significance

Family	Status	Species
	*	*Lolium rigidum*
		Neurachne alopecuroidea
	*	*Paspalum dilatatum*
		Poa porphyroclados
	*	*Poaceae sp.*
		Rytidosperma setaceum
Polygonaceae		
	*	*Rumex crispus*
Primulaceae		
	*	*Lysimachia arvensis*
Proteaceae		
		Banksia armata var. armata
		Banksia dallanneyi
		Grevillea preissii
		Hakea undulatum
		Hakea erinacea
		Hakea prostrata
		Hakea trifurcata
		Synaphea ?spinulosa
Pteridaceae		
		Cheilanthes austrotenuifolia
Restionaceae		
		Desmocladus asper
		Leptocarpus canus
Rosaceae		
	*	*Rosa sp.*
Rubiaceae		
		Opercularia vaginata
Solanaceae		
	*	*Solanum nigrum*
Stylidiaceae		
		Stylidium dichotomum
		Stylidium repens
		Stylidium thesioides
Thymelaeaceae		
		Pimelea imbricata var. piligera

Flora Species List - Part Middle Swan Brickworks

Note: * denotes introduced weed species, Pl=planted, DP=declared pest under the BAM Act, WoNS=weed of National significance

Family	Status	Species
Xanthorrhoeaceae		
		Chamaescilla corymbosa
		Xanthorrhoea preissii

Appendix D

Conservation Significant Communities and Likelihood of Occurrence Assessment

Table Appendix D1: Significant communities known or likely to occur within 10 km of the site

<table>
<tr><th rowspan="2">Code</th><th rowspan="2">Community name</th><th rowspan="2">TEC/ PEC</th><th colspan="2">Level of significance</th></tr>
<tr><th>State</th><th>EPBC Act</th></tr>
<tr><td>Mound Springs SCP</td><td>Assemblages of plants and invertebrate animals of tumulus (organic mound) springs of the Swan Coastal Plain</td><td>TEC</td><td>Endangered</td><td>Critically Endangered</td></tr>
<tr><td>SCP3a</td><td>Corymbia calophylla - Kingia australis woodlands on heavy soils, Swan Coastal Plain</td><td>TEC</td><td>Endangered</td><td>Critically Endangered</td></tr>
<tr><td>SCP3c</td><td>Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain</td><td>TEC</td><td>Endangered</td><td>Critically Endangered</td></tr>
<tr><td>Multiple</td><td>Claypans of the Swan Coastal Plain</td><td>TEC</td><td>-</td><td>Critically Endangered</td></tr>
<tr><td>SCP20c</td><td>Shrublands and woodlands of the eastern Swan Coastal Plain</td><td>TEC</td><td>Critically Endangered</td><td>Endangered</td></tr>
<tr><td>-</td><td>Tuart (Eucalyptus gomphocephala) woodlands and forests of the Swan Coastal Plain ecological community</td><td>TEC/ PEC</td><td>Priority 3</td><td>Endangered</td></tr>
<tr><td>SCP20a</td><td>Banksia attenuata woodlands over species rich dense shrublands</td><td>TEC</td><td>Endangered</td><td rowspan="3">Endangered (Banksia woodlands of the Swan Coastal Plain)</td></tr>
<tr><td>SCP20b</td><td>Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain</td><td>TEC</td><td>Endangered</td></tr>
<tr><td>SCP 21c</td><td>Low lying Banksia attenuata woodlands or shrublands</td><td>TEC/ PEC</td><td>Priority 3</td></tr>
<tr><td>Coastal Saltmarsh</td><td>Subtropical and temperate coastal saltmarsh</td><td>TEC</td><td>Priority 3</td><td>Vulnerable</td></tr>
<tr><td>Multiple</td><td>Banksia dominated woodlands of the Swan Coastal Plain IBRA region</td><td>PEC</td><td>Priority 3</td><td>-</td></tr>
<tr><td>-</td><td>Central Northern Darling Scarp Granite Shrubland Community</td><td>PEC</td><td>Priority 4</td><td>-</td></tr>
</table>

*Communities considered to be potentially present within the site shaded green.

Appendix E

Sample Data

Vegetation Sample Data

Sample Name: Q1

Project no.:	EP19-105(07)		
Date:	18/09/2019	**Status**	Non-permanent
Author:	RAW,other		Q1: Page 1 of 3

Quadrat and landform details

Sample type:	quadrat	Size:	10 m x 10 m
NW corner easting:	406227	NW corner northing:	6473199
Altitude (m):	N/A	Geographic datum/zone:	GDA94/Zone 50
Soil water content:	slightly damp	Landform:	flat
Time since fire:	no evidence	Disturbance:	low - weeds
Soil type/texture	clay	Bare ground (%):	5
Rocks (%) and type:	No rocks	Soil colour:	brown
Litter:	5% (leaves,twigs)	Vegetation condition:	excellent-very good

Vegetation Sample Data

Sample Name: Q1

Project no.: EP19-105(07)
Date: 18/09/2019 **Status** Non-permanent
Author: RAW,other Q1: Page 2 of 3

Species Data
* denotes non-native species

Status	Confirmed name	Cover (%)
	Acacia pulchella var. pulchella	10
	Babingtonia camphorosmae	1
	Banksia dallanneyi	<1
*	*Briza maxima*	<1
	Burchardia congesta	<1
	Cassytha glabella	<1
	Centrolepis aristata	<1
	Chamaescilla corymbosa	<1
	Cyathochaeta avenacea	<1
	Cyperaceae sp.	<1
	Drosera ?menziesii	<1
	Drosera glanduligera	<1
	Gompholobium marginatum	<1
	Hakea erinacea	<1
	Hakea undulatum	2
*	Hesperantha falcata	<1
	Hypocalymma angustifolium	15
	Isolepis sp.	<1
	Lepidosperma leptostachyum	1
	Lomandra caespitosa	<1
	Mesomelaena tetragona	70
	Neurachne alopecuroidea	10
	Opercularia vaginata	<1
*	Oxalis glabra	10
*	Oxalis purpurea	<1
*	Parentucellia latifolia	<1
	Phyllanthus calycinus	<1
	Pimelea imbricata var. piligera	<1
	Sowerbaea laxiflora	<1
	Stylidium dichotomum	<1
	Stylidium repens	1
	Stylidium thesioides	<1
	Tetraria octandra	<1
	Thelymitra antennifera	<1
	Thysanotus manglesianus	<1

Vegetation Sample Data

Sample Name: Q1

Project no.:	EP19-105(07)		
Date:	18/09/2019	**Status**	Non-permanent
Author:	RAW,other	Q1: Page 2 of 3	

Species Data

* denotes non-native species

Status	Confirmed name	Cover (%)
	Tribonanthes longipetala	Opp.
	Verticordia densiflora var. densiflora	<1
*	*Watsonia meriana var. bulbillifera*	<1
	Xanthorrhoea preissii	Opp.
	Xanthosia huegelii	<1

Vegetation Sample Data

Sample Name: Q2

Project no.: EP19-105(07)
Date: 18/09/2019
Status Non-permanent
Author: RAW,other
Q2: Page 1 of 3

Quadrat and landform details

Sample type:	quadrat	Size:	10 m x 10 m
NW corner easting:	406303	NW corner northing:	6473196
Altitude (m):	N/A	Geographic datum/zone:	GDA94/Zone 50
Soil water content:	slightly damp	Landform:	flat
Time since fire:	no evidence	Disturbance:	low - weeds
Soil type/texture	clay/loam with organic layer	Bare ground (%):	1
Rocks (%) and type:	No rocks	Soil colour:	brown
Litter:	30% (leaves)	Vegetation condition:	very good

Vegetation Sample Data

Sample Name: Q2

Project no.: EP19-105(07)
Date: 18/09/2019 **Status** Non-permanent
Author: RAW,other Q2: Page 2 of 3

Species Data
* denotes non-native species

Status	Confirmed name	Cover (%)
	Acacia pulchella var. pulchella	10
	Agrostocrinum hirsutum	15
	Allocasuarina humilis	<1
	Austrostipa elegantissima	2
	Banksia armata var. armata	<1
	Banksia dallanneyi	1
*	*Briza maxima*	<1
	Burchardia congesta	<1
	Caesia micrantha	<1
	Cassytha glabella	<1
	Corymbia calophylla	25
	Cyathochaeta avenacea	<1
	Dampiera linearis	<1
	Daviesia decurrens subsp. decurrens	<1
	Desmocladus asper	<1
*	*Ehrharta calycina*	<1
*	*Eragrostis curvula*	30
*	*Fumaria capreolata*	<1
	Gompholobium marginatum	<1
	Gonocarpus cordiger	opp
	Haemodorum laxum	<1
	Hakea undulatum	10
*	*Hesperantha falcata*	<1
	Hibbertia hypericoides	10
	Lepidosperma leptostachyum	<1
	Mesomelaena tetragona	15
	Microtis media	<1
*	*Oxalis glabra*	5
	Phyllanthus calycinus	<1
*	*Plantago lanceolata*	<1
*	*Poaceae sp.*	<1
	Stylidium dichotomum	<1
	Stylidium repens	<1
	Synaphea ?spinulosa	<1
	Tetraria octandra	<1

Vegetation Sample Data

Sample Name: Q2

Project no.: EP19-105(07)
Date: 18/09/2019 **Status** Non-permanent
Author: RAW,other Q2: Page 2 of 3

Species Data
* denotes non-native species

Status	Confirmed name	Cover (%)
	Thysanotus gracilis	<1
	Tricoryne elatior	<1
	Xanthorrhoea preissii	5

Vegetation Sample Data

Sample Name: Q3

Project no.:	EP19-105(07)		
Date:	18/09/2019	**Status**	Non-permanent
Author:	RAW,other		Q3: Page 1 of 2

Quadrat and landform details

Sample type:	quadrat	Size:	10 m x 10 m
NW corner easting:	406248	NW corner northing:	6473232
Altitude (m):	N/A	Geographic datum/zone:	GDA94/Zone 50
Soil water content:	slightly damp	Landform:	flat
Time since fire:	no evidence	Disturbance:	low - weeds
Soil type/texture	clay	Bare ground (%):	2
Rocks (%) and type:	No rocks	Soil colour:	brown/yellow
Litter:	30% (leaves,twigs)	Vegetation condition:	very good

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Vegetation Sample Data

Sample Name: Q3

Project no.: EP19-105(07)
Date: 18/09/2019 **Status** Non-permanent
Author: RAW,other Q3: Page 2 of 2

Species Data
* denotes non-native species

Status	Confirmed name	Cover (%)
	Acacia pulchella var. pulchella	<1
	Agrostocrinum hirsutum	<1
	Austrostipa macalpinei	opp
	Babingtonia camphorosmae	1
	Banksia dallanneyi	<1
	Billardiera heterophylla	opp
*	*Briza maxima*	<1
	Burchardia congesta	Opp.
	Cassytha glabella	Opp.
	Cheilanthes austrotenuifolia	opp
	Corymbia calophylla	40
	Cyathochaeta avenacea	60
*	*Ehrharta calycina*	<1
*	*Gladiolus caryophyllaceus*	<1
	Hakea erinacea	2
*	*Hesperantha falcata*	<1
	Hibbertia diamesogenos	opp
	Hypocalymma angustifolium	Opp.
	Kunzea micrantha	Opp.
	Lepidosperma leptostachyum	<1
	Lomandra micrantha subsp. micrantha	<1
	Mesomelaena tetragona	5
	Neurachne alopecuroidea	<1
	Opercularia vaginata	1
*	*Oxalis glabra*	10
	Phyllanthus calycinus	<1
	Poa porphyroclados	opp
	Rytidosperma setaceum	opp
	Stylidium dichotomum	1
	Tetraria octandra	<1
	Thelymitra macrophylla	<1
	Thysanotus manglesianus/pattersonii	<1
	Tricoryne elatior	<1
	Xanthorrhoea preissii	Opp.

Vegetation Sample Data

Sample Name: Q4

Project no.:	EP19-105(07)		
Date:	18/09/2019	**Status**	Non-permanent
Author:	RAW,other		Q4: Page 1 of 2

Quadrat and landform details

Sample type:	quadrat	Size:	10 m x 10 m
NW corner easting:	405999	NW corner northing:	6473101
Altitude (m):	N/A	Geographic datum/zone:	GDA94/Zone 50
Soil water content:	near saturated	Landform:	flat
Time since fire:	> 5 yrs	Disturbance:	low - weeds
Soil type/texture	clay with organic layer	Bare ground (%):	1
Rocks (%) and type:	No rocks	Soil colour:	grey
Litter:	10% (leaves)	Vegetation condition:	excellent-very good

Vegetation Sample Data

Sample Name: Q4

Project no.: EP19-105(07)
Date: 18/09/2019
Status Non-permanent
Author: RAW,other
Q4: Page 2 of 2

Species Data
* denotes non-native species

Status	Confirmed name	Cover (%)
*	*Babiana angustifolia*	<1
	Baumea preissii	90
	Billardiera heterophylla	1
	Carex appressa	1
	Cycnogeton lineare	<1
*	*Cynodon dactylon*	1
*	*Cyperus congestus*	<1
	Eucalyptus rudis	30
*	*Paspalum dilatatum*	<1

Vegetation Sample Data

Sample Name: R7

Project no.:	EP19-105(07)		
Date:	18/09/2019	**Status**	Non-permanent
Author:	RAW		R7: Page 1 of 2

Quadrat and landform details

Sample type:	releve	Size:	other
NW corner easting:	406036	NW corner northing:	6473121
Altitude (m):	N/A	Geographic datum/zone:	GDA94/Zone 50
Soil water content:	slightly damp	Landform:	mid-slope
Time since fire:	no evidence	Disturbance:	moderate - weeds
Soil type/texture	clay	Bare ground (%):	5
Rocks (%) and type:	No rocks	Soil colour:	brown
Litter:	60% (leaves,branches,logs)	Vegetation condition:	good

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Vegetation Sample Data

Sample Name: R7

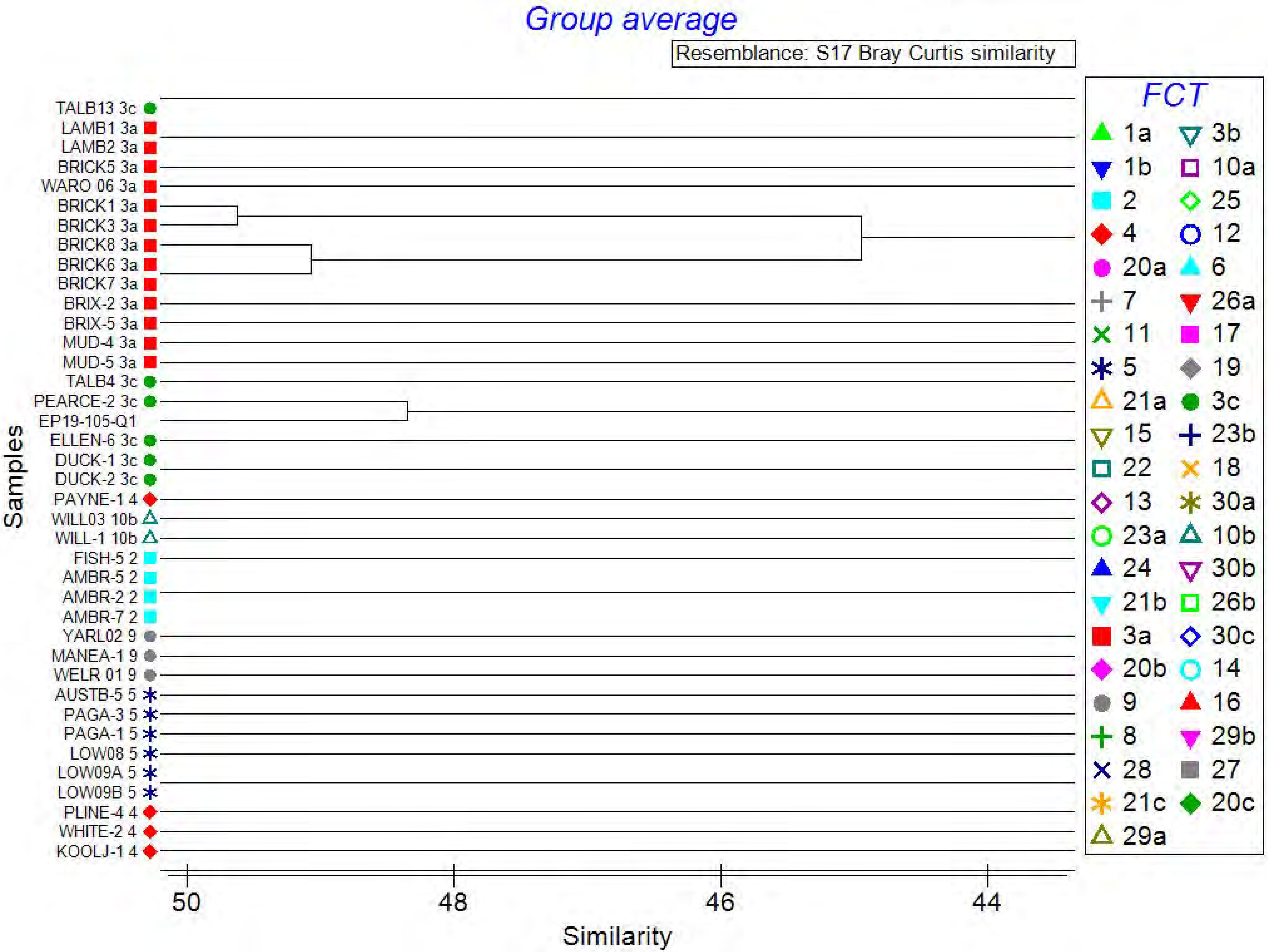
Project no.: EP19-105(07)
Date: 18/09/2019 **Status** Non-permanent
Author: RAW R7: Page 2 of 2

Species Data
* denotes non-native species

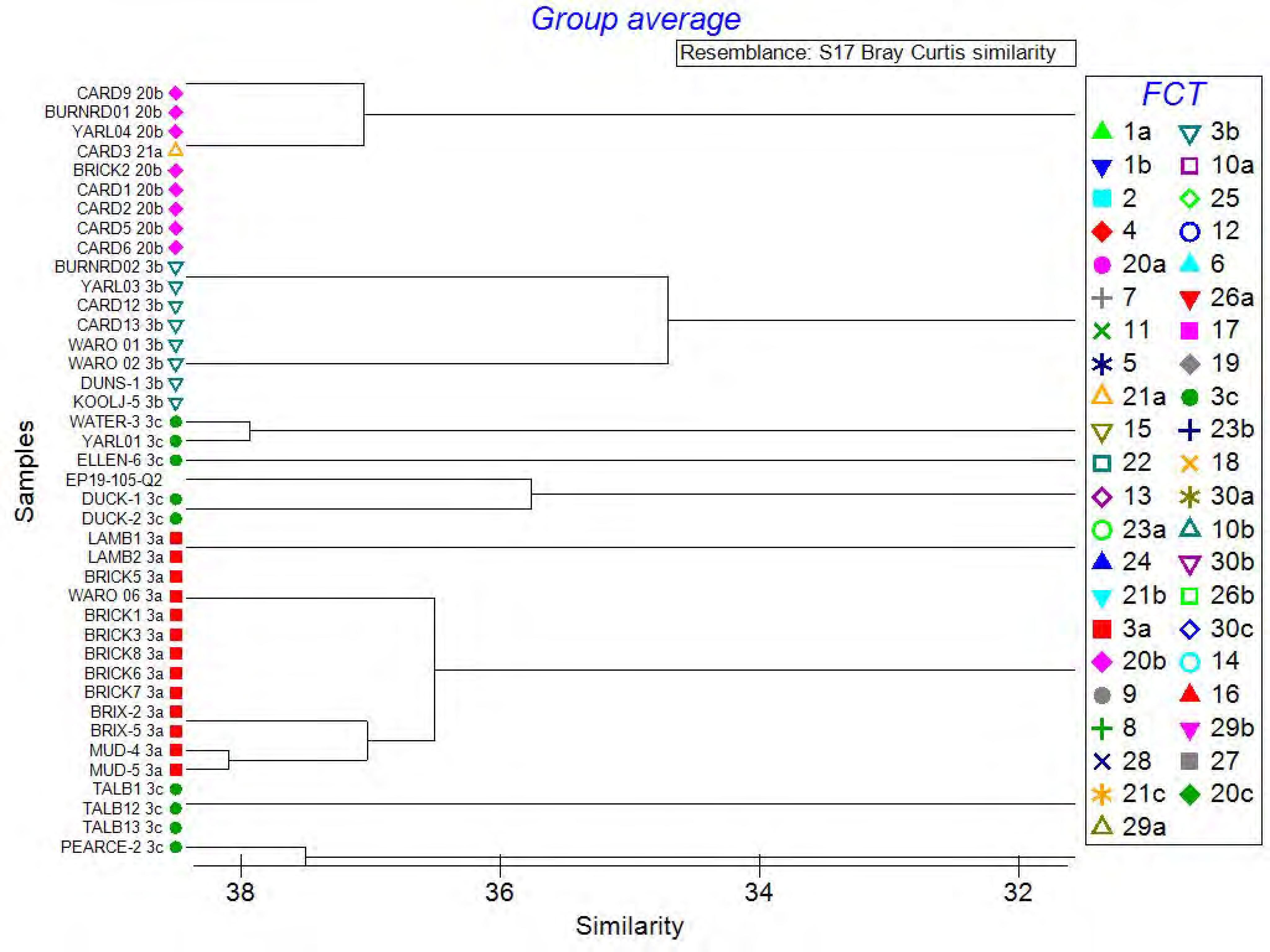
Status	Confirmed name	Cover (%)
	Acacia pulchella var. pulchella	
	Acacia saligna	
	Acacia sp.	
	Billardiera heterophylla	
*	*Briza maxima*	
*	*Cenchrus setaceus*	
*DP,WONS	*Chrysanthemoides monilifera subsp. monilifera*	
*	*Ehrharta calycina*	
*	*Ehrharta longiflora*	
*	*Eragrostis curvula*	
	Eucalyptus rudis	
	Gastrolobium nervosum	
	Haemodorum laxum	
	Hakea erinacea	
	Hakea prostrata	
	Hakea trifurcata	
	Hakea undulatum	
*	*Hesperantha falcata*	
	Hypocalymma angustifolium	
	Jacksonia sternbergiana	
	Kennedia prostrata	
*	*Oxalis glabra*	
*	*Oxalis pes-caprae*	
	Patersonia occidentalis	
	Phyllanthus calycinus	
	Thelymitra ?macrophylla	

Appendix F

Cluster Dendrograms



Group average
Resemblance: S17 Bray Curtis similarity
FCT
1a
3b
1b
10a
2
25
4
12
20a
6
7
26a
11
17
5
19
21a
3c
15
23b
22
18
13
30a
23a
10b
24
30b
21b
26b
3a
30c
20b
14
9
16
8
29b
28
27
21c
20c
29a
Samples
TALB13 3c
LAMB1 3a
LAMB2 3a
BRICK5 3a
WARO 06 3a
BRICK1 3a
BRICK3 3a
BRICK8 3a
BRICK6 3a
BRICK7 3a
BRIX-2 3a
BRIX-5 3a
MUD-4 3a
MUD-5 3a
TALB4 3c
PEARCE-2 3c
EP19-105-Q1
ELLEN-6 3c
DUCK-1 3c
DUCK-2 3c
PAYNE-1 4
WILL03 10b
WILL-1 10b
FISH-5 2
AMBR-5 2
AMBR-2 2
AMBR-7 2
YARL02 9
MANEA-1 9
WELR 01 9
AUSTB-5 5
PAGA-3 5
PAGA-1 5
LOW08 5
LOW09A 5
LOW09B 5
PLINE-4 4
WHITE-2 4
KOOLJ-1 4
50
48
46
44
Similarity



Group average
Resemblance: S17 Bray Curtis similarity
CARD9 20b
BURNRD01 20b
YARL04 20b
CARD3 21a
BRICK2 20b
CARD1 20b
CARD2 20b
CARD5 20b
CARD6 20b
BURNRD02 3b
YARL03 3b
CARD12 3b
CARD13 3b
WARO 01 3b
WARO 02 3b
DUNS-1 3b
KOOLJ-5 3b
WATER-3 3c
YARL01 3c
ELLEN-6 3c
EP19-105-Q2
DUCK-1 3c
DUCK-2 3c
LAMB1 3a
LAMB2 3a
BRICK5 3a
WARO 06 3a
BRICK1 3a
BRICK3 3a
BRICK8 3a
BRICK6 3a
BRICK7 3a
BRIX-2 3a
BRIX-5 3a
MUD-4 3a
MUD-5 3a
TALB1 3c
TALB12 3c
TALB13 3c
PEARCE-2 3c
Samples
38
36
34
32
Similarity
FCT
1a
3b
1b
10a
2
25
4
12
20a
6
7
26a
11
17
5
19
21a
3c
15
23b
22
18
13
30a
23a
10b
24
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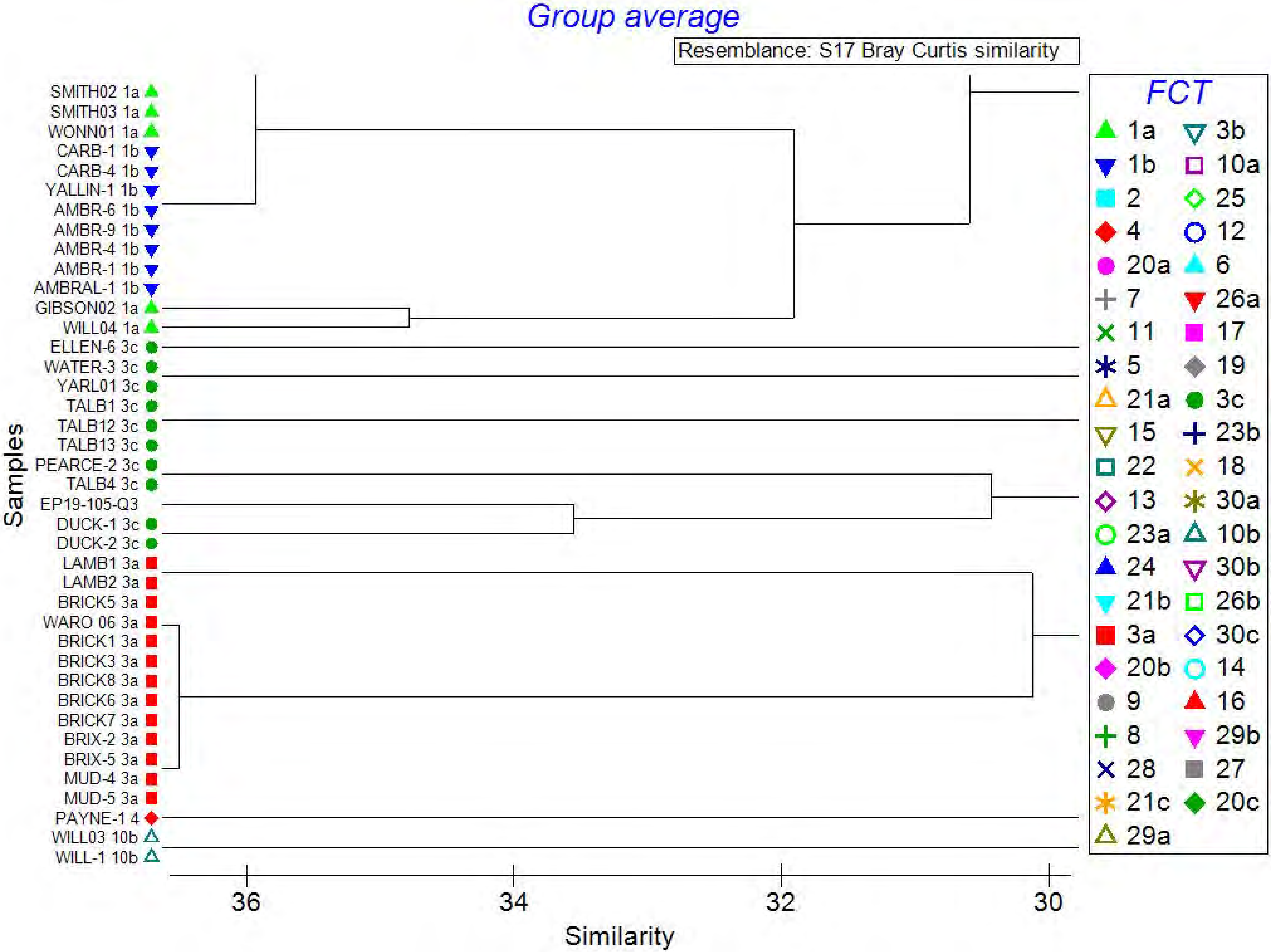
3a
30c
20b
14
9
16
8
29b
28
27
21c
20c
29a


Group average
Resemblance: S17 Bray Curtis similarity
SMITH02 1a
SMITH03 1a
WONN01 1a
CARB-1 1b
CARB-4 1b
YALLIN-1 1b
AMBR-6 1b
AMBR-9 1b
AMBR-4 1b
AMBR-1 1b
AMBRAL-1 1b
GIBSON02 1a
WILL04 1a
ELLEN-6 3c
WATER-3 3c
YARL01 3c
TALB1 3c
TALB12 3c
TALB13 3c
PEARCE-2 3c
TALB4 3c
EP19-105-Q3
DUCK-1 3c
DUCK-2 3c
LAMB1 3a
LAMB2 3a
BRICK5 3a
WARO 06 3a
BRICK1 3a
BRICK3 3a
BRICK8 3a
BRICK6 3a
BRICK7 3a
BRIX-2 3a
BRIX-5 3a
MUD-4 3a
MUD-5 3a
PAYNE-1 4
WILL03 10b
WILL-1 10b
Samples
36
34
32
30
Similarity
FCT
1a
3b
1b
10a
2
25
4
12
20a
6
7
26a
11
17
5
19
21a
3c
15
23b
22
18
13
30a
23a
10b
24
30b
21b
26b
3a
30c
20b
14
9
16
8
29b
28
27
21c
20c
29a

Appendix D

Noise Assessment Plan - Watermark Stage 3 Local Structure Plan (Lloyd George Acoustics 2021)

Lloyd George Acoustics
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Noise Management Plan

'Rivermark' Area 3 Local Scheme Amendment

Reference: 20085657-14 Area 3

Prepared for:
Hesperia

Association of Australasian Acoustical Consultants

Report: 20085657-14 Area 3

Lloyd George Acoustics Pty Ltd

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P:	0457 095 555	0410 107 440	0420 364 650	0438 481 207

Date:	Rev	Description	Prepared By	Verified
26-Aug-21	1	Draft for comment	Terry George	-
22-Oct-21	0	Updated with element comments	Terry George	-

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Appendices

1 INTRODUCTION

Hesperia Pty Ltd is the Development Manager for the owners of the land (Capitary No.2) east of Cranwood Crescent in Viveash, currently occupied by the Midland Brick Industrial site. This report forms the Noise Management Plan (NMP) for Area 3 of the project as located in *Figure 1-1*.

Figure 1-1 Project Locality

This NMP is provided in support of the proposed local scheme amendment to the City of Swan, which seeks to rezone the site from Industrial to Residential – R20. The future overall residential subdivision development will occur in an orderly stage along with the contraction of the brickworks footprint. An application was made in late 2020 to have Kilns 7 and 8 removed from the current Part V Licence. In addition, Kiln 11 will be decommissioned and removed from the Part V Licence in April 2022, with an application having been made to this effect.

Capitary No.2 has leased portions of the brickworks site to BGC. A general summary of the lease arrangements is provided below and on *Figure 1-3*:

- Existing brickworks site area will remain active until April 2022;
- In April 2022, BGC access reverts to the Clay Shed lease area (Area C), the Masonry Facility area (Lot 11) and the kiln 9 and 10 lease area (Area B1 and B2). That is, the only brickwork related activity south of Bassett Road after April 2022 will be the Clay Shed. **Area 3 is expected to be subdivided after this time**;
- The Clay Shed lease is for a period between 5 and 10 years;
- The Masonry Facility will be created on a standalone title and is envisaged to operate into the long term;
- The Kiln 9 and 10 lease area is for a period between 5 and 15 years.

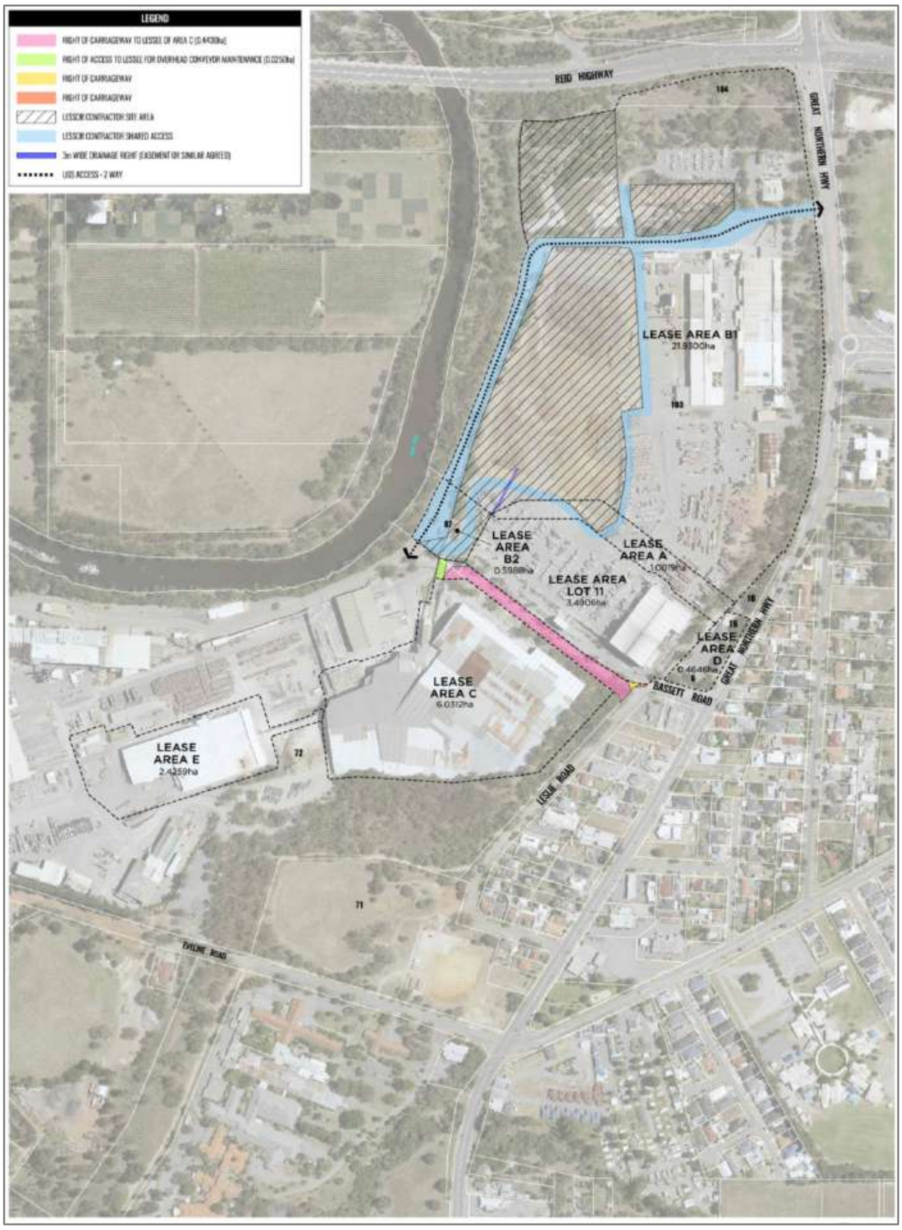


Figure 1-2 Lease Area Plan

The formal arrangement between Capitary No.2 and BGC to operate the Midland Brick site is with the knowledge by both Parties, that the southern portion of the brickworks is proposed as residential development. As part of this arrangement, Herring Storer Acoustics (HSA) was engaged to act as an independent acoustic consultant for both Parties. HSA has considered three operational scenarios that are likely to occur until the clay brickworks are fully decommissioned:

A. Full brickwork operations north of Bassett Road (i.e. Kilns 9 and 10 and Masonry Facilities) plus the Clay Shed operations;

B. Full operations north of Bassett Road only (i.e. Kilns 9 and 10 and Masonry Facilities and no Clay Shed operations); and

C. Masonry Facility only, located immediately north of Bassett Road.

The HSA report is contained within *Appendix A*[1] having assessed the noise emissions to the proposed residential development against the prescribed standards of the *Environmental Protection (Noise) Regulations 1997*. The findings of this study have been considered for Area 3.

As well as the potential impacts of industrial noise, noise from aircraft is also given consideration, noting the 20 ANEF (Aircraft Noise Exposure Forecast) contour is located across the site. Aircraft noise is assessed against the requirements of *State Planning Policy No. 5.1 Land Use Planning in the Vicinity of Perth Airport*.

2 CRITERIA

2.1 Industrial Noise

Noise from the Midland Brick site to the proposed urban development is governed by the *Environmental Protection Act 1986*, through the *Environmental Protection (Noise) Regulations 1997* (the Regulations).

Regulation 7 defines the prescribed standard for noise emissions as follows:

"7. (1) Noise emitted from any premises or public place when received at other premises –

(a) Must not cause or significantly contribute to, a level of noise which exceeds the assigned level in respect of noise received at premises of that kind; and

(b) Must be free of –

i. tonality;

ii. impulsiveness; and

iii. modulation,

when assessed under regulation 9"

A "…noise emission is taken to significantly contribute to a level of noise if the noise emission … exceeds a value which is 5 dB below the assigned level…"

Tonality, impulsiveness and modulation are defined in Regulation 9. Noise is to be taken to be free of these characteristics if:

(a) The characteristics cannot be reasonably and practicably removed by techniques other than attenuating the overall level of noise emission; and

(b) The noise emission complies with the standard prescribed under regulation 7 after the adjustments of *Table 2-1* are made to the noise emission as measured at the point of reception.

[1] *Acoustic Assessment, Midland Brick Site Redevelopment*; July 2021, Reference: 27982-2-20355-02

Table 2-1 Adjustments Where Characteristics Cannot Be Removed

Where Noise Emission is Not Music			Where Noise Emission is Music	
Tonality	Modulation	Impulsiveness	No Impulsiveness	Impulsiveness
+ 5 dB	+ 5 dB	+ 10 dB	+ 10 dB	+ 15 dB

Note: The above are cumulative to a maximum of 15dB.

The baseline assigned levels (prescribed standards) are specified in Regulation 8 and are shown in *Table 2-2*.

Table 2-2 Baseline Assigned Noise Levels

Premises Receiving Noise	Time Of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises: highly sensitive area[1]	0700 to 1900 hours Monday to Saturday (Day)	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sunday and public holidays (Sunday)	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days (Evening)	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays (Night)	35 + influencing factor	45 + influencing factor	55 + influencing factor

1. ***highly sensitive area*** means that area (if any) of noise sensitive premises comprising —
   (a) a building, or a part of a building, on the premises that is used for a noise sensitive purpose; and
   (b) any other part of the premises within 15 metres of that building or that part of the building.

The influencing factor, applicable at noise sensitive premises varies depending upon their proximity to commercial and industrial zoned land within a 450 metre radius. As such, the assigned noise level varies at different future residences within the existing and proposed urban zoned land and becomes a complex analysis. HSA has discussed the assigned noise levels in their report in Section 4.0, providing Map C, shown as *Figure 2-1*, demonstrating the various assigned levels based on the ultimate scenario (Masonry Facility only). The influencing factor across Area 3 is shown to be 0 dB and thus the assigned night-time level is 35 dB L_{A10}.

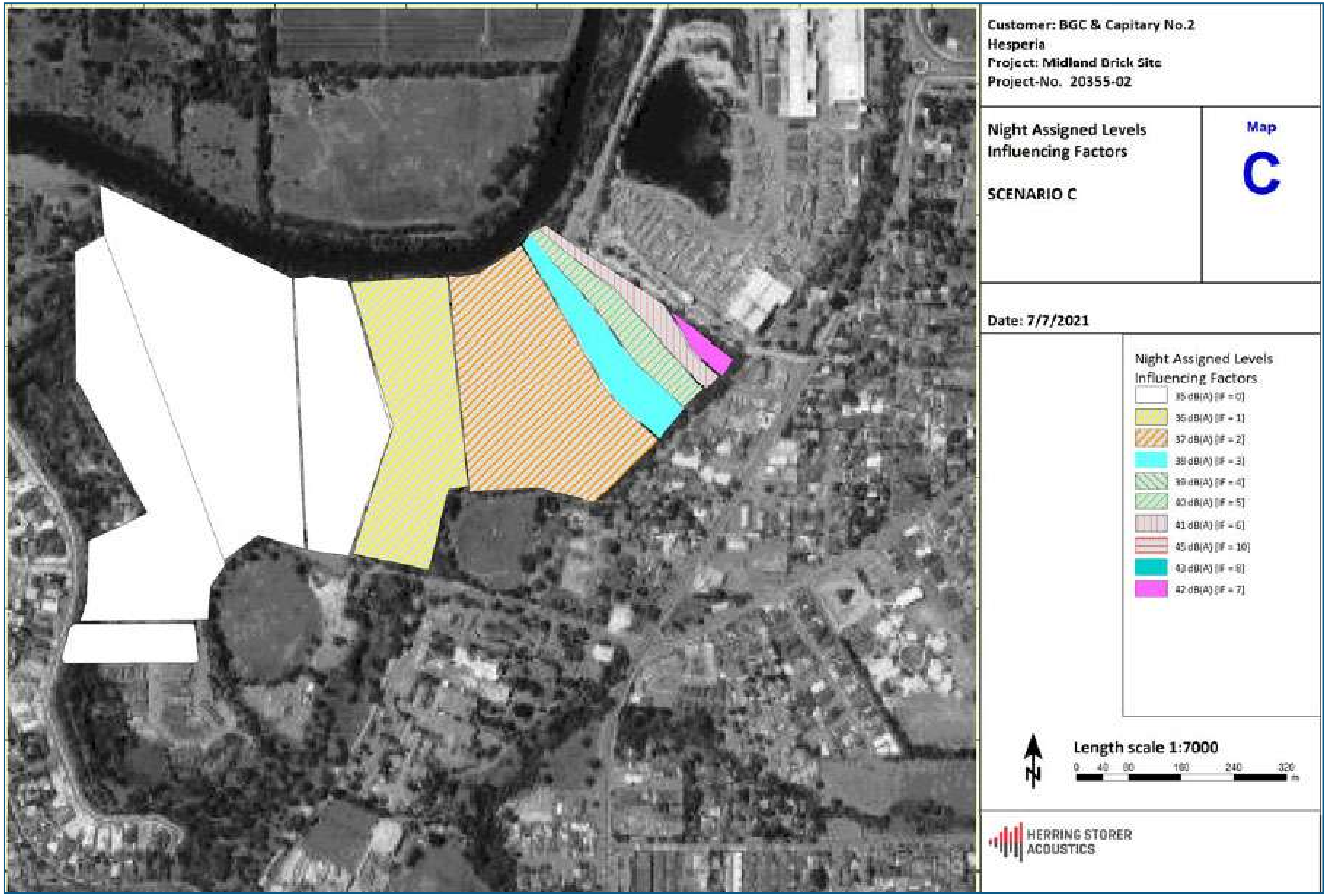


Figure 2-1 Night-time Assigned Noise Levels

2.2 Aircraft Noise

The relevant planning policy in Western Australia in relation to aircraft noise is *State Planning Policy 5.1 Land Use Planning in the Vicinity of Perth Airport*; July 2015, Western Australian Planning Commission (SPP 5.1). SPP 5.1 applies to any land within ANEF 20 and separates land into three zones:

- Areas below 20 ANEF;
- Areas between 20 ANEF and 25 ANEF; and
- Areas above 25 ANEF.

The entirety of Area 3 falls within 20 ANEF (refer *Figure 2-2* where the pink shading is the 20-25 ANEF zone). Note that the ANEF contours are associated with the future parallel runway.

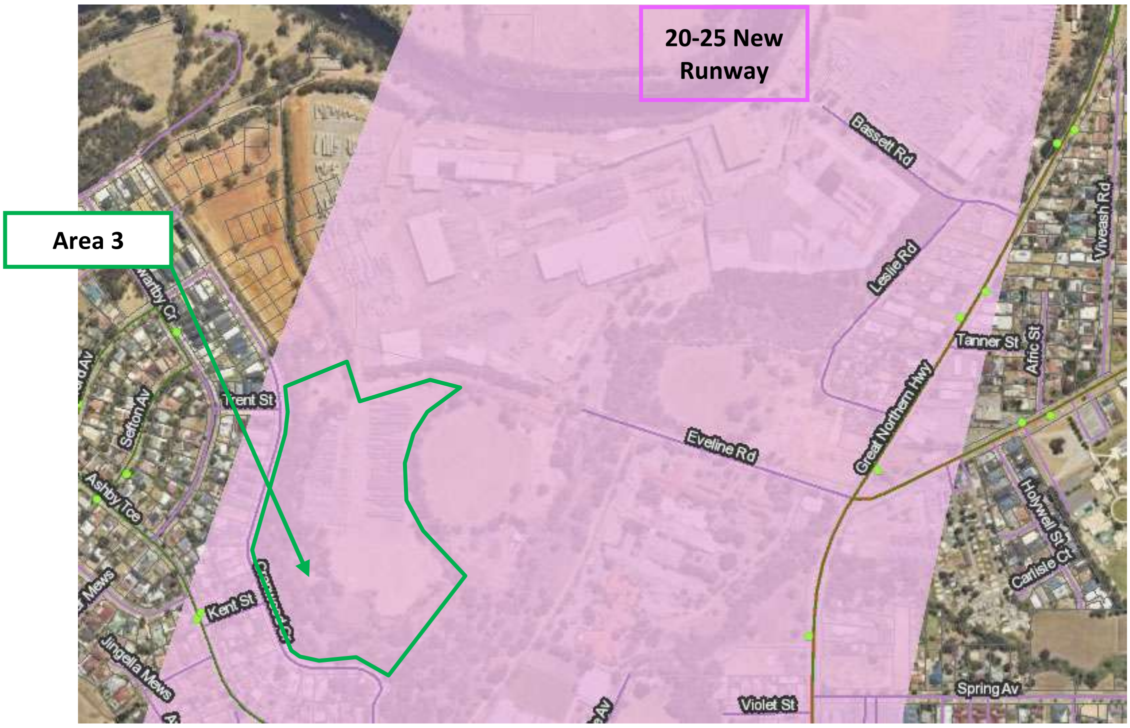


Figure 2-2 ANEF Contour Over Site

For areas within the 20-25 ANEF contour, SPP 5.1 states the following:

- Maximum residential density should be limited to R20;
- Noise insulation is not mandatory for residential development. Some areas however, may experience peak aircraft noise levels in excess of the Indoor Design Levels specified in AS2021, and noise insulation is recommended in such cases.
- Closure of windows and other openings to habitable rooms can significantly reduce the intrusion of aircraft noise. This will normally require forced ventilation, and may also necessitate some form of active cooling, such as refrigerative air conditioning. The operational management of buildings however, is outside the ambit of this policy, and will therefore be subject only to advice.
- A 'notice on title'advising of the potential for noise nuisance is to be required as a condition of any subdivision or planning approval within this noise exposure zone.

3 METHODOLOGY

3.1 Industrial Noise

As described, Herring Storer Acoustics (HSA) was engaged to undertake noise modelling from the Midland Brick site. HSA has used the noise modelling package *SoundPLAN 8.2* along with the *CONCAWE* algorithms and worst-case meteorological conditions as part of the assessment – refer *Appendix A* for full report and methodology.

3.2 Aircraft Noise

Figure 2-2 showed Area 3 will be within the 20-25 ANEF contour. SPP 5.1 states that whilst noise insulation is not mandatory, some areas may experience maximum aircraft noise levels in excess of the Indoor Design Sound Levels specified in AS2021[2], and noise insulation is recommended in such cases. Guidance on noise insulation measures is contained within the Western Australian Planning Commission report, *Aircraft Noise Insulation for Residential Development in the Vicinity of Perth Airport* (Noise Insulation report).

The ANEF contours are a planning tool and do not represent actual noise levels. As such, Perth Airport also produce N65 Contours, which represent the average number of daily aircraft above a noise level of 65 dB L_{Amax}, considered to represent a point at which normal conversation may be disturbed. An extract of these contours taken from *Perth Airport Master Plan 2020 Summary* is provided in *Figure 3-1* with the approximate location of Area 3. This shows that the area is expected to be subjected to 100-200 events per day above a noise level of 65 dB L_{Amax}.

Aircraft noise levels can be further explored by using the AS2021:2015 look-up tables. For this runway and area, the departing Airbus 330 is likely to result in the worst-case maximum noise levels. An extract of the noise level table for this aircraft is provided in *Figure 3-2* noting the noise level varies with distance from the far end of the runway (DT) and the offset (DS) distance (refer *Figure 3-3*). The relevant noise levels are within the red area in *Figure 3-2*.

[2] Indoor design sound levels for residences are 50 dB L_{Amax} in bedrooms and 55 dB L_{Amax} in living areas.

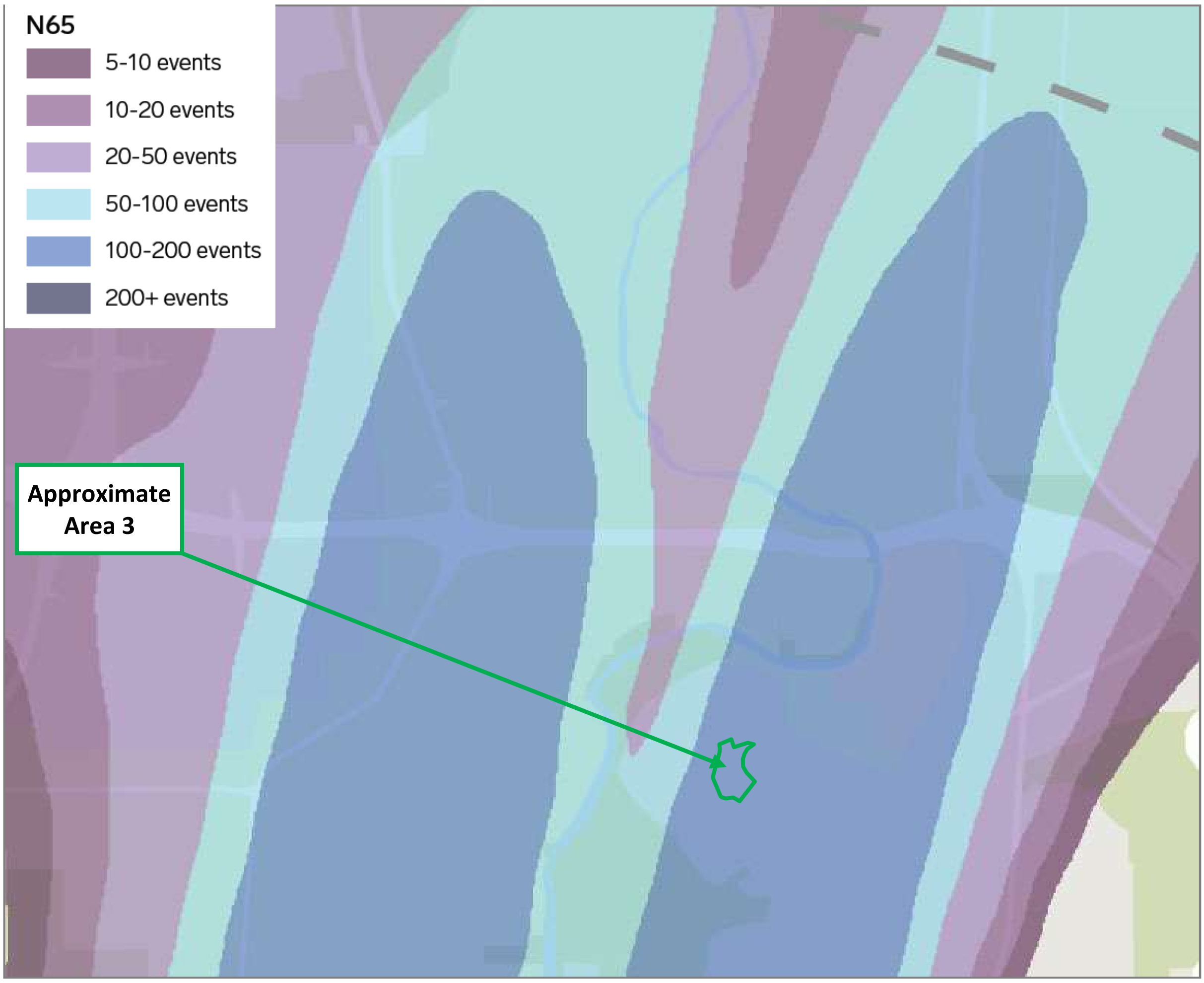


Figure 3-1 Site Locality in Relation to Ultimate N65 Contours

NOISE LEVELS FOR AIRBUS A330-301 DEPARTURES

Centre-line distance (DT), m	Noise levels, dB(A)																		
	Sideline distance (DS), m																		
	0	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000	2200	2400	2600
10 000	77	77	76	76	76	75	74	73	72	72	71	69	67	65	63	62	60	59	57
10 500	76	76	76	75	75	74	74	73	72	71	70	68	67	65	63	62	60	59	58
11 000	75	75	75	75	74	74	73	73	72	71	70	68	67	65	63	62	60	59	58
11 500	75	75	75	74	74	74	73	72	72	71	70	68	67	65	63	62	60	59	58
12 000	75	75	74	74	74	73	73	72	72	71	70	68	67	65	63	62	61	59	58
12 500	74	74	74	74	74	73	73	72	72	71	70	68	67	65	64	62	61	59	58
13 000	74	74	74	74	74	73	73	72	71	71	70	68	67	65	64	62	61	59	58
13 500	74	74	74	74	73	73	73	72	71	71	70	68	67	65	64	62	61	59	58
14 000	74	74	74	73	73	73	72	72	71	70	70	68	67	65	64	62	61	59	58

Figure 3-2 AS2021 Look-up Table for Departing Airbus 330

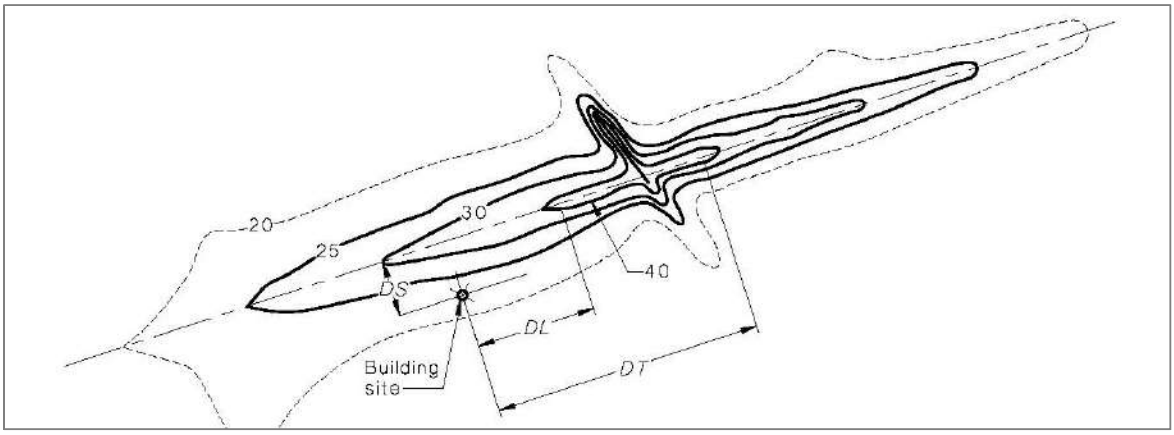


Figure 3-3 AS2021 Determination of Distances

4 RESULTS

4.1 Industry Noise

Herring Storer Acoustics (HSA) considered three scenarios of noise emissions from the Midland Brick site as follows:

A. Full brickwork operations north of Bassett Road (i.e. Kilns 9 and 10 and Masonry Facilities) plus the Clay Shed operations south of Bassett Road;

B. Full operations north of Bassett Road only (i.e. Kilns 9 and 10 and Masonry Facilities and no Clay Shed operations); and

C. Masonry Facility only, located immediately north of Bassett Road.

4.1.1 Scenario A

In this scenario, everything on the north side of Bassett Road is operational, consisting mostly of Kilns 9 and 10 and the Masonry Facility. The Clay Shed will operate only during the day and evening, with the exception of conveyor transfer of materials from the Clay Shed (bins) to Kilns 9 and 10. This scenario is relevant for between the next 5 and 10 years. Two noise contour plots are provided:

- *Figure 4-1* representing the day/evening scenario, at which time the assigned noise levels are at least 5 dB higher than those during the night, and
- *Figure 4-2* representing the night scenario (*Figure 4-2*).

Triple stacked shipping containers are included on the west side of the Clay Shed and double stacked shipping containers at the nearest future residences to act as noise barriers.

The thick red line on these plots indicates the point at which residential development is compliant with the Noise Regulations. Area 3 is outside of this line and therefore considered compliant.

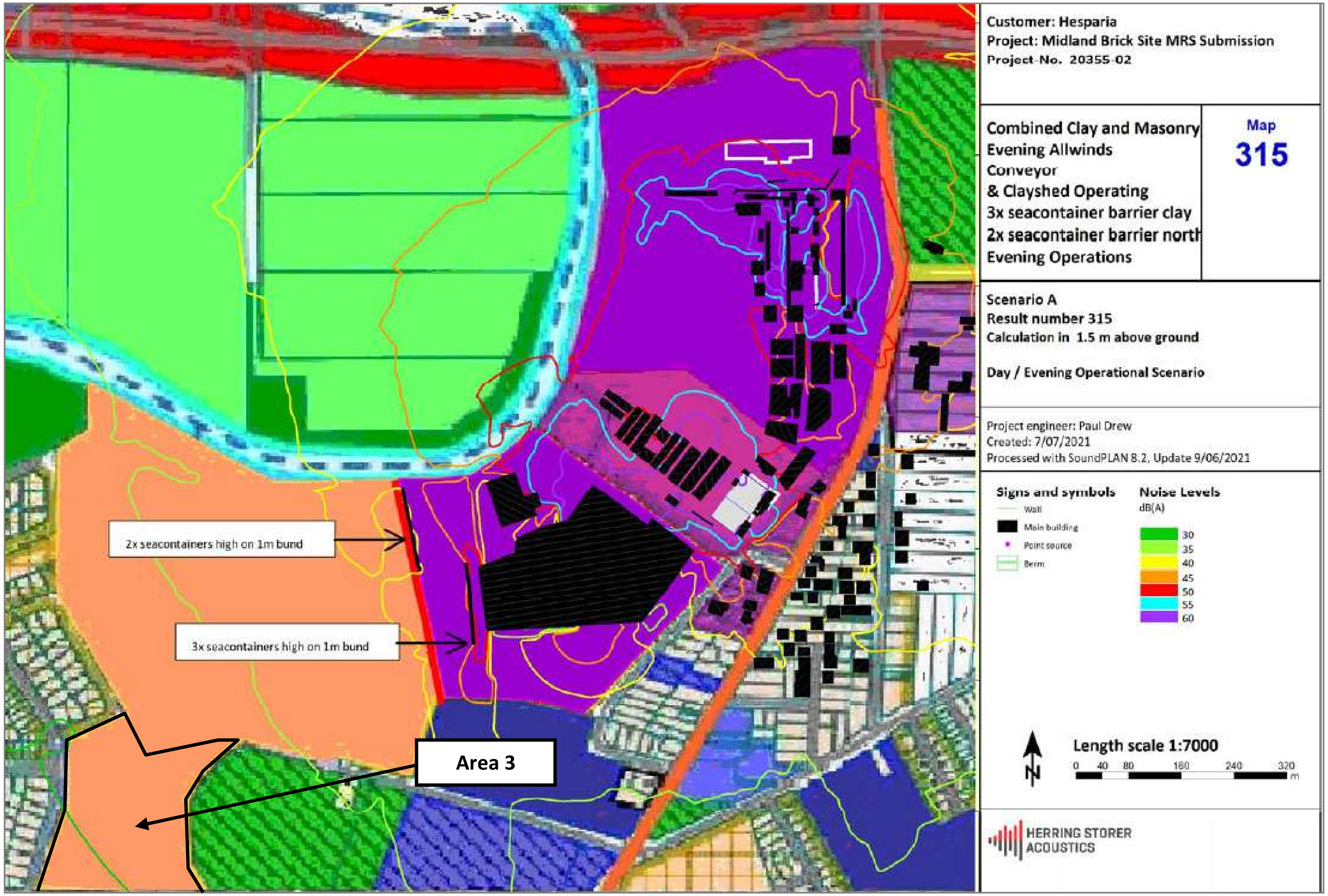


Figure 4-1 Noise Contour Plot: Scenario A Day/Evening Period

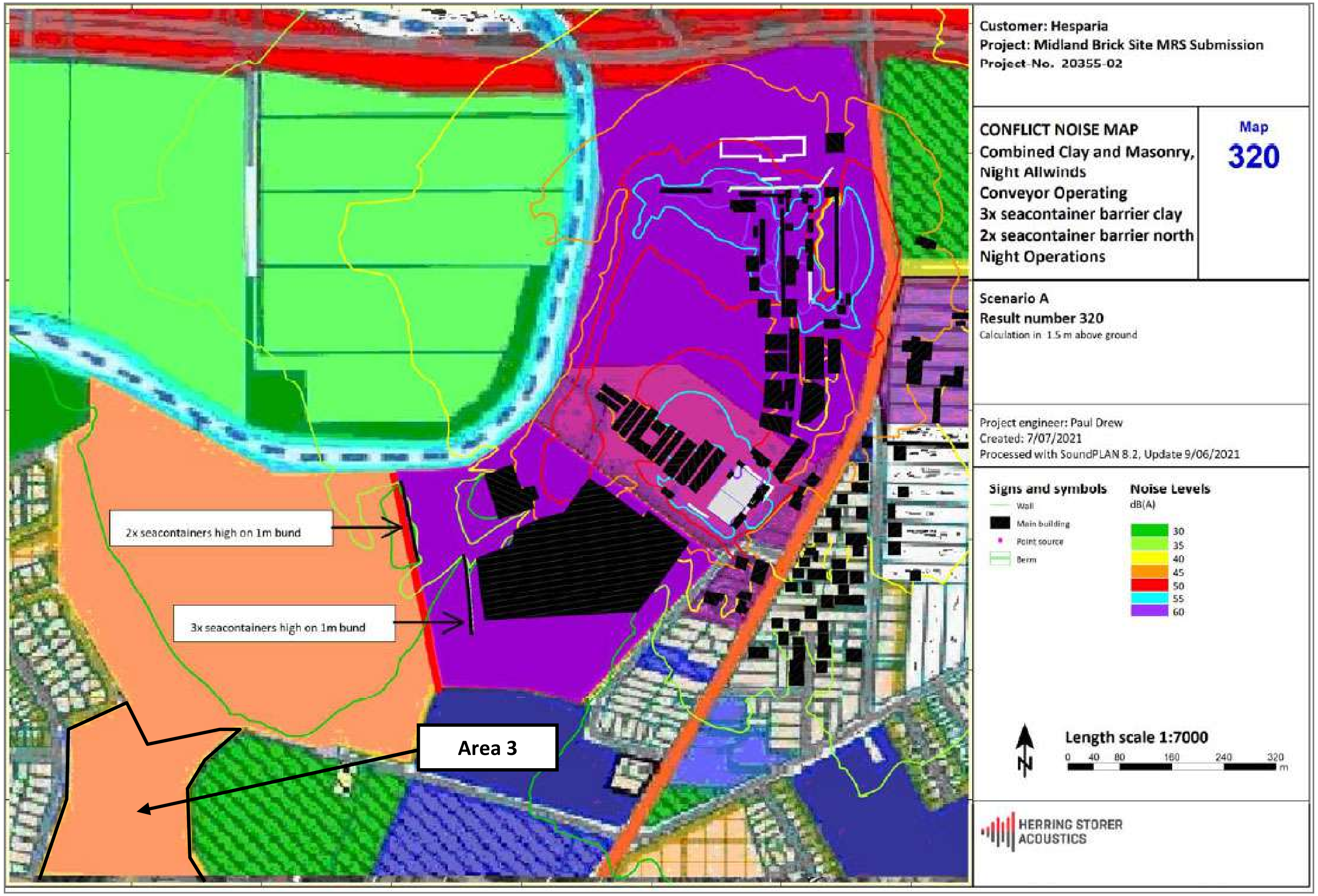


Figure 4-2 Noise Contour Plot: Scenario A Night Period

4.1.2 Scenario B

Scenario B is the same as Scenario A, with the exception that the Clay Shed on the south side of Bassett Road and associated conveyor are no longer in use. Before the Clay Shed is demolished, a 5-metre high wall will be constructed abutting the south side of the masonry lot to act as a noise barrier.

The noise contour plot associated with this scenario is provided in *Figure 4-3*. Also shown is the line indicating the point where compliance is achieved. Area 3 is outside of this line and therefore considered compliant.

4.1.3 Scenario C

Scenario C represents the long term scenario where the only remaining plant operating at the Midland Brick site is the Masonry Facility. This is to be assumed to be operating indefinitely and represents the scenario that will exist in 10-15 years time, depending on whether BGC take up the additional 5 year option for the clay operations.

The noise contour plot associated with this scenario is provided in *Figure 4-4*. Compliance is achieved at all proposed residential land including the proposed Area 3.

4.1.4 Summary

The outcome of the industrial noise assessment by HSA is that noise to Area 3 will comply with the *Environmental Protection (Noise) Regulations 1997* at all times. This is on the basis of:

- the only operations existing south of Bassett Road is the Clay Shed;
- the Clay Shed does not operate during the night, with the exception of the conveyor transfer of materials from the Clay Shed (bins) to kilns 9 and 10;
- Triple stacked shipping containers are included on the west side of the Clay Shed and double stacked shipping containers at the nearest future residences to act as noise barriers.

The above relates to Scenario A. Before the Clay Shed is demolished, a 5-metre high wall will be constructed abutting the south side of the masonry lot to act as a noise barrier.

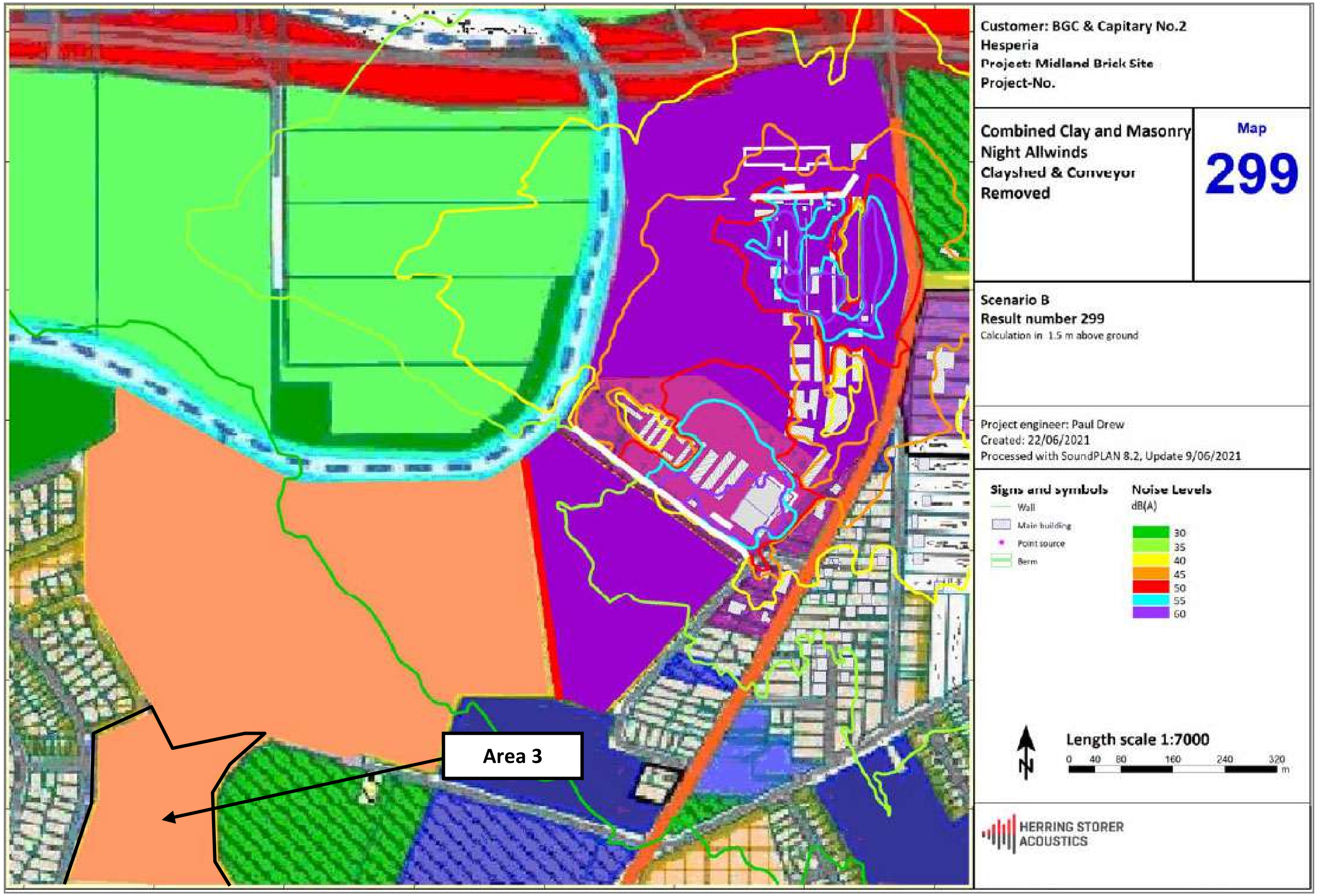


Figure 4-3 Noise Contour Plot: Scenario B

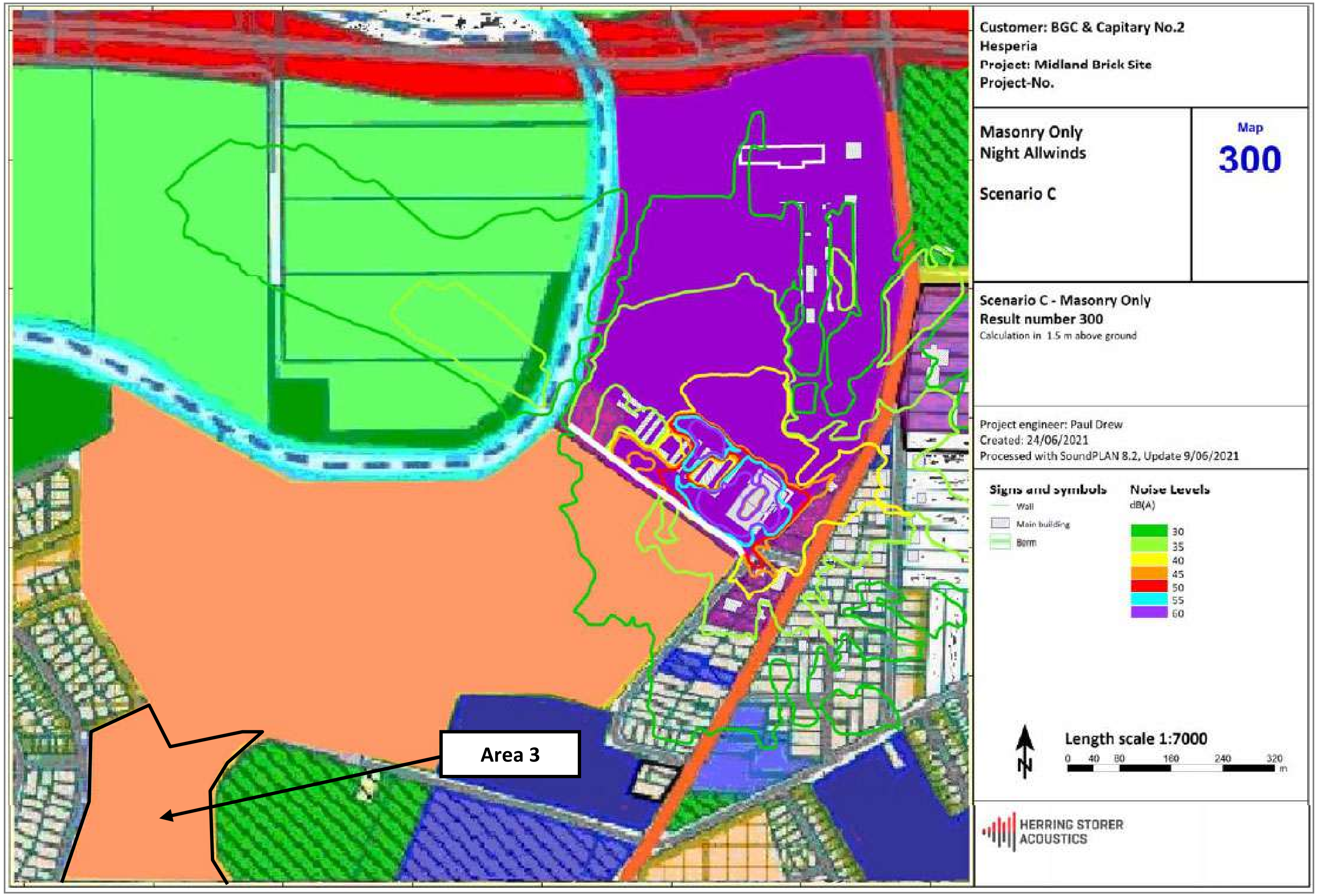


Figure 4-4 Noise Contour Plot: Scenario C

4.2 Aircraft Noise

As described in *Section 3.2*, Area 3 is expected to be subjected to 100-200 aircraft events per day above 65 dB L_{Amax}. The Airbus A330 on departure is expected to align with the typical aircraft maximum noise levels and these have been shown across the site on *Figure 4-5*.

The noise level on the subject site will range 74-75 dB L_{Amax} from a departing Airbus A330 with arrivals being a similar noise level (within 1 dB) to departures. Other aircraft (Airbus A380 and Boeing 737-700 and 737-800) are also expected to be around the 73-74 dB L_{Amax} level. The indoor design sound levels from AS2021 for a residential building are 50 dB L_{Amax} inside bedrooms and 55 dB L_{Amax} inside living areas, meaning an aircraft noise reduction from outside to inside of 25 dB and 20 dB respectively is required.

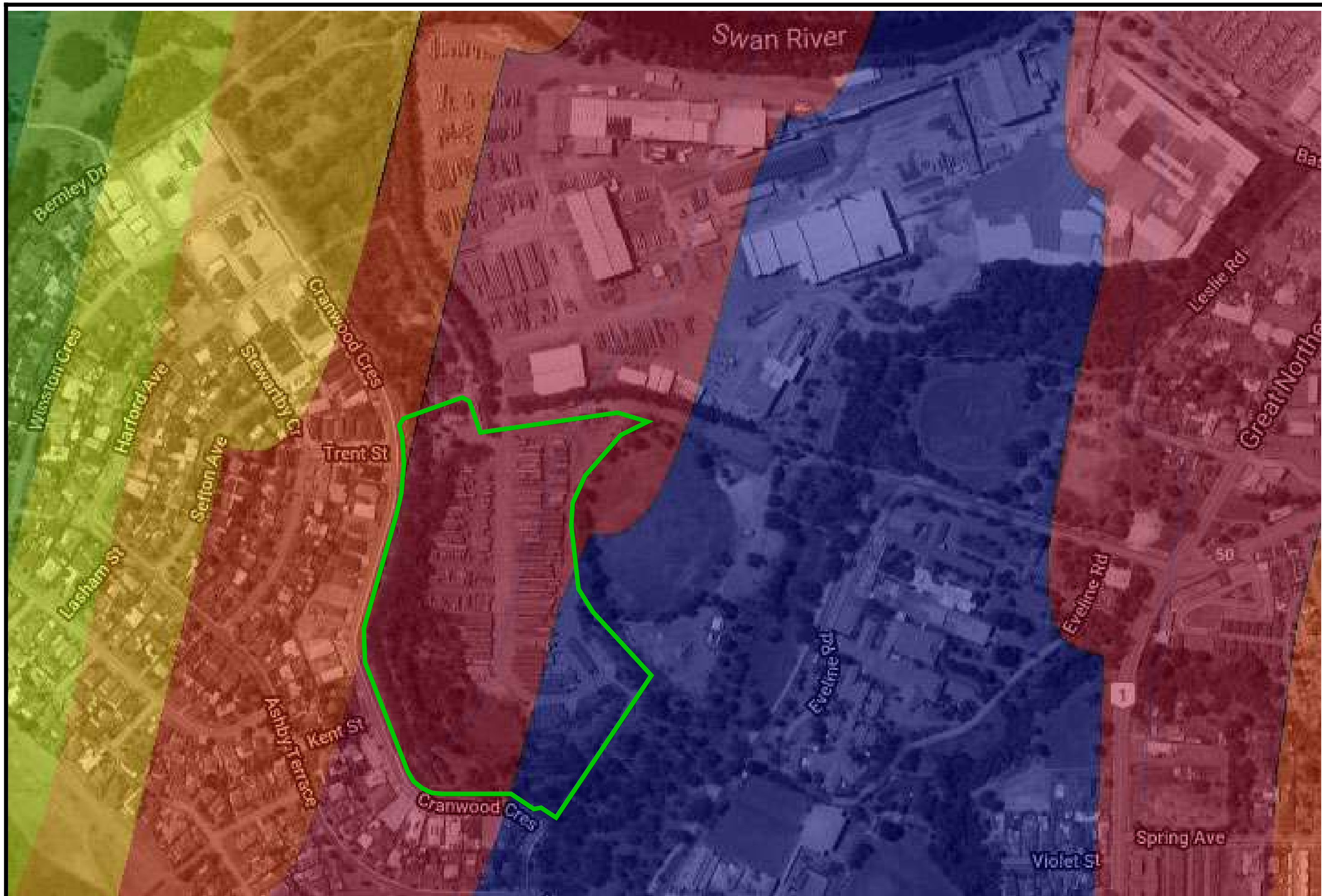
A noise reduction of 20 dB(A) is generally readily achievable with standard construction, provided windows and doors are closed and of a standard size (that is, the larger the glazing the more noise entering via this element). For instance, 4mm thick glass in a sliding window frame is expected to achieve $R_w + C_{tr}$ 20 performance.

SPP 5.1 does not mandate any noise insulation where residences are located within the 20-25 ANEF contour but does require notifications on lot title. Given the expected number of aircraft movements above 65 dB L_{Amax}, it is suggested that the following be considered:

- Walls to achieve $R_w + C_{tr}$ 45 construction. Appropriate constructions may be:
    - double leaf cavity brickwork; or
    - brick veneer being 90mm brick, 50mm cavity stud with 90mm thick, 11kg/m^3 fibrous insulation and 13mm plasterboard/6mm fibre cement sheet; or
    - 6mm fibre cement sheet to 140mm timber stud with 70mm thick *Soundscreen 2.0* fibrous insulation and 13mm thick sound-rated plasterboard to furring channels and resilient mounts.
- Roof/ceiling to achieve $R_w + C_{tr}$ 35 construction (e.g. 24^o metal deck or tiled roof, 10mm thick plasterboard with R4.0 fibrous insulation above). Where a raked ceiling is proposed, plasterboard to be 13mm thick fire/sound-rated;
- All external glazing to habitable rooms be minimum 6mm thick;
- External windows to habitable rooms be fixed or awning style with acoustic seals;
- External sliding doors, bi-fold doors or similar to be fitted with acoustic seals;
- Entry door to be minimum 35mm thick, solid timber core with full perimeter acoustic seals;
- Air-conditioning recommended with fresh air intakes to allow windows to be closed.

The upgraded construction listed above is expected to achieve a 25-28 dB noise reduction (depending on glazing size). Alternative constructions can be assessed by a suitably qualified acoustical consultant (member firm of the Association of Australasian Acoustic Consultants).

Figure 4-5



Lmax Noise Level
in dB(A)

<	70
>=	70
>=	71
>=	72
>=	73
>=	74
>=	75

Legend
Area 3

Typical Maximum Aircraft Noise Level -
Airbus A330 Departure on Future Parallel Runway

L_{Amax} Noise Level Contours Future Runway

25 August 2021

Length Scale 1:7000

0 35 70 140 210 280 m

Lloyd George Acoustics
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(08) 9401 7770

5 CONCLUSION

To manage noise impacts to the proposed urban area of Area 3, the following is proposed to be implemented:

- All residential lots are to incorporate the following notifications:

  "This lot is in close proximity to an existing bricks works and may be adversely affected by virtue of gaseous, odour, noise and/or dust emissions from that facility."

  "This lot is situated in the vicinity of Perth Airport, and is currently affected, or may in the future, be affected by aircraft noise. Noise exposure levels are likely to increase in the future as a result of increases in numbers of aircraft using the airport, changes in aircraft type or other operational changes. Further information about aircraft noise, including development restrictions and noise insulation requirements for noise affected properties, are available on request from the relevant local government offices."

- It is suggested (not mandatory) that the following be considered in the construction of dwellings:
  - Walls to achieve $R_w + C_{tr}$ 45 construction. Appropriate constructions may be:
    - double leaf cavity brickwork; or
    - brick veneer being 90mm brick, 50mm cavity stud with 90mm thick, 11kg/m^3 fibrous insulation and 13mm plasterboard/6mm fibre cement sheet; or
    - 6mm fibre cement sheet to 140mm timber stud with 70mm thick *Soundscreen 2.0* fibrous insulation and 13mm thick sound-rated plasterboard to furring channels and resilient mounts.
  - Roof/ceiling to achieve $R_w + C_{tr}$ 35 construction (e.g. 24^o metal deck or tiled roof, 10mm thick plasterboard with R4.0 fibrous insulation above). Where a raked ceiling is proposed, plasterboard to be 13mm thick fire/sound-rated;
  - All external glazing to habitable rooms be minimum 6mm thick;
  - External windows to habitable rooms be fixed or awning style with acoustic seals;
  - External sliding doors, bi-fold doors or similar to be fitted with acoustic seals;
  - Entry door to be minimum 35mm thick, solid timber core with full perimeter acoustic seals;
  - Air-conditioning recommended with fresh air intakes to allow windows to be closed.

- No brick work operations shall occur south of Bassett Road other than the Clay Shed. Whilst the Clay Shed remains in operation, all but the conveyor transfer of materials from the Clay Shed (bins) to kilns 9 and 10, shall be during the day and evening only. Triple stacked shipping containers are included on the west side of the Clay Shed and double stacked shipping containers at the nearest future residences to act as noise barriers. Before the Clay Shed is demolished, a 5-metre high wall will be constructed abutting the south side of the masonry lot to act as a noise barrier.

Appendix A

Herring Storer Acoustics Report

ACOUSTIC ASSESSMENT

MIDLAND BRICK SITE REDEVELOPMENT

FOR

CAPITARY NO. 2

JUNE 2021

REFERENCE: 27982-2-20355-02

Rochdale Holdings Pty Ltd A.B.N. 85 009 049 067 trading as:
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DOCUMENT CONTROL PAGE

ACOUSTIC ASSESSMENT

MIDLAND BRICK SITE REDEVELOPMENT

Job No: 20355-02

Document Reference: 27982-2-20355-02

FOR

CAPITARY NO. 2

DOCUMENT INFORMATION			
Author:	Paul Drew	**Checked By:**	Tim Reynolds
Date of Issue :	28 June 2021		

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2	Revised figures	7/7/2021	PD	

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Copy No.	**Version No.**	**Destination**	**Hard Copy**	**Electronic Copy**
1	2	Capitary No. 2 Attn: Brett Chivers Email: brett@hesperia.com.au		✓

CONTENTS

APPENDIX

1.0 INTRODUCTION

Capitary No. 2 commissioned Herring Storer Acoustics to carry out an acoustic assessment of a proposed rezoning to the Metropoloitan Region Scheme (MRS) of part of the existing Midland Brick site from 'Industrial and Rural' land use to 'Urban'. The assessment addresses the potential acoustic impact of the remaining Midland Brickworks operations on the proposed residential subdivision, through a number of phases, as the brickwork operations contract in an orderly manner over time.

An acoustic model of the Midland Brickworks Clay (Kilns 9 & 10 and materials feed bins), Clayshed and the Masonry Plant has been used in the assessment. The acoustic model was jointly prepared by Herring Storer Acoustics for Capitary No. 2 and BGC (the Parties) as part of the transfer of the operational business from capitary No. 2 to BGC, and is subject to confidentiality restrictions. The Parties have agreed that the modelling predictions may be used by Capitary No.2 for the purpose of assessing potential impact of the brickwork operations on the proposed residential subdivision. The agreement between the Parties identifies that there needs to be adequate separation between the proposed residential development and the brickwork operations. This separation will reduce as the brickwork operations contract over time.

The acoustic criteria for the proposed residential subdivision is that any proposed residential redevelopment is to only be considered if the predicted noise emissions from the residual brickworks operations are compliant with the 'assigned levels' of the *Environmental Protection (Noise) Regulations 1997* at the proposed redevelopment areas. By reducing the amount of industrial land, the 'assigned levels' at existing residences (external to the proposed residential redevelopment area) may also be reduced. This has been considered within this assessment to ensure there are no exceedances at these locations.

A graphic of the site is shown in Figure 1. Proposed Lot 11 is the Masonry plant site. Area B is the Clay operations site. Area C is a BGC lease area for the existing clay shed.

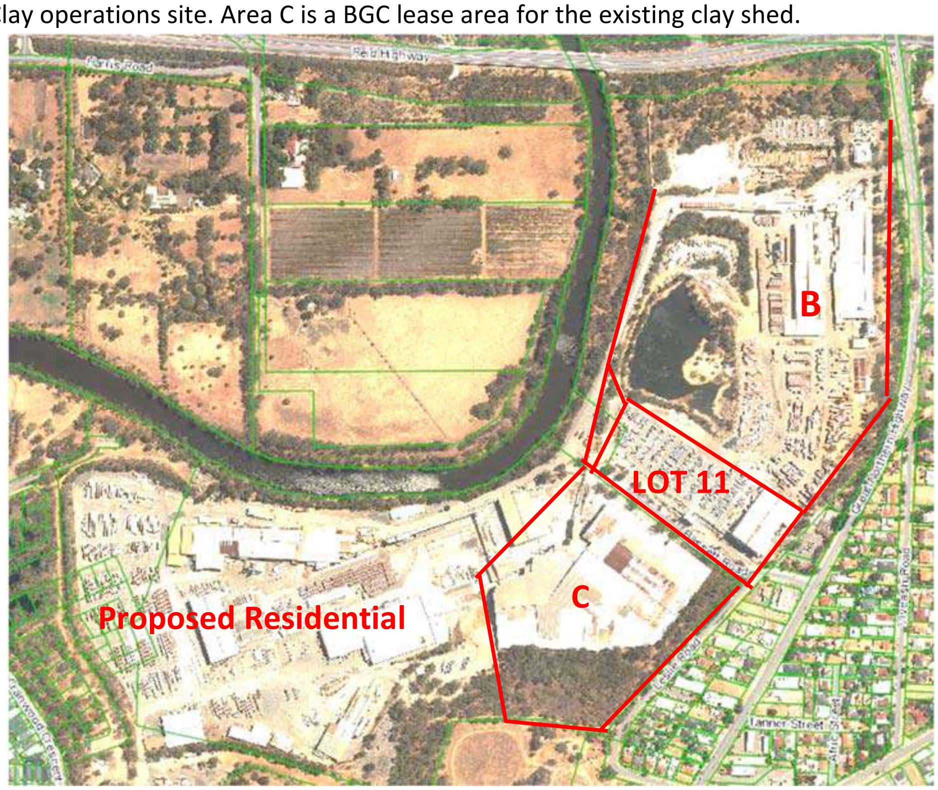


FIGURE 1 – AREA PLAN – MIDLAND BRICK SITE

2.0 METHODOLOGY

An acoustic model has been developed for the Midland Brick site on behalf of BGC and Capitary No.2 (Hesperia). While there are contractual and confidentiality aspects to this modelling, modelling outputs have been permitted to be used for assessment of noise emissions to the proposed MRS rezoning area.

The acoustic model was developed for operational noise emisions north of Bassett Road (the typical night time noise emissions from the brickworks) and verified through a process of measurement of existing noise levels throughout and around the site. A ‘measurement map’ of the measured noise emissions was generated, and compared to the model predicted emissions to assist in verification of the acoustic model. The clayshed operations were subsequently measured and added to the model.

The basic model development steps were:

- Measure baseline noise emissions of clay and masonry operations operating at an agreed production condition, selected to be representative of historically ‘normal’ maximum production operating condition.

- Develop an acoustic model to represent the baseline noise emissions.

- Establish the basis for determining the ‘assigned levels’.

- Determine influencing factors and ‘assigned levels’ for the nominated land use scenarios.

- Assessment of compliance with the ‘assigned levels’ under the regulations.

To assist in the process, tools available in the SoundPlan software were utilized, as due to the large areas and multiple receptor locations involved, a graphics based presentation of noise emission exceedance was considered easier to interpret than a table based approach. Therefore, compliance was assessed on the basis of conflict maps, reflecting interpolated assigned levels from manually determined influencing factors at a number of receptor points.

The baseline measurements from the 23rd November 2020 – 17th December 2020 were used to develop the combined plant 'measurement map', plot 65 (Figure 2). The clayshed and converyor operations were later measured and added to the acoustic model.

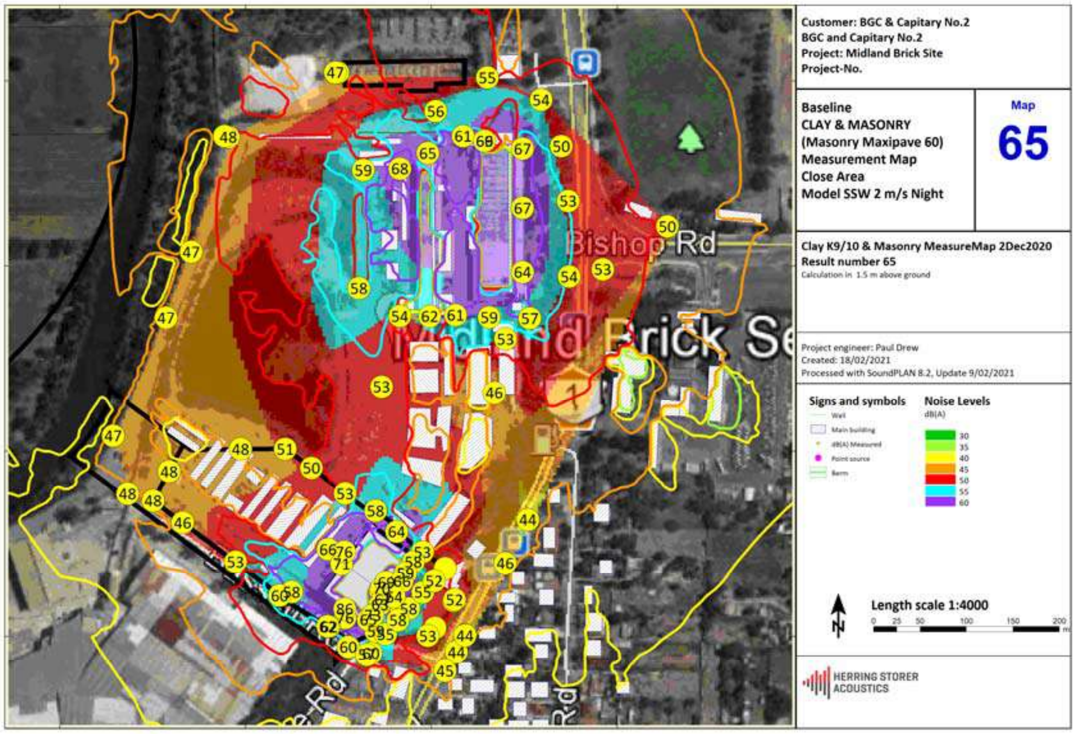


FIGURE 2 - MEASUREMENT MAP AND PREDICTED EMISSIONS FOR COMBINED PLANTS

There is close alignment of the modelled noise emissions (solid contour lines) with the shaded noise contours derived from the baseline noise measurements.

The acoustic model was then used to predict noise emissions for the various stages of transition from existing operations to future 'masonry plant only' operations.

3.0 STAGES OF PHASED REDEVELOPMENT

The proposal is to stage the redevelopment of the existing industrial land to the south/west of Bassett Road to residential. There is a planned phased contraction of the existing brickworks operations, based on contractual agreements with Capitary No.2 (the owner) and brickwork operators / owner BGC.

The arrangements are summarised below;

- Kiln 11 and all asurrounding industrial areas south of the clayshed –BGC have use of these areas until April 2022. Capitary No. 2 will commence demolition of existing industrial infrastructure south of Bassett Road in May 2022.

- Clayshed – Lease Area C. Capitary No. 2 will commence demolition soon after BGC vacate.

- Kilns 9 and 10 and Associated hardstand – Lease Area B. Capitary No. 2 will commence demolition soon after BGC vacate.

- Masonry plant (proposed Lot 11)– BGC will acquire this 3.5ha site and propose to continue operating as a masonry brickworks.

The extent of each stage of proposed residential redevelopment has been based on maintaining compliance of brickworks noise emissions to all residential development. The remaining industrial zoned land (as shown on Local Planning Scheme (LPS) No. 17) contributes to maintaining the relevant 'assigned levels' under the noise regulations.

These phases and the relevant operations affecting noise emissions are:

<u>Scenario A</u> – Continued operation of brickworks Kilns 9 and 10, brick yards, masonry plant and clayshed but all other brickwork operations south of Bassett Road have ceased. Land west of this to be potentially redeveloped as residential, with an appropriate buffer as shown in Figure 3. This proposal includes for the operation of the existing clayshed during the weekday and evening periods as defined by the *Environmental Protection (Noise) Regulations 1997*. During the night period the clayshed operations are to cease, with the exception of conveyor transfer of materials from the clayshed (bins) to Kilns 9 and 10.

FIGURE 3 – SCENARIO A LAND USE

Scenario B – Continued operation of brickworks Kilns 9 and 10, brick yards, masonry plant, with the clayshed removed and conveyor not in operation. Additional land west of Bassett Road to be potentially redeveloped as residential, with a buffer as shown in Figure 4.

FIGURE 4 – SCENARIO B LAND USE

Scenario C – Continued operation of masonry plant, with a 5m acoustic barrier wall constructed along the Bassett Road alignment. The clayshed and clay brickworks including kilns 9 and 10 to have ceased operation (removed). Additional land south-west of Basset Road to be potentially redeveloped as residential, up to Bassett Road, as shown in Figure 5.

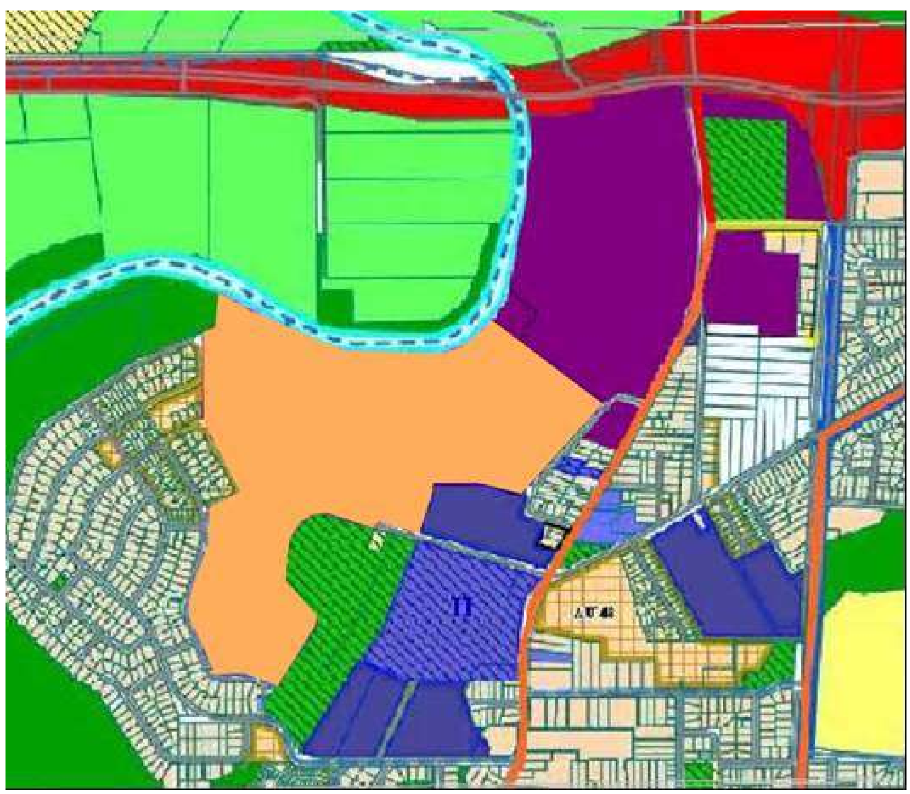


FIGURE 5 – SCENARIO C – FINAL LAND USE

4.0 ACOUSTIC CRITERIA

4.1 ENVIRONMENTAL NOISE REGULATIONS

The criteria used is in accordance with the *Environmental Protection (Noise) Regulations 1997 (as amended).* These regulations stipulate maximum allowable external noise levels determined by the calculation of an influencing factor. The influencing factor is calculated for the usage of land within the two circles, having radii of 100m and 450m from the premises of concern. For commercial and industrial premises, the allowable assigned noise levels are fixed, as listed in Table 4.1.

TABLE 4.1 – ASSIGNED OUTDOOR NOISE LEVELS

Type of premises receiving noise	Time of day	Assigned level (dB)		
		$L_{A\,10}$	$L_{A\,1}$	$L_{A\,max}$
Noise sensitive premises: highly sensitive area (i.e within 15m of a dwelling)	0700 to 1900 hours Monday to Saturday	45 + IF	55 + IF	65 + IF
	0900 to 1900 hours Sunday and public holidays	40 + IF	50 + IF	65 + IF
	1900 to 2200 hours all days	40 + IF	50 + IF	55 + IF
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + IF	45 + IF	55 + IF
Noise sensitive premises: any area other than highly sensitive area	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial Premises	All hours	65	80	90

Note: The L_{A10} noise level is the noise that is exceeded for 10% of the time.
The L_{A1} noise level is the noise that is exceeded for 1% of the time.
The L_{Amax} noise level is the maximum noise level recorded.
IF = Influencing Factor

It is a requirement that noise from the site be free of annoying characteristics (tonality, modulation and impulsiveness) at other premises, defined below as per Regulation 9.

Where the above characteristics are present and cannot be practicably removed, the following adjustments are made to the measured or predicted level at other premises.

TABLE 4.2 – ADJUSTMENTS FOR ANNOYING CHARACTERISTICS WHEN MUSIC IS NOT PRESENT

Where tonality is present	Where modulation is present	Where impulsiveness is present
+ 5 dB	+ 5 dB	+ 10 dB

The influencing factors and associated 'assigned levels' are described in following sections of this report.

The most critical assessment parameter is the L_{A10} 'assigned level' at the respective receptor locations. Noise sources / operations that contribute to short duration noise emissions that occur less than 10% of the representative assessment period have not been described in detail.

4.2 LAND USE MAPS

The City of Swan Local Planning Scheme No. 17 (LSP-17) has been accepted as being the relevant land use planning map for determination of influencing factors and 'assigned levels' under the *Environmental Protection (Noise) Regulations 1997*. The most current revision of LSP17 can be viewed on the City of Swan Intramaps portal. It is noted this differs from the MRS zoning.

4.3 ROAD SYSTEMS

Main Roads Department of Western Australia provides access to the 'Traffic Map' web accessed portal. This provides detail of publicly available traffic monitoring data for selected road systems.

The determination of the more significant road systems status in terms of average weekday traffic counts (vehicles per day) to determine whether road systems are classified as 'secondary' or 'major' roads under Schedule 3 of the Noise Regulations.

> Roads are classified as 'secondary' where the daily average traffic count is between 6,000 – 15,000 vehicles.
>
> Roads are classified as 'major where the daily average traffic count is greater than 15,000 vehicles.

Schedule 3, section 1 (2) and (3) outline the acceptable methods of determining the traffic count. Clause (3) directs that if the count is unknown, the road is not to be taken as a secondary or major road for the determination of the 'influencing factor'.

There is one available count for Lloyd Street, south of Toodyay Road for 2020, which indicates that section of road has a count of less than 15,000 vpd. Reid Highway and Roe Highway have counts greater than 15,000 vpd. The road system classifications used in the assessment are shown on the Figures included in this report (colour coded). The traffic counts are listed in Table 4.3.

The section of Great Northern Highway south of Roe/Reid intersection to Bishop Road has been interpreted as a major road due to the available traffic count (2015/2016) of 19,451 vpd. A review of traffic flows in the area implies that around 2017, some traffic moved from GNHwy (south of Toodyay Road) to Lloyd Street, around 2,500vpd. This change may not have affected the northern section of GNHwy next to Midland Brick. However, recent introduction of the North Link system may have, although there are no recent traffic counts available and a decrease from 19,451 vpd to below 15,000 vpd (required to change status from major road to secondary road) is a significant change.

TABLE 4.3 –ROAD TRAFFIC COUNTS SURROUNDING SITE (MRWA TRAFFIC MAP)

Road	vpd	year	Designation
Reid Highway	38,752	2017/2018	Major
Roe Highway	31,443	2015/2016	Major
GNHwy (south of Toodyay Road)	14,694	2017/2018	Secondary
GNHwy (south of Reid/Roe Hwy) to Bishop Road.	19,451	2015/2016	Major
GNHwy north of Reid/Roe	26,603	2017/2018	Major
Toodyay Road	4,229	2017/2018	Not significant
Lloyd Street	14,107	2020/2021	Secondary

As there is no official traffic count for Bishop Road, it has not been included as either a secondary or major road.

4.4 NOISE CHARACTERISTICS & SIGNIFICANTLY CONTRIBUTING ASPECTS

Noise characteristic can require an adjustment to the measured noise emission, reference (regulation 7 (1) (a), and (9)).

Noise emissions from industrial plants typically demonstrate 'tonality' noise characteristic for locations strongly affected by the industrial noise emission. This requires and adjustment of +5 dB(A) where present as defined under regulation 9.

At further distance, the merging of the noise emission and local background noise can 'mask' noise characteristic, and the adjustment is no longer applicable.

For the acoustic assessment, it has been assumed that noise emissions greater than 35 dB(A) may exhibit tonal characteristic, with adjustment of emitted levels by + 5 dB(A) for the compliance assessment. Noise emissions of 35 dB(A) and lower have been assessed as not exhibiting 'tonal characteristic'. There is background noise surrounding the site associated with the high traffic flow Reid Highway and other significant roads. Background noise monitoring undertaken in the early morning on various occasions has consistently resulted in measured levels above 35 dB(A), consistent with this assumption.

There are no other major noise emitting industries close to the proposed residential subdivision areas, therefore significantly contributing noise emissions are not expected to be applicable.

4.5 EXISTING ASSIGNED LEVELS

The noise sensitive premises surrounding the Midland Brick site, particularly those sections under consideration of development, could potentially have their 'influencing factor' and associated 'assigned levels' reduced by rezoning of industrial classified land to residential. This has been considered and a comparison made between the predicted noise levels and the future assigned levels.

In undertaking this assessment, a number of assumptions and interpretations have been made. The assumptions regarding traffic flows have been discussed in Section 4.3. Other assumptions include:

- The existing City of Swan works depot has been assessed as 'industrial' classification, as this area is zoned for 'residential redevelopment', but the current use is permitted until such development occurs.

- The former school site at Eveline Road / Leslie Street corner is zoned 'Private Clubs and Institutions'. Zoning includes clubs, which are commercial classification, therefore as highest classification presides in determining influencing factor, zoning will be treated as commercial for determination of influencing factor. However, usage is Aged Care, so will be a 'highly noise sensitive' premises on the site. Developer DA plans show future residential on section of land to the west (north edge of former school oval).

- Swan Hospital site: Zoned public purposes, which has no direct classification. Last use was Hospital of 192 beds, which is classified as 'commercial', however hospital has been closed for some time and LSP17-179 Rezoning Amendment being considered by City of Swan would change usage to predominantly 'Aged Care' use, which is 'noise sensitive'. Interpretation is 'commercial classification for determination of influencing factor, unoccupied noise sensitive land for receptor (at present).

Figure 6 shows the base land use classifications (under the Regulations) used.

Table 4.3 shows the determined influencing factors under the existing LSP17.

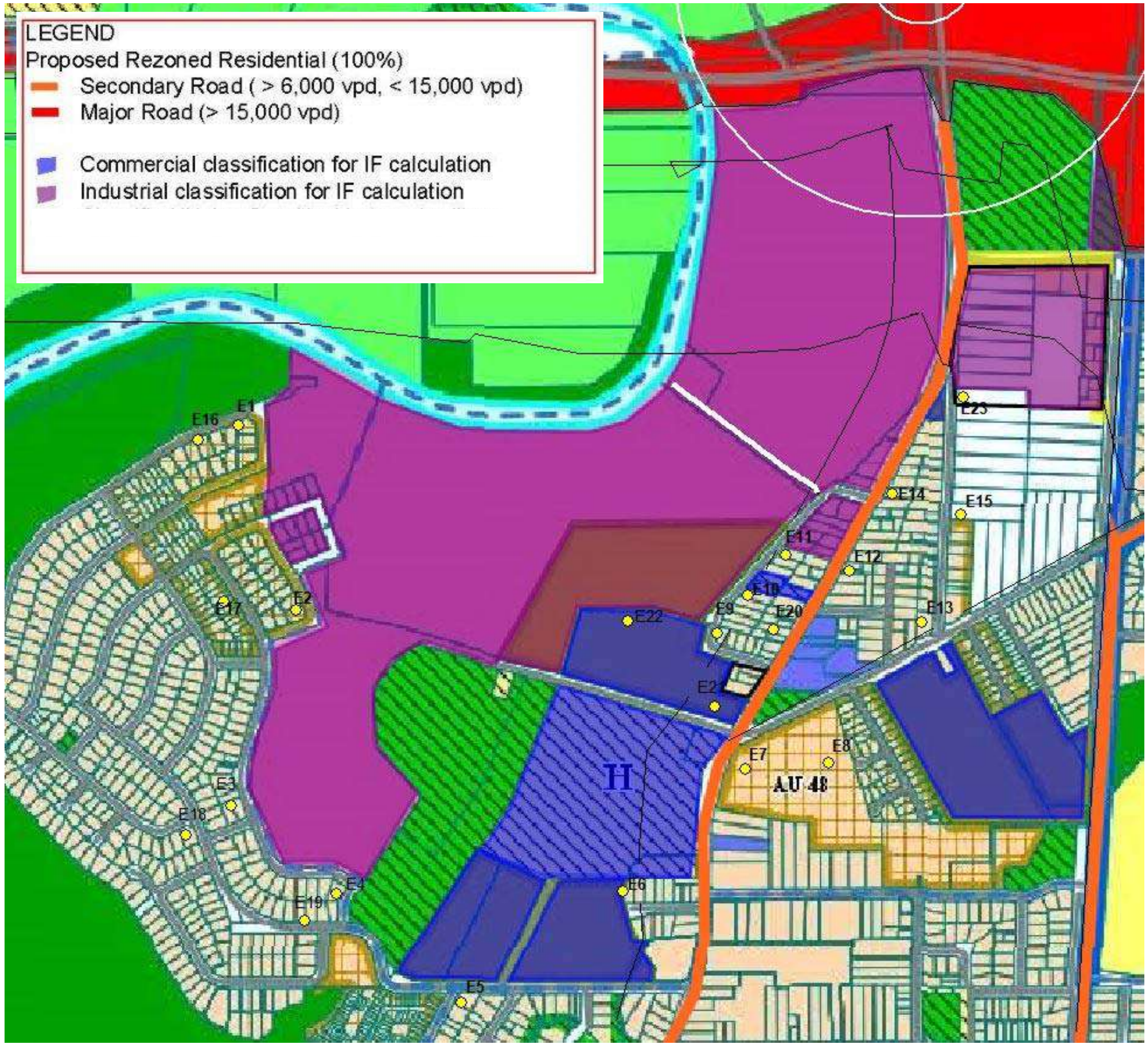


FIGURE 6 - EXISTING INFLUENCING FACTORS – ASSESSMENT MAP AND CALCULATION LOCATIONS

TABLE 4.3 – CALCULATED INFLUENCING FACTORS FOR EXISTING LSP-17

Ref	Industrial		Commercial		Industrial		Commercial		Circle IF	TF	IF
	Inner Area, m2	Outer Area, m2	Inner Area, m2	Outer Area, m2	Inner %	Outer %	Inner %	Outer %			
E-1	6095	136315	0	0	19	21	0	0	4.1	0	4
E-2	12886	284449	0	0	41	45	0	0	8.6	0	9
E-3	7687	110429	0	6590	24	17	0	1	4.2	0	4
E-4	6025	91744	0	78635	19	14	0	12	4.0	0	4
E-5	0	27330	8031	116045	0	4	26	18	2.6	0	3
E-6	0	3652	20760	211231	0	1	66	33	5.0	0	5
E-7	0	45333		122849	0	7	0	19	1.7	2	4
E-8	0	25697	0	225877	0	4	0	36	2.2	0	2
E-9	5451	228150	8073	156675	17	36	26	25	7.8	0	8
E-10	9093	251744	3175	130292	29	40	10	20	8.4	2	10
E-11	15169	262373	3770	96928	48	41	12	15	10.3	2	12
E-12	4677	102451	298	95787	15	16	1	15	3.9	2	6
E-13	0	48204	2568	105874	0	8	8	17	2.0	0	2
E-14	6823	273252	0	37859	22	43	0	6	6.8	2	9
E-15	0	189619	0	53819	0	30	0	8	3.4	0	3
E-16	0	119556	0	0	0	19	0	0	1.9	0	2
E-17	0	205070	0	0	0	32	0	0	3.2	0	3
E-18	0	92227	0	0	0	14	0	0	1.4	0	1
E-19	0	79875	0	50852	0	13	0	8	1.7	0	2
E-20	0	190840	3608	151970	0	30	11	24	4.8	2	7
E-21	0	133188	12907	196287	0	21	41	31	5.7	2	8
E-22	11723	277943	17353	171018	37	44	55	27	12.2	0	12
E-23	9824	278172	1343	1343	31	44	4	0	7.7	4	12

4.6 PROPOSED FINAL REZONED ASSIGNED LEVELS

The assigned levels following the proposed rezoning of the south-western part of the brickworks land to residential have been determined.

The interim phases of development (Scenarios A and B) 'assigned levels' have not been detailed in this report, although these have been assessed, and the 'conflict maps' are provided in Appendix A, with assessment of compliance in Appendix C.

The process is to first identify the surrounding land classification and minor/major roads surrounding the area of interest. Using this base, the influencing factors for key surrounding land can be determined, including the potential rezoned site land. Once this is completed, predicted noise emissions can be compared to the assigned levels at the critical time period (night time in this case), to determine the compliance status.

Figure 7 shows the base land use classifications (under the Regulations).

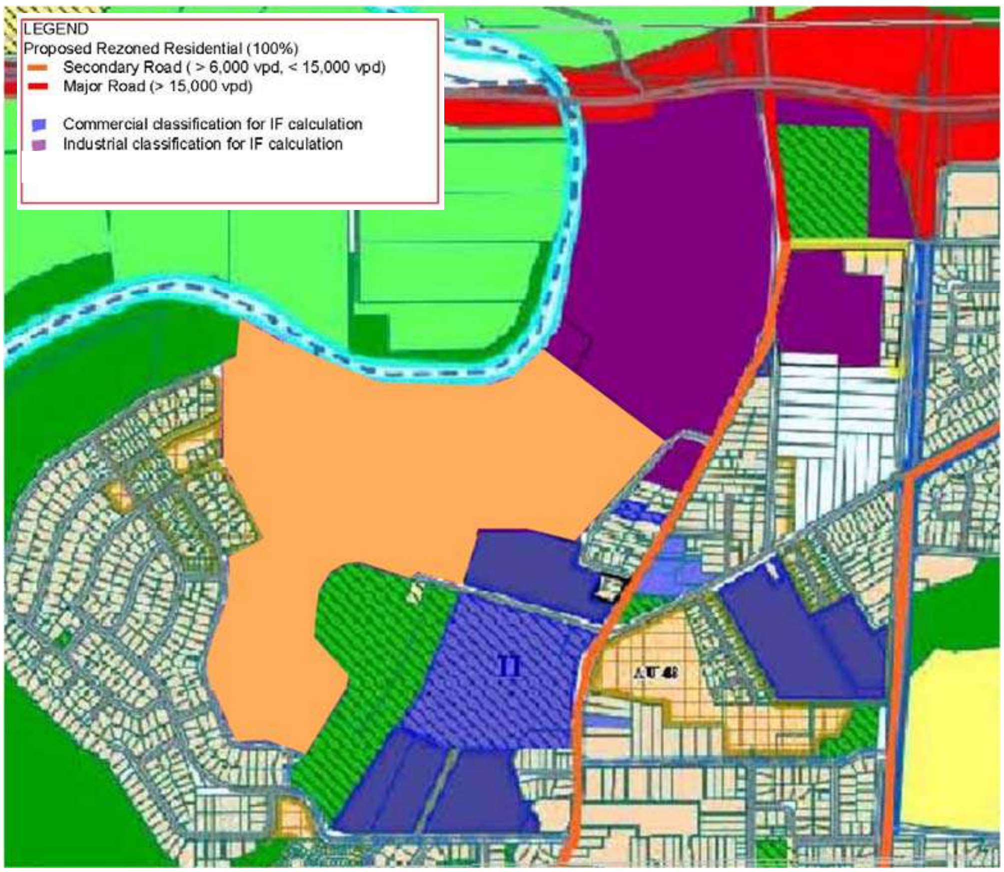


FIGURE 7 – LAND CLASSIFICATIONS AND ROAD SYSTEMS USED FOR ASSIGNED LEVEL DETERMINATION

Figure 8 shows the determined influencing factors and night-time 'assigned levels' based on all redeveloped land south of Bassett Road being residential. Detail on how these were derived are provided in Table 4.4. Figure 9, show the potential residences south of Bassett Road for which the Influencing Factor has been calculated.

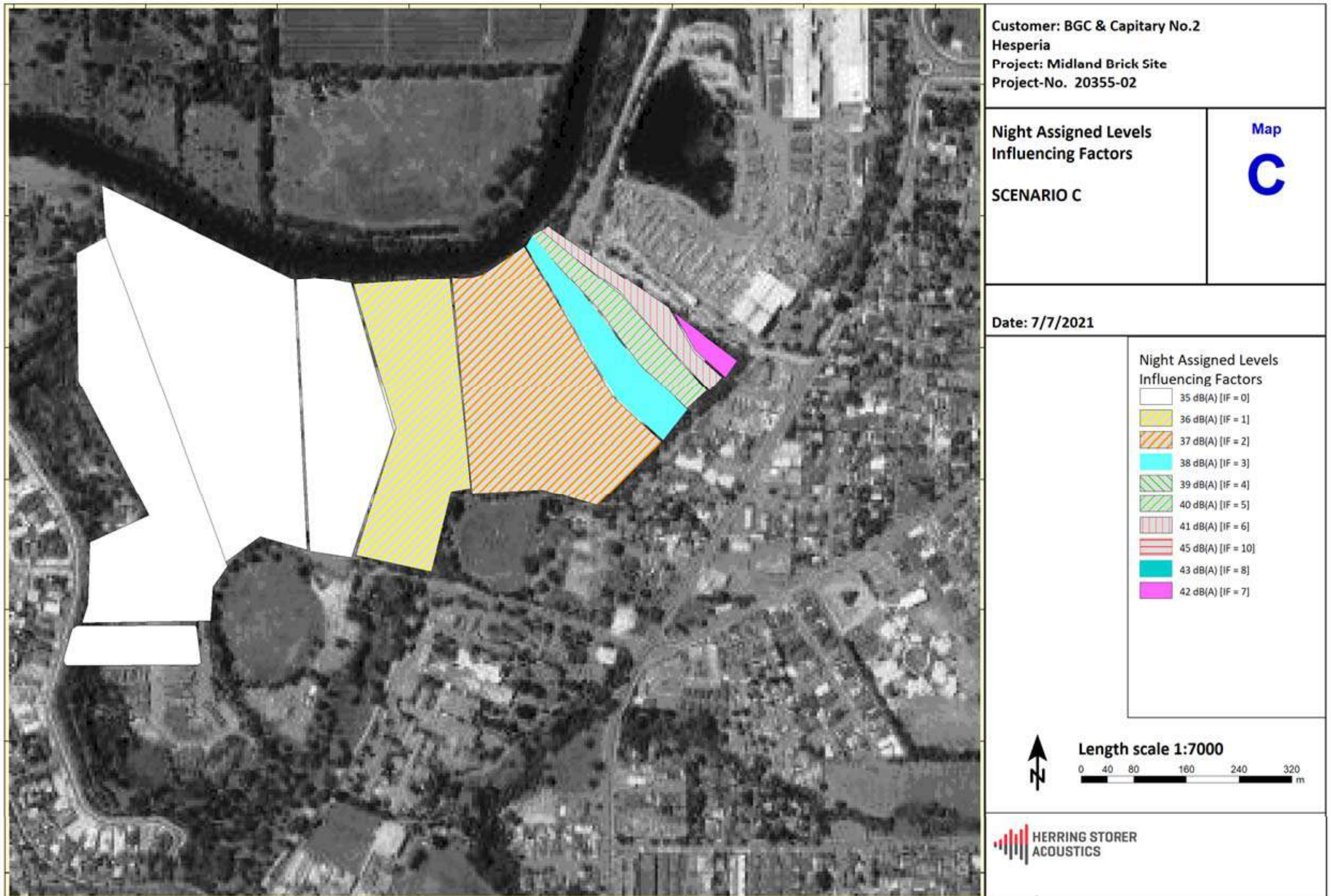


FIGURE 8 – DETERMINED NIGHT-TIME ASSIGNED LEVELS FOR POTENTIAL FULL RESIDENTIAL DEVELOPMENT

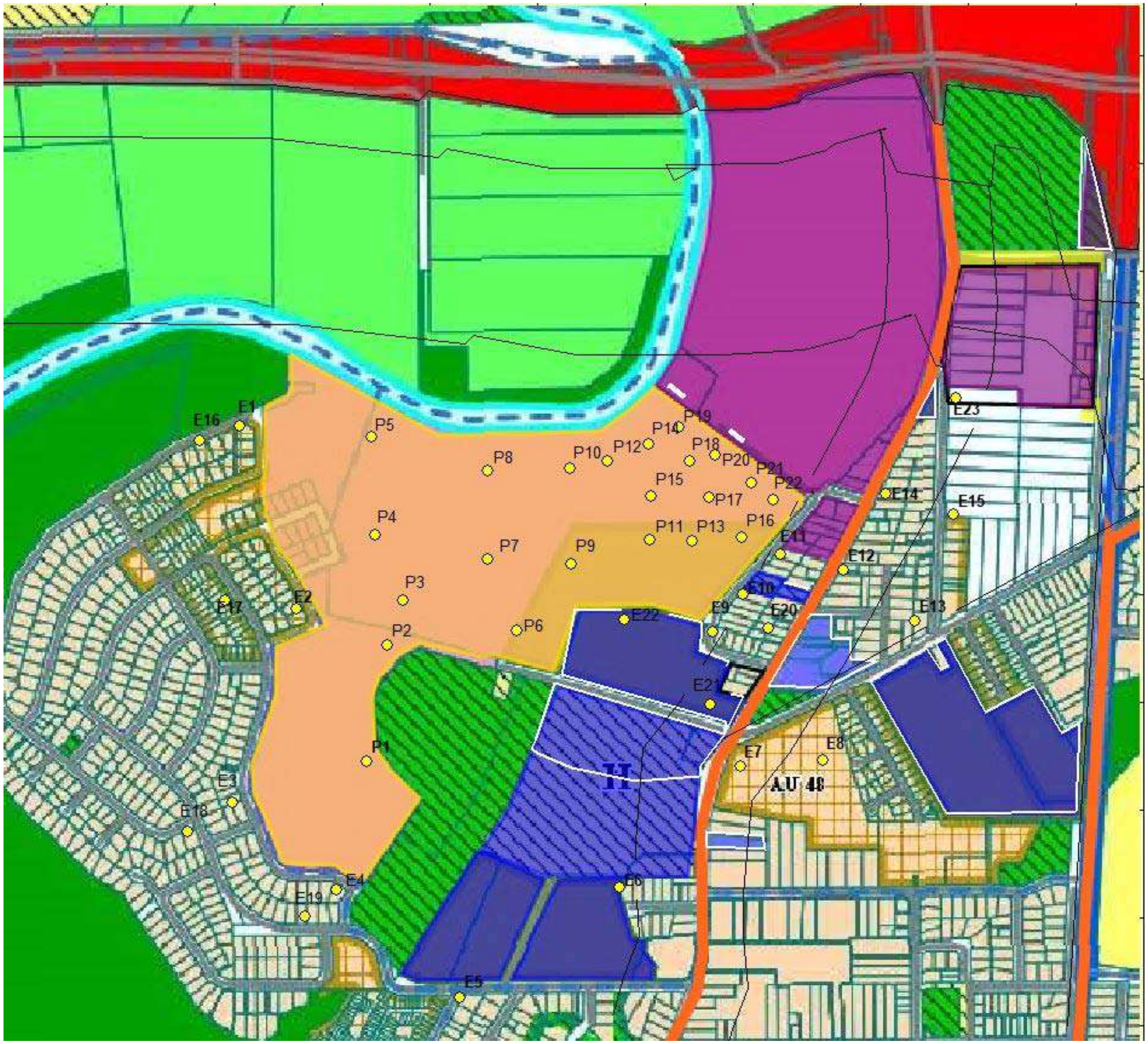


FIGURE 9 - POTENTIAL RESIDENTIAL SOUTH OF BASSETT ROAD INFLUENCING FACTORS – ASSESSMENT MAP AND CALCULATION LOCATIONS

TABLE 4.4 – CALCULATED INFLUENCING FACTORS FOR POTENTIAL REZONE ALL SOUTH OF BASSETT ROAD TO RESIDENTIAL

Ref	Industrial		Commercial		Industrial		Commercial		Circle IF	TF	IF
	Inner Area, m2	Outer Area, m2	Inner Area, m2	Outer Area, m2	Inner %	Outer %	Inner %	Outer %			
E-1	0	0	0	0	0	0	0	0	0.0	0	0
E-2	0	0	0	0	0	0	0	0	0.0	0	0
E-3	0	0	0	6590	0	0	0	1	0.1	0	0
E-4	0	0	0	78635	0	0	0	12	0.6	0	1
E-5	0	0	8031	116045	0	0	26	18	2.2	0	2
E-6	0	0	20760	211231	0	0	66	33	5.0	0	5
E-7	0	2847	1649	235561	0	0	5	37	2.2	2	4
E-8	0	5000	0	225877	0	1	0	36	1.9	0	2
E-9	0	45121	8073	156675	0	7	26	25	3.2	0	3
E-10	0	81917	3175	83995	0	13	10	13	2.5	2	4
E-11	4389	119171	3763	95700	14	19	12	15	4.6	2	7
E-12	4677	102451	298	95787	15	16	1	15	3.9	2	6
E-13	0	48204	2568	105874	0	8	8	17	2.0	0	2
E-14	6828	207559	0	37859	22	33	0	6	5.7	2	8
E-15	0	163758	0	53819	0	26	0	8	3.0	0	3
E-16	0	0	0	0	0	0	0	0	0.0	0	0
E-17	0	0	0	0	0	0	0	0	0.0	0	0
E-18	0	0	0	0	0	0	0	0	0.0	0	0
E-19	0	0	0	50852	0	0	0	8	0.4	0	0
E-20	0	56588	3608	151970	0	9	11	24	2.7	2	5
E-21	0	9677	12907	196287	0	2	41	31	3.8	2	6
E-22	0	25264	17353	171018	0	4	55	27	4.5	0	5
E-23	9824	264048	1343	1343	31	42	4	0	7.5	4	12
P1	0	0	0	97063	0	0	0	15	0.8	0	1
P2	0	0	0	52279	0	0	0	8	0.4	0	0
P3	0	0	0	38463	0	0	0	6	0.3	0	0
P4	0	0	0	5277	0	0	0	1	0.0	0	0
P5	0	0	0	0	0	0	0	0	0.0	0	0
P6	0	0	0	134678	0	0	0	21	1.1	0	1

Ref	Industrial		Commercial		Industrial		Commercial		Circle IF	TF	IF
	Inner Area, m2	Outer Area, m2	Inner Area, m2	Outer Area, m2	Inner %	Outer %	Inner %	Outer %			
P7	0	0	0	67512	0	0	0	11	0.5	0	1
P8	0	10729	0	20174	0	2	0	3	0.3	0	0
P9	0	25554	555	101383	0	4	2	16	1.3	0	1
P10	0	62340	0	39605	0	10	0	6	1.3	0	1
P11	0	88838	0	101636	0	14	0	16	2.2	0	2
P12	0	102720	0	42307	0	16	0	7	1.9	0	2
P13	0	108703	0	95388	0	17	0	15	2.5	0	2
P14	0	146273	0	37381	0	23	0	6	2.6	0	3
P15	0	118700	0	71867	0	19	0	11	2.4	0	2
P16	609	127578	1400	101286	2	20	4	16	3.2	0	3
P17	0	146434	0	70885	0	23	0	11	2.9	0	3
P18	2346	164667	0	53454	7	26	0	8	3.8	0	4
P19	8501	184243	0	27685	27	29	0	4	5.8	0	6
P20	7511	180324	0	48044	24	28	0	8	5.6	0	6
P21	7403	177135	0	61707	24	28	0	10	5.6	0	6
P22	10017	169659	0	66508	32	27	0	10	6.4	0	6

The potential impact of re-zoning industrial land to residential is shown in Table 4.5, based on predicted noise emissions for Scenario C 'masonry only' operating under 'worst case' night conditions.

The assessment shows that the proposed rezoning will not have an adverse impact on existing residential receptors in relation to the Midland Brick noise emissions.

TABLE 4.5 – CHANGE IN INFLUENCING FACTOR DUE TO REZONING TO 100% RESIDENTIAL

Loc	IF Exist	IF	Decrease in IF	Night AL	Predicted Level	Exceedance	Impact
E-1	4	0	4	35	20	-15	No
E-2	9	0	9	35	20	-15	No
E-3	4	0	4	35	16	-19	No
E-4	4	1	3	36	17	-19	No
E-5	3	2	1	37	18	-19	No
E-6	5	5	0	40	20	-20	No
E-7	4	4	0	39	25	-14	No
E-8	2	2	0	37	26	-11	No
E-9	8	3	5	38	28	-9	No
E-10	10	4	6	39	30	-7	No
E-11	12	7	5	42	35	-6	No
E-12	6	6	0	41	33	-8	No
E-13	2	2	0	37	31	-6	No
E-14	9	8	1	43	37	-6 (-1)	No
E-15	3	3	0	38	33	-5 (0)	No
E-16	2	0	2	35	20	-15	No
E-17	3	0	3	35	19	-16	No
E-18	1	0	1	35	15	-20	No
E-19	2	0	2	35	17	-18	No
E-20	7	5	2	40	31	-9	No
E-21	8	6	2	41	27	-14	No
E-22	12	5	7	40	27	-13	No
E-23	12	12	0	47	37	-10	No
E-24	7	7	0	42	23	-19	No

Note: Where noise emissions are known or expected to exhibit tonal characteristic, this is shown by (xx) as the exceedance (adjusted). The exceedance shown includes the adjustment for tonal characteristic in accordance with the regulations.

5.0 REDEVELOPMENT - BRICKWORKS NOISE INGRESS ASSESSMENT

Brickworks operations noise emissions are predicted to comply with the 'assigned levels' of the *Environmental Protection (Noise) Regulations 1997* at the proposed residential areas for the various phases of redevelopment.

The phased development proposals outlined in this assessment have been developed on the basis that the predicted operational noise emissions from the brickworks operations will comply with the *Environmental Protection (Noise) Regulation 1997* 'assigned levels'.

Scenario A, the initial phase of residential development allows for the operation of the existing brickworks Kilns 9 and 10, the masonry plant and the clayshed conveyor system. During the weekday and evening period the clayshed operations including truck deliveries, crushing and screening and loader operations have been modelled. Included in the acoustic modelling are the proposed final topography, with inclusion of acoustic barriers formed with stacked seacontainers. The seacontainers are currently located on site, having been used for this purpose in other locations. The proposed brickworks operations are expected to generate compliant noise emissions at the Scenario A residential development areas (plot 320, Appendix B).

Scenario B, an interim phase of residential development allows for the decommissioning of the clayshed and conveyor operations. Upon removal of the clayshed building, a 5m acoustic barrier wall is to be constructed on the southern side of the Bassett Road extension into the site. This will assist in the mitigation of noise emissions from the masonry plant and clay operations. The proposed brickworks operations are expected to generate compliant noise emissions at the Scenario B residential development areas (plot 299, Appendix B).

Scenario C, allows for residential development up to the western side of Bassett Road, and the extension of Bassett Road into the site to the river. This scenario is based on ceasation of the clay operations (kilns 9 and 10, clayshed), with the existing masonry plant continuing to operate. The 5m high acoustic barrier wall is to remain along the southern side of Bassett Road, providing acoustic attenuation from the masonry plant operations. The proposed masonry plant operations are expected to generate compliant noise emissions at the Scenario C residential development areas (plot 300, Appendix B).

The Clay and Masonry plant operations have a number of processes that occur within the different time periods as defined under the Noise Regulations. Some of the operating scenarios have less equipment operating than others in the same regulation time period. Therefore, not every scenario needs to be modelled in order to identify the most significant noise emissions for that time period. The significant operating scenarios have been modelled. Scenario A includes separate modelling contour plots (Appendix B) for the weekday / evening scenario, and the night-time scenario operations.

The assessment of compliance with the regulation 'assigned levels' for the surrounding area has been undertaken using graphic 'conflict maps', which are contained in Appendix C. These show that the predicted noise emissions are compliant at the proposed residential development areas.

It is noted that the whole of this site is and will be subject to aircraft noise and significant traffic noise. The residential dwellings are required to be constructed to reduce noise ingress in accordance with *State Planning Policy 5.1 Land Use Planning in the Vicinity of Perth Airport*.

6.0 CONCLUSION

Capitary No. 2 commissioned Herring Storer Acoustics to carry out an acoustic assessment of a proposed rezoning to the Metropoloitan Region Scheme (MRS) of part of the existing Midland Brick site from 'Industrial and Rural' land use to 'Urban'. The assessment addresses the potential acoustic impact of the remaining Midland Brickworks operations on the proposed residential subdivision, through a number of phases, as the brickwork operations contract in an orderly manner over time.

An acoustic model of the Midland Brickworks Clay (Kilns 9 & 10 and materials feed bins, clayshed and converyor) and the Masonry Plant has been used in the assessment.

The acoustic criteria for the proposed residential subdivision is that any proposed redevelopment is to only be considered if the predicted noise emissions from the residual brickworks operations are compliant with the 'assigned levels' of the *Environmental Protection (Noise) Regulations 1997* at the proposed redevelopment areas and existing residences.

The proposal is to stage the redevelopment of the existing industrial land to the south/west of Bassett Road to residential. There is a planned phased movement of existing brickworks operations, based on contractual agreements with Capitary No.2 (the owner) and brickwork operators / owner BGC.

Brickworks operations noise emissions are predicted to comply with the 'assigned levels' of the *Environmental Protection (Noise) Regulations 1997* at the proposed residential areas for the various phases of redevelopment.

Scenario A, the initial phase of residential development allows for the operation of the existing brickworks Kilns 9 and 10, the masonry plant and the clayshed converyor system. During the weekday and evening period the clayshed operations including truck deliveries, crushing and screening and loader operations have been modelled. Included in the acoustic modelling are the proposed final topography, with inclusion of acoustic barriers formed with stacked seacontainers. The seacontainers are currently located on site, having been used for this purpose in other locations.

Scenario B, an interim phase of residential development allows for the decommissioning of the clayshed and conveyor operations. Upon removal of the clayshed building, a 5m high acoustic barrier wall is to be constructed on the southern side of the Bassett Road extension into the site. This will assist in the mitigation of noise emissions from the masonry plant and clay operations.

Scenario C allows for the proposed ultimate residential development up to the southern side of Bassett Road. This scenario is based on ceasation of the clay operations (kilns 9 and 10, clayshed), with the existing masonry plant continuing to operate. The 5m high acoustic barrier wall is to remain along the souhern side of the Bassett Road extension into the site, providing acoustic mitigation from the masonry plant operations.

The assessment of compliance with the regulation 'assigned levels' for the surrounding area show that the predicted noise emissions are compliant at the proposed and existing residential - areas.

APPENDIX A

INFLUENCING FACTOR CALCULATION ASSUMPTIONS

SCENARIO ‘ASSIGNED LEVEL’ MAPS

NOTES: INTERPRETATION OF NOISE REGULATION CLASSIFICATIONS
EXISTING LOCAL STRUCTURE PLAN

1. Shire of Swan Depot. Located on "Residential Redevelopment" zoned land, but existing use is not residential, so receptor is interpreted as 'industrial' user as a permitted use prior to urban redevelopment includes the City of Swan Depot workshops for repair / maintenance.

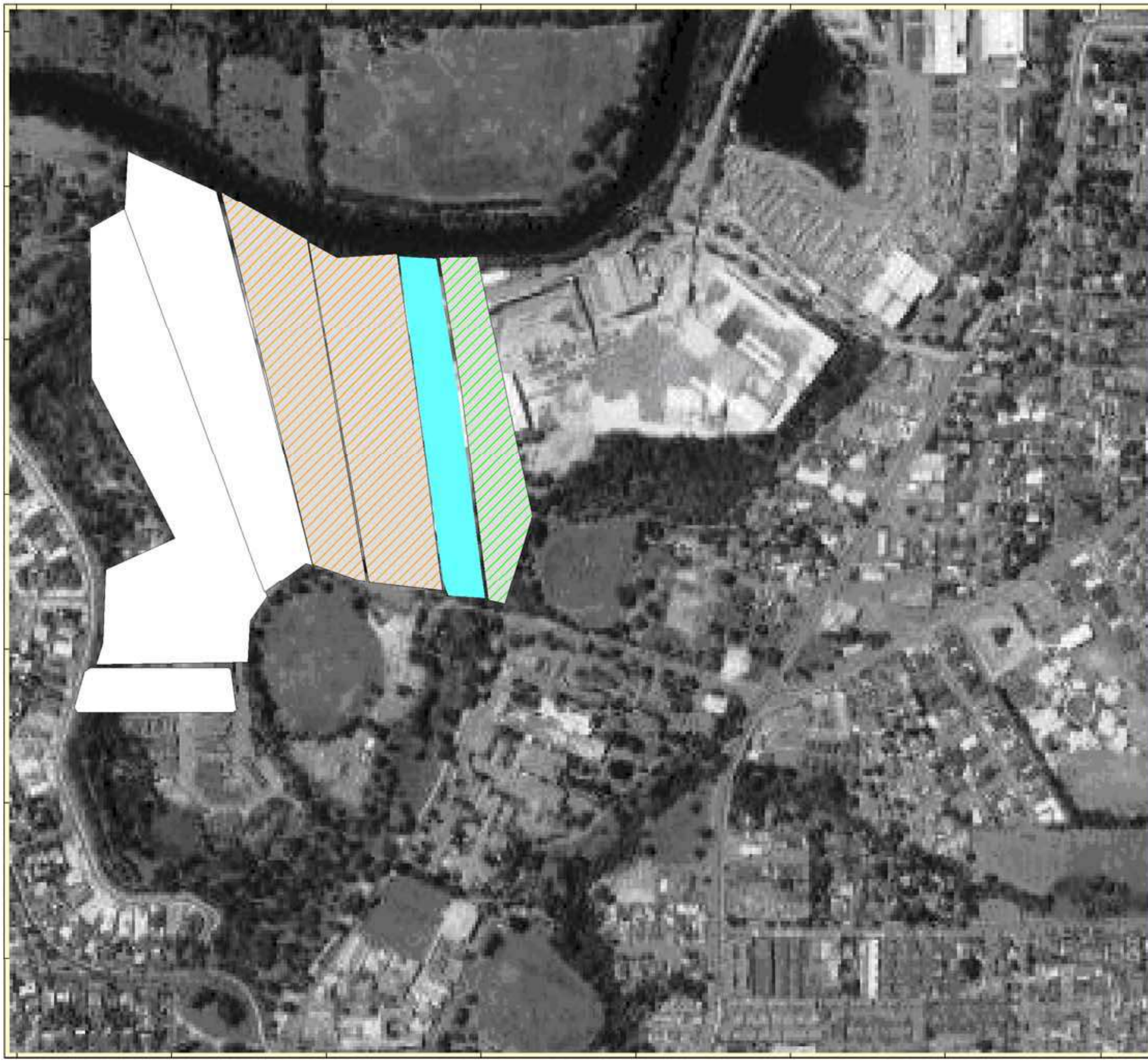
2. Private Clubs and Institutions – formerly a school and now being developed for Aged Care facility. Zoning includes clubs, which are commercial classification, therefore as highest classification presides in determining influencing factor, zoning will be treated as commercial for determination of influencing factor. However, usage is Aged Care, so will be a 'highly noise sensitive' premises on the site. Developer DA plans show future residential on section of land to the west (north edge of former school oval).

3. Swan Hospital site: Zoned public purposes, which has no direct classification. Last use was Hospital of 192 beds, which is classified as 'commercial', however hospital has been closed from some time and LSP17-179 Rezoning Amendment being considered by City of Swan would change usage to predominantly 'Aged Care' use, which is 'noise sensitive'. Interpretation is 'commercial' classification for determination of influencing factor, unoccupied noise sensitive land for receptor (at present).

4. In determining existing assigned levels, there are some locations which are zoned residential, but which are currently not developed as such (no residence). Example is small lot at NE corner of the Eveline / Leslie St Aged Care. Classification is noise sensitive for determination of influencing factor, but there is no dwelling, so criteria is L_{A10} of 60 dB(A).

5. Road systems to east of Midland Brick site have all appeared to have had a decline in vehicles per day since 2015/16, although traffic counts are not comprehensive. In accordance with regulations, roads with traffic counts are classified based on the latest traffic count. Roads with no traffic count are not included as affecting the Traffic Factor.

6. For calculation of proportion of area classification to determine influencing factors, areas were measured. The 100% area for the 100m radius and 450m radius circles used to determine influencing factor are 31,389 m^2 for 100m radius and 636,054 m^2 for 450m radius.



Customer: BGC & Capitary No.2 Hesperia
Project: Midland Brick Site
Project-No. 20355-02

Night Assigned Levels Influencing Factors

SCENARIO A

Map

A

Date: 7/7/2021

Night Assigned Levels Influencing Factors

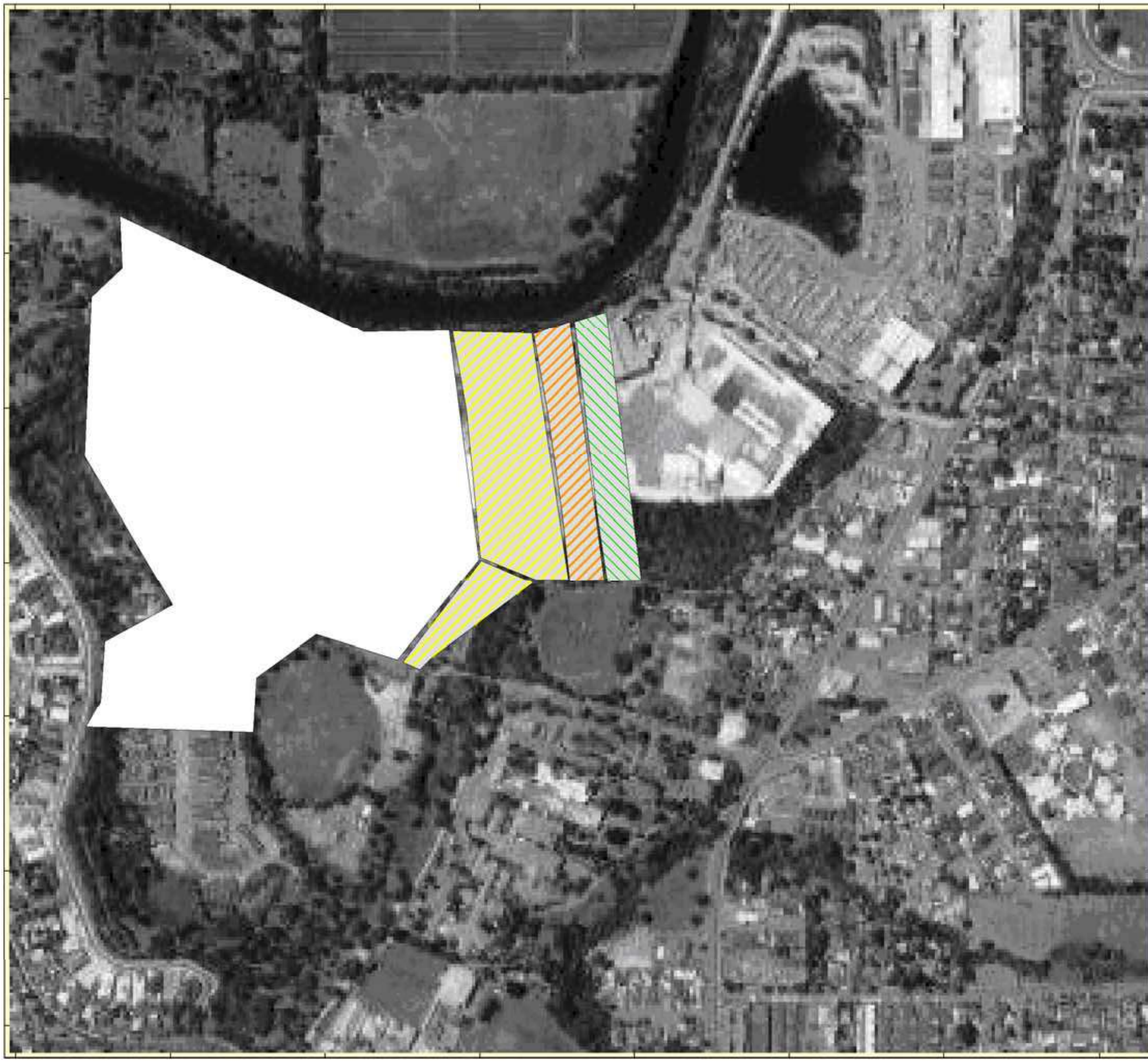
- 35 dB(A) [IF = 0]
- 36 dB(A) [IF = 1]
- 37 dB(A) [IF = 2]
- 38 dB(A) [IF = 3]
- 39 dB(A) [IF = 4]
- 40 dB(A) [IF = 5]
- 41 dB(A) [IF = 6]
- 45 dB(A) [IF = 10]
- 43 dB(A) [IF = 8]
- 42 dB(A) [IF = 7]

N

Length scale 1:7000

0 40 80 160 240 320 m

HERRING STORER ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No.

Night Assigned Levels
Influencing Factors

SCENARIO B

Map
B

Date: 7/7/2021

Night Assigned Levels
Influencing Factors

- 35 dB(A) [IF = 0]
- 36 dB(A) [IF = 1]
- 37 dB(A) [IF = 2]
- 38 dB(A) [IF = 3]
- 39 dB(A) [IF = 4]
- 40 dB(A) [IF = 5]
- 41 dB(A) [IF = 6]
- 45 dB(A) [IF = 10]
- 43 dB(A) [IF = 8]
- 42 dB(A) [IF = 7]

Length scale 1:7000

0 40 80 160 240 320 m

HERRING STORER ACOUSTICS

Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No. 20355-02

Night Assigned Levels
Influencing Factors

SCENARIO C

Map
C

Date: 7/7/2021

Night Assigned Levels
Influencing Factors

- 35 dB(A) [IF = 0]
- 36 dB(A) [IF = 1]
- 37 dB(A) [IF = 2]
- 38 dB(A) [IF = 3]
- 39 dB(A) [IF = 4]
- 40 dB(A) [IF = 5]
- 41 dB(A) [IF = 6]
- 45 dB(A) [IF = 10]
- 43 dB(A) [IF = 8]
- 42 dB(A) [IF = 7]

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS

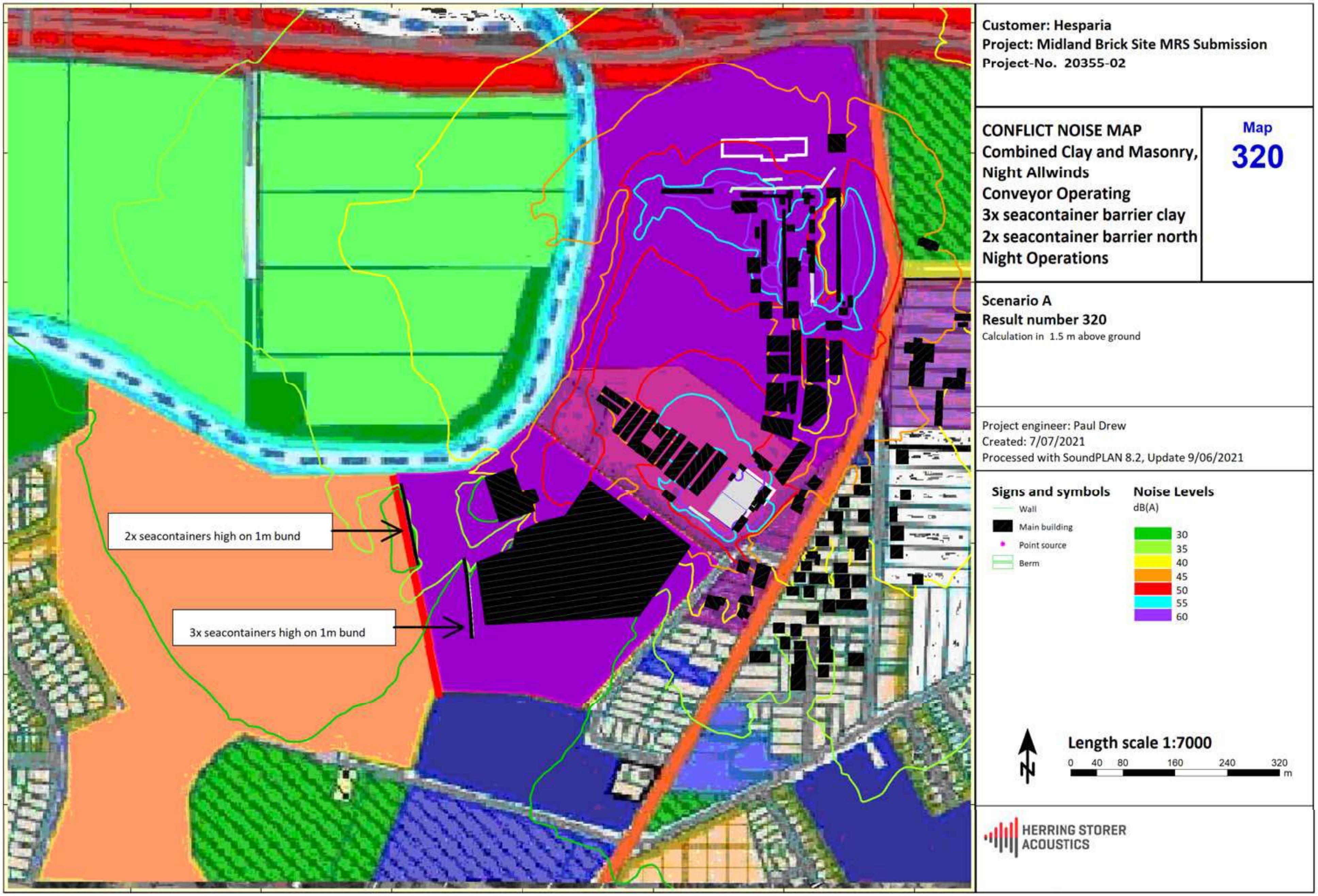
APPENDIX B

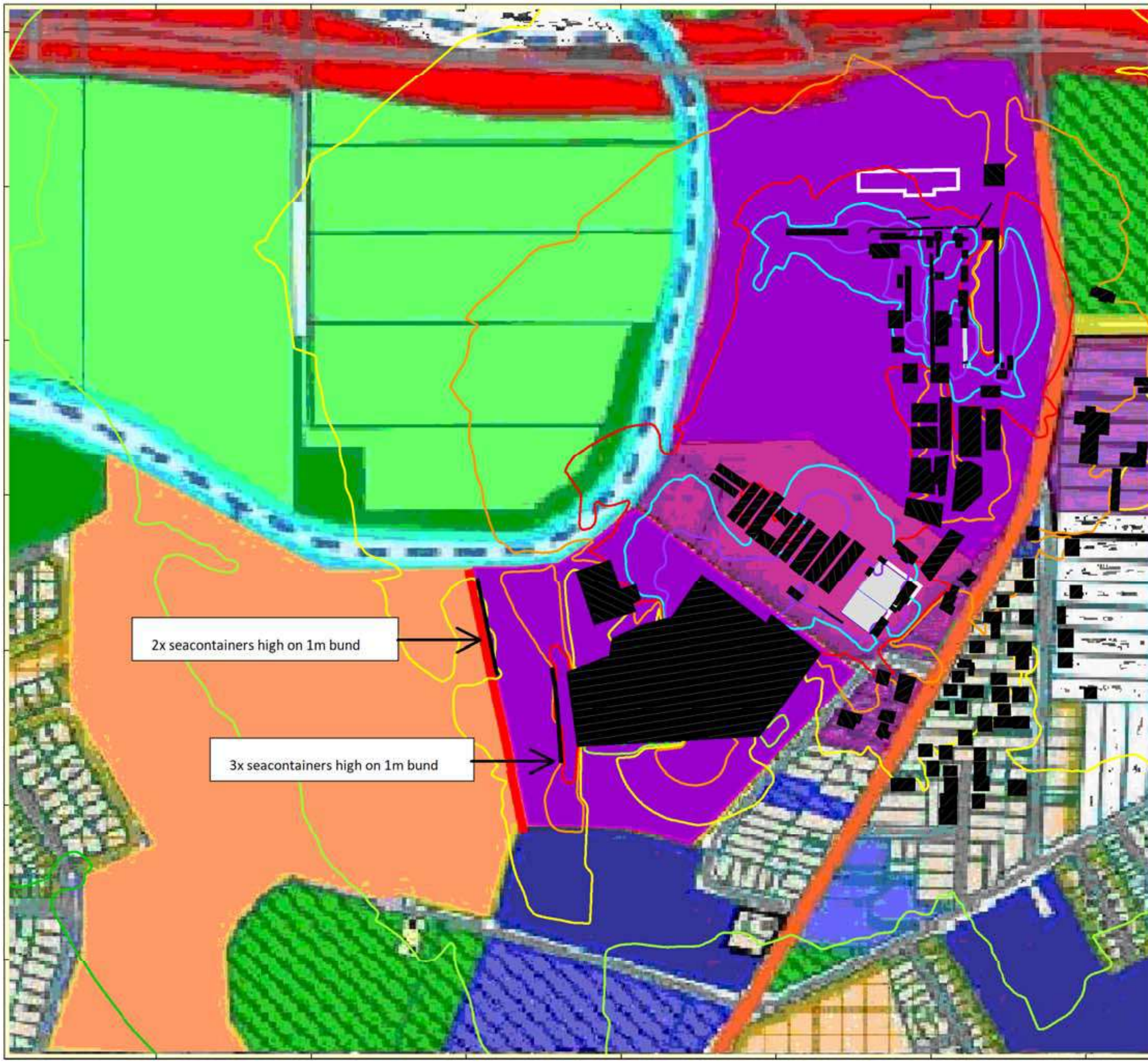
NOISE EMISSION NOISE CONTOUR PLOTS

Scenario A: CLAY & MASONRY – INCLUDING OPERATING CLAY BUILDINGS

Scenario B: CLAY & MASONRY –CLAY BUILDINGS REMOVED

Scenario C: MASONRY ONLY


2x seacontainers high on 1m bund
3x seacontainers high on 1m bund
Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02
CONFLICT NOISE MAP
Combined Clay and Masonry,
Night Allwinds
Conveyor Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Night Operations
Map
320
Scenario A
Result number 320
Calculation in 1.5 m above ground
Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021
Signs and symbols
Wall
Main building
Point source
Berm
Noise Levels
dB(A)
30
35
40
45
50
55
60
N
Length scale 1:7000
0 40 80 160 240 320
m
HERRING STORER ACOUSTICS



Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02

Combined Clay and Masonry
Evening Allwinds
Conveyor
& Clayshed Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Evening Operations

Map
315

Scenario A
Result number 315
Calculation in 1.5 m above ground

Day / Evening Operational Scenario

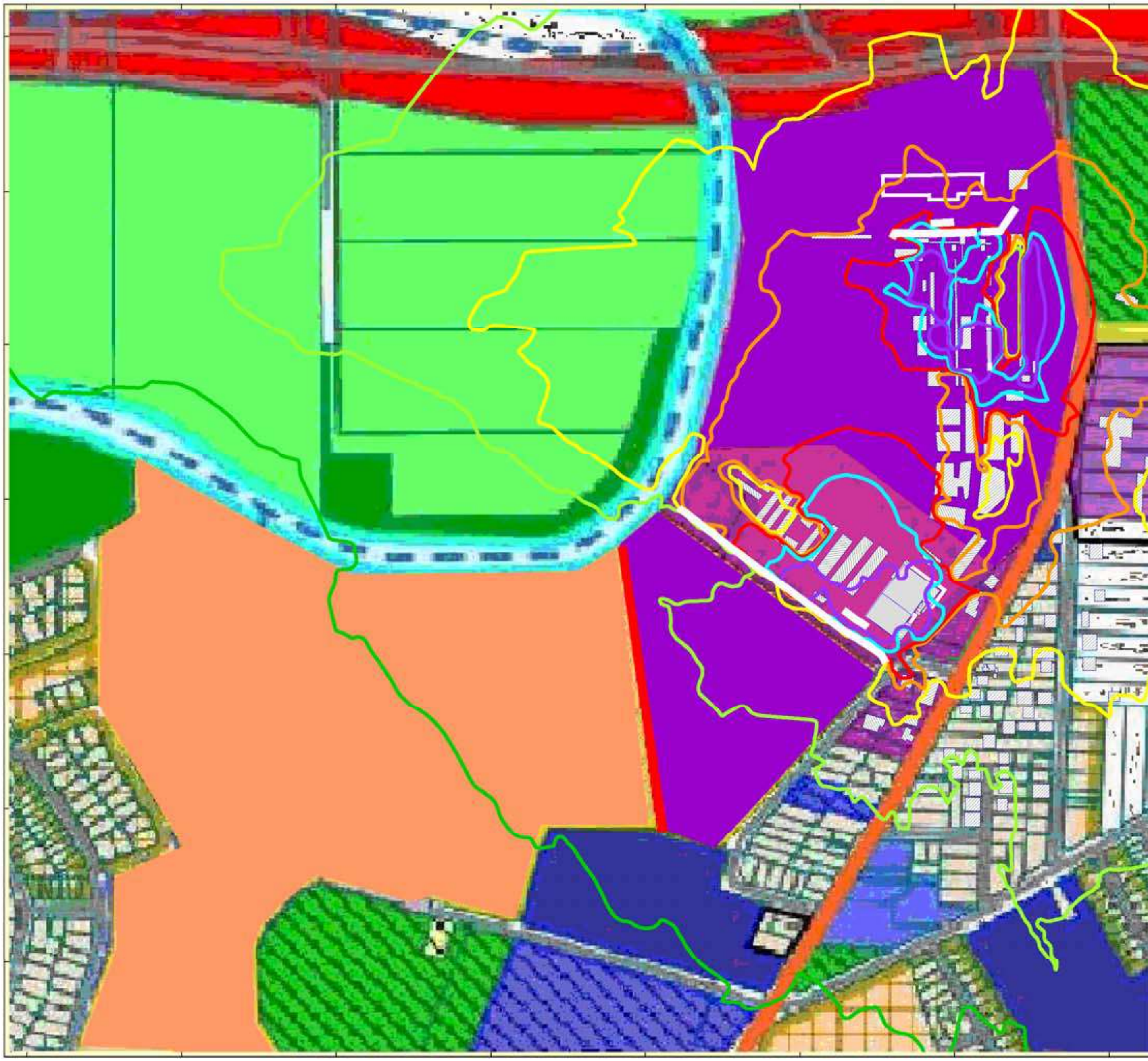
Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No.

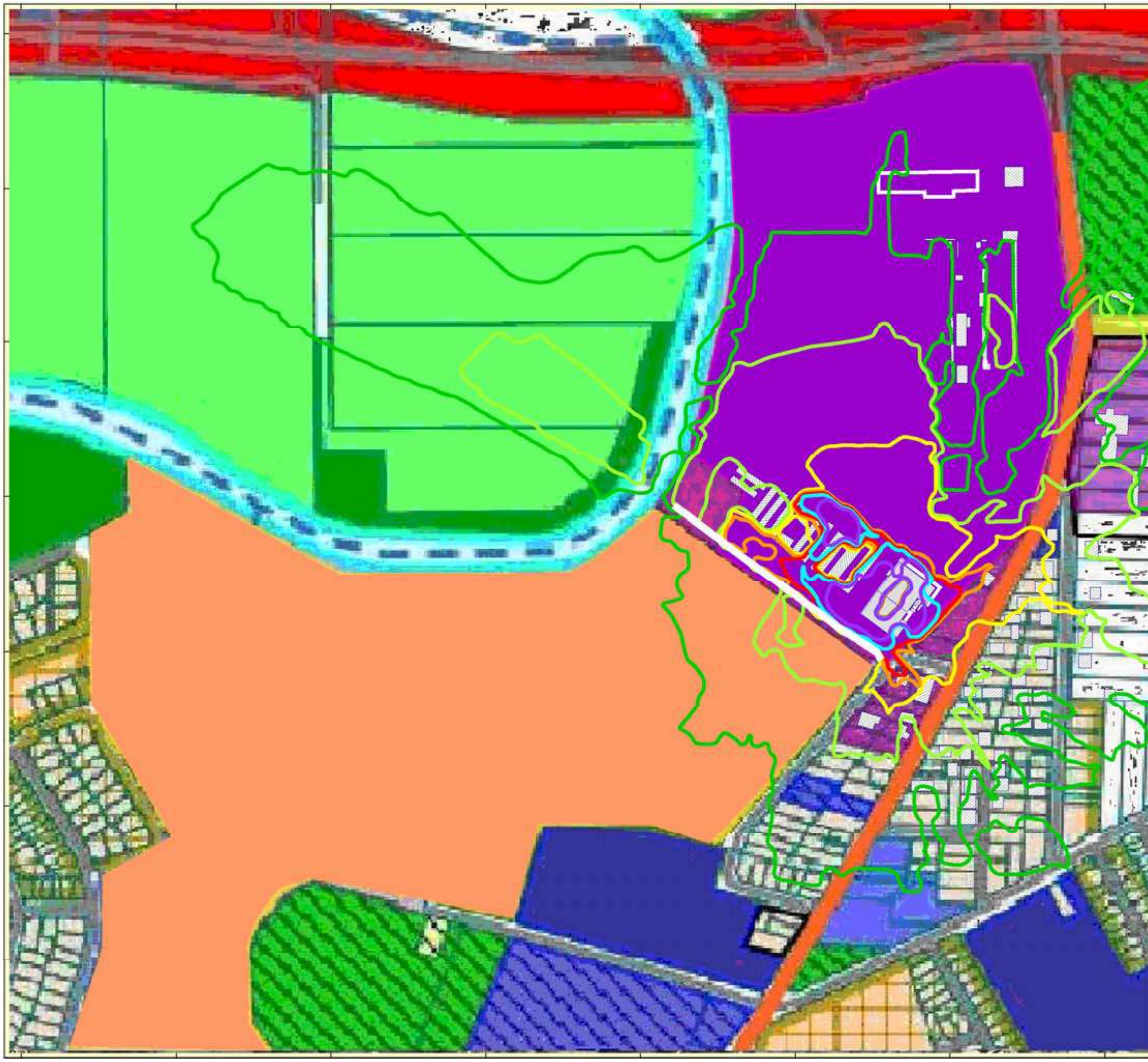
Combined Clay and Masonry
Night Allwinds
Clayshed & Conveyor
Removed

Map
299

Scenario B
Result number 299
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 22/06/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

HERRING STORER ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No.

Masonry Only
Night Allwinds

Scenario C

Map
300

Scenario C - Masonry Only
Result number 300
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 24/06/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols
- Wall
- Main building
- Berm

Noise Levels
dB(A)
- 30
- 35
- 40
- 45
- 50
- 55
- 60

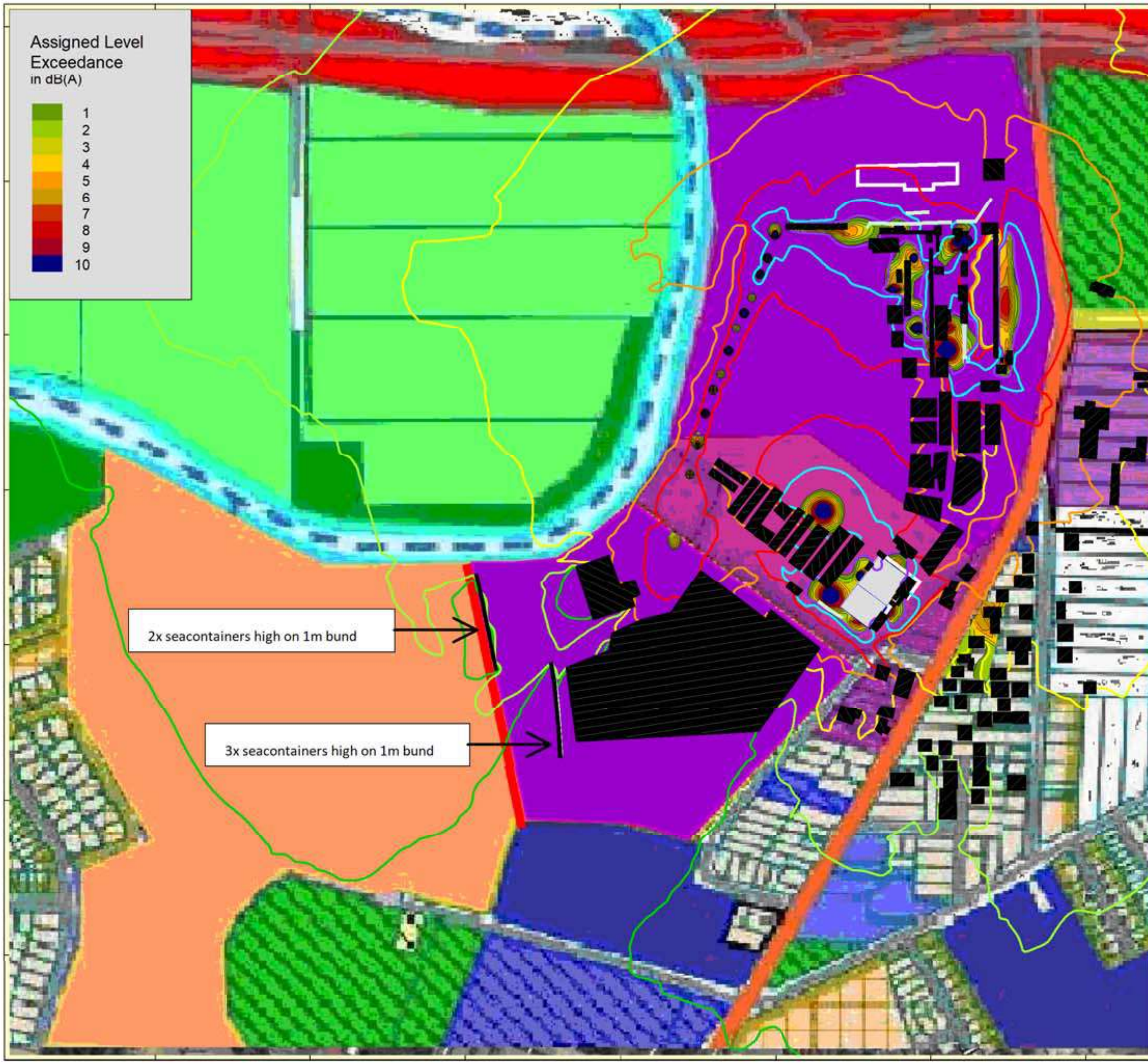
Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS

APPENDIX C

NOISE EMISSION CONFLICT MAPS

(ASSIGNED LEVEL EXCEEDANCE MAPS)



Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02

CONFLICT NOISE MAP
Combined Clay and Masonry,
Night Allwinds
Conveyor Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Night Operations

Map
320
CNMT

Scenario A
Result number 320
Calculation in 1.5 m above ground

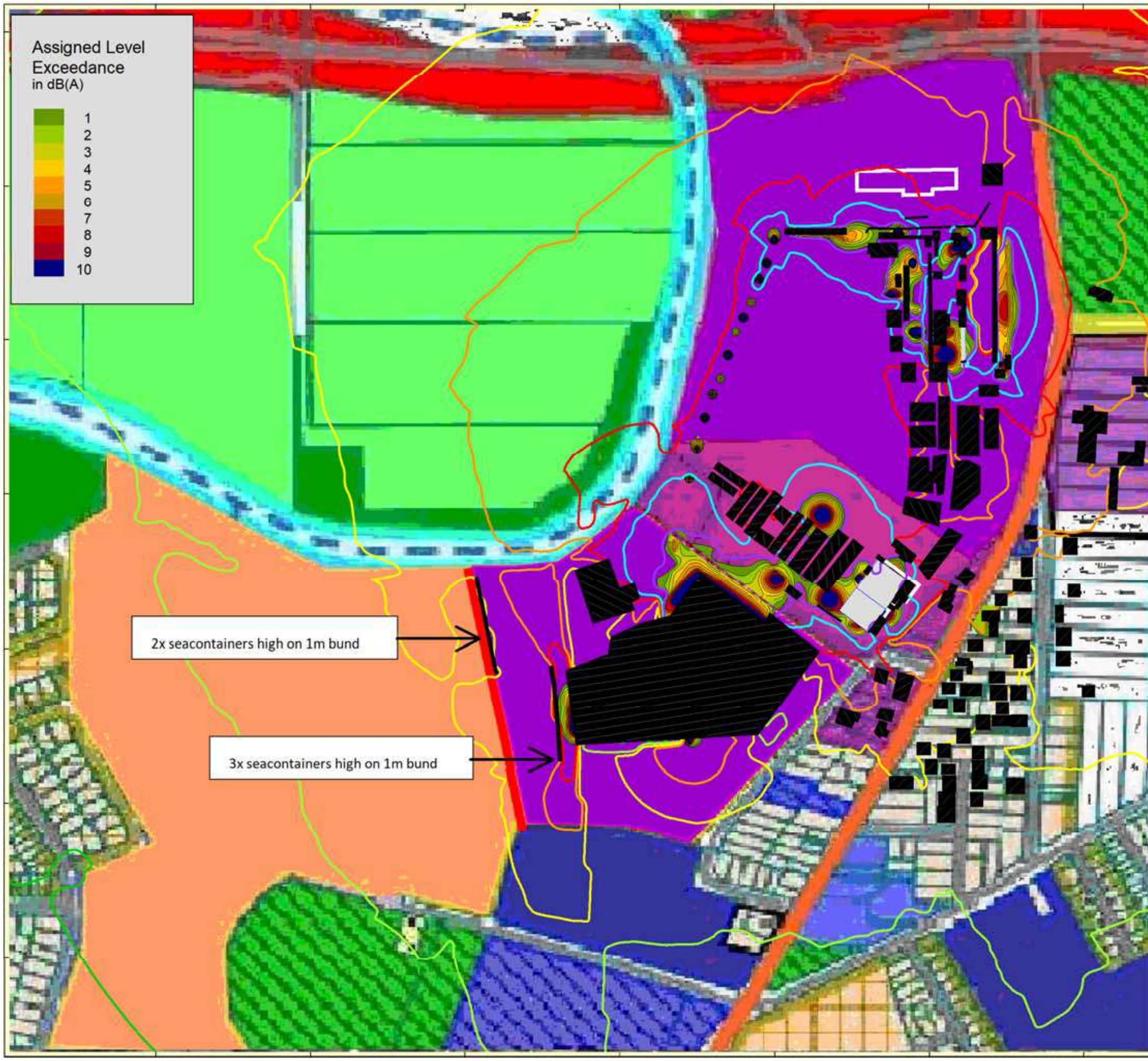
Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS



Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02

Combined Clay and Masonry
Evening Allwinds
Conveyor
& Clayshed Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Evening Operations

Map
315
CMET

Scenario A
Result number 315
Calculation in 1.5 m above ground

Day / Evening Operational Scenario

Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

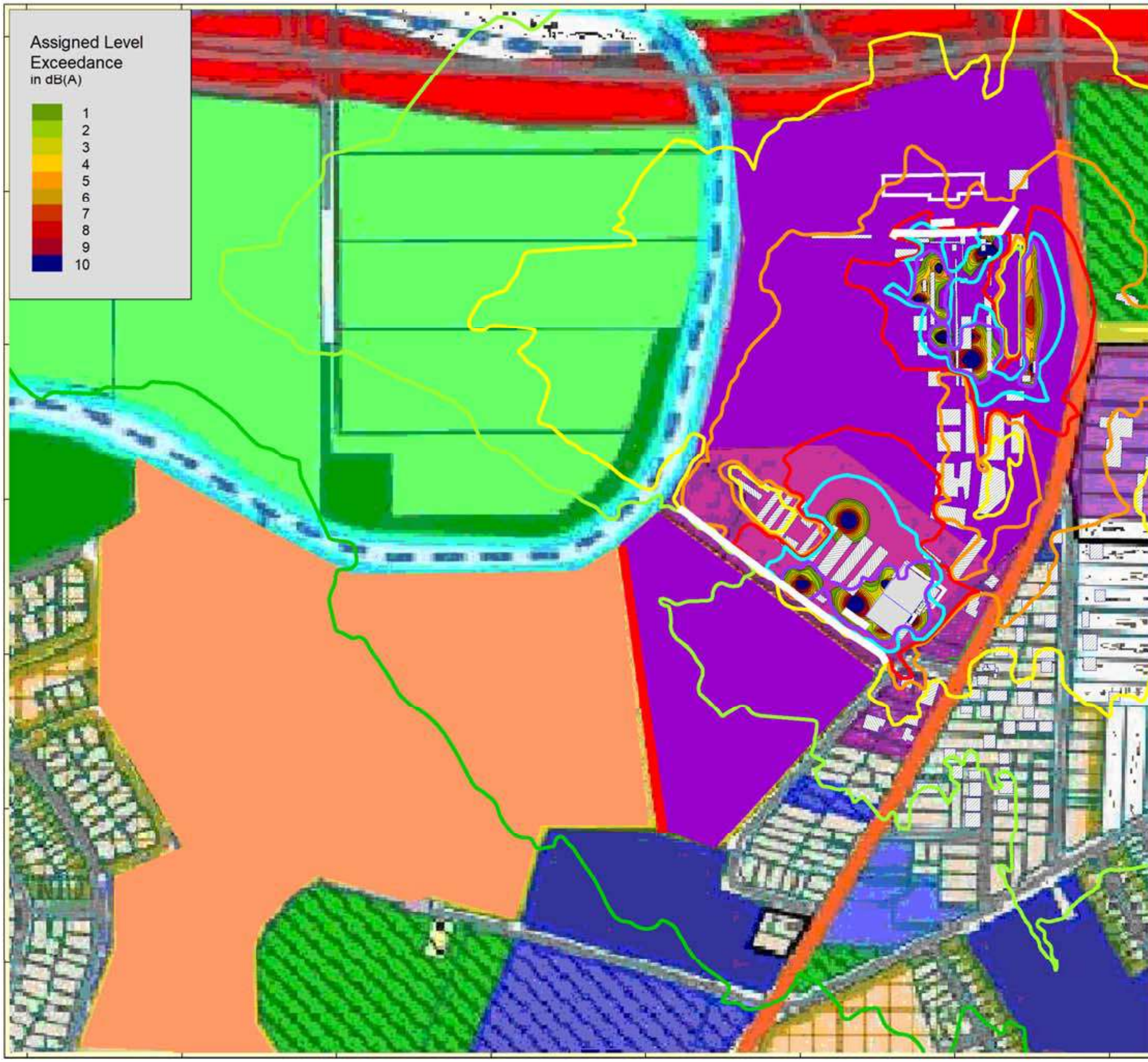
Signs and symbols
- Wall
- Main building
- Point source
- Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

N

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS



Customer: BGC & Capitary No.2 Hesperia
Project: Midland Brick Site
Project-No. 20355-02

CONFLICT NOISE MAP
Combined Clay and Masonry
Night Allwinds
Clayshed & Conveyor Removed

Map
299
CNMT

Scenario B
Result number 299
Calculation in 1.5 m above ground

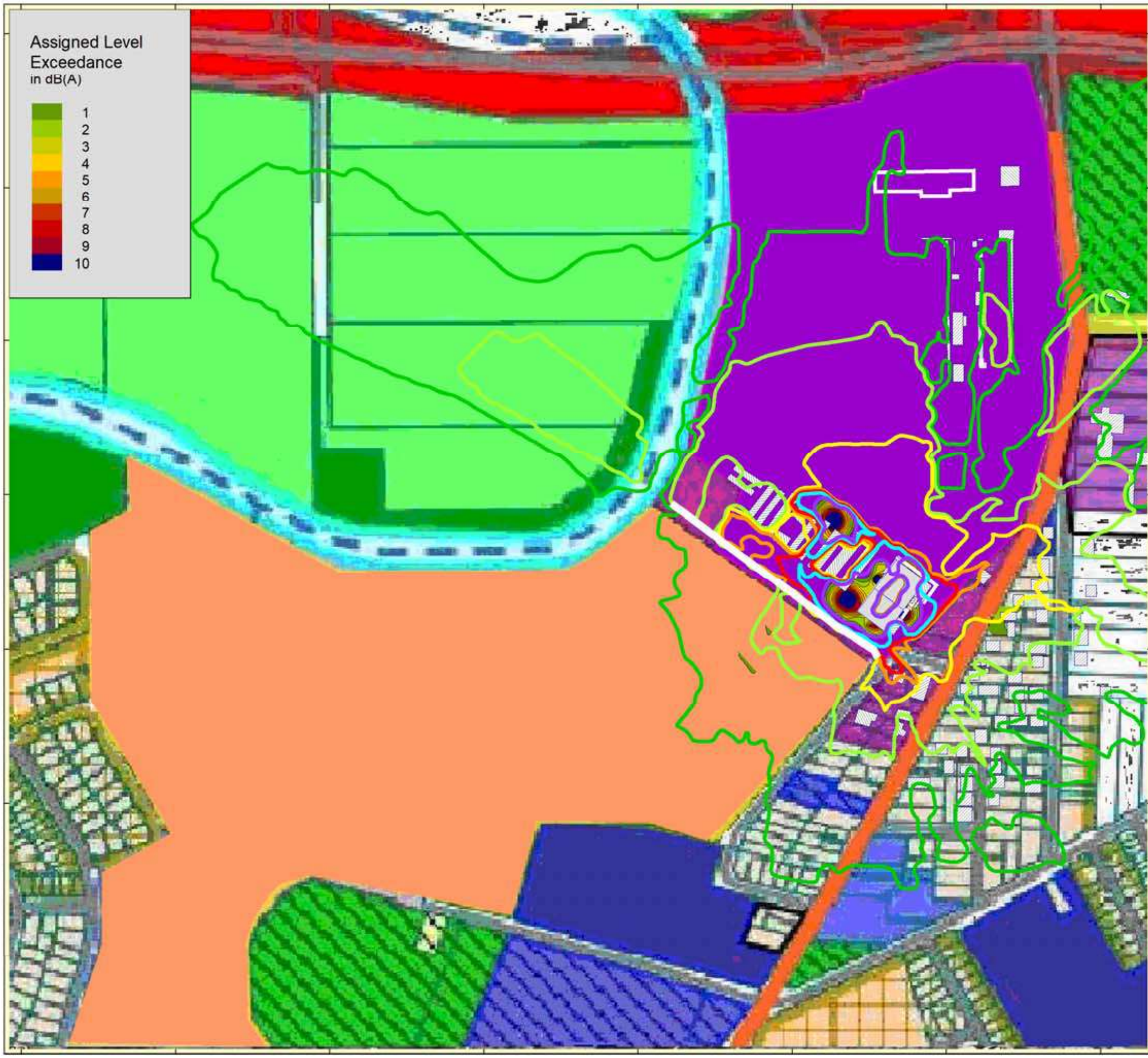
Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No.

CONFLICT MAP - NIGHT
Masonry Only
Night Allwinds

Scenario C

Map
300
CMNT

Scenario C - Masonry Only
Result number 300
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 24/06/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols
Wall
Main building
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

Length scale 1:7000
0 40 80 160 240 320
m

HERRING STORER ACOUSTICS

Appendix B

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)
The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

A-Weighting
An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

L_1
An L_1 level is the noise level which is exceeded for 1 per cent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{10}
An L_{10} level is the noise level which is exceeded for 10 per cent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{90}
An L_{90} level is the noise level which is exceeded for 90 per cent of the measurement period and is considered to represent the "*background*" noise level.

L_{eq}
The L_{eq} level represents the average noise energy during a measurement period.

$L_{A10,18hour}$
The $L_{A10,18\ hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight. The *CoRTN* algorithms were developed to calculate this parameter.

$L_{Aeq,24hour}$
The $L_{Aeq,24\ hour}$ level is the logarithmic average of the hourly L_{Aeq} levels for a full day (from midnight to midnight).

$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$
The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$
The $L_{Aeq\ (Day)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is typically 1-3 dB less than the $L_{A10,18hour}$.

Noise-sensitive land use and/or development
Land-uses or development occupied or designed for occupation or use for residential purposes (including dwellings, residential buildings or short-stay accommodation), caravan park, camping ground, educational establishment, child care premises, hospital, nursing home, corrective institution or place of worship.

About the Term 'Reasonable'

An assessment of reasonableness should demonstrate that efforts have been made to resolve conflicts without comprising on the need to protect noise-sensitive land-use activities. For example, have reasonable efforts been made to design, relocate or vegetate a proposed noise barrier to address community concerns about the noise barrier height? Whether a noise mitigation measure is reasonable might include consideration of:

- The noise reduction benefit provided;
- The number of people protected;
- The relative cost vs benefit of mitigation;
- Road conditions (speed and road surface) significantly differ from noise forecast table assumptions;
- Existing and future noise levels, including changes in noise levels;
- Aesthetic amenity and visual impacts;
- Compatibility with other planning policies;
- Differences between metropolitan and regional situations and whether noise modelling requirements reflect the true nature of transport movements;
- Ability and cost for mobilisation and retrieval of noise monitoring equipment in regional areas;
- Differences between Greenfield and infill development;
- Differences between freight routes and public transport routes and urban corridors;
- The impact on the operational capacity of freight routes;
- The benefits arising from the proposed development;
- Existing or planned strategies to mitigate the noise at source.

About the Term 'Practicable'

'Practicable' considerations for the purposes of the policy normally relate to the engineering aspects of the noise mitigation measures under evaluation. It is defined as "reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge" (*Environmental Protection Act 1986*). These may include:

- Limitations of the different mitigation measures to reduce transport noise;
- Competing planning policies and strategies;
- Safety issues (such as impact on crash zones or restrictions on road vision);
- Topography and site constraints (such as space limitations);
- Engineering and drainage requirements;
- Access requirements (for driveways, pedestrian access and the like);
- Maintenance requirements;
- Bushfire resistance or BAL ratings;
- Suitability of the building for acoustic treatments.

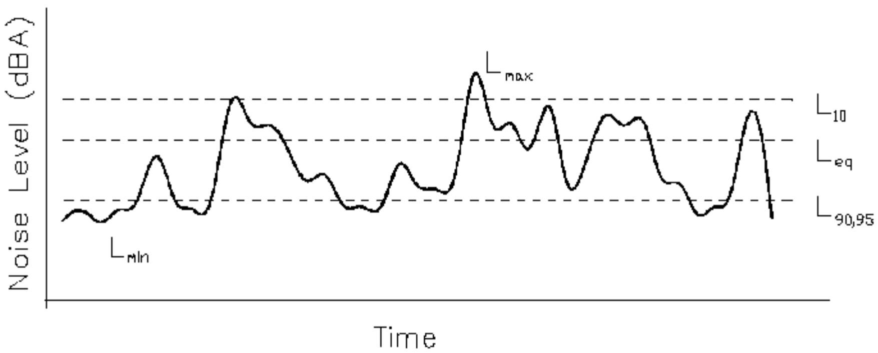
R_w

This is the weighted sound reduction index and is similar to the previously used STC (Sound Transmission Class) value. It is a single number rating determined by moving a grading curve in integral steps against the laboratory measured transmission loss until the sum of the deficiencies at each one-third-octave band, between 100 Hz and 3.15 kHz, does not exceed 32 dB. The higher the R_w value, the better the acoustic performance.

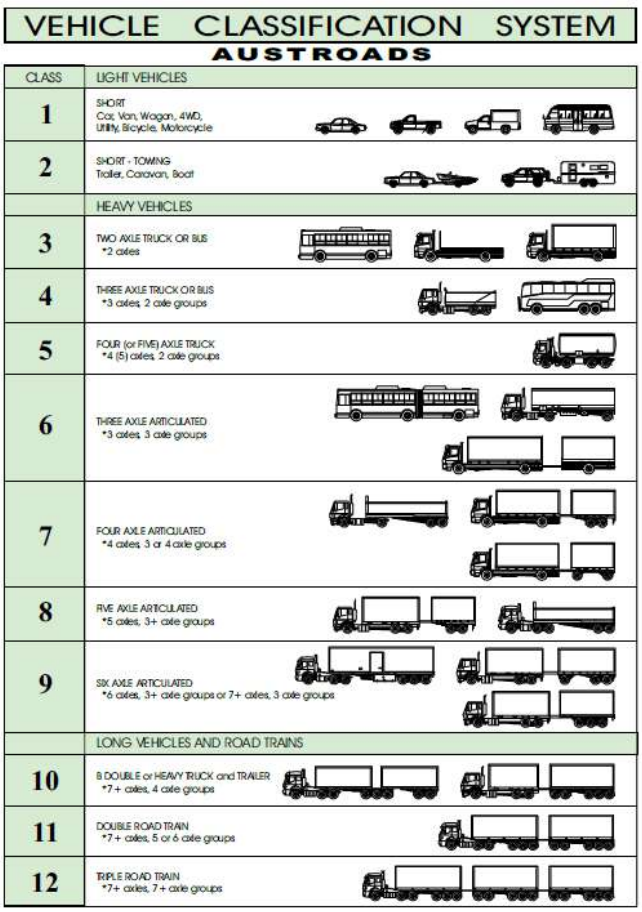
C_{tr}

This is a spectrum adaptation term for airborne noise and provides a correction to the R_w value to suit source sounds with significant low frequency content such as road traffic or home theatre systems. A wall that provides a relatively high level of low frequency attenuation (i.e. masonry) may have a value in the order of –4 dB, whilst a wall with relatively poor attenuation at low frequencies (i.e. stud wall) may have a value in the order of -14 dB.

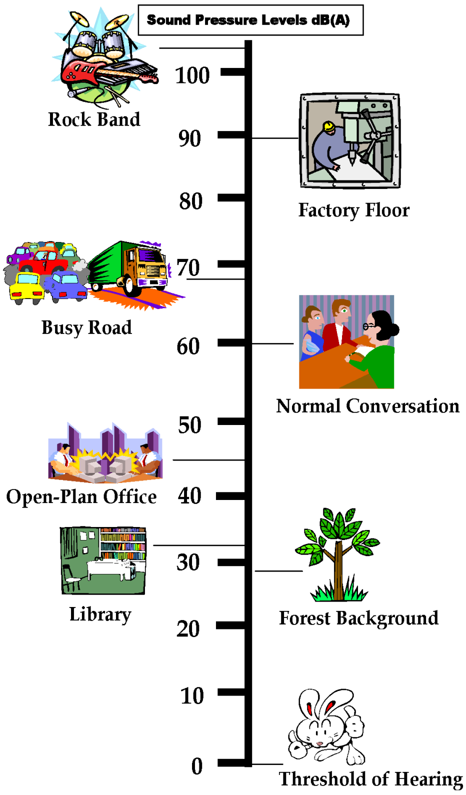
Chart of Noise Level Descriptors



Austroads Vehicle Class



Typical Noise Levels



Appendix E

Human Health Risk Assessment Midland Brick - Midland Brick MRS Rezoning (Environment Risk Sciences 2021)

Midland Brick MRS Rezoning: Human Health Risk Assessment

Prepared for: Hesperia

6 August 2021

Document History and Status

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Limitations

Environmental Risk Sciences has prepared this report for the use of Hesperia in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

It is prepared in accordance with the scope of work and for the purpose outlined in the Section 1 of this report.

The methodology adopted, and sources of information used are outlined in this report. Environmental Risk Sciences has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the reports provided for use in this assessment was false.

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Glossary of terms and abbreviations

Term	Definition
Acute exposure	Contact with a substance that occurs once or for only a short time (up to 14 days)
Adverse health effect	A change in body function or cell structure that might lead to disease or health problems
ATSDR	Agency for Toxic Substances and Disease Register
ANZECC	Australia and New Zealand Environment and Conservation Council
Background level	An average or expected amount of a substance or material in a specific environment, or typical amounts of substances that occur naturally in an environment.
Biodegradation	Decomposition or breakdown of a substance through the action of micro-organisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).
Carcinogen	A substance that causes cancer.
CCME	Canadian Council of Ministers of the Environment
Chronic exposure	Contact with a substance or stressor that occurs over a long time (more than one year) [compare with acute exposure and intermediate duration exposure].
CO	Carbon monoxide
DECCW	NSW Department of Environment, Climate Change and Water
DEFRA	Department for Environment, Food & Rural Affairs
DEH	Australian Department of Environment and Heritage
DER	Department of Environment Regulation
DWER	Department of Water and Environmental Regulation
Detection limit	The lowest concentration of a substance that can reliably be distinguished from a zero concentration.
Dose	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An 'exposure dose' is how much of a substance is encountered in the environment. An 'absorbed dose' is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Also includes contact with a stressor such as noise or vibration. Exposure may be short term [acute exposure], of intermediate duration, or long term [chronic exposure].
Exposure assessment	The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.
Exposure pathway	The route a substance takes from its source (where it began) to its endpoint (where it ends), and how people can come into contact with (or get exposed) to it. An exposure pathway has five parts: a source of contamination (such as chemical substance leakage into the subsurface); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Term	Definition
Genotoxic carcinogen	These are carcinogens that have the potential to result in genetic (DNA) damage (gene mutation, gene amplification, chromosomal rearrangement). Where this occurs, the damage may be sufficient to result in the initiation of cancer at some time during a lifetime.
Guideline value	Guideline value is a concentration in soil, sediment, water, biota or air (established by relevant regulatory authorities such as the NSW Department of Environment and Conservation (DEC) or institutions such as the National Health and Medical Research Council (NHMRC), Australia and New Zealand Environment and Conservation Council (ANZECC) and World Health Organization (WHO)), that is used to identify conditions below which no adverse effects, nuisance or indirect health effects are expected. The derivation of a guideline value utilises relevant studies on animals or humans and relevant factors to account for inter and intra-species variations and uncertainty factors. Separate guidelines may be identified for protection of human health and the environment. Dependent on the source, guidelines would have different names, such as investigation level, trigger value and ambient guideline.
HCl	Hydrogen chloride
HF	Hydrogen fluoride
HHRA	Human health risk assessment
IARC	International Agency for Research on Cancer
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see route of exposure].
LOR	Limit of Reporting
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
NSW	New South Wales
NSW EPA	NSW Environment Protection Authority
OEH	NSW Office of Environment and Heritage
OEHHA	Office of Environmental Health Hazard Assessment, California Environment Protection Agency (Cal EPA)
PM	Particulate matter
$PM_{2.5}$	Particulate matter of aerodynamic diameter 2.5 µm and less
PM_{10}	Particulate matter of aerodynamic diameter 10 µm and less
Point of exposure	The place where someone can come into contact with a substance present in the environment [see exposure pathway].
Population	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).
Receptor population	People who could come into contact with hazardous substances [see exposure pathway].
Risk	The probability that something would cause injury or harm.
Route of exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].
SO_2	Sulfur dioxide
TCEQ	Texas Commission on Environmental Quality
Toxicity	The degree of danger posed by a substance to human, animal or plant life.

Term	Definition
Toxicity data	Characterisation or quantitative value estimated (by recognised authorities) for each individual chemical substance for relevant exposure pathway (inhalation, oral or dermal), with special emphasis on dose-response characteristics. The data are based on based on available toxicity studies relevant to humans and/or animals and relevant safety factors.
Toxicology	The study of the harmful effects of substances on humans or animals.
TSP	Total suspended particulates
UK	United Kingdom
US	United States
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WA	Western Australia
WHO	World Health Organization
$\mu g/m^3$	Micrograms per cubic metre

Section 1. Introduction

1.1 Background

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by Hesperia to prepare a human health risk assessment (HHRA) as part of considerations for the rezoning of part of the existing Midland Brick site (northern portions of Lots 23 and 72 Eveline Road, Middle Swan) (the “site”).

The brickworks site has been used for industrial purposes (Brickworks) and parts of the site are being considered for rezoning from rural and industrial zoning to urban zoning and parks and recreation zoning in Perth’s Metropolitan Region Scheme (MRS). The consolidated brickworks will continue to operate on land adjacent to the land proposed to be rezoned and redeveloped.

The human health risk assessment is required to determine the potential risks to human health for the areas of the site which will be zoned urban from the ongoing operations of the site. The key issues of concern identified for the site relate to:

- community exposures to emissions to air from the ongoing brickworks operations
- community exposure to noise derived from the ongoing brickworks operations.

While not the focus of the HHRA, the available information relating to land contamination has been reviewed to understand the potential for contamination to be present and whether the site can be made suitable for the proposed rezoning and development.

A number of assessments have been undertaken to assess air quality, noise and contamination. These assessments have been referenced and utilised in this report.

1.2 Objectives

The objectives of the HHRA presented in this report are:

- review the available data for site contamination
- review the available monitoring data for emissions to air and air dispersion modelling for emissions from the brickworks
- review noise monitoring and modelling data
- undertake a human health risk assessment for risks arising from impacts related to the former and ongoing operation of the brickworks
- on the basis of the HHRA, identify any additional data or measures that may be required to assist in refining the assessment of risk or in considering additional risk management measures that may be needed.

The HHRA has only addressed risks to human health for the portion of the brickworks site to be rezoned. The HHRA has not addressed any impacts in off-site areas, nor any environmental risks.

1.3 Approach and scope of works

The HHRA has been undertaken in accordance with the following guidance (and associated references as relevant):

- enHealth (2012) Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards (enHealth 2012a)

- enHealth (2012) Australian Exposure Factor Guide (enHealth 2012b)
- NEPC 2016. National Environment Protection (Ambient Air Quality) Measure (NEPC 2016)
- NEPC 2011. National Environmental Protection (Air Toxics) Measure (NEPC 2011)
- ASC NEPM (1999 amended 2013) National Environmental Protection Measure – Assessment of Site Contamination including:
  - Schedule B1 Investigation Levels for Soil and Groundwater (NEPC 1999 amended 2013a)
  - Schedule B4 Guideline on Site-Specific Health Risk Assessment Methodology (NEPC 1999 amended 2013b)
  - Schedule B6 Guideline on the Framework for Risk-Based Assessment of Groundwater Contamination (NEPC 1999 amended 2013c) (as required)
  - Schedule B7 Guideline on Health-Based Investigation Levels (NEPC 1999 amended 2013d)
  - Toolbox Note – Key principles for the remediation and management of contaminated sites (NEPC 2013)
- Technical guidance in relation to the assessment of vapour risks (CRC CARE 2011, 2013; Davis, Wright & Patterson 2009)
- Relevant guidance on risk assessment for WA, that includes:
  - Health Risk Assessment in Western Australia 2006[1].
- Relevant guidance on air quality for WA, that includes:
  - *Environmental Protection Act 1986*
  - Environmental Factor Guideline: Air quality 2016
  - Draft Guideline: Air emissions 2019
  - Air quality modelling guidance notes 2006
- Relevant guidance on noise for WA, that includes:
  - *Environmental Protection (Noise) Regulation 1997*
  - *State Planning Policy 5.1: Land Use Planning in the Vicinity of Perth Airport*

In addition, guidance available from international agencies such as the US EPA and WHO have been utilised, where relevant, as referenced in this report.

1.4 Available information

This assessment has been undertaken on the basis of information provided in the following reports:

- Proposed development:
  - Element 2020, Metropolitan Region Scheme Amendment Request, Minor amendment Midland Brick Site – Portions of Lots 23 and 72 Eveline Road, Middle Swan LGA: City of Swan, dated May 2020.
- Air quality impact assessment:

[1] It is noted that this guideline (dated 2006) was based on the enHealth guidance on risk assessment published in 2004 which has since been updated, as enHealth 2012a listed above. Any specific requirements from this document (where relevant) have been considered in addition to the requirements from enHealth 2012.

- ETA 2020a, Metropolitan Region Scheme, Proposed Amendment – Midland Brick, Air Quality Impact Assessment, Final Report, Version 0. Prepared for Emerge Associates, dated February 2020.
    - WA DER 2014, 2011-12 Midland Background Air Quality Study, Department of Environment Regulation 2014. Western Australia Department of Environment Regulation (DER), Final dated March 2015.
    - WA DEC 2008, Fact sheet: Midland Background Air Quality Study, August 2007 – November 2008. Western Australia Department of Environment and Conservation.
    - Other reports for surrounding areas (not directly relevant to the site):
        - Environmental Technologies & Analytics (ETA) 2019, Cranwood Crescent Proposed Subdivision Air Quality Impact Assessment, Final Report, Version 1. Prepared for Emerge Associates, dated December 2019.
        - ETA 2020b, Local Structure Plan – Midland Brick, Air Quality Impact Assessment, Final Report, Version 0. Prepared for Emerge Associates, dated April 2020.
- Noise impact assessment:
    - Lloyd George Acoustics 2021, Noise Assessment, MRS Amendment, Middle Swan. Revision 2, prepared for Hesperia 8 July 2021.
    - Lloyd George Acoustics 2020a, Noise Impact Assessment, Englobo Residential Area, Viveash. Revision B, prepared for Linc Property C/- Emerge Associates.
    - Other reports for surrounding areas (not directly relevant to the site):
        - Lloyd George Acoustics 2019, Noise Impact Assessment, Winston Crescent/Somerset Street, Viveash. Revision C, prepared for Linc Property C/- Emerge Associates
        - Lloyd George Acoustics 2020b, Stage 2 Noise Management Plan, Cranwood Crescent Subdivision. Revision A, prepared for Hesperia.
        - Lloyd George Acoustics 2021, Stage 1 Noise Management Plan, Cranwood Crescent Subdivision. Revision E, prepared for Hesperia.
        - WA DWER 2020, Technical (Review) Report, Advice on the Environmental Noise Assessment for the subdivision of land adjacent to Midland Brick Viveash, prepared for the WAPC. Department of Water and Environmental Regulation (DWER) dated May 2020.
- Contaminated land:
    - Emerge Associates (Emerge) 2019a, Groundwater Assessment Report, Midland Brick. Prepared for Boral Ltd, dated February 2019.
    - Emerge 2019b, Preliminary Site Investigation, Boral Midland Brickworks. Prepared for APP Corporation Pty Ltd dated May 2019.
    - Emerge 2019c, Targeted Factual Site Investigation, Midland Brick. Prepared for Linc Property Pty Ltd dated December 2019.
    - Emerge 2020a, Detailed Site Investigation, Midland Brick Stage 1 Subdivision. Prepared for Capitary No. 2 Pty Ltd dated April 2020.
    - Emerge 2020b, Management of Biogenic Hydrocarbons in Sediment: Stage 1 Subdivision. Letter dated 27 November 2020.
    - Emerge 2021a, Detailed Site Investigation, Midland Brick Stage 2 Subdivision. Prepared for Hesperia Pty Ltd dated June 2021.

- Emerge 2021b, Baseline Environmental Site Assessment, Midland Brick Lease Area A & Proposed Lot 11. Prepared for Hesperia Pty Ltd and BGC (Australia) Pty Ltd dated March 2021.
- Emerge 2020c, Baseline Environmental Site Assessment, Midland Brick Lease Area B. Prepared for Hesperia Pty Ltd and BGC (Australia) Pty Ltd dated March 2021.
- Emerge 2021c, Baseline Environmental Site Assessment, Midland Brick Lease Area C. Prepared for Hesperia Pty Ltd and BGC (Australia) Pty Ltd dated March 2021.
- Emerge 2021d, Baseline Environmental Site Assessment, Midland Brick Lease Area D. Prepared for Hesperia Pty Ltd and BGC (Australia) Pty Ltd dated March 2021.
- Emerge 2021e, Baseline Environmental Site Assessment, Midland Brick Lease Area E. Prepared for Hesperia Pty Ltd and BGC (Australia) Pty Ltd dated March 2021.

- Other reports (not directly relevant to the site):
  - WA DWER 2020, Application No. 158848 – Lot 142-169, 190-198, 200-205, 221, 23, 72, 900 Winston Crescent, Cranwood Crescent, York Street, Somerset Street, Surrey Court, Viveash & Eveline Road, Middle Swan. Letter from the DWER dated 18 May 2020.

Section 2. Project description and identification of key issues

2.1 Site description and location

The rezoning application (Element 2020) relates to the proposal to rezone portions of the existing Midland Brick site, located in Middle Swan in Western Australia, from the existing 'Rural' and 'Industrial' zones to 'Urban' zone. These portions of land are described as the northern portion of Lots 23 and 72 Eveline Road in Middle Swan, which are located approximately 16 km from Perth Central Business District, and 1.5 km from Midland City Centre (refer to **Figure 1**).

The area to be rezoned is bound by the Swan River to the north, Bassett Road to the east, Eveline Road to the south and the proposed Cranwood Crescent residential subdivision area to the west, as illustrated in **Figure 2**. A vegetated area is located along the south eastern site boundary to provide a buffer between the existing industrial activities and off-site residential properties.

These lots form part of a much larger landholding owned by Capitary No. 2 Pty Ltd which is currently used for brickmaking operations.

The site evaluated in this assessment was originally used as rural land with brickmaking operations occurring in the 1950's. The current Midland Brick operations includes all stages of the brick manufacturing process. This includes clay preparation, product shaping, drying and firing.

An application was made in late 2020 to have Kilns 7 and 8 removed from the current Part V Licence. In addition, Kiln 11 will be decommissioned and removed from the Part V Licence in April 2022, with an application having been made to this effect.

The existing brickworks site area will remain active until April 2022. After April 2022 the only brickworks related activity occurring south of Bassett Road will be the Clay Shed (which will be leased for a period of 5 to 10 years).

For the proposed development, all brickmaking infrastructure located on the site, including Kilns 7 and 8 (previously decommissioned), Kiln 11, sheds and office buildings, warehouses (including the Clay Shed) and hardstand areas are to be demolished.

Existing Kilns 9 and 10 are to be retained. These are located on land to the northeast of the site (refer to **Figure 3**) that will remain for industrial use, and where brickmaking operations are proposed to be consolidated. No additional Kilns are proposed to be constructed.

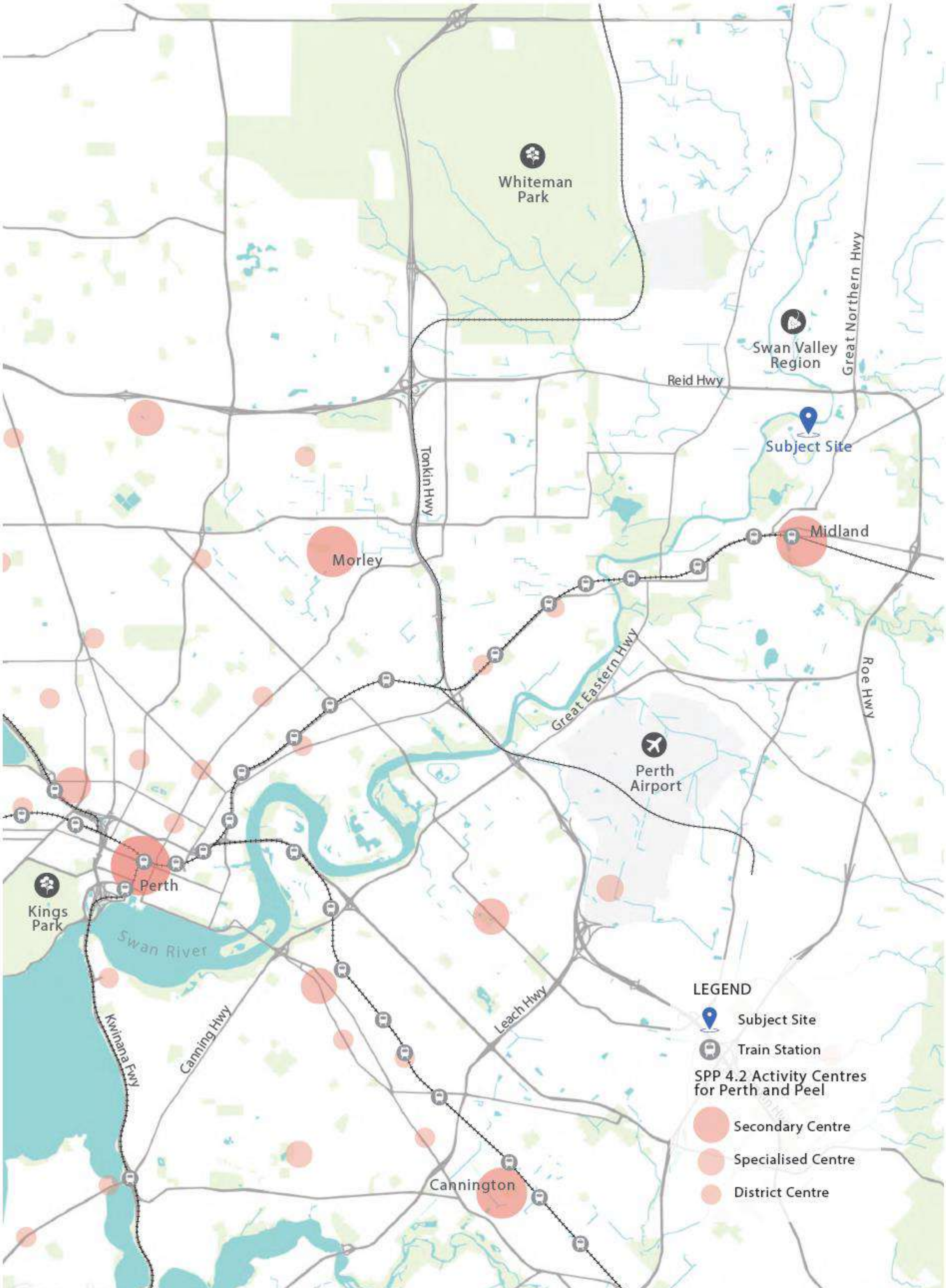

Figure 1: General site location (ref: Element 2020)

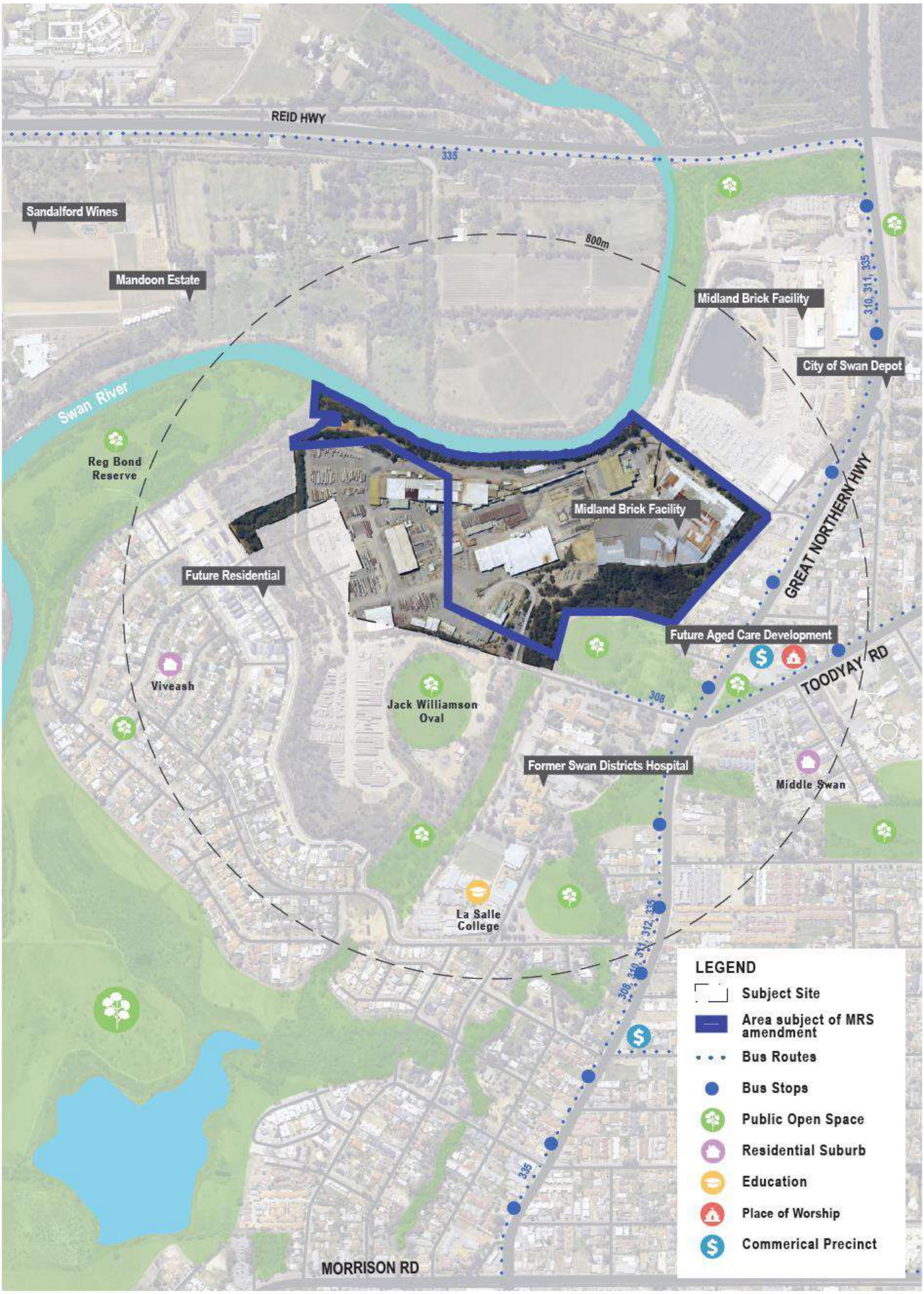

Figure 2: Land subject to rezoning for urban use as per the MRS (ref: Element 2020)

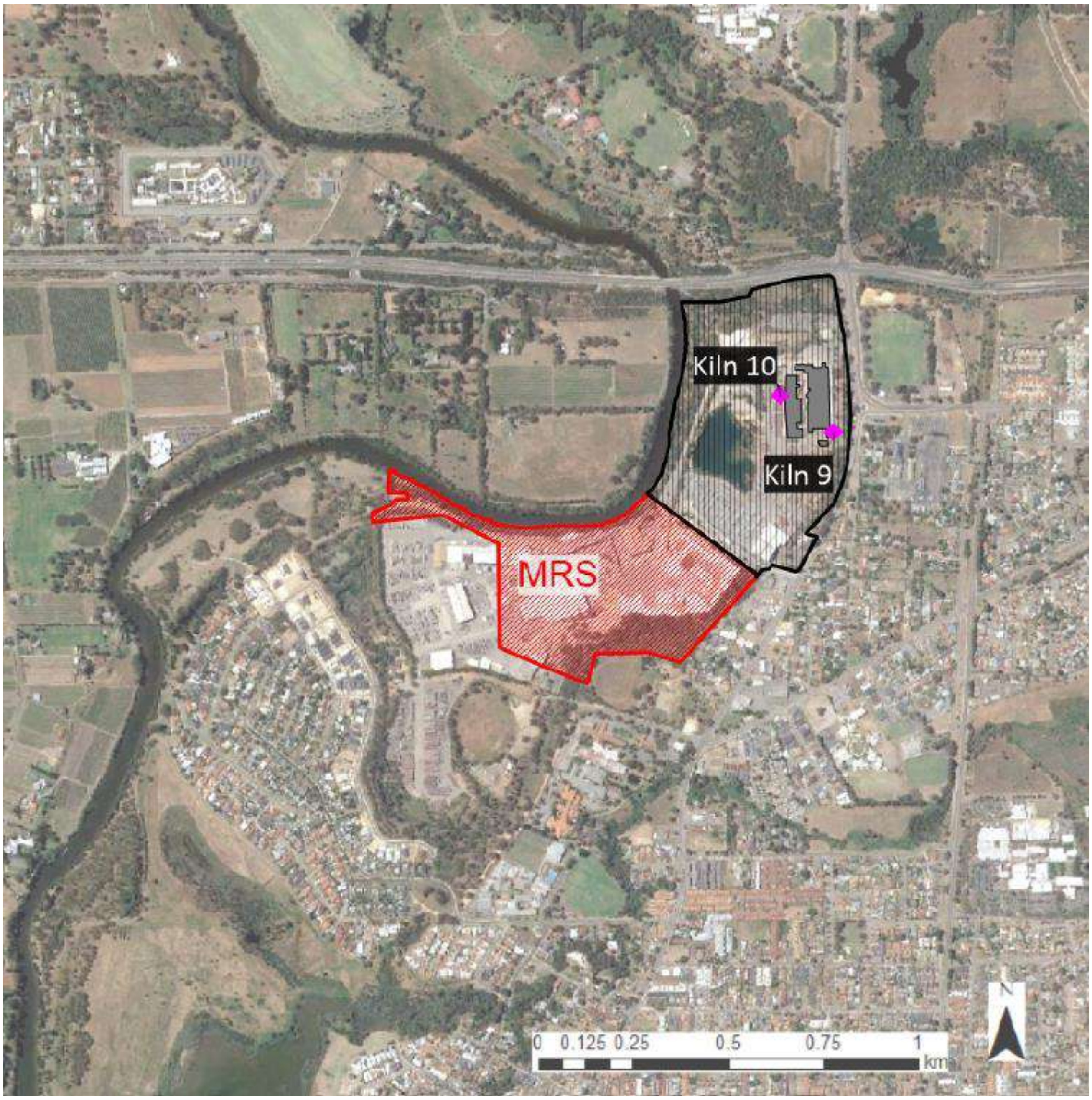

Figure 3: Land subject to rezoning and location of ongoing brickmaking operations (ref: ETA 2020)

2.2 Proposed rezoning

Based on information provided in the MRS Amendment Application (Element 2020) the site is proposed to be rezoned for urban uses. The site sits within a larger urban redevelopment area that includes a number of residential precincts, open space and vegetated areas. This includes the retention of existing vegetation along the southern portion of Lot 72, as well as a number of existing trees (refer to **Figure 4**).

Development of the larger urban redevelopment area has been undertaken in stages. Figure 5 presents the various development stages and proposed timelines for access and construction in these areas.

This assessment relates to land that is required to be rezoned prior to development and includes part of Stages 5 and 6, Stage 7, as well as the northern part of Stage 4 (along the river).

The urban residential development will include a number of roads to connect to the existing road network (including Great Northern Highway), which will include a new east-west road to connect Eveline Road to Cranwood Crescent.

A noise bund is proposed to be constructed along Bassett Road between Lot 72 and the consolidated brickworks (residential/industrial boundary or interface). This area is proposed to also include high quality dense landscaping.

The density of the proposed urban development on the site has not yet been determined. Hence this assessment will consider the more sensitive residential land uses associated with low to medium density developments.

2.3 Identification of key issues

The focus of this assessment relates to potential impacts on human health associated with the proposed rezoning and redevelopment of the site.

In relation to potential risks from environmental contamination or emissions, the key issues of concern relate to:

- The presence of contamination in soil or groundwater within the site that may be of concern for the proposed residential and open space use of the site.
- Emissions to air from the ongoing brick making operations on the consolidated Midland Bricks site adjacent to the north-eastern site boundary, and the impact of these emissions on the health of future occupants of the site. These emissions are principally from the ongoing operation of Kilns 9 and 10. All other kilns associated with former activities on the site have already been decommissioned and all other infrastructure on the site will be demolished for the development.
- Noise emissions from the ongoing operations on the consolidated Midland Bricks site adjacent to the north-eastern site boundary, and the potential for these to impact on the health of future occupants. It is noted that aircraft noise has also been identified as a source relevant to the proposed redevelopment.

The following sections provides a more detailed review of the existing information relating to the above, in terms of potential impacts/risks to human health, relevant to the rezoning area.

REDEVELOPMENT CONSIDERATIONS	
Environmental	
E1	• Opportunity to achieve improved access to and along the Swan River for residents and the broader community. • Foreshore Interface – Compliance with Swan River Trust Policies (No.42,48,49); consideration in context of existing bunding and preference for improved visual linkage between foreshore and residential precinct. Design to worked through with DBCA.
E2	• Opportunity to retain existing trees within proposed extension of Eveline Road reserve, subject to detailed engineering investigations with arborist.
E3	• Opportunity to retain and integrate vegetation to contribute to enhancing amenity in the area and create potential green link.
E4	• Opportunity to review and refine the existing subdivision design (residential lots and roads are already titled) to better integrate existing trees within road reserve design and proposed introduced pocket park.
Residential and Industrial Interface	
I1	• Potential POS 'green link' – width and design requirements to be set.
I2	• Management of noise between brickworks operations (Kilns operate 24/7) and noise associated with truck movements (western boundary) to sensitive receptors. Achieve compliant noise emissions to Stage 1 residential precinct by the staged relocation of existing operations from western portion of the site to the north-east. Noise attenuation solutions to be investigated.

Residential Precinct	
R1	• Existing residential zoned land being brought online first (Stage 1).
R2	• Future residential precinct design vision to be worked through as part of the structure plan process. • 20-25 ANEF contour recently revised – approach to density within the residential precinct to be further worked through with WAPC and City of Swan in line with *SPP 5.1 – Land use planning in the vicinity of Perth Airport.*
R3	• Integrate major service corridors - retention of high pressure gas infrastructure (gas stations/pipelines) including appropriate separation distances.
R4	• Potential Stage 1 public open space.
Servicing and Engineering	
S1	• Opportunity to repurpose Jack Williamson Park as part of project.
S2	• Challenge to address existing level difference with interface with river bank.
Movement Network	
T2	• Opportunity to improve upon existing bushfire emergency access by introducing new road connection between Eveline Road and Cranwood Crescent.
T3	• Potential movement network requirements (investigation into proposed access, intersections, capacities).

Figure 4: Concept plan and design consideration for site and larger urban development (ref: Element 2020)

Stage	Access	Construction Duration
1A	Approved	Completion: Oct-21
1B	Approved	Completion: Oct-21
2	31-Jan-22	Comm: Feb-22 Complete: Sept-22
3	31-Jan-22	Comm: Nov-22 Complete: Jan-25
4	30-Apr-22	Comm: Jun-24 Complete: Sept-26
5	30-Apr-22	Comm: Feb-26 Completion: Nov-27
6	30-Apr-22	Comm: Apr-27 Complete: May-28
7	31-Mar-26 31-Mar-31 31-Mar-36	

Figure 5: Larger urban redevelopment, Masterplan timing

Section 3. Review of contamination issues

This section provides an overview of the available information relating to land contamination on the site, as a result of the brickworks activities and operations to support the brickworks activities. This information has been reviewed in the context of the proposed redevelopment of the site for urban residential land use.

Emerge has undertaken a number of site investigations that cover different areas of the former brickworks operations that are located on the land to be rezoned and redeveloped. The investigations undertaken included the sampling of soil and groundwater for the purpose of characterising the nature and extent of potential contamination, and whether the site is suitable for the proposed redevelopment.

It is noted that the assessment of contamination on the site is subject to contaminated site auditing, consistent with the Voluntary Audit Reporting or Mandatory Audit Reporting (MAR) process within the Western Australian Contaminates Sites Auditor Scheme, operating under the *Contaminated Sites Act 2003* and *Contaminated Sites Regulations 2006* and the revised national site assessment framework provided in the NEPM (NEPC 1999 amended 2013e). This process relates to ensuring investigations are adequate to demonstrate that the land is suitable for the proposed use.

The site investigations have been completed for separate areas of the former brickworks site (refer to report list in **Section 1.4**). Some of the investigation reports relate to land outside of the area to be rezoned. Reports relevant to the site relate to the sampling of soil and groundwater (Emerge 2019a, 2019b, 2019c, 2021c and 2021e). These reports have identified the potential for some contamination to be present as a result of the former operations. There is no evidence that the land is not suitable or cannot be made suitable for residential land use.

On the basis of the above, in relation to contamination, the site can be made suitable for the proposed residential land use. Hence no further, detailed assessment of risks related to contaminated land has been undertaken in this assessment.

Section 4. Review of air emissions and impacts

4.1 Introduction

This section presents a review of potential risks to human health associated with the proposed residential land use of the site, where emissions to air from ongoing brickworks operations (specifically Kilns 9 and 10) occur throughout the proposed (and staged) redevelopment of the site.

4.2 Overview of kiln operations

For the proposed redevelopment of the site for urban residential land use, all existing brickworks operations on the site would be decommissioned and removed. The only remaining operations would be in the consolidated brickworks located to the north of Bassett Road. This involves the operation of Kilns 9 and 10.

Emissions to air from Kilns 9 and 10 are regulated by licence L4511/1967/13 issued by the WA Department of Water and Environmental Regulation (DWER) under the Part V provisions of the *Environmental Protection Act 1986*.

The manufacture of bricks requires the firing of the clay bricks in a kiln. Acid gases that include hydrogen fluoride (HF), hydrogen chloride (HCl) and sulfur dioxide (SO_2) are key pollutants released to air from the kiln. To reduce the emission of these gases, a flue gas treatment system (FGTS) is used on Kilns 9 and 10. The FGTS comprises a hydrated lime scrubber and baghouse.

The following relates to the operation of the kilns and FGTS on Kilns 9 and 10 in relation to emissions to air during all operating conditions (based on information supplied by Midland Brick, also refer to **Figure 6** for a process diagram of the baghouse set-up):

- There is no bypass system that would enable untreated kiln exhaust gases to enter the stack and be discharged to air.
- The kiln and FGTS are connected by an electrical interlock in accordance with relevant Australia Standards for gas appliances and are inspected by Gas Inspectors from Energy Safety to ensure the interlock meets the criteria for compliance. This electrical interlock ensures that if there is a failure with the FGTS or kilns, the kilns will automatically shut down immediately followed by a shutdown of the FGTS. This prevents any untreated kiln exhaust gas from entering the stack.
- When the FGTS shuts down there are gate valves on the inlet side (kiln side) of the scrubber baghouse and on the outlet side (stack side) of the scrubber baghouse which shut to ensure no gases are released into the stack without being fully treated. Due to the gate valves being shut there is no release of untreated or partially treated kiln exhaust gases.
- Bricks will remain in the kiln during an unscheduled shut-down unless there is a kiln collapse and then the brick cars will be removed.
- The interlocking arrangement, gate valves and lack of a bypass, means that there are no abnormal emissions to air during upset conditions.

More specifically the following is relevant during start-up and shut-down conditions:

- Due to the electrical interlocking between a kiln, and the FGTS, a kiln cannot not be operated without the FGTS also being operational.

- During a complete maintenance shut-down, a kiln's burners are turned off and the kiln cooled and FGTS completely shut down before work is commenced. No gases are released into the scrubber baghouse (due to gate valves being shut) or generated due to the reduced temperatures.
- Kiln gas emissions arise when the bricks are placed into the kilns; during start-up, no bricks enter a kiln until the FGTS is fully operational.
- During shut-down, the FGTS is fully operational until there are no bricks remaining in the kiln.
- During the start-up and shut-down process the source of air pollutants, the bricks, are never in a kiln without the FGTS being fully operational, therefore there are no elevated emissions of air pollutants during this process.

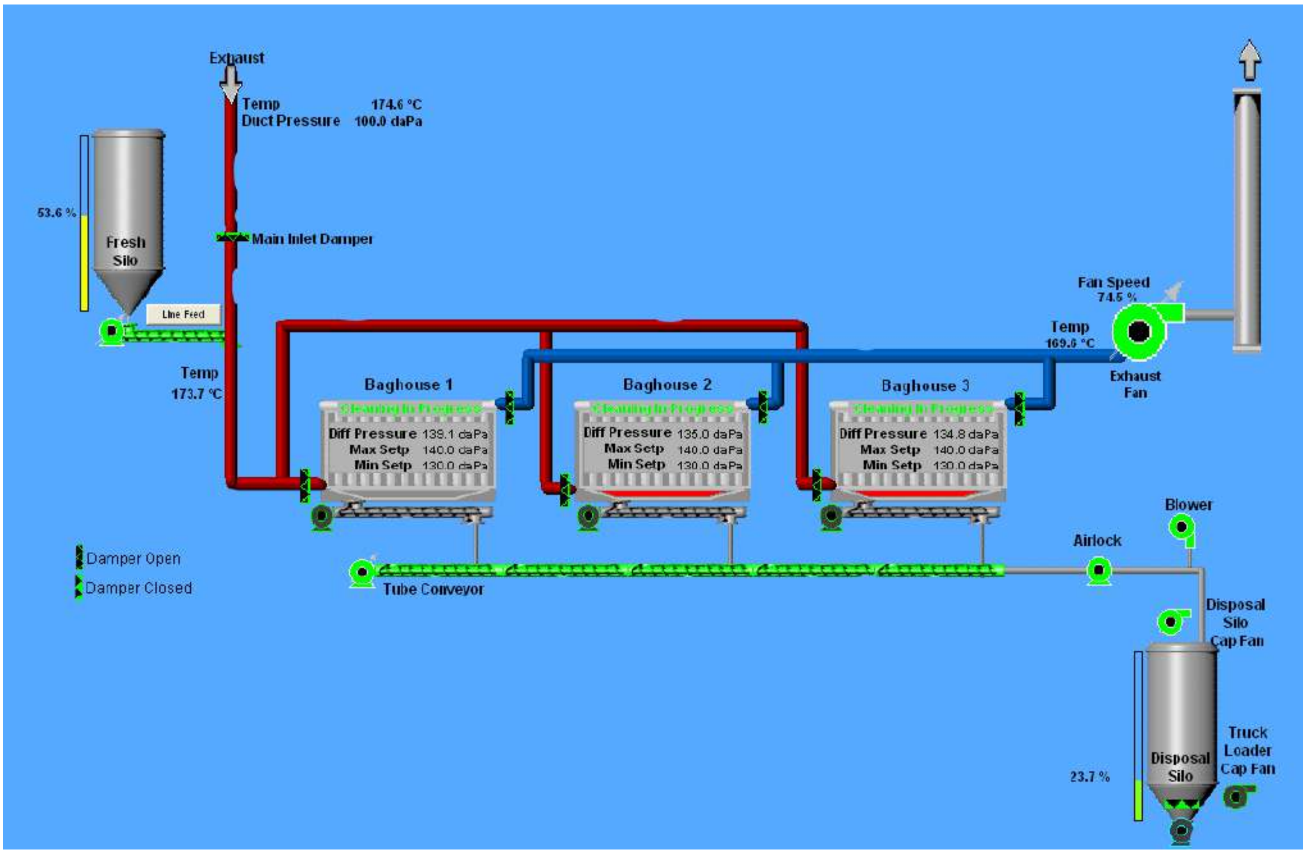

Figure 6: Process diagram of kiln baghouse operations (relevant to Kilns 9 and 10) (supplied by Midland Bricks)

Based on the above information, the design and operation of Kilns 9 and 10 prevents the release of emission gases to air that have not been treated through the FGTS, including during upset, start-up and shut-down operations. Hence emissions to air characterised during normal operating conditions, as measured, are expected to be representative of emissions to air during all conditions. Emissions to air from the stacks of Kilns 9 and 10 (after the FGTS) are routinely monitored as required in the licence. This requires the monitoring of HF, HCl and SO_2 along with other parameters. These data have been considered in the modelling of emissions to air from Kilns 9 and

10 as discussed further in **Section 4.3**. Further, as a worst-case, emissions to air that are at the licence limit were also assessed in the air modelling (refer to **Section 4.3**).

4.3 Review of air impact assessment

Emissions to air from ongoing operations of the brickworks, specifically emissions from Kilns 9 and 10 which are located to the northeast of the site to be rezoned are of importance for the assessment of potential exposures by future residents living on the site (once developed).

Impacts from air emissions have been evaluated by ETA (2020), where emissions to air from Kilns 9 and 10 have been modelled, with concentrations predicted in proposed residential development areas surrounding the operations. This includes the land referred to as the Local Structure Plan (LSP) that includes the site (ETA 2020b), and land specific to the Amendment application (ETA 2020a).

Modelling of air quality impacts from Kilns 9 and 10 relevant to the broader community for all pollutants (ETA 2020a and 2020b) shows the maximum predicted impacts are in the vicinity of the kilns, on the consolidated brickworks site or immediately off-site. Concentrations do not increase with increasing distance from these areas. Hence review and assessment of maximum predicted impacts (on the site, or anywhere) against health based guidelines is also considered to address impacts within the broader community.

This assessment has only further considered impacts modelled within the site subject to the Amendment application (ETA 2020a), the land proposed to be re-zoned. This assessment evaluated emissions to air from the operation of Kilns 9 and 10, where the pollutants evaluated were:

- Particulate matter (as $PM_{2.5}$ and PM_{10})
- Carbon monoxide (CO)
- Acid gases:
  - Hydrogen chloride (HCl)
  - Hydrogen fluoride (HF)
  - Sulfur dioxide (SO_2)

The air quality impact assessment (ETA 2020a) considered measured emissions in the stacks (representative of emissions during all operations, refer to **Section 4.3**) as well as the maximum allowable emissions limits prescribed in the environmental licence. The modelling considered the operation of both Kilns 9 and 10 at the same time. These scenarios allow assessment of operational and worst-case impacts from the operation of the kilns under all operating conditions.

The air quality impact assessment adopted guidelines from the NEPM (Ambient Air Quality, including the proposed variation [now approved]), as well as guidelines from ANZEC (1990), guidelines from the NSW EPA and the draft guidelines from DWER. These guidelines relate to a range of different averaging times (ranging from 1 hour to annual average).

Air concentrations were predicted over a grid that covered the whole site, with the maximum impacts reported anywhere on the site (i.e. on the boundary between the site and the operational brickworks) compared against the criteria adopted. The assessment determined that the predicted concentrations, during operational and worst-case emissions (at licence limits) were below all the criteria adopted and the area was suitable for residential land use.

4.4 Ambient air data and surveys

4.4.1 Ambient air monitoring

DEC (2008) and DER (2015) have undertaken ambient air quality in the community at Midland and surrounding suburbs to understand existing levels of various pollutants in air in these areas.

The work completed in 2008 monitored acid gases (HCl, HF, SO_2 and nitrogen dioxide [NO_2]), particulates, metals, volatile organic compounds (VOCs) and carbonyls in air. The study also evaluated odours. In relation to brickworks operations, key pollutants of interest are acid gases (HCl, HF and SO_2) and odours. In relation to acid gases, there were no concentrations reported above health-based guidelines adopted in the assessment. However, odours relating to the brickworks operations (described as acrid smell, caustic stench, chemical odour, sugary smell and sulfur smell) were reported in the community around the Midland Brick site. Health effects reported from these odours included headache, nausea, sore/burning throat, burning sensation in the nose. Insufficient additional detail is available for this study to provide a more refined evaluation. It is noted that Midland Brick was operating across the whole site, including kilns that have since been decommissioned (Kilns 7 and 8) and Kiln 11 (that will be decommissioned and removed before the site is redeveloped for residential land use).

The more recent works for the period 2011-2012 focused on acid gases (HCl, HF and SO_2) as well as odours related to brickworks operations. It is noted that the broader Midlands Area included 4 brickworks that are assumed to contribute to ambient air quality in the area (refer to **Figure 7** for locations). For Midland Bricks, the site is understood to have been fully operational where kilns that are now decommissioned (Kilns 7 and 8) were operating and Kiln 11 (which will be decommissioned prior to residential development on the site) was operating. Hence emissions from the Midland Bricks site at the time of the sampling are expected to be an overestimation of future operations when the site is to be redeveloped for residential land use.

Monitoring locations closest to the Midland Bricks site are Jack Mann Oval and Harris Road with Midland Sports Complex located further away (refer to **Figure 7**). Low concentrations of HCl, HF and SO_2 were reported at these locations (below the criteria adopted in the assessment). Odours (typically transient in nature) were reported at a number of locations including Jack Mann Oval (where the duration of odours was noted to be longer than at other locations). Only low levels of acid gases were reported when odours were present.

The ambient air data, as well as the results of air modelling show compliance with the air guidelines adopted for the assessment of key pollutants, acid gases. Compliance with these guidelines, however, does not appear (based on the ambient air monitoring data) to indicate that the community would not notice odours from the brickworks operations. Further discussion on the adopted guidelines and odours is presented in **Sections 4.5 and 4.6**.

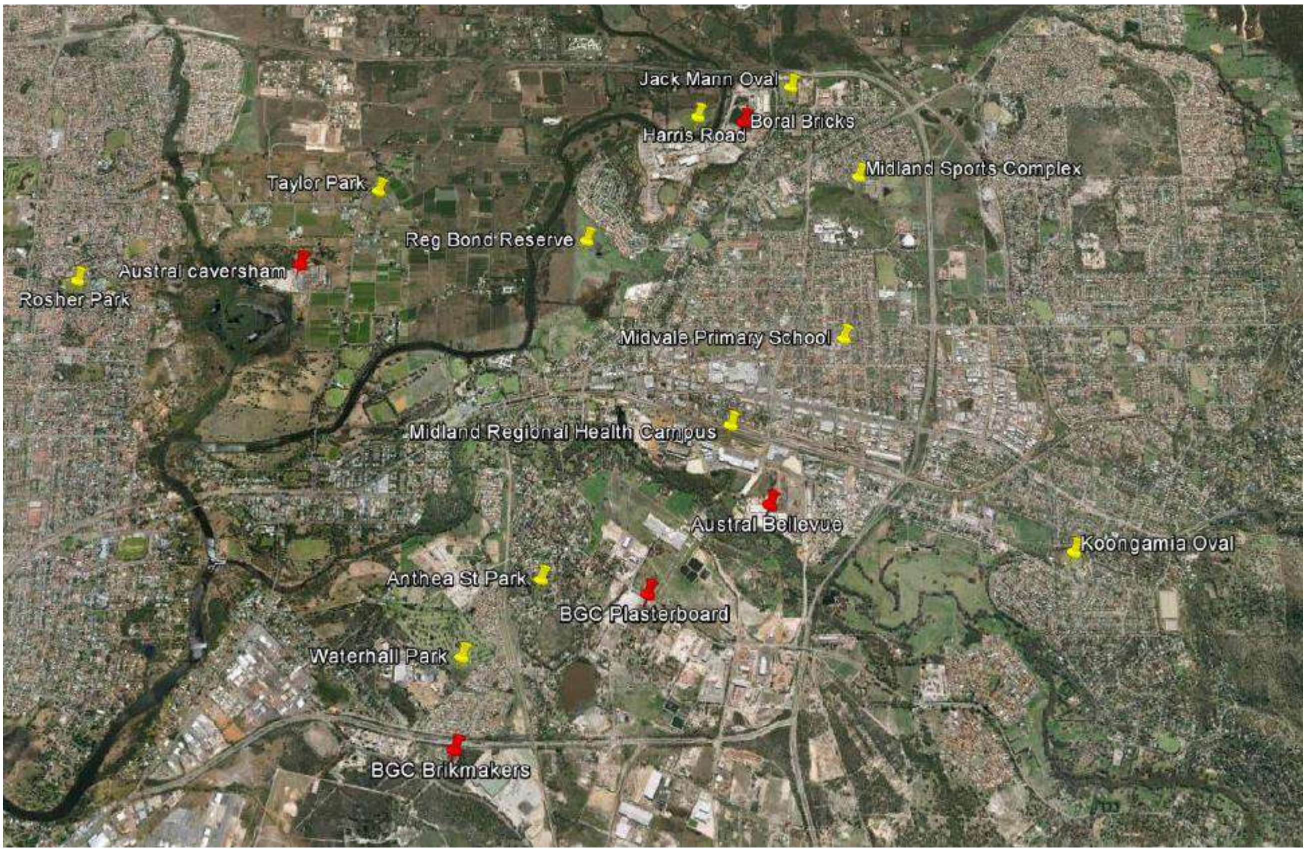

Figure 7: Ambient air monitoring locations (ref DER 2015)

4.4.2 Vegetation surveys

Midland Brick engages consultants to conduct vegetation surveys in the vicinity of the brickworks operations every 5 years (approximately) to evaluate the potential for fluoride impacts on vegetation. The last report was prepared by Terratree Pty Ltd (Terratree) in 2015 (with the report dated 2015). The work involved a visual assessment of fluoride sensitive trees and shrubs surrounding the facility for fluoride injury symptoms. The trees and shrubs evaluated were within the larger operational Midlands Brick site, surrounding and directly adjacent to the production areas. None of the vegetation surveyed was outside of the brickworks boundaries.

The outcome of the vegetation survey conducted in 2014 indicates that the majority of foliage injury attributed to fluoride exposure were in the injury category range 1 (very slight) to 3 (distinct). Category 4 injury (marked) was only observed in one tree. Many of the trees in injury category 3 and 4 had evidence of other (non-fluoride) impacts that were the cause or a contributing factor to the observed foliage injury. Overall, the vegetation survey indicated compliance with ANZEC goals for fluoride. However, the survey noted that fluoride-attributable foliar injury has increased in occurrence and severity from the previous survey and ongoing monitoring is important (particularly if production at the brickworks increases).

It is noted that this survey would have been undertaken when all kilns from the brickworks were operating. Two of these are now decommissioned, with another (Kiln 11) to be decommissioned prior to April 2022. Production and emissions from the brickworks has been reduced since the survey has been undertaken.

4.5 Further review of air guidelines for acid gases

4.5.1 General

This review has further focused on acid gases as these are the key pollutants of concern related to emissions from the operation of the kilns, and the source of odours.

4.5.2 Hydrogen fluoride

The air quality assessment (ETA 2020a) adopted guidelines for HF from the ANZEC National Goals for Fluoride in Ambient Air and Forage (ANZEC 1990), as listed in **Table 2**. These guidelines were developed to provide concentrations of fluoride (and HF) in air that were protective of damage to plant populations relevant to Australia. The values adopted by ETA (2020a) relate to those for general land use. Lower guidelines are available for specialised land use which includes locations with commercially valuable plants, sensitive to fluoride, and national parks. There are no specialised land uses or national parks in the areas surrounding this site. The guidelines adopted are not specifically targeted to address odour or community health.

The most current detailed review of hydrogen fluoride (and other soluble inorganic fluorides) in air has been completed by the Texas Commission on Environmental Quality (TCEQ 2015a). This has evaluated and derived guidelines for HF in air that are protective of a range of effects, odour, vegetation and health. These guidelines are included in **Table 2**. The following provides a short summary of the guidelines for HF derived from TCEQ:

- Health
  - Acute air guideline has been established based on the protection of the most sensitive effect, airway inflammation, with a no observed adverse effect level (NOAEL) determined from a human study, with application of an uncertainty factor to address human variability. The guideline of 60 $\mu g/m^3$ is protective of short-term exposures by all members of the population for exposures over a 1 hour averaging period. This value is noted to be lower than the acute reference concentration established by California (OEHHA) of 240 $\mu g/m^3$ and higher than the acute guideline from ATSDR (ATSDR 2003) of 16 $\mu g/m^3$. All these guidelines are based on the same study (with different interpretations of the NOAEL and selection of uncertainty factors).
  - The major effect on long-term inhalation exposures to fluorides in air are skeletal fluorosis and respiratory effects. The guideline is based on data associated with skeletal fluorosis and increased bone density from a chronic occupational study and application of an uncertainty factor to address human variability. As this is a chronic guideline, it is typically applied as an annual average concentration. It can also be used for comparison with a 90-day average.
- Odour - HF has an irritating and pungent odour, with an odour threshold of 42 ppb (34 $\mu g/m^3$) reported in two studies. The perception of odour is a concentration dependent effect and hence the value applies to all averaging times.

- Vegetation effects - The effect of fluorides in air on plants has been well documented. Effects include reduction of plant growth, induction of leaf chlorosis (killing leaf cells), effects on photosynthesis, respiration and enzyme activities. Fluorides are an accumulative toxicant, with injury usually associated with long-term exposure. Air guidelines have been established to address short-term and long term exposures, based on effects data from various different species. The guidelines established are similar to those established by ANZEC (1990).
- Livestock – Fluorosis in livestock has been shown to be caused by the consumption of pasture or cured forage contaminated with inorganic fluorine. Dairy cattle have been determined to be the most sensitive species. A guideline based on data from livestock studies has been used, with a relationship between air concentration and concentration in forage used. The guideline relates to exposures over a 30-day averaging period. It is noted that there are no agricultural areas surrounding the site. Hence while the guideline is included for completeness, it is not directly relevant to this assessment.

Table 2 also includes the maximum modelled concentrations of HF anywhere on the site (ETA 2020a) for comparison with these guidelines.

Table 2: Summary of air guidelines for HF

Guideline or data	Air concentrations for different averaging periods (µg/m³)						
	1-hour	12-hour	24-hour	7-day	30-day	90-day	Annual
ANZEC guidelines protective of vegetation effects for general land use (ANZEC 1990)	--	3.7	2.9	1.7	0.84	0.5	--
TCEQ guidelines protective of various effects (TCEQ 2015a)							
Vegetation		--	3	--	0.6	--	--
Odour	34	34	34	34	34	34	34
Livestock health	--	--	--	--	0.75	--	--
Health effects	60	--	--	--	--	29	29
Maximum modelled air concentrations on the site (ETA 2020a)							
Typical operations	0.95 A	0.46	0.38	0.19	0.15	0.11	0.057 B
Worst-case (at licence limits)	2.57 A	1.24	1.03	0.52	0.39	0.29	0.15 B

A = 1-hour average concentration calculated from modelled 24-hour average based on an averaging time conversion ratio of 2.5 (Ontario MfE 2004)
B = annual average concentration calculated from modelled 24-hour average based on an averaging time conversion ratio of 0.15 (Ontario MfE 2004)

Review of **Table 2** indicates the following:

- The ANZEC guidelines adopted in the air quality modelling (ETA 2020a) are sufficiently low to be protective of all effects, including vegetation, odour and health.
- The maximum predicted concentrations of HF in air on the site, for typical and worst-case emissions, over all averaging times are below all adopted guidelines.

On the basis of the above there are no vegetation, odour or health effects that would be of concern in relation to emissions of HF from Kilns 9 and 10, where the site is redeveloped for residential use.

4.5.3 Hydrogen chloride

The air quality assessment (ETA 2020a) adopted guidelines for HCl from the NSW EPA approved methods (for a 1-hour average) and the USEPA (for an annual average). These guidelines are included in **Table 3**.

The NSW EPA guideline for HCl is based on an EPA Victoria air criteria intended to be protective of health effects. The derivation of the guideline is not available.

The USEPA guideline adopted is the chronic inhalation reference concentration (USEPA IRIS). This guideline was established in 1995 and is based on the most sensitive effects, which were respiratory effects in a rat study with application of uncertainty factors to address extrapolation from animals to humans, human variability and the use of a LOAEL (lowest observed adverse effect level) rather than a NOAEL.

In addition to the above, guidelines that are protective of short and long term health effects as well as odours are available. This includes more recent detailed evaluations and guidelines. These additional guidelines are listed in **Table 3** with relevant references. **Table 3** also presents the maximum predicted concentrations of HCl in air, anywhere on the site (ETA 2020a) for comparison with these guidelines.

Table 3: Summary of air guidelines for HCl

Guideline or data	**Air concentrations for different averaging periods (µg/m^3)**	
	1-hour	**Annual**
Guidelines adopted in air modelling (ETA 2020a) – health based	146	20
Other guidelines relevant to protection of health and odour		
TCEQ evaluation (TCEQ 2015b)		
Health (most sensitive effects being respiratory)	660	26
Odour (irritating and pungent odour)	1100	89
OEHHA – health based criteria	2100	9
Maximum modelled air concentrations on the site (ETA 2020a)		
Typical operations	24.16	1.27
Worst-case (at licence limits)	28.38	1.54

Review of **Table 3** indicates the following:

- The guidelines adopted in the air quality assessment (ETA 2020a) are generally consistent with other guidelines that are protective of short and long-term health effects as well as odours.
- All predicted maximum concentrations of HCl are below all guidelines protective of odours (based on odour thresholds) and health effects.

On the basis of the above there are no vegetation, odour or health effects that would be of concern in relation to emissions of HCl from Kilns 9 and 10, where the site is redeveloped for residential use.

4.5.4 Sulfur dioxide

The air quality assessment (ETA 2020a) adopted guidelines for SO_2 from the NEPM, current and proposed variation (approved in 2021). These guidelines are presented in **Table 4**.

In relation to SO_2 the most recent revision to the air quality NEPM reduced the guideline. This was to incorporate more current research on the health effects of SO_2 (including short-term effects on the respiratory system [key health effect], as well as morbidity and mortality). The evidence for long-term effects associated with SO_2 is weak (with limited data available), hence the former annual average guideline has been revoked. The NEPM guidelines for SO_2 are considered to be protective of health effects for all members of the community.

In relation to other effects, the WHO (WHO 2000) has summarised air guidelines that are protective of vegetation effects. The guidelines adopted by the WHO are consistent with those developed by other such as the EU, ENECE and the International Union of Forest Research Organizations (IUFRO).

SO_2 has a strong, irritating and pungent odour. There are a range of odour thresholds reported, ranging from 266 to 12,500 μg/m^3 (Kleinbeck et al. 2011; NRC 2010).

These additional guidelines are included in **Table 4** along with the maximum predicted concentrations modelled on the site (ETA 2020a).

Table 4: Summary of air guidelines for SO_2

Guideline or data	**Air concentrations for different averaging periods (μg/m^3)**		
	1-hour	**24-hour**	**Annual**
Guidelines adopted in air modelling (ETA 2020a) – health based			
Current NEPM (NEPC 2016)	571	229	57
Revised NEPM (NEPC 2021)	262 196 (in 2025)	52	withdrawn
Other guidelines			
Vegetation (WHO 2000)	--	100	30
Odour	266 to 12,500		
Maximum modelled air concentrations on the site (ETA 2020a)			
Typical operations	44.38	17.08	2.54
Worst-case (at licence limits)	56.65	20.55	3.07

Review of **Table 4** indicates the following:

- The guidelines adopted in the air quality assessment (ETA 2020a) protective of short and long-term health effects and would also be protective of odours and effects on vegetation.
- All predicted maximum concentrations of SO_2 are below all guidelines protective of odours (based on odour thresholds) and health effects.

On the basis of the above there are no vegetation, odour or health effects that would be of concern in relation to emissions of SO_2 from Kilns 9 and 10, where the site is redeveloped for residential use.

4.5.5 Acid gases

The Western Australia Department of Health has established a guideline for acid gases, which is the sum of concentrations from HCl, HF, SO_2 and sulfur trioxide (SO_3) of 500 µg/m^3 for averaging periods of 10-minutes to 1 hour as referenced by DER (2015). The earlier ambient air monitoring work conducted by DEC (2008) indicate the use of a guideline for acid gases of 100 µg/m^3 over a 24-hour averaging period. No details are available on the basis for this guideline, with references only indicating this value is provided in an internal Department of Health document.

Based on the maximum 1 hour average concentrations presented in **Tables 2 to 4**, the following is noted:

- For typical emissions from Kilns 9 and 10, the total acid gases (1-hour average) is 69.5 µg/m^3, which is below the above guideline of 500 µg/m^3, and also below the guideline of 100 µg/m^3 (should this be applied to the 1 hour average).
- For worst-case (licence limit) emissions from Kilns 9 and 10, the total acid gases (1-hour average) is 87.6 µg/m^3, which is below the above guideline of 500 µg/m^3, and also below the guideline of 100 µg/m^3 (should this be applied to the 1 hour average).

There are no other published guidelines available for total acid gases that are based on the protection of health or other effects (such as odour or vegetation). Assessment of acid gases is undertaken based on data for the individual components, as presented above.

4.6 Health effects of odours

An odour is another word for a smell. Odours can be either unpleasant or pleasant. When an odour is noticeable, this means that the individual is exposed to something in the air that triggered their sense of smell. An odour may be due to a single chemical or mixture of chemicals. Chemicals vary in their ability to produce odours and people vary in their ability to smell odours. Smelling an odour does not indicate the level of exposure to a chemical or multiple chemicals, nor does it mean that the exposures will cause health effects.

An individual's ability to smell a particular odour will vary. At low levels, some individuals will notice the odour while others will not notice any. At higher levels, most individuals will likely notice an odour. Individuals also react to odours in different ways. An odour that is pleasant to one individual may be unpleasant to another. Individuals exposed to the same odour for a long time may no longer notice the odour, even if it is unpleasant. However, for intermittent odours, these may be noticeable much more often.

In general, those that are young or female, may be more sensitive to odours. Non-smokers are usually more sensitive to odours than smokers. Those that suffer from depression and anxiety disorders, or have migraines, allergies, asthma, and other chronic lung conditions, may feel worse when exposed to unpleasant odours over an extended period of time (ATSDR 2021).

Substances that produce odours can sometimes trigger physical symptoms. These would typically occur when a substance is present at levels that cause irritation, however sometimes individuals may have symptoms when concentrations are below the levels were irritation occurs.

The most common symptoms associated with environmental odours are headache and nausea. Other effects include dizziness; watery eyes, stuffy nose, irritated throat; cough or wheeze, especially if you have allergies, asthma, and other chronic lung problems; sleep problems due to throat irritation and cough (ATSDR 2021). In addition, the presence of an odour may trigger an emotional response, where there is the perception of being exposed to something harmful (EA 2007).

The assessment presented in Section 4.5 considered exposure to gases derived from the operation of the brickworks (Kilns 9 and 10), adjacent to the proposed residential area. The review considered guidelines that are based on the protection of short term health effects that include irritation, as well as the odour threshold available for the acid gases. There are no maximum predicted concentrations in air on the proposed residential development that exceed any guideline protective of odours and health. It is noted that the odour guidelines are based on threshold for detection, which is the concentration at which an odour may be just detected or perceived, not where odour recognition occurs (i.e. where an odour character may be able to be described or distinguished).

On this basis, where concentrations that may be present in the residential area are below the odour threshold for the acid gases, the potential for odours from the brickworks operations to be noticeable is considered negligible, resulting in a negligible potential for any health effects associated with the presence of odours (from the brickworks).

It is noted that this assessment cannot evaluate the odour of mixtures, hence the presence of any odours at any time, from the brickworks operations cannot be precluded.

Section 5. Review of noise emissions and impacts

5.1 Introduction

This section presents a more detailed review of the potential for noise in the proposed residential area, as a result of industrial noise from ongoing (and staged decommissioning) brickworks operations and aircraft noise.

Sound is a natural phenomenon that only becomes noise when it has some undesirable effect on people or animals. Unlike chemical pollution, noise energy does not accumulate either in the body or in the environment, but it can have both short-term and long-term adverse effects on people. These health effects include (WHO 1999, 2011, 2018):

- Sleep disturbance (sleep fragmentation that can affect psychomotor performance, memory consolidation, creativity, risk-taking behaviour and risk of accidents)
- Annoyance
- Cardiovascular health
- Hearing impairment and tinnitus
- Cognitive impairment (effects on reading and oral comprehension, short and long-term memory deficits, attention deficit).

Other effects for which evidence of health impacts exists, and are considered to be important, but for which the evidence is weaker, include:

- Effects on quality of life, well-being and mental health (usually in the form of exacerbation of existing issues for vulnerable populations rather than direct effects)
- Adverse birth outcomes (pre-term delivery, low birth weight and congenital abnormalities)
- Metabolic outcomes (type 2 diabetes and obesity).

Often, annoyance is the major consideration because it reflects the community's dislike of noise and their concerns about the full range of potential negative effects, and it affects the greatest number of people in the population (I-INCE 2011; WHO 2011, 2018).

There are many possible reasons for noise annoyance in different situations. Noise can interfere with speech communication or other desired activities. Noise can contribute to sleep disturbance which has the potential to lead to other long-term health effects. Sometimes noise is just perceived as being inappropriate in a particular setting without there being any objectively measurable effect at all. In this respect, the context in which sound becomes noise can be more important than the sound level itself (I-INCE 2011; WHO 2011, 2018).

Different individuals have different sensitivities to types of noise and this reflects differences in expectations and attitudes more than it reflects any differences in underlying auditory physiology. A noise level that is perceived as reasonable by one person in one context (e.g. in their kitchen when preparing a meal) may be considered completely unacceptable by that same person in another context (e.g. in their bedroom when they are trying to sleep). In this case the annoyance relates, in part, to the intrusion from the noise. Similarly, a noise level considered to be completely unacceptable by one person, may be of little consequence to another even if they are in the same room. In this case, the annoyance depends almost entirely on the personal preferences, lifestyles and attitudes of the listeners concerned (I-INCE 2011; WHO 2011, 2018).

In relation to the available noise guidelines, the most recent review of noise by the WHO (WHO 2018) provided an update in relation to environmental noise guidelines (and targets) that more specifically relate to transportation (road, rail and air), wind turbines and leisure noise sources. The more comprehensive guideline levels for noise (related to all sources) remain the former WHO guidelines (WHO 1999) and night noise guidelines (WHO 2009).

5.2 Review of noise impacts

5.2.1 General

The impact of noise, from the ongoing operation of Midland Bricks on land to the northeast of the site proposed for redevelopment, and from aircraft noise has been evaluated in Environmental Noise Assessments completed by Lloyd George Acoustics (LGA).

Assessment of noise impacts for the Englobo residential area (LGA 2020) covers the proposed residential development of the site, as well as additional land to the southwest. This assessment was updated and targeted to the MRS area in the LGA (2021) assessment.

Due to the staged approach to the decommissioning of brickworks operations and the development of the larger urban area, the following scenarios have been considered as likely to occur until the brickworks operations are fully decommissioned:

A. Full brickwork operations north of Bassett Road (i.e. Kilns 9 and 10 and Masonry Facilities) plus the Clay Shed operations
B. Full operations north of Bassett Road only (i.e. Kilns 9 and 10 and Masonry Facilities and no Clay Shed operations)
C. Masonry Facility only, located immediately north of Bassett Road.

The noise assessment has considered impacts of both industrial noise (associated with the above scenarios) and noise from aircraft on the site, noting that the 20 ANEFF (aircraft Noise Exposure Forecast) contour is located across the site. The site sits outside the trigger distance required to assess road and rail noise and hence these noise sources have not been further evaluated.

The following provides a summary of the outcomes of the noise impact assessment relevant to the site.

5.2.2 Industrial noise

In relation to noise derived from the Midland Brick operations the assessment adopted noise criteria as defined in the *Environmental Protection (Noise) Regulations 1997* (the Regulations). These guidelines provide the basis for determining noise criteria for day, evening and night noise as L_{A10}, L_{A1} and L_{Amax} in residential areas, based on distance from the source. The noise criteria adopted for day/evening and night time operations are consistent with noise guidelines established by the WHO (WHO 1999, 2009) to be protective of health (as relevant to noise levels outdoors). Hence meeting these guidelines would be protective of residential health.

Noise impacts from the operation of Midland Bricks was determined on the basis of noise modelling (using the modelling package SoundPLAN 8.2, CONCAWE algorithms and worst-case meteorological conditions). Noise sources (which included truck movements, crushing and screening [where relevant] conveyors, Kilns 9 and 10 [where relevant]) were identified and characterised for the three scenarios (A, B and C). The noise modelling was verified through the use of noise measurements throughout the existing operational brickworks site. The modelling incorporated noise mitigation measures relevant to each of these scenarios.

Scenario A: The modelling included triple stacked shipping containers to the west of the Clay Shed and double stacked shipping containers adjacent to the closest future residential properties (as noise barriers). For this scenario, with these noise barriers in place, the predicted noise levels during the day, evening and night comply with the adopted noise guidelines at future residential properties that may be constructed (as relevant to this scenario, as illustrated by **Figure 8**).

Scenario B: The modelling no longer includes the Clay Shed and conveyor (present in Scenario A) and includes a 5 m high noise wall along the southern side of the brickworks area (southern side of the masonry lot), however the modelling assumes the presence of a buffer to the west of Bassett Road (refer to **Figure 8**). For this scenario the predicted noise levels during the day, evening and night comply with the adopted noise guidelines at future residential properties in all areas of the site.

Scenario C: The modelling relates to only the masonry shed remaining operation on the brickworks site (not Kilns 9 and 10), with residential development up to Bassett Road (refer to **Figure 8**). The noise barrier included in Scenario 2 remains in place. For this scenario the predicted noise levels during the day, evening and night comply with the adopted noise guidelines at future residential properties in all areas of the site.

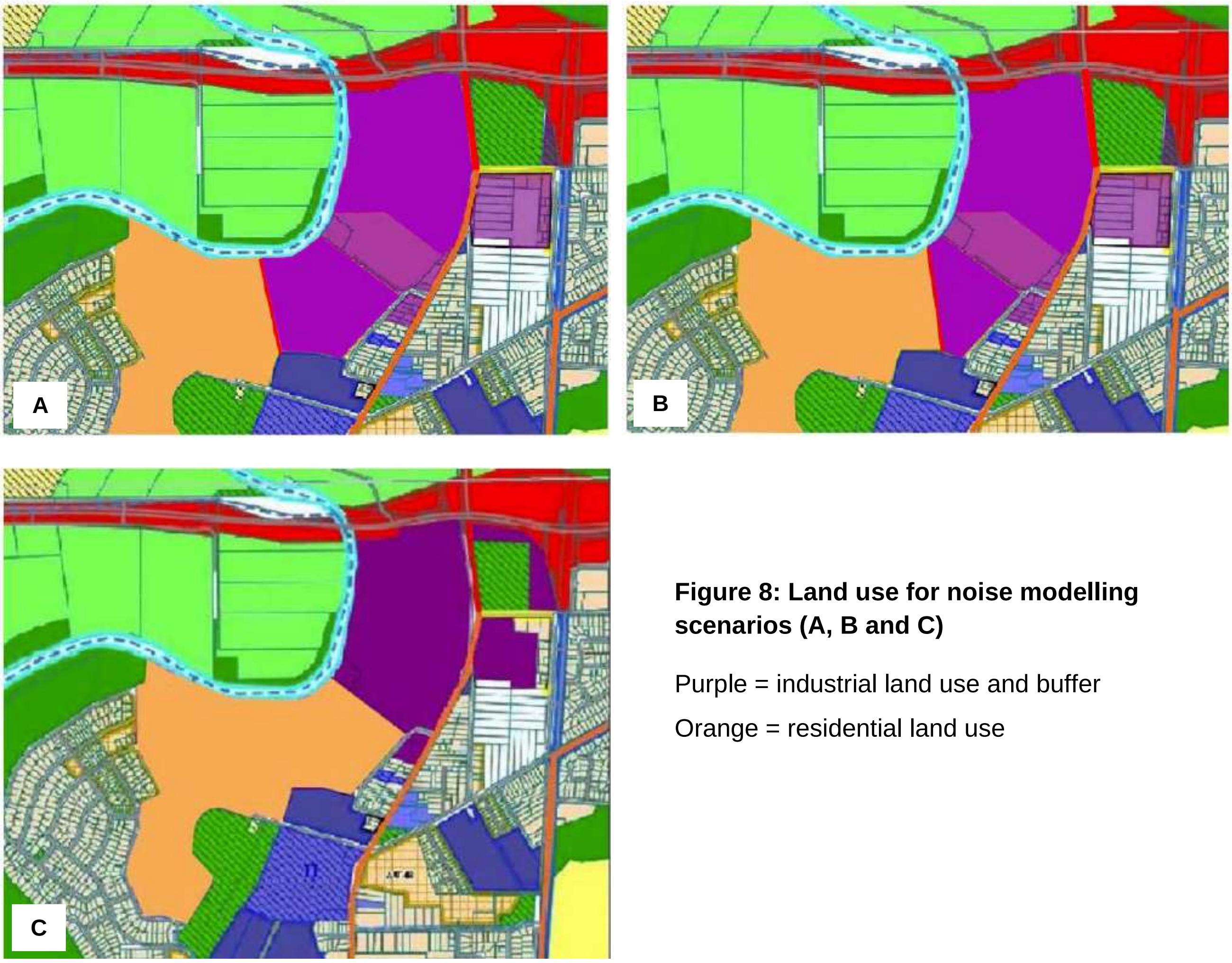

Figure 8: Land use for noise modelling scenarios (A, B and C)

Purple = industrial land use and buffer

Orange = residential land use

Based on the noise modelling, where the proposed residential development is staged along with the decommissioning of the brickworks operations as considered in Scenarios A, B and C, there would be no exceedance of the noise guidelines for industrial noise. The noise modelling outputs (contours) are included in **Appendix A** for reference.

Where there are no exceedances of these guidelines, impacts on residential health are expected to be negligible. This does not mean that residents in newly constructed premises may not be able to distinguish specific noises relating to brickworks activities. The noise levels, however, during the day, evening and night however are not sufficiently elevated to be of concern.

On the basis of the above there are no noise impacts (derived from the operational brickworks) that would preclude the residential use of the site.

5.2.3 Aircraft noise

The site is located to the north northeast of the existing and proposed runways at Perth Airport. Aircraft noise has been assessed by reviewing where the proposed residential development sits within the noise contours defined in State Planning Policy 5.1: Land Use Planning in the Vicinity of Perth Airport.

The majority of the site sits within the 20 ANEF, while other parts are within the 20-25 ANEF zone. These contours relate to the future parallel runway.

It is noted that the ANEF contours are a planning tool and do not represent actual noise contours. SPP 5.1 states that for areas in the 20-25 ANEF zone:

- Maximum residential density should be limited to R20
- Noise insulation is not mandatory for residential development
- A 'notice on title' advising of the potential for noise nuisance is to be required as a condition of any subdivision or planning approval within this noise exposure zone.

Perth Airport provides N65 contours that represent the average number of daily aircraft above a noise level of 65 dB L_{Amax}. This indicates that the site is expected to be subject to 100-200 events per day above a noise level of 65 dBA L_{Amax}. Further review of noise impacts has been undertaken based on noise from various aircraft (worst case being Airbus A330) on departure and arrival.

The noise modelling indicates L_{Amax} levels of 73-75 dBA. To comply with noise guidelines inside a home (for L_{Amax} of 50 to 55 dBA) noise reductions of between 20 to 25 dBA are required. This can be achieved with standard construction and windows and doors shut. As noted above SPP 5.1 does not mandate the installation of noise insulation for residences in the 20-25 ANEF.

The noise assessment provides recommended minimum construction specifications to minimise noise impacts from aircraft noise on the site. These are suggested measures.

On the basis of the above there are no noise impacts (derived from aircraft noise) that would preclude the residential use of the site. It is noted that residential properties on the site would require a notice on title advising of potential noise nuisance from aircraft noise.

Section 6. Conclusions

The HHRA presented in this report specifically relates to the proposed rezoning of part of the existing Midland Brick site (northern portions of Lots 23 and 72 Eveline Road, Middle Swan) (the "site") from rural and industrial zoning to urban zoning and parks and recreation zoning in Perth's Metropolitan Region Scheme (MRS).

Operations at the brickworks site have already been reduced (with the decommissioning of Kilns 7 and 8) and Kiln 11 is to be decommissioned by April 2022. Brickworks operations would further reduce and contract to a consolidated area located to the north of the site (north of Bassett Road) where Kilns 9 and 10 would continue to operate.

This assessment has specifically reviewed information relating to land contamination, air emissions and noise as these relate to the health of future residents at the site, following rezoning.

Based on the assessment undertaken the following can be concluded:

- **Land contamination:** Some contamination (petroleum hydrocarbons) has been identified in soil and groundwater at the site as a result of historic land uses. On the basis of the investigations undertaken at the site, in relation to contamination, the site can be made suitable for the proposed land use. This would be undertaken through the contaminated site audit scheme, to provide certainty that the site would be suitable for residential land use.
- **Air emissions:** Emissions to air from the ongoing operation of Kilns 9 and 10 have been reviewed. The engineering of these kilns and the flue gas treatment system (for each kiln) means that there are no situations where emissions to air could occur, even during upset, start-up or shut-down conditions, that are higher than the emissions scenarios evaluated in the air quality modelling. The maximum concentrations predicted on the site, as a result of ongoing operation of Kilns 9 and 10, have been reviewed against guidelines that are protective of human health (for all residents), odour and vegetation effects. There are no exceedances of any of these guidelines. Hence there are no air quality impacts (derived from the brick works operations) that would be of concern to the health of future residents at the site.
- **Noise:** Noise impacts from the staged decommissioning and demolition of the brickworks, and the operation of the brickworks on the consolidated area to the north of the site have been evaluated. There are no noise impacts identified from the operation of the brickworks that would exceed the relevant guidelines (which are protective of health) in the residential area. Aircraft noise impacts are also relevant to the site, due to its location in the ANEF 20-25 contour zone. Residential use of the site would not be precluded as a result of noise from aircraft where standard construction methods are used. Suggested minimum requirements of construction to reduce noise impacts have been recommended, however these are not mandatory for residential use.

Overall, there are no health risk issues of concern that would preclude the rezoning and redevelopment of the site.

Section 7. References

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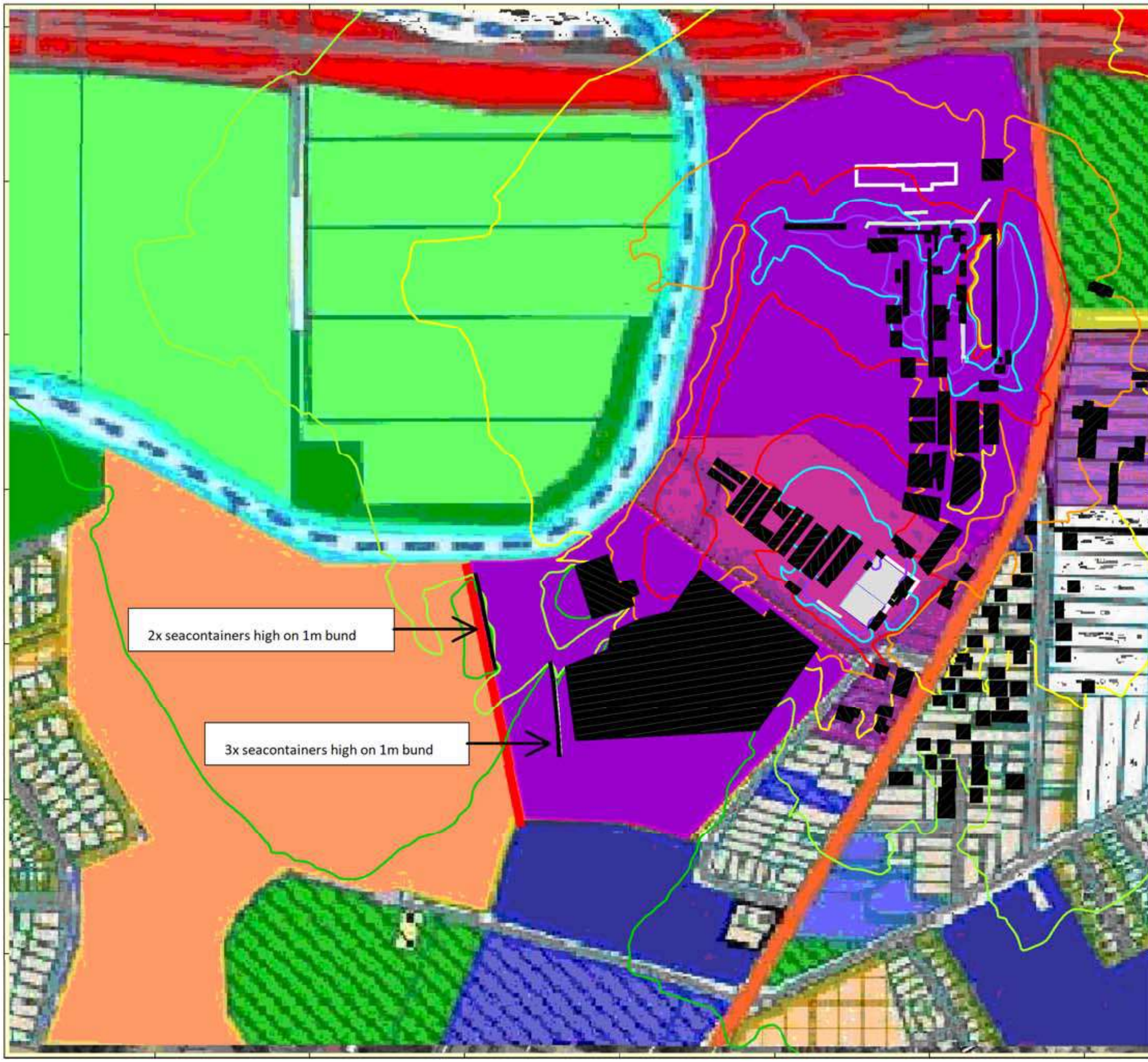
Appendix A Noise modelling outputs

NOISE EMISSION NOISE CONTOUR PLOTS

Scenario A: CLAY & MASONRY – INCLUDING OPERATING CLAY BUILDINGS

Scenario B: CLAY & MASONRY –CLAY BUILDINGS REMOVED

Scenario C: MASONRY ONLY



Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02

CONFLICT NOISE MAP
Combined Clay and Masonry, Night Allwinds
Conveyor Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Night Operations

Map
320

Scenario A
Result number 320
Calculation in 1.5 m above ground

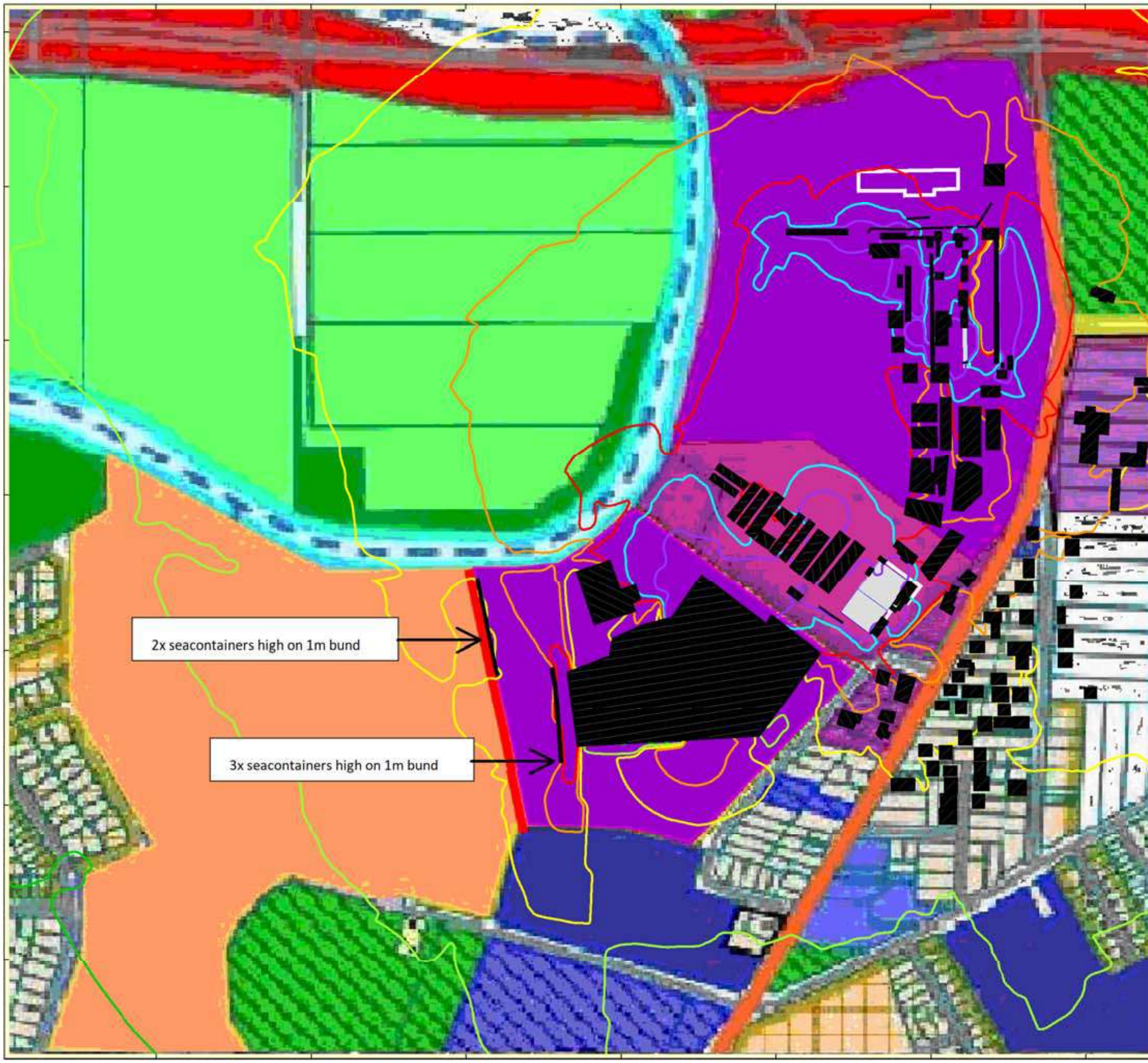
Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

Length scale 1:7000
0 40 80 160 240 320
m

HERRING STORER ACOUSTICS



Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02

Combined Clay and Masonry
Evening Allwinds
Conveyor
& Clayshed Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Evening Operations

Map
315

Scenario A
Result number 315
Calculation in 1.5 m above ground

Day / Evening Operational Scenario

Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

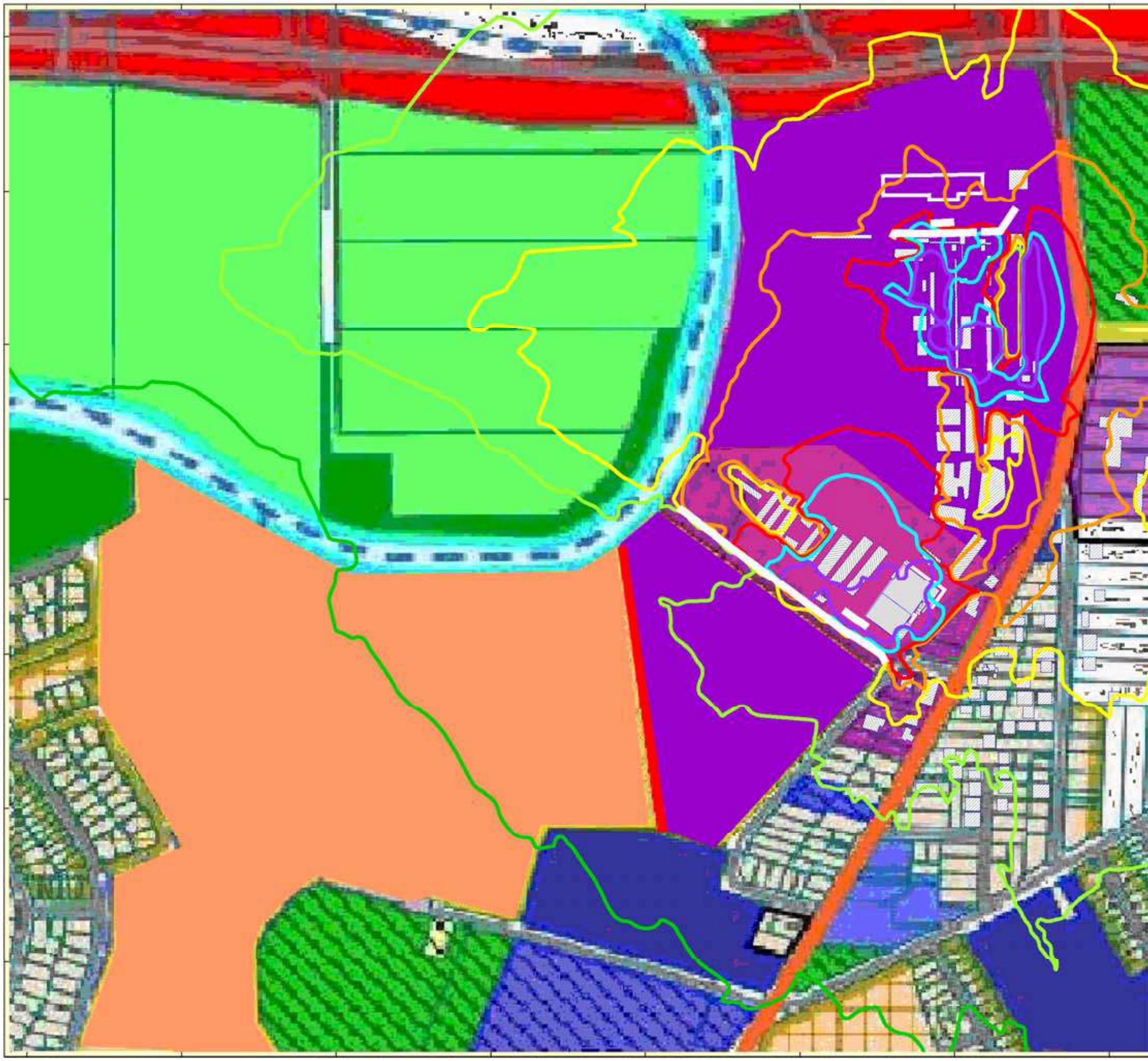
Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

N

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No.

Combined Clay and Masonry
Night Allwinds
Clayshed & Conveyor
Removed

Map
299

Scenario B
Result number 299
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 22/06/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

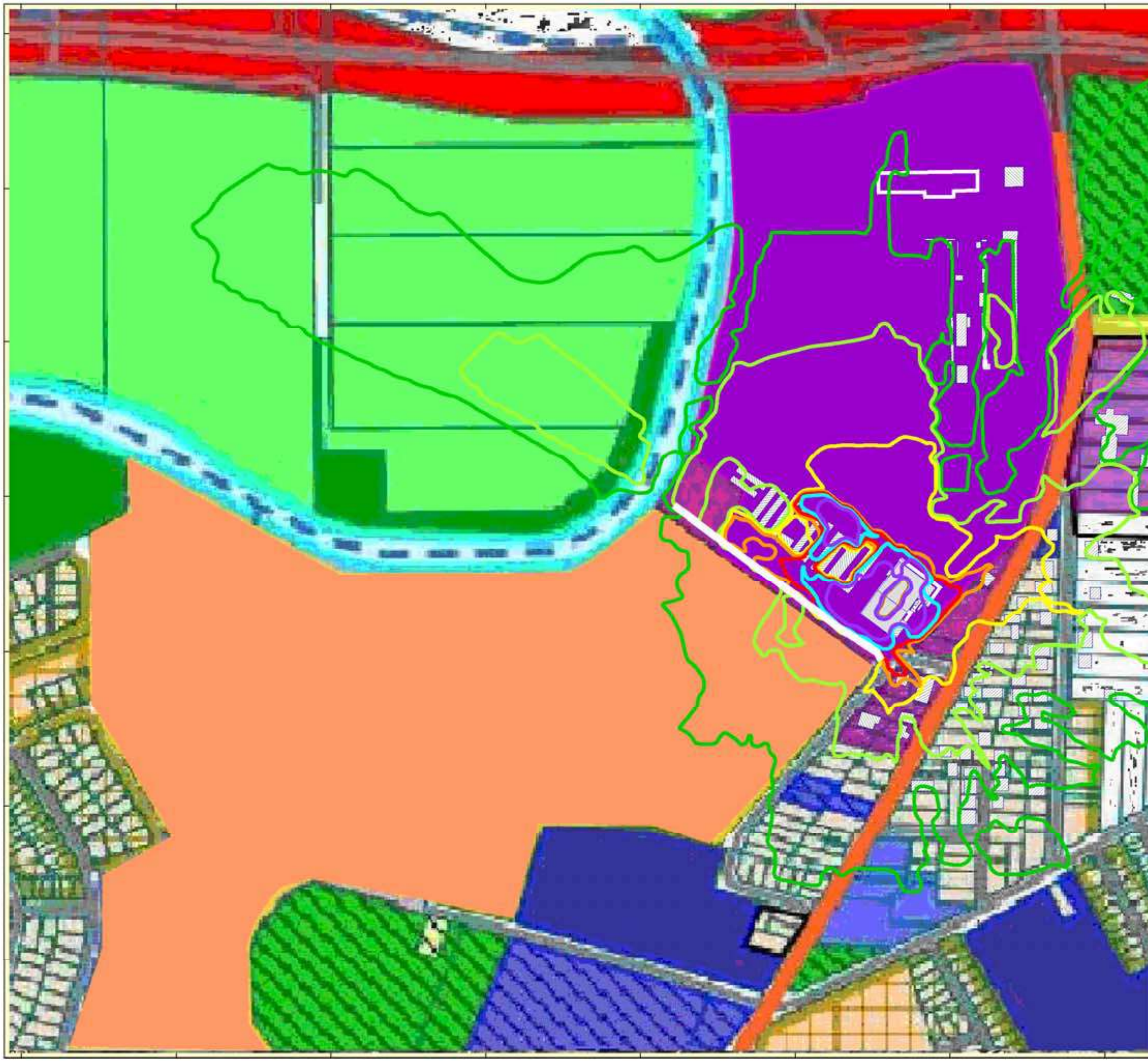
Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

N

Length scale 1:7000
0 40 80 160 240 320
m

HERRING STORER ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No.

Masonry Only
Night Allwinds

Scenario C

Map
300

Scenario C - Masonry Only
Result number 300
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 24/06/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols	Noise Levels dB(A)
Wall	30
Main building	35
Berm	40
	45
	50
	55
	60

Length scale 1:7000

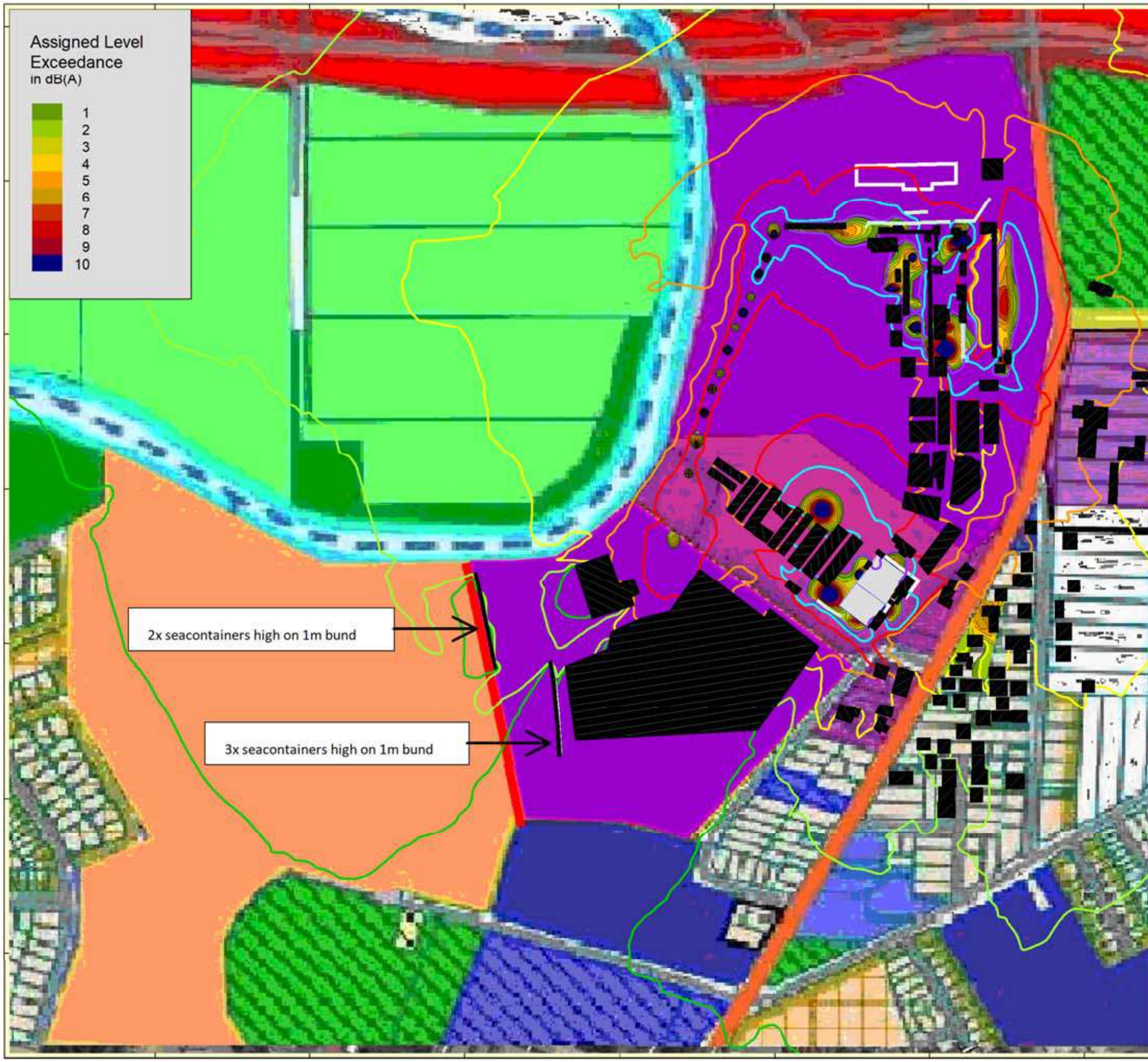
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS

APPENDIX C

NOISE EMISSION CONFLICT MAPS

(ASSIGNED LEVEL EXCEEDANCE MAPS)



Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02

CONFLICT NOISE MAP
Combined Clay and Masonry,
Night Allwinds
Conveyor Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Night Operations

Map
320
CNMT

Scenario A
Result number 320
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

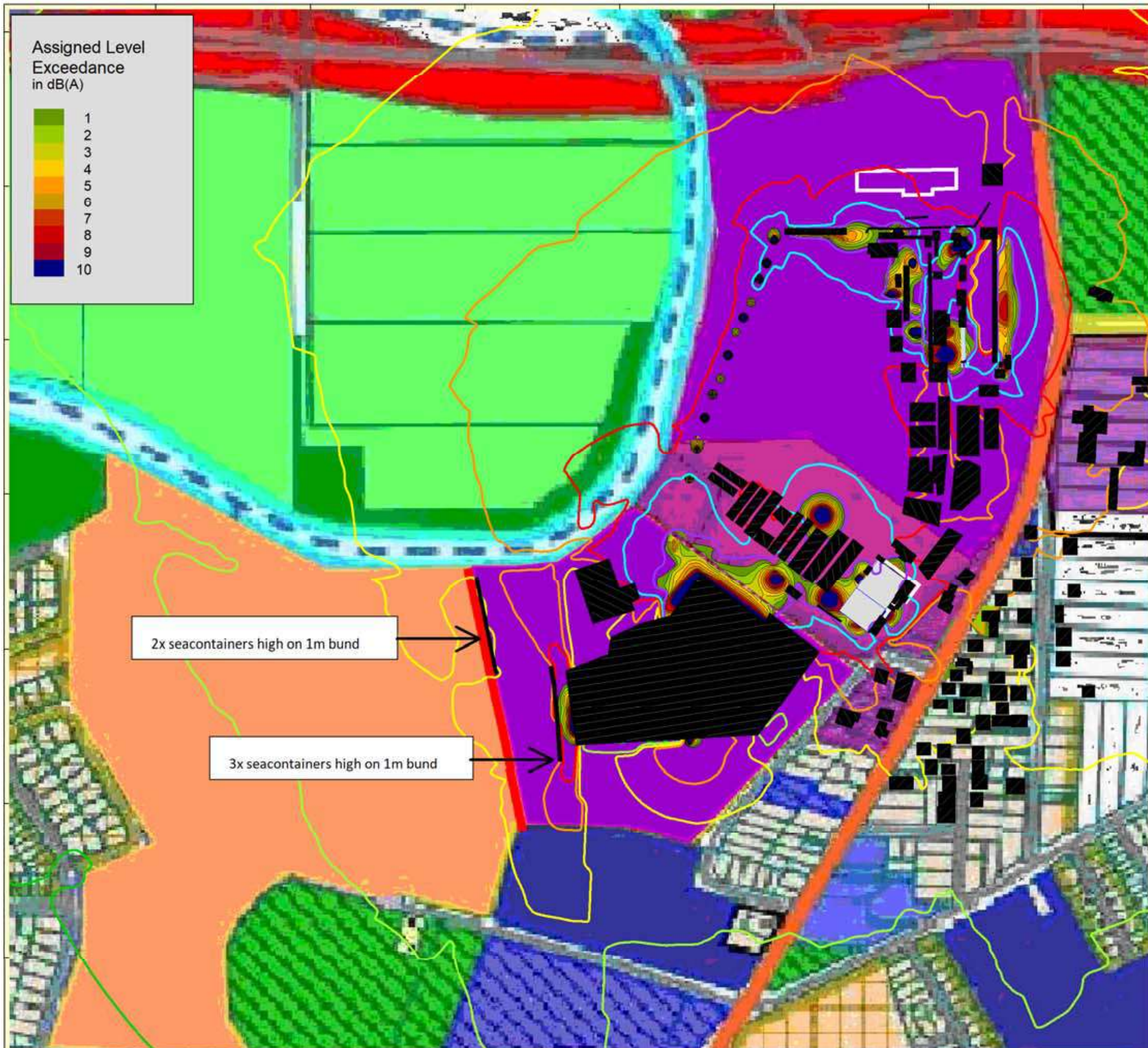
Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

N

Length scale 1:7000
0 40 80 160 240 320
m

HERRING STORER ACOUSTICS



Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02

Combined Clay and Masonry
Evening Allwinds
Conveyor
& Clayshed Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Evening Operations

Map
315
CMET

Scenario A
Result number 315
Calculation in 1.5 m above ground

Day / Evening Operational Scenario

Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

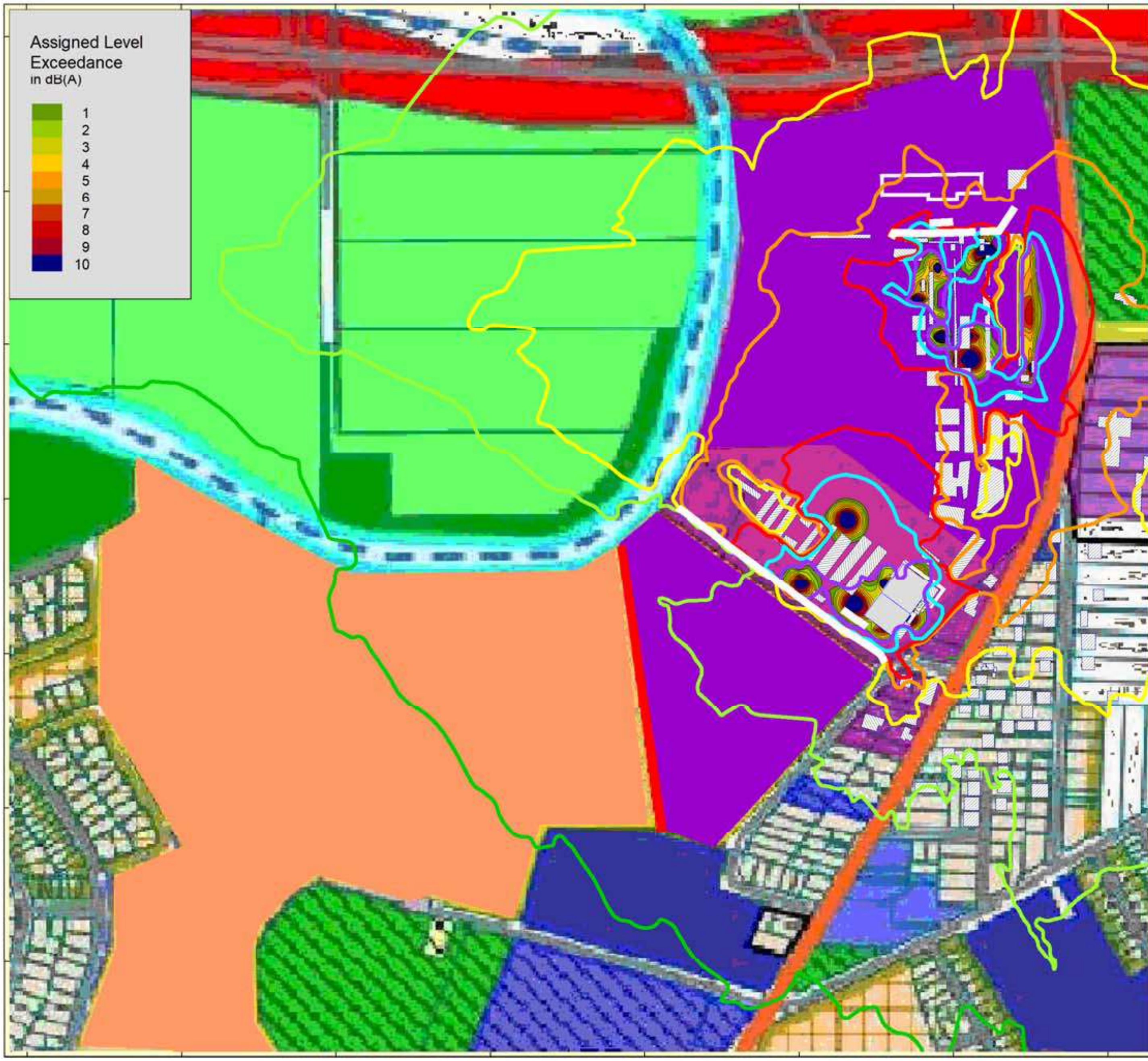
Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

N

Length scale 1:7000
0 40 80 160 240 320
m

HERRING STORER
ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No. 20355-02

CONFLICT NOISE MAP
Combined Clay and Masonry
Night Allwinds
Clayshed & Conveyor
Removed

Map
299
CNMT

Scenario B
Result number 299
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

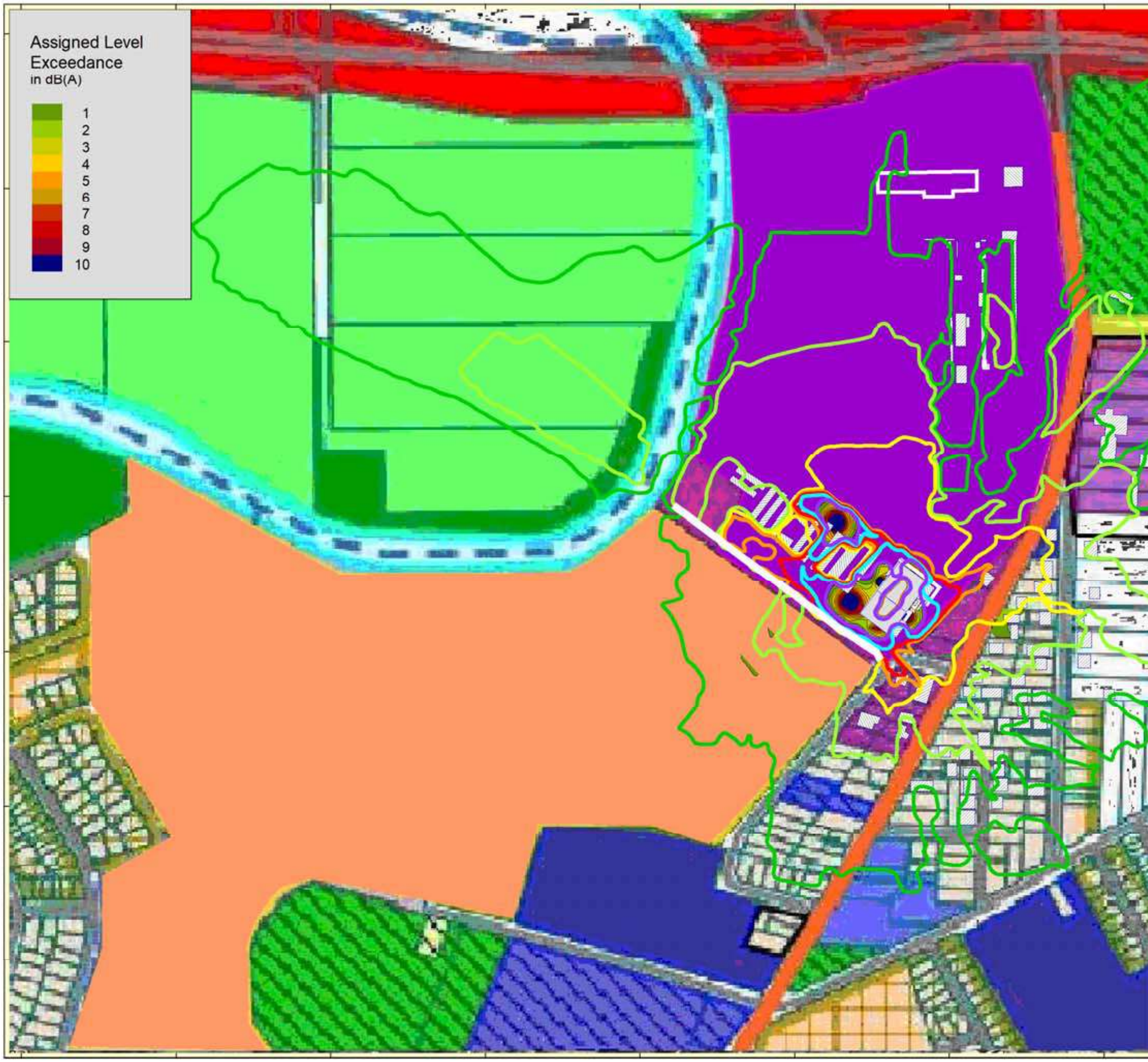
Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

N

Length scale 1:7000
0 40 80 160 240 320
m

HERRING STORER
ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No.

CONFLICT MAP - NIGHT
Masonry Only
Night Allwinds

Scenario C

Map
300
CMNT

Scenario C - Masonry Only
Result number 300
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 24/06/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols
Wall
Main building
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS

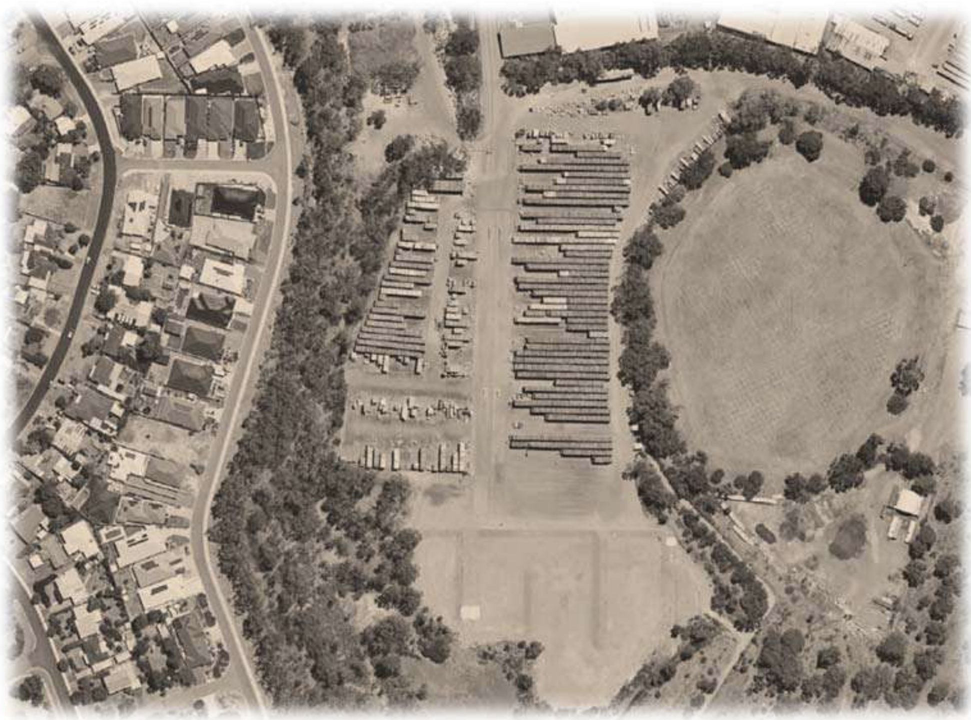
Appendix F

Local Water Management Strategy - Watermark Area 3
(Hyd2o Hydrology 2021)

Watermark Area 3

Local Water Management Strategy

September 2021



Client: HESPERIA

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This document is published in accordance with and subject to an agreement between Hyd2o and the Client for whom it has been prepared, and is restricted to those issues that have been raised by the Client in its engagement of Hyd2o. It has been prepared using the skill and care ordinarily exercised by hydrologists in the preparation of such documents.

Hyd2o recognise site conditions change and contain varying degrees of non-uniformity that cannot be fully defined by field investigation. Measurements and values obtained from sampling and testing in this document are indicative within a limited timeframe, and unless otherwise specified, should not be accepted as conditions on site beyond that timeframe.

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Executive Summary

Hyd2o was commissioned by Hesperia to prepare this Local Water Management Strategy (LWMS) to support the proposed Watermark Area 3 local structure plan (LSP) within the existing Midland Brick site in Middle Swan.

The LSP area is approximately 10 ha in size and located approximately 20 km north east of the Perth central business district within the City of Swan. The proposed urban development consists of residential lots, roads, and public open space creating public amenity in connectivity to a Blackadder Creek tributary.

This LWMS presents stormwater management in the context of the whole of the Midland Brick site including areas outside of the LSP area to provide a comprehensive overall assessment of the existing water management system of the area and its performance and how this will be modified to improve water sensitive urban design outcomes as a result of the proposed land use change.

Understanding key hydrological considerations has informed the development of the LWMS. The Midland Brick site has been a brickworks since 1946 with operations and brick sales currently operating. The LSP area is generally characterised as having low permeability soils, good clearance to groundwater, and no ASS risk. It is part of a larger existing stormwater system which operates via a pumped system to transfer water from the Midland Brick site to the Blackadder Creek Tributary, with larger events also flowing to the Swan River.

The environmental considerations and values of the Blackadder Creek tributary and the Eveline Reserve have guided the hydrological design for the LSP area.

This document has been prepared in accordance with the principles and objectives of Better Urban Water Management (Western Australian Planning Commission, 2008) and its overarching District Water Management Strategy (DWMS) (Hyd2o, 2020a). Key agencies ultimately involved with its implementation including the City of Swan, (CoS), Department of Biodiversity, Conservation, and Attractions (DBCA) and Department of Water and Environmental Regulation (DWER), have been widely consulted during the planning process.

Implementation of the strategy will be undertaken in accordance with Better Urban Water Management through the development and implementation of Urban Water Management Plans for individual stages of development within the LSP area.

The Better Urban Water Management LWMS checklist is included as Appendix A.

Local Water Management Strategy Summary

Water Use Sustainability	
Water Efficiency	• Promotion of 6 star building standards (water efficient fixtures and fittings). • Use of water-wise plantings in POS and landscape rehabilitation areas. • Maximise infiltration of residential stormwater runoff.
Water Supply	• Construction: Temporary DWER groundwater licence and use of brickworks stormwater • Lots: Water Corporation IWSS and rainwater tanks (optional). • POS: Groundwater irrigation. • Retained industrial outside of LSP area to continue with Water Corporation IWSS and stormwater harvesting via Clay Basin/Swale storage for dust suppression.
Wastewater	• Water Corporation reticulated sewerage.
Stormwater	
Design & Management Principles	• Habitable development levels have suitable clearance above the 1% AEP flood level of the Swan River (5.7-6.0 mAHD) and Blackadder Creek (6.43 mAHD at Muriel St). • Water quality to be managed through biofiltration treatment of runoff generated by first 15mm of rainfall prior to discharge to Blackadder Creek tributary. • Maintain the overall water balance at Muriel St and maintain the peak discharge at the existing southern outlet of the Midland Brick site to existing flows. • For the remaining industrial area and its upstream external catchment, continue to provide a flow path and operation consistent with existing practice.
Lot Scale Measures	• Soakwells sized to retain and infiltrate first 15 mm rainfall on lots within sand fill. • Rainwater tanks (optional). • Water-wise landscaping to retain stormwater and minimise runoff
Street Scale Measures	• Biofiltration as specified in POS, with additional areas identified at UWMP scale as necessary if required • Piped drainage, with opportunities for localised swales in road reserves to be reviewed at UWMP stage. • GPT's
Estate Scale Measures	• Water quality treatment areas for treatment of runoff from first 15mm rainfall via biolfitration. Estimated area and volume required of 0.12 ha and 355 m^3, based on assumed 0.3m depth. • Flood management storage areas within POS areas to attenuate flows in accordance with agency requirements. • Post development groundwater, surface water, and system performance monitoring and annual reporting.
Groundwater	
Fill & Subsoil	• Use of imported fill, with subsoil to be implemented to control perched water levels within the imported fill.
Acid Sulphate Soils	▪ Development area has no known risk of ASS.
Implementation	
Process	• Predevelopment groundwater and surface water monitoring program complete. • Future stages of planning consistent with BUWM including preparation of UWMP's. • Staging of stormwater changes to be detailed in the relevant UWMP's and implemented to ensure key hydrological performance criteria for the receiving environment are maintained during the transitional process.

1. Introduction

Hyd2o was commissioned by Hesperia to prepare this Local Water Management Strategy (LWMS) to support the proposed Watermark Area 3 local structure plan (LSP) for land within the existing Midland Brick site in Middle Swan.

The LSP area is approximately 10 ha in size and located approximately 20 km north east of the Perth central business district within the City of Swan (Figure 1). The proposed urban development consists of residential lots, roads, and public open space creating public amenity in connectivity to a Blackadder Creek tributary.

Note this LWMS considers the whole of the Midland Brick site including areas outside of the LSP area to provide a comprehensive overall assessment of the existing water management system of the area and its performance and how this will ultimately be modified to improve water sensitive urban design outcomes as a result of the proposed land use change.

This LWMS provides a total water cycle management approach to development. It has been prepared in accordance with the principles and objectives of Better Urban Water Management (Western Australian Planning Commission, 2008) and the overarching District Water Management Strategy (DWMS) (Hyd2o, 2020a).

This document provides the outcomes of detailed site specific analysis relating to groundwater and surface water and provides a clear vision in terms of adopting best management practices to achieve water sensitive design.

A copy of the Better Urban Water Management (WAPC, 2008) LWMS Checklist for Developers is included as Appendix A to assist the Department of Water and Environmental Regulation (DWER) and City of Swan in review of this document.

Key stakeholders involved with its implementation of this strategy including the City of Swan, (CoS), Department of Biodiversity, Conservation, and Attractions (DBCA) and Department of Water and Environmental Regulation (DWER), have been widely consulted during the planning process.

1.1 Planning Background

This LSP Area is zoned General Industrial under the City of Swan Local Planning Scheme 17.

The urban water management planning process is shown in Table 1. This LWMS supports the proposed development of the LSP area of the Midland Brick site to urban development.

Table 1: Integrated Planning and Urban Water Management Process

Planning Phase	Planning Document	Urban Water Management Documents
MRS Amendment	MRS Amendment	Midland Brick District Water Management Strategy (Hyd2o, 2020a)
Local Structure Plan/TPS Amendment	Local Structure Plan	Watermark Area 3 Local Water Management Strategy **THIS DOCUMENT**
Subdivision	Subdivision Application	Urban Water Management Plan **FUTURE PREPARATION**

1.2 Key Documents and Previous Studies

This LWMS uses the following key documents to define its principles, criteria, objectives, and implementation responsibilities:

- Midland Brick District Water Management Strategy (Hyd2o, 2020a)
- Decision Process for Stormwater Management in WA (DWER, 2017)
- Planning for Land Use, Development and Permitting Affecting the Swan Canning Development Control Area (Department of Parks and Wildlife/Swan River Trust, 2016a)
- Planning for Stormwater Management Affecting the Swan Canning Development Control Area (Department of Parks and Wildlife/Swan River Trust, 2016b)
- Handbook of Stormwater Drainage Design, City of Swan (2012)
- Swan Canning Water Quality Improvement Plan (Swan River Trust 2009)
- Better Urban Water Management (WAPC, 2008)
- Stormwater Management Manual for WA (Department of Water, 2007)

2. Proposed Development

The local structure plan (LSP) for the area is shown in Figure 2, providing a unique opportunity for urban infill in close proximity to the Midland town centre.

The LSP area covers 10 ha. The proposed development consists of replacing existing industrial hardstand with residential lots, roads, and public open space, adjacent to existing developed areas of Viveash, Jack Williamson Park, and the Blackadder Creek Tributary.

From a stormwater management perspective, the development will seek to provide improvements in local water management and interaction with adjacent watercourses and seek to improve existing water quality management outcomes as the area transitions from its current industrial use.

3. Existing Environment

3.1 Site Conditions

The 10 ha LSP area is located in the suburb of Middle Swan in the City of Swan.

The Midland Brick site in which the LSP area is located is bound to the north by Reid Hwy, to the west by the Swan River, to the south and east by existing urban development and Eveline Reserve (Figure 1). It has been used for brick making purposes since 1946 and is currently operational and operates under a DWER Part V Licence.

The LSP area is currently utilised by Midland Brick for brick storage and contains some sedimentation storage ponds. Topography across the LSP area varies between 6 mAHD and 16 mAHD. The area has been modified for industrial use to have flat areas at 9 mAHD for brick storage, falling to 6 mAHD in some storage areas. Bunds to heights of 16 mAHD are adjacent to external development along the western and southern boundaries.

Figure 3 shows an aerial photograph with existing land use and topography.

3.2 Geotechnical

According to the Perth Metropolitan Region 1:50 000 Environmental Geology Series Perth Sheet 2034 II and Part of 2034 III and 2134 III, the LSP area is characterised by Pebbly Silt (Mgs1) (Gozzard, 1986). The Pebbly Silt is described as strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weather granite pebble, some fine to medium grained quartz sand of alluvial origin.

A geotechnical investigation for the wider Midland Brick site was undertaken by Douglas Partners in June 2019. The geotechnical report is included as Appendix B. This investigation included excavation of 11 test pits and 8 cone penetration tests. A dynamic cone penetrometer (DCP) test was also undertaken at each test pit location.

Test locations within the LSP area are shown on Figure 4. The encountered ground conditions at the test locations generally comprised uncontrolled fill, generally clayey although some granular fill was also encountered, overlying variable, though generally clayey, natural soils. The typical soil profile as described by Douglas Partners (2019) is as follows:

- ***Clayey Fill (Sandy Clay, Clayey Sand, Gravelly Clay, Clayey Gravel, Clay, Bricks and Sand with Clay)*** *– generally stiff to hard, encountered at all test pit locations, generally forming most of the encountered fill depth. Loose silty or clayey gravel, inferred as possible fill, was encountered between depths of 1.5 m and 4.0 m at test location 7. Firm to very stiff clay fill was encountered to a depth of approximately 5.5 m at test location 6. The clayey fill general contained brick fragments and/or bricks, and occasionally fragments of plastic, rubber, wood, wire, fabric, carpet and concrete.*
- ***Granular Fill (Sand, Gravelly Sand, Sandy Gravel)*** *– generally medium dense to very dense, granular fill, generally encountered from the surface to depths of less than 0.5 m. Granular fill (i.e. fill with no clay content) was encountered at test pit locations 11, 12, 13, 15, 16 and 17 and cone penetration locations 2 and 3. A granular fill layer was encountered at test location 13, underlying clayey fill from a depth of approximately 0.4 m to the termination depth of the test pit at 1.6 m. The fill generally contained brick*

fragments and/or unbroken bricks. Inferred granular fill or disturbed ground was encountered to a depth of approximately 9.8 m at test location 3, with loose silty sand being encountered between depths of approximately 3.0 m and 8.0 m.

- *Natural Soils – generally clayey soils from the Guildford Formation, including:*
  - ***Clayey Sand** – hard / very dense orange-brown mottled red-brown and grey, fine to medium grained clayey sand, encountered underlying the fill from a depth of 0.75 m at test location 11. Sand with sand clay was encountered from the surface at test location 5.*
  - ***Clay** – stiff to hard clay, encountered underlying the fill from a depth of approximately 0.75 m at test location 14 and cone penetration test locations 1, 3, and 6.*
  - ***Sand and Silty Sand** – generally medium dense to dense, orange-brown fine to medium grained sand, sometimes with clay, encountered underlying the clayey sand at test pit location 11 and cone penetration test location 5*

Groundwater was not observed in any test pit locations on 24 June 2019 however groundwater was measured within some of the cone penetration test locations at levels ranging between -1.3 mAHD and 2.9 mAHD (interpolated levels only, not surveyed).

3.2.1 Acid Sulphate Soils

Acid Sulphate Soil (ASS) is the common name given to naturally occurring soil and sediment containing iron sulfides. These naturally occurring iron sulfides are generally found in a layer of waterlogged soil or sediment and are benign in their natural state. When disturbed and exposed to air, however, they oxidise and produce sulfuric acid, iron precipitates, and concentrations of dissolved heavy metals such as aluminium, iron and arsenic. Release of acid and metals as a result of the disturbance of ASS can cause significant harm to the environment and infrastructure.

WAPC's Bulletin 64 (WAPC, 2003) ASS risk mapping indicates that the LSP area is classified as no known risk (Figure 4).

3.2.2 Contaminated Sites

Contaminated site investigations have been undertaken over part of the Midland Brick site due to localised areas of elevated petroleum hydrocarbon concentrations in soil and water in several isolated areas. Remediation will be required for residential land use in these areas and are likely to include the excavation and treatment of affected soils and groundwater remediation. These areas will be remediated prior to any subdivision application being made, consistent with Contaminated Sites Act (2003) processes.

3.3 Wetlands and Waterway Assessment

The LSP area contains no mapped wetlands.

The Midland Brick site is however located adjacent to the Swan River and associated Swan River Regional Park. The Swan River is classified as a conservation category wetland as shown in Figure 5.

The foreshore area adjacent to the Midland Brick site is largely occupied by the brickworks with industrial development abutting the banks of the river. The banks are relatively steep and vegetated, and act as a bund to protect the brickworks from flooding during major events in the Swan River. It is not clear if the bunds were constructed for such purposes or represent a remnant outcome of site excavation over time (or combination of both).

On the western side of the Midland Brick site there is an established foreshore reserve adjacent to the Swan River. A foreshore area study has recently been undertaken by Emerge Associates including an assessment of biophysical characteristics for the portion of the Midland Brick site adjacent to the Swan River to guide future planning of that area.

3.4 Surface Water

3.4.1 Swan River & Blackadder Creek Tributary Flood Levels

The Swan River 1% Annual Exceedance Probability (AEP) levels adjacent to Midland Brick range from 5.7 mAHD near the downstream boundary to 6.0 mAHD at the northern boundary (Table 2 and Appendix D). These levels have been recently updated by DWER based on an updated flood study of the Swan River (BMT WBM Pty Ltd, 2017). These levels supersede previous estimates and are approximately 1m lower than those of the previous 1985 flood study.

The Midland Brick site is predominately located outside the 1% AEP floodplain of the Swan River with only a minor area (outside the LSP area) classified as floodway and flood fringe.

The time of concentration for peak flows in the River is very different to that of the local catchment and not coincident. This suggests non-attenuated rather than attenuated flows from the Midland Brick site during major events to be beneficial from a flood management perspective.

Development that is located in the floodway and is considered obstructive to major flows is not permitted, and no new buildings are considered acceptable within the floodway. Proposed development that is located outside of the floodway is considered acceptable with respect to major flooding. However, a minimum habitable floor level of 0.5 m above the appropriate 1 % AEP flood level is recommended to ensure adequate flood protection.

With respect to the Blackadder Creek Tributary, the 1% AEP level is also shown in Table 2 and Appendix D. The 1% AEP level value at the confluence of the Blackadder Creek and the Blackadder Creek Tributary near the LSP area is shown as 6.43 mAHD.

Table 2: Watercourse Flood Levels

Watercourse	Location	1% AEP Flood Level (mAHD)
Swan River	Downstream near Bernley Drive and Colyton St intersection	5.7 mAHD
Swan River	Upstream of Midland Brick near Reid Hwy	6.0 mAHD
Blackadder Creek	At confluence of Blackadder Creek Tributary	6.43 mAHD

3.4.2 Existing Stormwater Management for Midland Brick site

The Midland Brick site has no specific Environmental Protection Act licence conditions for water control, however objectives for stormwater management are detailed in Boral (2011) and Hyd2o (2021) as follows:

- All industrial surface runoff water is to be treated in an appropriate manner prior to discharge to the Swan River.
- Maximise the storage and reuse of industrial surface runoff water for dust suppression and industrial purposes on site.
- Freshwater runoff may be discharged from site without further treatment if it is segregated from other site water management.

Figure 6 details a map of the key existing stormwater infrastructure and system of the Midland Brock site in the proximity of the LSP area, with plates of key locations shown in Appendix C. A plan showing the wider Midland Brick site stormwater management system reproduced from the DWMS is contained in Appendix D. The function of the existing Midland Brick stormwater management system is summarised as follows:

- The site lies between two watercourses which receive stormwater runoff from the site; the Swan River to the north and a tributary of Blackadder Creek to the south.
- Due to clay soils onsite infiltration is limited and stormwater is managed through offsite discharge. The current stormwater system on site comprises of various storage ponds for attenuation and settlement of stormwater and a series of outlets to the Swan River and Blackadder Creek tributary. In general terms, for the majority of the site minor event flows are discharged to the Blackadder Creek tributary, while more major events have an outlet to the Swan River.
- The majority of stormwater from the site flows to an existing sump located abutting Kiln 8 (herein called the main site pump), where it is then pumped to the northern storage ponds in the north west of the site. Hyd2o understand this pumped system was installed in approximately 2000 to divert flows from the site to the Blackadder Creek Tributary and prior to this flows from the site discharged to the Swan River. Pump capacities as reported in SKM (2003) are 170 l/s for the main electric pump and 125 l/s for the diesel pump.
- This water then flows south along the western boundary of the site before entering a further series of storages (southern storage ponds) and discharging to the Blackadder Creek Tributary.
- Flows from the Clay Shed roof area represent a separate stormwater system which discharge into a storage area to the south of the Clay Shed and then into the top of the Blackadder Creek tributary.

The total catchment draining to the Swan River and Blackadder Creek Tributary in this area is estimated to be 116.6 ha. Subcatchments are shown in Figure 6 and Appendix D and were mapped based on site inspections, Boral (2011) and available pipe survey data. This includes an external local authority catchment of approximately 16 ha associated with Great Northern Hwy, Richardson Rd, and Leslie Rd which drains into and is managed within the Midland Brick site.

With respect to the Clay Basin, the total catchment draining to basin is estimated to be 31.7 ha, with an estimated equivalent impervious area (EIA) of 19.5 ha during major events. The external local authority catchment contributing flow to the Clay Basin is 10.7 ha (EIA 6.4 ha) and is estimated to contribute 33% of the runoff which currently flows to this storage.

3.4.3 Modelling of Existing System

Stormwater modelling for the existing system using XP-Storm has been reported in detail in a range of various documents prepared by Hyd2o including the following:

- Midland Brick, Middle Swan District Water Management Strategy (Hyd2o, 2020a)
- Midland Brick, Middle Swan Brickworks Kiln 10 Hardstand Expansion Stormwater Management: Updated Report (Hyd2o, 2020b).
- Midland Brick, Middle Swan Local Water Management Strategy Bridging Document, (Hyd2o, 2020c).
- Midland Brick, Middle Swan Brickworks: Southern Replacement Storage Design (Hyd2o (2020d)
- Midland Brick, Middle Swan Brickworks: Masonry Site Stormwater Management, (Hyd2o, 2020e)
- Cranwood Crescent Viveash Stages 1a & 1b Urban Water Management Plan (Hyd2o, 2020f)

Key modelling outcomes and extracts from these studies used to inform this LWMS are contained in Appendix D, with design flows at key locations within the Midland Brick site summarised in Table 3. Note that recent updates to Australian Rainfall and Runoff (Ball et al, 2016) have resulted in changes in terminology being recommended to describe design rainfalls. Annual Exceedance Probability (AEP, %) terminology has therefore been adopted to replace Average Rainfall Interval (ARI) terminology in this report as follows:

- Frequent Events : previously 1 Year ARI, replaced with 63% AEP
- Minor Events : previously 5 Year ARI, replaced with 20% AEP
- Major Events : previously 100 Year ARI, replaced with 1% AEP

Table 3: Existing Midland Brick Site Stormwater Management Flow Summary

Location	Flows (m^3/s)		
	63% AEP	20% AEP	1% AEP
Clay Basin	0.05	0.06	0.07
Swan River Outflow	-	0.08	0.27
Blackadder Creek Tributary at Southern Outlet	0.20	0.21	0.26
Clay Shed Flow	0.33	0.53	1.02
Flow in Blackadder Creek Tributary at Eveline St	0.19	0.24	0.27
Blackadder Creek Tributary at Muriel St culvert	0.28	0.45	0.67

3.4.4 Surface Water Quality

Hyd2o undertook a pre development surface water quality monitoring program over the wider Midland Brick site from September 2019 to September 2020. Sampling locations are shown in Appendix E. This program was supplemented by data previously collected by Midland Brick as part of broader environmental monitoring within the site over a 15 year period.

Parameters analysed for this LWMS include physical parameters (temperature, electrical conductivity, pH, and turbidity), nutrients, and metals. Surface water quality results are summarised in Table 4 for physical parameters and nutrients compared to ANZECC (2000) guideline trigger values for freshwater lowland river ecosystems and the Swan River Trust's Swan Canning Water Quality Improvement Plan (2009) long term targets.

Full results are contained in Appendix E for locations considered relevant to the LSP area, including metals. Key results are summarised as follows:

- Mean pH at all sites are within the ANZECC guideline range (6.5 – 8) except for the Clay Basin where the mean pH (8.31) was marginally higher than the upper limit.
- Mean EC (µS/cm) at the Swan River downstream site was higher (15455 µS/cm) than at the upstream site (14012 µS/cm). Swan River sites were well outside the ANZECC guideline range (120 - 300 µS/cm) but this is typical of the Upper Swan Catchment of the Swan-Canning River system (DoW, 2009). Mean EC (µS/cm) at the locations within the Midland Brick site were well below the levels within the Swan River but outside the ANZECC guideline range.
- Mean TN at Swan River sites were slightly higher downstream (1.31 mg/L) than upstream (1.24 mg/L), and both locations were only marginally above the ANZECC guideline value of 1.2 mg/L and the SCWQIP long term target of 1.0 mg/L. Mean TN at the monitoring locations within the Midland Brick site were all within the ANZECC guideline value and long term SCWQIP target.
- Mean TP at Swan River sites were slightly higher downstream (0.09 mg/L) than upstream (0.08 mg/L), and both were slightly above the ANZECC guideline value of 0.065 mg/L but were both consistent with the SCWQIP long term target of 0.1 mg/L. Mean TP at the monitoring locations within the Midland Brick site were all within the ANZECC guideline value and long term SCWQIP target.

With respect to metals, mean results were as follows relative to ANZECC guideline values:

- Arsenic was within the 95% protection limit for all sites.
- Cadmium was outside the 80% protection limit for all sites except SW4 (Site Outlet) and SW5 (Blackadder Creek Tributary at Muriel) which are within the 95% protection limit.
- Chromium was within the 80% protection limit for all sites.
- Copper was outside the 80% protection limit at all sites, except SW4 (Site Outlet), which was within the 99% protection limit.
- Lead was within the 80% protection limit for all sites, except SW10 (Southern Storage) which was outside the 80% protection limit.
- Nickel was within the 95% protection limit for all sites, except SW10 (Southern Storage) which was outside the 80% protection limit.

- Zinc was within the 80% protection limit for all sites, except SW5 (Blackadder Creek Tributary at Muriel) and SW10 (Southern Storage) which were outside the 80% protection limit.
- Mercury was within the 95% protection limit for all sites, except SW6 (Clay Basin) which fell within the 90% protection limit.

Table 4: Existing Surface Water Quality

Parameter	Mean of Parameter Values							
	Swan River Upstrm	Swan River Dnstrm	Clay Basin	Southern Storage Area	Site Outlet	Blackadder Trib @ Muriel	ANZECC	Long term SCWQIP
EC	14012	15455	718	384	516	1170	120-300	-
pH	7.56	7.52	8.31	7.70	7.30	7.59	6.5-8.0	-
TN (mg/L)	1.24	1.31	0.72	0.70	0.50	2.40	1.2	1.0
Ammonia (mg/L)	0.12	0.13	0.05	0.05	0.01	0.01	0.32 – 2.3 (99% - 80%)	-
TP (mg/L)	0.08	0.09	0.03	0.04	0.05	0.05	0.065	0.1
FRP (mg/L)	0.02	0.03	0.00	0.00	0.01	0.01	0.04	-
Nitrate (mg/L)	0.43	0.48	0.17	0.59	0.01	2.30	0.017 – 17 (99% - 80%)	-
Nitrite (mg/L)	0.05	0.06	0.03	0.05	0.01	0.01	-	-

3.5 Groundwater

3.5.1 Groundwater Levels

The Perth Groundwater Map (DWER, online) indicates the superficial aquifer base at the LSP area is approximately -20 mAHD and has a saturated thickness of approximately 21 m.

Groundwater levels in the Perth Groundwater Map are representative of typical end of summer groundwater levels and estimate groundwater levels of less than 1 mAHD for the LSP area, with groundwater flow in an easterly direction towards the Swan River.

Emerge Associates installed 10 groundwater monitoring bores within the wider Midland Brick site on 20 August, 2018. Lithological logs for the two bores in proximity to LSP area are included as Appendix F.

Water levels in all bores were measured monthly from Sept 2018 to Feb 2019 with further monitoring over 2 winters then undertaken by Hyd2o from September 2019.

The estimated average annual maximum groundwater levels (AAMGL) across the Midland Brick site are shown in Figure 7 based on this data. Hyd2o have calculated the AAMGL by adjusting levels at the bores based on the recorded level in DWER bores MM38 and GD8 referenced to their long term historical data (Table 5). DWER bores MM38 and GD8 long-term hydrographs are provided in Appendix G. The data considered for the calculation is from the year 2000, which is considered representative of current climate conditions

The AAMGL and MGL for each groundwater bore based on this analysis is shown in Table 6. Perching of groundwater appears to be occurring at some bores due to their proximity to existing stormwater storage areas.

For the LSP area, the mapping indicates an AAMGL of approximately 2 mAHD in this area.

It is important to note this LWMS only uses the terminology AAMGL to represent a valid statistical property of groundwater in the area, and not as a concept as per previous DWER policies. This LWMS presents details of the groundwater's seasonal variation, AAMGL, and MGL all as measures of its seasonal, annual, and interannual behaviour. Simply presenting an MGL is not considered adequate to represent the groundwater characteristics and behaviour of a site.

Table 5: AAMGL and MGL for DWER Bores

Bore	Period of Record	Groundwater Level (mAHD) 21/10/2019	AAMGL 2000-2020 (mAHD)	Correction Factor (m)	MGL (mAHD)	Correction Factor (m)
MM38	1974 – 2020	20.23	20.29	+0.06	20.64	+0.41
GD8	1978-2020	4.01	4.07	+0.06	4.94	+0.94
Correction Factors for Midland Brick Site Bores				+0.06		+0.67

Table 6: AAMGL and MGL for Midland Brick Site Bores

Bore	Natural Surface (mAHD)	AAMGL (mAHD)	MGL (mAHD)	Depth to AAMGL Below Natural Surface (m)
EMW01	5.60	0.67	1.28	4.93
EMW02	9.55	1.26	1.87	8.29
EMW03	10.82	1.42	2.03	9.40
EMW04	9.29	2.14	2.75	7.15
EMW05	10.96	7.38*	7.99	3.58*
EMW06	5.57	4.09	4.70	1.48
EMW07	8.37	6.36	6.97	2.01
EMW08	8.58	3.30	3.91	5.28
EMW09	7.00	1.76	2.37	5.24
EMW10	10.35	5.86	6.47	4.49

- EMW05 calculated AAMGL level above considered to be possibly perched due to comparison which other previously installed and monitored bores in close proximity to this area. Possibly due to stormwater ponding in the area behind the Clay Shed.

3.5.2 Groundwater Quality

Groundwater quality was monitored at the 10 groundwater bores by Emerge on a single occasion in September 2018 and by Hyd2o quarterly from September 2019 to September 2020. Groundwater bore locations are shown in Figure 7 and Appendix E.

Physical parameters (temperature, electrical conductivity, and pH) were measured in situ. Samples were sent to the NATA approved MPL Laboratory for total nitrogen, ammonia, nitrate, nitrite, total phosphorus, filterable reactive phosphorus, and heavy metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury, and zinc).

Groundwater water quality results for the two bores within the LSP area are outlined in Table 7 compared to ANZECC (2000) guideline trigger values for freshwater lowland river ecosystems. Full results are contained in Appendix E. Results are summarised as follows:

- Mean pH ranged from 6.61 to 6.74, within the ANZECC guideline range.
- Mean EC ranged from 668 µs/cm to 1896 µs/cm across all groundwater samples, above the ANZECC guideline range for freshwater, indicating that the groundwater is fresh to marginal.
- Mean values for total nitrogen (TN) ranged from 0.82 mg/L to 1.20 mg/L, at or below the ANZECC guideline value of 1.2 mg/L.
- Mean total phosphorous ranged from 0.53 mg/L to 0.60 mg/L across all bores, above the ANZECC guideline value of 0.065 mg/L.

With respect to metals, mean results were as follows relative to ANZECC guideline values:

- Arsenic, Lead, and Nickel were within the 99% protection limit.
- Cadmium, Chromium, and Mercury were within the 95% protection limit.
- Copper was within the 95% protection limit at EMW3, but outside 80% at EMW4.
- Zinc was within the 90% protection limit.

- **Table 7: Existing Groundwater Quality**

Groundwater Bore	Parameters							
	EC (µS/cm)	pH	TN (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	TP (mg/L)	FRP (mg/L)
ANZECC	120-300	6.5-8.0	1.2	0.32 – 2.3 (99% - 80% protection)	0.017 – 17 (99% - 80% protection)	-	0.065	0.04
EMW03	1896	6.74	1.20	0.03	0.01	0.01	0.60	0.15
EMW04	668	6.61	0.82	0.01	0.04	0.01	0.53	0.01

3.6 Constraints and Opportunities

Based on the LSP areas existing environment, the following key constraints and opportunities are identified to guide the development of the water management strategy:

- The area is outside the floodplain of the Swan River and Blackadder Creek.
- There is good clearance to regional groundwater across the area.
- Underlying clay soils limit opportunities for stormwater management via infiltration.
- There are existing flow paths to the Blackadder Creek tributary.
- Re-development of the area provides opportunities to improve the existing interface and relationship with the Blackadder Creek tributary.

4. Design Criteria & Objectives

Key design principles and criteria for the LSP area are shown in Table 8 and have been established consistent with the key reference documents previously detailed in Section 1.2, and reflect the site constraints and opportunities identified in Section 3.

These principles and criteria are used to formulate the water management strategy for the LSP area to remain within the identified constraints and opportunities of the existing environment.

Table 8: Design Principles & Criteria

Strategy Elements	Method & Approach
Water Use Sustainability	
Water Efficiency	• Water efficiency implementation to be consistent with Building Codes of Australia requirements • Aim for less than 100 kL/person/year water use • Establish "Waterwise" Public Open Space • Maximise infiltration and reuse of stormwater
Water Supply	• Minimise overall use of scheme water for non-drinking purposes • Water Corporation IWSS for lots plus use of rainwater tanks (non mandated) • Use of groundwater for POS irrigation.
Wastewater	• Water Corporation reticulated sewerage
Stormwater	
Ecological Protection	• Lot soakwells (15mm event infiltration on lot) to be used to maintain the overall required ecological water balance for receiving environments post development. • Establishment of biofiltration areas within POS for treatment of first 15mm road runoff and subsoil.
Serviceability	• Piped drainage system sized to convey 20% AEP event
Flood Protection	• Establish minimum habitable floor levels at 0.5m above the 1% AEP flood level of the Swan River and Blackadder Creek. • Overland flow paths within road reserves for safe conveyance of flows exceeding pipe drainage system capacity • 1% average exceedance probability (AEP) events to be discharged offsite at acceptable rates consistent with downstream ecological and infrastructure constraints.
Groundwater	
Fill Requirement & Subsoil Drainage	• Development levels to establish an acceptable clearance to groundwater systems via the use of a combination of subsoil drainage and sand fill above less permeable soils.
Acid Sulphate Soils & Contamination	• No known risk of ASS.

5. Water Use Sustainability

5.1 Water Efficiency Measures

Development of the LSP area will lead to an increased demand of potable water for residential use as irrigation of gardens and POS areas. Water conservation measures will be implemented to reduce scheme water consumption within the development will be consistent with Water Corporation's "Waterwise" land development criteria including:

- Promotion of use of waterwise practices including water efficient fixtures and fittings (taps, showerheads, toilets, rainwater tanks, waterwise landscaping).
- All houses to be built to 6 star building standards (water efficient fixtures and fittings).
- Use of water wise plantings in POS areas.
- Maximising onsite retention and reuse of stormwater.
- Use of high density residential zoning to reduce garden (ex-house) use of water and minimise fertiliser nutrient inputs.

5.2 Water Supply

The Water Corporation's Integrated Water Supply System (IWSS) will supply potable water to future homes within the LSP area.

Rainwater tanks will not be implemented/mandated at estate scale to supplement the domestic water supply scheme. Residents who wish to supplement scheme water supply with rainwater tanks will be provided for by individual builders during the building application process.

The LSP area is located within the Perth (Superficial-Swan) Groundwater Management Area (GMA), Shire of Swan South groundwater sub area. DWER's online Water Register for Licence and Water Availability Information indicates that the superficial aquifer is fully allocated within this sub area. The deeper Leederville aquifer is also fully allocated.

With respect to construction water requirements, discussions with DWER's Swan Avon region indicate temporary licences are still issued in this groundwater sub area. To this end the developer has already acquired a groundwater licence of 30,000 kl/yr valid until May 2025 for dust suppression for earthworks and construction purposes (Appendix H).

With respect to POS irrigation, the extent of POS area within the LSP area is minor and a small volume of water will be required. Water is regularly available within this groundwater area for purchase and transfer within this subarea, and the developer is currently negotiating opportunities for transfers. Obtaining POS water via licencing will be undertaken via a commercial transaction to facilitate development.

Upon handover of POS areas groundwater licences will be handed over to the City of Swan.

Landscape masterplanning is contained as Appendix I. Landscaping will be designed with recognition of the generally low availability of water in the area, with local species incorporated to minimise water use.

Preparation and agency approval of final landscape plans will be undertaken at UMWP stage based on final stormwater design requirements. The UWMP will also include detailed irrigation usage tables demonstrating water use and distribution at local scale.

Note the stormwater areas shown in Appendix I should be considered indicative only, with the final form of this area undertaken at UWMP stage based on refined stormwater modelling and landscape design.

5.3 Wastewater Management

Wastewater will be reticulated sewerage with management by the Water Corporation.

6. Stormwater Management Strategy

Stormwater management has been designed in accordance with Better Urban Water Management (WAPC, 2008), City of Swan's principles for water quality and quantity management, DBCA and DWER requirements, Stormwater Management Manual for Western Australia (DoW, 2007), and overarching DWMS (Hyd2o,2020).

Post development, annual stormwater discharge volumes and peak flows are typically required to be maintained relative to pre development conditions and water quality maintained and/or improved with the aim of maintaining and restoring ecological systems. These principles are the key guiding principles applied to the Blackadder Creek tributary to maintain its existing hydrology.

A summary of the overarching ultimate stormwater management strategy for the Midland Brick site as modelled and detailed in Hyd2o (2020a) is provided as Appendix J. Key elements of the proposed stormwater management system to facilitate the land use change for Area 3 are shown in Figure 8, with the aim of providing stormwater quality and quality management, and staged land use transition.

In broad terms the system will comprise the following:

- For Blackadder Creek tributary, the stormwater management area will be required to provide stormwater storage to attenuate flows to existing levels for events up to the 1% AEP. This storage area will be integrated within the landscaped POS, with opportunities for smaller scale distributed storage considered at UWMP stage.
- For the existing brickworks site and its external contributing local authority catchment, the strategy will be to continue to provide a functioning stormwater management system in accordance with existing environmental requirements. This will require the continued use of a pumped stormwater management system. Additional staging works will be required in due course, including relocation of the existing southern storage area once development proceeds.

Staging of stormwater works will be required to maintain a functioning stormwater management system for the existing brickworks and external council drainage system which drains into Midland Brick throughout the development transition period.

Staging details will be appropriately documented in the UWMP.

6.1 Stormwater Event Modelling

Post development stormwater modelling for the LSP area was performed using XP-Storm.

Post development catchment areas and runoff rates are detailed in Appendix K. Runoff coefficients adopted for modelling purposes for various events and durations were calculated in detail using Hyd2o's CURRV runoff rate estimator based on various individual land use characteristics. Lots are proposed to infiltrate stormwater runoff from constructed impervious surfaces via soakwells sized to retain the 15 mm rainfall event at source.

The LSP Area catchment is proposed to flow to a biofilter and flood storage area located in POS adjacent to Jack Williamson Oval. The design of this area has been undertaken based on ensuring the 1% AEP discharge from this area is similar to the existing flow from southern area which currently occurs. It is estimated the biofiltation area will be 1182 m^2 in size at 0.3m depth to provide 355 m^3 of storage, while the1% AEP area will be 1937 m^2 (1585 m^3 volume).

The proposed stormwater management system post development is shown in Figure 9, showing catchment areas, flows paths, and key infrastructure details based on modelling outcomes using XP-Storm for various AEP events. Table 9 summarises the stormwater management sizing details for individual areas, with more detailed modelling results provided in Appendix K.

Note that the extent of inundation in the POS area shown in Figure 9 for various flood management events are shown to scale. The storage shapes however should be considered indicative only for determination of area requirements and as a representation of storage areas required in relation to POS areas allocated in the local structure plan.

The final flood attenuation area configuration (side slopes etc), locations, and elevations will be documented in future UWMPs and will be dependent on final earthworks, drainage, and road design levels for the development. Minor refinements to catchment areas shown in this report are considered likely to occur as detailed design proceeds, and stormwater modelling will be updated accordingly during the UWMP process.

Table 9: Stage 3 Stormwater Management

Catchment	Stage 3 POS Main Catchment
Lots (ha)	7.45
POS (ha)	0.40
Road Reserve (ha)	4.04
Total Area (ha)	11.89
Equivalent Impervious Area (15mm event) ha	2.36
Equivalent Impervious Area (20% &1% AEP) ha	6.74
Storage Characteristics	
Side Slopes (v:h) Biofilter Flood Storage	 0 6
System Component and Design Approach	Biofilter and flood storage in POS discharge to Blackadder Creek Tributary
Water Quality : 15 mm Event	
Invert (mAHD)	8.0
Flood Rise (m)	0.3
TWL (mAHD)	8.3
Volume (m^3)	355
TWL Area (m^2)	1182
Flood Storage: 20% AEP Event	
Invert (mAHD)	8.0
Flood Rise (m)	0.63
TWL (mAHD)	8.63
Volume (m^3)	794
TWL Area (m^2)	1476
Flood Storage: 1% AEP Event	
Flood Rise (m)	1.09
TWL (mAHD)	9.09
Volume (m^3)	1585
TWL Area (m^2)	1937

6.2 Ecological Protection

This LWMS proposes a treatment train approach to water quality management which includes non- structural as well as structural controls:

- **Non-Structural Controls**
  Planning: POS location, lot product and subdivision layout.
  Maintenance: regular stormwater system maintenance including POS biofilter area.
  Monitoring: Post development program and performance review.
- **Structural Controls**
  Catchment Scale Infrastructure: bioretention in POS, integration with living streams.
  Local Scale Infrastructure: soakwells, GPT's.
  Landscape: Native plantings, integration of POS and downstream environment

Measures adopted represent known best management practice as detailed in the Stormwater Management Manual for Western Australia (DoW, 2007). Table 10 details a summary from the Stormwater Management Manual for Western Australia (DoW, 2007) of expected pollutant removal efficiencies for various WSUD measures in relation to water quality design criteria.

While DoW (2007) does not provide expected pollutant removal efficiencies for all BMP's, application of a treatment train approach using a combination of the non-structural and structural measures will therefore clearly achieve the design objectives for water quality as detailed in Better Urban Water Management (WAPC, 2008).

Stormwater volumes for ecological protection based on water quality treatment of the 15mm event are provided in Table 9 and Figure 10. The total area required is approximately 0.12 ha. This provides approximately 355 m^3 of storage at 0.3 m depth.

Figure 11 provides an indicative cross section of the POS biofilter. Biofiltration systems will be designed at the UWMP stage consistent with the Adoption Guidelines for Stormwater Biofiltration Systems (CRC for Water Sensitive Cities, 2015).

Table 10: BMP Water Quality Performance In Relation to Design Criteria

Parameter	Design Criteria via (WAPC, 2008) (required removal as compared to a development with no WSUD)	Structural Controls Nutrient Output Reduction [1]	
		Vegetated Swales/ Bioretention Systems	Detention/ Retention Storages
Total Suspended Solids	80%	60-80%	65-99%
Total Phosphorus	60%	30-50%	40-80%
Total Nitrogen	45%	25-40%	50-70%
Gross Pollutants	70%	-	>90%

1. Typical Performance Efficiencies via DoW (2007)

7. Groundwater Management Strategy

7.1 Post Development Groundwater Levels

Development levels within the LSP area are not dominated by fill requirements to achieve adequate separation to regional groundwater, given the proximity of groundwater levels to natural surface.

Due to the underlying impermeable soils however, it is envisaged that subsoil drainage will be required within the development to control water rise within imported fill above less permeable soils. Subsoil drainage is a widely used practice across the Swan Coastal Plain.

7.2 Earthworks, Fill and Subsoil Drainage

Development will require the removal of all brick and clay stock, as well as the demolition of any existing structures, pavements and services. Site works will then generally comprise the clearing of existing vegetation (where necessary), stripping of topsoil, earthworking of the existing surface, compaction to areas of existing fill, and importing fill with a top sand layer to facilitate the proposed form of development.

The clayey subgrade surface will be earthworked and shaped, before the sand is placed, to ensure drainage of perched water. Following the subgrade works, a layer of clean sand fill will be imported and placed above the clayey material to achieve the proposed finished levels and desired site classification. The imported material used for sand fill will be a free draining clean sand material with a fines content less than 5% and permeability of greater than 5m/day.

Preliminary earthwork levels prepared by TABEC are detailed in Appendix L on the basis of the following considerations:

- Fill requirement to achieve the required site classification.
- The minimum level required to ensure adequate separation from perched groundwater within sand fill.
- Interfacing levels with the adjacent development and existing infrastructure.
- Ensuring finished floor levels for buildings are a minimum 500mm above estimated 1% AEP flood levels of adjacent watercourses.

These earthwork levels have informed the establishment of catchment boundaries for stormwater modelling previous detailed in the DMWS (Hyd2o, 2020a) and Section 6.

As previously discussed, development levels are generally not dominated by fill requirements to achieve adequate separation to regional groundwater, given the proximity of groundwater levels to natural surface. However, due to the underlying impermeable soils, it is envisaged that subsoil drainage will be required within the development to control the perching of groundwater from rainfall.

Subsoil drainage is proposed to be located within road reserves. All subsoil drainage will have free outfalls and discharge to the biofiltration area for treatment. Ongoing management of subsoil drainage will be required to ensure its ongoing performance in accordance with design.

Groundwater/subsoil modelling will be performed at the UWMP stage in accordance with the IPWEA (2016) Draft Specification on Separation Distances for Groundwater Controlled Urban Development. This guideline recommends the establishment of development levels on the basis of detailed modelling of subsoil drainage utilising a 30 year daily rainfall record obtained from DWER based on a future median rainfall scenario as outlined in Selection of Future Climate Projections for Western Australia (DoW, 2015).

IPWEA (2016) requires the provision of a minimum 0.3 m of coarse sand in the rear of lots above the 50% AEP phreatic surface for residential lots of size 400-800m^2, and a 0.15m clearance for lots <400 m^2. This criteria will be used as the initial basis for establishing fill requirements for the LSP area, in consultation with City of Swan.

Final design lot levels and fill specification are a detailed design issue to be addressed during the preparation of detailed engineering design drawings and preparation of the UWMP and will be ultimately submitted for council approval at that stage.

In situ permeability testing is recommended to be undertaken once the LSP area has been filled to confirm that permeability rates meet those used in detailed design. The testing will be detailed in the UWMP and undertaken by the developer in consultation with the City of Swan.

7.3 Acid Sulphate Soils

Acid sulphate soil mapping has been previously discussed in Section 3.2.1 as no known risk.

8. Urban Water Management Plans

Consistent with processes defined in WAPC (2008), Urban Water Management Plans (UWMPs) will be developed and submitted to support subdivision applications for various stages of development within the LSP area.

Preparation of the UWMP will be the responsibility of the developer. UWMPs will address:

- Demonstrated compliance with LWMS criteria and objectives to the satisfaction of the City of Swan, DBCA and DWER.
- Agreed/approved measures to achieve water conservation and efficiencies of water use, including provision of POS irrigation water use distribution details.
- Detailed stormwater management design including the size, location and design of public open space areas, integrating major and minor flood management capability.
- Management of groundwater levels including proposed cut/fill levels.
- Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, expected performance and agreed ongoing management arrangements.
- Management of subdivisional works including development of a strategy for sediment control during construction.
- Implementation plan including roles, responsibilities, funding and maintenance arrangements.
- Specific monitoring and reporting to be undertaken for each UWMP area consistent with the monitoring program defined in the LWMS.
- Contingency plans (where necessary).

Further detail of the integration of stormwater within POS areas and any improvements to the Blackadder Creek Tributary area adjacent to the LSP area will be provided during the development of the relevant UWMP's covering those specific areas. This will include the refinement of stormwater modelling, preparation of detailed landscape plans (species selection and treatments), and detailed engineering design drawings.

Staging of stormwater changes will be detailed in the relevant UWMP's and implemented to ensure key hydrological performance criteria in relation to the receiving environment and key design objectives are maintained during the transition process.

9. Monitoring

9.1 Pre Development

Baseline surface and groundwater monitoring of existing conditions commenced in winter 2019 and was completed in winter 2020 as detailed in Chapter 3. Some additional monitoring was also undertaken in 2021 to monitor the performance of the Midland Brick site following recent changes to its overall system. No further specific monitoring is considered to be required to inform development of the Stage 3 area.

9.2 Post Development

Department of Water (2012) indicates a minimum of 3 years post development monitoring is required, and defines post development as "from completion of first subdivision to five years after 80 per cent of the development (by land area) has been completed".

The post development monitoring program is summarised in Table 11. Post development groundwater monitoring is proposed in 2 groundwater monitoring bores and 4 surface water monitoring sites as shown in Figure 12. Locations have been selected based on maintaining existing sampling locations where possible.

The following frequency of monitoring is proposed:

- Monthly groundwater level measurements.
- Quarterly groundwater quality measurements.

Groundwater levels will also be measured in DWER bores MM38 and GD8 consistent with pre development monitoring. Groundwater quality will be monitored quarterly (typically January, April, July, October) for physical parameters (pH, electrical conductivity), nutrients (total nitrogen, total Kjeldahl nitrogen, ammonia, nitrate, nitrite, total phosphorus, and filterable reactive phosphorus) and heavy metals.

Surface water samples will be taken in the Swan River upstream and downstream of the LSP area as well as within the Blackadder Creek Tributary at Muriel St. Samples will be taken on up to four occasions over each winter monitoring period, when water is flowing, via a collected grab sample. Samples of the stormwater outflow from the main stormwater basin and biofilter area will be taken when/if water is present. Visual assessment of these areas will also be undertaken on a quarterly basis via a standardised proforma, to assess performance in relation to design.

All water quality samples will be analysed at a NATA approved laboratory.

The monitoring schedule will be undertaken for a three year period consistent with DWER requirements. An annual report will be prepared summarising the results of the program, with results compared to predevelopment monitoring data. The program may need to be modified as data is collected to increase or decrease the monitoring effort in a particular area, or to alter the scope of the program itself. This will require the agreement of all parties.

If required, contingency actions will include a review of all monitoring data to determine the likely cause of any significant changes in water quality, consideration of additional monitoring required to assist a determination, and consideration of remedial actions.

A contingency plan including targets estimated on the basis of predevelopment monitoring is presented in Table 12. Implementation of the post development monitoring program is the responsibility of the developer. Where any staging aspects require specific additional monitoring to be conducted, this will be appropriately detailed at UWMP stage.

Table 11: Post Development Monitoring Program

Monitoring	Parameter	Location	Method	Frequency and Timing
Groundwater level	Water level (m AHD)	2 bores within LSP area and 2 DWER bores	Electrical depth probe or similar	Monthly (12x annually)
Groundwater quality	Physical, nutrients and heavy metals	2 bores within LSP area	Pumped bore sample	Quarterly (4x annually)
Surface water /Stormwater quality	Physical, nutrients and heavy metals	Blackadder Creek Tributary @ Muriel Rd, 2 locations Swan River, Site Storage	Collected grab samples	Maximum four occasions during each annual winter monitoring period
System performance	Profroma	Site storage, Blackadder Creek Tributary @ Muriel Rd	Visual Assessment	Maximum four occasions during each annual winter monitoring period

Table 12: Contingency Planning

Type	Criteria for Assessment	Frequency	Process & Possible Actions
Water Quality	Surface and groundwater quality significantly worse than: a) predevelopment water quality; and/or b) typical urban stormwater quality on the Swan Coastal Plain (Martens et al 2005) TN : 1.1 mg/l TP : 0.21 mg/l with reference to ANZECC guidelines [1]	Ongoing assessment following monitoring with annual review	**Process** 1. Assess spatial extent of occurrence. 2. Determine if due to development or other factors. 3. Perform appropriate action as required (refer below) 4. Record and report any breach and action taken. 5. If necessary, inform residents of any required works. 6. Inform and provide monitoring data to DWER/ City of Swan. **Possible Actions** 1. Resample location to determine if it is a false reading. 2. Identify and remove point sources of pollution. 3. Review operational and maintenance practices. 4. Consider alterations to POS areas including landscape regimes and soil amendment. 5. Consider modifications to the stormwater system. 6. Consider initiation of community based projects.

1. ANZECC guidelines to be used as a reference point only. ANZECC guidelines state that guidelines values are not intended to be directly applied to stormwater quality, however are applicable where the stormwater system are regarded as having conservation value. ANZECC guideline values are derived for unmodified or slightly modified ecosystems. ANZECC recommends the values only be applied where site specific values do not exist, or site specific targets cannot be derived.

10. Implementation

Table 13 details the roles, responsibilities and funding to implement the LWMS.

Monitoring outcomes will be used in a continual improvement capacity to review the implemented WSUD within the LSP area and inform the planning and design approaches for subsequent stages of development.

Details of construction and maintenance activities and responsibilities will be appropriately detailed at UWMP stage, and will include details of any specific staging considerations, and the need for ongoing management of subsoil drainage to ensure its ongoing performance in accordance with design.

Monitoring outcomes will also be used to inform continual design and planning improvements as the development proceeds, particularly in relation to maintaining and improving the hydrology of the Blackadder Creek Tributary.

Table 13: Implementation, Roles and Responsibilities

Implementation Action	Responsibility		
	Developer	DWER / DBCA	City of Swan
Review and approval of this LWMS		✓	✓
Preparation of a UWMP for individual development stages	✓		
Review and approval of UWMP		✓	✓
Construction of stormwater system and maintenance post construction until council handover	✓		
Long term stormwater system operation and maintenance			✓
Conduct post development monitoring program and annual reporting	✓		
Review of monitoring data and annual reports		✓	✓

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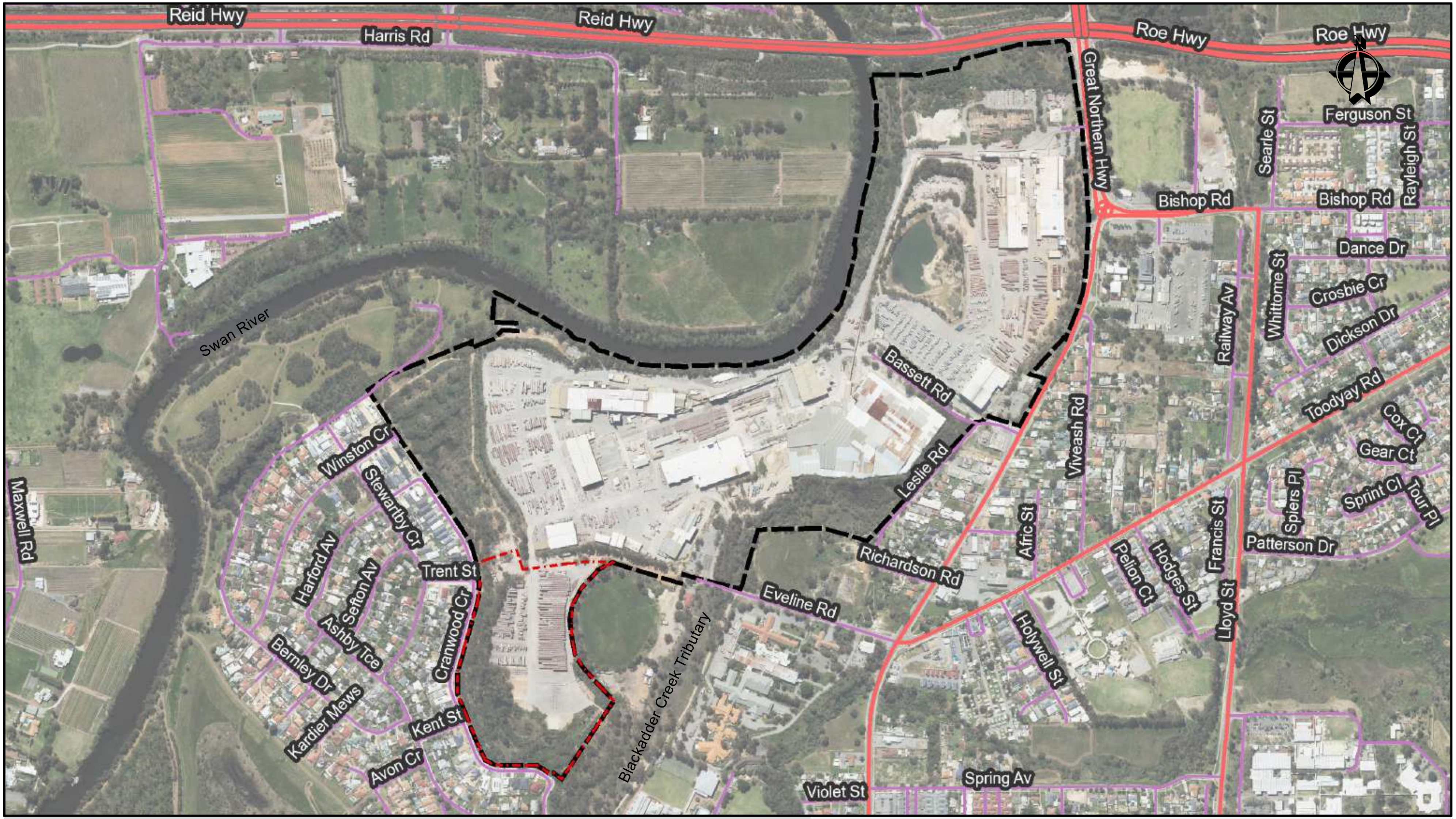
FIGURES

Date: 30/08/2021 Job No. H121087



Midland Brick Site

Local Structure Plan Area (LWMS Site)

0 125 250 375 500 Meters

hyd2o

Watermark Area 3 Local Water Management Strategy

Location Plan

Figure 1

Date: 1/09/2021 Job No. H21087

hyd2o

Watermark Area 3 Local Water Management Strategy

Local Structure Plan

Figure 2

Date: 30/08/2021 Job No. H21087

Site

Topography (mAHD)

hyd2o

Watermark Area 3 Local Water Management Strategy

Site Conditions Plan

Figure 3

Date: 31/08/2021 Job No. H21087

LSP Area
Bund/Slope Excavation
Cone Penetration Test
Test Pit
Mcs- Clayey Silt
Mgs1- Pebbly Silt
Water
High to moderate risk of ASS

hyd2o

Watermark Area 3 Local Water Management Strategy

Environmental Geology

Figure 4

Date: 31/08/2021 Job No. H21087

LSP Area

SCP Wetlands

Conservation

Multiple Use

hyd2o

Watermark Area 3 Local Water Management Strategy

Environmental Plan

Figure 5

Date: 31/08/2021 Job No. H21087

Midland Brick Site
LSP Area
Subcatchments
Lots
Road
POS
Open Drain/Swale
Pressure Main
Southern Settling Ponds
Southern Settling Storage
Temp Storage

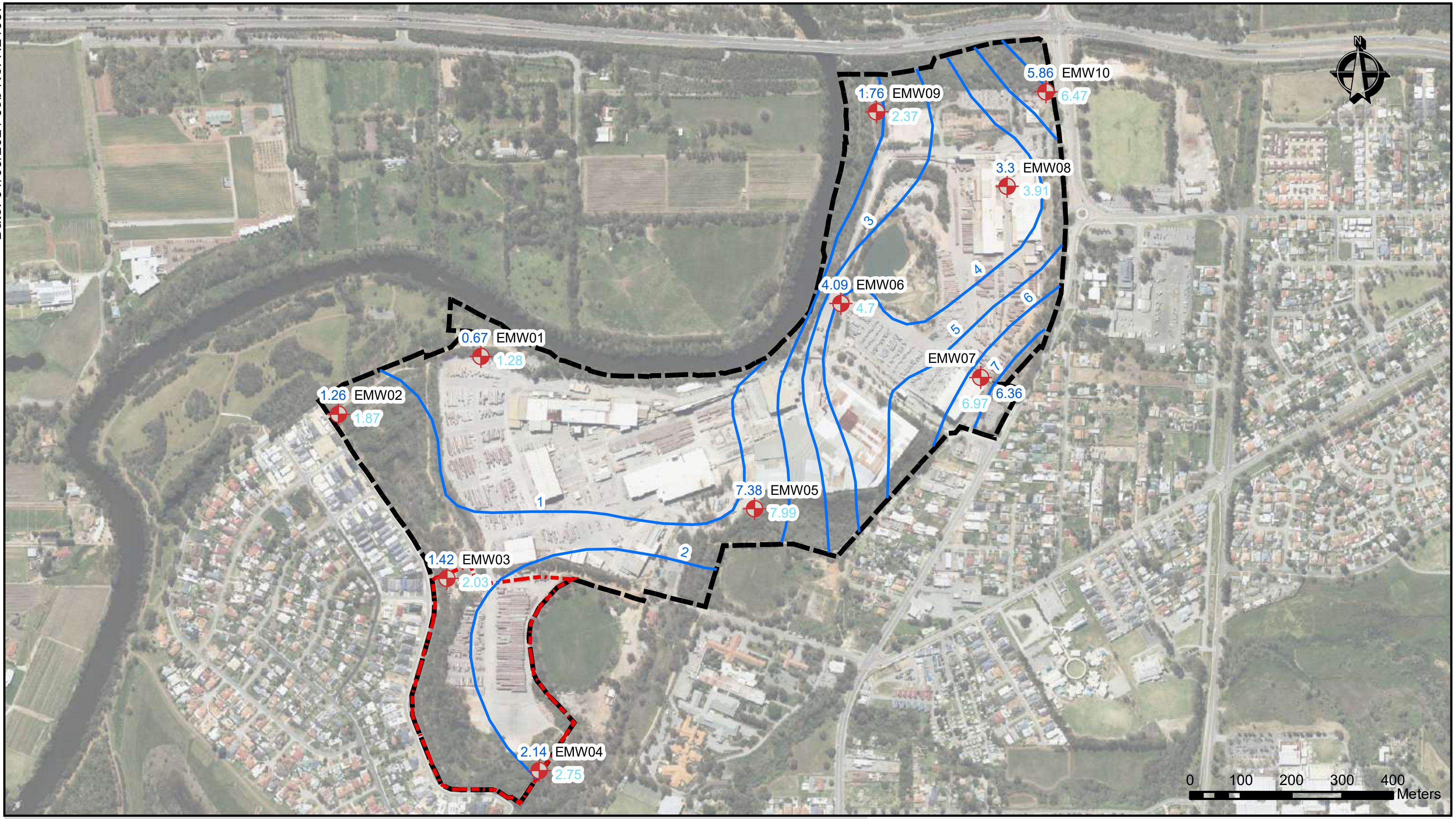
hyd2o

Watermark Area 3 Local Water Management Strategy

Surface Water Plan

Figure 6

Date: 01/09/2021 Job No. H21087



Midland Brick Site

LSP Area

Groundwater Bores

AAMGL mAHD

MGL mAHD

AAMGL Contour (mAHD)

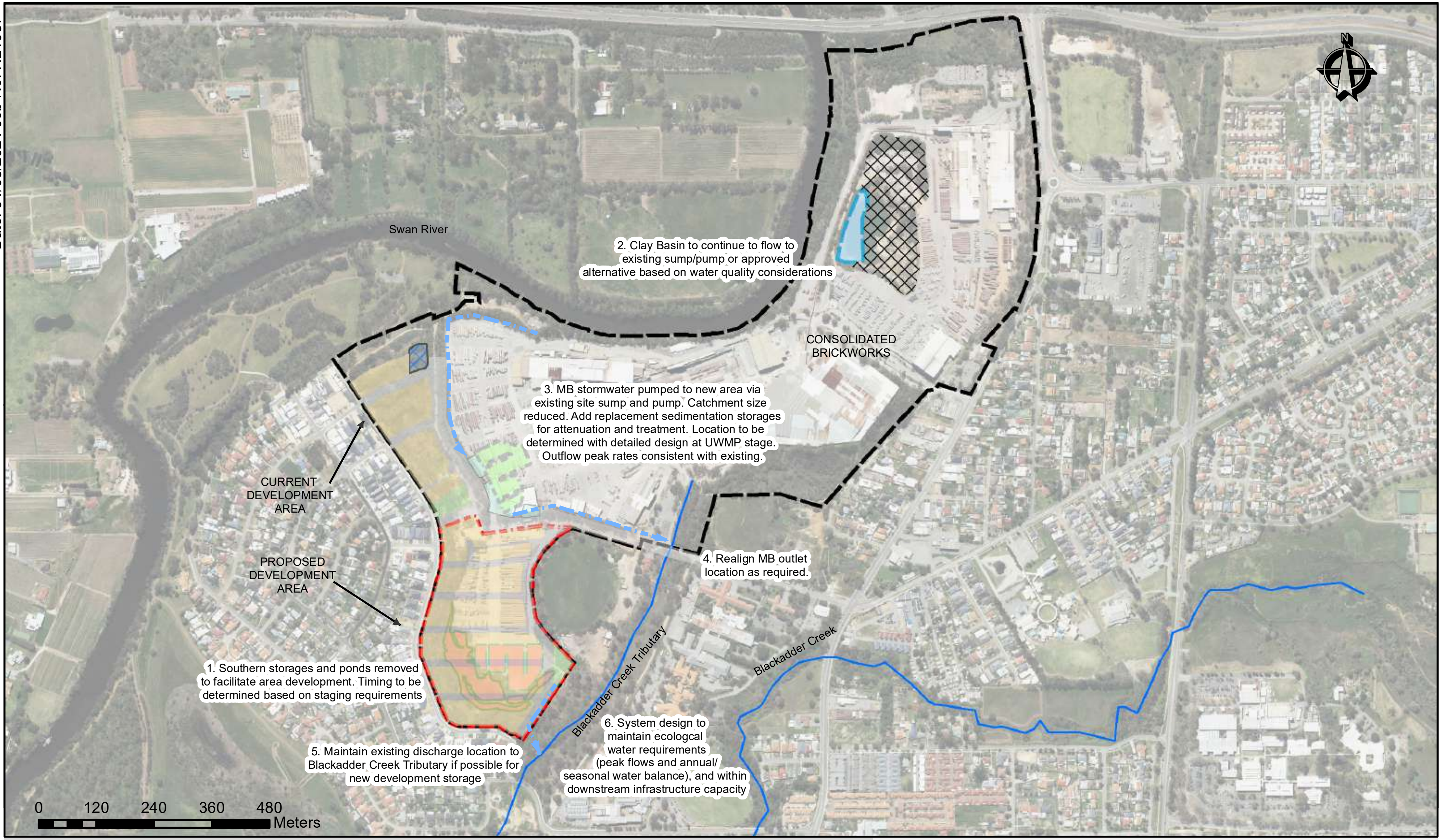
hyd2o

Watermark Area 3 Local Water Management Strategy

Groundwater Plan

Figure 7

Date: 31/08/2021 Job No. H21087



Midland Brick Site
LSP Area
Existing Storages
Temporary Additional Storages
Hardstand Expansion
Revised Clay Basin
Stormwater Flow Paths
Blackadder Creek & Tributary

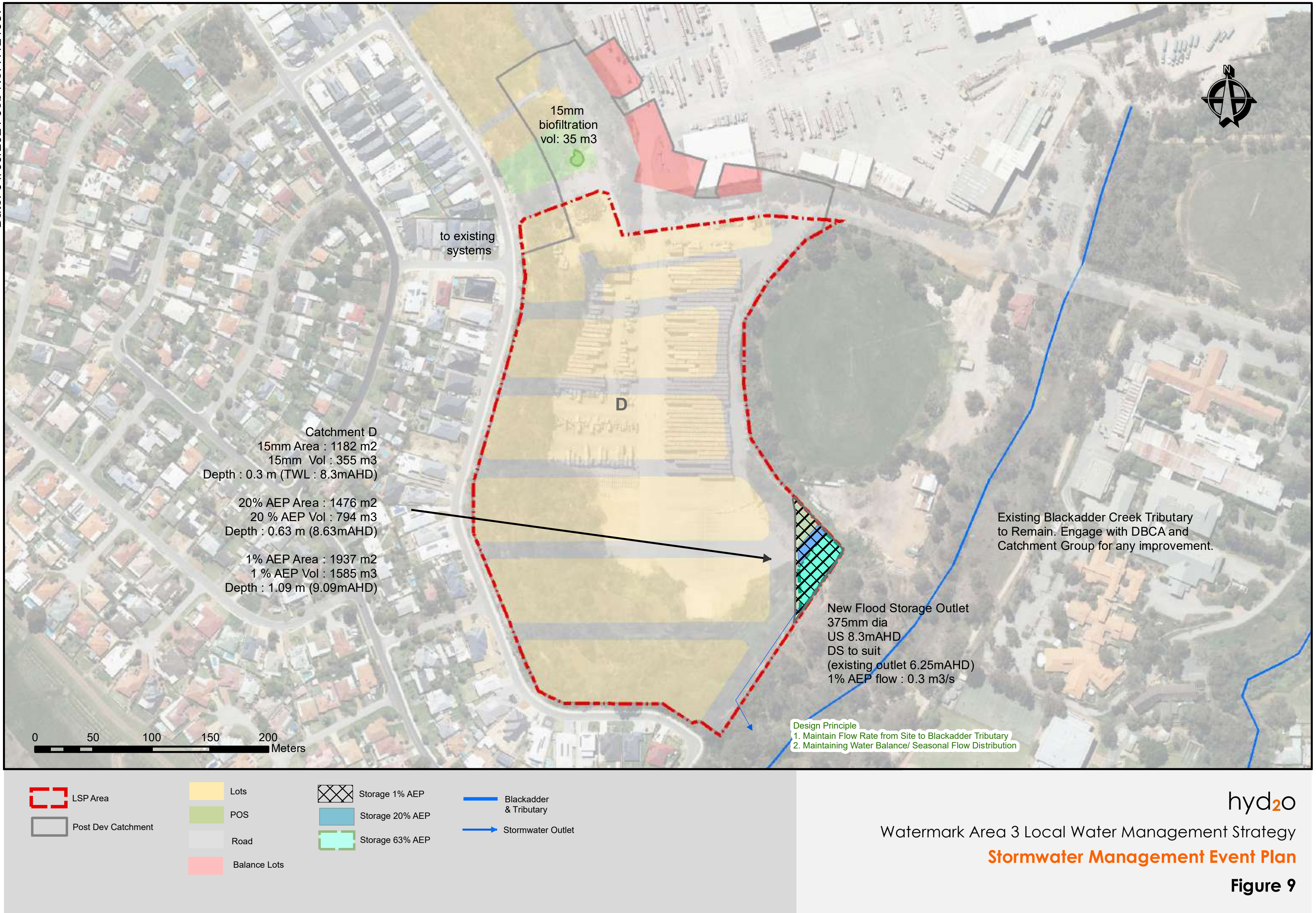
hyd2o

Watermark Area 3 Local Water Management Strategy

Stormwater Management Changes Overview

Figure 8

Date: 01/09/2021 Job No. H121087



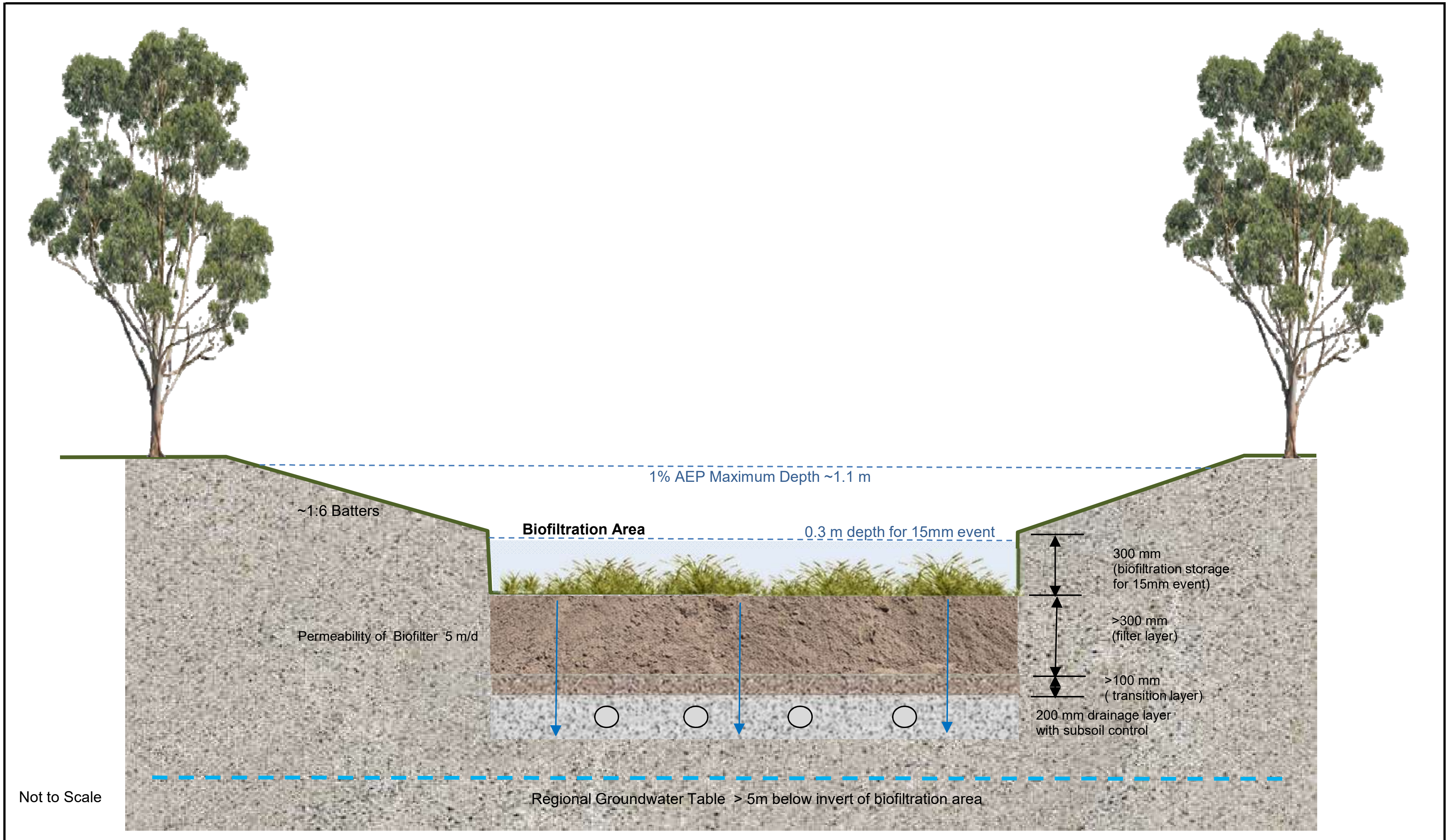
hyd2o

Watermark Area 3 Local Water Management Strategy

Stormwater Management Event Plan

Figure 9

Date: 1/9/2021 Job No H21087



Basin cross section shown indicative only
Actual depth and width to vary based on individual detailed design requirements at UWMP stage

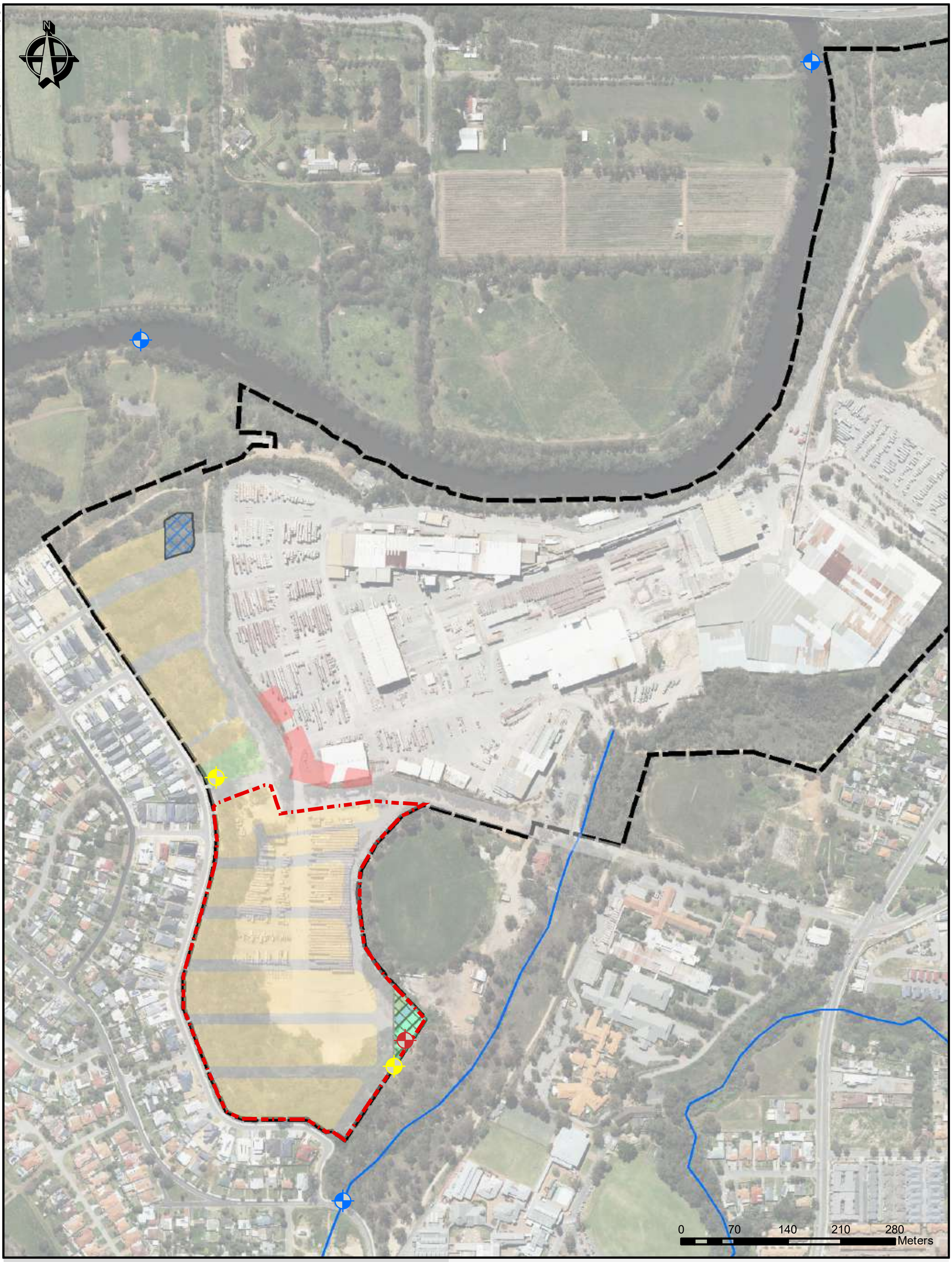
hyd$_2$o

Watermark Area 3 Local Water Management Strategy

Indicative Biofiltration System

Figure 10

Date: 01/09/2021 Job No. H21087



Midland Brick Site

LSP Area

Groundwater Bores

Surface Water Sites

Stormwater Sites

hyd2o

Watermark Area 3 Local Water Management Strategy

Post Development Monitoring

Figure 11

APPENDIX A
Better Urban Water Management Checklist

Better Urban Water Management LWMS Checklist

Local Water Management Strategy Item	Deliverable	✓	Comments
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: design elements and requirements for BMP's and critical control points	☑	Executive Summary
Introduction			
Total water cycle management - principles and objectives Planning background Previous studies		☑	Chapter 1, Figure 1
Proposed development			
Structure plan, zoning and land use Key landscape features Previous land use	Site Context Plan Structure Plan	☑	Section 1.1, Section 2, Figure 2
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape plan	☑	Section 5.2, Appendix I
Design criteria			
Agreed design objective and source of objective		☑	Section 4, Table 8
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☑	Section 3, Figures 3-8
Site conditions- existing topography/ contours, aerial photo underlay, major physical features	Site Condition plan	☑	Section 3.1, Figure 3
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	☑	Section 3.2, Figure 4, Appendix B
Environmental- areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental plan plus supporting data where appropriate	☑	Sections 3.3, Figures 5
Surface water- topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface water plan	☑	Section 3.4, Figures 6 & 7, Appendix C-D
Groundwater - topography, pre development groundwater levels and water quality, test bore locations	Groundwater plan plus details of groundwater monitoring and testing	☑	Section 3.5, Figure 8, Appendices D-G
Water use sustainability initiatives			
Water efficiency measures- private and public open spaces including method of enforcement		☑	Section 5.1
Water supply (fit- for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		☑	Section 5.2
Wastewater management		☑	Section 5.3
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points, 100 year flow paths and 100 year detentions storage areas	100yr event plan Long section of critical points	☑	Section 6.1, Table 9, Figures 9 & 10, Appendix J & K
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5yr event plan	☑	Section 6.1, Table 9, Figures 9 &10, Appendix J & K
Protect ecology - detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1 yr event plan Typical cross sections	☑	Section 6.1 & 6.2 Table 9 & 10, Figures 9, 10,& 11

Local Water Management Strategy Item	Deliverable	✓	Comments
Groundwater management strategy			
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoil areas/exclusion zones	Groundwater/subsoil plan	☑	Section 7.1 & 7.2, Appendix L
Actions to address acid sulphate soils or contamination		☑	Section 7.3
The next stage - subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design		☑	Section 8
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		☑	Section 9, Figure 13, Table 11 & 12
Implementation			
Developer commitments		☑	Section 10, Table 13
Roles, responsibilities, funding for implementation		☑	Section 10, Table 13
Review		☑	Section 10, Table 13

APPENDIX B
Geotechnical Report

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on Geotechnical Investigation

Project Texas
102 Great Northern Highway, Middle Swan, WA

Prepared for
Linc Property Pty Ltd

Project 96584.01
June 2019

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	96584.01	Document No.	R.001.Rev0
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Report prepared for	Linc Property Pty Ltd		
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Document status and review

Status	Prepared by	Reviewed by	Date issued
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Revision 0	1	-	Judd Dyer, Linc Property Pty Ltd

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		26 JUNE 2019
Reviewer	F. L - j A.	26 June 2019

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Table of Contents

Report on Geotechnical Investigation
Project Texas
102 Great Northern Highway, Middle Swan, WA

1. Introduction

This report presents the results of a geotechnical investigation undertaken for Project Texas at 102 Great Northern Highway, Middle Swan, WA. The investigation was commissioned on 20 June 2019 by Judd Dyer of Linc Property Pty Ltd and was undertaken in accordance with Douglas Partners' proposal PER190248 dated 11 June 2019.

It is understood that the proposed development comprises a residential subdivision development in the western part of the site and an industrial development in the eastern part. Preliminary site formation earthworks design includes cutting below existing surface levels in the western and central parts of the site and filling elsewhere. It is understood that finished levels are proposed to be achieved, following bulk earthworks, by placing approximately 1.2 m of clean granular fill over the existing soils underlying the site in the proposed residential development area (western part of the site) and 0.5 m of clean, granular fill in the industrial (eastern) part of the site.

A desktop study of the site has been previously undertaken by Douglas Partners and is presented in Douglas Partners report 96584.00.R.001.

The aim of the investigation was to assess the subsurface soil and groundwater conditions across the site in order to provide preliminary information on:

- the geotechnical suitability of the site for the proposed development;
- the thickness, consistency, strength and density of uncontrolled fill, including in the areas of former clay pits;
- site classification in accordance with AS 2870-2011 following recommended site preparation works;
- the suitability of the encountered existing fill to be left in place below the proposed development, and advice on ground improvement of existing uncontrolled fill if required;
- suitability of encountered uncontrolled fill for reuse as structural fill, and recommendations to improve unsuitable fill to make it suitable for reuse; and
- site preparation, earthworks and ground improvement requirements, if any, required to remediate the existing deep basin in the northern part of the site.

The investigation included the excavation of eleven test pits and the supervision of eight cone penetration tests. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

2. Site Description

The site is approximately 82 ha in size. It is mostly developed as a brick manufacturing facility, with numerous large industrial buildings scattered across the site, and associated areas of hardstand for storage. There are undeveloped areas around the edges of the site, particularly the western and south western side. A bund of soil has been constructed around the western end of the site. A relatively large water body (approximately 250 m by 175 m maximum dimensions) occupies an inferred former clay pit in the northern part of the site. Most of the site is currently covered with hardstand pavement, apart from the undeveloped fringes which are vegetated.

It is understood that brick making operations have been present on the site since the late nineteenth century. Historical photographs indicate that clay quarrying has been undertaken on parts of the site, notably in the south eastern area and northern part of the site. As previously noted, one relatively deep excavation is partially filled with water in the northern part of the site but the other clay pits have been backfilled.

Douglas Partners has previously undertaken a desktop study of the site. The findings of the desktop study are presented in Douglas Partners repot 96584.00.R.001.

3. Field Work Methods

Field work was carried out on 21 June 2019 and comprised:

- Eight cone penetration tests;
- Eleven test pits; and
- A dynamic cone penetrometer (DCP) test at each test pit location.

The cone penetration tests (test locations 1 to 8) were carried out using a 36 mm diameter instrumented cone with a following 130 mm long friction sleeve attached to rods of the same diameter, pushed continuously at a rate of 20 mm/sec into the soil by hydraulic thrust from a ballasted 12 tonne tracked rig. Strain gauges in the cone and sleeve measure resistance to penetration and this data allows assessment of the type and condition of the materials penetrated. The cone penetration tests were undertaken to depths of up to approximately 12.9 m, though several tests encountered refusal at shallower depth and three encountered refusal at depths of less than 1 m.

Test pits at test locations 9 to 16 were excavated using a 5 tonne excavator with a 450 mm wide toothed bucket to depths of up to 2.8 m. Several test pits encountered refusal at shallower depths due to slow digging. The pits in the side of the western bund (test locations 17 to 19) were excavated using the same excavator to a depth of 0.4 m and 0.5 m respectively.

Ground conditions were logged in general accordance with AS1726-2017 by a suitably experienced geotechnical engineer from Douglas Partners. Soil samples were recovered for subsequent geotechnical laboratory testing. Laboratory testing had not commenced at time of issue of this report due to timing constraints.

Dynamic cone penetrometer testing was carried out in accordance with AS 1289.6.3.2, adjacent to each test pit, to assess the in situ density of the shallow soils. The results of these penetrometer tests are presented on the test pit log sheets in Appendix B.

Test locations were determined with reference to existing site features, and are presented on Drawing 1 in Appendix A. Surface elevations at each test location were interpolated from publicly available LiDAR data.

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing carried out on 21 June 2019 are presented in Appendix B, with notes defining descriptive terms and classification methods provided in Appendix A.

The encountered ground conditions at the test locations generally comprised uncontrolled fill, generally clayey although some granular fill was also encountered, overlying variable, though generally clayey, natural soils.

A summary of the general ground conditions encountered at the test locations is given below:

- **Clayey Fill (Sandy Clay, Clayey Sand, Gravelly Clay, Clayey Gravel, Clay, Bricks and Sand with Clay)** – generally stiff to hard, encountered at all test pit locations, generally forming most of the encountered fill depth. Loose silty or clayey gravel, inferred as possible fill, was encountered between depths of 1.5 m and 4.0 m at test location 7. Firm to very stiff clay fill was encountered to a depth of approximately 5.5 m at test location 6. The clayey fill general contained brick fragments and/or bricks, and occasionally fragments of plastic, rubber, wood, wire, fabric, carpet and concrete.
- **Granular Fill (Sand, Gravelly Sand, Sandy Gravel)** – generally medium dense to very dense, granular fill, generally encountered from the surface to depths of less than 0.5 m. Granular fill (i.e. fill with no clay content) was encountered at test pit locations 11, 12, 13, 15, 16 and 17 and cone penetration locations 2 and 3. A granular fill layer was encountered at test location 13, underlying clayey fill from a depth of approximately 0.4 m to the termination depth of the test pit at 1.6 m. The fill generally contained brick fragments and/or unbroken bricks.

  Inferred granular fill or disturbed ground was encountered to a depth of approximately 9.8 m at test location 3, with loose silty sand being encountered between depths of approximately 3.0 m and 8.0 m.
- Natural Soils – generally clayey soils from the Guildford Formation, including:
  - **Clayey Sand** – hard / very dense orange-brown mottled red-brown and grey, fine to medium grained clayey sand, encountered underlying the fill from a depth of 0.75 m at test location 11. Sand with sand clay was encountered from the surface at test location 5.
  - **Clay** – stiff to hard clay, encountered underlying the fill from a depth of approximately 0.75 m at test location 14 and cone penetration test locations 1, 3, and 6.

- **Sand and Silty Sand** – generally medium dense to dense, orange-brown fine to medium grained sand, sometimes with clay, encountered underlying the clayey sand at test pit location 11 and cone penetration test location 5.

4.2 Groundwater

Free groundwater was not observed in test pit locations undertaken on 24 June 2019.

Groundwater was measured within some of the cone penetration test locations, as summarised in Table 1 below, and are indicated on the logs in Appendix B. Some of the cone penetration test holes collapsed prior to dipping for groundwater, precluding measurement of groundwater levels.

Table 1: Summary of Groundwater Observations

Test Location	Surface Level [1] (m AHD)	Groundwater Depth (m)	Groundwater Level (RL m AHD)
1	5.9	7.2	-1.3
3	5.8	2.9	2.9
5	9.2	9.1	0.1
6	9.2	8.0	1.2
7	8.3	9.9	1.6

Notes: [1]: Interpolated from publicly available LiDAR data

The Perth Groundwater Atlas (2004) indicates that the level of the regional superficial aquifer beneath the site was at approximately RL 2 m AHD in May 2003 in the north eastern corner of the site but generally below RL 1 m AHD, which is from approximately 3 m to more than 10 m below the estimated current surface elevation of the site. Desktop information and our general experience in the area indicates that perched groundwater may be present at higher elevations (see Douglas Partners report 96584.00.R.001).

It should be noted that groundwater levels are affected by climatic conditions and soil permeability, and will therefore vary with time.

5. Proposed Development

It is understood that the proposed development comprises a residential subdivision development in the western part of the site and an industrial development in the eastern part. Preliminary site formation earthworks design includes cutting below existing surface levels in the western and central parts of the site and filling elsewhere. It is understood that finished levels will be achieved, following bulk earthworks, by placing approximately 1.2 m of clean granular fill over the existing soils in the proposed residential development area (western part of the site) and 0.5 m of clean, granular fill in the industrial (eastern) part of the site.

6. Comments

6.1 Site Suitability

Results of the investigation indicate that the site is generally underlain by generally clayey fill overlying clayey natural soils. Granular fill and natural sand (with some clay content) are present in some locations.

The fill is generally stiff to hard, or medium dense to very dense. Loose inferred fill and disturbed ground was encountered to a depth of approximately 8 m at test location 3, adjacent to the existing large pit in the northern part of the site. Loose and firm soils, interpreted to be possible fill, were identified to depths of between 4 m and 5.5 m at test locations 6 and 7. The fill across the site generally contains brick fragments or bricks, and occasionally contains traces of other materials such as wood, fabric, wire, plastic, rubber and concrete.

It is considered that, from a geotechnical perspective, the site is considered suitable for the proposed redevelopment, as evidenced by existing facilities on the site. The following should be considered:

- The site is underlain by variable, uncontrolled fill of generally unknown thickness. Much of the fill is clayey in nature and commonly contains brick fragments and bricks. In current encountered condition, the fill appears to generally form a suitable foundation material without the requirement of full depth removal of the fill, although partial removal to a given depth to ensure a minimum thickness of engineered ground beneath proposed founding levels should be considered to reduce geotechnical risk, as discussed in Section 6.2. Removal, screening/crushing and replacement of the uncontrolled fill such that a layer of controlled fill with a thickness of at least 1.2 m below the proposed layer of imported sand is suggested at this stage of the study. Following removal of the 1.2 m layer of uncontrolled fill, the exposed surface should be heavily compacted by an impact roller or similar. Given the size of the site, the duration of industrial activity and the limited extent of current investigation, it is considered likely that some areas of unsuitable fill that do not form a suitable foundation layer and require removal, deep ground improvement or soil reinforcement may be encountered.
- The site classification of the site in accordance with AS 2870-2011 in existing condition is considered to be "Class P" due to presence of uncontrolled filling. The site classification of the natural clayey soils underlying the site is indicated to be "Class M" by previous investigations and corroborates Douglas Partners' general experience in the Midland area. Laboratory testing on the clayey fill to further define site classification was outside the scope of this report owing to timing requirements. The following equivalent site classifications are considered likely appropriate following proposed earthworks:
    - An equivalent site classification of "Class S" is considered to be likely suitable for the residential development in the western part of the site, following placement of 1.2 m of imported clean, granular fill as described in Section 5 and suitable preparation of the existing soils.
    - An equivalent site classification of either "Class S" or "Class M" is considered to be likely suitable for the industrial development in the eastern part of the site, following placement of 0.5 m of imported clean, granular fill as described in Section 5 and suitable preparation of existing soils. Increasing the proposed thickness of granular fill to at least, say, 0.8 m would reduce the risk of areas of the site being "Class M" in finished condition. Additionally, AS2870-2011 requires placement of at least 0.8 m of

non-reactive, structural fill to change the site classification from that applying to the previous condition.

- o To achieve a site classification of "Class A", all of the existing fill would need to be removed and replaced by at least 1.8 m of compacted granular fill.

- It is considered that the encountered fill, including the fill in the bund around the western part of the site, could generally be reused as fill elsewhere on the site. Given the abundance of bricks and brick fragments, fill excavated from within the site should be fed through a crusher, or screened and the oversized particles crushed, to reduce the size of the bricks and brick fragments (and over oversized particles such as concrete, to be less than 50 mm in size. However, as discussed above, the presence of unsuitable fill material in some locations may be anticipated and close supervision and testing of fill material excavated on the site will be necessary prior to its reuse elsewhere within the development.
- Remediation of the existing basin in the northern part of the site may require dewatering, removal of soft deposits from within the inundated area, excavation of loose fill and over-steepened slopes (if present) around the basin, and backfilling in a controlled, engineered manner. It is recommended that clayey fill is used to backfill the basin to create ground conditions similar to the natural ground and avoid creation of a 'swimming pool' effect.
- Desktop information (see Douglas Partners report 96584.00.R.001) indicates that shallow groundwater may be present in some western areas of the site, particularly adjacent to the Swan River, and perched groundwater is anticipated to form, at least during the wet months of the year, on the surface of clayey soils (i.e. Guildford Formation and some of the uncontrolled fill).

6.2 Suitability of the Existing Fill to be Left in Place

The encountered existing fill was generally clayey in nature, with granular fill present in some locations, generally as a thick surface layer. The encountered fill was generally in a stiff to hard, or medium denser or denser condition at the test locations.

Based on the encountered fill, and the current land use of the site as an active industrial development, it is considered that some ground improvement provisions are required to ensure that a minimum thickness of controlled soils exists beneath founding levels.

The degree of ground improvement provisions will be proportionate to the level of project risk considered acceptable for the proposed structures. The following alternative scenarios may be considered to address geotechnical risks:

- To fully mitigate the geotechnical risk associated with the existing uncontrolled fill, undertake full depth excavation, screening/crushing and replacement of the uncontrolled fill;

  or alternatively, with potentially some residual risk;

- Partial excavation and reinstatement of the uncontrolled fill to form a controlled, engineer foundation layer, as follows:
  - Excavation of the uncontrolled fill to a depth of 1.2 m. The suggested depth can possibly be adjusted (say to 1.0 m) depending on detailed investigation results and compaction details;
  - Heavy compaction of the uncontrolled fill left in place using an impact roller or possibly heavy (18 tonne) roller (compaction details subject to findings of detailed investigation and may differ across the site depending on uncontrolled fill thickness);
  - Treatment of the excavated controlled fill by screening and crushing as described in Section 6.4; and
  - Replacement of the excavated uncontrolled fill in an engineering manner.

The above methodology for partial excavation of the uncontrolled fill is considered a reasonable level of mitigation to address most of the geotechnical risks associated with the uncontrolled fill material. The proposed compacted sand layer could then be constructed above the improved uncontrolled fill platform. It is possible that soil reinforcement (e.g. geogrids) may be required within the foundation layer to reduce differential settlements in areas of poor filling, where encountered, if this approach is adopted.

Notwithstanding the above, given the large size of the site, the duration of industrial developments within the site and the limited scope of investigations undertaken at this stage, it may be anticipated that areas of unsuitable fill may be encountered during redevelopment of the site. Areas of the site requiring full depth fill replacement, deep ground improvement or exclusion from development of the site cannot be precluded at this stage of the study. Detailed investigations should be undertaken during design development to address this matter. Earthworks should be supervised during construction, particularly exposures of fill, so that unsuitable material, if present, can be identified and removed.

6.3 Site Classification

The site is generally underlain by generally clayey, with some sandy, uncontrolled fill to various, and generally unknown, depths.

The site classification of the site in its current condition is “Class P” in accordance AS2870-2011 because of the presence of uncontrolled fill.

The encountered fill was generally in a medium dense or denser or stiff to hard condition, except at test location 3, located adjacent to the existing flooded excavation (see Section 6.5 for a discussion of this area).

It is understood that it is proposed to place a layer of compacted, granular fill over the site to achieve finished levels. The proposed thickness of the granular fill layer is understood to be approximately 1.2 m for the proposed residential development in the western part of the site and 0.5 m for the industrial eastern part of the site.

At this stage, soil reactivity testing has not been undertaken on samples of existing clayey uncontrolled fill.

However, based on Douglas Partners experience, it is anticipated that an equivalent site classification of “Class S” will likely apply to most of the proposed residential area, following placement of a 1.2 m thick layer of compacted, non-reactive, granular fill and following some provisions regarding site preparation as discussed in previous sections to ensure a minimum thickness of controlled founding materials beneath proposed founding levels.

In the proposed industrial area, where a reduced thickness of 0.5 m of compacted granular fill is proposed, a site classification of either “Class S” or Class M” may apply the zones within the area, depending on the reactivity of the existing uncontrolled fill and following site preparation as discussed in previous sections. Increasing the thickness of the proposed fill layer to, say, 0.8 m would reduce the risk of a “Class M” site in finished condition. It should be noted that, in strict accordance to AS-2870-2011, a controlled fill layer thickness of at least 0.8 m is required to change the site classification from the existing condition prior to filling.

Existing information suggests that the natural clayey soils underlying the site may have a site classification of “Class M”. Therefore, if required, a site classification of “Class M” should be assumed for footings founded in natural clayey soils.

In order to achieve a site classification of “Class A”, which assumes no surface movement, it would be necessary to remove the full depth of uncontrolled fill and replace with a layer of controlled, non-reactive granular at least 1.8 m thick. Although the encountered existing fill is generally stiff to hard, the potential variability in the fill material and the possibility of creep within the fill material precludes the application of a site classification of “Class A” unless the uncontrolled fill is removed.

Loose sandy soils were encountered at test locations 3 and 7. The density of loose sand underlying the site would need to be increased to medium dense or denser to achieve the site classifications given above.

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.

6.4 Geotechnical Suitability for Re-Use of Uncontrolled Fill

The encountered uncontrolled fill was generally clayey in nature, though granular fill was encountered in some locations, mostly as a thin surface layer. Two pits excavated into the bund located around the western end of the site also encountered clayey fill.

Occurrence of brick fragments and bricks within the fill was frequent. A trace of other materials, such as rubber, wood, fabric, wire and carpet was encountered at some locations.

It is considered that existing fill excavated from the site could be generally suitable for reuse as fill below the proposed surface layer of granular, non-reactive fill, provided that the material is put through a crusher to reduce oversized particles such as bricks and concrete to be less than 50 mm in size, or screened if the soil is suitable for screening. Following screening, oversized fragments such as bricks and concrete could be crushed and remixed with the fill material.

Notwithstanding the above, as discussed in Section 6.2, it is possible that fill that is not suitable for reuse will be encountered. Close supervision and frequent testing of fill material excavated from the site will be required prior to reuse as fill elsewhere on the site.

It should be noted that this geotechnical study does not assess whether unacceptable levels of contaminants (including asbestos) exist within the fill material as this was outside the scope of the geotechnical investigation. Such levels, if they occur, may limit or prevent the use of this material.

6.5 Remediation of the Flooded Excavation

A deep excavation, partially filled with water, is located in the northern part of the site in an area indicated by historical aerial maps to have been part of a former clay pit. The depth of the pit and ground conditions within the inundated area were not known to Douglas Partners at the time of writing this report.

Test locations around the basin by Douglas Partners and others encountered clayey fill on the northern side of the basin and deep granular fill on the southern side. Test location 3 encountered inferred fill or disturbed ground to a depth of approximately 9.8 m at test location 3, with loose silty sand encountered between depths of approximately 1.5 m and 8 m. It is possible that the encountered loose granular soil is material that has been pushed into the former clay pit to form the existing ground elevation at the test location.

Remediation of the basin and backfilling to design surface levels may require the following:

- Dewatering of the basin;
- Removal of anticipated soft deposits from within the inundated area, which will likely require removal from site;
- Excavation of loose material where present around the edges of the basin, such as at test location three, and to make the area within the basin safe for workers to enter;
- Backfilling of the basin to the required elevation in a controlled manner. It is suggested that clayey fill excavated from elsewhere on the site is used to backfill the basin to avoid creating a 'swimming pool' effect that may occur if granular fill is used; and
- Finish the site to design levels with the proposed layer of granular, non-reactive fill.

7. References

1. Australian Standard AS2870-2011, 'Residential Slabs and Footings', April 2011, Standards Australia
2. Australian Standard AS 1289-2000, Methods of Testing Soils for Engineering Purposes.
3. Australian Standard AS 1289.6.3.2-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Dynamic Cone Penetrometer Test.
4. Australian Standard AS 1726-2017, Geotechnical Site Investigation.
5. Australian Standard AS 3798-2007, Guidelines on Earthworks for Commercial and Residential Developments.
6. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004

8. Limitations

Douglas Partners (DP) has prepared this report for this project at in accordance with DP's proposal dated 11 June 2019 and acceptance received from Linc Property Pty Ltd dated 20 June 2019. The work was carried out under a Professional Services Agreement, with amended terms and conditions. This report is provided for the exclusive use of Linc Property Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. 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 on the site only at the specific sampling and/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 human 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 affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing 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 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 stated 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 scope for work for this investigation/report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. Should evidence of filling of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such filling may contain contaminants and hazardous building materials.

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 / environmental / groundwater) 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
Drawing

About this Report

Douglas Partners

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.

Copyright

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.

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.

Cone Penetration Tests

Douglas Partners

Introduction

The Cone Penetration Test (CPT) is a sophisticated soil profiling test carried out in-situ. A special cone shaped probe is used which is connected to a digital data acquisition system. The cone and adjoining sleeve section contain a series of strain gauges and other transducers which continuously monitor and record various soil parameters as the cone penetrates the soils.

The soil parameters measured depend on the type of cone being used, however they always include the following basic measurements

- Cone tip resistance q_c
- Sleeve friction f_s
- Inclination (from vertical) i
- Depth below ground z

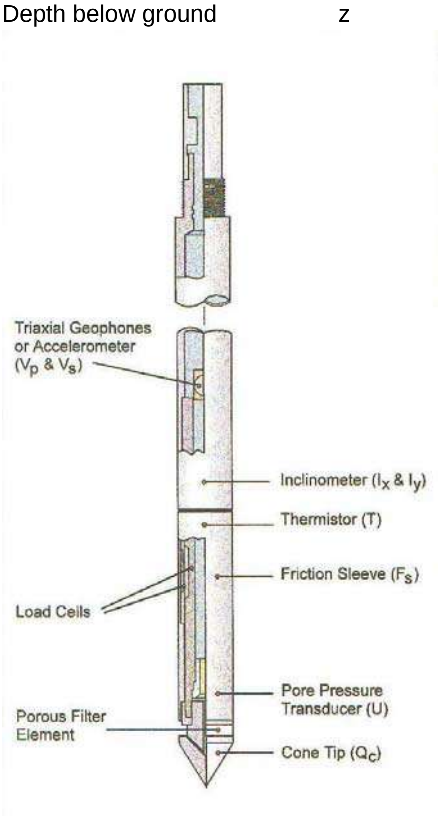


Figure 1: Cone Diagram

The inclinometer in the cone enables the verticality of the test to be confirmed and, if required, the vertical depth can be corrected.

The cone is thrust into the ground at a steady rate of about 20 mm/sec, usually using the hydraulic rams of a purpose built CPT rig, or a drilling rig. The testing is carried out in accordance with the Australian Standard AS1289 Test 6.5.1.

Figure 2: Purpose built CPT rig

The CPT can penetrate most soil types and is particularly suited to alluvial soils, being able to detect fine layering and strength variations. With sufficient thrust the cone can often penetrate a short distance into weathered rock. The cone will usually reach refusal in coarse filling, medium to coarse gravel and on very low strength or better rock. Tests have been successfully completed to more than 60 m.

Types of CPTs

Douglas Partners (and its subsidiary GroundTest) owns and operates the following types of CPT cones:

Type	Measures
Standard	Basic parameters (q_c, f_s, i & z)
Piezocone	Dynamic pore pressure (u) plus basic parameters. Dissipation tests estimate consolidation parameters
Conductivity	Bulk soil electrical conductivity (σ) plus basic parameters
Seismic	Shear wave velocity (V_s), compression wave velocity (V_p), plus basic parameters

Strata Interpretation

The CPT parameters can be used to infer the Soil Behaviour Type (SBT), based on normalised values of cone resistance (Qt) and friction ratio (Fr). These are used in conjunction with soil classification charts, such as the one below (after Robertson 1990)

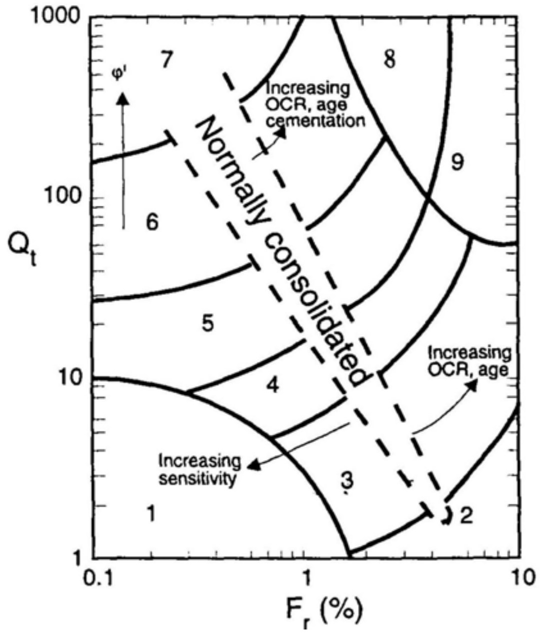


Figure 3: Soil Classification Chart

DP's in-house CPT software provides computer aided interpretation of soil strata, generating soil descriptions and strengths for each layer. The software can also produce plots of estimated soil parameters, including modulus, friction angle, relative density, shear strength and over consolidation ratio.

DP's CPT software helps our engineers quickly evaluate the critical soil layers and then focus on developing practical solutions for the client's project.

Engineering Applications

There are many uses for CPT data. The main applications are briefly introduced below:

Settlement

CPT provides a continuous profile of soil type and strength, providing an excellent basis for settlement analysis. Soil compressibility can be estimated from cone derived moduli, or known consolidation parameters for the critical layers (eg. from laboratory testing). Further, if pore pressure dissipation tests are undertaken using a piezocone, in-situ consolidation coefficients can be estimated to aid analysis.

Pile Capacity

The cone is, in effect, a small scale pile and, therefore, ideal for direct estimation of pile capacity. DP's in-house program ConePile can analyse most pile types and produces pile capacity versus depth plots. The analysis methods are based on proven static theory and empirical studies, taking account of scale effects, pile materials and method of installation. The results are expressed in limit state format, consistent with the Piling Code AS2159.

Dynamic or Earthquake Analysis

CPT and, in particular, Seismic CPT are suitable for dynamic foundation studies and earthquake response analyses, by profiling the low strain shear modulus G_0. Techniques have also been developed relating CPT results to the risk of soil liquefaction.

Other Applications

Other applications of CPT include ground improvement monitoring (testing before and after works), salinity and contaminant plume mapping (conductivity cone), preloading studies and verification of strength gain.

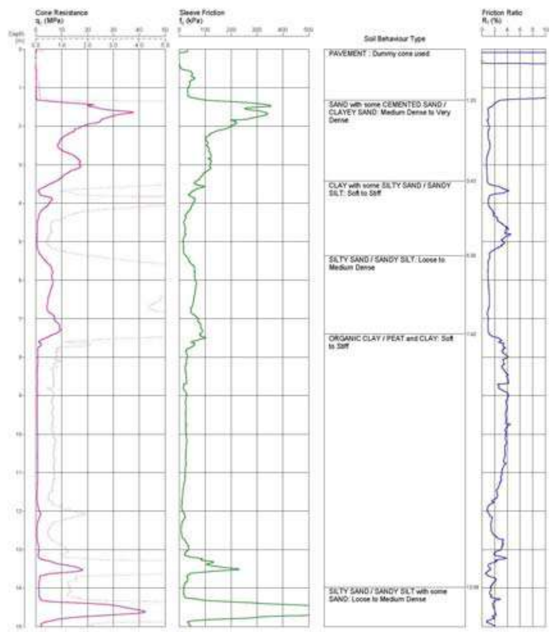


Figure 4: Sample Cone Plot

Soil Descriptions

Douglas Partners

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. 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	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

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

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with 'Mix of Soil and Cobbles/Boulders' with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

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
Friable	Fr	-

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	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

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;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) Non-cohesive and free-running.
- Moist (M) Soil feels cool, darkened in colour.

  Soil tends to stick together.

  Sand forms weak ball but breaks easily.
- Wet (W) Soil feels cool, darkened in colour.

  Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- 'Moist, dry of plastic limit' or 'w <PL' (i.e. hard and friable or powdery).
- 'Moist, near plastic limit' or 'w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- 'Moist, wet of plastic limit' or 'w >PL' (i.e. soils usually weakened and free water forms on the hands when handling).
- 'Wet' or 'w ≈LL' (i.e. near the liquid limit).
- 'Wet' or 'w >LL' (i.e. wet of the liquid limit).

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

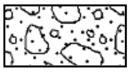
fg	fragmented
bnd	band
qtz	quartz

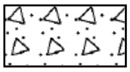
Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General

 Asphalt

 Road base

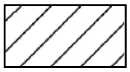
 Concrete

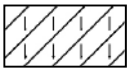
 Filling

Soils

 Topsoil

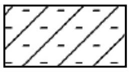
 Peat

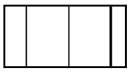
 Clay

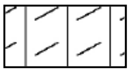
 Silty clay

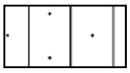
 Sandy clay

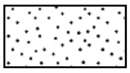
 Gravelly clay

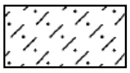
 Shaly clay

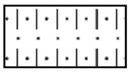
 Silt

 Clayey silt

 Sandy silt

 Sand

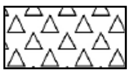
 Clayey sand

 Silty sand

 Gravel

 Sandy gravel

 Cobbles, boulders

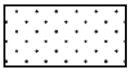
 Talus

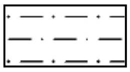
Sedimentary Rocks

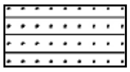
 Boulder conglomerate

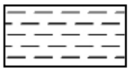
 Conglomerate

 Conglomeratic sandstone

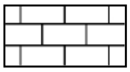
 Sandstone

 Siltstone

 Laminite

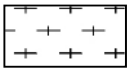
 Mudstone, claystone, shale

 Coal

 Limestone

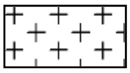
Metamorphic Rocks

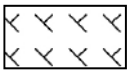
 Slate, phyllite, schist

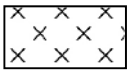
 Gneiss

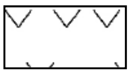
 Quartzite

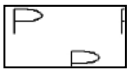
Igneous Rocks

 Granite

 Dolerite, basalt, andesite

 Dacite, epidote

 Tuff, breccia

 Porphyry

Test Location	Easting (m)	Northing (m)
1	406463	6473965
2A	406483	6473872
3	406403	6473637
4	406120	6473251
5	405343	6473459
6	405713	6473064
7	405590	6472813
8	405758	6472805
9	406393	6474041
10	406457	6473795
11	405541	6473078
12	406038	6473420
13	405523	6473542
14	405522	6473154
15	405898	6473062
16	405709	6472872
17	405721	6473142
18	405728	6472758
19	405519	6473149
Easting and Northing in MGA Zone 50		

Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT:	Linc Property Pty Ltd	**Location of Tests**	PROJECT No:	96584.01
OFFICE:	Perth	**Proposed Residential & Industrial Development**	DRAWING No:	1
DATE:	25 June 2019	**102 Great Northern Highway, Middle Swan, WA**	REVISION:	A

Appendix B

Results of Field Work

CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan, WA

REDUCED LEVEL: 5.9 m AHD

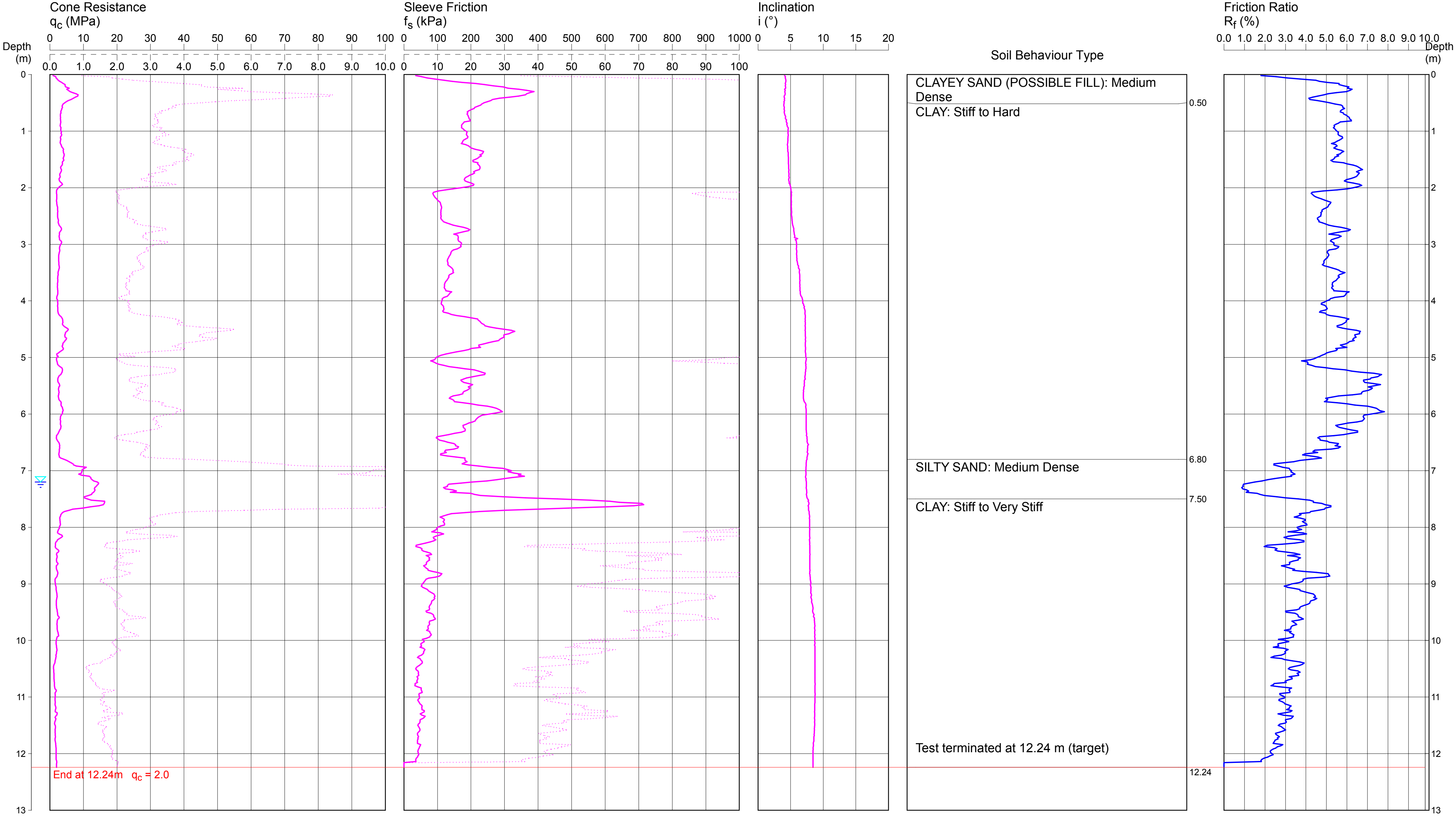
COORDINATES: 406463E 6473965N MGA Zone 50

CPT1

Page 1 of 1

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly availble LiDAR data.

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT1.CP5

Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

Water depth after test: 7.20m depth (measured)

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Geotechnics | Environment | Groundwater

CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

REDUCED LEVEL: 5.5 m AHD

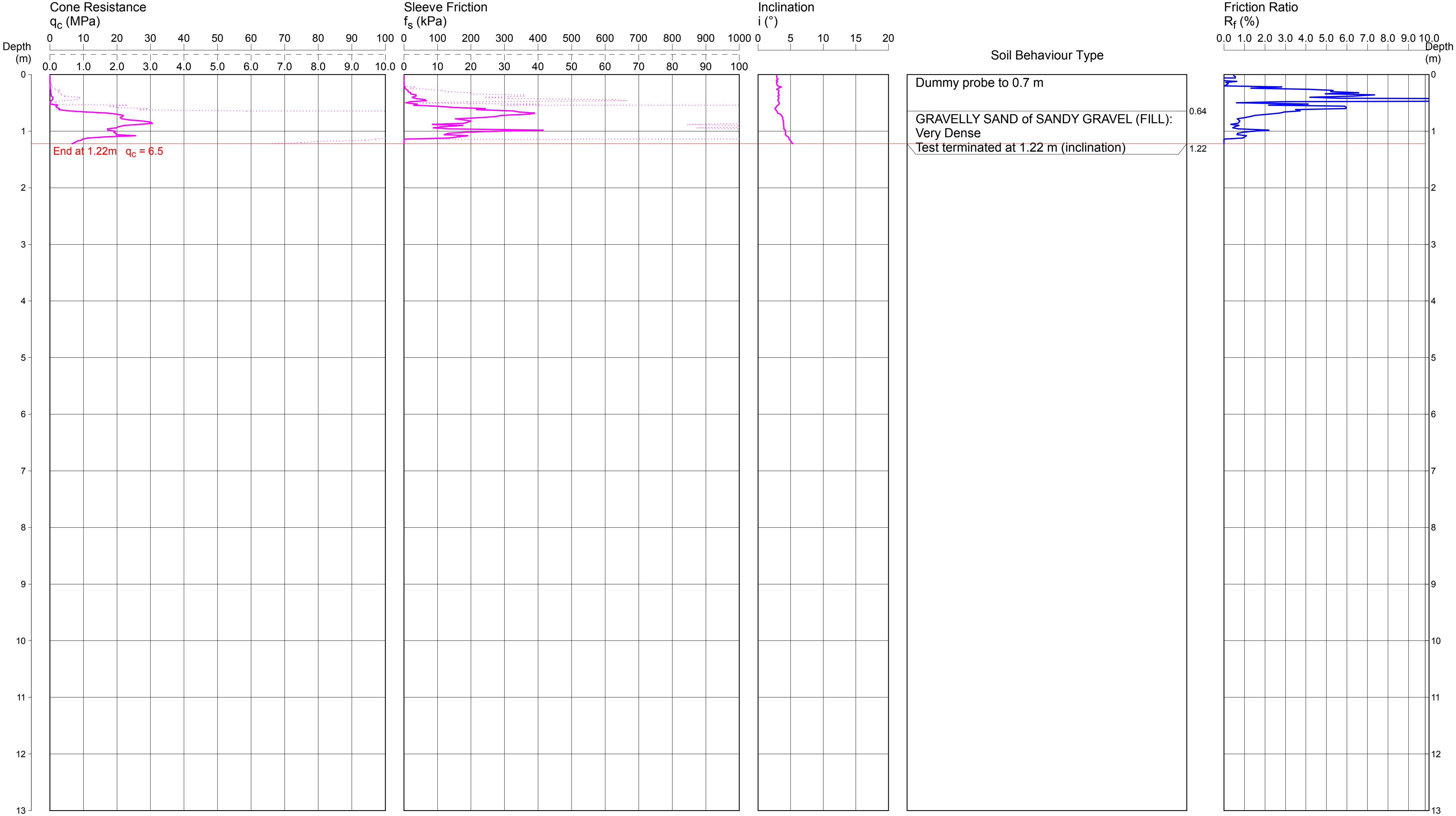
COORDINATES: 406483E 6473872N MGA Zone 50

CPT2A

Page 1 of 1

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels estimated from publicly available LiDAR data and site observations.

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT2A.CP5

Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

Douglas Partners
Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

REDUCED LEVEL: 5.8 m AHD

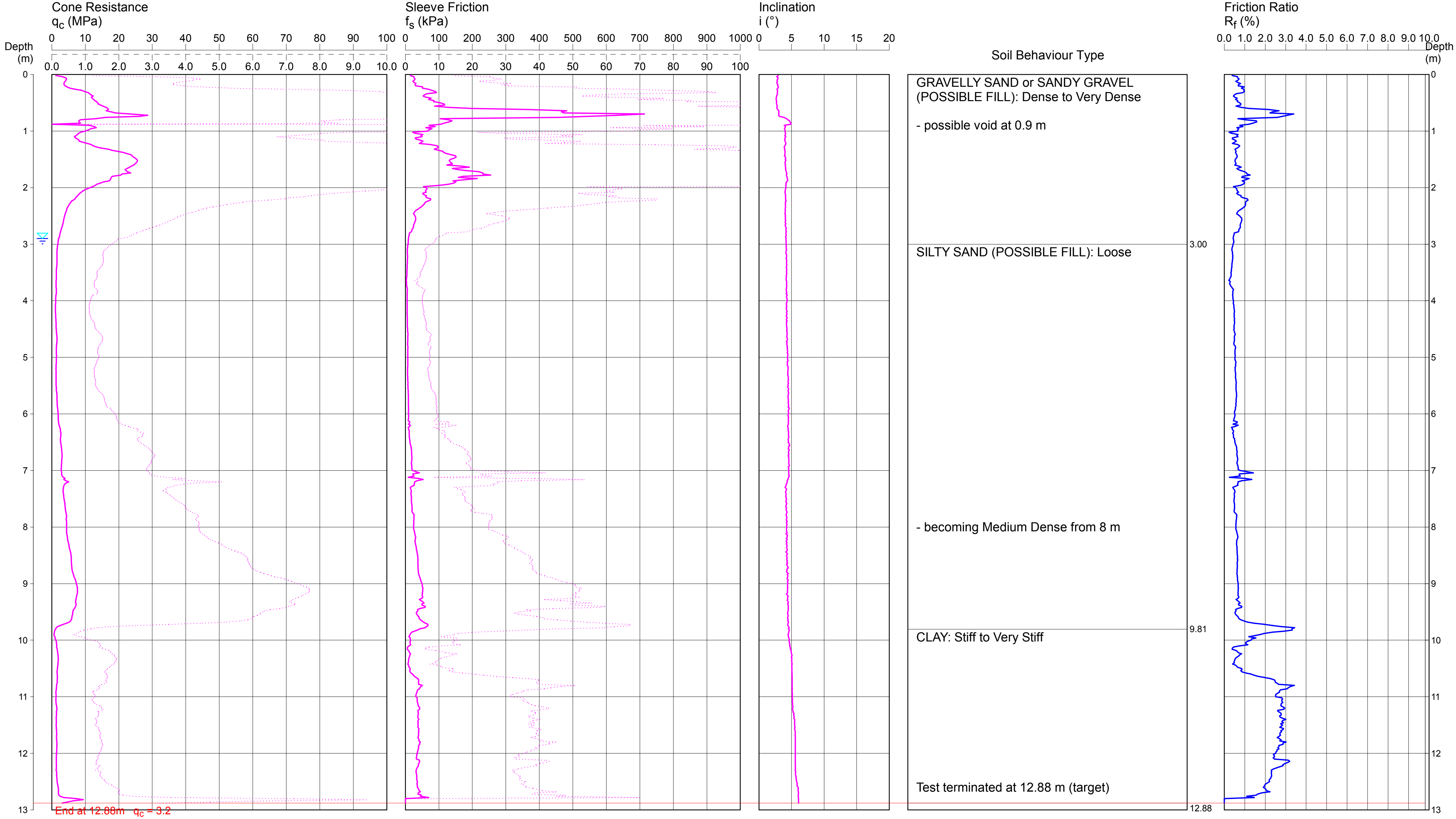
COORDINATES: 406403E 6473637N MGA Zone 50

CPT3

Page 1 of 1

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

Water depth after test: 2.90m depth (measured)

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT3.CP5
Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

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Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

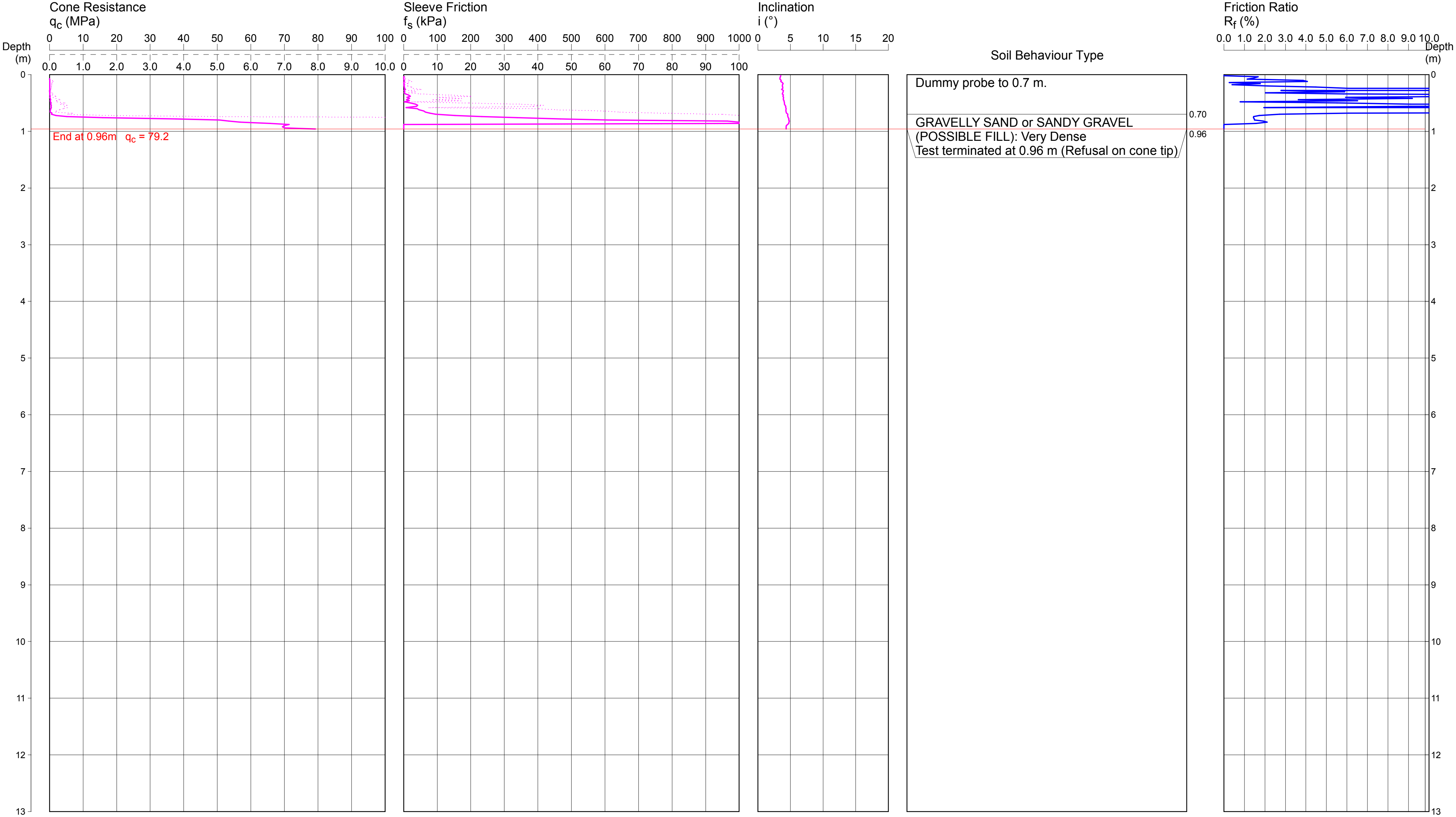
REDUCED LEVEL: 11.7 m AHD

COORDINATES: 406120E 6473251N MGA Zone 50

CPT4

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT4.CP5

Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

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Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

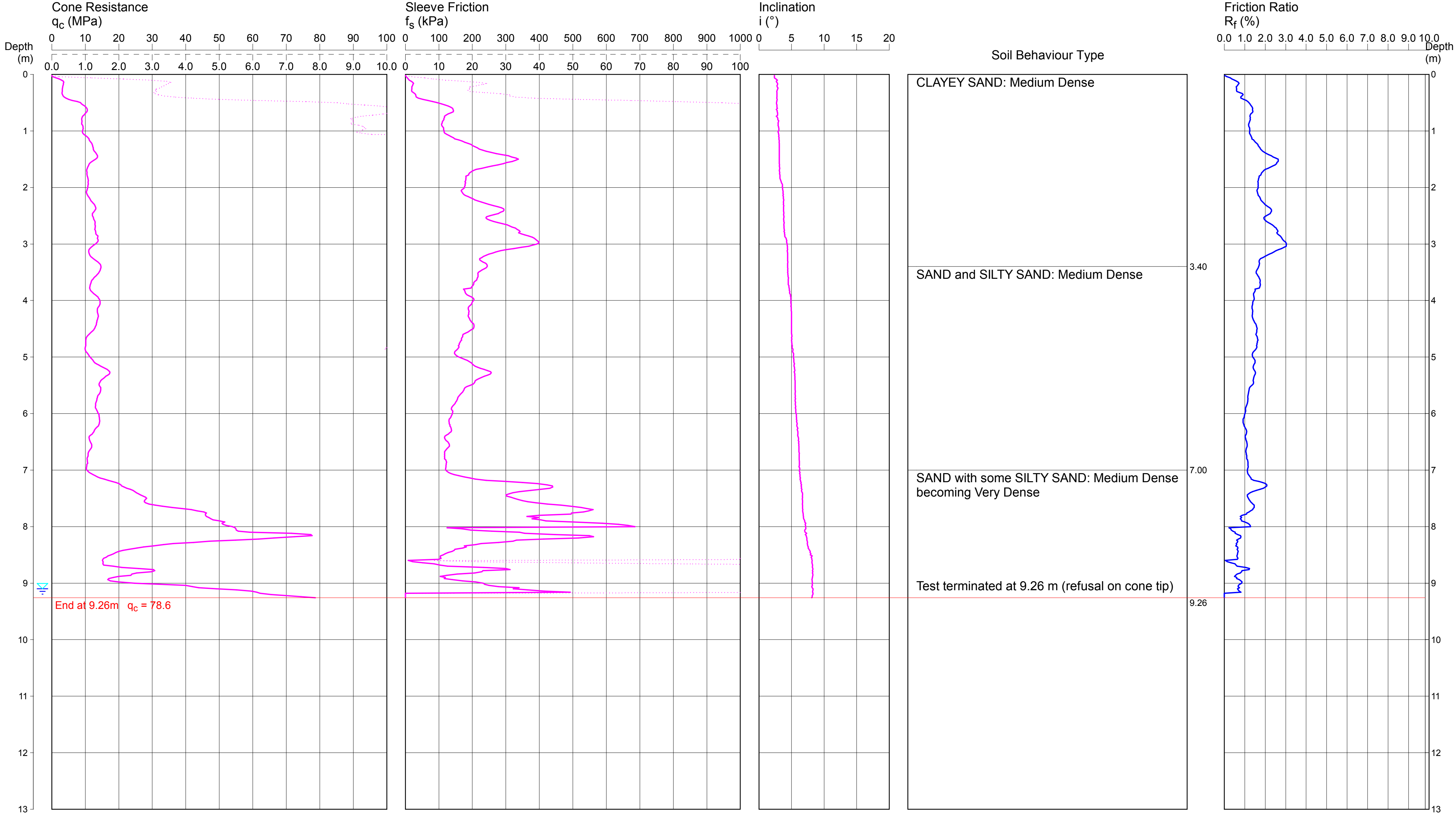
REDUCED LEVEL: 9.2 m AHD

COORDINATES: 405343E 6473459N MGA Zone 50

CPT5

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

Water depth after test: 9.10m depth (measured)

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT5.CP5
Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

Douglas Partners
Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

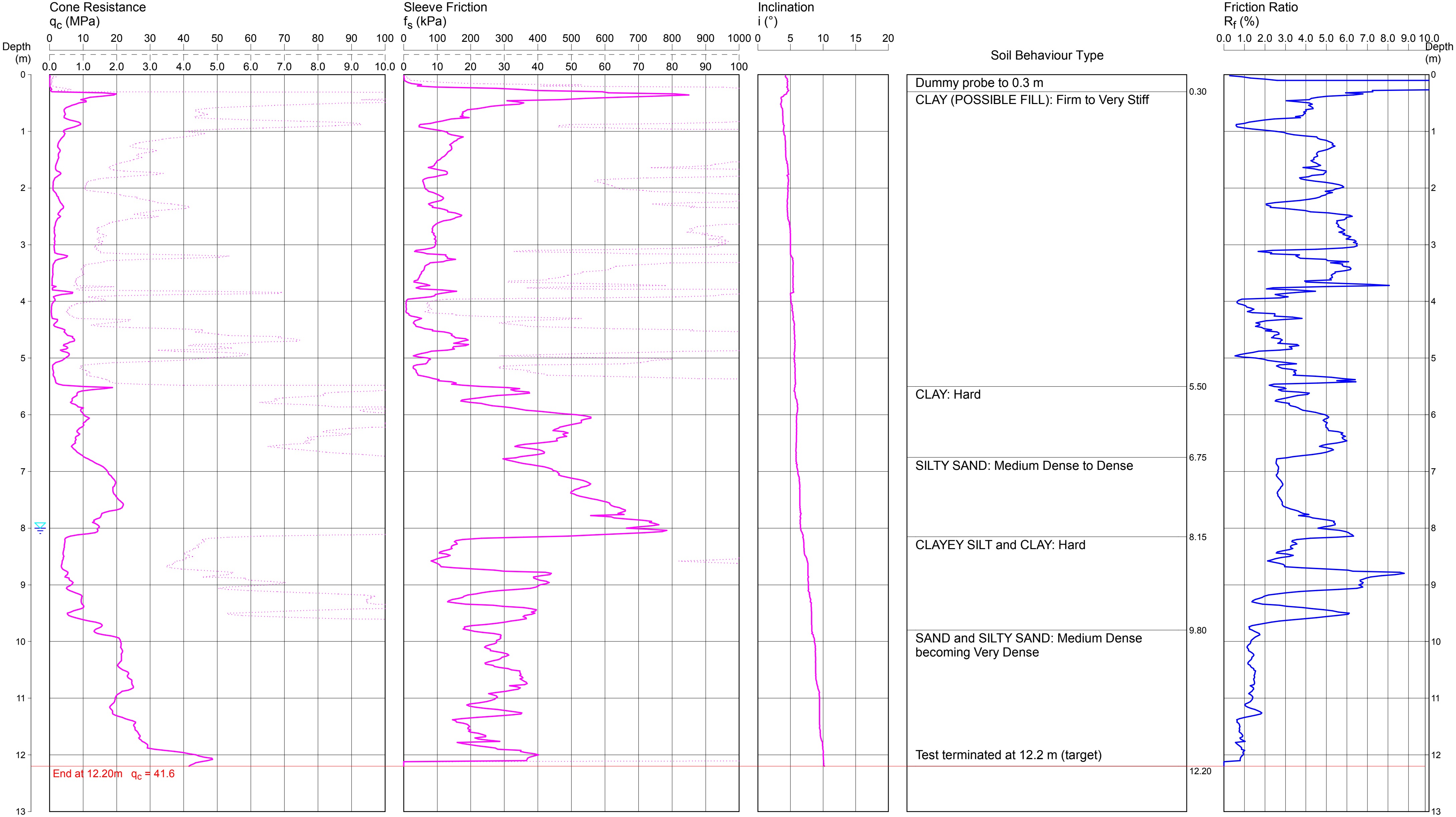
REDUCED LEVEL: 9.2 m AHD

COORDINATES: 405713E 405713N MGA Zone 50

CPT6

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

Water depth after test: 8.00m depth (measured)

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT6.CP5

Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

Douglas Partners
Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

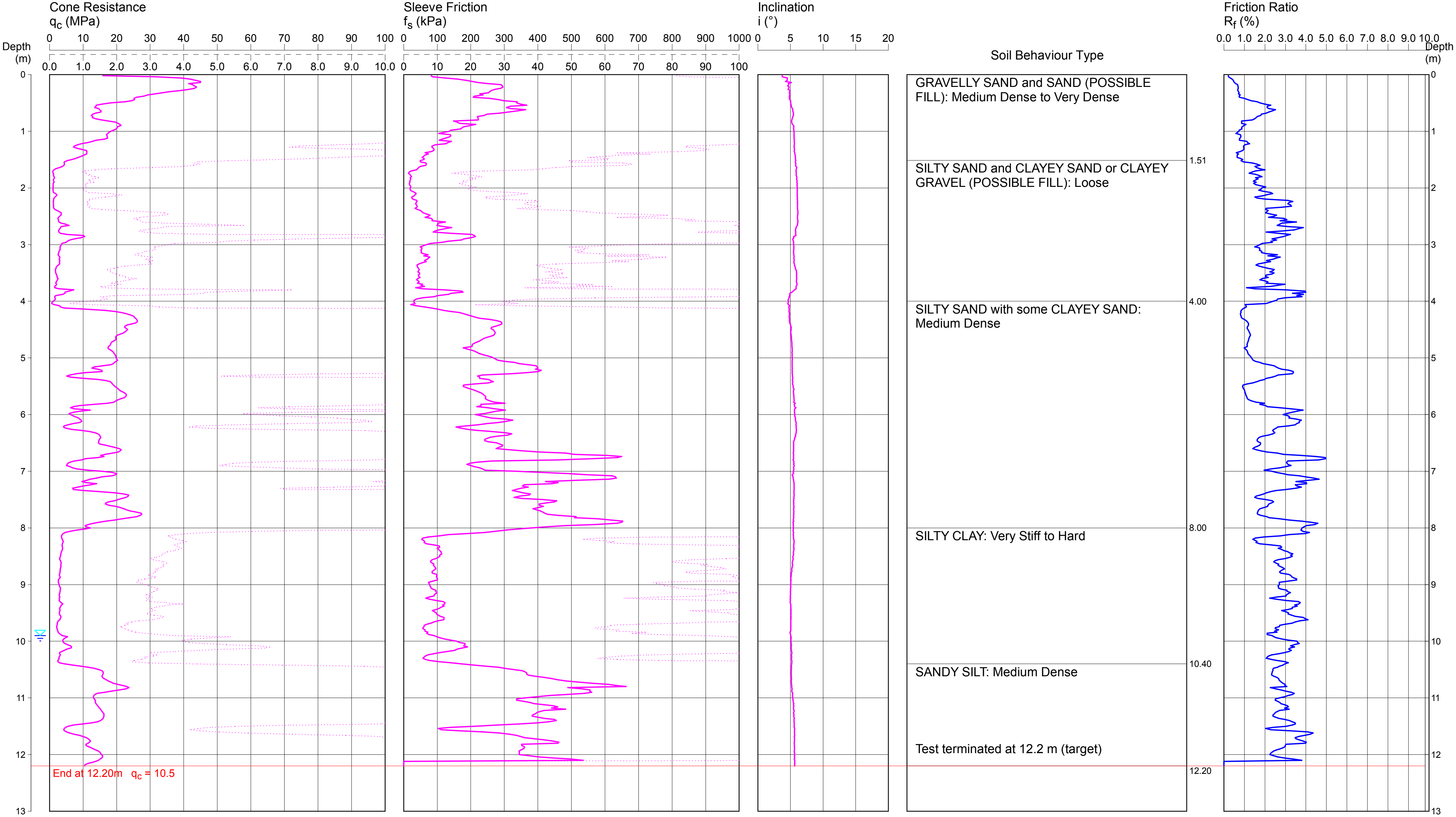
REDUCED LEVEL: 8.3

COORDINATES: 405590E 6472813N MGA Zone 50

CPT7

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT7.CP5
Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

Water depth after test: 9.90m depth (measured)

CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

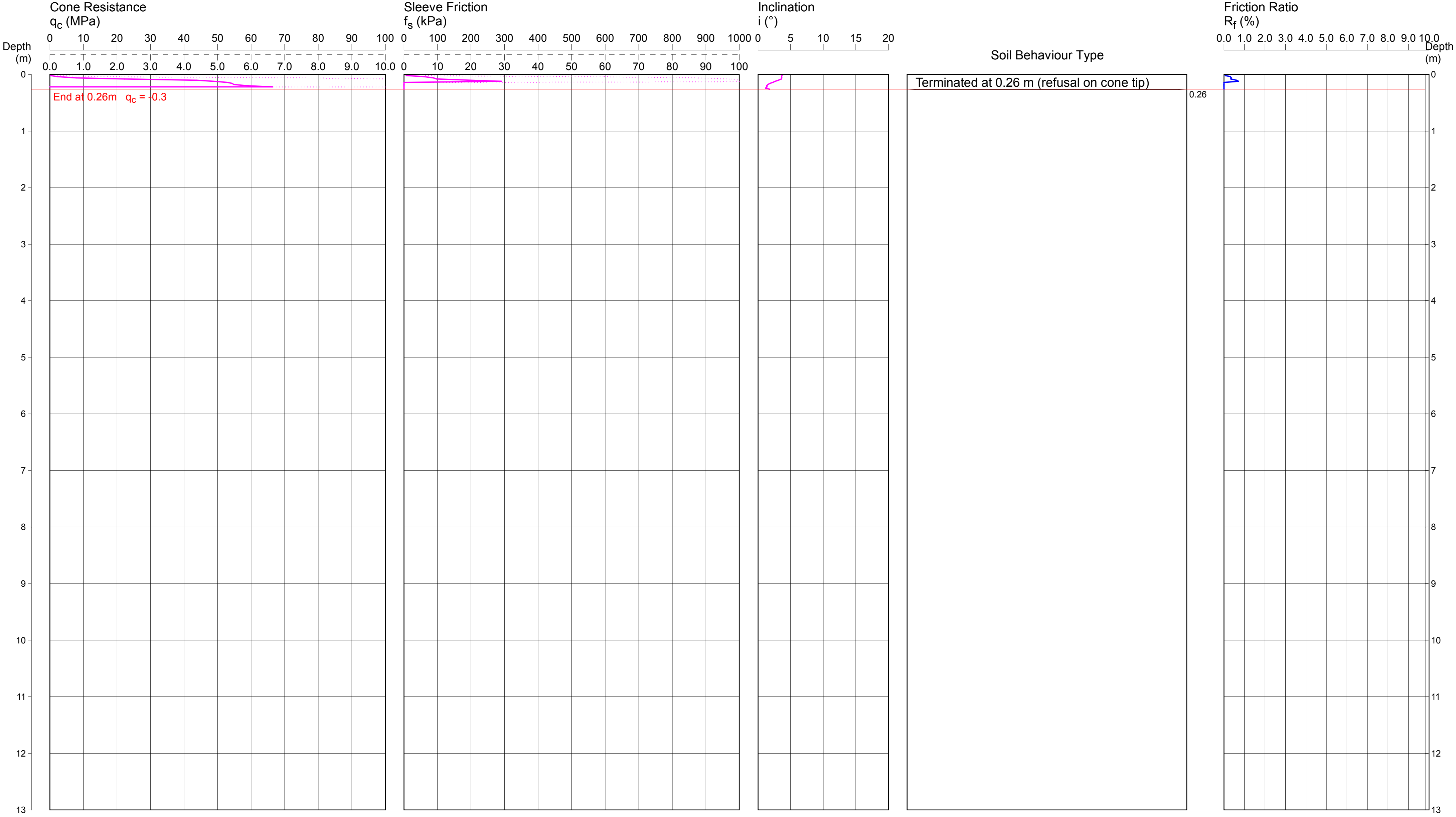
REDUCED LEVEL: 9.5 m AHD

COORDINATES: 405758E 6472805N MGA Zone 50

CPT8

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT8.CP5
Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

Douglas Partners
Geotechnics / Environment / Groundwater

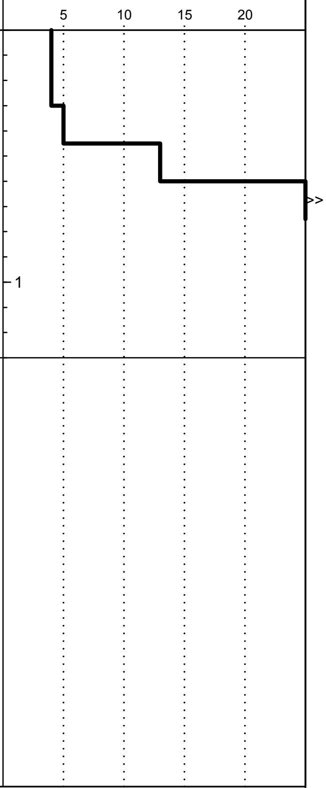
TEST PIT LOG

CLIENT: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 10.2 m AHD*
EASTING: 406393
NORTHING: 6474041

PIT No: 9
PROJECT No: 96584.01
DATE: 24/6/2019
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)
10		FILL (SANDY CLAY, CI) - stiff, brown sandy clay, trace gravel and brick fragments and full sized bricks, moist. Sand is fine grained. Gravel is angular, fine to medium sized quartz). - becoming hard from 0.45 m		B	0.6				
9	1	- with brick fragments from 0.8 m to 1.0 m - slow digging and dry from 1.0 m							
	1.3	Pit discontinued at 1.3m (slow digging)							
8	2								



RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 5.7 m AHD*
EASTING: 406457
NORTHING: 6473795

PIT No: 10
PROJECT No: 96584.01
DATE: 24/6/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		FILL (GRAVELLY CLAY, CI) - hard, red-brown gravelly clay with sand, moist. Sand is fine to medium grained. Gravel is fine to coarse brick fragments). - red-brown mottled white and with cobble sized brick fragments from 0.25 m			0.3		PP >600 kPa		>>
	0.55	FILL (SANDY CLAY, CI) - hard, brown mottled red-brown sandy clay, trace gravel and brick fragments, moist. Sand is fine to medium grained.		B	0.5		PP >600 kPa		
5					0.7		PP >600 kPa		
	1				0.9		PP >600 kPa		
	1.15	Pit discontinued at 1.15m (slow digging)			1.1		PP >600 kPa		
4	2								
3									

RIG: 5 tonne excavator with 450 mm wide toothed bucket **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan
SURFACE LEVEL: 11.0 m AHD*
EASTING: 405541
NORTHING: 6473078
PIT No: 11
PROJECT No: 96584.01
DATE: 24/6/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
11		FILL (BRICK and GRAVELLY SAND, SP-SM) - bricks and red-brown mottled brown, fine to coarse grained gravelly sand, dry. Gravelly sand is crushed brick. Plastic and fabric observed.							>>
	0.55	FILL (SANDY GRAVEL, GP-GM) - yellow-brown, fine to coarse sized sandy gravel, dry. Gravel is lateritic.							
10	0.75	CLAYEY SAND (CS) - hard/very dense, orange-brown mottled red-brown and grey, fine to medium grained clayey sand, dry. Hard digging.		B	1.0				
	1.1	SAND (SP-SC) - estimated dense, orange-brown, fine to medium grained sand with clay, dry.							
9	1.5	Pit discontinued at 1.5m (slow digging)							

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 11.5 m AHD*
EASTING: 406038
NORTHING: 6473420

PIT No: 12
PROJECT No: 96584.01
DATE: 24/6/2019
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) 5 10 15 20
	0.15	FILL (SANDY GRAVEL, GS) - very dense, grey-brown, fine to coarse sized sandy gravel with cobbles, moist. Gravel and cobbles are concrete. Possible demolition debris.							>>
11	1	Pit discontinued at 0.15m (refusal on concrete)							
10	2								
9									

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 5.7 m AHD*
EASTING: 405523
NORTHING: 6473542

PIT No: 13
PROJECT No: 96584.01
DATE: 24/6/2019
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) 5 10 15 20
	0.05	FILL (TOPSOIL, SM) - dark brown, fine to medium grained silty sand, with organics, moist.							
	0.2	FILL (SANDY GRAVEL, GS) - very dense, red-brown, fine to coarse sized gravel, trace cobbles, moist. Gravel and cobbles are brick fragments.							>>
	0.25	FILL (GRAVELLY SAND, SP-SM) - pale brown, fine to coarse grained gravelly sand, moist. Gravel is fine to medium sized brick fragments.							
5	0.4	FILL (GRAVELLY CLAY, CI) - red-brown gravelly clay, moist. Gravel is fine to coarse sized ferricrete and brick fragments.							
	0.45	FILL (SANDY GRAVEL, GM) - grey, fine to coarse sandy gravel, moist. Crushed rock roadbase.							
4	1.6	FILL (BRICKS and SANDY GRAVEL, GS) - brick cobbles and fine to coarse sandy gravel (crushed bricks), dry. Occasional pieces of plastic, rubber, wood and wire observed.							
3		Pit discontinued at 1.6m (bricks collapsing)							

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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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TEST PIT LOG

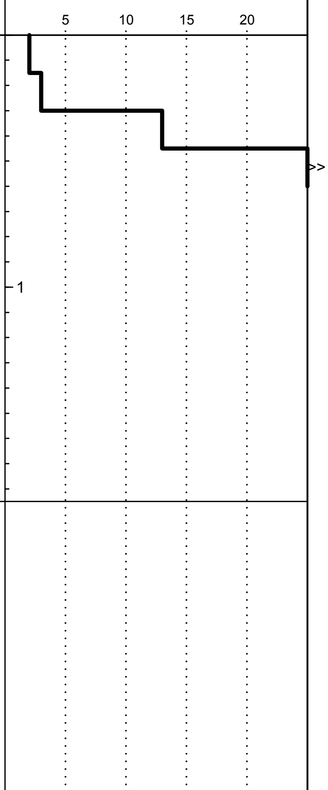
CLIENT: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 11.8 m AHD*
EASTING: 405522
NORTHING: 6473154

PIT No: 14
PROJECT No: 96584.01
DATE: 24/6/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		FILL (CLAYEY SAND, CS) - very stiff becoming hard, red-brown and brown, fine to medium grained clayey sand, with pockets of silty sand, moist. Concrete boulder and fabric observed.						
11	0.75	CLAY (CL) - red clay with sand, dry, low plasticity. Hard digging. - tree root approx. 5 cm diamter at 1 m deep.		B	1.2			
10	1.85	Pit discontinued at 1.85m (slow digging)						
9								

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 11.2 m AHD*
EASTING: 405898
NORTHING: 6473062

PIT No: 15
PROJECT No: 96584.01
DATE: 24/6/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
11		FILL (SANDY GRAVEL, GS) - very dense, red-brown, fine to coarse sized gravel, trace cobbles and boulders, moist. Gravel and cobbles are ferricrete.		B	0.4				>>
10	0.45	FILL (SANDY CLAY, CI) - stiff, brown sandy clay, trace gravel and brick fragments and full sized bricks, moist. Sand is fine grained. Gravel is angular, fine to medium sized quartz). Hard digging. - increasing sand content from 0.9 m deep		D	0.8				
9	1.6	FILL (CLAYEY GRAVELLY SAND, SC) - estimated dense, red-brown mottled light brown clayey gravelly sand, dry to moist. Gravel is fine to coarse sized brick fragments. - carpet, wood and fabric pieces from 1.8 m deep - trace brick fragments and with ferricrete cobbles and occasionale boulders from 2.2 m		B	2.5				
	2.5	Pit discontinued at 2.5m (maximum excavator reach)							

RIG: 5 tonne excavator with 450 mm wide toothed bucket **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 8.3 m AHD*
EASTING: 405709
NORTHING: 6472872

PIT No: 16
PROJECT No: 96584.01
DATE: 24/6/2019
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)
		FILL (SANDY GRAVEL, GS) - very dense, red-brown, fine to coarse sized gravel, trace cobbles, moist. Gravel and cobbles are brick fragments.							
8	0.3	FILL (SAND, SP-SM) - blue-grey, fine to coarse grained sand with silt, moist.							
	0.4								
	0.6	FILL (SANDY CLAYEY GRAVEL, GC) - very dense, orange-brown, fine to coarse sized sandy clayey gravel, moist. Gravel is ferricrete. Sand is fine to coarse grained.							
	1	FILL (BRICKS and SAND, SP-SC) - estimated dense, brown, fine to medium grained sand with clay and bricks, moist.							
	1.2	FILL (CLAYEY GRAVEL, GC) - blue-grey, fine to medium sized clayey gravel, moist to wet. Gravel is subangular crushed granite aggregate.							
7	1.35								
	1.6	FILL (BRICKS and SAND, SP-SC) - estimated dense, brown, fine to medium grained sand with clay and bricks, moist.							
	2	FILL (GRAVELLY SANDY CLAY, CI) - grey-brown gravelly sandy clay, moist. Sand is fine to coarse grained. Gravel is fine to medium sized. - mottled red-brown and with brick fragments up to cobble size, moist to wet from 2.0 m							
6				B	2.5				
	2.6	Pit discontinued at 2.6m (maximum excavator reach)							

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 6.0 m AHD*
EASTING: 405721
NORTHING: 6473142

PIT No: 17
PROJECT No: 96584.01
DATE: 24/6/2019
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 mm) 5 10 15 20
6		FILL (SANDY GRAVEL, GP-SM) - grey-brown, fine to coarse sandy gravel, moist. Gravel is brick fragments, ferricrete and granitic. Plastic tape observed.							
	0.4	Pit discontinued at 0.4m (target depth)							
5	1								
4	2								

RIG: 5 tonne excavator with 450 mm wide toothed bucket **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 11.0 m AHD*
EASTING: 405728
NORTHING: 6472758

PIT No: 18
PROJECT No: 96584.01
DATE: 24/6/2019
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 mm) 5 10 15 20
11		FILL (SANDY CLAY, CI) - brown sandy clay with gravel, brick fragments and bricks, moist. Sand is fine to medium grained.							
	0.4	Pit discontinued at 0.4m (target depth)							
10	1								
9	2								

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 13.2 m AHD*
EASTING: 405519
NORTHING: 6473149

PIT No: 19
PROJECT No: 96584.01
DATE: 24/6/2019
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 mm) 5 10 15 20
13	0.2	FILL (CLAY, CI) - grey clay with sand, trace gravel, moist to wet.							
	0.5	FILL (SANDY CLAY, CL) - red-brown sandy clay, trace gravel, moist, low plasticity. Sand is fine grained.							
12	1	Pit discontinued at 0.5m (target depth)							
11	2								

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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
Existing Stormwater System Plates

PLATES

PLATE 1: Southern sedimentation storage area, main storage

PLATE 2: Southern sedimentation storage area, forebay

PLATE 3: Additional southern storage area downstream of Southern Sedimentation Storagea

PLATE 4: Existing open drain from southern storage areas to southern outlet

PLATE 5 : Southern outlet in concrete tomb at end of open drain

PLATE 6: 400 mm dia southern outlet

PLATE 7: Culvert under Muriel St at low point (approx. opposite vehicle location).
Blackadder Creek Tributary is piped under development area immediately downstream of Muriel St.

PLATE 8: 900 mm dia pipe under Muriel St. Invert of pipe is several metres below road level.

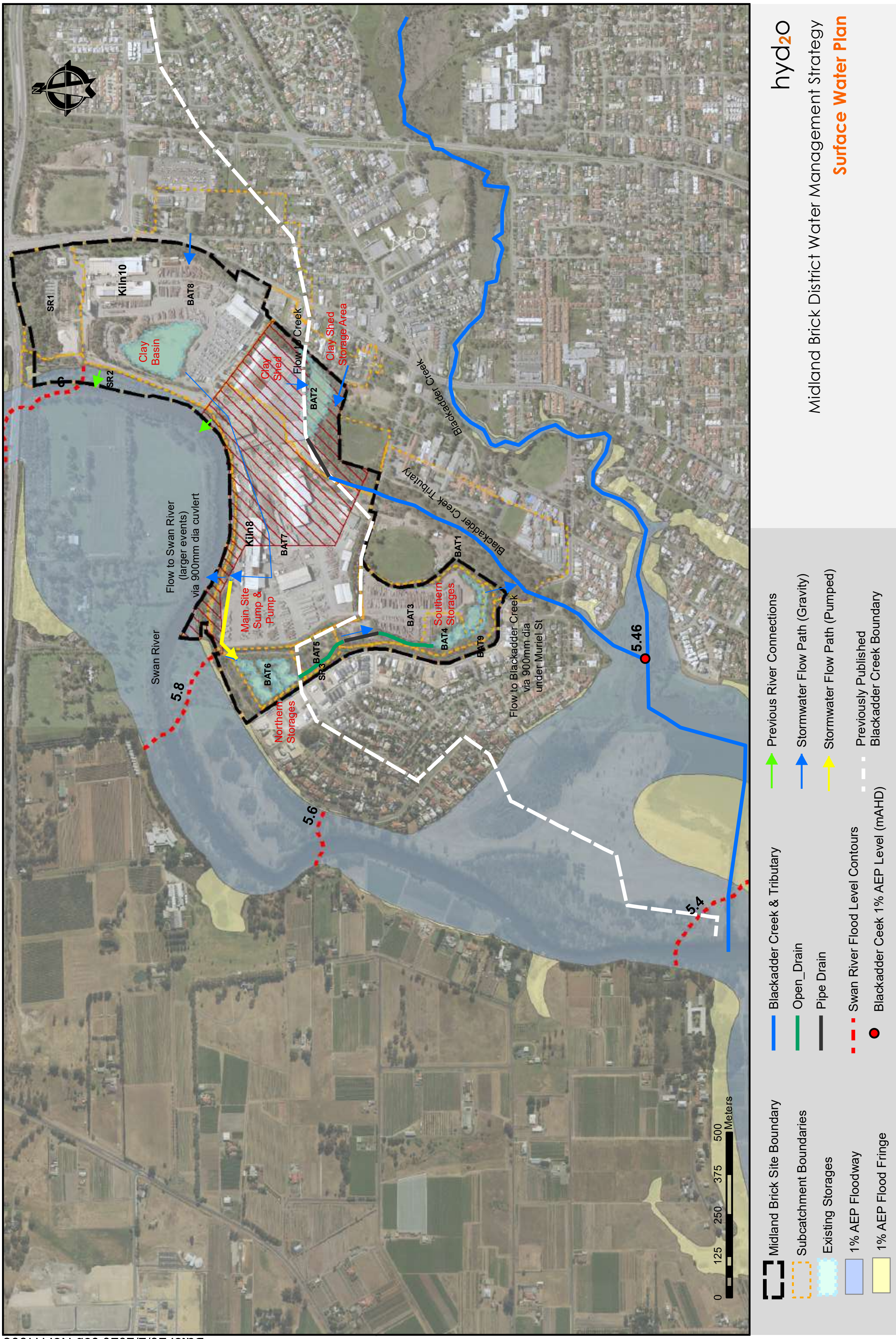
PLATE 9: Recently upgraded Clay Basin storage area in Midland Brick following construction

PLATE 10: Recently upgraded Clay Basin storage area commences filling following construction

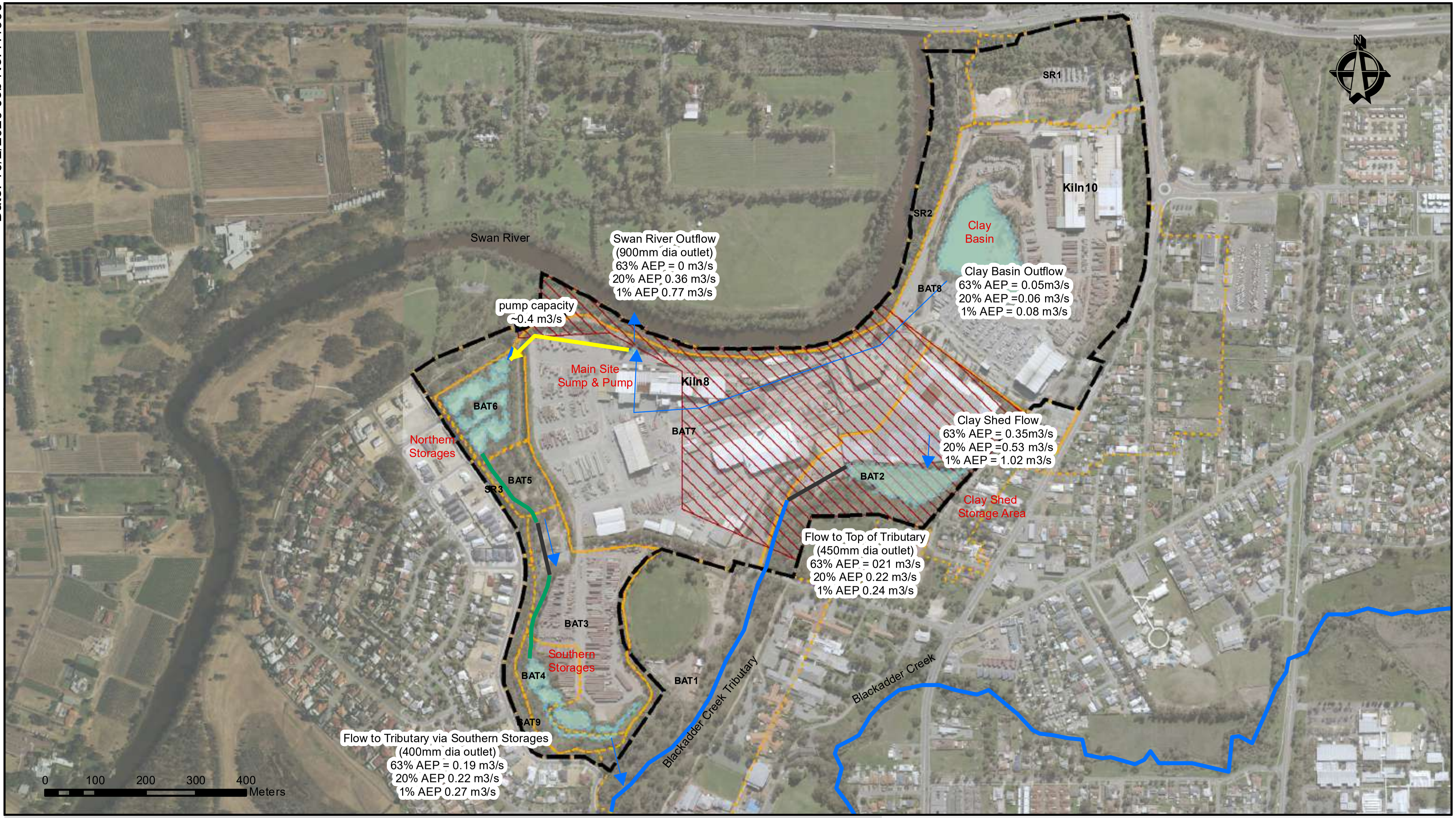
PLATE 11 : Existing site outlet to Blackadder Creek Tributary

APPENDIX D
Existing System Stormwater Modelling Extracts
(Hyd2o 2020a, 2020b, 2020c, 2020d)

DWMS EXISTING SYSTEM & FLOODPLAIN MAPPING



Date: 26/2/2020 Job No. H19054



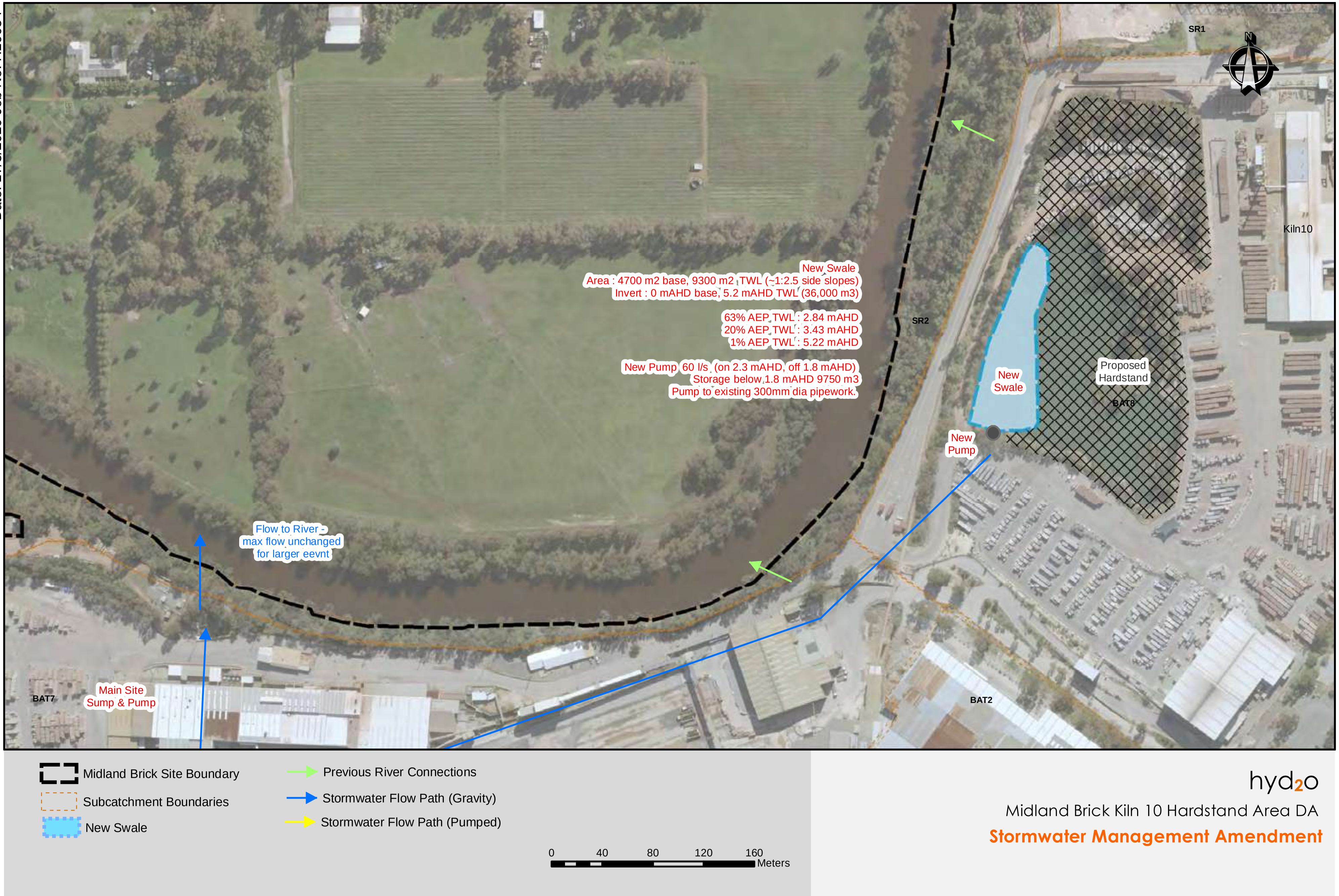
hyd2o

Midland Brick District Water Management Strategy

Stormwater Event Modelling of Existing System Flows

Date: 10/2/2020 Job No. H19054

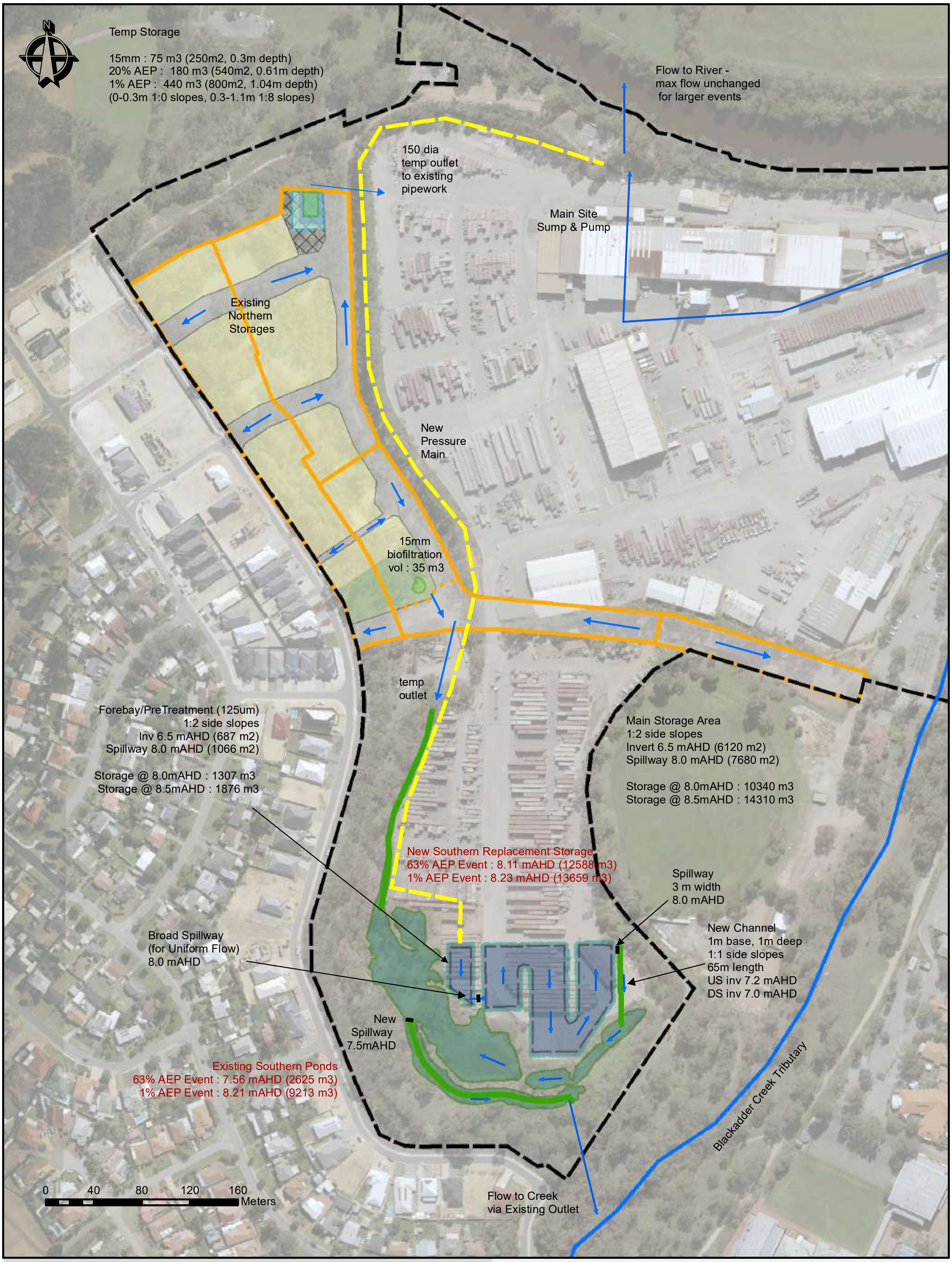
CLAY BASIN NEW STORAGE MODELLING



Date: 17/3/2020 Job No. H19054

NEW SOUTHERN STORAGE MODELLING

Date: 27/5/2020 Job No. H19054



Site

Temp Storage

63% AEP

20% AEP

1% AEP

Lots

POS

Road

Existing Southern Ponds (area @ 8mAHD)

Replacement Southern Storage (area @ 8mAHD)

Open Drain/Swale

New Pressure Main

Subcatchments

hyd2o

Midland Brick Southern Replacement Storage Design

Stage 1 & Southern Storage Design

MASONRY PLANT NEW STORAGE MODELLING

Date: 12/5/2020 Job No. H19054

APPENDIX E
Predevelopment Site Monitoring Data

Date: 01/09/2021 Job No. H21087

Midland Brick Site

Groundwater Monitoring Bores

Surface Water Monitoring Locations

hyd2o

Watermark Area 3 Local Water Management Strategy

Groundwater and Surface Water Monitoring Locations

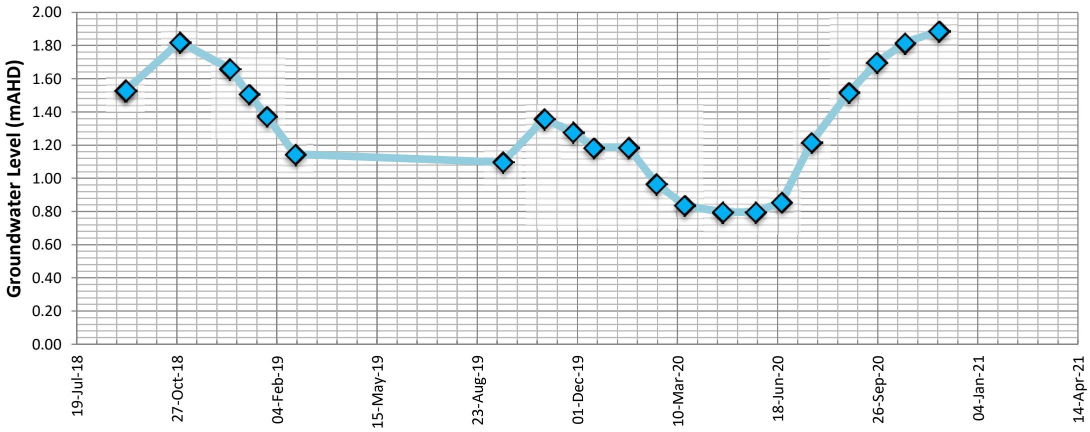
Appendix E

H21087 Watermark Area 3

EMW03 Groundwater Bore 3
Oval Storage Area East Bore

Data Analysis Period Start Date	01-01-04	Easting	405530	Natural Surface (mAHD)	10.82
Data Analysis Period End Date	31-12-20	Northing	6473108	Top of Casing (m AHD)	11.34
				End of Hole (mAHD)	-2.88

Report Date : 01-09-21



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
05-09-18	9.81	1.53	9.29
06-09-18	9.81	1.53	9.29
30-10-18	9.52	1.82	9.00
19-12-18	9.68	1.66	9.16
07-01-19	9.83	1.51	9.31
25-01-19	9.96	1.38	9.45
22-02-19	10.19	1.15	9.67
18-09-19	10.24	1.10	9.72
29-10-19	9.98	1.36	9.46
27-11-19	10.06	1.28	9.54
17-12-19	10.15	1.19	9.63
21-01-20	10.15	1.19	9.63
18-02-20	10.37	0.97	9.85
17-03-20	10.50	0.84	9.98
24-04-20	10.54	0.80	10.02
27-05-20	10.54	0.80	10.02
22-06-20	10.48	0.86	9.96
22-07-20	10.12	1.22	9.60
28-08-20	9.82	1.52	9.30
25-09-20	9.64	1.70	9.12
23-10-20	9.52	1.82	9.00
26-11-20	9.45	1.89	8.93

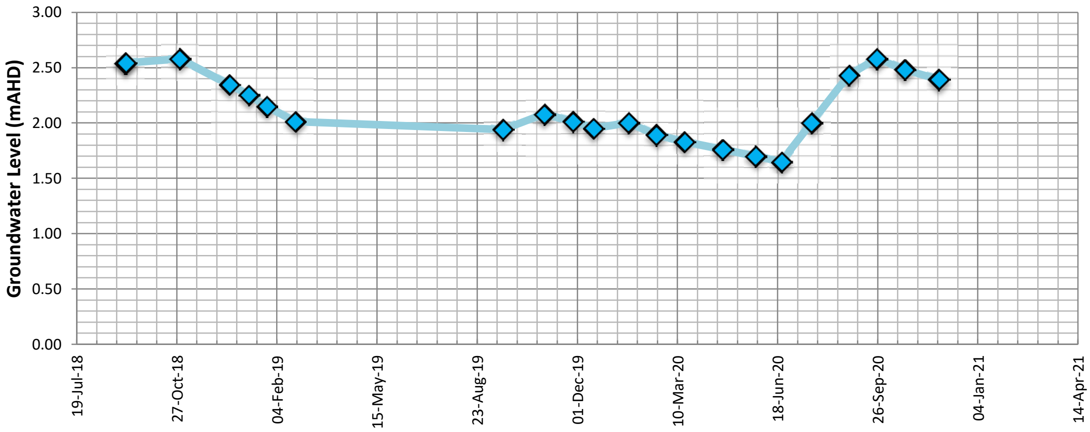
Minimum Recorded Level (mAHD)	0.797
Maximum Recorded Level (mAHD)	1.887

H21087 Watermark Area 3

EMW04 Groundwater Bore 4
Oval Storage Area South Bore

				Natural Surface (mAHD)	9.29
Data Analysis Period Start Date	01-01-04	Easting	405712	Top of Casing (m AHD)	9.75
Data Analysis Period End Date	31-12-20	Northing	6472730	End of Hole (mAHD)	0.49

Report Date : 01-09-21



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
05-09-18	7.21	2.54	6.75
06-09-18	7.21	2.54	6.75
30-10-18	7.17	2.58	6.71
19-12-18	7.41	2.35	6.94
07-01-19	7.50	2.25	7.04
25-01-19	7.60	2.15	7.14
22-02-19	7.74	2.01	7.28
18-09-19	7.81	1.94	7.35
29-10-19	7.67	2.08	7.21
27-11-19	7.74	2.01	7.28
17-12-19	7.80	1.95	7.34
21-01-20	7.75	2.00	7.29
18-02-20	7.86	1.89	7.40
17-03-20	7.92	1.83	7.46
24-04-20	7.99	1.76	7.53
27-05-20	8.05	1.70	7.59
22-06-20	8.10	1.65	7.64
22-07-20	7.75	2.00	7.29
28-08-20	7.32	2.43	6.86
25-09-20	7.17	2.58	6.71
23-10-20	7.27	2.48	6.81
26-11-20	7.36	2.39	6.90

Minimum Recorded Level (mAHD)	1.651
Maximum Recorded Level (mAHD)	2.581

H21087 Watermark Area 3

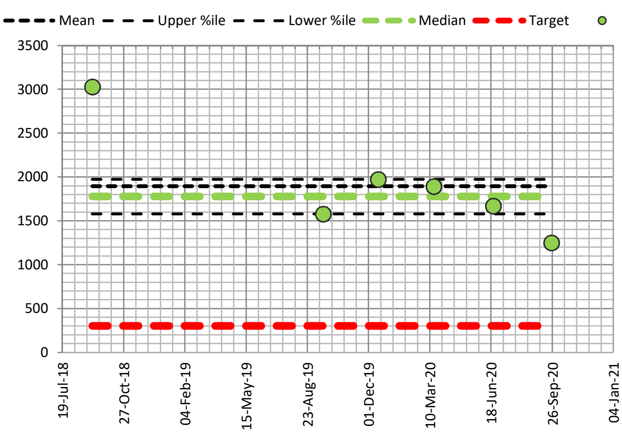
EMW03 Groundwater Bore 3
Oval Storage Area East Bore

Easting	405530	Data Analysis Period Start Date	01-01-04
Northing	6473108	Data Analysis Period End Date	31-12-20

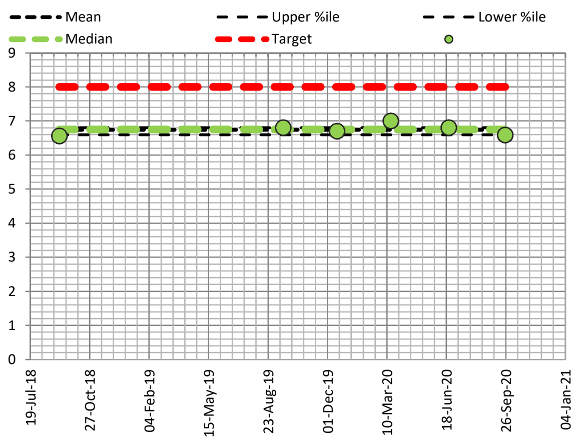
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	22	9.45	9.70	10.02	**10.02**	10.34	10.54		0
GWL mAHD	Groundwater Level	mAHD	22	0.80	0.99	1.32	**1.32**	1.63	1.89		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	6	20.40	21.60	22.68	**21.95**	22.90	27.30		0
EC	Electrical Conductivity	uS/cm	6	1247.00	1576.00	1896.17	**1777.50**	1972.00	3027.00	300.00	6
DO	Dissolved Oxygen	mg/L	2	2.04	2.12	2.25	**2.25**	2.38	2.46		0
DO %	Dissolved Oxygen	%	6	14.20	17.90	28.19	**25.97**	36.00	49.10	80.00	0
pH	pH	pH	6	6.56	6.59	6.74	**6.75**	6.80	7.00	8.00	0
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	6	0.10	0.40	1.20	**0.75**	1.20	4.00	1.20	1
TKN	Total Kjeldahl Nitrogen	mg/L	3	0.10	0.22	0.33	**0.40**	0.46	0.50		0
NH3-N	Ammonia as N	mg/L	6	0.01	0.01	0.03	**0.02**	0.04	0.11	1.43	0
NO_3-N	Nitrate as N	mg/L	6	0.01	0.01	0.01	**0.01**	0.01	0.05	3.40	0
NO_2-N	Nitrite as N	mg/L	6	0.01	0.01	0.01	**0.01**	0.01	0.01		0
TP	Total Phosphorous	mg/L	6	0.35	0.42	0.60	**0.53**	0.68	1.10	0.07	6
FRP	Filterable Reactive Phosphorous	mg/L	6	0.05	0.08	0.15	**0.09**	0.20	0.37	0.04	6
As	Arsenic	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.09400	0
Cd	Cadmium	mg/L	6	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010	0.00040	0
Cr	Chromium	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		0
Cu	Copper	mg/L	6	0.00100	0.00100	0.00133	**0.00100**	0.00100	0.00300	0.00180	1
Pb	Lead	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.00560	0
Ni	Nickel	mg/L	6	0.00100	0.00100	0.00267	**0.00150**	0.00500	0.00600	0.01300	0
Zn	Zinc	mg/L	6	0.00200	0.00200	0.00483	**0.00200**	0.00300	0.01800	0.01500	1
Hg	Mercury	mg/L	6	0.00005	0.00005	0.00006	**0.00005**	0.00005	0.00010	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0
Nox as N	Nox as N	mg/L	1	0.01	0.00500	0.01	**0.01**	0.00500	0.01		0

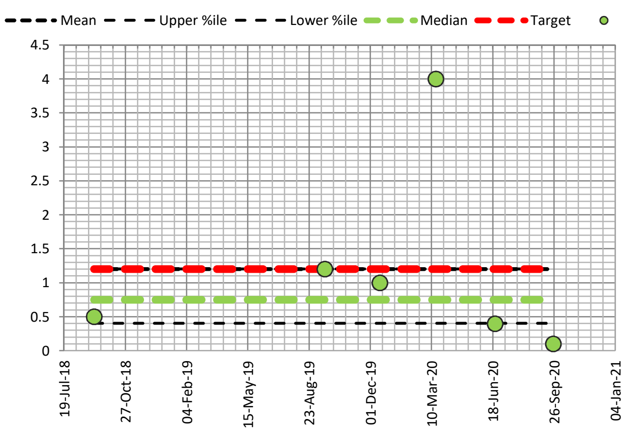
Electrical Conductivity



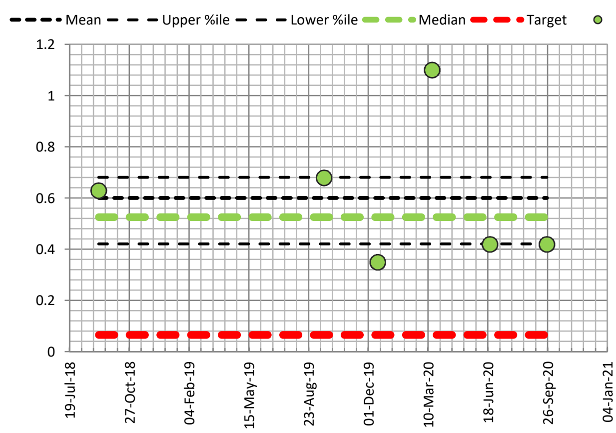
pH



Total Nitrogen



Total Phosphorous



FieldDAE
Field Data Analysis & Evaluation System

H21087 Watermark Area 3

EMW04 Groundwater Bore 4
Oval Storage Area South Bore

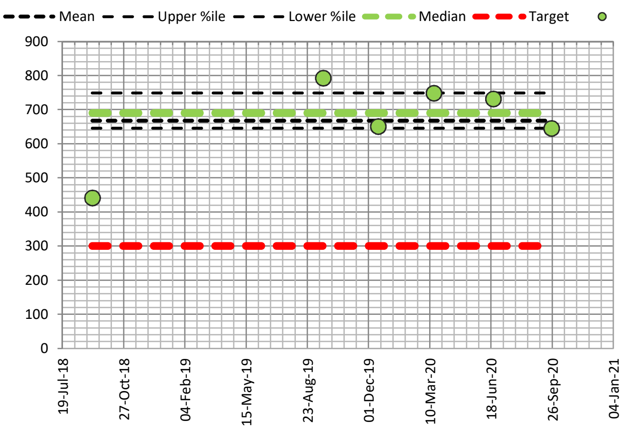
Easting	405712	Data Analysis Period Start Date	01-01-04
Northing	6472730	Data Analysis Period End Date	31-12-20

hyd2o HYDROLOGY

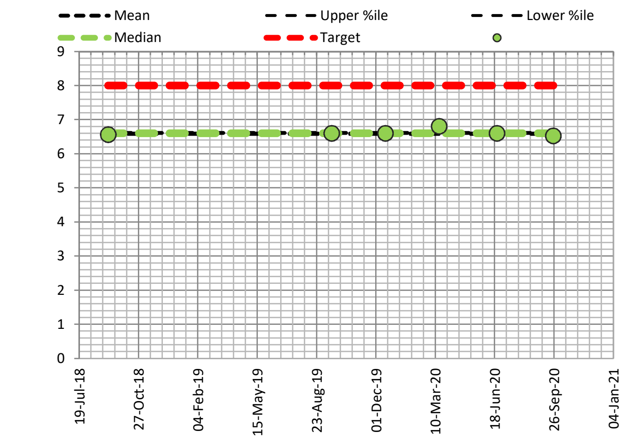
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	22	7.17	7.28	7.61	**7.70**	7.85	8.10		0
GWL mAHD	Groundwater Level	mAHD	22	1.65	1.90	2.14	**2.05**	2.47	2.58		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	6	20.60	20.60	22.17	**21.00**	23.30	26.50		0
EC	Electrical Conductivity	uS/cm	6	441.00	645.00	667.83	**690.50**	748.00	792.00	300.00	6
DO	Dissolved Oxygen	mg/L	2	2.32	2.41	2.55	**2.55**	2.69	2.78		0
DO %	Dissolved Oxygen	%	6	8.50	17.50	20.46	**19.25**	26.30	31.96	80.00	0
pH	pH	pH	6	6.52	6.56	6.61	**6.60**	6.60	6.80	8.00	0
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	6	0.10	0.20	0.82	**0.60**	1.10	2.30	1.20	1
TKN	Total Kjeldahl Nitrogen	mg/L	3	0.10	0.14	0.27	**0.20**	0.38	0.50		0
NH3-N	Ammonia as N	mg/L	6	0.01	0.01	0.01	**0.01**	0.02	0.04	1.43	0
NO_3-N	Nitrate as N	mg/L	6	0.01	0.01	0.04	**0.02**	0.09	0.10	3.40	0
NO_2-N	Nitrite as N	mg/L	6	0.01	0.01	0.01	**0.01**	0.01	0.01		0
TP	Total Phosphorous	mg/L	6	0.05	0.11	0.53	**0.19**	0.41	2.20	0.07	5
FRP	Filterable Reactive Phosphorous	mg/L	6	0.01	0.01	0.01	**0.01**	0.01	0.01	0.04	0
As	Arsenic	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.09400	0
Cd	Cadmium	mg/L	6	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010	0.00040	0
Cr	Chromium	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		0
Cu	Copper	mg/L	6	0.00100	0.00100	0.00350	**0.00100**	0.00200	0.01500	0.00180	2
Pb	Lead	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.00560	0
Ni	Nickel	mg/L	6	0.00100	0.00100	0.00217	**0.00100**	0.00300	0.00600	0.01300	0
Zn	Zinc	mg/L	6	0.00200	0.00200	0.00883	**0.00350**	0.01500	0.02700	0.01500	1
Hg	Mercury	mg/L	6	0.00005	0.00005	0.00006	**0.00005**	0.00005	0.00010	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0
Nox as N	Nox as N	mg/L	1	0.01	0.00500	0.01	**0.01**	0.00500	0.01		0

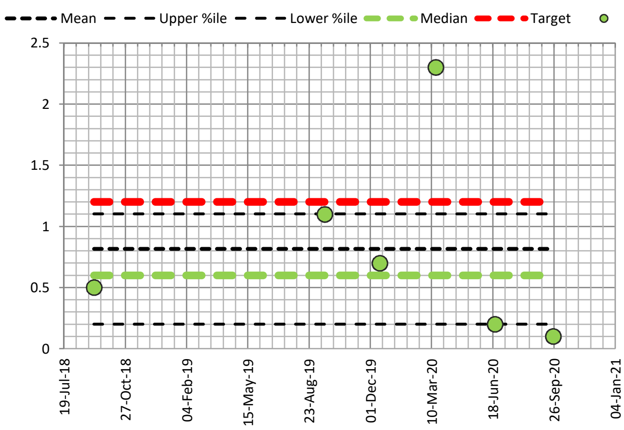
Electrical Conductivity



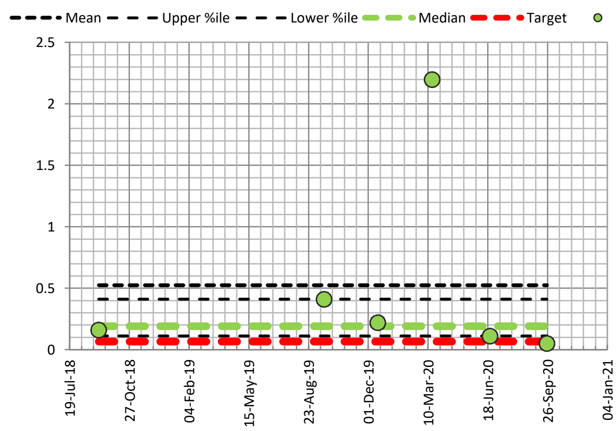
pH



Total Nitrogen



Total Phosphorous



H21087 Watermark Area 3

SW4 Surface Water Site 4

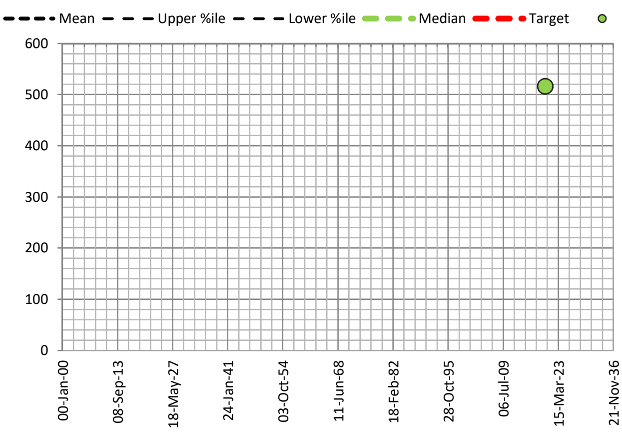
Site Outlet

Easting		Data Analysis Period Start Date	01-01-04
Northing		Data Analysis Period End Date	31-12-20

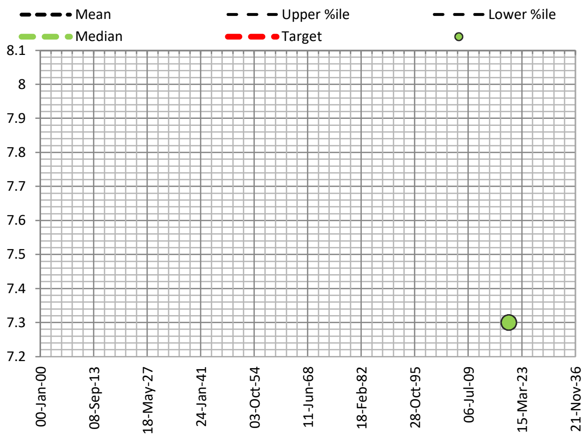
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	1	26.60	26.60	26.60	**26.60**	26.60	26.60		0
EC	Electrical Conductivity	uS/cm	1	516.00	516.00	516.00	**516.00**	516.00	516.00	300.00	1
DO	Dissolved Oxygen	mg/L	1	5.16	5.16	5.16	**5.16**	5.16	5.16		0
DO %	Dissolved Oxygen	%	1	64.70	64.70	64.70	**64.70**	64.70	64.70	80.00	0
pH	pH	pH	1	7.30	7.30	7.30	**7.30**	7.30	7.30	8.00	0
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	1	0.68	0.68	0.68	**0.68**	0.68	0.68	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	1	0.50	0.50	0.50	**0.50**	0.50	0.50	1.20	0
TKN	Total Kjeldahl Nitrogen	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
NH3-N	Ammonia as N	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01	1.43	0
NO_3-N	Nitrate as N	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01	3.40	0
NO_2-N	Nitrite as N	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01		0
TP	Total Phosphorous	mg/L	1	0.05	0.05	0.05	**0.05**	0.05	0.05	0.07	0
FRP	Filterable Reactive Phosphorous	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01	0.04	0
As	Arsenic	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.09400	0
Cd	Cadmium	mg/L	1	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010	0.00040	0
Cr	Chromium	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		0
Cu	Copper	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.00180	0
Pb	Lead	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.00560	0
Ni	Nickel	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.01300	0
Zn	Zinc	mg/L	1	0.00600	0.00600	0.00600	**0.00600**	0.00600	0.00600	0.01500	0
Hg	Mercury	mg/L	1	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005	0.00190	0
TDS	Total Dissolved Solids	mg/L	1	336.00	336.00000	336.00	**336.00**	336.00000	336.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0

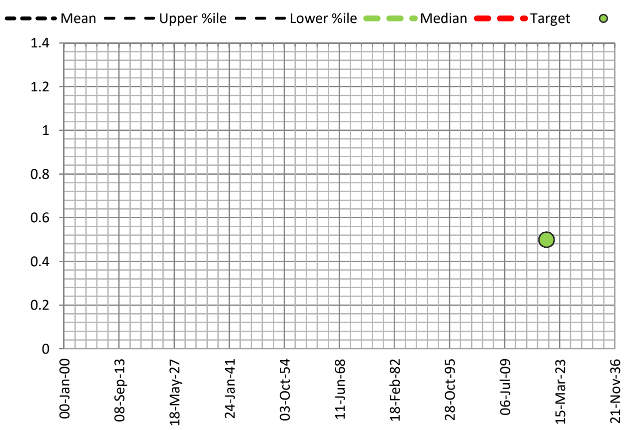
Electrical Conductivity



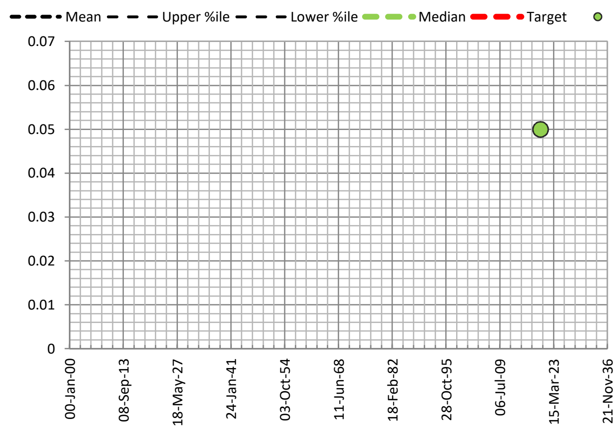
pH



Total Nitrogen



Total Phosphorous



H21087 Watermark Area 3

SW5 Surface Water Site 5

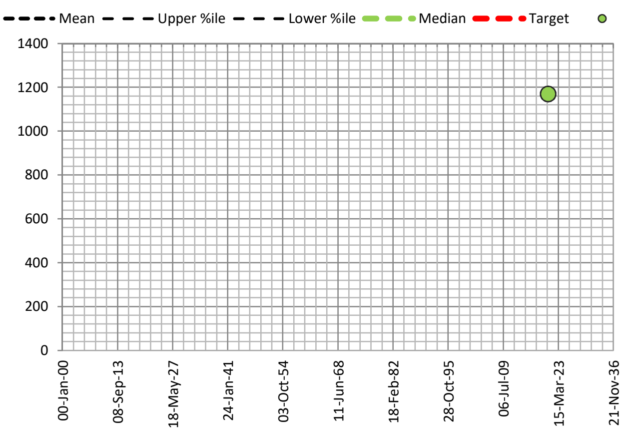
Blackadder Tributary : Muriel St

Easting		Data Analysis Period Start Date	01-01-04
Northing		Data Analysis Period End Date	31-12-20

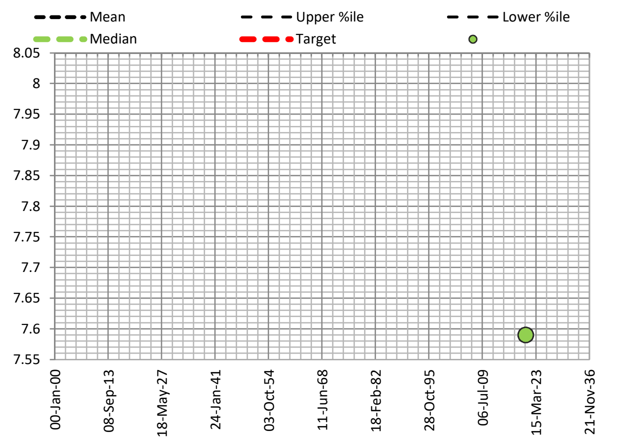
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	1	17.70	17.70	17.70	**17.70**	17.70	17.70		0
EC	Electrical Conductivity	uS/cm	1	1170.00	1170.00	1170.00	**1170.00**	1170.00	1170.00	300.00	1
DO	Dissolved Oxygen	mg/L	1	7.31	7.31	7.31	**7.31**	7.31	7.31		0
DO %	Dissolved Oxygen	%	1	77.30	77.30	77.30	**77.30**	77.30	77.30	80.00	0
pH	pH	pH	1	7.59	7.59	7.59	**7.59**	7.59	7.59	8.00	0
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	1	2.40	2.40	2.40	**2.40**	2.40	2.40	1.20	1
TKN	Total Kjeldahl Nitrogen	mg/L	1	0.10	0.10	0.10	**0.10**	0.10	0.10		0
NH3-N	Ammonia as N	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01	1.43	0
NO_3-N	Nitrate as N	mg/L	1	2.30	2.30	2.30	**2.30**	2.30	2.30	3.40	0
NO_2-N	Nitrite as N	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01		0
TP	Total Phosphorous	mg/L	1	0.05	0.05	0.05	**0.05**	0.05	0.05	0.07	0
FRP	Filterable Reactive Phosphorous	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01	0.04	0
As	Arsenic	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.09400	0
Cd	Cadmium	mg/L	1	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010	0.00040	0
Cr	Chromium	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		0
Cu	Copper	mg/L	1	0.08200	0.08200	0.08200	**0.08200**	0.08200	0.08200	0.00180	1
Pb	Lead	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.00560	0
Ni	Nickel	mg/L	1	0.00600	0.00600	0.00600	**0.00600**	0.00600	0.00600	0.01300	0
Zn	Zinc	mg/L	1	0.06000	0.06000	0.06000	**0.06000**	0.06000	0.06000	0.01500	1
Hg	Mercury	mg/L	1	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0

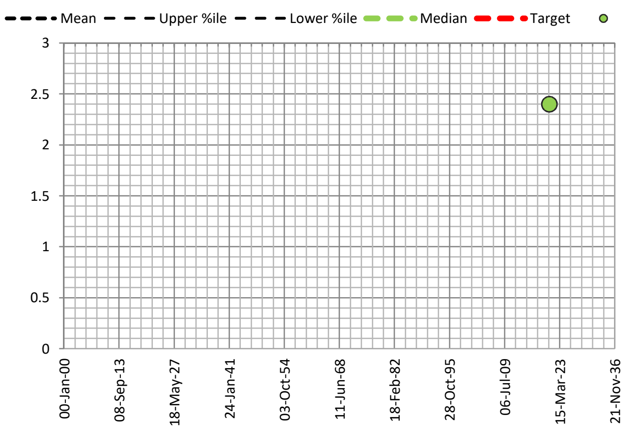
Electrical Conductivity



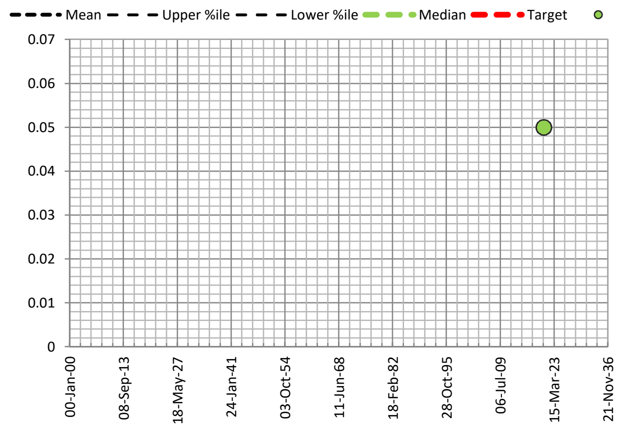
pH



Total Nitrogen



Total Phosphorous



H21087 Watermark Area 3

SW6 Surface Water Site 6

MB : Clay Basin

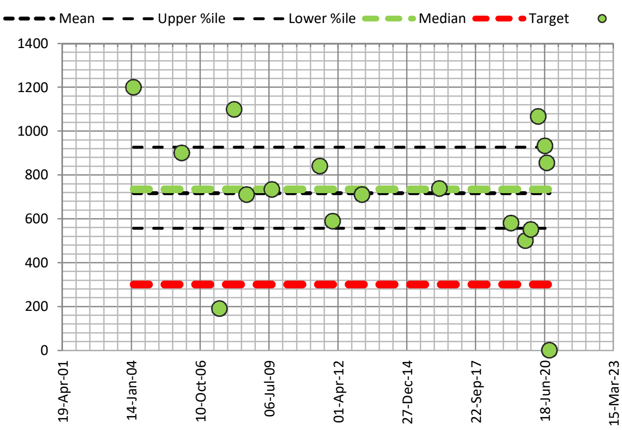
Easting		Data Analysis Period Start Date	01-01-04
Northing		Data Analysis Period End Date	31-12-20

hyd2o HYDROLOGY

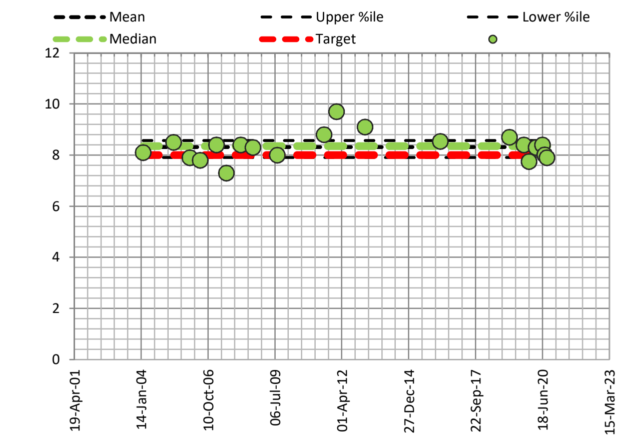
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	5	16.70	17.74	21.60	**20.40**	25.22	28.50		0
EC	Electrical Conductivity	uS/cm	17	1.23	556.80	717.60	**734.00**	926.40	1200.00	300.00	15
DO	Dissolved Oxygen	mg/L	15	6.10	7.53	8.51	**8.50**	9.39	11.20		0
DO %	Dissolved Oxygen	%	5	60.40	76.48	87.20	**84.00**	98.08	118.00	80.00	4
pH	pH	pH	20	7.30	7.90	8.31	**8.35**	8.56	9.70	8.00	14
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	1	8.07	8.07	8.07	**8.07**	8.07	8.07	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	18	0.30	0.46	0.72	**0.66**	0.94	1.30	1.20	2
TKN	Total Kjeldahl Nitrogen	mg/L	9	0.53	0.56	0.77	**0.70**	0.89	1.30		0
NH3-N	Ammonia as N	mg/L	15	0.01	0.01	0.05	**0.02**	0.08	0.26	1.43	0
NO_3-N	Nitrate as N	mg/L	19	0.01	0.01	0.17	**0.05**	0.20	1.60	3.40	0
NO_2-N	Nitrite as N	mg/L	10	0.01	0.01	0.03	**0.03**	0.05	0.06		0
TP	Total Phosphorous	mg/L	20	0.01	0.01	0.03	**0.03**	0.05	0.09	0.07	3
FRP	Filterable Reactive Phosphorous	mg/L	8	0.00	0.01	0.00	**0.01**	0.01	0.01	0.04	0
As	Arsenic	mg/L	23	0.00100	0.00100	0.00174	**0.00100**	0.00200	0.00500	0.09400	0
Cd	Cadmium	mg/L	23	0.00010	0.00010	0.00136	**0.00010**	0.00340	0.00500	0.00040	10
Cr	Chromium	mg/L	22	0.00010	0.00100	0.01387	**0.00200**	0.04480	0.05000		0
Cu	Copper	mg/L	23	0.00010	0.00100	0.01283	**0.00100**	0.03400	0.05000	0.00180	10
Pb	Lead	mg/L	23	0.00010	0.00100	0.00840	**0.00100**	0.00500	0.05000	0.00560	3
Ni	Nickel	mg/L	23	0.00100	0.00100	0.00874	**0.00100**	0.00500	0.05000	0.01300	3
Zn	Zinc	mg/L	23	0.00100	0.00500	0.02013	**0.00900**	0.05000	0.11000	0.01500	6
Hg	Mercury	mg/L	21	0.00005	0.00005	0.00009	**0.00005**	0.00005	0.00080	0.00190	0
TDS	Total Dissolved Solids	mg/L	1	358.00	358.00000	358.00	**358.00**	358.00000	358.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0

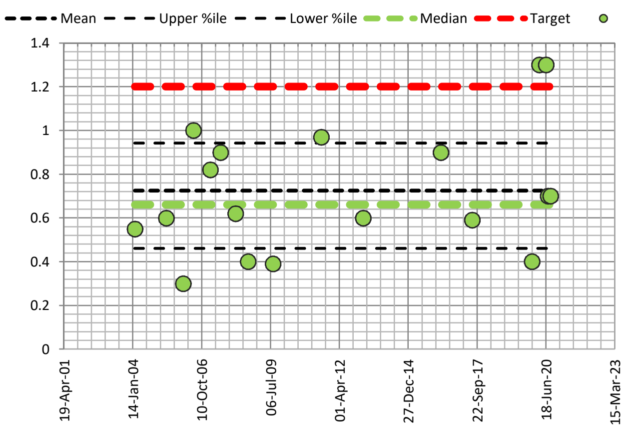
Electrical Conductivity



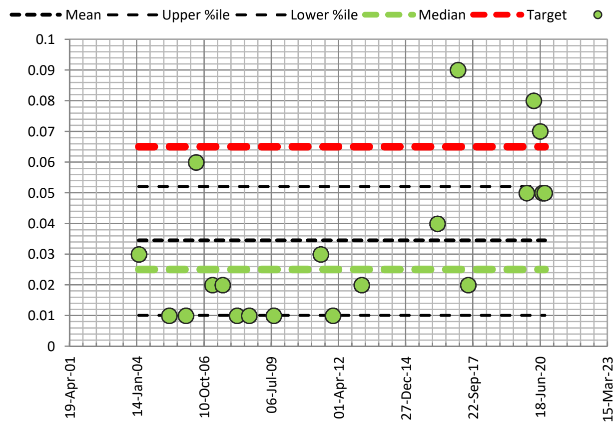
pH



Total Nitrogen



Total Phosphorous



H21087 Watermark Area 3

SW10 Surface Water Site 10

MB : Southern Storage Area

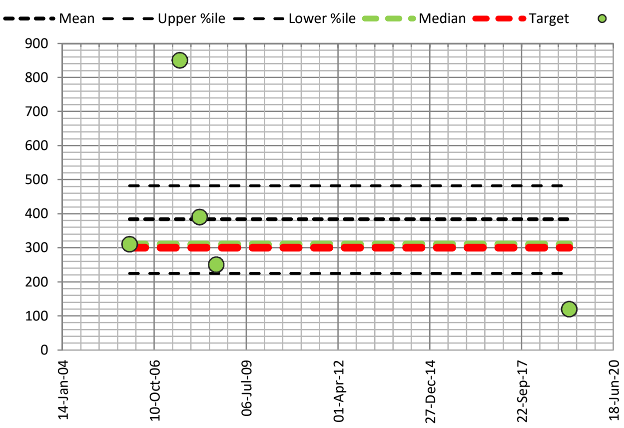
Easting		Data Analysis Period Start Date	01-01-04
Northing		Data Analysis Period End Date	31-12-20

hyd2o HYDROLOGY

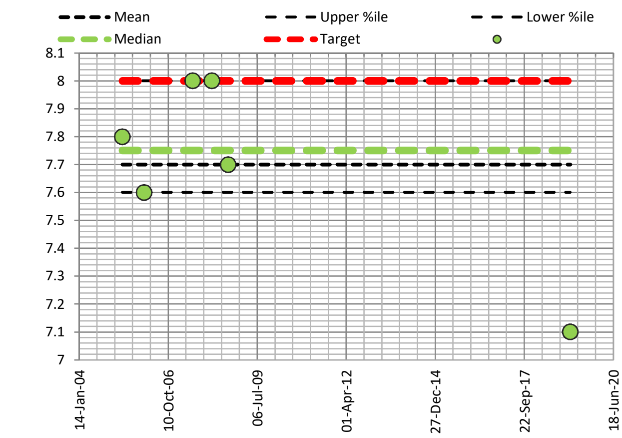
Report Date : 01-09-21

					Low %ile			High %ile		Target	Times
Parameter	Description	Units	Samples	Minimum	20	Mean	Median	80	Maximum	ANZECC 90%	Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
EC	Electrical Conductivity	uS/cm	5	120.00	224.00	384.00	**310.00**	482.00	850.00	300.00	3
DO	Dissolved Oxygen	mg/L	4	7.00	7.66	8.58	**8.55**	9.48	10.20		0
DO %	Dissolved Oxygen	%	0	0.00	0.00	0.00	**0.00**	0.00	0.00	80.00	0
pH	pH	pH	6	7.10	7.60	7.70	**7.75**	8.00	8.00	8.00	0
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	5	0.18	0.44	0.70	**0.71**	1.02	1.10	1.20	0
TKN	Total Kjeldahl Nitrogen	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
NH3-N	Ammonia as N	mg/L	5	0.01	0.01	0.05	**0.06**	0.07	0.10	1.43	0
NO_3-N	Nitrate as N	mg/L	5	0.05	0.05	0.59	**0.05**	0.63	2.70	3.40	0
NO_2-N	Nitrite as N	mg/L	2	0.05	0.05	0.05	**0.05**	0.05	0.05		0
TP	Total Phosphorous	mg/L	5	0.02	0.02	0.04	**0.04**	0.05	0.06	0.07	0
FRP	Filterable Reactive Phosphorous	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00	0.04	0
As	Arsenic	mg/L	6	0.00100	0.00100	0.00183	**0.00100**	0.00200	0.00500	0.09400	0
Cd	Cadmium	mg/L	6	0.00010	0.00100	0.00218	**0.00100**	0.00500	0.00500	0.00040	5
Cr	Chromium	mg/L	5	0.00500	0.00500	0.02760	**0.02800**	0.05000	0.05000		0
Cu	Copper	mg/L	6	0.00100	0.00500	0.02100	**0.01000**	0.05000	0.05000	0.00180	5
Pb	Lead	mg/L	6	0.00100	0.00500	0.01933	**0.00500**	0.05000	0.05000	0.00560	2
Ni	Nickel	mg/L	6	0.00100	0.00500	0.01933	**0.00500**	0.05000	0.05000	0.01300	2
Zn	Zinc	mg/L	6	0.00900	0.01300	0.03850	**0.02950**	0.05000	0.10000	0.01500	4
Hg	Mercury	mg/L	6	0.00005	0.00005	0.00006	**0.00005**	0.00005	0.00010	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0

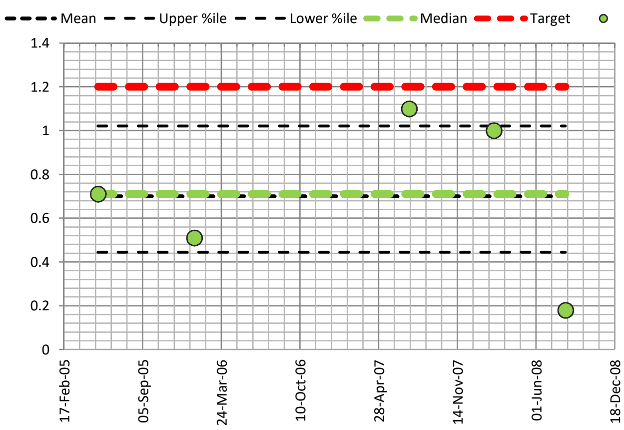
Electrical Conductivity



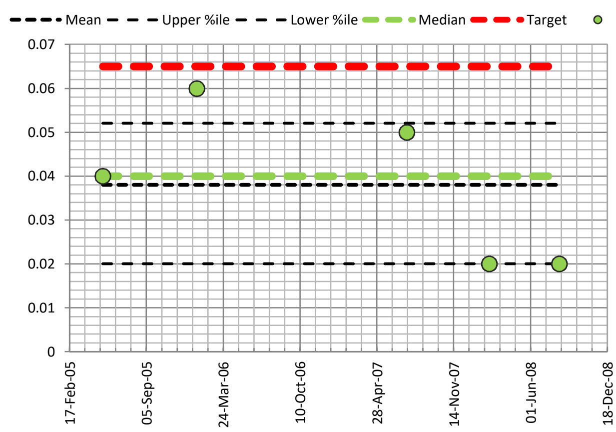
pH



Total Nitrogen



Total Phosphorous



H21087 Watermark Area 3

Swan River Sites
Swan River Upstream Site

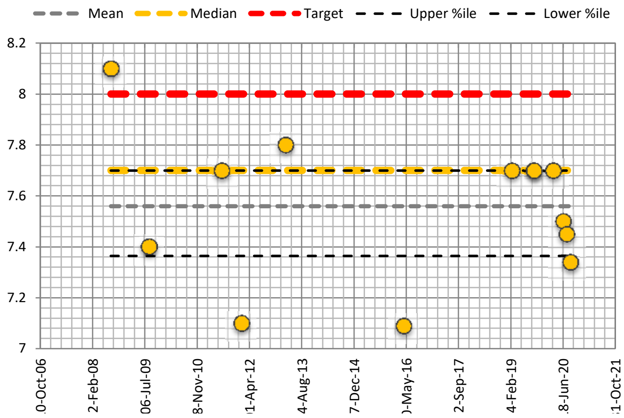
Data Analysis Period Start Date	01-01-04
Data Analysis Period End Date	31-12-20

HYDROLOGY

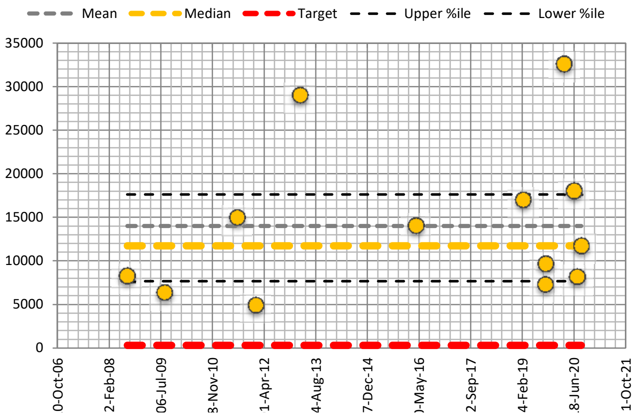
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.00	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.00	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	5	15.20	16.16	18.52	**17.30**	20.86	23.50		0
EC	Electrical Conductivity	uS/cm	13	4900.00	7656.00	14012.08	**11720.00**	17631.80	32612.00	300.00	13
DO	Dissolved Oxygen	mg/L	9	3.16	4.72	6.51	**5.74**	9.08	10.30		0
DO %	Dissolved Oxygen	%	5	46.30	47.74	53.03	**53.20**	56.45	62.65	80.00	0
pH	pH	pH	13	7.09	7.36	7.56	**7.70**	7.70	8.10	8.00	1
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	11	0.80	0.90	1.24	**1.10**	1.54	2.20	1.20	4
TKN	Total Kjeldahl Nitrogen	mg/L	9	0.80	0.86	1.49	**1.10**	2.16	2.70		0
NH3-N	Ammonia as N	mg/L	9	0.01	0.03	0.12	**0.06**	0.20	0.40	1.43	0
NO_3-N	Nitrate as N	mg/L	12	0.01	0.04	0.43	**0.10**	0.41	2.25	3.40	0
NO_2-N	Nitrite as N	mg/L	9	0.01	0.01	0.05	**0.01**	0.07	0.25		0
TP	Total Phosphorous	mg/L	13	0.01	0.04	0.08	**0.06**	0.10	0.23	0.07	6
FRP	Filterable Reactive Phosphorous	mg/L	8	0.01	0.01	0.02	**0.01**	0.03	0.08	0.04	2
As	Arsenic	mg/L	15	0.00100	0.00100	0.00340	**0.00400**	0.00500	0.01000	0.09400	0
Cd	Cadmium	mg/L	15	0.00010	0.00010	0.00092	**0.00010**	0.00060	0.00500	0.00040	7
Cr	Chromium	mg/L	14	0.00050	0.00100	0.00411	**0.00100**	0.00500	0.02500		0
Cu	Copper	mg/L	15	0.00050	0.00100	0.00437	**0.00300**	0.00500	0.02500	0.00180	10
Pb	Lead	mg/L	15	0.00050	0.00100	0.00250	**0.00100**	0.00500	0.00500	0.00560	0
Ni	Nickel	mg/L	15	0.00100	0.00100	0.00467	**0.00300**	0.00500	0.02500	0.01300	1
Zn	Zinc	mg/L	15	0.00100	0.00460	0.01600	**0.01300**	0.02500	0.05000	0.01500	6
Hg	Mercury	mg/L	13	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0

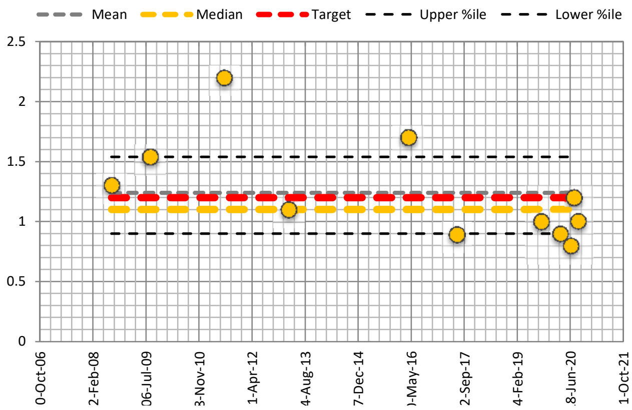
pH



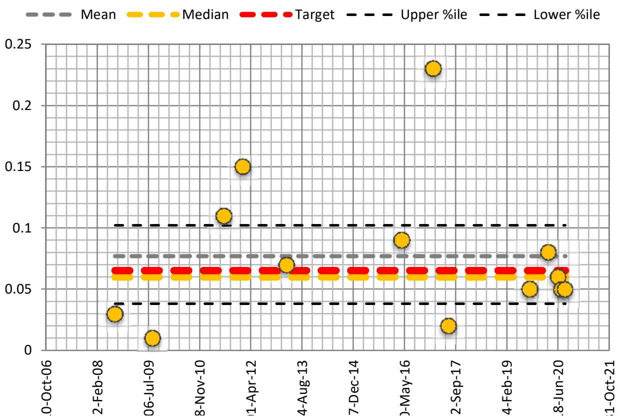
Electrical Conductivity



Total Nitrogen



Total Phosphorous



H21087 Watermark Area 3

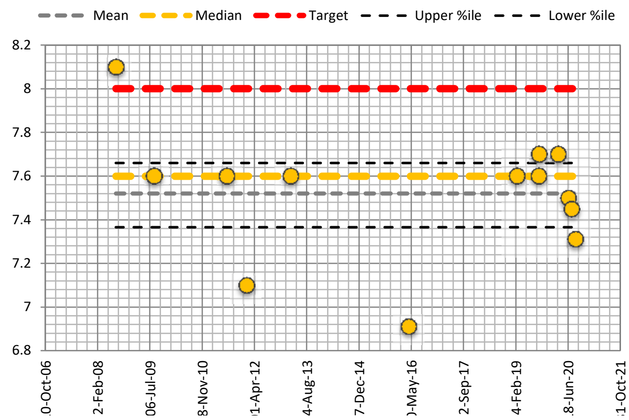
Swan River Sites
Swan River Downstream Site

Data Analysis Period Start Date	01-01-04
Data Analysis Period End Date	31-12-20

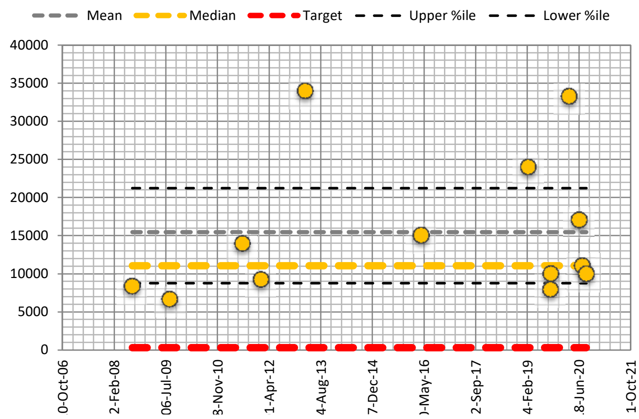
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.00	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.00	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	5	15.70	15.78	18.48	**17.80**	20.38	23.50		0
EC	Electrical Conductivity	uS/cm	13	6675.00	8760.00	15455.31	**11061.00**	21227.60	34000.00	300.00	13
DO	Dissolved Oxygen	mg/L	9	2.85	4.86	6.42	**5.82**	8.80	10.20		0
DO %	Dissolved Oxygen	%	5	37.50	42.30	53.85	**62.30**	62.69	63.47	80.00	0
pH	pH	pH	13	6.91	7.37	7.52	**7.60**	7.66	8.10	8.00	1
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	11	0.80	0.90	1.31	**1.10**	1.69	2.30	1.20	5
TKN	Total Kjeldahl Nitrogen	mg/L	9	0.70	0.83	1.57	**1.40**	2.26	3.00		0
NH3-N	Ammonia as N	mg/L	9	0.01	0.02	0.13	**0.07**	0.22	0.43	1.43	0
NO_3-N	Nitrate as N	mg/L	12	0.01	0.05	0.48	**0.12**	0.39	2.68	3.40	0
NO_2-N	Nitrite as N	mg/L	9	0.01	0.01	0.06	**0.01**	0.08	0.30		0
TP	Total Phosphorous	mg/L	13	0.03	0.04	0.09	**0.06**	0.12	0.23	0.07	6
FRP	Filterable Reactive Phosphorous	mg/L	8	0.01	0.01	0.03	**0.01**	0.06	0.08	0.04	3
As	Arsenic	mg/L	15	0.00100	0.00100	0.00320	**0.00200**	0.00500	0.01000	0.09400	0
Cd	Cadmium	mg/L	15	0.00010	0.00010	0.00092	**0.00010**	0.00060	0.00500	0.00040	7
Cr	Chromium	mg/L	14	0.00050	0.00100	0.00411	**0.00100**	0.00500	0.02500		0
Cu	Copper	mg/L	15	0.00050	0.00180	0.00510	**0.00500**	0.00500	0.02500	0.00180	12
Pb	Lead	mg/L	15	0.00050	0.00100	0.00257	**0.00100**	0.00500	0.00500	0.00560	0
Ni	Nickel	mg/L	15	0.00100	0.00100	0.00547	**0.00500**	0.00560	0.02500	0.01300	1
Zn	Zinc	mg/L	15	0.00100	0.00500	0.01853	**0.02100**	0.02560	0.05000	0.01500	8
Hg	Mercury	mg/L	13	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0

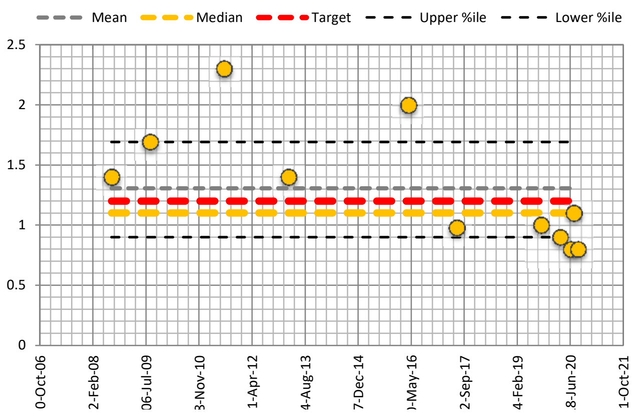
pH



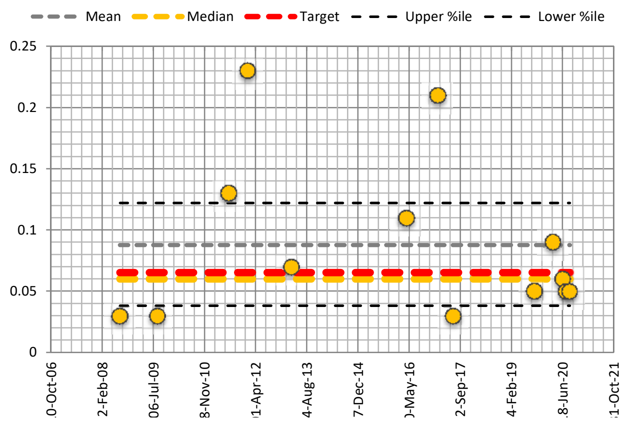
Electrical Conductivity



Total Nitrogen



Total Phosphorous



APPENDIX F
Lithological Logs

Well ID: EMW03

emerge ASSOCIATES Integrated Science & Design

PROJECT NUMBER: EP18-062(01)
CLIENT: Boral Limited

PROJECT NAME: Boral Midland Groundwater Assessment
PROJECT LOCATION: 102 Great Northern Highway Midvale

DATE INSTALLED: 20/08/2018
DRILLING CONTRACTOR: Strataprobe
DRILLING METHOD: Auger
LOGGED BY: MM

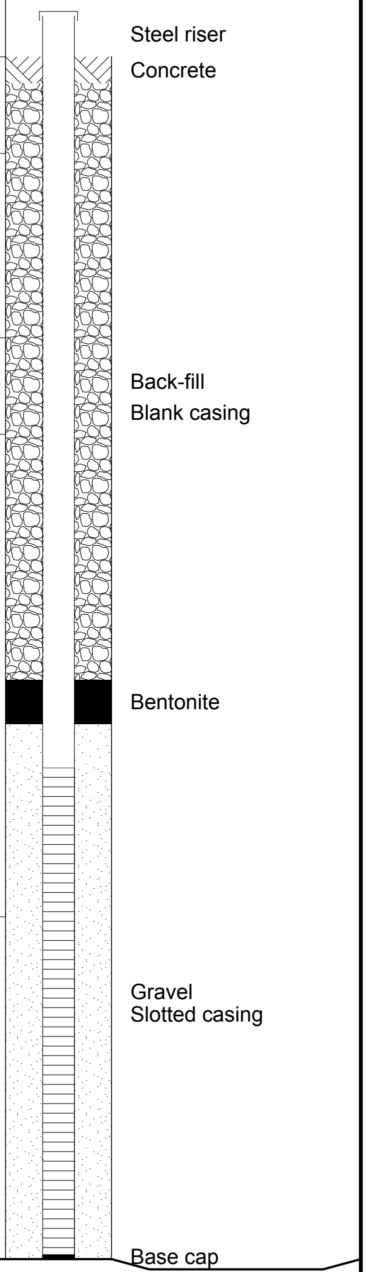
SURVEY SOURCE: Surveyed
EASTING: 405529.696
NORTHING: 6473108.240
PROJECTION: MGA, GDA94

ELEVATION (GROUND): 10.8 mAHD
ELEVATION (TOP OF CASING): 11.3 mAHD
CASING DIAMETER: 50 mm

DEPTH (mBGL)	DEPTH (mAHD)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONTENT
0			0.0m: UNCONTROLLED FILL: dark grey, plastic, brick, bluemetal.	
1	10		1.1m: SANDY CLAY: dark red/brown, fine to medium grained, low plasticity, orange mottling.	Dry To Moist
2	9			
3	8		3.2m: CLAYEY SAND: dark red/brown, fine grained, low plasticity, fine sands with charcoal fines.	Moist
4	7		4.3m: SANDY CLAY: light brown, fine grained, low plasticity, firm to stiff layer, slow penetration.	Dry
5	6			
6	5			
7	4			
8	3			
9	2			
10	1		9.8m: CLAYEY SAND: light brown, fine to coarse grained, medium plasticity, soft to firm, water bearing layer encountered .	Wet
11	0			
12	-1			
13	-2			

Total drilled depth: 13.7 mBGL

WELL CONSTRUCTION



COMMENTS: Water was observed at 10.00 mBGL during well install. Standing water level recorded in September 2018 was 9.291 mBGL

Well ID: EMW04

PROJECT NUMBER: EP18-062(01)
CLIENT: Boral Limited

PROJECT NAME: Boral Midland Groundwater Assessment
PROJECT LOCATION: 102 Great Northern Highway Midvale

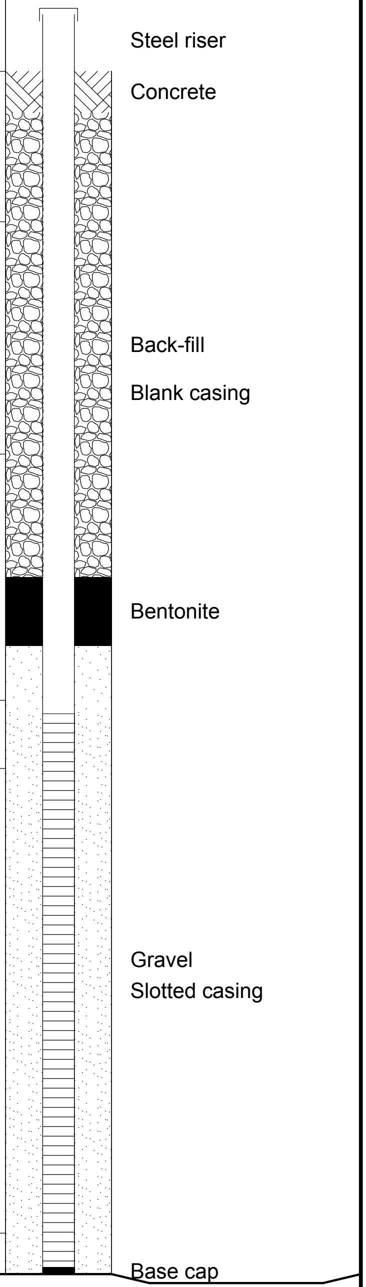
DATE INSTALLED: 20/08/2018
DRILLING CONTRACTOR: Strataprobe
DRILLING METHOD: Sonic
LOGGED BY: MM

SURVEY SOURCE: Surveyed
EASTING: 405712.103
NORTHING: 6472730.410
PROJECTION: MGA, GDA94

ELEVATION (GROUND): 9.3 mAHD
ELEVATION (TOP OF CASING): 9.8 mAHD
CASING DIAMETER: 50 mm

DEPTH (mBGL)	MATERIAL DESCRIPTION	MOISTURE CONTENT
0.0m	SANDY CLAYEY UNCONTROLLED FILL: dark brown/grey, brick and bitumen rubble, plastics, unable to sonic core due to rubble.	Dry To Moist
1.1m	CLAY: dark brown, medium plasticity.	Moist
2.8m	SANDY CLAY: light brown, low plasticity, firm to stiff layer, slow to gradual penetration.	Dry
4.6m	GRAVELLY CLAY: dark brown/purple, medium plasticity, purple mottling.	Moist
5.1m	CLAYEY SAND: light brown, fine to coarse grained, low plasticity, water bearing layer.	Wet
8.5m	SANDY CLAY: light brown/red, medium plasticity, more clays at depth.	Wet

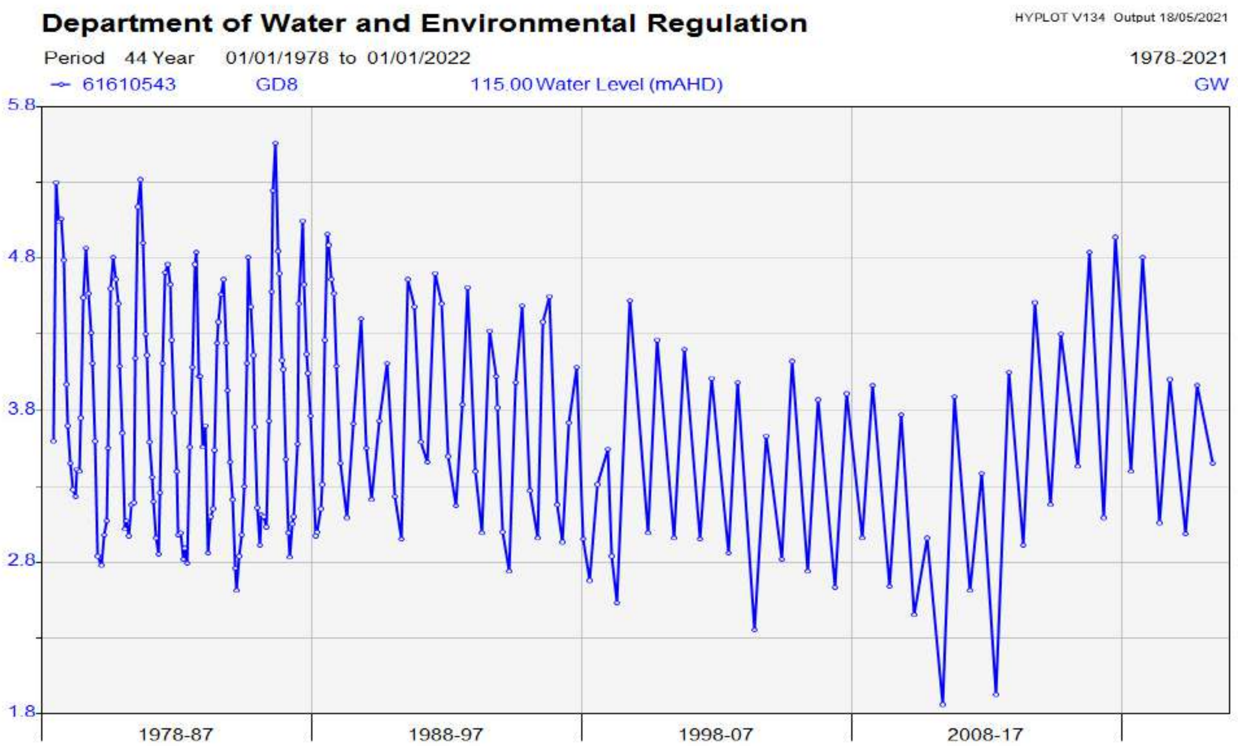
Total drilled depth: 8.8 mBGL

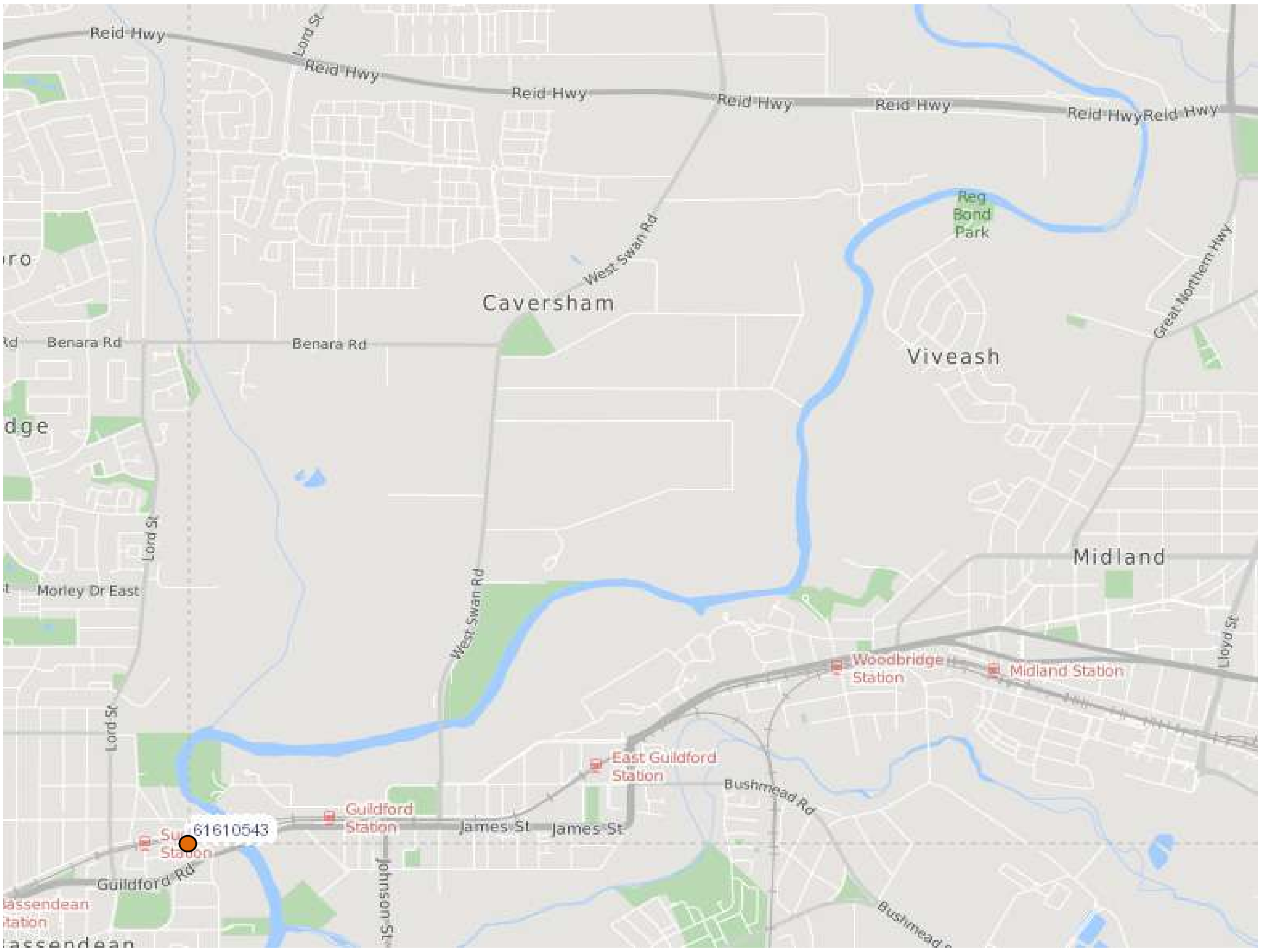


COMMENTS: water was observed at 5.10 mBGL during well install. Standing water level recorded in September 2018 was 6.808 mBGL.

APPENDIX G
DWER Groundwater Monitoring Data

Date :1/9/2021 Job No. H21087





Source: Department of Water and Environmental Regulation (2021)

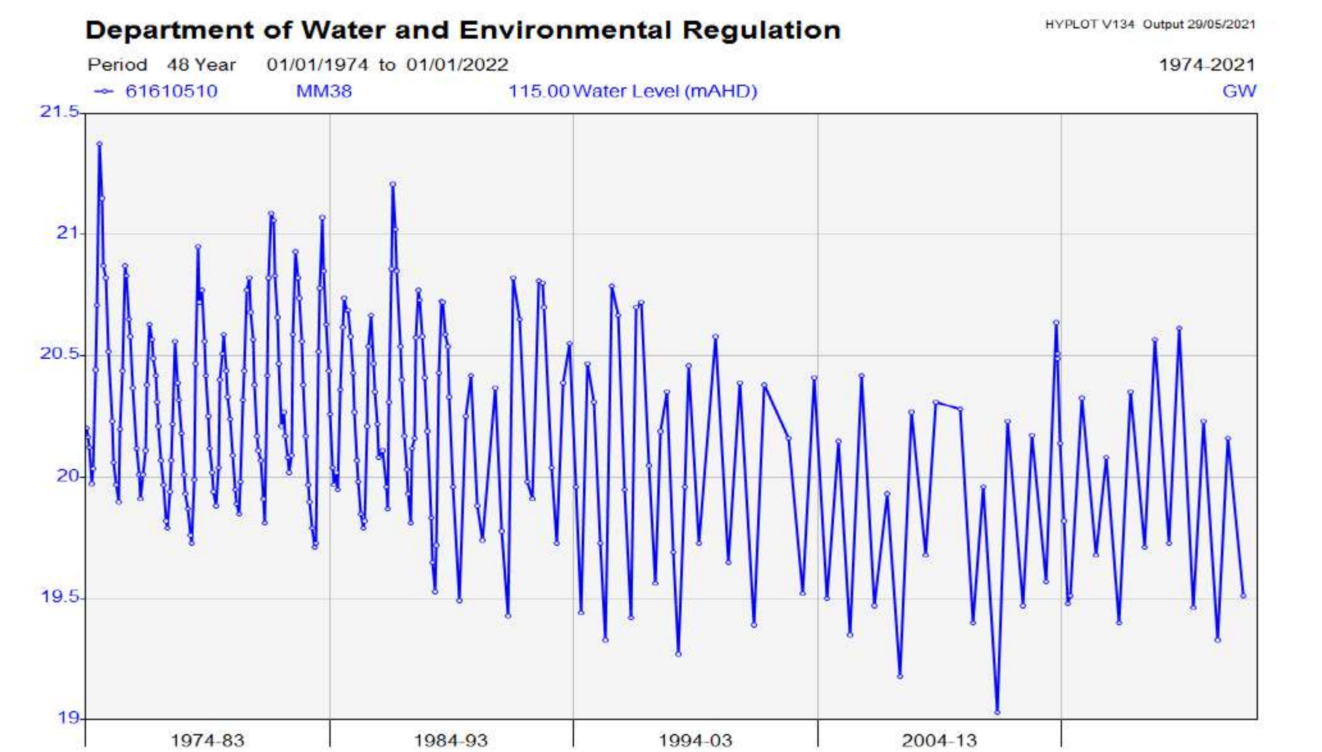
hyd2o

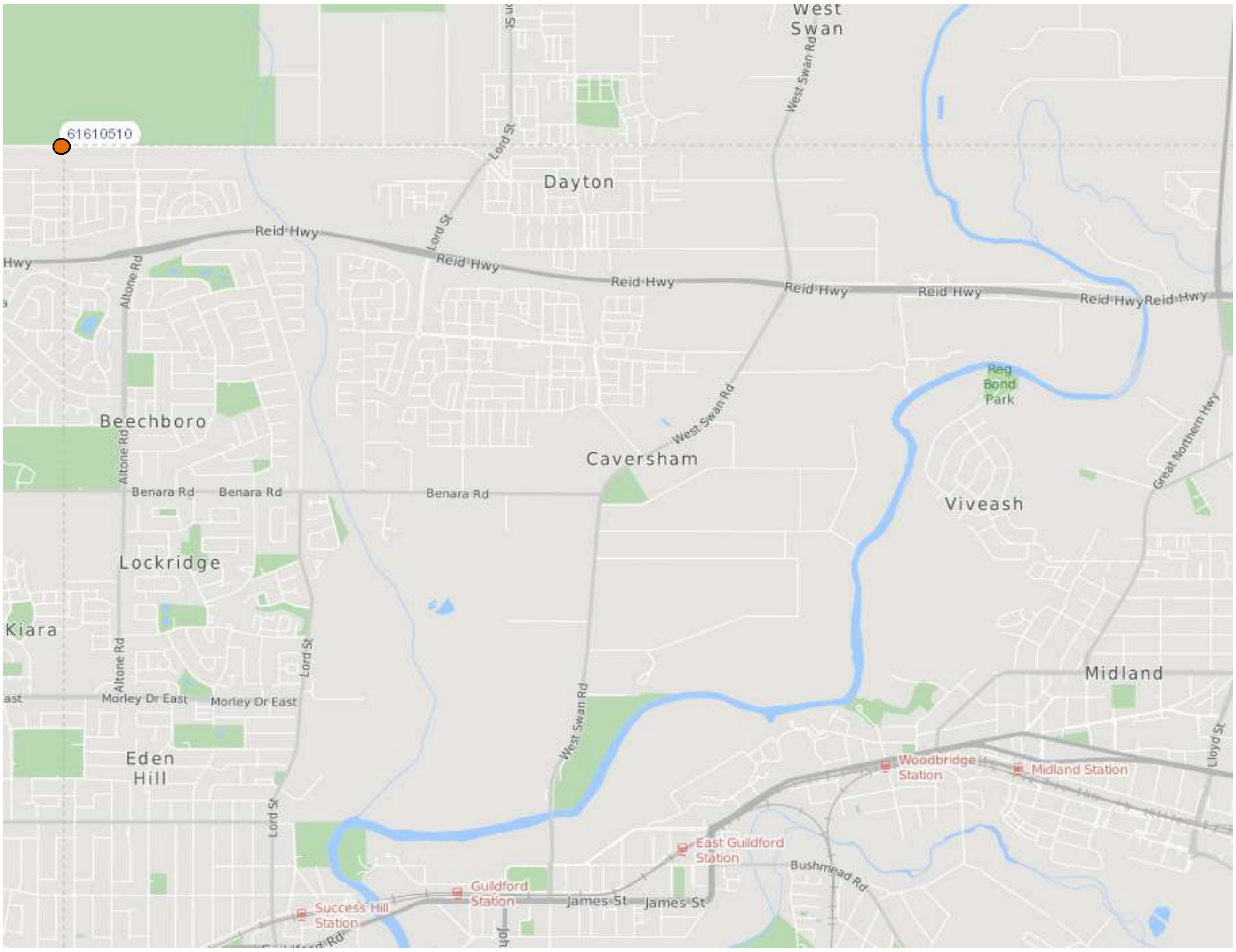
Watermark Area 3 Local Water Management Strategy

DWER Bore Hydrographs : GD8

Appendix G1

Date :1/9/2021 Job No. H21087





Source: Department of Water and Environmental Regulation (2021)

hyd2o

Watermark Area 3 Local Water Management Strategy

DWER Bore Hydrographs : MM388

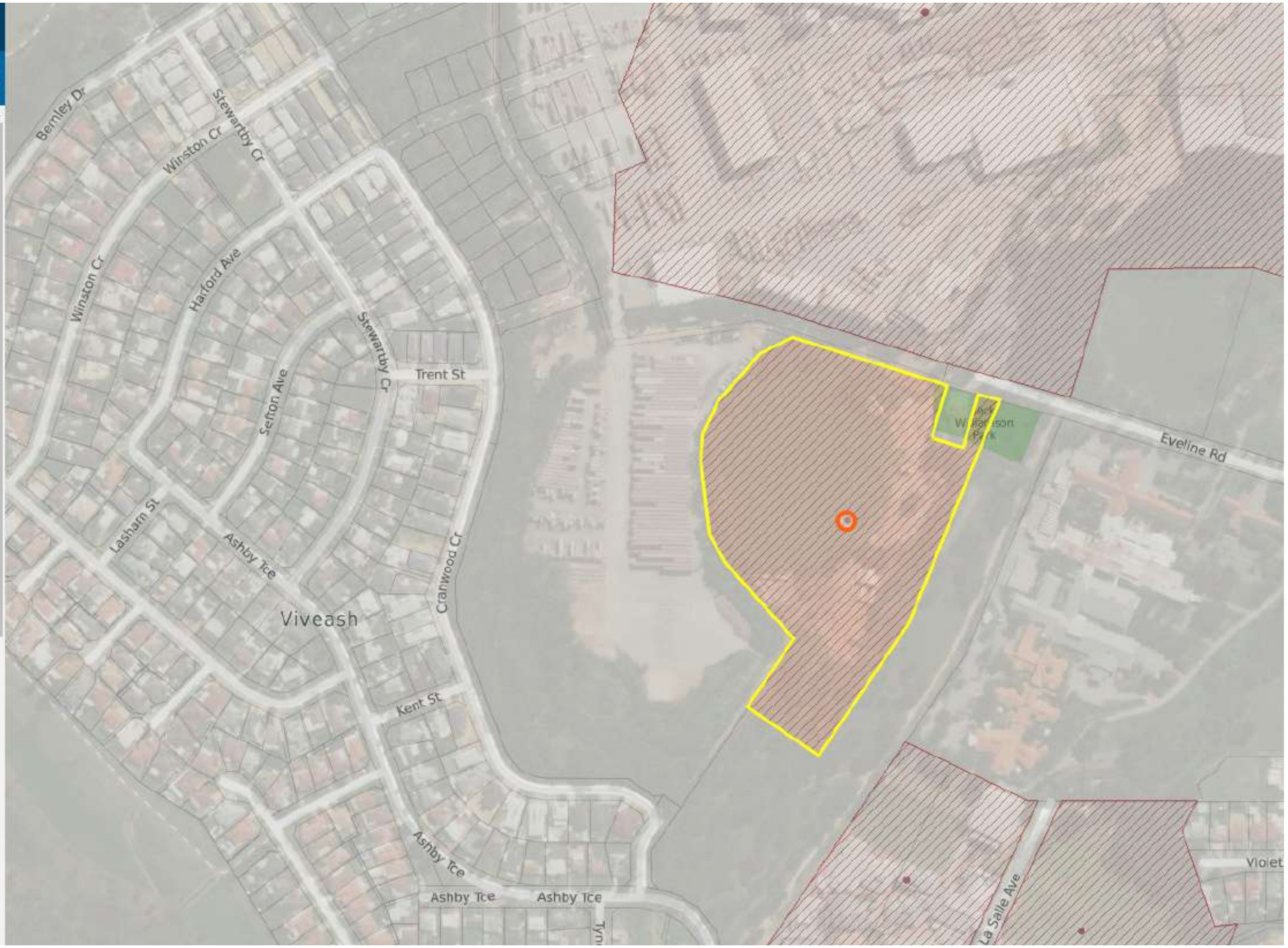
Appendix G2

APPENDIX H
Groundwater Licence

← Licence details

Selected 1 of 1

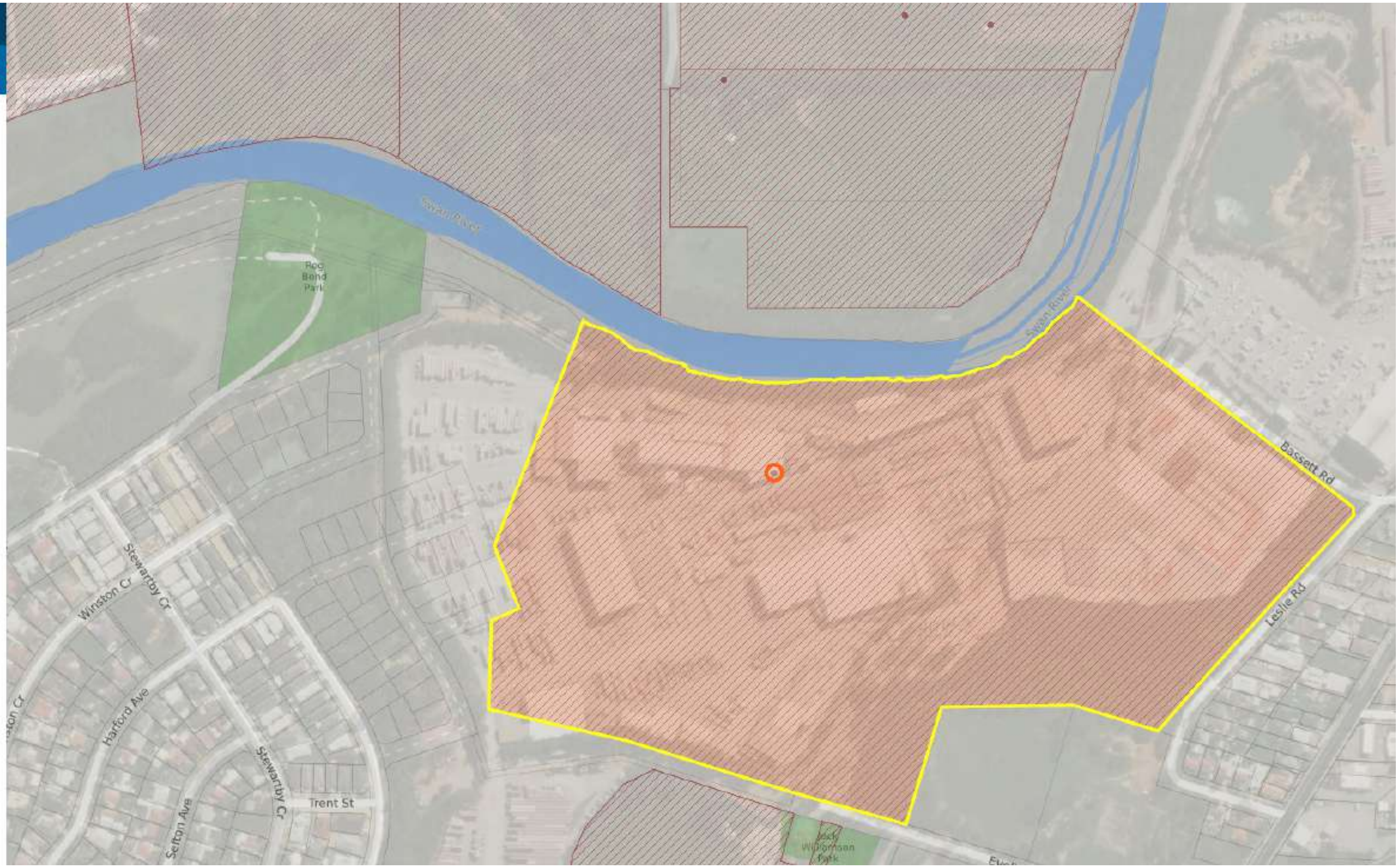
Licence Number:	168139
Licence Type:	Groundwater Licence
Issue Date:	29/8/2019
Expiry Date:	28/8/2029
Licence Allocation:	280775 KL
Parties:	City of Swan
Postal Address:	PO BOX 196 Midland DC WA 6936 Australia
Groundwater Area:	Perth
Groundwater Subarea:	Perth South Confined
Aquifer:	Perth - Leederville.
Surface Water Area:	
Surface Water Subarea:	
Surface Water Resource:	
Licence Address:	Lot 234 On Plan 188150 Volume/Folio Lr3041/230 Lot 234 Helena St Guildford Kings Meadow Polo Grou; Lot 191 On Plan 222550 Volume/Folio 199/195 Lot 191 Meadow St Guildford Stirling Square And Meado; Crown Reserve 35349 Lot 9803 Blackadder Rd Swan View Swan View Park; Lot 98 Harper Street Woodbridge Ray Marshall Park; Lot 13421 On Plan 220279 Volume/Folio Lr3114/605 Lot 13421 Eddie Barron Dr Middle Swan Velodrome; Lot 9808 On Plan 215911 Volume/Folio Lr3011/723 Lot 9808 The Quarry Swan View The Quarry; Lot 5 On Diagram 48300 Volume/Folio 1406/686 Lot 5 Great Northern Hwy Middle Swan Lot 56 On Plan ; Lot 144 On Plan 222536 Volume/Folio 1228/232 Lot 144 Helena St Guildford Spring Reserve; Lot 216 On Plan 3298 Volume/Folio 2156/710 Lot 216 The Avenue Midland Midland Oval; Crown



← Licence details

Selected 1 of 2

Licence Number:	204304
Licence Type:	Groundwater Licence
Issue Date:	8/5/2020
Expiry Date:	7/5/2025
Licence Allocation:	30000 KL
Parties:	Linc Property Pty Ltd
Postal Address:	PO Box 782 Subiaco WA 6904 Australia
Groundwater Area:	Perth
Groundwater Subarea:	Shire of Swan South
Aquifer:	Perth - Superficial Swan
Surface Water Area:	
Surface Water Subarea:	
Surface Water Resource:	
Licence Address:	LOT 72 EVELINE ROAD MIDDLE SWAN 6056
Security Interests:	No
Convictions:	No
Agreements:	No
Notations:	No
Directions:	No



APPENDIX I
Landscape Masterplan

Internal road layout is indicative only.

MIDLAND BRICK
INDICATIVE LANDSCAPE MASTERPLAN

udla pty. ltd. www.udla.com.au p: +61 8 9336 7577 Level 1A, 3-5 Josephson St, Fremantle, 6160.

NEW IDEAS THROUGH SHARED DESIGN-THINKING

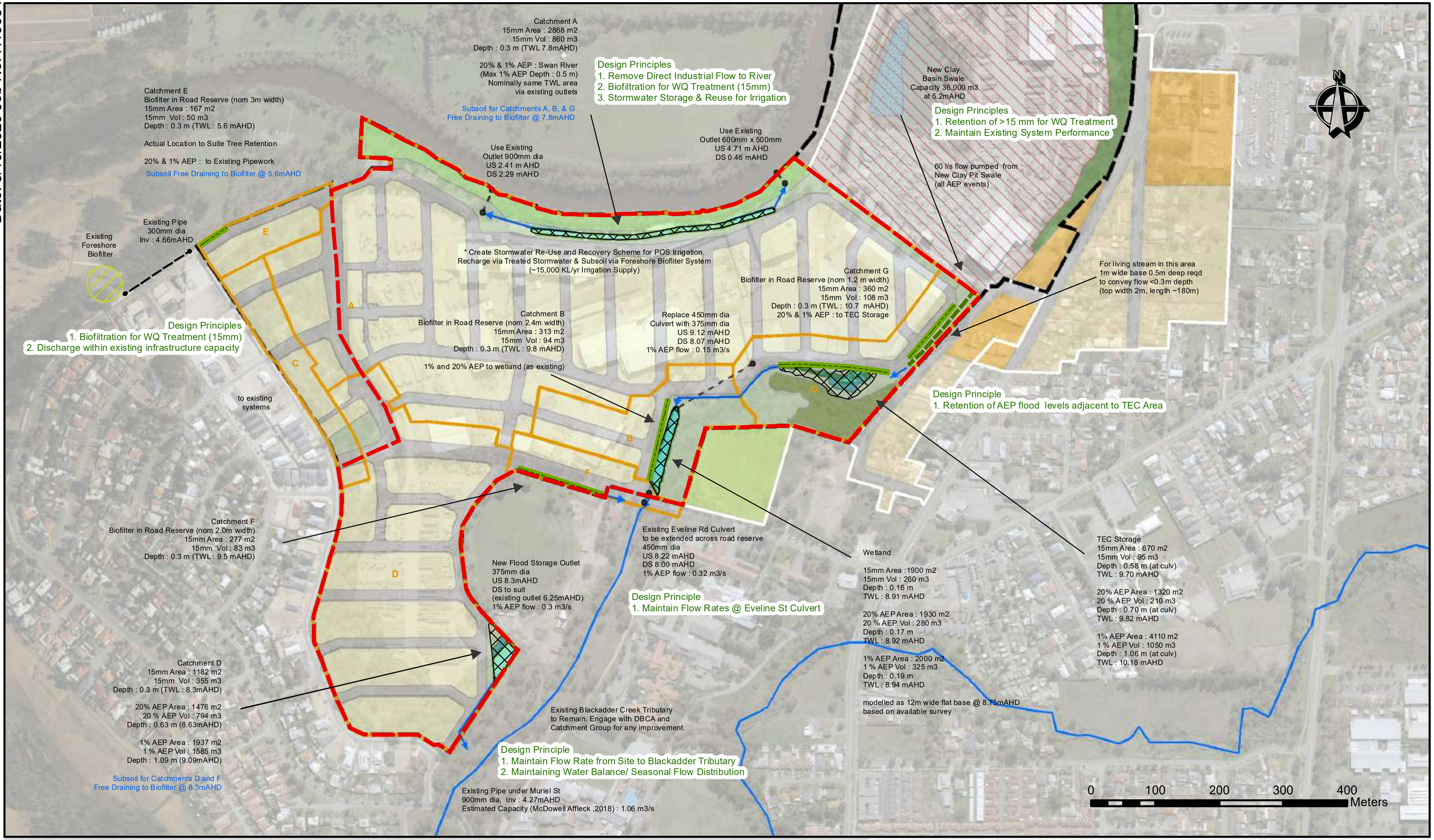
N

PROJECT NAME:	CLIENT:	DRAWN:	SCALE:	ISSUE DATE:	REVISION:
Midland Brick	Linc	KT	1:4000 @A3	April 2020	H

APPENDIX J
Post Development Stormwater Modelling Extracts (Hyd2o, 2020a)

DWMS POST DEVELOPMENT SYSTEM MODELLING

Date: 5/10/2020 Job No. H19054



Site
Indicative Concept Plan Area
Blackadder & Tributary
New Pipework
Existing Pipework
Storage 1% AEP
Storage 20% AEP
Storage 63% AEP
Living Stream
Biofilter swales in Road Reserves (15mm)
Post Dev Catchments
Lots
POS
TEC
Foreshore Res
Road
External Catchments
Hardstand
Industrial
POS
Residential
Vegetation

hyd2o

Midland Brick District Water Management Strategy

Indicative Stormwater Management Event Plan

APPENDIX K
Post Development Runoff Rate Estimation

CURRV

Calculator for Urban Runoff Rates & Volumes

1/09/2021

Project: Watermark Area 3 Post Development Model : Total Southern POS Catchment

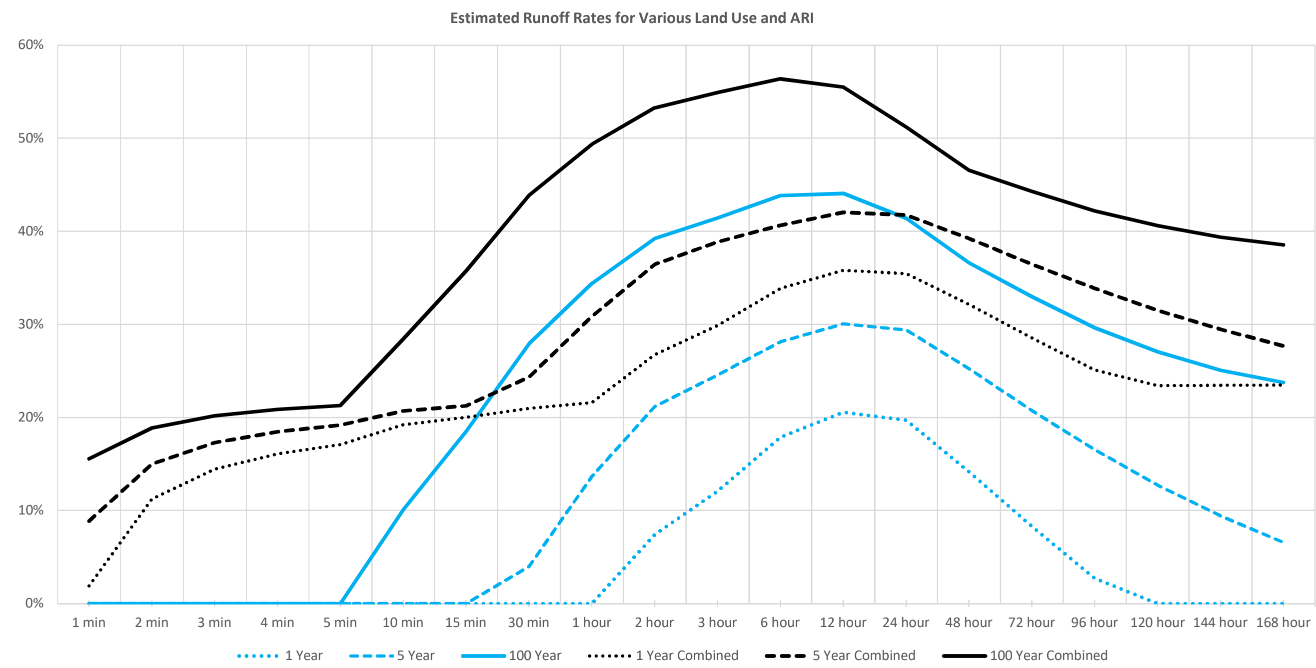
	Land Use Description	Area (ha)	Use in Calc	Imperv Initial Loss mm	Perv Initial Loss mm	Perv Continue Loss mm/hr	On Site Soak (mm)	Empty (days)	AR&R EIA/TIA System Connect Ratio	Roof %	Ext Imp %	Ext Perv %	Comment
1	Residential Lots	7.45	Yes	1.5	20.0	4.0	15.0	1.00	60%	65	22	13	
2	Roads	4.04	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	
3	POS	0.40	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	
4				1.5	20.0	4.0		1.00					
5				1.5	20.0	4.0		1.00					
6				1.5	20.0	4.0		1.00					
7				1.5	20.0	4.0		1.00					
8				1.5	20.0	4.0		1.00					
9				1.5	20.0	4.0		1.00					
10				0.0	20.0	4.0		1.00					

EIA : Effective Impervious Area, TIA : Total Impervious Area

Land Use Graph Selector	1

(11 - combined total)

Residential Lots



Rainfall IFD Data

Annual Exceedence Probability

	Duration	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
1	1 min	1.6	1.8	2.4	2.8	3.2	3.8	4.3
2	2 min	2.8	3.1	4.1	4.7	5.4	6.4	7.2
3	3 min	3.8	4.2	5.5	6.4	7.3	8.7	9.8
4	4 min	4.6	5.1	6.7	7.8	9.0	10.7	12.1
5	5 min	5.3	5.9	7.7	9.1	10.4	12.4	14.0
6	10 min	7.8	8.6	11.4	13.4	15.5	18.3	20.6
7	15 min	9.4	10.4	13.8	16.2	18.7	22.1	24.9
8	30 min	12.5	13.8	18.2	21.3	24.6	29.0	32.7
9	1 hour	16.1	17.8	23.2	27.2	31.4	37.3	42.2
10	2 hour	20.7	22.7	29.5	34.7	40.2	48.3	55.2
11	3 hour	23.9	26.2	34.1	40.2	46.8	56.6	65.1
12	6 hour	30.8	33.7	43.9	52.0	61.0	74.7	86.7
13	12 hour	39.6	43.3	56.6	67.1	78.8	96.7	112.0
14	24 hour	50.6	55.4	72.1	84.7	98.3	119.0	137.0
15	48 hour	63.8	70.1	90.0	104.0	118.0	139.0	156.0
16	72 hour	73.1	80.2	102.0	116.0	130.0	151.0	167.0
17	96 hour	80.7	88.5	112.0	127.0	141.0	162.0	177.0
18	120 hour	87.6	96.0	121.0	137.0	152.0	174.0	190.0
19	144 hour	94.1	103.0	130.0	148.0	164.0	187.0	205.0
20	168 hour	101.0	110.0	139.0	158.0	177.0	203.0	223.0

Estimated Runoff Rates

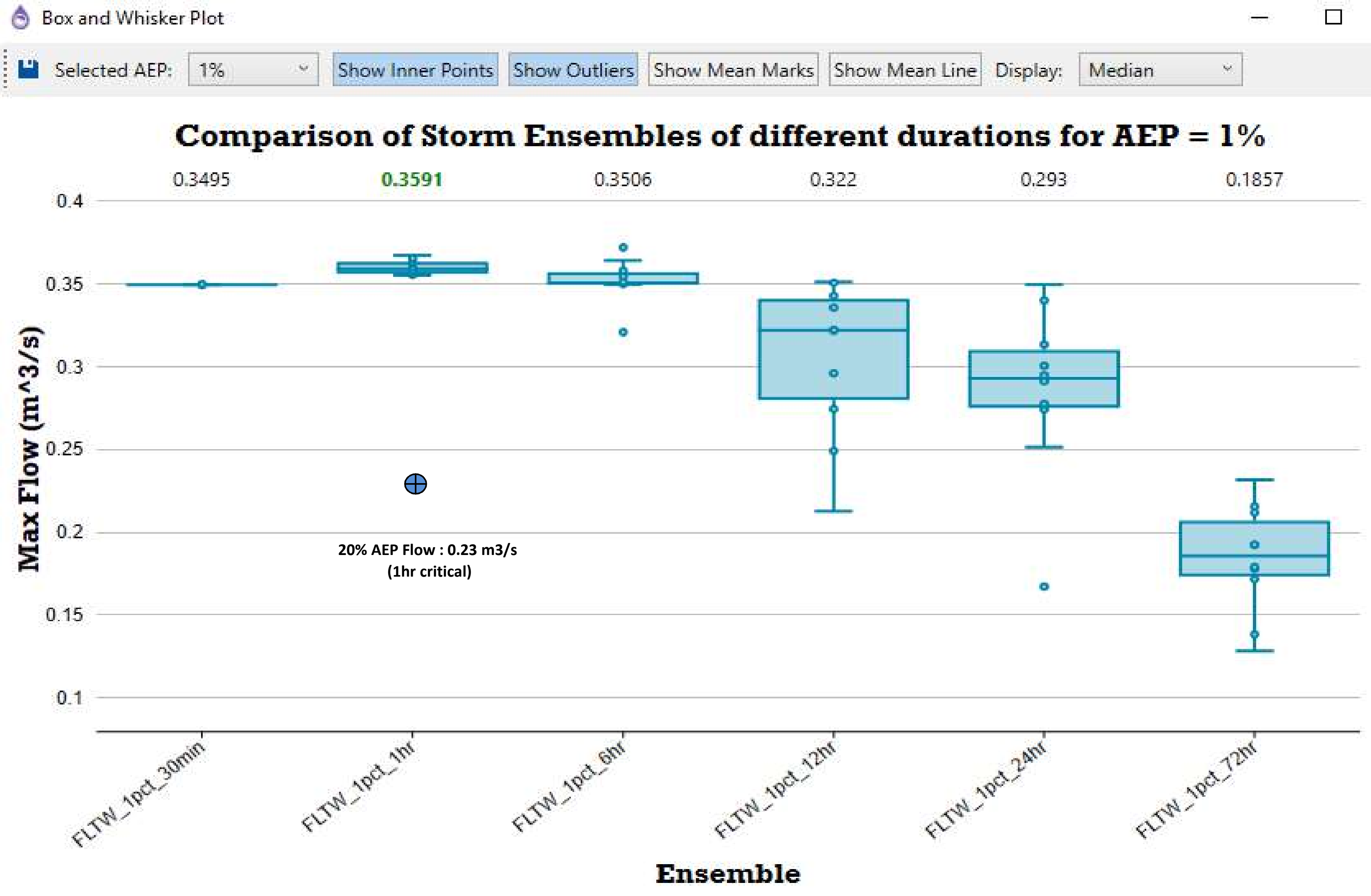
Annual Exceedence Probability

Maximum of All Events	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
Residential Lots	21%	23%	30%	34%	37%	42%	44%
Roads	69%	69%	69%	74%	77%	81%	84%
POS	1%	1%	3%	7%	10%	14%	16%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	36%	38%	42%	46%	50%	54%	56%

Event Selector	9	1 hour					
Residential Lots	0%	2%	14%	20%	26%	31%	34%
Roads	63%	64%	65%	70%	74%	78%	80%
POS	1%	1%	1%	5%	8%	12%	14%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	22%	23%	31%	37%	41%	46%	49%

APPENDIX L
LSP Area Stormwater Modelling Outputs

Date: 1/9/2021 Job No H21087



hyd2o

Watermark Area 3 Local Water Mangement Strategy

Post Development System : Modelling Results at POS Basin Outlet (Box & Whisker)

Appendix L

APPENDIX M
Engineering Drawings

3 SITEWORKS AND EARTHWORKS

Siteworks to support residential urban development will generally comprise the clearing of existing vegetation, stripping of topsoil, earthworking of the existing ground surface, compaction to areas of existing fill and import of a sand topping to facilitate the proposed form of development.

While the majority of the site is utilised for the manufacture of bricks and masonry product, there are some stands of vegetation which may ultimately impact on the concept design. One of these is along the Swan River foreshore within an area identified as Bush Forever and the other is near the Leslie Road frontage.

Given the existing soils within the site consist of material unsuitable for residential development in its current state and the geotechnical requirement for imported sand fill, limited vegetation will be able to be retained during site preparation. However, some of the more significant trees have been identified with the planning and conceptual earthworks design taking in to account these trees for retention.

Development of the site will require removal of all brick and clay stock on site as well as the demolition of existing buildings, pavements and services prior to undertaking site earthworks, servicing and roadworks to produce the desired development form. Following demolition of existing infrastructure, earthworking will take place to provide for a desired development form while addressing the engineering constraints of the site.

The clayey subgrade surface will be earthworked and shaped, before the sand is placed, to ensure no ponding of perched water occurs. Following the subgrade works, a layer of clean sand fill will be imported and placed above the clayey material to achieve the proposed finished levels and desired site classification. Earthworking of the site is also required to ensure the positive drainage of the allotments to the road and drainage reserves for disposal.

The Douglas Partners geotechnical review recommends that there is a minimum depth zone of at least 1.2m of compacted clay fill that sits below the sand topping layer. Therefore, areas where there is less than 1.2m of clay filling required below the sand layer will need to be over-excavated and recompacted. Where the excavated material has brick or other deleterious inclusions, a screening and crushing process will be required to downsize material to less than 50mm to ensure there are no voids in the future structural fill matrix.

The imported material used for filling should be a free drainage clean sand material having a fines content less than 5% and permeability greater than 5m/day to avoid the imported material having a negative impact on site drainage.

Once an appropriate level of site preparation is undertaken to address the geotechnical risk from the existing fill, compaction of the clayey subgrade and depending on the thickness of the proposed sand fill layer over the clayey soils, it is expected that the post development site classification will be “A” or “S”, in accordance with AS2870.

It is anticipated that the final levels across the site will be dictated by either the fill required for improvement of the AS2870 site classification or the minimum level required to ensure adequate separation from the Guildford formation and groundwater levels. Additionally, final levels will need to accommodate interface levels with the adjacent developments and existing infrastructure. Furthermore, finished floor levels for the buildings will need to be at least 500mm above the estimated 1% average exceedance probability (AEP) flood levels.

In accordance with current market expectations flat residential allotments will generally be created. Due to the proposed earthworks strategy, stepping between allotments is likely to be achieved with the minimal use of retaining.

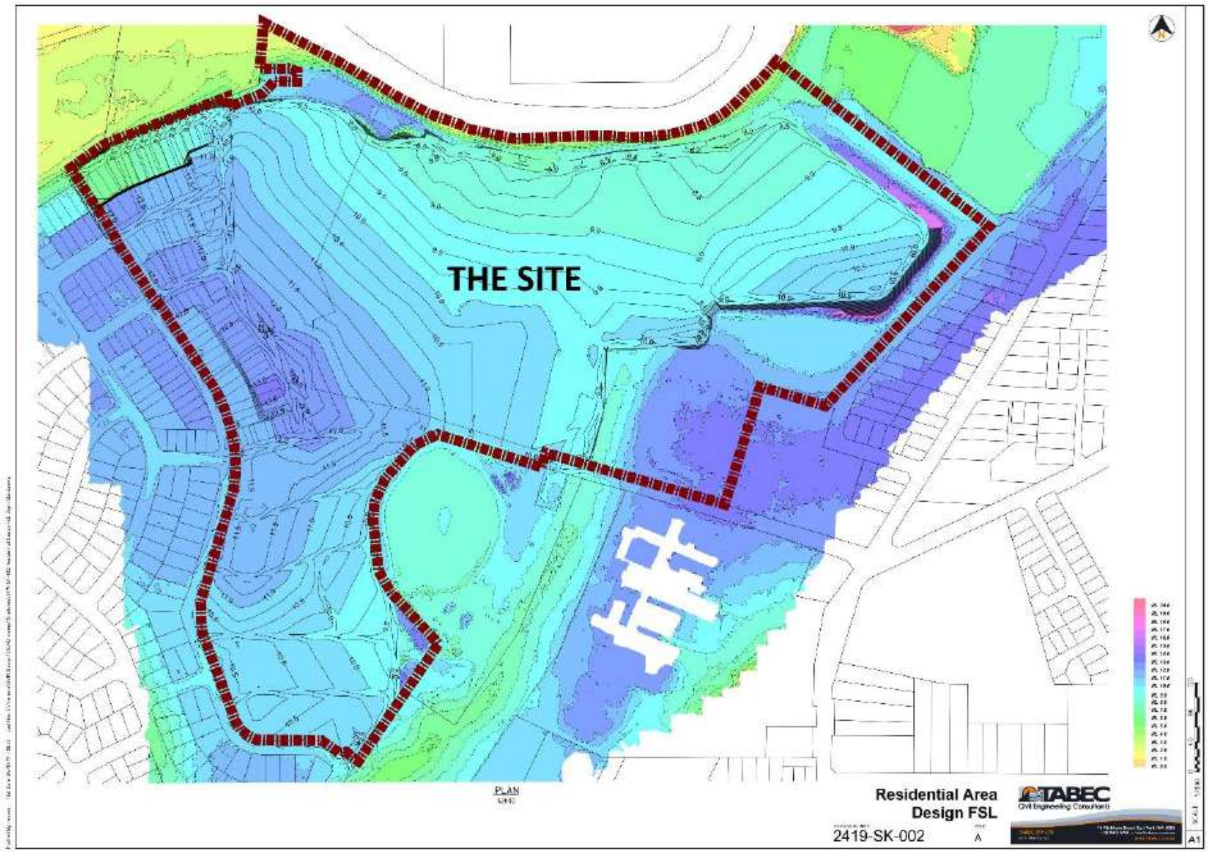
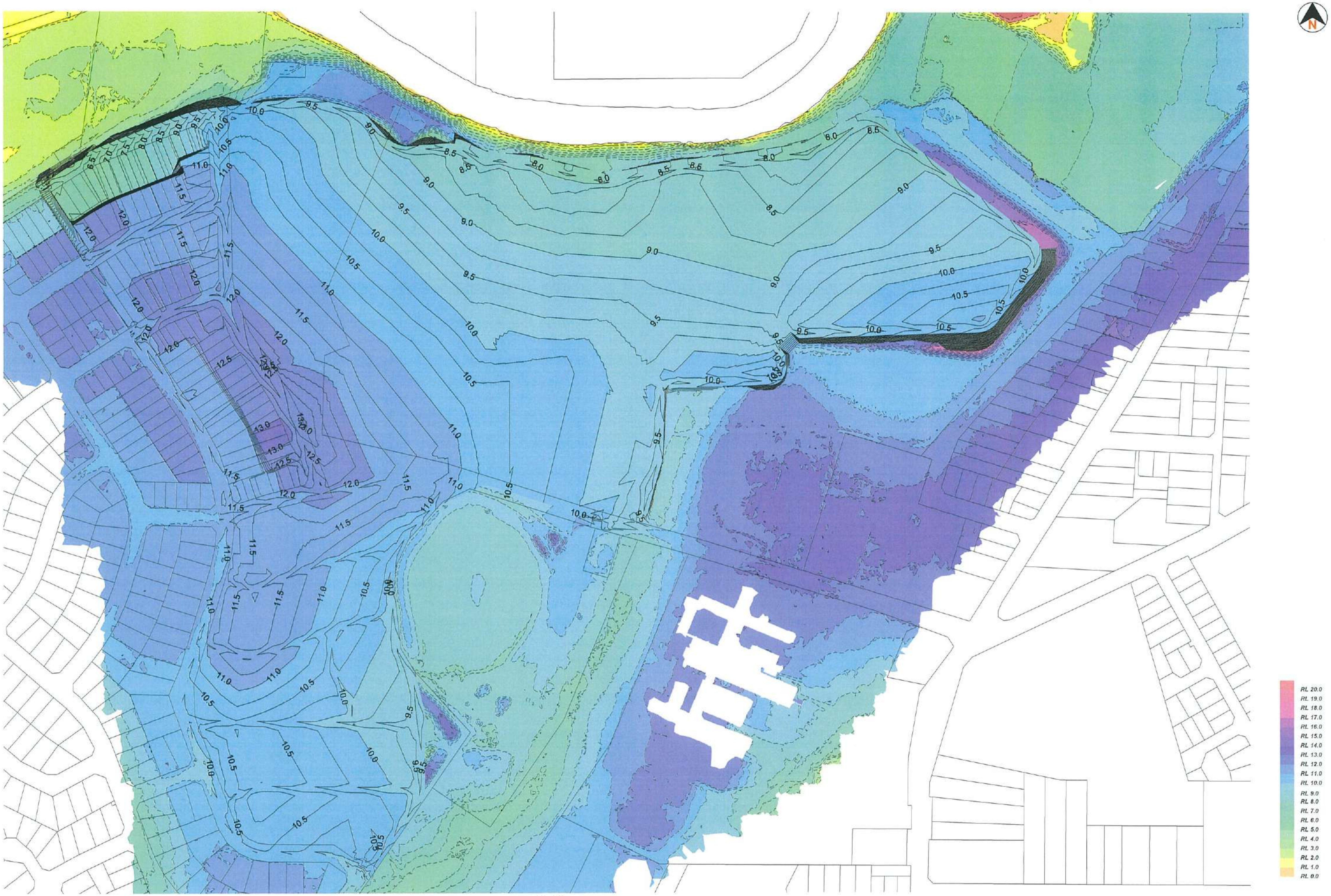


Figure 7 – Concept Bulk Earthworks Design (TABEC, July 2019)



PLAN
1:2000

SCALE 1:2000
0 40 80 120

Residential Area Design FSL

DRAWING NUMBER
2419-SK-002

ISSUE
A

A1

TABEC
Civil Engineering Consultants
TABEC PTY LTD
ACN 090 796 204
14 Wickham Street, East Perth WA 6004
t 08 9425 5900 e info@tabec.com.au
www.tabec.com.au

Plotted By: revans Plot Date: 24/10/19 - 08:31 Cad File: T:\Projects\2419\Design\CAD\Drawings\Sketches\2419-SK-002 Residential Design FSL Depth Bands.dwg

hyd2o
HYDROLOGY

abn 93 697 380 883
suite 6b 103 rokeby rd subiaco wa 6008
PO Box 1055 subiaco wa 6904
p 08 9382 8683 f 08 9382 8712
www.hyd2o.com.au

Appendix B

Bushfire Management Plan (Emerge Associates)

Bushfire Management Plan

Area 3 Middle Swan Brickworks Local Structure Plan

Project No: EP19-105(44)

Prepared for Hesperia Pty Ltd
March 2024

Document Control

Doc name:	Bushfire Management Plan Area 3 Middle Swan Brickworks Local Structure Plan				
Doc no.:	EP19-105(44)--080 BRB				
Version	**Date**	**Author**		**Reviewer**	
1	September 2021	Bianca Bertelli	BRB	Dana Elphinstone	DAE
	Report issued for client comment.				
A	July 2022	Pascal Scholz	PPS	Jason Hick	JDH
				Dana Elphinstone	DAE
	Report updated to incorporate updated local structure plan.				
B	May 2023	Pascal Scholz	PPS	Anthony Rowe	AJR
	Report updated to incorporate updated local structure plan.				
C	March 2024	Pascal Scholz	PPS	Anthony Rowe	AJR
	Report updated to incorporate changes to the landscape concept.				

Executive Summary

Hesperia Pty Ltd (the proponent) is progressing structure planning over Lot 9000 Cranwood Crescent, Viveash (herein referred to as 'the site') in the City of Swan. The site is 10.9 hectares in area and located approximately 17 km north-east of the Perth Central Business District. The site includes a 5.40 hectare portion of the existing Middle Swan Brickworks site. As a result of the existing brickworks infrastructure, the site is almost entirely covered with sealed surfaces, sedimentation ponds and hardstand areas. It is bounded by a developing residential subdivision (WAPC Subdivision Approval reference #158848) and Eveline Road to the north, the Midland Bricks industrial hardstand areas to the north-east, Jack Williamson Park to the east and Cranwood Crescent and existing urban development to the south and west. The site is currently zoned 'Urban' under the *Metropolitan Region Scheme* and 'Industrial' under the City of Swan *Local Planning Scheme No.17*. A scheme amendment request to the City of Swan *Local Planning Scheme No. 17* to rezone the site from 'Industrial' to 'Residential' has been lodged.

The site is comprised of industrial uses associated with the Middle Swan Brickworks, which is in the process of being decommissioned. The lodged local planning scheme amendment proposal is intended to facilitate future residential development following the decommissioning of a portion of the Middle Swan Brickworks in alignment with the proposed Local Structure Plan provided in **Appendix A.**

The site is located within a 'bushfire prone area' under the state-wide Map of Bush Fire Prone Areas prepared by the Office of Bushfire Risk Management (OBRM 2021). The identification of a site within an area declared as bushfire prone necessitates a further assessment of the determined bushfire risk affecting the site in accordance with *Australian Standard 3959:2018 Construction of buildings in bushfire prone areas* (AS 3959), and the satisfactory compliance of the proposal with the policy measures described in *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015) and the *Guidelines for Planning in Bushfire Prone Areas Version 1.4* (the Guidelines) (DPLH & WAPC 2021).

The purpose of this BMP is to assess the bushfire hazards, both within and nearby the site, and identify the 'management' strategies required to ensure the development of the land is consistent with the intent of SPP 3.7 - *to preserve life and reduce the impact of bushfire on property and infrastructure.*

This BMP has followed the requirements of SPP 3.7 to identify bushfire risk and the bushfire protection measures that will make the land suitable for its intended purpose. As part of this, a Bushfire Attack Level (BAL) assessment involving the classification and condition of vegetation within 150 m of the site has been undertaken.

As part of assessing the long-term bushfire risk to the site, vegetation classifications have been detailed for the pre and post-development scenario (in accordance with AS 3959) in order to inform a bushfire attack level (BAL) assessment. The following bushfire hazards were identified as applicable to the site following residential development (post-development):

- Forest (Class A) vegetation to the south-east of the site, north of Muriel Street, and associated with a foreshore area.
- Grassland (Class G) vegetation, associated with a proposed drainage area that will include sedge planting. This area may be managed in the future, but for the purposes of this assessment is assumed to be unmanaged.

To consider the likely bushfire risk applicable to future development at the site, the post-development vegetation classification scenario has been considered in which existing classified vegetation within the site will predominantly be removed or managed to a 'low threat' standard. The drainage/ public open space area within the site will be planted and potentially not subject to regular management, and has been assumed to be a grassland classification. Forest vegetation outside the site has been assumed to remain the same post-development of the site.

Compliance Assessment

The outcomes of this BMP demonstrate that as development progresses, it will be possible for an acceptable solution to be adopted for each of the applicable bushfire protection criteria outlined in the Guidelines. This includes:

- **Location**: Results of the bushfire attack level (BAL) assessment demonstrate that the future development (i.e. residential dwellings) can be located in an area (within future lots) that will, on completion, achieve BAL–29 or below (predominantly BAL- 12.5 and BAL-LOW).
- **Siting and Design**: All future habitable buildings can be sited within the proposed development so that BAL-29 or less can be achieved based on the local structure plan. Asset Protection Zones are achieved for all lots through management of residential lots, non-vegetated areas and low threat vegetation in the design including within lots, roadways and public open space.
- **Vehicular Access**: The local structure plan provides for connections to Surrey Way and Eveline Road to the north, which further connects onto Great Northern Highway providing egress to the north and south, and multiple connections to Cranwood Crescent to the west and south.
- **Water**: the development will be provided with a permanent and reticulated water supply to support onsite firefighting requirements.

The management/mitigation measures to be implemented through the future subdivision of the site have been outlined as part of this BMP. Following certification, the BAL ratings indicated within this BMP (or as part of future stage-based BAL assessments) can be used to support future building approval processes.

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List of Abbreviations

Table A1: Abbreviations – General terms

General terms	
AHD	Australian Height Datum
AS	Australian Standard
APZ	Asset Protection Zone
BAL	Bushfire Attack Level
BHL	Bushfire Hazard Level
BMP	Bushfire Management Plan
BPAD	Bushfire Planning and Design
CCW	Conservation category wetland
ESA	Environmentally Sensitive Area
FDI	Fire Danger Index
FZ	Flame Zone
TEC	Threatened ecological community

Table A2: Abbreviations – Organisations

Organisations	
BoM	Bureau of Meteorology
DBCA	Department of Biodiversity Conservation and Attractions
DoW	Department of Water (now known as Department of Water and Environment Regulation)
DFES	Department of Fire and Emergency Services
DPLH	Department of Planning, Lands and Heritage
OBRM	Office of Bushfire Risk Management
WAPC	Western Australian Planning Commission

Table A3: Abbreviations – Legislation and policies

Legislation	
AS 3959	Australian Standard 3959-2018 Construction of buildings in bushfire-prone areas
Guidelines	*Guidelines for Planning in Bushfire Prone Areas version 1.4* (DPLH & WAPC 2021)
SPP 3.7	State Planning Policy 3.7 Planning in Bushfire Prone Areas (WAPC 2015)

Table A4: Abbreviations – Planning and building terms

Planning and building terms	
MRS	Metropolitan Regional Scheme
POS	Public Open Space
LPS	Local Planning Scheme

1 Proposal Details

1.1 Background

Hesperia Pty Ltd (the proponent) is progressing structure planning over Lot 9000 Cranwood Crescent, Viveash (herein referred to as 'the site') in the City of Swan (CoS) to facilitate future residential development. The site is 10.9 hectares (ha) in area and located approximately 17 km north-east of the Perth Central Business District. The site includes a 5.40 ha portion of the existing Middle Swan Brickworks site. As a result of existing brickworks infrastructure, the site is almost entirely covered with sealed surfaces, sedimentation ponds and hardstand areas. It is bounded by a developing residential subdivision (WAPC Subdivision Approval reference #158848) and Eveline Road to the north (presently undergoing extension to connect to the Great Northern Highway), the Midland Bricks industrial hardstand areas to the north-east, Jack Williamson Park to the east, and Cranwood Crescent and existing urban development to the south and west. The site is currently zoned 'Urban' under the Metropolitan Region Scheme (MRS), as shown in **Plate 1**, and 'Industrial' under the CoS LPS No.17, as shown in **Plate 2**. A scheme amendment request to the CoS LPS No. 17 to rezone the site from 'Industrial' to 'Residential' has been lodged.

The site is comprised of industrial uses associated with the Middle Swan Brickworks, which is in the process of being decommissioned. The lodged LPS amendment proposal is intended to facilitate future residential development following the decommissioning of a portion of the Middle Swan Brickworks in alignment with the Local Structure Plan provided in **Appendix A.**

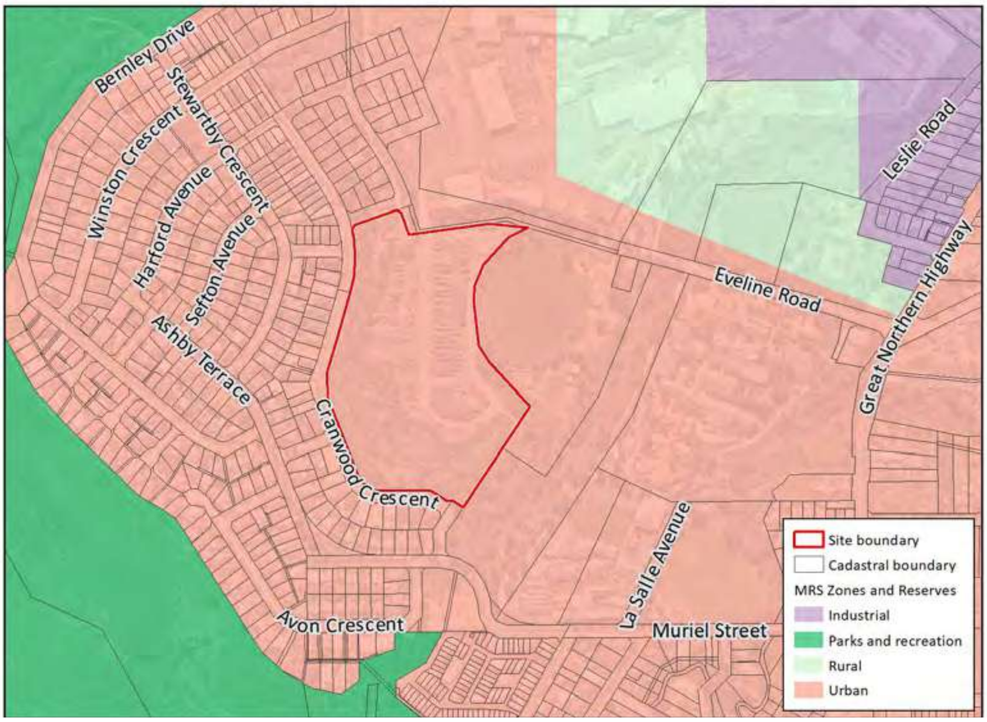

Plate 1: Metropolitan Region Scheme (MRS) zones and reserves within and surrounding the site

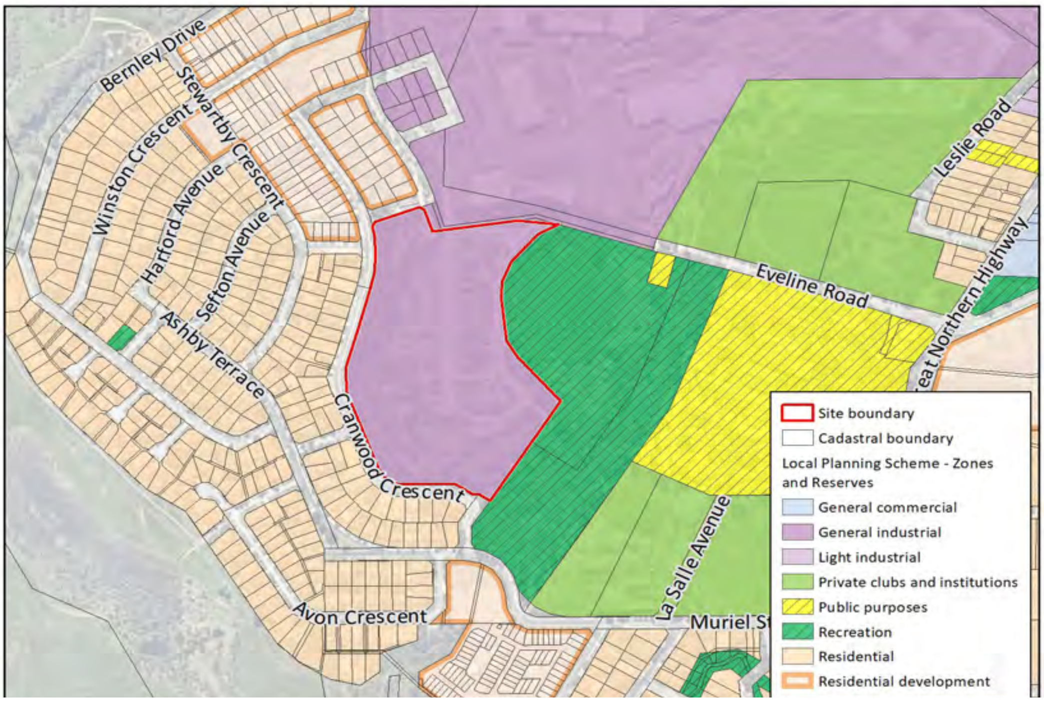

Plate 2: City of Swan Local Planning Scheme No.17 zones and reserves within and surrounding the site

The site is currently located within a 'bushfire prone area' under the state-wide Map of Bush Fire Prone Areas prepared by the Office of Bushfire Risk Management (OBRM 2021) as shown in **Plate 3**. The identification of a site within an area declared as bushfire prone necessitates a further assessment of the determined bushfire risk affecting the site in accordance with *Australian Standard 3959:2018 Construction of buildings in bushfire prone areas* (AS 3959), and the satisfactory compliance of the proposal with the policy measures described in *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015) and the *Guidelines for Planning in Bushfire Prone Areas Version 1.4* (the Guidelines) (DPLH & WAPC 2021).

The purpose of SPP 3.7 and its policy intent is to preserve life and reduce the impact of bushfires on property and infrastructure through effective risk-based land use planning. Importantly, it is risk-based, requiring a methodical approach to identify and evaluate the hazards and provide the treatments to ameliorate these hazards to an acceptable level. SPP 3.7 requires that the determining authority give consideration to the precautionary principle (clause 6.11 in SPP 3.7) and they must be satisfied that the potential for significant adverse impacts can be adequately reduced or managed. In particular:

> *SPP 3.7 does not require that there be no increase at all in the threat of bushfire to people property or infrastructure. Rather, as is seen in clause 2 of SPP 3.7, the intention of the policy is to 'implement effective, risk¬based land use planning and development to preserve life and* ***reduce the impact of bushfire on property and infrastructure'****.* (emphasis added) [1]

[1] Harmanis Holdings No. 2 Pty Ltd and Western Australian Planning Commission [2019] WASAT 43 (Harmanis).

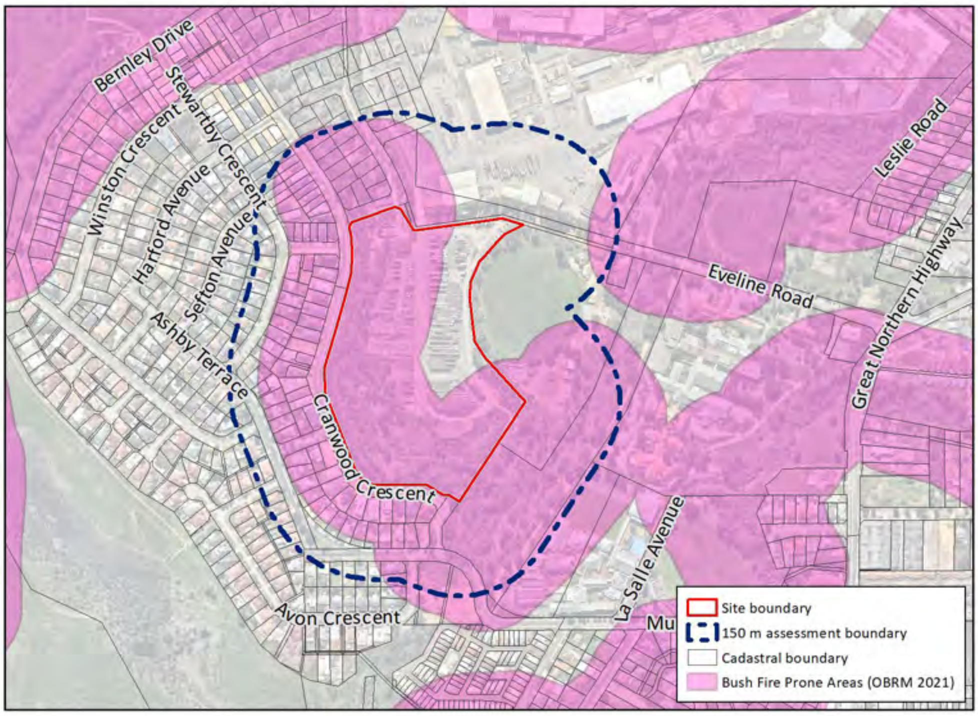

Plate 3: Areas within and surrounding the site are identified as 'bushfire prone areas' (as indicated in purple) under the state-wide Map of Bush Fire Prone Areas (OBRM 2021).

1.2 Aim of this report

The purpose of this BMP is to assess bushfire hazards both within the site and nearby and demonstrate that the threat posed by any identified hazards can be appropriately mitigated and managed. This BMP has been prepared to support the proposed structure plan of the site and addresses the requirements of SPP 3.7 (WAPC 2015), the Guidelines (DPLH & WAPC 2021) and (AS 3959) (Standards Australia 2018). The document includes:

- An assessment of the existing classified vegetation in the vicinity of the site (within 150 m) and consideration of bushfire hazards that will exist in the post-development scenario (**Section 3**).
- Commentary on how the future development can achieve the bushfire protection criteria outlined within the Guidelines including an indication of BAL ratings likely to be applicable to future dwellings (**Section 5**).
- An outline of the roles and responsibilities associated with implementing this BMP (see **Section 6**).

1.3 Statutory policy and framework

The following key legislation, policies and guidelines are relevant to the preparation of a bushfire management plan:

- *Bush Fires Act 1954*
- *Fire and Emergency Services Act 1998*
- *Planning and Development Act 2005* and associated regulations
- *Building Act 2011* and associated regulations
- *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (WAPC 2015)
- *Guidelines for Planning in Bushfire Prone Areas Version 1.4* (DPLH & WAPC 2021)
- *Australian Standard AS 3959 – 2018 Construction of buildings in bushfire prone areas* (Standards Australia 2018)

1.4 Description of the proposed development

A Local Structure Plan has been prepared for the proposed 'Residential' area, as shown in **Appendix A**. The Local Structure Plan intends to demonstrate how the site can be developed within the context of the relevant environmental considerations and provides and outline how the structure and layout of development should be progressed for the site.

Development within the site will include:

- residential lots
- an interconnected public road network
- public open space.

1.5 Description of the land characteristics

Publicly available topographical contours (Landgate 2021) indicate that the topography across the site varies between 8 m AHD within the central portion of the site to 17 m AHD along the western boundary. Topographic contours are shown in **Figure 1.**

The western portion of the site supports remnant native vegetation in 'degraded' condition (Emerge Associates (2020b)) comprising native trees over non-native shrubs and grasses, extending over 4.56 ha. The remainder of the site comprises a 5.40 ha portion of the existing Middle Swan Brickworks site. As a result of existing brickworks infrastructure, this portion of the site is almost entirely covered with sealed surfaces, sedimentation ponds and hardstand areas, with small areas of non-native vegetation.

A review of historical aerial imagery indicates that portions of the site have been cleared since 1953 with the exception of the patch of remnant vegetation within the western portion of the site adjoining the oval, and tree lines along the boundary of the site. Some additional tree planting has occurred since the initial clearing along Eveline Road to the north of the site and surrounding the perimeter of Jack Williamson's oval.

2 Environmental Considerations

In accordance with the *Bushfire Management Plan – BAL Contour* template prepared by the Department of Planning, Lands and Heritage (2018), this BMP has considered whether there are any environmental values that may require specific consideration through either protection, retention or revegetation. To support this, a review of publicly available databases has been undertaken, with particular reference to the Shared Location Information Platform (SLIP) databases. A summary of the search results has been provided in **Table 1**.

Table 1: Summary of potential environmental considerations that may be associated with the site (based on a search of the SLIP databases and site-specific information)

Key environmental feature:	Yes / no / potentially occurring within the site	If yes / potentially, describe the value that may be impacted
Conservation category wetlands and buffer (Geomorphic wetlands Swan Coastal Plain) (DBCA-019)	No	No geomorphic wetlands are mapped as occurring within the site. The Swan River Estuary Conservation Category Wetland (CCW) (UFI# 14,356) occurs approximately 450 m to the north of the site.
Waterways (DWER-031)	No	No natural waterways are identified within the site. The Swan River occurs approximately 450 m to the north of the site.
RAMSAR wetlands (DBCA-010)	No	Not applicable. No RAMSAR wetlands were identified within the site.
Threatened and priority flora (DBCA-036)	No	A flora and vegetation assessment completed by Emerge Associates (2020b) determined that the majority of the site does not provide suitable habitat for threatened or priority flora, due to the high level of historical disturbance. No threatened or priority flora were recorded within the site during the field study.
Threatened and priority fauna (DBCA-037)	Potentially	A fauna survey completed by Emerge Associates (2020a), determined that the site contains fauna habitat for a number of threatened and priority species. No listed conservation significant species were directly or indirectly (from secondary evidence) recorded during the field survey. The likelihood that the site would provide important habitat for these species is low, as the majority of habitat within the site is in relatively poor condition and limited in extent.
Threatened Ecological Communities (TECs) (DBCA-038)	No	The flora and vegetation assessment completed by Emerge Associates (2020b) did not identify any threatened or priority ecological communities within the site, nor was it considered likely for any to occur within the site due to the high level of historical disturbance.
Bush Forever areas (DPLH-019)	No	No Bush Forever Sites are located within the site. Bush Forever Site 302 'Swan River and Jane Brook, Ashfield to Upper Swan' is located approximately 430 m to the north of the site which extends further to the east and west of the site, associated with the Swan River.

Table 1: Summary of potential environmental considerations that may be associated with the site (based on a search of the SLIP databases and site-specific information) (continued)

Key environmental feature:	Yes / no / potentially occurring within the site	If yes / potentially, describe the value that may be impacted
Clearing regulations – Environmentally Sensitive Areas (ESAs) (DWER-046)	No	No ESAs occur within the site. One large ESA is located to the north of the site following the general orientation of the Swan River watercourse. The ESA appears to be associated with the Conservation Category Wetland (CCW) 'Swan River Estuary' (UFI 14,356) which extends over 53.96 ha to the north, east and west of the site.
DBCA controlled lands or waters (DBCA-011)	No	Not applicable. No DBCA controlled lands or waters are identified within the site. It is noted that the Swan River Reserve which adjoins the northern boundary is under Crown land tenure for Landscape Protection.
Swan Bioplan Regionally Significant Natural Areas 2010 (DWER-070)	No	Not applicable.
Aboriginal heritage (DPLH-001)	Yes	The site is adjacent to the boundary of the registered Aboriginal Heritage Site 'Swan River' (ID 3536). While the site intersects with the boundaries of the Registered Heritage Sites; 'Turtle Swamp', 'Blackadder and Woodbridge Creek' and 'Jane Brook' and 'Bishop Road Camp', their actual physical location is not within the site.
Non-indigenous heritage (DPLH-006)	No	There are no non-indigenous heritage sites identified within the site.

2.1 Native vegetation – modification and clearing

<u>Within the site</u>

A large portion of the site is almost entirely covered in sealed surfaces, sedimentation ponds and hardstand areas as a result of existing brickworks infrastructure. Numerous existing planted and naturally regrown trees in the western portion of the site were determined to comprise amenity and environmental values and were assigned a 'high' retention value; therefore, opportunities to retain some of this vegetation within proposed residential lots have been considered in the local structure plan. It is envisaged that all existing classified vegetation to be retained within future residential lots in the western portion of the site will be managed to a low threat standard.

Some clearing of vegetation within the site will be required for bushfire management purposes as part of implementing this BMP, specifically to enable the proposed urban development and associated buildings to meet the relevant siting requirements of the Guidelines. It is envisaged that all clearing of vegetation within the site will be exempt from requiring a clearing permit under Schedule 6 of the *Environmental Protection Act 1986* (EP Act) in accordance with a future subdivision approval under the *Planning and Development Act 2005*. Additionally, a clearing permit will not be required where other exemptions pursuant to the EP Act or Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (where outside and ESA) exist, such as those associated with a building licence or Section 33 of the *Bush Fires Act 1954*.

Outside the site

The residential subdivision area to the north of the site was granted Development Approval by the West Australian Planning Commission on the 4th of August 2020, Ref #158848), therefore it has been assumed that the vegetation in this area will remain cleared and managed to a low threat standard, as detailed in the BMP that supports the subdivision application (Emerge Associates 2019). No other areas of native vegetation outside the site are proposed to be modified or cleared by the proponent as part of the proposed development; therefore, all other vegetation outside the site is assumed to remain in its existing condition (unless where specified otherwise).

2.2 Revegetation and landscape plans

The area identified as public open space in the proposed structure plan will be utilised predominantly for drainage purposes. Based on the required vegetation planting for the drainage area to effectively treat stormwater, low growing reeds and sedges as well as sparse trees that would ultimately comprise less than 10% foliage cover will likely be utilised. There is a potential that this area will not be subject to regular management and is assumed to comprise a grassland (Class G) classification based on the mature state of the vegetation. Any other retained vegetation within the site such as individual mature trees will be managed to a low threat condition in accordance with clause 2.2.3.2 of AS3959.

Where relevant, management of areas of low threat vegetation should include, but not limited to:

- Regular mowing/slashing of grass to less than 100 mm in height (where present).
- Irrigation of grass and garden beds (where required).
- Regular removal of weeds and built up dead material (such as fallen branches, leaf litter etc.).
- Low pruning of trees (branches below 2 m in height removed where appropriate/applicable).
- Application of ground/surface covers such as mulch or non-flammable materials as required/applicable.

3 Bushfire Assessment Results

Bushfire risk for the site has been appropriately considered both in context to the site and potential impact upon the site using AS 3959 and the Guidelines.

The objective of AS 3959 is to reduce the risk of ignition and loss of a building to bushfire. It provides a consistent method for determining a radiant heat level (radiant heat flux) as a primary consideration of bushfire attack. AS 3959 measures the Bushfire Attack Level (BAL) as the radiant heat level (kW/m^2) over a distance of 100 m. AS 3959 also prescribes deemed-to-satisfy construction responses that can resist the determined radiant heat level at a given distance from the fire. It is based on six Bushfire Attack Level (BAL) ratings: BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ.

A BAL contour plan has been prepared in accordance with Appendix Three of the Guidelines and Method 1 of AS 3959 to determine the BAL ratings likely to be applicable to future buildings. This has been based on the vegetation classifications and the effective slope under the vegetation, with the result presented on the BAL contour plan, as shown in **Figure 5**.

3.1 Assessment inputs

This bushfire attack level (BAL) assessment was undertaken in accordance with Method 1 of AS 3959. Vegetation classifications and effective slope post-development have been detailed in **Figure 3** and **Figure 4**, respectively. A BAL Contour Plan has been prepared based on the developed condition of the site in accordance with Appendix Three of the Guidelines and is provided as **Figure 5**.

3.1.1 Assumptions

The BAL assessment is based on the following assumptions:

- **Designated FDI**: 80
- **Flame temperature**: 1090 K
- **Effective slope** beneath classified vegetation: flat/upslope (**Figure 4**)
- The public open space area within the site will be serve as a drainage basin and is assumed to be classified grassland (Class G) vegetation at a mature state.
- All other vegetation within the site will be managed in order to achieve a low threat classification in accordance with Section 2.2.3.2 of AS 3959. Management may include:
  - Clearing of vegetation.
  - Regular maintenance including removal of weeds and dead material.
  - Where remnant trees are retained, these will be low pruned to 2 m from the ground.
  - Application of ground covers such as mulch or non-flammable materials.
  - Where grass/turf is present, this will be regularly cut so that the grass is maintained at or below 100 mm in height.
- As part of staged development, classified vegetation within the site will be removed as part of future subdivision works. Future subdivision will be developed with a combination of non-vegetated land and low threat vegetation within future residential lots managed in perpetuity. Where trees are to be retained within future lots in the western portion of the site, these will be

managed to a low threat standard. All classified forest vegetation surrounding the site will remain in its existing state in the future, and will, therefore, remain a bushfire risk to the site.

- Areas outside the site within private landholdings that have been identified as a low threat will continue to be managed and/or considered to achieve low threat (in accordance with Section 2.2.3.2 of AS 3959) based on the existing maintenance regimes.
- The proponent has entered into an agreement with the City of Swan that the existing Jack Williamson Oval and associated bund to the east of the site will be upgraded and achieve low threat in accordance with clause 2.2.3.2(f) of AS 3959. All classified grassland vegetation will be removed and the post-development condition of this area will include a combination of turf, low planting (in garden beds) and mulch as part of the POS and will be managed to low threat in perpetuity.

3.1.2 Vegetation classification

All vegetation within 150 m of the site was classified in accordance with Clause 2.2.3 of AS 3959. Each distinguishable vegetation plot is described in **Table 2** and shown in **Figure 2**. This classification is a conservative assessment of the vegetation which includes areas that should be managed to a low threat under the City of Swan Fire Hazard Reduction Notice.

Not all vegetation is classified as a bushfire risk. Vegetation and ground surfaces that are exempt from classification as a potential hazard are identified as a low threat under Section 2.2.3.2 of AS 3959. Low threat vegetation includes the following:

a) Vegetation of any type that is more than 100 m from the site.
b) Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified.
c) Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other or of other areas of vegetation being classified.
d) Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified.
e) Non-vegetated areas, that is, areas permanently cleared of vegetation, including waterways, exposed beaches, roads, footpaths, buildings, and rocky outcrops.
f) Vegetation regarded as low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves, and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops), cultivated gardens, commercial nurseries, nature strips and wind breaks.

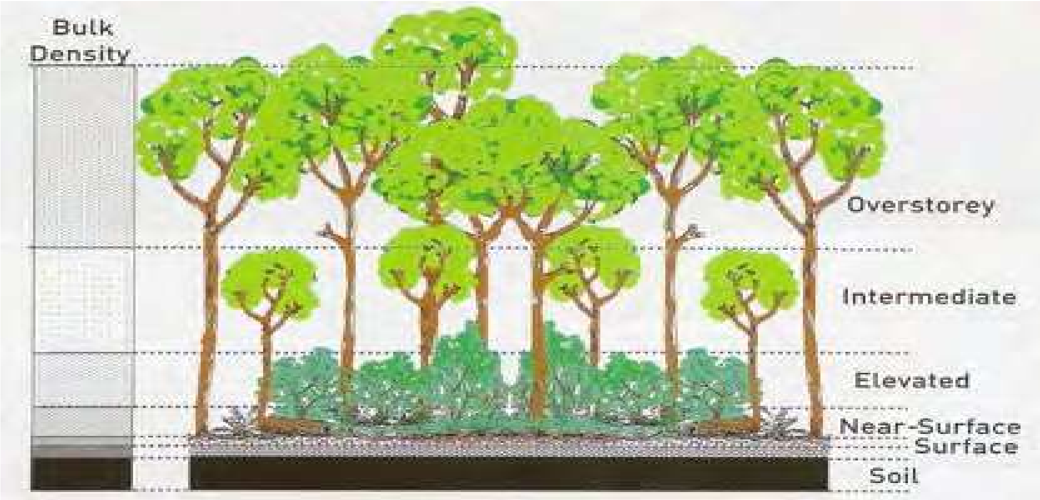

Plate 4: The five fuel layers in a forest environment that could be associated with fire behaviour (Gould et al. 2007)

Table 2: Vegetation classification, bushfire hazard rating and future management

Pre-development (Figure 2)			Post development (Figure 3 and Figure 4)	
Plot	**AS 3959 classification**	**Site photo/s (location points shown in Figure 2)**	**Plot**	**AS 3959 classification, effective slope and assumptions**
1	AS 3959 classification (Figure 2): Forest (Class A) Forest vegetation was identified within the southern portion and along the western boundary of the site along Cranwood Crescent. Forest vegetation within the site is characterised by a mixture of native and planted vegetation, including areas of marri and planted non-native *Eucalyptus* spp., growing to a height of > 15 m, with native and non-native understorey species. This vegetation has a foliage cover greater than 30%.	 Photo location 1: Forest vegetation within the western portion of the site along Cranwood Crescent  Photo location 2: Forest vegetation (background) within the north-western portion of the site along Cranwood Crescent	5	AS 3959 classification (Figure 3): Low threat (exclusion clause 2.2.3.2(f)) **Effective slope (**Figure 4**):** Not applicable The forest vegetation along the western site boundary along Cranwood Crescent will be modified and managed to achieve a low threat standard within future residential lots in perpetuity. Additionally, a small portion of forest vegetation in the eastern portion of the site will be modified and managed within the proposed POS areas. This management will involve the removal of vegetation from the understorey and intermediate fuel layers, in addition to elevated fuel layers where appropriate/required.
		 Photo location 3: Forest vegetation within the southern portion of the site  Photo location 4: Forest vegetation within the eastern portion of the site	6	AS 3959 classification (Figure 3): Non vegetated area (exclusion 2.2.3.2(e)) **Effective slope (**Figure 4**):** Not applicable The remaining forest vegetation not identified for retention within future residential lots will be removed as part of the proposed development to form future residential lots and roads and has been identified as non-vegetated.

Table 2: Vegetation classification, bushfire hazard rating and future management (continued)

Pre-development (Figure 2)			Post development (Figure 3 and Figure 4)	
Plot	**AS 3959 classification**	**Site photo/s (location points shown in Figure 2)**	**Plot**	**AS 3959 classification, effective slope and assumptions**
2	AS 3959 classification (Figure 2): Forest (Class A) Forest vegetation has been identified to the south and south-east of the site and is characterised by native and non-native Eucalyptus spp. growing to a height of 8 - > 15 m with more than 30% foliage cover and minimal understorey growth. Understorey vegetation consists of non-native grasses and occasional native shrubs in the understorey.	 Photo location 5: Forest vegetation to the south of the site  Photo location 6: Forest vegetation to the south-east of the site  Photo location 7: Forest vegetation to the south-east of the site  Photo location 8: Forest vegetation to the south-east of the site	2a and 2b	AS 3959 classification (Figure 3): Forest (Class A) **Effective slope (**Figure 4**):** Flat/upslope (Plot 2a) Downslope 0-5 (Plot 2b) The forest vegetation located to the south and south-east of the site abutting Jack Williamson Park is assumed to be unmanaged and remain forest (Class A) classification. These areas of vegetation will, therefore, remain a bushfire risk to the site.

Table 2: Vegetation classification, bushfire hazard rating and future management (continued)

Pre-development (Figure 2)			**Post development (Figure 3 and Figure 4)**	
Plot	**AS 3959 classification**	**Site photo/s (location points shown in Figure 2)**	**Plot**	**AS 3959 classification, effective slope and assumptions**
3	AS 3959 classification (Figure 2): Grassland (Class G) Grassland vegetation has been identified to the east of the site. The areas of grassland vegetation to the east of the site contain surface and near-surface fuel loads, containing non-native grass species that are unmanaged. The vegetation on the oval to the south-west is no longer used as a sports ground and grows to over 10 cm in height. Emerge has visited the area numerous times and observed the oval in various states of management. Whilst some evidence of management was observed in these images, at the time of the site inspection it was classified as unmanaged grassland.	 Photo location 9: Grassland vegetation to the east of the site within Jack Williamson's Park  Photo location 10: Grassland vegetation to the east of the site within Jack Williamson's Park  Photo location 11: Grassland vegetation to the east of the site within Jack Williamson's Park  Photo location 12: Grassland vegetation to the east of the site within Jack Williamson's Park	4	AS 3959 classification (Figure 3): Low threat (exclusion clause 2.2.3.2(f)) **Effective slope (**Figure 4**):** Not applicable The proponent has entered into an agreement with the City of Swan that the existing Jack Williamson Oval and associated bund will be upgraded and achieve low threat in accordance with clause 2.2.3.2(f). The post-development condition of this area will include a combination of turf, low planting (in garden beds) and mulch as part of the POS and will be managed to low threat in perpetuity.

Table 2: Vegetation classification, bushfire hazard rating and future management (continued)

Pre-development (Figure 2)			Post development (Figure 3 and Figure 4)	
Plot	**AS 3959 classification**	**Site photo/s (location points shown in Figure 2)**	**Plot**	**AS 3959 classification, effective slope and assumptions**
5	AS 3959 classification (Figure 2): Low threat vegetation (exclusion 2.2.3.2(f)) Low threat vegetation has been to the northwest of the site within a managed park with cleared understorey and managed ground cover (photo points 13 and 14). Low threat vegetation north of the site is associated with single rows of trees that have been identified as windbreaks (photo points 15 and 16). Low threat vegetation to the west of the site is associated with areas of managed grassland, which is irrigated and regularly cut to less than 10 cm.	 Photo location 13 – managed vegetation to the north of the site (behind the fence)  Photo location 14 – managed vegetation to the north of the site (behind fence)  Photo location 15 – managed vegetation to the north east of the site  Photo location 16 – managed vegetation to the north of the site	5	AS 3959 classification (Figure 3): Low threat vegetation (exclusion 2.2.3.2(f)) **Effective slope (**Figure 4**):** Not applicable The maintenance regimes for all existing low threat vegetation surrounding the site is assumed to continue in the long-term based on current land uses and management arrangements, in accordance with the requirements of the City of Swan.

Table 2: Vegetation classification, bushfire hazard rating and future management (continued)

Pre-development (Figure 2)				Post development (Figure 3 and Figure 4)	
Plot	**AS 3959 classification**	**Site photo/s (location points shown in Figure 2)**		**Plot**	**AS 3959 classification, effective slope and assumptions**
4	AS 3959 classification (Figure 3): Non-vegetated area (exclusion 2.2.3.2(e)) Non-vegetated areas such as existing roads, driveways, existing dwellings and areas of mineral earth within and surrounding the site have been excluded in accordance with Clause 2.2.3.2(e) of AS 3959. Areas associated with developed residential land may contain areas of low threat vegetation. This has been mapped as non-vegetated for ease of reference.	 *Photo location 17: non-vegetated brickworks within the central portion of the site*	 *Photo location 18: non-vegetated area to the east of the site.*	6	AS 3959 classification (Figure 3): Non-vegetated area (exclusion clause 2.2.3.2(e)) **Effective slope (**Figure 4**):** N/A Areas within and external to the site that have been identified as non-vegetated will remain non-vegetated when converted to public roads and/or residential land uses as part of the proposed development of the site.

3.1.3 Assessment outputs

3.1.3.1 Bushfire attack level assessment

The BAL assessment completed for the site indicates that a BAL rating of BAL-29 or less can be achieved at future habitable buildings based on the indicated spatial layout; this is dependent on the requirement for setbacks provided by the internal road network, specifically along the eastern and southern boundaries of the site, see **Figure 5**.

Table 3 provides a summary of the setback distances necessary from classified vegetation to achieve the indicated BAL ratings, with the BAL Contour Plan (**Figure 5**) being a visual representation of these distances. The setback distances are based on the post-development classified vegetation (**Figure 3**) and effective slope (**Figure 4**), and are taken from Table 2.5 of AS 3959.

Table 3: Setbacks required from classified vegetation in order to achieve BAL-29

Plot number (Figure 3)	Vegetation classification (Figure 3)	Effective slope (Figure 4)	Distance to vegetation (from Table 2.5 of AS 3959)	BAL rating (Figure 5)
2a	Forest (Class A)	Flat/upslope	< 16 m	BAL-FZ
			16 - < 21 m	BAL-40
			21 - < 31 m	BAL-29
			31 - < 42 m	BAL-19
			42 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
2b	Forest (Class A)	Downslope 0-5°	< 20 m	BAL-FZ
			20 - < 27 m	BAL-40
			27 - < 37 m	BAL-29
			37 - < 50 m	BAL-19
			50 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
3	Grassland (Class G)	Flat/upslope	< 6 m	BAL-FZ
			6 - < 8 m	BAL-40
			8 - < 12 m	BAL-29
			12 - < 17 m	BAL-19
			17 - < 50 m	BAL-12.5
			> 50 m	BAL-LOW

4 Identification of Bushfire Hazard Issues

From a bushfire hazard management perspective, the key issues that are likely to require management and/or consideration as part of the future building permit process include:

- Provision of appropriate separation distance from bushfire hazards within and surrounding the site (to the east and south), to ensure a BAL rating of BAL-29 or less can be achieved at future habitable buildings (built form). The minimum setback distances required have been provided in **Table 3**.
- Where applicable ensuring that site landscaping is designed, implemented and managed to achieve low threat standards to reduce the risk of fires starting onsite.
- Provision of appropriate vehicular access to ensure that when development within the site is fully constructed, egress to at least two different destinations will be available to residents, visitors, future workers and emergency personnel.
- Provision of appropriate water supply and associated infrastructure.

These issues are considered further in **Section 5**.

5 Assessment against the Bushfire Protection Criteria

This BMP provides an outline of the mitigation strategies that will ensure that as development progresses within the site, an acceptable solution can be adopted for each of the bushfire protection criteria detailed within Appendix Four of the Guidelines. The applicable bushfire protection criteria identified in the Guidelines and addressed as part of this BMP are:

- Element 1: Location of the development
- Element 2: Siting and design of the development
- Element 3: Vehicular access
- Element 4: Water supply.

As part of future development, it is likely that an 'acceptable solution' will be able to address the intent of all four bushfire protection criteria as part of future subdivision of the site. A summary of how this can be achieved and an associated compliance statement for each has been provided in **Table 4.**

Table 4: Assessment against the bushfire protection criteria

Bushfire protection criteria	Proposed bushfire management strategies
Element 1: Location	
A1.1 Development location	The permanent bushfire hazards to future built form are associated with the forest (Class A) vegetation external to the site to the east and south and the grassland (Class G) vegetation within the public open space (drainage area) within the site. The residential areas have been located adjacent to roads which provide appropriate setbacks to this vegetation according to the distances set out in **Table 3**, such that future residential built form will not exceed BAL-29. Based on the BAL Contour Plan (see **Figure 5**), the majority of the proposed residential areas can achieve separation for BAL-29 construction or lower, compliant with A1.1. Part of proposed residential cells in the south-eastern portion of the site are subject to an incursion of BAL-FZ/BAL-40; however, future lots can be appropriately sized such that future habitable dwellings can be located to achieve BAL-29 or less (through public road,/public open space and/or the application of an in-lot setback from the lot boundary and restrictive covenant over the BAL-FZ and BAL-40 portion of the lots). The proposed structure plan complies with A1.1.
Element 2: Siting and design	
A2.1 Asset Protection Zone	One of the most important bushfire protection criteria measures influencing the safety of people and property is to create an Asset Protection Zone (APZ) around buildings. The APZ is a low fuel area immediately surrounding a building and can include non-flammable features such as irrigated landscapes, gardens, driveways, and roads. All future lots for residential development will be required to be maintained as an APZ. The APZ for each lot includes neighboring lots managed to a low-fuel state, public roads, footpaths, cultivated garden and managed parklands. The site is suitably sized to accommodate the minimum separation distances outlined in **Table 3** required to achieve BAL-29 or less for future habitable buildings from classified vegetation surrounding and within the site. APZs surrounding future buildings will be managed in accordance with the requirements of Schedule 1 of the Guidelines '*Standards for Asset Protection Zones'.* Any remaining vegetation within the APZs in this portion of the site will be managed to a low threat standard in accordance with AS 3959, compliant with A2.1.

Table 4: Assessment against the bushfire protection criteria (continued)

Bushfire protection criteria	Proposed bushfire management strategies
Element 3: Vehicular access	
A3.1 Public roads	Existing public roads within the site and surrounds, as well as proposed new public roads, can and will comply with the minimum standards outlined in Appendix Four of the Guidelines and with A3.1 (Table 6, Column 1) or as agreed with the City of Swan, and includes a minimum 6 m-wide trafficable surface, compliant with A3.1.
A3.2a Multiple access routes.	The proposed vehicle access is shown in **Figure 6**. The Local Structure Plan (**Appendix A**) includes connections to Eveline Road to the north, which further connects onto Great Northern Highway providing egress to the north and south, and multiple connections to Cranwood Crescent to the west and south. There are multiple connections to the existing public road network providing access routes for the site compliant with A3.2a.
A3.2b Emergency access way	Not applicable. Given the proposed development plan provides for egress to at least two different destinations, emergency access ways are not required as part of the proposed development of the site.
A3.3 Through-roads	All proposed roads are through-roads, compliant with A3.3.
A3.4a Perimeter roads	A public perimeter road, meeting the requirements contained in Appendix Four of the Guidelines (Table 6, Column 1), provides separation between the proposed lots and classified vegetation east and south-east of the site, compliant with A3.4a.
A3.4b Fire service access route	Not applicable. Future development within the site will be provided with appropriate vehicular access, as outlined above, and therefore fire service access routes are not required.
Element 4: Water	
A4.1 Identification of future water supply	Fire response services require ready access to an adequate water supply for firefighting. The site is located in an area serviced by reticulated water as evidenced by Water Corporation data on Locate (WCORP-002 and WCORP-070). The site will connect to the reticulated water supply and will include fire hydrants installed by the developer to meet the specifications of Water Corporation and DFES, compliant with A4.1

Table 6: Vehicular access technical requirements

TECHNICAL REQUIREMENTS	1 Public roads	2 Emergency access way[1]	3 Fire service access route[1]	4 Battle-axe and private driveways[2]
Minimum trafficable surface (metres)	In accordance with A3.1	6	6	4
Minimum horizontal clearance (metres)	N/A	6	6	6
Minimum vertical clearance (metres)	4.5			
Minimum weight capacity (tonnes)	15			
Maximum grade unsealed road[3]	As outlined in the IPWEA Subdivision Guidelines	1:10 (10%)		
Maximum grade sealed road[3]		1:7 (14.3%)		
Maximum average grade sealed road		1:10 (10%)		
Minimum inner radius of road curves (metres)		8.5		

Notes:
[1] To have crossfalls between 3 and 6%.
[2] Where driveways and battle-axe legs are not required to comply with the widths in A3.5 or A3.6, they are to comply with the Residential Design Codes and Development Control Policy 2.2 Residential Subdivision.
[3] Dips must have no more than a 1 in 8 (12.5% -7.1 degree) entry and exit angle.

Plate 5: Excerpt of Table 6 from The Guidelines

5.1 Additional management strategies

5.1.1 Future approval considerations

The BAL assessment is a conservative and cautious assessment of the potential bushfire risk posed to future habitable buildings within the site based on the proposed management of vegetation and assumptions outlined in **Section 3c**.

Once the structure plan and subdivision approval has been granted, the creation of lot titles and building licences will be required before the dwelling construction can commence. This BMP and the indicative BAL ratings (see **Figure 5**) can be used to inform the construction requirements for future dwellings.

This BMP may be used to support future subdivision applications assuming the layout, vehicle access, and vegetation assumptions remain the same.

5.1.2 Landscape Management

5.1.2.1 Within the site

Where vegetation is to be managed to a low threat standard within the site, this should occur in accordance with Section 2.2.3.2 of AS 3959 and the City of Swan Firebreak Notice/s. The areas of vegetation that will undergo management will predominantly include retained trees within future residential lots along Cranwood Crescent.

The public open space area/drainage area within the site is conservatively assumed to be grassland (Class G) vegetation given it is likely to be unmanaged and therefore a bushfire hazard in the long term.

5.1.2.2 Surrounding the site

Classified forest vegetation external to the site is expected to remain in its current condition and remain a permanent hazard.

The private residential landholdings surrounding the site should be managed by the applicable landowners in accordance with the *City of Swan Firebreak Notice* in perpetuity. Areas of non-vegetated and low threat land are assumed to continue to be managed in accordance with current arrangements.

5.1.3 City of Swan Firebreak Notice

The City of Swan releases a Firebreak Notice on an annual basis to provide a framework for bushfire management within the City. The City of Swan is able to enforce this notice in accordance with Section 33 of the *Bush Fires Act 1954*. In addition, Section 33.1(b) also provides the City with additional power to direct landowners to undertake works to remedy conditions conducive to the outbreak or spread of bushfire

Until development is progressed within the site, existing landowners are required to comply with the Firebreak Notice, including the maintenance of minimum 3 m-wide perimeter firebreaks (or as agreed with the City of Swan).

Once development progresses within the site, future landowners should refer to the *City of Swan Firebreak Notice*, to determine the measures required for compliance.

5.1.4 Vulnerable or high-risk land uses

There is no known vulnerable or high-risk land uses proposed for the site. Any future vulnerable or high-risk land use will be required to meet the requirements of SPP 3.7, which will be dealt with at detailed subdivision and/or development application stages.

5.1.5 Public education and preparedness

Community bushfire safety is a shared responsibility between individuals, the community, government and fire agencies. DFES has an extensive Community Bushfire Education Program including a range of publications, a website and Bushfire Ready Groups. The DFES publication '*Prepare. Act. Survive.'* (DFES 2014) provides excellent advice on preparing for and surviving the bushfire season. Other downloadable brochures are available from http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/pages/publications.aspx

The City of Swan provides bushfire safety advice to residents available from their website https://www.swan.wa.gov.au/Services-support/Emergency-management/Fire/Fire-breaks-hazard-reduction. Professional, qualified consultants also offer bushfire safety advice and relevant services to residents and businesses in high-risk areas in addition that that provided in this BMP.

Professional, qualified consultants also offer bushfire safety advice and relevant services to residents and businesses in addition to that provided in this BMP.

6 Responsibilities for Implementation and Management of Bushfire Measures

Table 5 outlines the responsibilities of the landowner/developer and the City of Swan associated with implementing this BMP at the **local structure plan stage** with reference to ongoing bushfire risk mitigation measures for existing land uses (through compliance with the *City of Swan Firebreak Notice*) or future mitigation measures to be accommodated as part of the future structure planning process. These responsibilities will need to be considered as part of the subsequent development and implementation process.

*Table 5: Responsibilities for the implementation of the BMP at the **structure planning** stage*

Management Action	
No.	**Developer**
1	Provide a copy of this BMP to the relevant decision makers to support approval of the proposed structure plan.
2	If required, prepare a new/revised BMP in accordance with SPP 3.7, the Guidelines and AS 3959 to support future subdivision applications, based on the proposed subdivision concept plan and in consideration of existing bushfire hazards or those that will be present following development. In addition, if the assumptions regarding the treatment of the public open space and public road reserves change as part of future detailed design stages, a revised BMP will be required.
3	Comply with the City of Swan fire control notice/s as published and/or in accordance with directions given by the local government.
4	Where applicable, as part of the subdivision process, make spatial provisions for: • A suitable public road network that provides egress to at least two different destinations and meets the technical requirements of Table 6 within Appendix Four of the Guidelines (or as updated), or as otherwise determined by a bushfire consultant and relevant approval authority. • Where possible, avoid no through roads and battle-axe access legs as part of the spatial layout. If these are proposed as part of future development, they will need to be justified from a planning/development perspective and consistent with the minimum requirements outlined in Appendix Four of the Guidelines (or as updated), or as otherwise determined by a bushfire consultant and relevant approval authority. • Ensure future habitable buildings are able to be located in an area subject to BAL-29 or less. The minimum separation distances between habitable buildings and classified vegetation to achieve BAL-29 should be in accordance with Table 3 in this BMP or as specified in subsequent BAL assessments. These separation distances can be accommodated through locating public roads and/or managed public open space between the habitable building and classified vegetation and/or ensuring proposed residential lots are adequately sized to ensure BAL-29 is not exceeded at the future dwelling and use of in-lot setbacks).

Table 6 outlines the responsibilities of the landowner/developer and the City of Swan associated with implementing this BMP at the **subdivision stage** with reference to ongoing bushfire risk mitigation measures for to be accommodated as part of the future structure planning process. If a new BMP is prepared for subdivision, that document will override the responsibilities in **Table 6**, below.

*Table 6: Responsibilities for implementation of this BMP at the **subdivision** stage*

Management Action		Timing
No.	Developer	
1	If in accordance with the developer's responsibilities outlined in **Table 5,** a new BMP is required at subdivision stage where the embellishment and management to low threat in accordance with Section 2.2.3.2 of AS 3959 of the Jack Williamson public open space area to the east of the site is different to that outlined in this BMP. Additionally, a review of the management requirements to achieve low threat in the proposed landscape lots (adjacent to the western site boundary) will be undertaken as part of any future BMP. As outlined in this BMP, trees can be retained and still achieve low threat.	At the time of subdivision application
2	Where Jack Williamson Oval is designed, implemented and managed to achieve low threat in accordance with Section 2.2.3.2 of AS 3959, the following management (but is not limited to) will apply: • Regular mowing/slashing of grass to less than 100 mm in height (where present). • Irrigation of grass and garden beds (where required). • Regular removal of weeds and built up dead material (such as fallen branches, leaf litter etc.). • Low pruning of trees (branches below 2 m in height removed where appropriate/applicable). • Application of ground/surface covers such as mulch or non-flammable materials as required/applicable.	As part of future development, and can be post creation of lot titles
3	As part of any potential future BMP, a review will be undertaken to address the adequacy of the proposed road and the adjoining interface of the foreshore (forest vegetation to the east). If required and in consultation with the City of Swan, a Local Development Plan prepared as a condition of subdivision approval should provide for adequate setbacks within future lots to ensure future habitable buildings achieve BAL-29 or less.	To support the creation of lot titles.
4	Reticulated water supply and hydrants are to be installed as part of subdivision development in accordance with standard Water Corporation requirements unless otherwise agreed.	To support the creation of lot titles
5	As part of future subdivision works, classified vegetation is to be removed from the site or modified to achieve a low threat standard in accordance with Section 2.2.3.2 of AS 3959. Areas of public open space have been assumed to be classified grassland vegetation and a bushfire hazard when implemented.	To support the creation of lot titles
6	Install the public roads to the standards outlined in Appendix Four of the Guidelines or as agreed with the City. Public road reserves should be designed and maintained to achieve low threat in accordance with Section 2.2.3.2 of AS 3959. Construct roads to ensure all development has two access routes at all stages of subdivision.	To support the creation of lot titles
7	Confirm BAL ratings for all lots designated as bushfire prone at the time titles are created, based on the BAL Contour Plan and/or in accordance with a BAL assessment if the site conditions are different.	To support the creation of lot titles.
8	For each new lot created within areas exposed to a BAL rating exceeding BAL-LOW, lodge a Section 165 Notification on the Certificate of Title in order to alert purchasers and successors in title of the existence of the overarching BMP and the requirements associated with meeting AS 3959 construction standards. This should be based on the outcomes of the BAL certification process.	To support the creation of lot titles.

*Table 6: Responsibilities for implementation of this BMP at the **subdivision** stage(continued)*

Management Action		Timing
No.	Developer	
9	For the residential land subject to BAL-40 or above, a restrictive covenant to the benefit of the local government, pursuant to section 129BA of the Transfer of Land Act 1893, is to be placed on the certificate(s) of title of the proposed lot(s) advising of the existence of a restriction on the use of the land within areas that have been assessed as BAL- 40 or BAL-FZ.	To support the creation of lot titles.
10	Where relevant**, certify BAL ratings for the lots designated bushfire prone within the *Map of Bush Fire Prone Areas* at the time lot titles are created, based on the BAL Contour Plan (see **Figure 5**) and/or in accordance with a revised BAL assessment if the vegetation classifications are different to those identified within this BMP (in particular if vegetation classifications change as a result of the detailed landscape design and assumptions regarding the retained vegetation). The certified BAL ratings can then be submitted to the City of Swan to support future building licenses. **The developer may choose to certify BAL ratings, or may leave this for future lot owners to complete at the time of building licence**	Prior to issue of building licenses.

7 Applicant Declaration

7.1 Accreditation

This assessment report has been prepared by Emerge Associates who have a number of team members who have undertaken Bushfire Planning and Design (BPAD) Level 1 and Level 2 training and are Fire Protection Association of Australia (FPAA) accredited practitioners. Emerge Associates have been providing bushfire risk management advice for more than 10 years, undertaking detailed bushfire assessments (and associated approvals) to support the land use development industry.

7.2 Declaration

I declare that the information provided is true and correct to the best of my knowledge.

Signature:

Name: Anthony Rowe

Date: 25/05/2023

BPAD Accreditation: Level 3 BPAD no. 36690

8 References

8.1 General references

The references listed below have been considered as part of preparing this document.

Department of Fire and Emergency Services (DFES) 2014, *Prepare. Act. Survive.*, Perth. August 2014.

Department of Planning, Lands and Heritage, and Western Australian Planning Commission, (DPLH & WAPC) 2021, *Guidelines for Planning in Bushfire Prone Areas Version 1.4*, Perth, Western Australia.

Emerge Associates 2019, *Bushfire Management Plan - Proposed Subdivision - Cranwood Crescent, Viveash*, EP19-101(25)--009 SCM, Version 1.

Emerge Associates 2020a, *Technical Memorandum - Fauna Assessment Part Lots 23 Winston Crescent and 73 Eveline Road, Middle Swan*, EP19-105(26)--036 RAW, Version 1.

Emerge Associates 2020b, *Technical Memorandum - Flora and Vegetation Assessment Part Lots 23 Winston Crescent and 73 Eveline Road, Middle Swan*, EP19-105(07)--035 RAW, Version 1.

Gould, J., McCaw, W., Cheney, N., Ellis, P. and Matthews, S. 2007, *Field Guide: Fuel Assessment and Fire Behaviour Prediction in Dry Eucalypt Forest*, CSIRO and Department of Environment and Conservation, Perth, Western Australia.

Office of Bushfire Risk Management (OBRM) 2021, *Map of Bush Fire Prone Areas*, Landgate, https://maps.slip.wa.gov.au/landgate/bushfireprone/.

Standards Australia 2018, *AS 3959:2018 Construction of buildings in bushfire-prone areas*, Sydney.

Western Australian Planning Commission (WAPC) 2015, *State Planning Policy 3.7 Planning in Bushfire Prone Areas*, Perth.

8.2 Online references

Landgate 2020, *Map Viewer*, viewed July 2022, https://www0.landgate.wa.gov.au/maps-and-imagery/interactive-maps/map-viewer

Office of Bushfire Risk Management (OBRM) 2021, *Map of Bush Fire Prone Areas*, viewed July 2022, https://maps.slip.wa.gov.au/landgate/bushfireprone/

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Figures

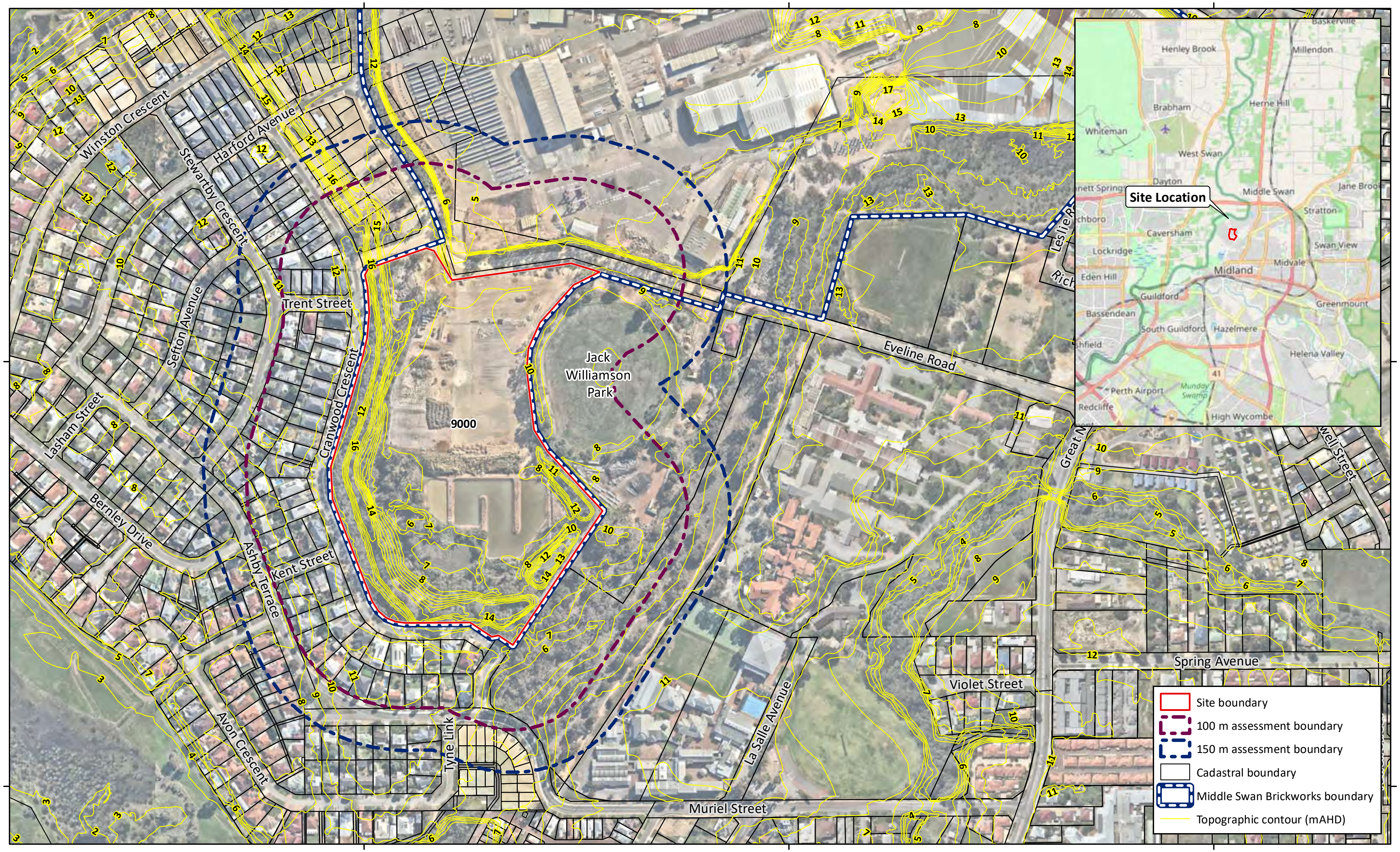

Figure 1: Site Plan and Topographic Contours

Project:	Bushfire Management Plan Local Structure Plan Area 3 Middle Swan Brickworks
Client:	Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F238c

Drawn:	GAR
Date:	19/05/2023
Checked:	PPS
Approved:	TB
Date:	19/05/2023

N

0 100 200
Metres
Scale: 1:6,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Figure 2: **Existing Site Conditions – AS 3959 Vegetation Classifications**

Project: Bushfire Management Plan
Local Structure Plan Area 3 Middle Swan Brickworks

Client: Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F239c

Drawn:	GAR
Date:	19/05/2023
Checked:	PPS
Approved:	TB
Date:	19/05/2023

N

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Metres
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GDA 1994 MGA Zone 50

emerge ASSOCIATES

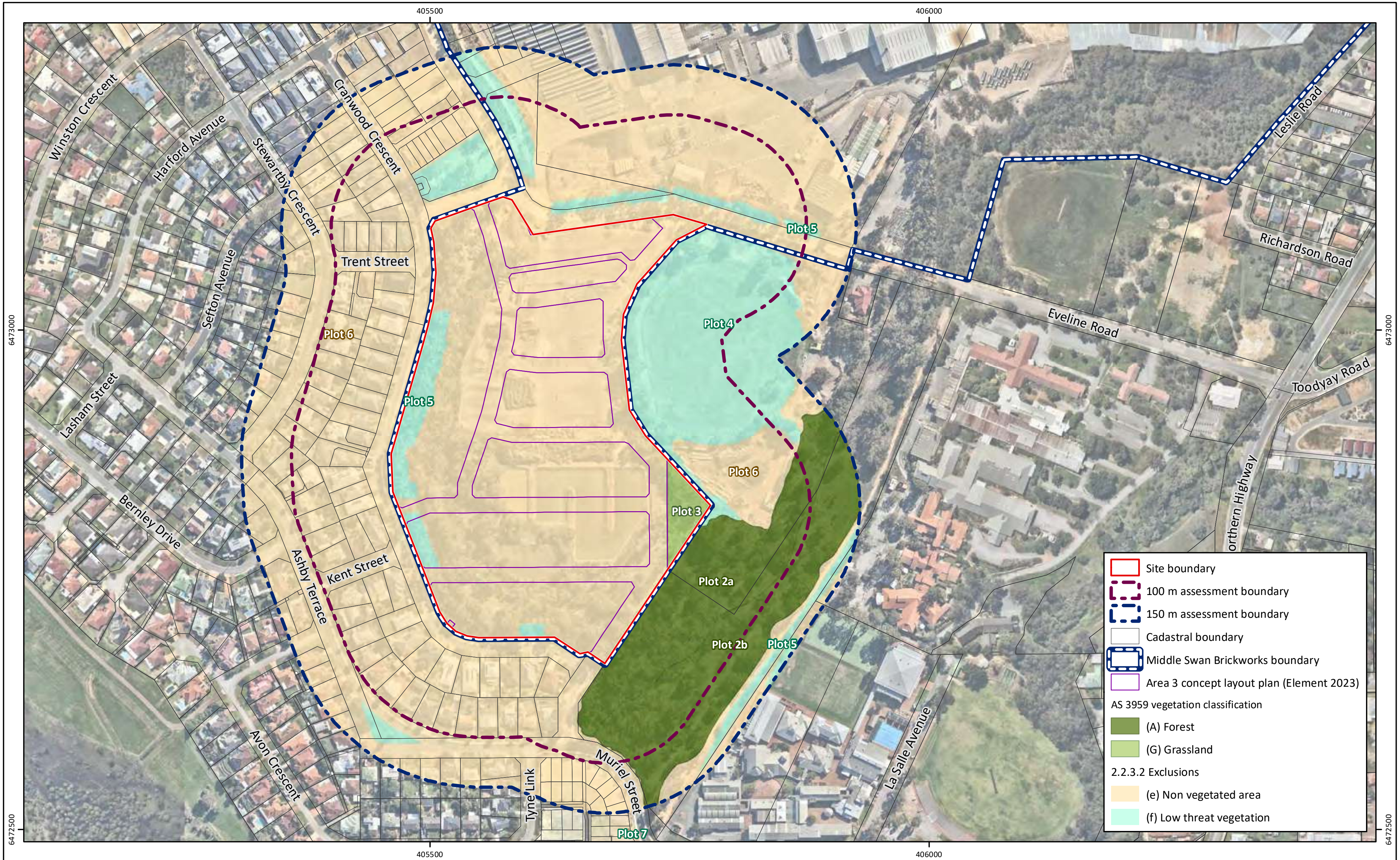

Figure 3: **Post Development Site Conditions – AS 3959 Vegetation Classifications**

Project: Bushfire Management Plan
Local Structure Plan Area 3 Middle Swan Brickworks
Client: Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F240d
Drawn: WJC
Date: 21/03/2024
Checked: PPS
Approved: KK
Date: 21/03/2024

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GDA 1994 MGA Zone 50

emerge ASSOCIATES

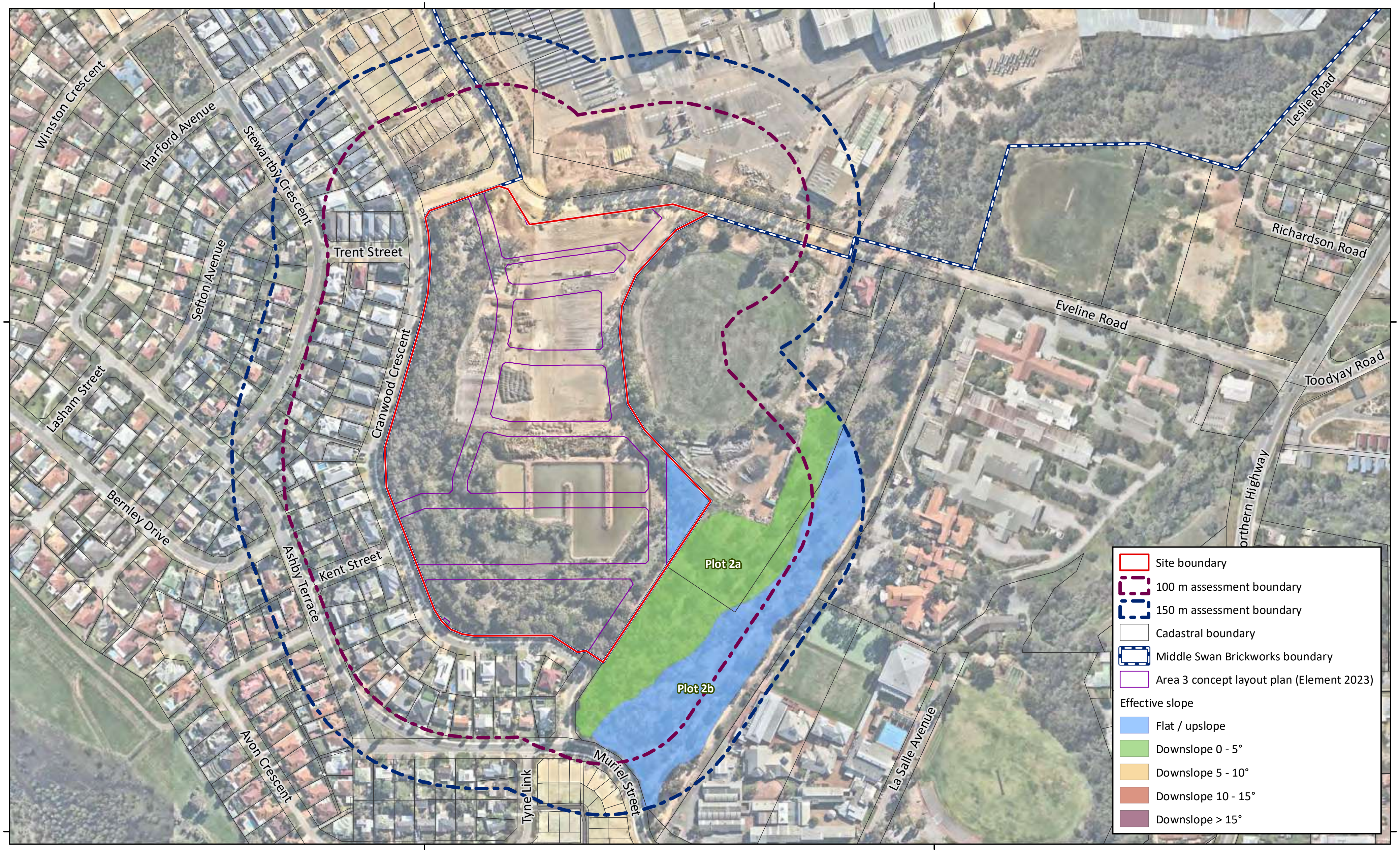

Figure 4: **Post Development Site Conditions – Effective Slope**

Project: Bushfire Management Plan
Local Structure Plan Area 3 Middle Swan Brickworks

Client: Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F241d
Drawn: WJC
Date: 21/03/2024
Checked: PPS
Approved: KK
Date: 21/03/2024

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Metres
Scale: 1:5,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

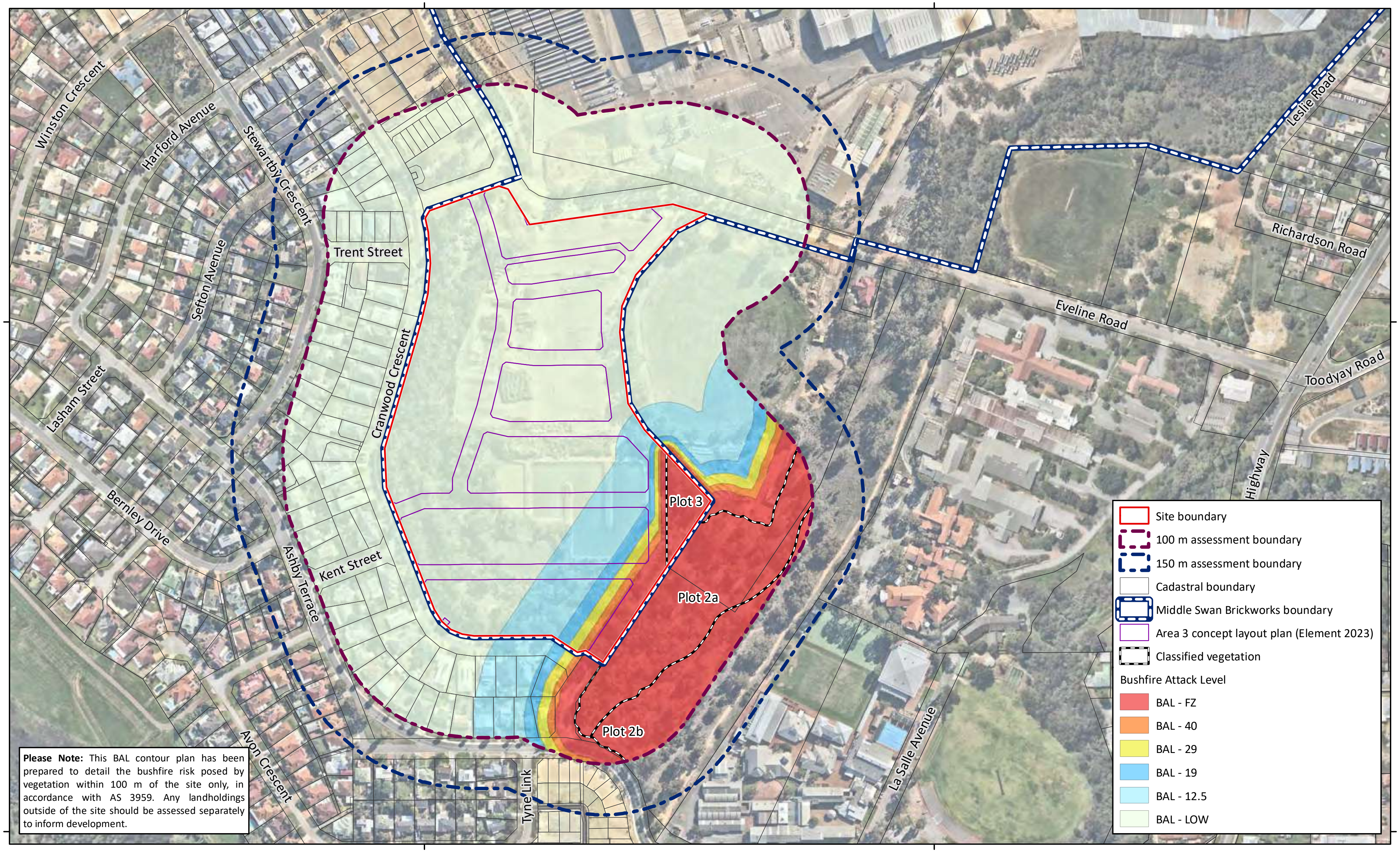

Figure 5:	**Bushfire Attack Level Contour Plan**
Project:	Bushfire Management Plan Local Structure Plan Area 3 Middle Swan Brickworks
Client:	Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F242e

Drawn:	WJC
Date:	21/03/2024
Checked:	PPS
Approved:	KK
Date:	21/03/2024

N

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Metres
Scale: 1:5,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

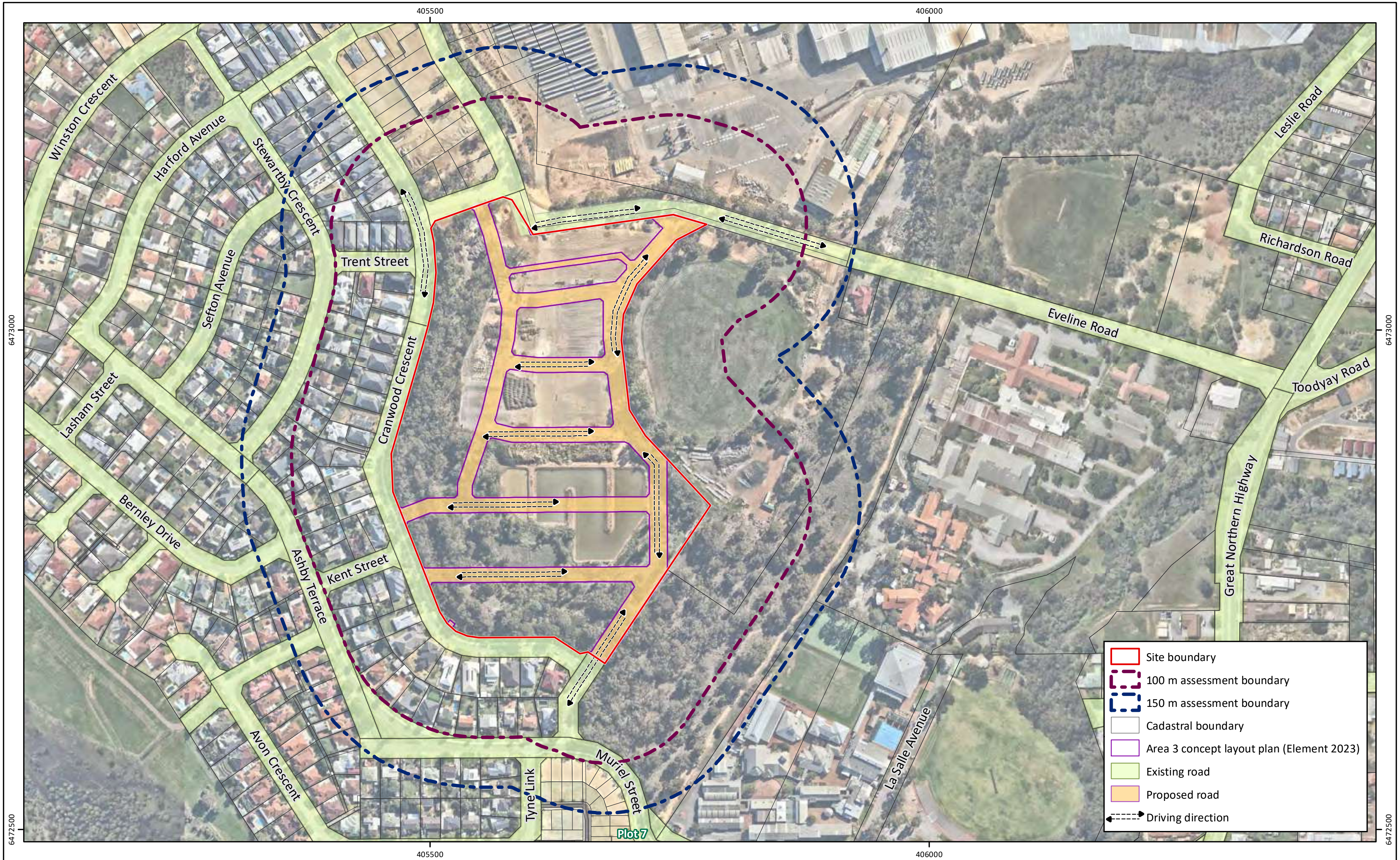


Figure 6: **Vehicle Access**

Project: Bushfire Management Plan
Local Structure Plan Area 3 Middle Swan Brickworks

Client: Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F243c

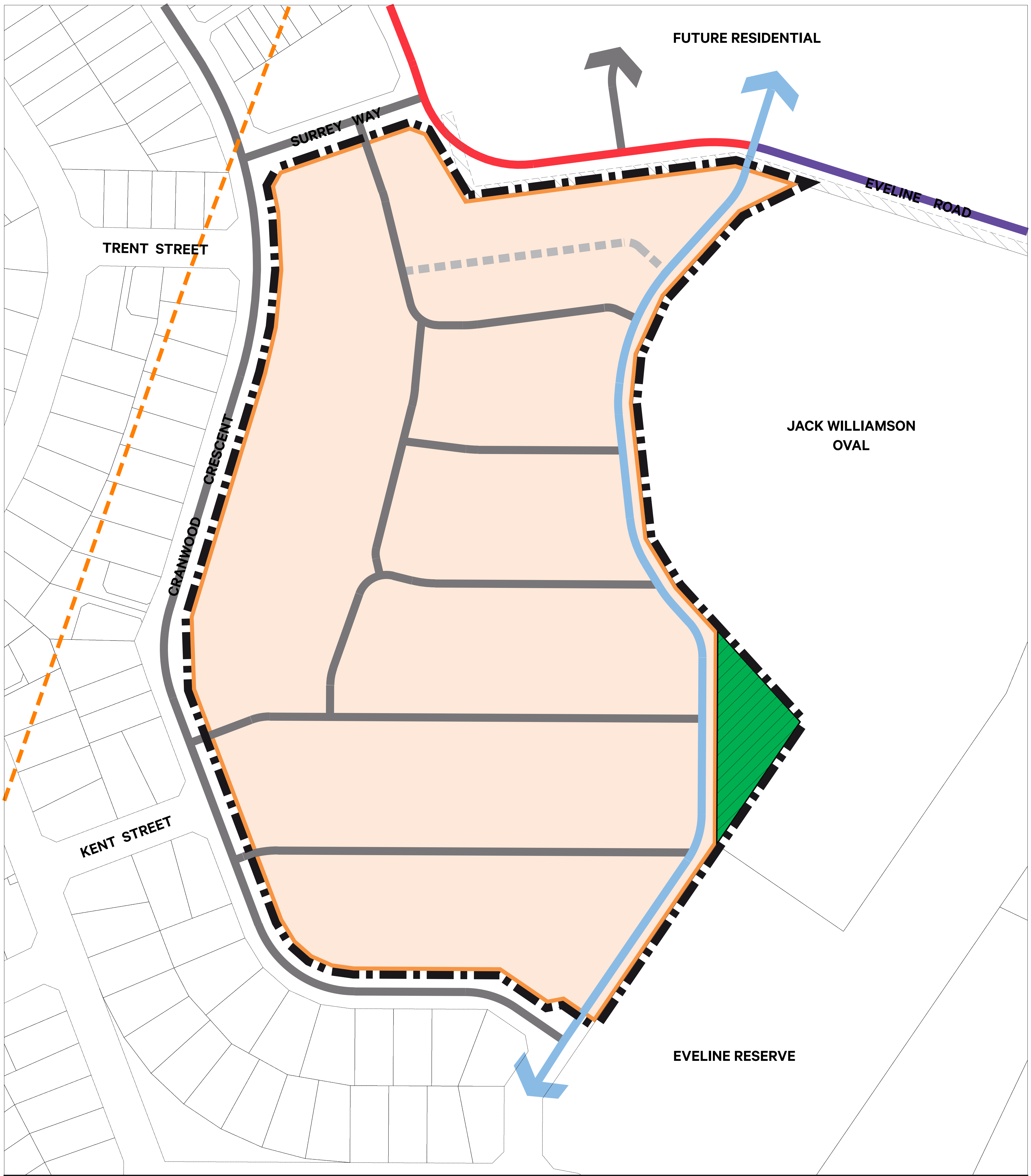
Drawn:	GAR
Date:	19/05/2023
Checked:	PPS
Approved:	TB
Date:	19/05/2023

Scale: 1:5,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix A

Area 3 Local Structure Plan (Element 2023)



LEGEND

Local Structure Plan Boundary

LOCAL SCHEME ZONES

Residential Development

LOCAL SCHEME RESERVES

Public Open Space

NEIGHBOURHOOD AND KEY ACCESS STREETS

Neighbourhood Connector A

Neighbourhood Connector B

Access Street C

LOCAL ACCESS STREETS (Indicative and subject to change)

Access Street D

Laneway

OTHER

Gas Pipeline Easement

ANEF 20-25

Area 3 Local Structure Plan

Lot 9000 Eveline Road, Viveash

N

0 20 40m

Date: 4 May 2023
File: **21-742 ST1 1**
Revision: A Initial issue 24.05.22
B Amended 04.05.23
\- -

Scale: 1:2000 @ A3
Staff: LC CW
Checked: MR

element.

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T. +61 8 9289 8300 | **E.** hello@elementwa.com.au **elementwa.com.au**

Appendix C

Noise Management Plan (Lloyd George Acoustics/Herring Storer)

Lloyd George Acoustics
PO Box 717
Hillarys WA 6923
T: 9401 7770
www.lgacoustics.com.au

Noise Management Plan

‘Rivermark’ Area 3 Local Scheme Amendment

Reference: 20085657-14 Area 3

Prepared for:
Hesperia

Report: 20085657-14 Area 3

Lloyd George Acoustics Pty Ltd ABN: 79 125 812 544 PO Box 717 Hillarys WA 6923 www.lgacoustics.com.au				
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Contacts	**Ben Hillion**	**Rob Connolly**	**Daryl Thompson**	**Hao Tran**
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Date:	Rev	Description	Prepared By	Verified
26-Aug-21	1	Draft for comment	Terry George	-
22-Oct-21	0	Updated with element comments	Terry George	-

Table of Contents

List of Tables

List of Figures

Appendices

1 INTRODUCTION

Hesperia Pty Ltd is the Development Manager for the owners of the land (Capitary No.2) east of Cranwood Crescent in Viveash, currently occupied by the Midland Brick Industrial site. This report forms the Noise Management Plan (NMP) for Area 3 of the project as located in *Figure 1-1*.

Figure 1-1 Project Locality

This NMP is provided in support of the proposed local scheme amendment to the City of Swan, which seeks to rezone the site from Industrial to Residential – R20. The future overall residential subdivision development will occur in an orderly stage along with the contraction of the brickworks footprint. An application was made in late 2020 to have Kilns 7 and 8 removed from the current Part V Licence. In addition, Kiln 11 will be decommissioned and removed from the Part V Licence in April 2022, with an application having been made to this effect.

Capitary No.2 has leased portions of the brickworks site to BGC. A general summary of the lease arrangements is provided below and on *Figure 1-3*:

- Existing brickworks site area will remain active until April 2022;
- In April 2022, BGC access reverts to the Clay Shed lease area (Area C), the Masonry Facility area (Lot 11) and the kiln 9 and 10 lease area (Area B1 and B2). That is, the only brickwork related activity south of Bassett Road after April 2022 will be the Clay Shed. **Area 3 is expected to be subdivided after this time**;
- The Clay Shed lease is for a period between 5 and 10 years;
- The Masonry Facility will be created on a standalone title and is envisaged to operate into the long term;
- The Kiln 9 and 10 lease area is for a period between 5 and 15 years.

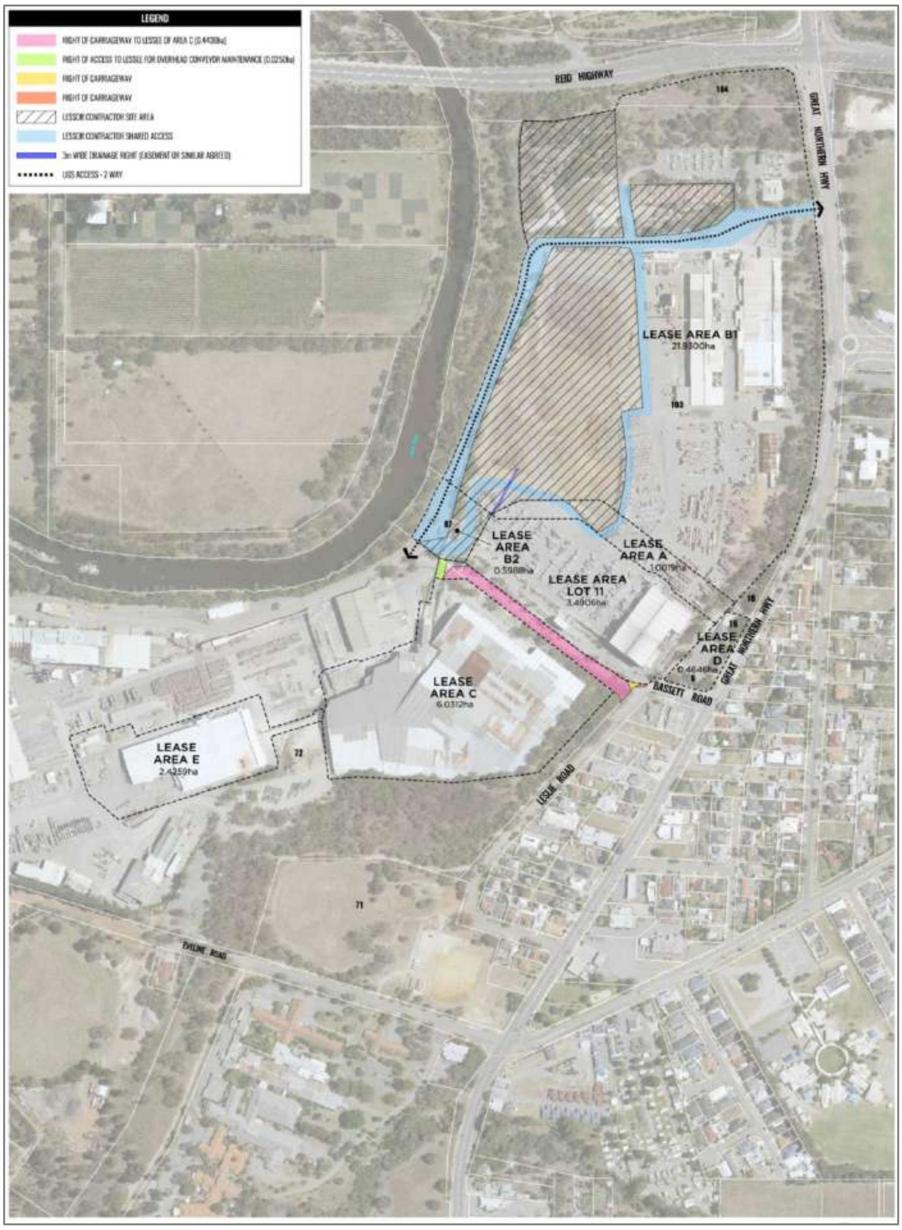


Figure 1-2 Lease Area Plan

The formal arrangement between Capitary No.2 and BGC to operate the Midland Brick site is with the knowledge by both Parties, that the southern portion of the brickworks is proposed as residential development. As part of this arrangement, Herring Storer Acoustics (HSA) was engaged to act as an independent acoustic consultant for both Parties. HSA has considered three operational scenarios that are likely to occur until the clay brickworks are fully decommissioned:

A. Full brickwork operations north of Bassett Road (i.e. Kilns 9 and 10 and Masonry Facilities) plus the Clay Shed operations;

B. Full operations north of Bassett Road only (i.e. Kilns 9 and 10 and Masonry Facilities and no Clay Shed operations); and

C. Masonry Facility only, located immediately north of Bassett Road.

The HSA report is contained within *Appendix A*[1] having assessed the noise emissions to the proposed residential development against the prescribed standards of the *Environmental Protection (Noise) Regulations 1997*. The findings of this study have been considered for Area 3.

As well as the potential impacts of industrial noise, noise from aircraft is also given consideration, noting the 20 ANEF (Aircraft Noise Exposure Forecast) contour is located across the site. Aircraft noise is assessed against the requirements of *State Planning Policy No. 5.1 Land Use Planning in the Vicinity of Perth Airport*.

2 CRITERIA

2.1 Industrial Noise

Noise from the Midland Brick site to the proposed urban development is governed by the *Environmental Protection Act 1986*, through the *Environmental Protection (Noise) Regulations 1997* (the Regulations).

Regulation 7 defines the prescribed standard for noise emissions as follows:

"7. (1) Noise emitted from any premises or public place when received at other premises –

(a) Must not cause or significantly contribute to, a level of noise which exceeds the assigned level in respect of noise received at premises of that kind; and

(b) Must be free of –

i. tonality;

ii. impulsiveness; and

iii. modulation,

when assessed under regulation 9"

A "…noise emission is taken to significantly contribute to a level of noise if the noise emission … exceeds a value which is 5 dB below the assigned level…"

Tonality, impulsiveness and modulation are defined in Regulation 9. Noise is to be taken to be free of these characteristics if:

(a) The characteristics cannot be reasonably and practicably removed by techniques other than attenuating the overall level of noise emission; and

(b) The noise emission complies with the standard prescribed under regulation 7 after the adjustments of *Table 2-1* are made to the noise emission as measured at the point of reception.

[1] *Acoustic Assessment, Midland Brick Site Redevelopment*; July 2021, Reference: 27982-2-20355-02

Table 2-1 Adjustments Where Characteristics Cannot Be Removed

Where Noise Emission is Not Music			Where Noise Emission is Music	
Tonality	Modulation	Impulsiveness	No Impulsiveness	Impulsiveness
+ 5 dB	+ 5 dB	+ 10 dB	+ 10 dB	+ 15 dB

Note: The above are cumulative to a maximum of 15dB.

The baseline assigned levels (prescribed standards) are specified in Regulation 8 and are shown in *Table 2-2*.

Table 2-2 Baseline Assigned Noise Levels

Premises Receiving Noise	Time Of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises: highly sensitive area[1]	0700 to 1900 hours Monday to Saturday (Day)	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sunday and public holidays (Sunday)	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days (Evening)	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays (Night)	35 + influencing factor	45 + influencing factor	55 + influencing factor

1. ***highly sensitive area*** means that area (if any) of noise sensitive premises comprising —
   (a) a building, or a part of a building, on the premises that is used for a noise sensitive purpose; and
   (b) any other part of the premises within 15 metres of that building or that part of the building.

The influencing factor, applicable at noise sensitive premises varies depending upon their proximity to commercial and industrial zoned land within a 450 metre radius. As such, the assigned noise level varies at different future residences within the existing and proposed urban zoned land and becomes a complex analysis. HSA has discussed the assigned noise levels in their report in Section 4.0, providing Map C, shown as *Figure 2-1*, demonstrating the various assigned levels based on the ultimate scenario (Masonry Facility only). The influencing factor across Area 3 is shown to be 0 dB and thus the assigned night-time level is 35 dB L_{A10}.

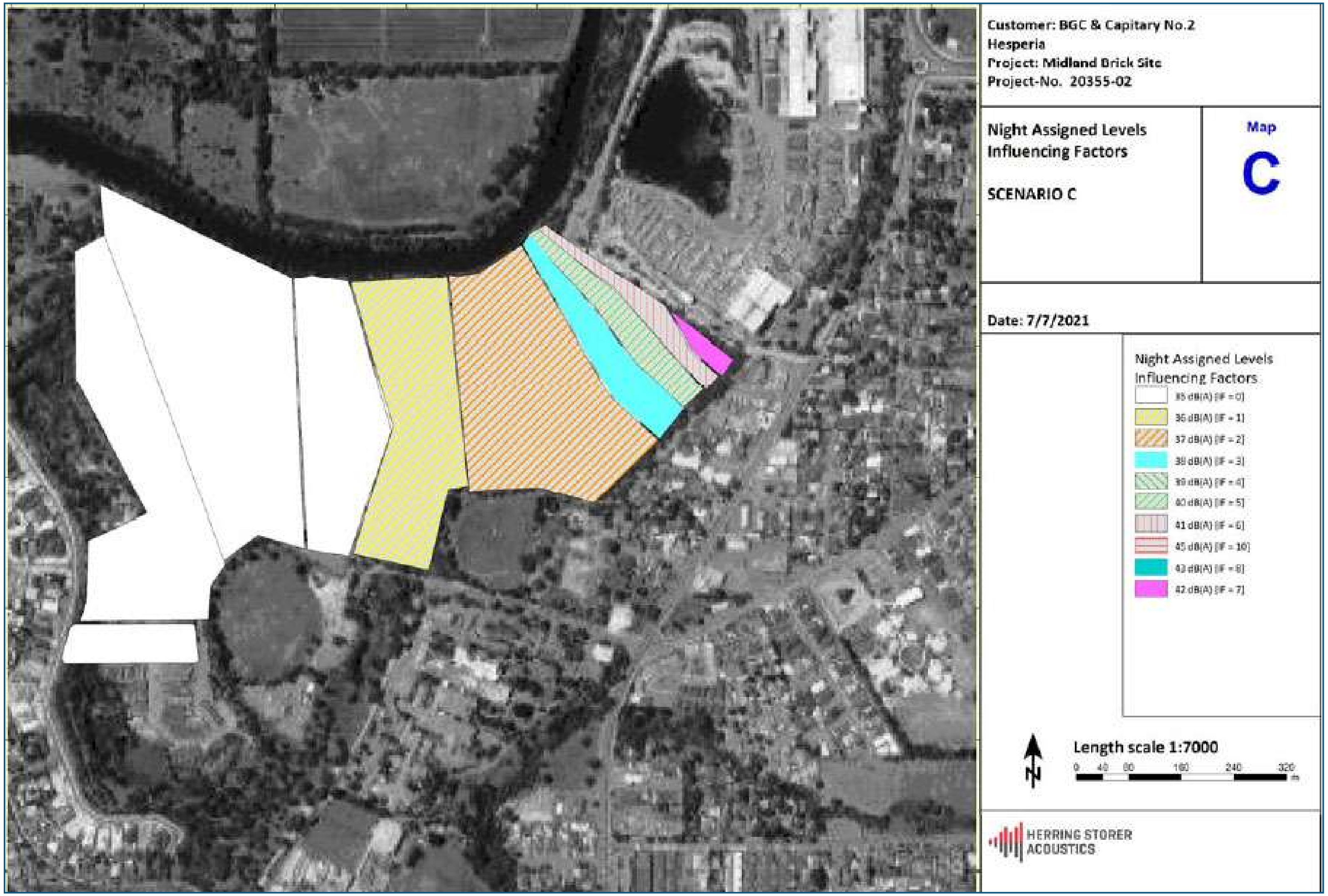


Figure 2-1 Night-time Assigned Noise Levels

2.2 Aircraft Noise

The relevant planning policy in Western Australia in relation to aircraft noise is *State Planning Policy 5.1 Land Use Planning in the Vicinity of Perth Airport*; July 2015, Western Australian Planning Commission (SPP 5.1). SPP 5.1 applies to any land within ANEF 20 and separates land into three zones:

- Areas below 20 ANEF;
- Areas between 20 ANEF and 25 ANEF; and
- Areas above 25 ANEF.

The entirety of Area 3 falls within 20 ANEF (refer *Figure 2-2* where the pink shading is the 20-25 ANEF zone). Note that the ANEF contours are associated with the future parallel runway.

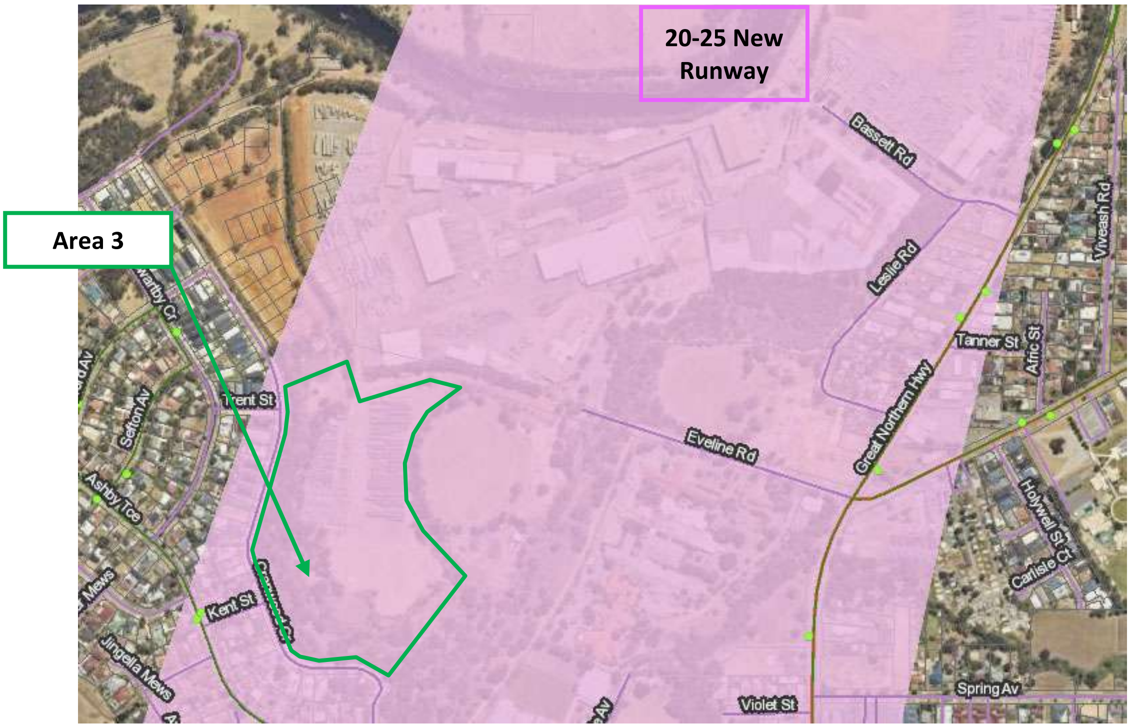


Figure 2-2 ANEF Contour Over Site

For areas within the 20-25 ANEF contour, SPP 5.1 states the following:

- Maximum residential density should be limited to R20;
- Noise insulation is not mandatory for residential development. Some areas however, may experience peak aircraft noise levels in excess of the Indoor Design Levels specified in AS2021, and noise insulation is recommended in such cases.
- Closure of windows and other openings to habitable rooms can significantly reduce the intrusion of aircraft noise. This will normally require forced ventilation, and may also necessitate some form of active cooling, such as refrigerative air conditioning. The operational management of buildings however, is outside the ambit of this policy, and will therefore be subject only to advice.
- A 'notice on title'advising of the potential for noise nuisance is to be required as a condition of any subdivision or planning approval within this noise exposure zone.

3 METHODOLOGY

3.1 Industrial Noise

As described, Herring Storer Acoustics (HSA) was engaged to undertake noise modelling from the Midland Brick site. HSA has used the noise modelling package *SoundPLAN 8.2* along with the *CONCAWE* algorithms and worst-case meteorological conditions as part of the assessment – refer *Appendix A* for full report and methodology.

3.2 Aircraft Noise

Figure 2-2 showed Area 3 will be within the 20-25 ANEF contour. SPP 5.1 states that whilst noise insulation is not mandatory, some areas may experience maximum aircraft noise levels in excess of the Indoor Design Sound Levels specified in AS2021[2], and noise insulation is recommended in such cases. Guidance on noise insulation measures is contained within the Western Australian Planning Commission report, *Aircraft Noise Insulation for Residential Development in the Vicinity of Perth Airport* (Noise Insulation report).

The ANEF contours are a planning tool and do not represent actual noise levels. As such, Perth Airport also produce N65 Contours, which represent the average number of daily aircraft above a noise level of 65 dB L_{Amax}, considered to represent a point at which normal conversation may be disturbed. An extract of these contours taken from *Perth Airport Master Plan 2020 Summary* is provided in *Figure 3-1* with the approximate location of Area 3. This shows that the area is expected to be subjected to 100-200 events per day above a noise level of 65 dB L_{Amax}.

Aircraft noise levels can be further explored by using the AS2021:2015 look-up tables. For this runway and area, the departing Airbus 330 is likely to result in the worst-case maximum noise levels. An extract of the noise level table for this aircraft is provided in *Figure 3-2* noting the noise level varies with distance from the far end of the runway (DT) and the offset (DS) distance (refer *Figure 3-3*). The relevant noise levels are within the red area in *Figure 3-2*.

[2] Indoor design sound levels for residences are 50 dB L_{Amax} in bedrooms and 55 dB L_{Amax} in living areas.

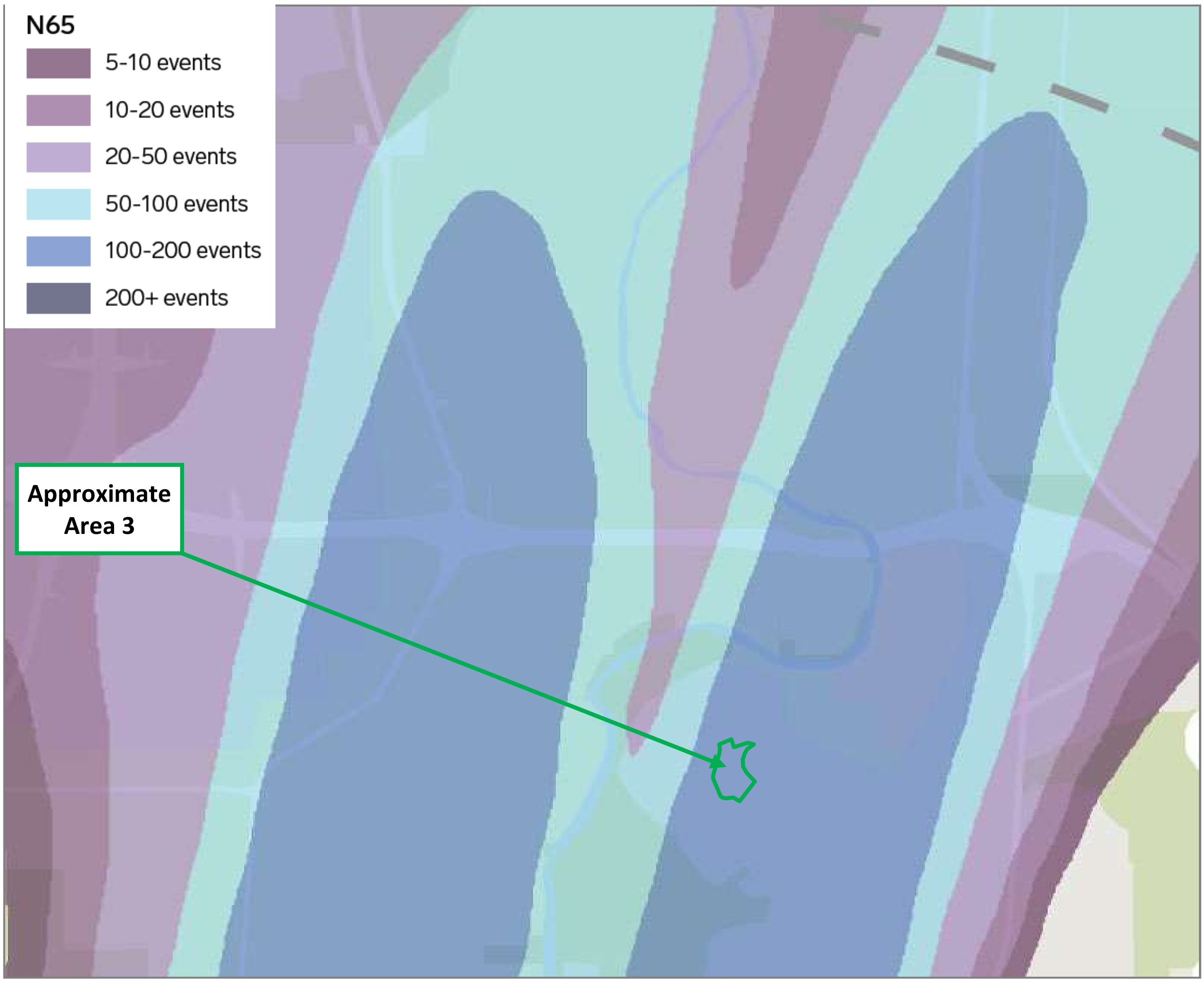


Figure 3-1 Site Locality in Relation to Ultimate N65 Contours

NOISE LEVELS FOR AIRBUS A330-301 DEPARTURES

Centre-line distance (*DT*), m	Noise levels, dB(A)																		
	Sideline distance (*DS*), m																		
	0	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000	2200	2400	2600
10 000	77	77	76	76	76	75	74	73	72	72	71	69	67	65	63	62	60	59	57
10 500	76	76	76	75	75	74	74	73	72	71	70	68	67	65	63	62	60	59	58
11 000	75	75	75	75	74	74	73	73	72	71	70	68	67	65	63	62	60	59	58
11 500	75	75	75	74	74	74	73	72	72	71	70	68	67	65	63	62	60	59	58
12 000	75	75	74	74	74	73	73	72	72	71	70	68	67	65	63	62	61	59	58
12 500	74	74	74	74	74	73	73	72	72	71	70	68	67	65	64	62	61	59	58
13 000	74	74	74	74	74	73	73	72	71	71	70	68	67	65	64	62	61	59	58
13 500	74	74	74	74	73	73	73	72	71	71	70	68	67	65	64	62	61	59	58
14 000	74	74	74	73	73	73	72	72	71	70	70	68	67	65	64	62	61	59	58

Figure 3-2 AS2021 Look-up Table for Departing Airbus 330

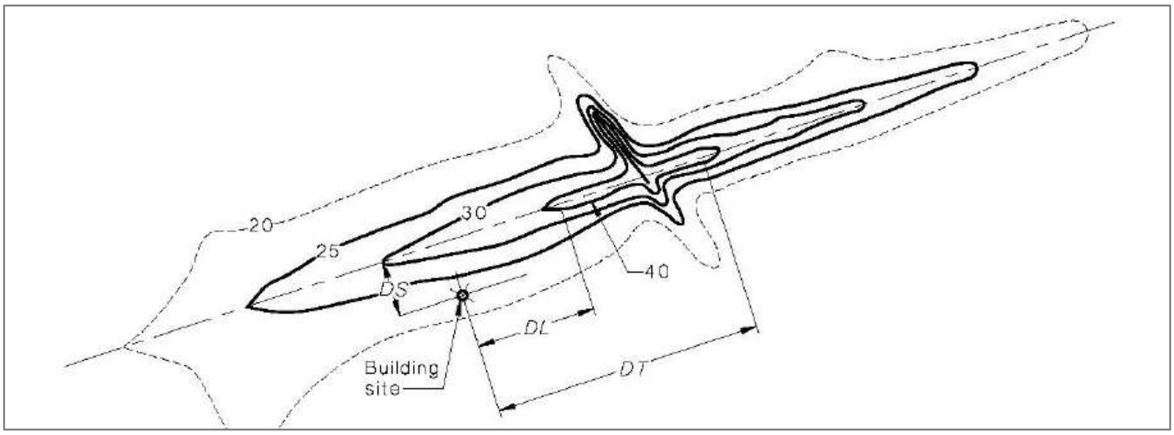


Figure 3-3 AS2021 Determination of Distances

4 RESULTS

4.1 Industry Noise

Herring Storer Acoustics (HSA) considered three scenarios of noise emissions from the Midland Brick site as follows:

A. Full brickwork operations north of Bassett Road (i.e. Kilns 9 and 10 and Masonry Facilities) plus the Clay Shed operations south of Bassett Road;

B. Full operations north of Bassett Road only (i.e. Kilns 9 and 10 and Masonry Facilities and no Clay Shed operations); and

C. Masonry Facility only, located immediately north of Bassett Road.

4.1.1 Scenario A

In this scenario, everything on the north side of Bassett Road is operational, consisting mostly of Kilns 9 and 10 and the Masonry Facility. The Clay Shed will operate only during the day and evening, with the exception of conveyor transfer of materials from the Clay Shed (bins) to Kilns 9 and 10. This scenario is relevant for between the next 5 and 10 years. Two noise contour plots are provided:

- *Figure 4-1* representing the day/evening scenario, at which time the assigned noise levels are at least 5 dB higher than those during the night, and
- *Figure 4-2* representing the night scenario (*Figure 4-2*).

Triple stacked shipping containers are included on the west side of the Clay Shed and double stacked shipping containers at the nearest future residences to act as noise barriers.

The thick red line on these plots indicates the point at which residential development is compliant with the Noise Regulations. Area 3 is outside of this line and therefore considered compliant.

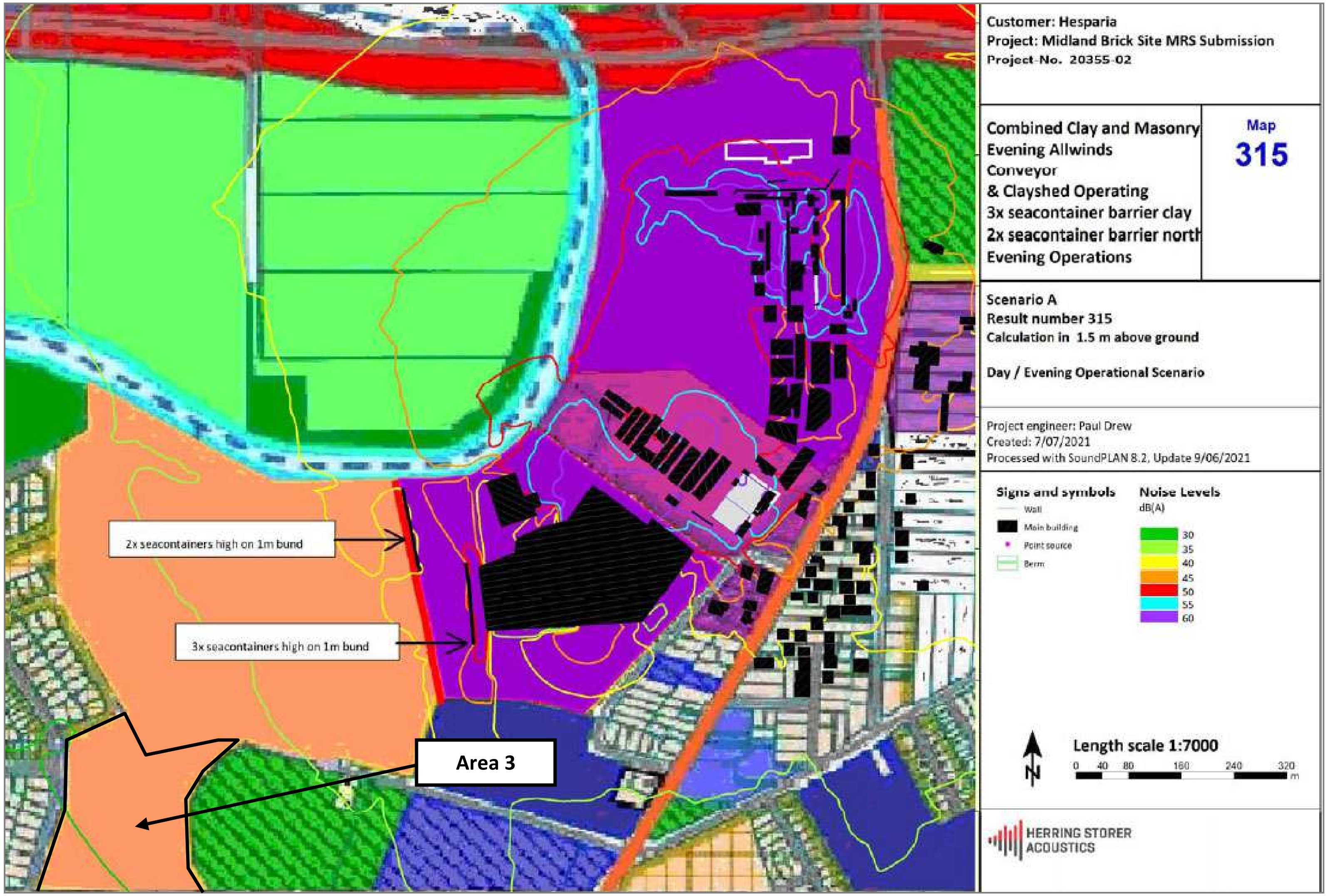


Figure 4-1 Noise Contour Plot: Scenario A Day/Evening Period

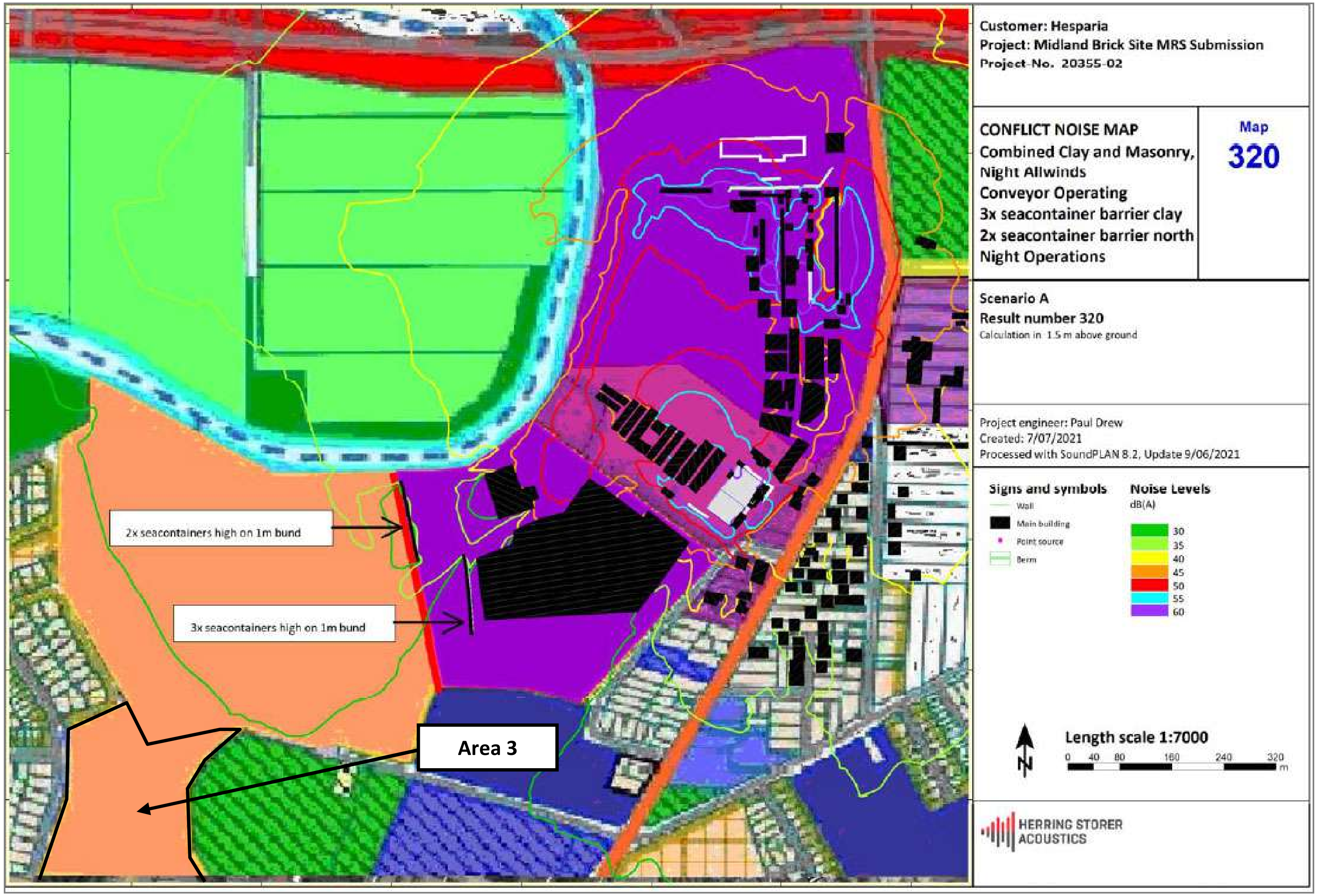


Figure 4-2 Noise Contour Plot: Scenario A Night Period

4.1.2 Scenario B

Scenario B is the same as Scenario A, with the exception that the Clay Shed on the south side of Bassett Road and associated conveyor are no longer in use. Before the Clay Shed is demolished, a 5-metre high wall will be constructed abutting the south side of the masonry lot to act as a noise barrier.

The noise contour plot associated with this scenario is provided in *Figure 4-3*. Also shown is the line indicating the point where compliance is achieved. Area 3 is outside of this line and therefore considered compliant.

4.1.3 Scenario C

Scenario C represents the long term scenario where the only remaining plant operating at the Midland Brick site is the Masonry Facility. This is to be assumed to be operating indefinitely and represents the scenario that will exist in 10-15 years time, depending on whether BGC take up the additional 5 year option for the clay operations.

The noise contour plot associated with this scenario is provided in *Figure 4-4*. Compliance is achieved at all proposed residential land including the proposed Area 3.

4.1.4 Summary

The outcome of the industrial noise assessment by HSA is that noise to Area 3 will comply with the *Environmental Protection (Noise) Regulations 1997* at all times. This is on the basis of:

- the only operations existing south of Bassett Road is the Clay Shed;
- the Clay Shed does not operate during the night, with the exception of the conveyor transfer of materials from the Clay Shed (bins) to kilns 9 and 10;
- Triple stacked shipping containers are included on the west side of the Clay Shed and double stacked shipping containers at the nearest future residences to act as noise barriers.

The above relates to Scenario A. Before the Clay Shed is demolished, a 5-metre high wall will be constructed abutting the south side of the masonry lot to act as a noise barrier.

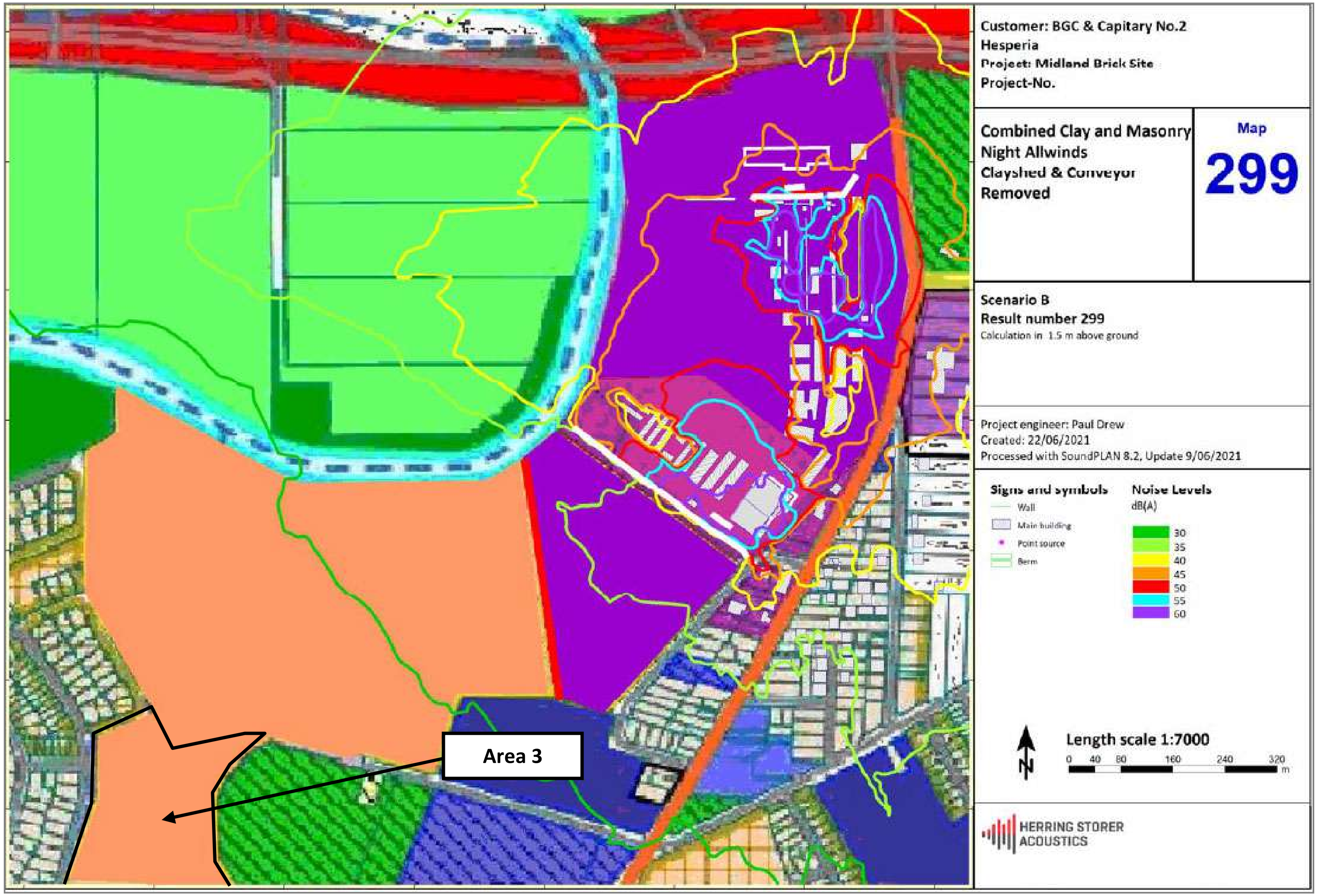


Figure 4-3 Noise Contour Plot: Scenario B

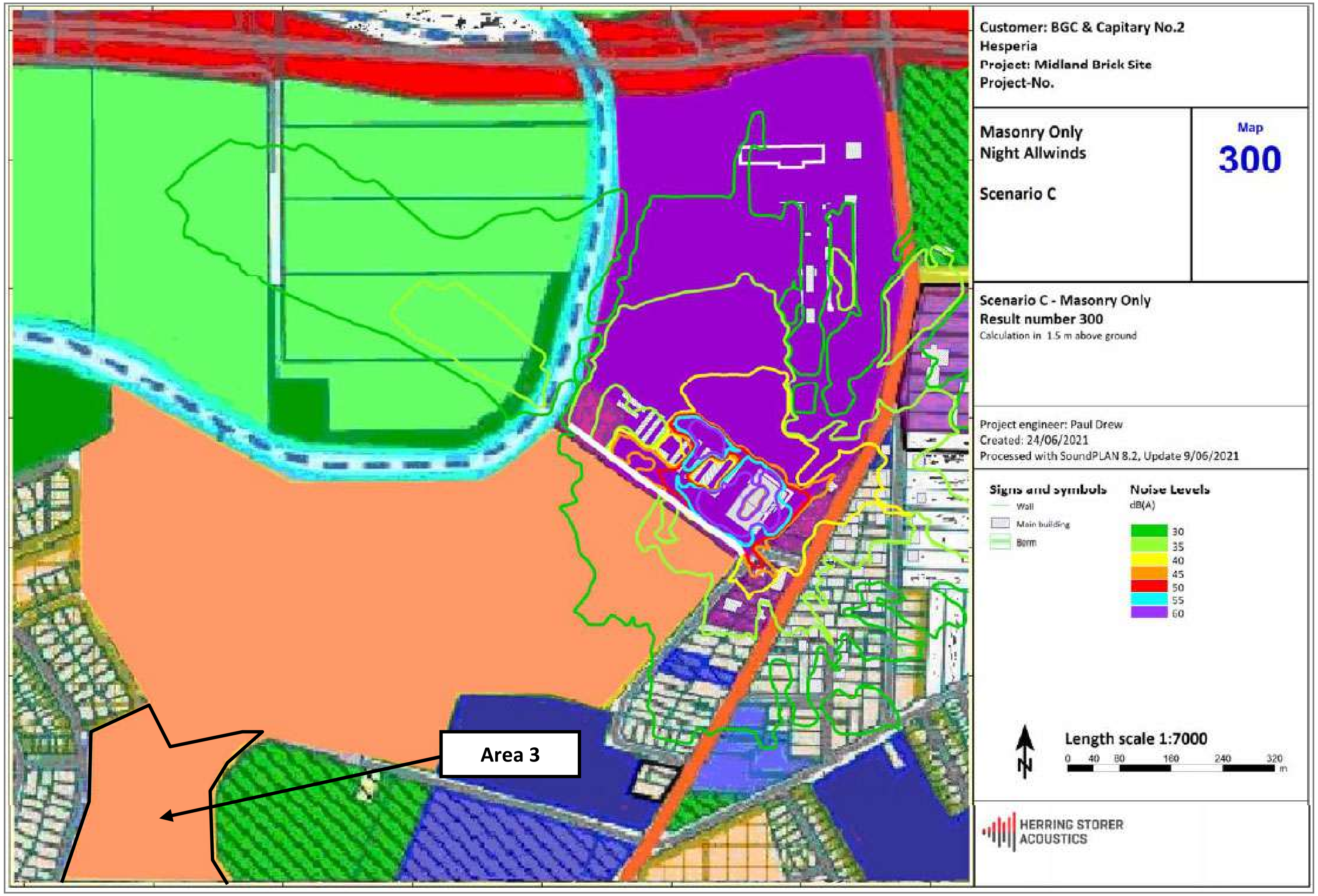


Figure 4-4 Noise Contour Plot: Scenario C

4.2 Aircraft Noise

As described in *Section 3.2*, Area 3 is expected to be subjected to 100-200 aircraft events per day above 65 dB L_{Amax}. The Airbus A330 on departure is expected to align with the typical aircraft maximum noise levels and these have been shown across the site on *Figure 4-5*.

The noise level on the subject site will range 74-75 dB L_{Amax} from a departing Airbus A330 with arrivals being a similar noise level (within 1 dB) to departures. Other aircraft (Airbus A380 and Boeing 737-700 and 737-800) are also expected to be around the 73-74 dB L_{Amax} level. The indoor design sound levels from AS2021 for a residential building are 50 dB L_{Amax} inside bedrooms and 55 dB L_{Amax} inside living areas, meaning an aircraft noise reduction from outside to inside of 25 dB and 20 dB respectively is required.

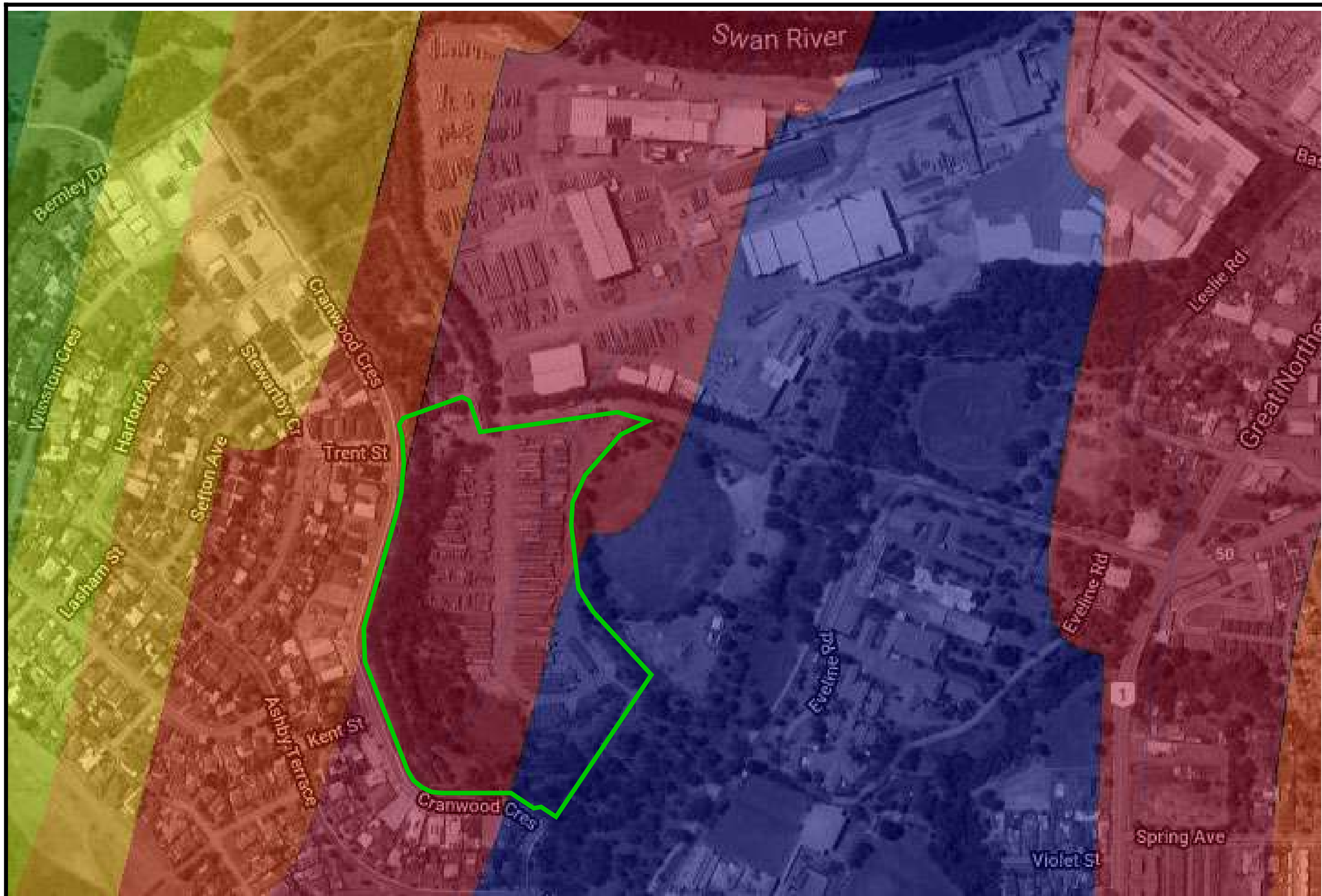
A noise reduction of 20 dB(A) is generally readily achievable with standard construction, provided windows and doors are closed and of a standard size (that is, the larger the glazing the more noise entering via this element). For instance, 4mm thick glass in a sliding window frame is expected to achieve $R_w + C_{tr}$ 20 performance.

SPP 5.1 does not mandate any noise insulation where residences are located within the 20-25 ANEF contour but does require notifications on lot title. Given the expected number of aircraft movements above 65 dB L_{Amax}, it is suggested that the following be considered:

- Walls to achieve $R_w + C_{tr}$ 45 construction. Appropriate constructions may be:
  - double leaf cavity brickwork; or
  - brick veneer being 90mm brick, 50mm cavity stud with 90mm thick, 11kg/m^3 fibrous insulation and 13mm plasterboard/6mm fibre cement sheet; or
  - 6mm fibre cement sheet to 140mm timber stud with 70mm thick *Soundscreen 2.0* fibrous insulation and 13mm thick sound-rated plasterboard to furring channels and resilient mounts.
- Roof/ceiling to achieve $R_w + C_{tr}$ 35 construction (e.g. 24^o metal deck or tiled roof, 10mm thick plasterboard with R4.0 fibrous insulation above). Where a raked ceiling is proposed, plasterboard to be 13mm thick fire/sound-rated;
- All external glazing to habitable rooms be minimum 6mm thick;
- External windows to habitable rooms be fixed or awning style with acoustic seals;
- External sliding doors, bi-fold doors or similar to be fitted with acoustic seals;
- Entry door to be minimum 35mm thick, solid timber core with full perimeter acoustic seals;
- Air-conditioning recommended with fresh air intakes to allow windows to be closed.

The upgraded construction listed above is expected to achieve a 25-28 dB noise reduction (depending on glazing size). Alternative constructions can be assessed by a suitably qualified acoustical consultant (member firm of the Association of Australasian Acoustic Consultants).

Figure 4-5



Lmax Noise Level in dB(A)

<	70
>=	70
>=	71
>=	72
>=	73
>=	74
>=	75

Legend

Area 3

Length Scale 1:7000

0 35 70 140 210 280 m

Typical Maximum Aircraft Noise Level -
Airbus A330 Departure on Future Parallel Runway

L_{Amax} Noise Level Contours Future Runway

25 August 2021

Lloyd George Acoustics
PO Box 717
HILLARYS WA 6923
(08) 9401 7770

5 CONCLUSION

To manage noise impacts to the proposed urban area of Area 3, the following is proposed to be implemented:

- All residential lots are to incorporate the following notifications:

  "This lot is in close proximity to an existing bricks works and may be adversely affected by virtue of gaseous, odour, noise and/or dust emissions from that facility."

  "This lot is situated in the vicinity of Perth Airport, and is currently affected, or may in the future, be affected by aircraft noise. Noise exposure levels are likely to increase in the future as a result of increases in numbers of aircraft using the airport, changes in aircraft type or other operational changes. Further information about aircraft noise, including development restrictions and noise insulation requirements for noise affected properties, are available on request from the relevant local government offices."

- It is suggested (not mandatory) that the following be considered in the construction of dwellings:
  - Walls to achieve $R_w + C_{tr}$ 45 construction. Appropriate constructions may be:
    - double leaf cavity brickwork; or
    - brick veneer being 90mm brick, 50mm cavity stud with 90mm thick, 11kg/m^3 fibrous insulation and 13mm plasterboard/6mm fibre cement sheet; or
    - 6mm fibre cement sheet to 140mm timber stud with 70mm thick *Soundscreen 2.0* fibrous insulation and 13mm thick sound-rated plasterboard to furring channels and resilient mounts.
  - Roof/ceiling to achieve $R_w + C_{tr}$ 35 construction (e.g. 24^o metal deck or tiled roof, 10mm thick plasterboard with R4.0 fibrous insulation above). Where a raked ceiling is proposed, plasterboard to be 13mm thick fire/sound-rated;
  - All external glazing to habitable rooms be minimum 6mm thick;
  - External windows to habitable rooms be fixed or awning style with acoustic seals;
  - External sliding doors, bi-fold doors or similar to be fitted with acoustic seals;
  - Entry door to be minimum 35mm thick, solid timber core with full perimeter acoustic seals;
  - Air-conditioning recommended with fresh air intakes to allow windows to be closed.
- No brick work operations shall occur south of Bassett Road other than the Clay Shed. Whilst the Clay Shed remains in operation, all but the conveyor transfer of materials from the Clay Shed (bins) to kilns 9 and 10, shall be during the day and evening only. Triple stacked shipping containers are included on the west side of the Clay Shed and double stacked shipping containers at the nearest future residences to act as noise barriers. Before the Clay Shed is demolished, a 5-metre high wall will be constructed abutting the south side of the masonry lot to act as a noise barrier.

Appendix A

Herring Storer Acoustics Report

ACOUSTIC ASSESSMENT

MIDLAND BRICK SITE REDEVELOPMENT

FOR

CAPITARY NO. 2

JUNE 2021

REFERENCE: 27982-2-20355-02

Rochdale Holdings Pty Ltd A.B.N. 85 009 049 067 trading as:
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DOCUMENT CONTROL PAGE

ACOUSTIC ASSESSMENT

MIDLAND BRICK SITE REDEVELOPMENT

Job No: 20355-02

Document Reference: 27982-2-20355-02

FOR

CAPITARY NO. 2

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Date of Issue :	28 June 2021		

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CONTENTS

APPENDIX

1.0 INTRODUCTION

Capitary No. 2 commissioned Herring Storer Acoustics to carry out an acoustic assessment of a proposed rezoning to the Metropoloitan Region Scheme (MRS) of part of the existing Midland Brick site from 'Industrial and Rural' land use to 'Urban'. The assessment addresses the potential acoustic impact of the remaining Midland Brickworks operations on the proposed residential subdivision, through a number of phases, as the brickwork operations contract in an orderly manner over time.

An acoustic model of the Midland Brickworks Clay (Kilns 9 & 10 and materials feed bins), Clayshed and the Masonry Plant has been used in the assessment. The acoustic model was jointly prepared by Herring Storer Acoustics for Capitary No. 2 and BGC (the Parties) as part of the transfer of the operational business from capitary No. 2 to BGC, and is subject to confidentiality restrictions. The Parties have agreed that the modelling predictions may be used by Capitary No.2 for the purpose of assessing potential impact of the brickwork operations on the proposed residential subdivision. The agreement between the Parties identifies that there needs to be adequate separation between the proposed residential development and the brickwork operations. This separation will reduce as the brickwork operations contract over time.

The acoustic criteria for the proposed residential subdivision is that any proposed residential redevelopment is to only be considered if the predicted noise emissions from the residual brickworks operations are compliant with the 'assigned levels' of the *Environmental Protection (Noise) Regulations 1997* at the proposed redevelopment areas. By reducing the amount of industrial land, the 'assigned levels' at existing residences (external to the proposed residential redevelopment area) may also be reduced. This has been considered within this assessment to ensure there are no exceedances at these locations.

A graphic of the site is shown in Figure 1. Proposed Lot 11 is the Masonry plant site. Area B is the Clay operations site. Area C is a BGC lease area for the existing clay shed.

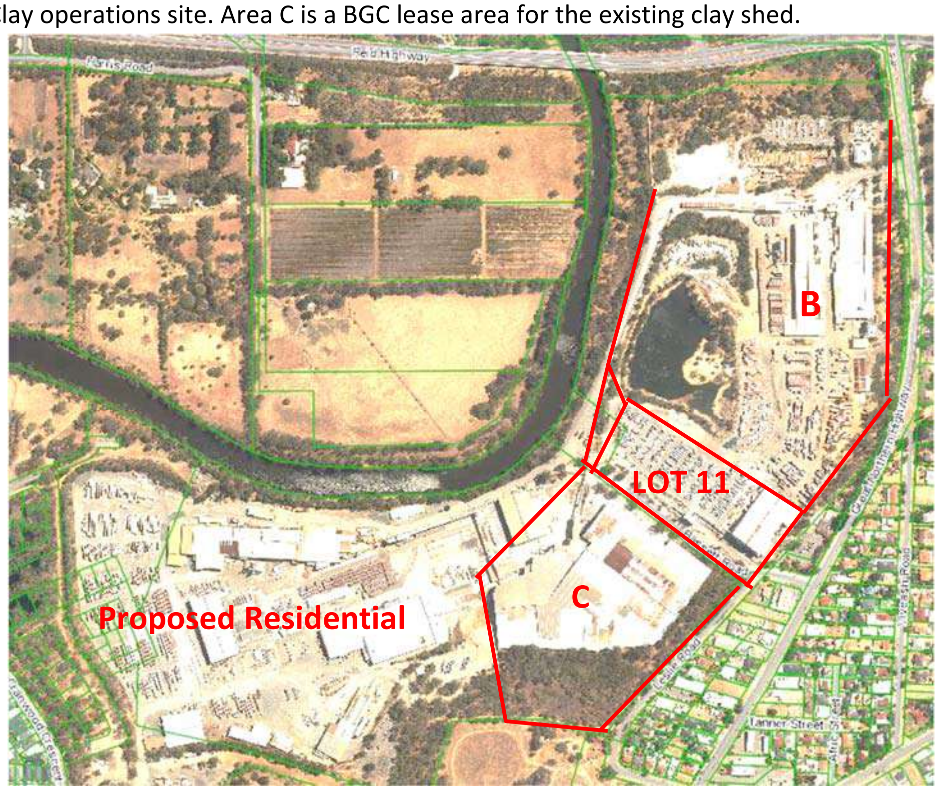


FIGURE 1 – AREA PLAN – MIDLAND BRICK SITE

2.0 METHODOLOGY

An acoustic model has been developed for the Midland Brick site on behalf of BGC and Capitary No.2 (Hesperia). While there are contractual and confidentiality aspects to this modelling, modelling outputs have been permitted to be used for assessment of noise emissions to the proposed MRS rezoning area.

The acoustic model was developed for operational noise emisions north of Bassett Road (the typical night time noise emissions from the brickworks) and verified through a process of measurement of existing noise levels throughout and around the site. A 'measurement map' of the measured noise emissions was generated, and compared to the model predicted emissions to assist in verification of the acoustic model. The clayshed operations were subsequently measured and added to the model.

The basic model development steps were:

- Measure baseline noise emissions of clay and masonry operations operating at an agreed production condition, selected to be representative of historically 'normal' maximum production operating condition.

- Develop an acoustic model to represent the baseline noise emissions.

- Establish the basis for determining the 'assigned levels'.

- Determine influencing factors and 'assigned levels' for the nominated land use scenarios.

- Assessment of compliance with the 'assigned levels' under the regulations.

To assist in the process, tools available in the SoundPlan software were utilized, as due to the large areas and multiple receptor locations involved, a graphics based presentation of noise emission exceedance was considered easier to interpret than a table based approach. Therefore, compliance was assessed on the basis of conflict maps, reflecting interpolated assigned levels from manually determined influencing factors at a number of receptor points.

The baseline measurements from the 23rd November 2020 – 17th December 2020 were used to develop the combined plant 'measurement map', plot 65 (Figure 2). The clayshed and converyor operations were later measured and added to the acoustic model.

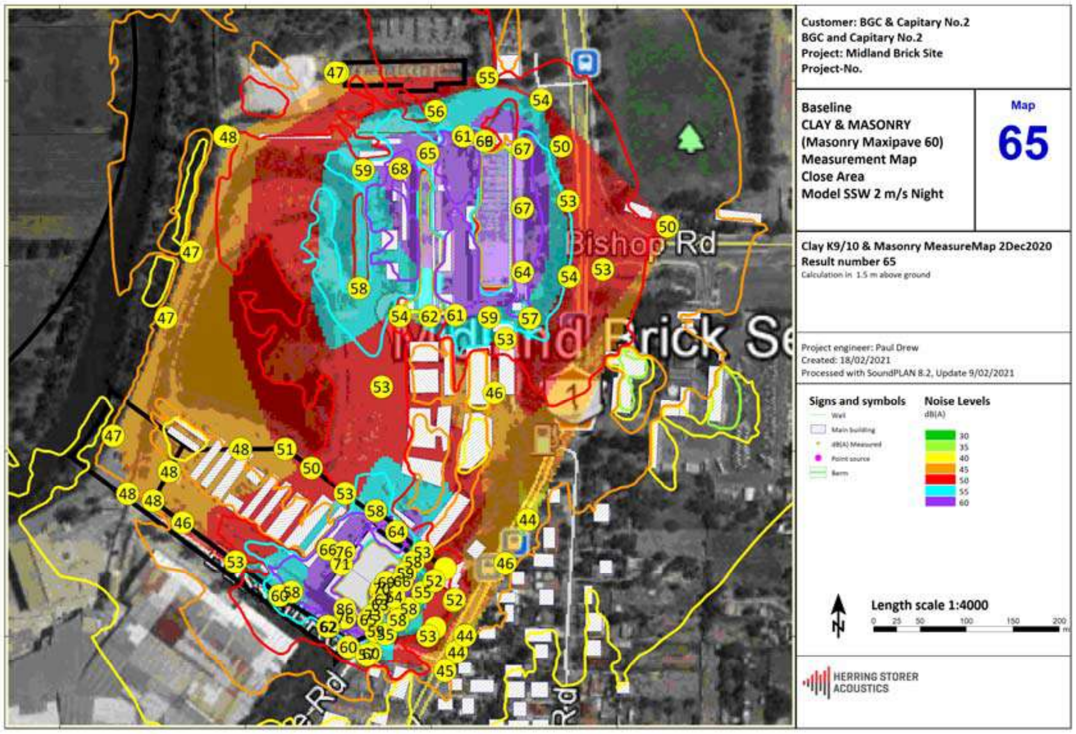


FIGURE 2 - MEASUREMENT MAP AND PREDICTED EMISSIONS FOR COMBINED PLANTS

There is close alignment of the modelled noise emissions (solid contour lines) with the shaded noise contours derived from the baseline noise measurements.

The acoustic model was then used to predict noise emissions for the various stages of transition from existing operations to future 'masonry plant only' operations.

3.0 STAGES OF PHASED REDEVELOPMENT

The proposal is to stage the redevelopment of the existing industrial land to the south/west of Bassett Road to residential. There is a planned phased contraction of the existing brickworks operations, based on contractual agreements with Capitary No.2 (the owner) and brickwork operators / owner BGC.

The arrangements are summarised below;

- Kiln 11 and all asurrounding industrial areas south of the clayshed –BGC have use of these areas until April 2022. Capitary No. 2 will commence demolition of existing industrial infrastructure south of Bassett Road in May 2022.

- Clayshed – Lease Area C. Capitary No. 2 will commence demolition soon after BGC vacate.

- Kilns 9 and 10 and Associated hardstand – Lease Area B. Capitary No. 2 will commence demolition soon after BGC vacate.

- Masonry plant (proposed Lot 11)– BGC will acquire this 3.5ha site and propose to continue operating as a masonry brickworks.

The extent of each stage of proposed residential redevelopment has been based on maintaining compliance of brickworks noise emissions to all residential development. The remaining industrial zoned land (as shown on Local Planning Scheme (LPS) No. 17) contributes to maintaining the relevant 'assigned levels' under the noise regulations.

These phases and the relevant operations affecting noise emissions are:

Scenario A – Continued operation of brickworks Kilns 9 and 10, brick yards, masonry plant and clayshed but all other brickwork operations south of Bassett Road have ceased. Land west of this to be potentially redeveloped as residential, with an appropriate buffer as shown in Figure 3. This proposal includes for the operation of the existing clayshed during the weekday and evening periods as defined by the *Environmental Protection (Noise) Regulations 1997*. During the night period the clayshed operations are to cease, with the exception of conveyor transfer of materials from the clayshed (bins) to Kilns 9 and 10.

FIGURE 3 – SCENARIO A LAND USE

Scenario B – Continued operation of brickworks Kilns 9 and 10, brick yards, masonry plant, with the clayshed removed and conveyor not in operation. Additional land west of Bassett Road to be potentially redeveloped as residential, with a buffer as shown in Figure 4.

FIGURE 4 – SCENARIO B LAND USE

Scenario C – Continued operation of masonry plant, with a 5m acoustic barrier wall constructed along the Bassett Road alignment. The clayshed and clay brickworks including kilns 9 and 10 to have ceased operation (removed). Additional land south-west of Basset Road to be potentially redeveloped as residential, up to Bassett Road, as shown in Figure 5.

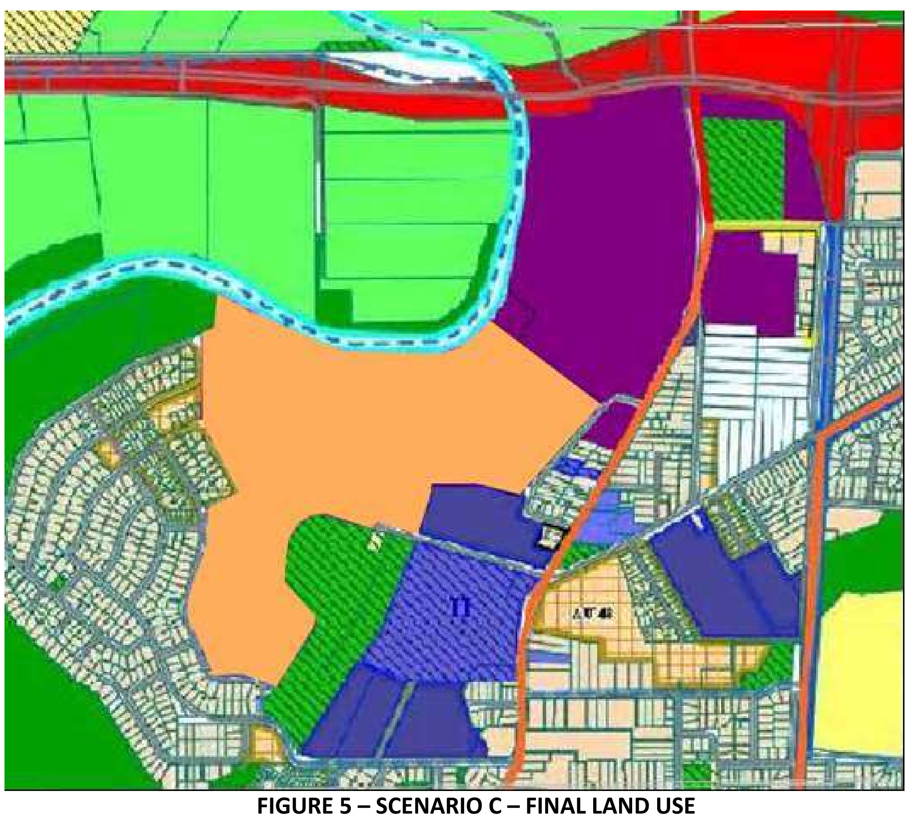


FIGURE 5 – SCENARIO C – FINAL LAND USE

4.0 ACOUSTIC CRITERIA

4.1 ENVIRONMENTAL NOISE REGULATIONS

The criteria used is in accordance with the *Environmental Protection (Noise) Regulations 1997 (as amended).* These regulations stipulate maximum allowable external noise levels determined by the calculation of an influencing factor. The influencing factor is calculated for the usage of land within the two circles, having radii of 100m and 450m from the premises of concern. For commercial and industrial premises, the allowable assigned noise levels are fixed, as listed in Table 4.1.

TABLE 4.1 – ASSIGNED OUTDOOR NOISE LEVELS

Type of premises receiving noise	Time of day	Assigned level (dB)		
		$L_{A\,10}$	$L_{A\,1}$	$L_{A\,max}$
Noise sensitive premises: highly sensitive area (i.e within 15m of a dwelling)	0700 to 1900 hours Monday to Saturday	45 + IF	55 + IF	65 + IF
	0900 to 1900 hours Sunday and public holidays	40 + IF	50 + IF	65 + IF
	1900 to 2200 hours all days	40 + IF	50 + IF	55 + IF
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + IF	45 + IF	55 + IF
Noise sensitive premises: any area other than highly sensitive area	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial Premises	All hours	65	80	90

Note: The L_{A10} noise level is the noise that is exceeded for 10% of the time.
The L_{A1} noise level is the noise that is exceeded for 1% of the time.
The L_{Amax} noise level is the maximum noise level recorded.
IF = Influencing Factor

It is a requirement that noise from the site be free of annoying characteristics (tonality, modulation and impulsiveness) at other premises, defined below as per Regulation 9.

Where the above characteristics are present and cannot be practicably removed, the following adjustments are made to the measured or predicted level at other premises.

TABLE 4.2 – ADJUSTMENTS FOR ANNOYING CHARACTERISTICS WHEN MUSIC IS NOT PRESENT

Where tonality is present	Where modulation is present	Where impulsiveness is present
+ 5 dB	+ 5 dB	+ 10 dB

The influencing factors and associated ‘assigned levels’ are described in following sections of this report.

The most critical assessment parameter is the L_{A10} ‘assigned level’ at the respective receptor locations. Noise sources / operations that contribute to short duration noise emissions that occur less than 10% of the representative assessment period have not been described in detail.

4.2 LAND USE MAPS

The City of Swan Local Planning Scheme No. 17 (LSP-17) has been accepted as being the relevant land use planning map for determination of influencing factors and 'assigned levels' under the *Environmental Protection (Noise) Regulations 1997*. The most current revision of LSP17 can be viewed on the City of Swan Intramaps portal. It is noted this differs from the MRS zoning.

4.3 ROAD SYSTEMS

Main Roads Department of Western Australia provides access to the 'Traffic Map' web accessed portal. This provides detail of publicly available traffic monitoring data for selected road systems.

The determination of the more significant road systems status in terms of average weekday traffic counts (vehicles per day) to determine whether road systems are classified as 'secondary' or 'major' roads under Schedule 3 of the Noise Regulations.

> Roads are classified as 'secondary' where the daily average traffic count is between 6,000 – 15,000 vehicles.
>
> Roads are classified as 'major where the daily average traffic count is greater than 15,000 vehicles.

Schedule 3, section 1 (2) and (3) outline the acceptable methods of determining the traffic count. Clause (3) directs that if the count is unknown, the road is not to be taken as a secondary or major road for the determination of the 'influencing factor'.

There is one available count for Lloyd Street, south of Toodyay Road for 2020, which indicates that section of road has a count of less than 15,000 vpd. Reid Highway and Roe Highway have counts greater than 15,000 vpd. The road system classifications used in the assessment are shown on the Figures included in this report (colour coded). The traffic counts are listed in Table 4.3.

The section of Great Northern Highway south of Roe/Reid intersection to Bishop Road has been interpreted as a major road due to the available traffic count (2015/2016) of 19,451 vpd. A review of traffic flows in the area implies that around 2017, some traffic moved from GNHwy (south of Toodyay Road) to Lloyd Street, around 2,500vpd. This change may not have affected the northern section of GNHwy next to Midland Brick. However, recent introduction of the North Link system may have, although there are no recent traffic counts available and a decrease from 19,451 vpd to below 15,000 vpd (required to change status from major road to secondary road) is a significant change.

TABLE 4.3 –ROAD TRAFFIC COUNTS SURROUNDING SITE (MRWA TRAFFIC MAP)

Road	vpd	year	Designation
Reid Highway	38,752	2017/2018	Major
Roe Highway	31,443	2015/2016	Major
GNHwy (south of Toodyay Road)	14,694	2017/2018	Secondary
GNHwy (south of Reid/Roe Hwy) to Bishop Road.	19,451	2015/2016	Major
GNHwy north of Reid/Roe	26,603	2017/2018	Major
Toodyay Road	4,229	2017/2018	Not significant
Lloyd Street	14,107	2020/2021	Secondary

As there is no official traffic count for Bishop Road, it has not been included as either a secondary or major road.

4.4 NOISE CHARACTERISTICS & SIGNIFICANTLY CONTRIBUTING ASPECTS

Noise characteristic can require an adjustment to the measured noise emission, reference (regulation 7 (1) (a), and (9)).

Noise emissions from industrial plants typically demonstrate ‘tonality’ noise characteristic for locations strongly affected by the industrial noise emission. This requires and adjustment of +5 dB(A) where present as defined under regulation 9.

At further distance, the merging of the noise emission and local background noise can ‘mask’ noise characteristic, and the adjustment is no longer applicable.

For the acoustic assessment, it has been assumed that noise emissions greater than 35 dB(A) may exhibit tonal characteristic, with adjustment of emitted levels by + 5 dB(A) for the compliance assessment. Noise emissions of 35 dB(A) and lower have been assessed as not exhibiting ‘tonal characteristic’. There is background noise surrounding the site associated with the high traffic flow Reid Highway and other significant roads. Background noise monitoring undertaken in the early morning on various occasions has consistently resulted in measured levels above 35 dB(A), consistent with this assumption.

There are no other major noise emitting industries close to the proposed residential subdivision areas, therefore significantly contributing noise emissions are not expected to be applicable.

4.5 EXISTING ASSIGNED LEVELS

The noise sensitive premises surrounding the Midland Brick site, particularly those sections under consideration of development, could potentially have their ‘influencing factor’ and associated ‘assigned levels’ reduced by rezoning of industrial classified land to residential. This has been considered and a comparison made between the predicted noise levels and the future assigned levels.

In undertaking this assessment, a number of assumptions and interpretations have been made. The assumptions regarding traffic flows have been discussed in Section 4.3. Other assumptions include:

- The existing City of Swan works depot has been assessed as ‘industrial’ classification, as this area is zoned for ‘residential redevelopment’, but the current use is permitted until such development occurs.

- The former school site at Eveline Road / Leslie Street corner is zoned ‘Private Clubs and Institutions’. Zoning includes clubs, which are commercial classification, therefore as highest classification presides in determining influencing factor, zoning will be treated as commercial for determination of influencing factor. However, usage is Aged Care, so will be a ‘highly noise sensitive’ premises on the site. Developer DA plans show future residential on section of land to the west (north edge of former school oval).

- Swan Hospital site: Zoned public purposes, which has no direct classification. Last use was Hospital of 192 beds, which is classified as 'commercial', however hospital has been closed for some time and LSP17-179 Rezoning Amendment being considered by City of Swan would change usage to predominantly 'Aged Care' use, which is 'noise sensitive'. Interpretation is 'commercial classification for determination of influencing factor, unoccupied noise sensitive land for receptor (at present).

Figure 6 shows the base land use classifications (under the Regulations) used.

Table 4.3 shows the determined influencing factors under the existing LSP17.

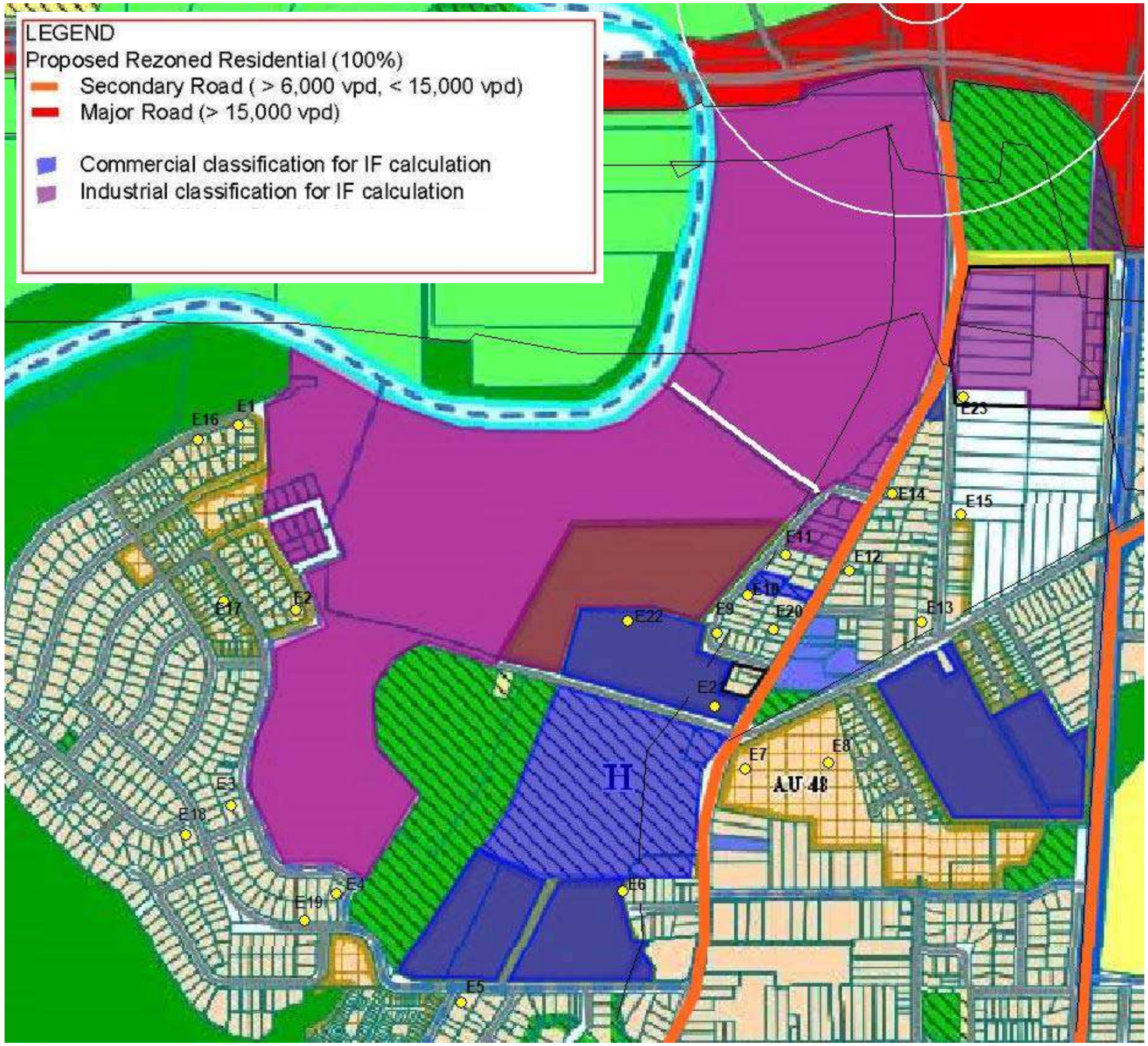


FIGURE 6 - EXISTING INFLUENCING FACTORS – ASSESSMENT MAP AND CALCULATION LOCATIONS

TABLE 4.3 – CALCULATED INFLUENCING FACTORS FOR EXISTING LSP-17

Ref	Industrial		Commercial		Industrial		Commercial		Circle IF	TF	IF
	Inner Area, m2	Outer Area, m2	Inner Area, m2	Outer Area, m2	Inner %	Outer %	Inner %	Outer %			
E-1	6095	136315	0	0	19	21	0	0	4.1	0	4
E-2	12886	284449	0	0	41	45	0	0	8.6	0	9
E-3	7687	110429	0	6590	24	17	0	1	4.2	0	4
E-4	6025	91744	0	78635	19	14	0	12	4.0	0	4
E-5	0	27330	8031	116045	0	4	26	18	2.6	0	3
E-6	0	3652	20760	211231	0	1	66	33	5.0	0	5
E-7	0	45333		122849	0	7	0	19	1.7	2	4
E-8	0	25697	0	225877	0	4	0	36	2.2	0	2
E-9	5451	228150	8073	156675	17	36	26	25	7.8	0	8
E-10	9093	251744	3175	130292	29	40	10	20	8.4	2	10
E-11	15169	262373	3770	96928	48	41	12	15	10.3	2	12
E-12	4677	102451	298	95787	15	16	1	15	3.9	2	6
E-13	0	48204	2568	105874	0	8	8	17	2.0	0	2
E-14	6823	273252	0	37859	22	43	0	6	6.8	2	9
E-15	0	189619	0	53819	0	30	0	8	3.4	0	3
E-16	0	119556	0	0	0	19	0	0	1.9	0	2
E-17	0	205070	0	0	0	32	0	0	3.2	0	3
E-18	0	92227	0	0	0	14	0	0	1.4	0	1
E-19	0	79875	0	50852	0	13	0	8	1.7	0	2
E-20	0	190840	3608	151970	0	30	11	24	4.8	2	7
E-21	0	133188	12907	196287	0	21	41	31	5.7	2	8
E-22	11723	277943	17353	171018	37	44	55	27	12.2	0	12
E-23	9824	278172	1343	1343	31	44	4	0	7.7	4	12

4.6 PROPOSED FINAL REZONED ASSIGNED LEVELS

The assigned levels following the proposed rezoning of the south-western part of the brickworks land to residential have been determined.

The interim phases of development (Scenarios A and B) 'assigned levels' have not been detailed in this report, although these have been assessed, and the 'conflict maps' are provided in Appendix A, with assessment of compliance in Appendix C.

The process is to first identify the surrounding land classification and minor/major roads surrounding the area of interest. Using this base, the influencing factors for key surrounding land can be determined, including the potential rezoned site land. Once this is completed, predicted noise emissions can be compared to the assigned levels at the critical time period (night time in this case), to determine the compliance status.

Figure 7 shows the base land use classifications (under the Regulations).

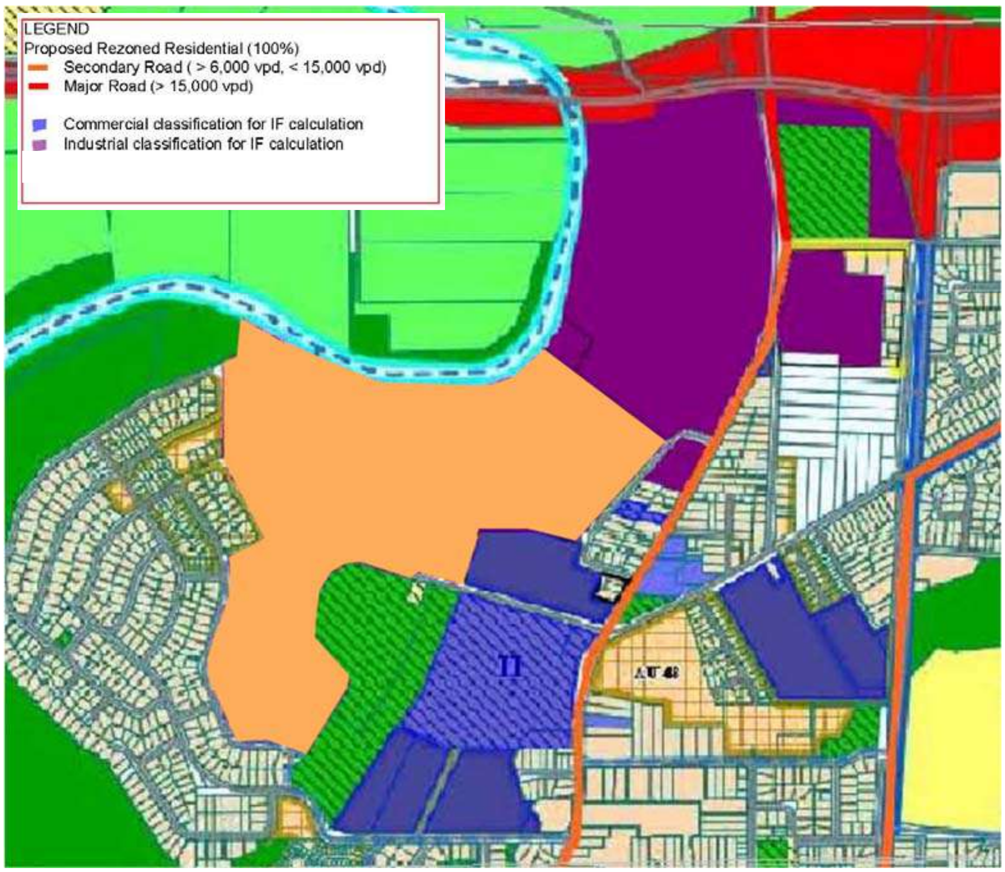


FIGURE 7 – LAND CLASSIFICATIONS AND ROAD SYSTEMS USED FOR ASSIGNED LEVEL DETERMINATION

Figure 8 shows the determined influencing factors and night-time 'assigned levels' based on all redeveloped land south of Bassett Road being residential. Detail on how these were derived are provided in Table 4.4. Figure 9, show the potential residences south of Bassett Road for which the Influencing Factor has been calculated.

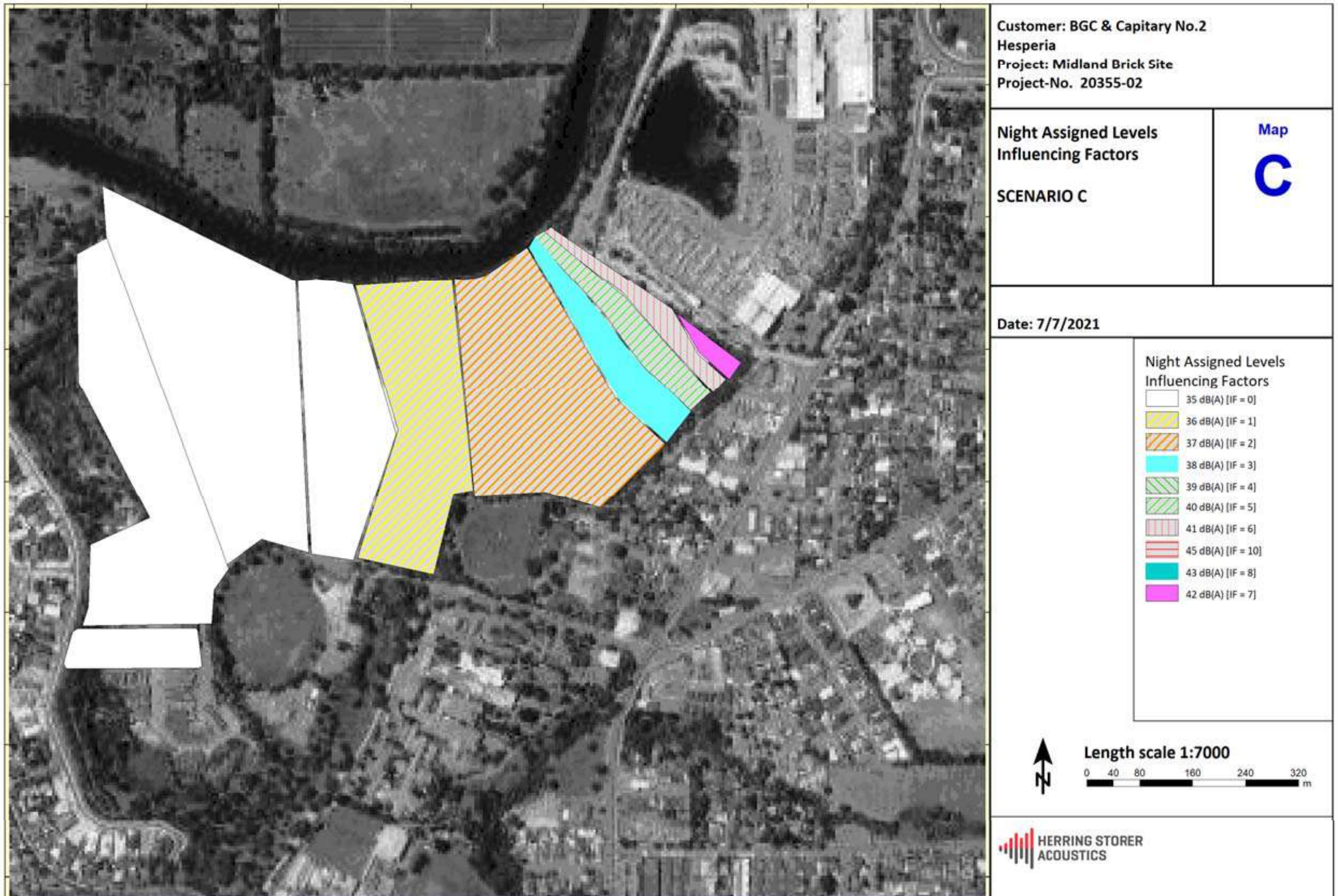


FIGURE 8 – DETERMINED NIGHT-TIME ASSIGNED LEVELS FOR POTENTIAL FULL RESIDENTIAL DEVELOPMENT

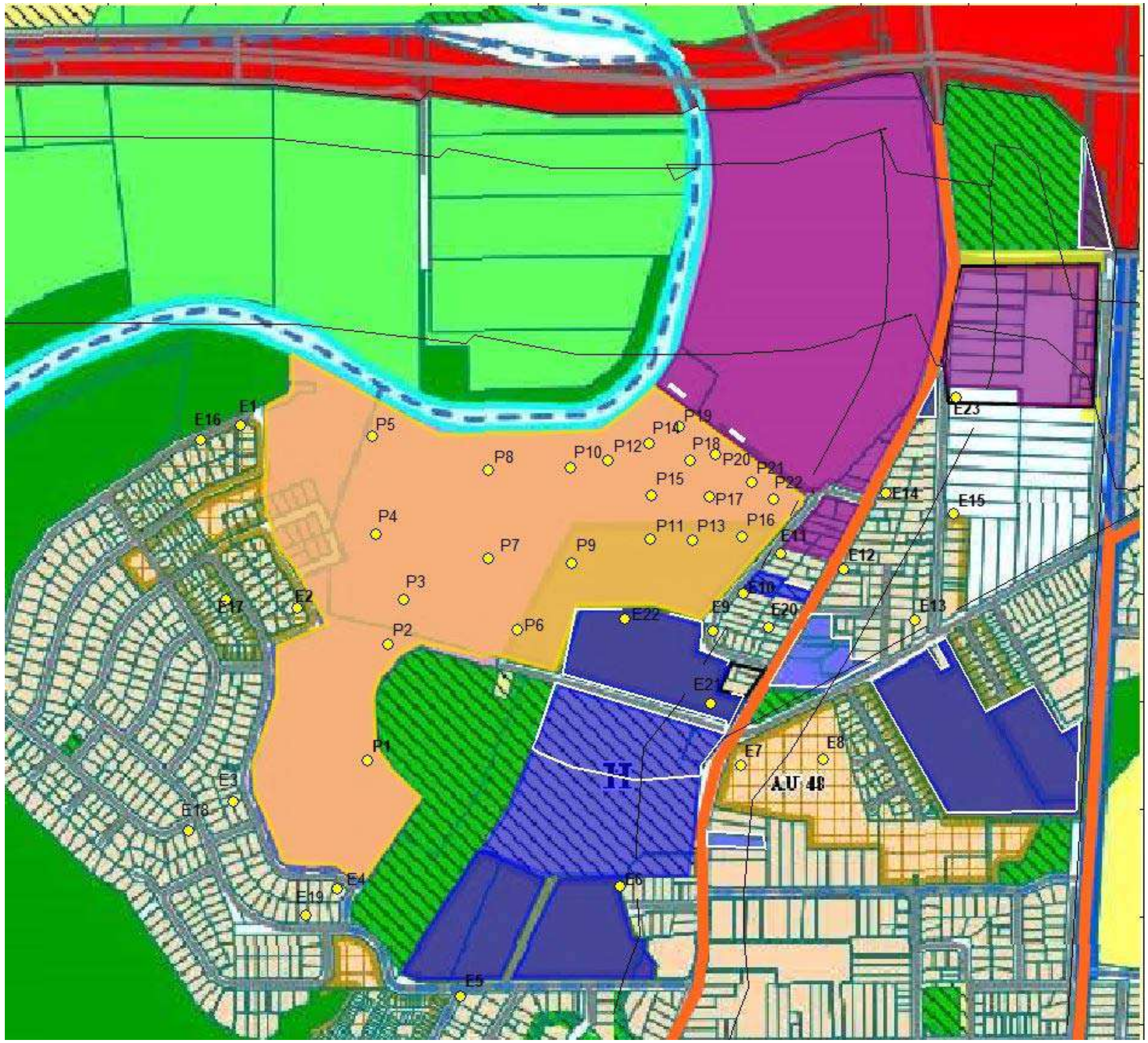


FIGURE 9 - POTENTIAL RESIDENTIAL SOUTH OF BASSETT ROAD INFLUENCING FACTORS – ASSESSMENT MAP AND CALCULATION LOCATIONS

TABLE 4.4 – CALCULATED INFLUENCING FACTORS FOR POTENTIAL REZONE ALL SOUTH OF BASSETT ROAD TO RESIDENTIAL

Ref	Industrial		Commercial		Industrial		Commercial		Circle IF	TF	IF
	Inner Area, m2	Outer Area, m2	Inner Area, m2	Outer Area, m2	Inner %	Outer %	Inner %	Outer %			
E-1	0	0	0	0	0	0	0	0	0.0	0	0
E-2	0	0	0	0	0	0	0	0	0.0	0	0
E-3	0	0	0	6590	0	0	0	1	0.1	0	0
E-4	0	0	0	78635	0	0	0	12	0.6	0	1
E-5	0	0	8031	116045	0	0	26	18	2.2	0	2
E-6	0	0	20760	211231	0	0	66	33	5.0	0	5
E-7	0	2847	1649	235561	0	0	5	37	2.2	2	4
E-8	0	5000	0	225877	0	1	0	36	1.9	0	2
E-9	0	45121	8073	156675	0	7	26	25	3.2	0	3
E-10	0	81917	3175	83995	0	13	10	13	2.5	2	4
E-11	4389	119171	3763	95700	14	19	12	15	4.6	2	7
E-12	4677	102451	298	95787	15	16	1	15	3.9	2	6
E-13	0	48204	2568	105874	0	8	8	17	2.0	0	2
E-14	6828	207559	0	37859	22	33	0	6	5.7	2	8
E-15	0	163758	0	53819	0	26	0	8	3.0	0	3
E-16	0	0	0	0	0	0	0	0	0.0	0	0
E-17	0	0	0	0	0	0	0	0	0.0	0	0
E-18	0	0	0	0	0	0	0	0	0.0	0	0
E-19	0	0	0	50852	0	0	0	8	0.4	0	0
E-20	0	56588	3608	151970	0	9	11	24	2.7	2	5
E-21	0	9677	12907	196287	0	2	41	31	3.8	2	6
E-22	0	25264	17353	171018	0	4	55	27	4.5	0	5
E-23	9824	264048	1343	1343	31	42	4	0	7.5	4	12
P1	0	0	0	97063	0	0	0	15	0.8	0	1
P2	0	0	0	52279	0	0	0	8	0.4	0	0
P3	0	0	0	38463	0	0	0	6	0.3	0	0
P4	0	0	0	5277	0	0	0	1	0.0	0	0
P5	0	0	0	0	0	0	0	0	0.0	0	0
P6	0	0	0	134678	0	0	0	21	1.1	0	1

Ref	Industrial		Commercial		Industrial		Commercial		Circle IF	TF	IF
	Inner Area, m2	Outer Area, m2	Inner Area, m2	Outer Area, m2	Inner %	Outer %	Inner %	Outer %			
P7	0	0	0	67512	0	0	0	11	0.5	0	1
P8	0	10729	0	20174	0	2	0	3	0.3	0	0
P9	0	25554	555	101383	0	4	2	16	1.3	0	1
P10	0	62340	0	39605	0	10	0	6	1.3	0	1
P11	0	88838	0	101636	0	14	0	16	2.2	0	2
P12	0	102720	0	42307	0	16	0	7	1.9	0	2
P13	0	108703	0	95388	0	17	0	15	2.5	0	2
P14	0	146273	0	37381	0	23	0	6	2.6	0	3
P15	0	118700	0	71867	0	19	0	11	2.4	0	2
P16	609	127578	1400	101286	2	20	4	16	3.2	0	3
P17	0	146434	0	70885	0	23	0	11	2.9	0	3
P18	2346	164667	0	53454	7	26	0	8	3.8	0	4
P19	8501	184243	0	27685	27	29	0	4	5.8	0	6
P20	7511	180324	0	48044	24	28	0	8	5.6	0	6
P21	7403	177135	0	61707	24	28	0	10	5.6	0	6
P22	10017	169659	0	66508	32	27	0	10	6.4	0	6

The potential impact of re-zoning industrial land to residential is shown in Table 4.5, based on predicted noise emissions for Scenario C 'masonry only' operating under 'worst case' night conditions.

The assessment shows that the proposed rezoning will not have an adverse impact on existing residential receptors in relation to the Midland Brick noise emissions.

TABLE 4.5 – CHANGE IN INFLUENCING FACTOR DUE TO REZONING TO 100% RESIDENTIAL

Loc	IF Exist	IF	Decrease in IF	Night AL	Predicted Level	Exceedance	Impact
E-1	4	0	4	35	20	-15	No
E-2	9	0	9	35	20	-15	No
E-3	4	0	4	35	16	-19	No
E-4	4	1	3	36	17	-19	No
E-5	3	2	1	37	18	-19	No
E-6	5	5	0	40	20	-20	No
E-7	4	4	0	39	25	-14	No
E-8	2	2	0	37	26	-11	No
E-9	8	3	5	38	28	-9	No
E-10	10	4	6	39	30	-7	No
E-11	12	7	5	42	35	-6	No
E-12	6	6	0	41	33	-8	No
E-13	2	2	0	37	31	-6	No
E-14	9	8	1	43	37	-6 (-1)	No
E-15	3	3	0	38	33	-5 (0)	No
E-16	2	0	2	35	20	-15	No
E-17	3	0	3	35	19	-16	No
E-18	1	0	1	35	15	-20	No
E-19	2	0	2	35	17	-18	No
E-20	7	5	2	40	31	-9	No
E-21	8	6	2	41	27	-14	No
E-22	12	5	7	40	27	-13	No
E-23	12	12	0	47	37	-10	No
E-24	7	7	0	42	23	-19	No

Note: Where noise emissions are known or expected to exhibit tonal characteristic, this is shown by (xx) as the exceedance (adjusted). The exceedance shown includes the adjustment for tonal characteristic in accordance with the regulations.

5.0 REDEVELOPMENT - BRICKWORKS NOISE INGRESS ASSESSMENT

Brickworks operations noise emissions are predicted to comply with the 'assigned levels' of the *Environmental Protection (Noise) Regulations 1997* at the proposed residential areas for the various phases of redevelopment.

The phased development proposals outlined in this assessment have been developed on the basis that the predicted operational noise emissions from the brickworks operations will comply with the *Environmental Protection (Noise) Regulation 1997* 'assigned levels'.

Scenario A, the initial phase of residential development allows for the operation of the existing brickworks Kilns 9 and 10, the masonry plant and the clayshed converyor system. During the weekday and evening period the clayshed operations including truck deliveries, crushing and screening and loader operations have been modelled. Included in the acoustic modelling are the proposed final topography, with inclusion of acoustic barriers formed with stacked seacontainers. The seacontainers are currently located on site, having been used for this purpose in other locations. The proposed brickworks operations are expected to generate compliant noise emissions at the Scenario A residential development areas (plot 320, Appendix B).

Scenario B, an interim phase of residential development allows for the decommissioning of the clayshed and conveyor operations. Upon removal of the clayshed building, a 5m acoustic barrier wall is to be constructed on the southern side of the Bassett Road extension into the site. This will assist in the mitigation of noise emissions from the masonry plant and clay operations. The proposed brickworks operations are expected to generate compliant noise emissions at the Scenario B residential development areas (plot 299, Appendix B).

Scenario C, allows for residential development up to the western side of Bassett Road, and the extension of Bassett Road into the site to the river. This scenario is based on ceasation of the clay operations (kilns 9 and 10, clayshed), with the existing masonry plant continuing to operate. The 5m high acoustic barrier wall is to remain along the southern side of Bassett Road, providing acoustic attenuation from the masonry plant operations. The proposed masonry plant operations are expected to generate compliant noise emissions at the Scenario C residential development areas (plot 300, Appendix B).

The Clay and Masonry plant operations have a number of processes that occur within the different time periods as defined under the Noise Regulations. Some of the operating scenarios have less equipment operating than others in the same regulation time period. Therefore, not every scenario needs to be modelled in order to identify the most significant noise emissions for that time period. The significant operating scenarios have been modelled. Scenario A includes separate modelling contour plots (Appendix B) for the weekday / evening scenario, and the night-time scenario operations.

The assessment of compliance with the regulation 'assigned levels' for the surrounding area has been undertaken using graphic 'conflict maps', which are contained in Appendix C. These show that the predicted noise emissions are compliant at the proposed residential development areas.

It is noted that the whole of this site is and will be subject to aircraft noise and significant traffic noise. The residential dwellings are required to be constructed to reduce noise ingress in accordance with *State Planning Policy 5.1 Land Use Planning in the Vicinity of Perth Airport*.

6.0 CONCLUSION

Capitary No. 2 commissioned Herring Storer Acoustics to carry out an acoustic assessment of a proposed rezoning to the Metropoloitan Region Scheme (MRS) of part of the existing Midland Brick site from ‘Industrial and Rural’ land use to ‘Urban’. The assessment addresses the potential acoustic impact of the remaining Midland Brickworks operations on the proposed residential subdivision, through a number of phases, as the brickwork operations contract in an orderly manner over time.

An acoustic model of the Midland Brickworks Clay (Kilns 9 & 10 and materials feed bins, clayshed and converyor) and the Masonry Plant has been used in the assessment.

The acoustic criteria for the proposed residential subdivision is that any proposed redevelopment is to only be considered if the predicted noise emissions from the residual brickworks operations are compliant with the ‘assigned levels’ of the *Environmental Protection (Noise) Regulations 1997* at the proposed redevelopment areas and existing residences.

The proposal is to stage the redevelopment of the existing industrial land to the south/west of Bassett Road to residential. There is a planned phased movement of existing brickworks operations, based on contractual agreements with Capitary No.2 (the owner) and brickwork operators / owner BGC.

Brickworks operations noise emissions are predicted to comply with the ‘assigned levels’ of the *Environmental Protection (Noise) Regulations 1997* at the proposed residential areas for the various phases of redevelopment.

Scenario A, the initial phase of residential development allows for the operation of the existing brickworks Kilns 9 and 10, the masonry plant and the clayshed converyor system. During the weekday and evening period the clayshed operations including truck deliveries, crushing and screening and loader operations have been modelled. Included in the acoustic modelling are the proposed final topography, with inclusion of acoustic barriers formed with stacked seacontainers. The seacontainers are currently located on site, having been used for this purpose in other locations.

Scenario B, an interim phase of residential development allows for the decommissioning of the clayshed and conveyor operations. Upon removal of the clayshed building, a 5m high acoustic barrier wall is to be constructed on the southern side of the Bassett Road extension into the site. This will assist in the mitigation of noise emissions from the masonry plant and clay operations.

Scenario C allows for the proposed ultimate residential development up to the southern side of Bassett Road. This scenario is based on ceasation of the clay operations (kilns 9 and 10, clayshed), with the existing masonry plant continuing to operate. The 5m high acoustic barrier wall is to remain along the souhern side of the Bassett Road extension into the site, providing acoustic mitigation from the masonry plant operations.

The assessment of compliance with the regulation ‘assigned levels’ for the surrounding area show that the predicted noise emissions are compliant at the proposed and existing residential - areas.

APPENDIX A

INFLUENCING FACTOR CALCULATION ASSUMPTIONS

SCENARIO ‘ASSIGNED LEVEL’ MAPS

NOTES: INTERPRETATION OF NOISE REGULATION CLASSIFICATIONS
EXISTING LOCAL STRUCTURE PLAN

1. Shire of Swan Depot. Located on “Residential Redevelopment” zoned land, but existing use is not residential, so receptor is interpreted as ‘industrial’ user as a permitted use prior to urban redevelopment includes the City of Swan Depot workshops for repair / maintenance.

2. Private Clubs and Institutions – formerly a school and now being developed for Aged Care facility. Zoning includes clubs, which are commercial classification, therefore as highest classification presides in determining influencing factor, zoning will be treated as commercial for determination of influencing factor. However, usage is Aged Care, so will be a ‘highly noise sensitive’ premises on the site. Developer DA plans show future residential on section of land to the west (north edge of former school oval).

3. Swan Hospital site: Zoned public purposes, which has no direct classification. Last use was Hospital of 192 beds, which is classified as ‘commercial’, however hospital has been closed from some time and LSP17-179 Rezoning Amendment being considered by City of Swan would change usage to predominantly ‘Aged Care’ use, which is ‘noise sensitive’. Interpretation is ‘commercial’ classification for determination of influencing factor, unoccupied noise sensitive land for receptor (at present).

4. In determining existing assigned levels, there are some locations which are zoned residential, but which are currently not developed as such (no residence). Example is small lot at NE corner of the Eveline / Leslie St Aged Care. Classification is noise sensitive for determination of influencing factor, but there is no dwelling, so criteria is L_{A10} of 60 dB(A).

5. Road systems to east of Midland Brick site have all appeared to have had a decline in vehicles per day since 2015/16, although traffic counts are not comprehensive. In accordance with regulations, roads with traffic counts are classified based on the latest traffic count. Roads with no traffic count are not included as affecting the Traffic Factor.

6. For calculation of proportion of area classification to determine influencing factors, areas were measured. The 100% area for the 100m radius and 450m radius circles used to determine influencing factor are 31,389 m^2 for 100m radius and 636,054 m^2 for 450m radius.

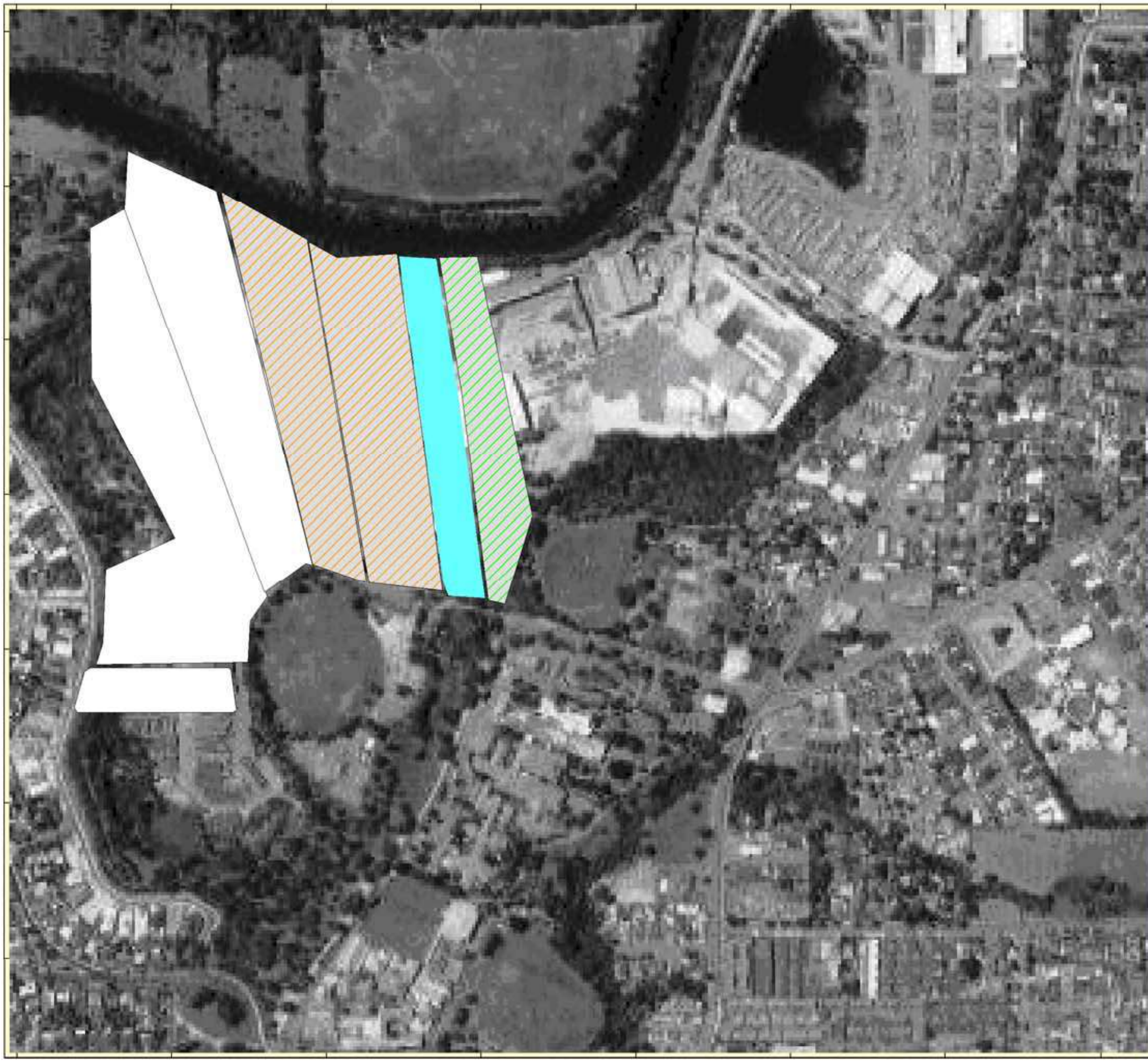
Customer: BGC & Capitary No.2 Hesperia
Project: Midland Brick Site
Project-No. 20355-02

Night Assigned Levels Influencing Factors

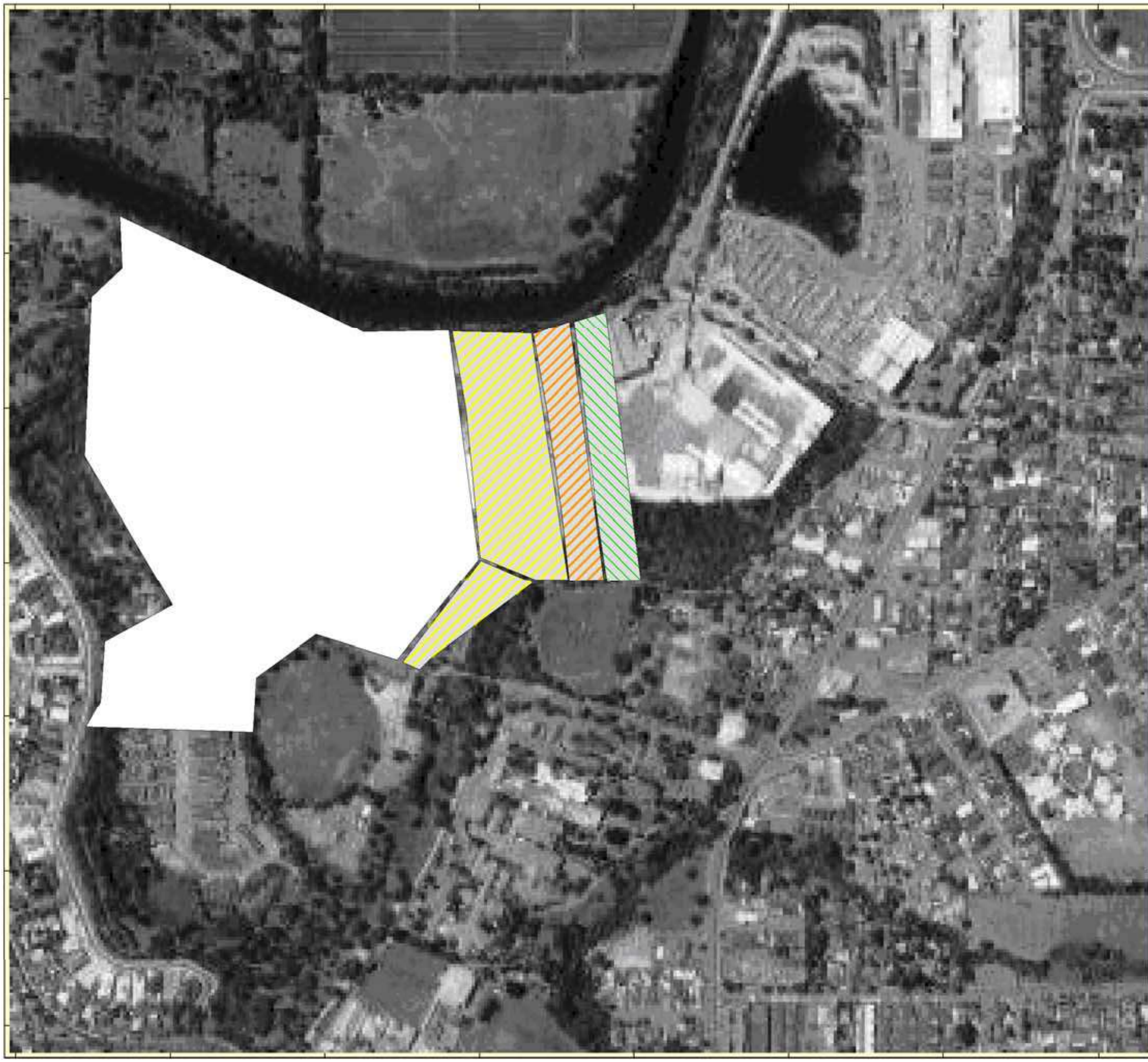
SCENARIO A

Map
A

Date: 7/7/2021



HERRING STORER ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No.

Night Assigned Levels
Influencing Factors

SCENARIO B

Map
B

Date: 7/7/2021

Night Assigned Levels
Influencing Factors

35 dB(A) [IF = 0]
36 dB(A) [IF = 1]
37 dB(A) [IF = 2]
38 dB(A) [IF = 3]
39 dB(A) [IF = 4]
40 dB(A) [IF = 5]
41 dB(A) [IF = 6]
45 dB(A) [IF = 10]
43 dB(A) [IF = 8]
42 dB(A) [IF = 7]

N

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS

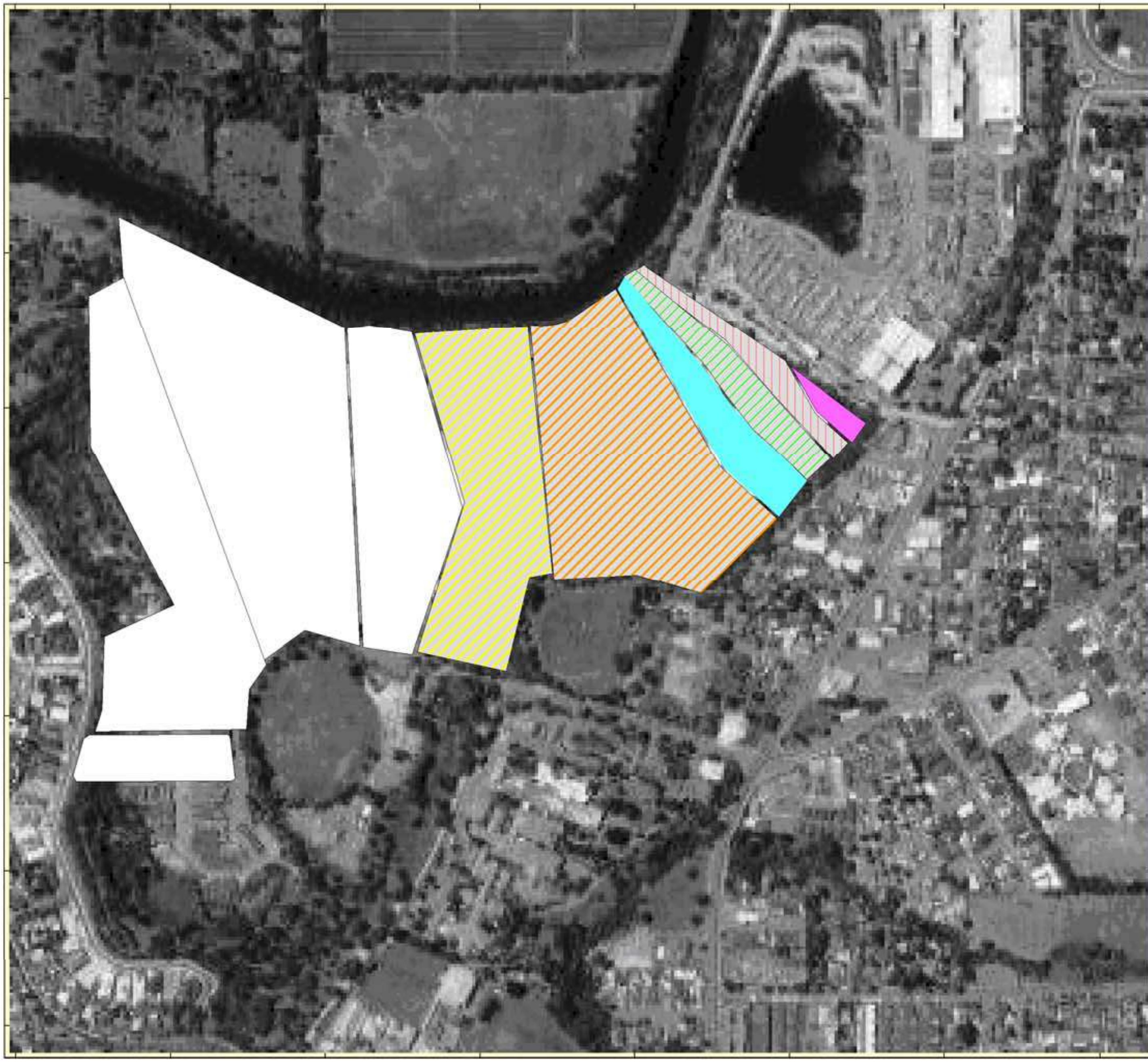
Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No. 20355-02

Night Assigned Levels
Influencing Factors

SCENARIO C

Map
C

Date: 7/7/2021



Night Assigned Levels
Influencing Factors
35 dB(A) [IF = 0]
36 dB(A) [IF = 1]
37 dB(A) [IF = 2]
38 dB(A) [IF = 3]
39 dB(A) [IF = 4]
40 dB(A) [IF = 5]
41 dB(A) [IF = 6]
45 dB(A) [IF = 10]
43 dB(A) [IF = 8]
42 dB(A) [IF = 7]

N

Length scale 1:7000

0 40 80 160 240 320 m

HERRING STORER ACOUSTICS

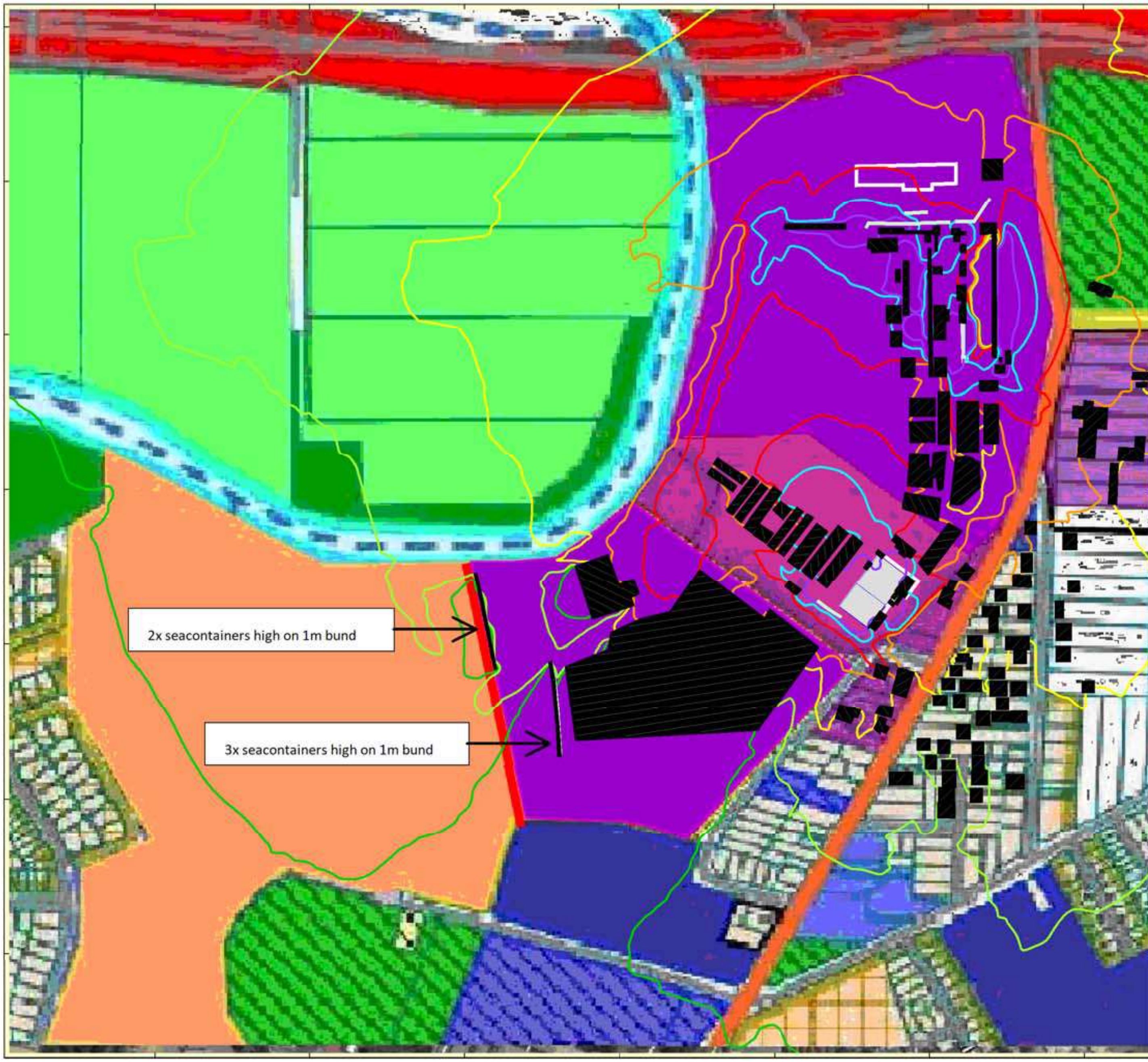
APPENDIX B

NOISE EMISSION NOISE CONTOUR PLOTS

Scenario A: CLAY & MASONRY – INCLUDING OPERATING CLAY BUILDINGS

Scenario B: CLAY & MASONRY –CLAY BUILDINGS REMOVED

Scenario C: MASONRY ONLY



Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02

CONFLICT NOISE MAP
Combined Clay and Masonry, Night Allwinds
Conveyor Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Night Operations

Map
320

Scenario A
Result number 320
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols

- Wall
- Main building
- Point source
- Berm

Noise Levels

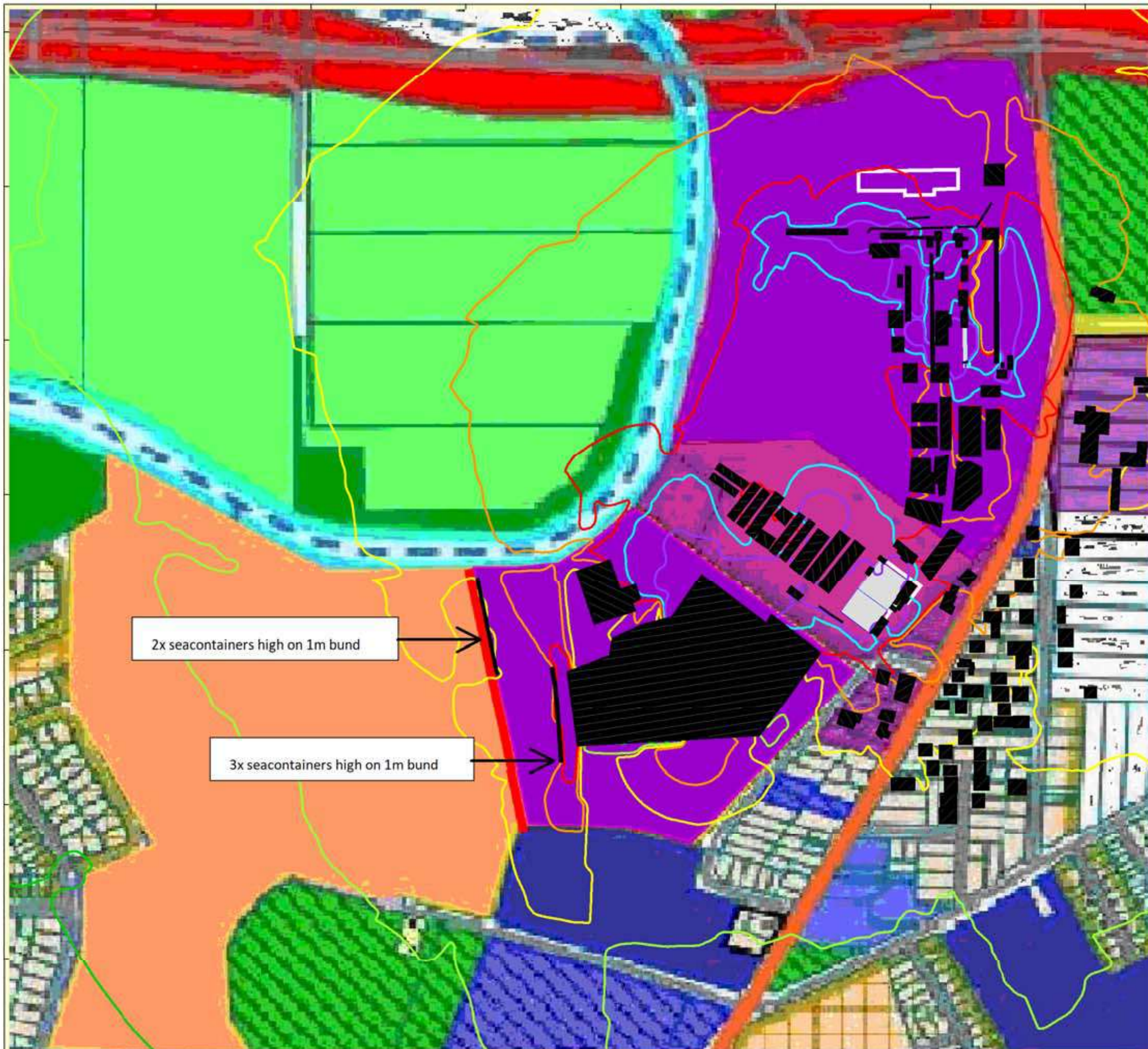
dB(A)

30
35
40
45
50
55
60

Length scale 1:7000

0 40 80 160 240 320 m

HERRING STORER ACOUSTICS



Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02

Combined Clay and Masonry
Evening Allwinds
Conveyor
& Clayshed Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Evening Operations

Map
315

Scenario A
Result number 315
Calculation in 1.5 m above ground

Day / Evening Operational Scenario

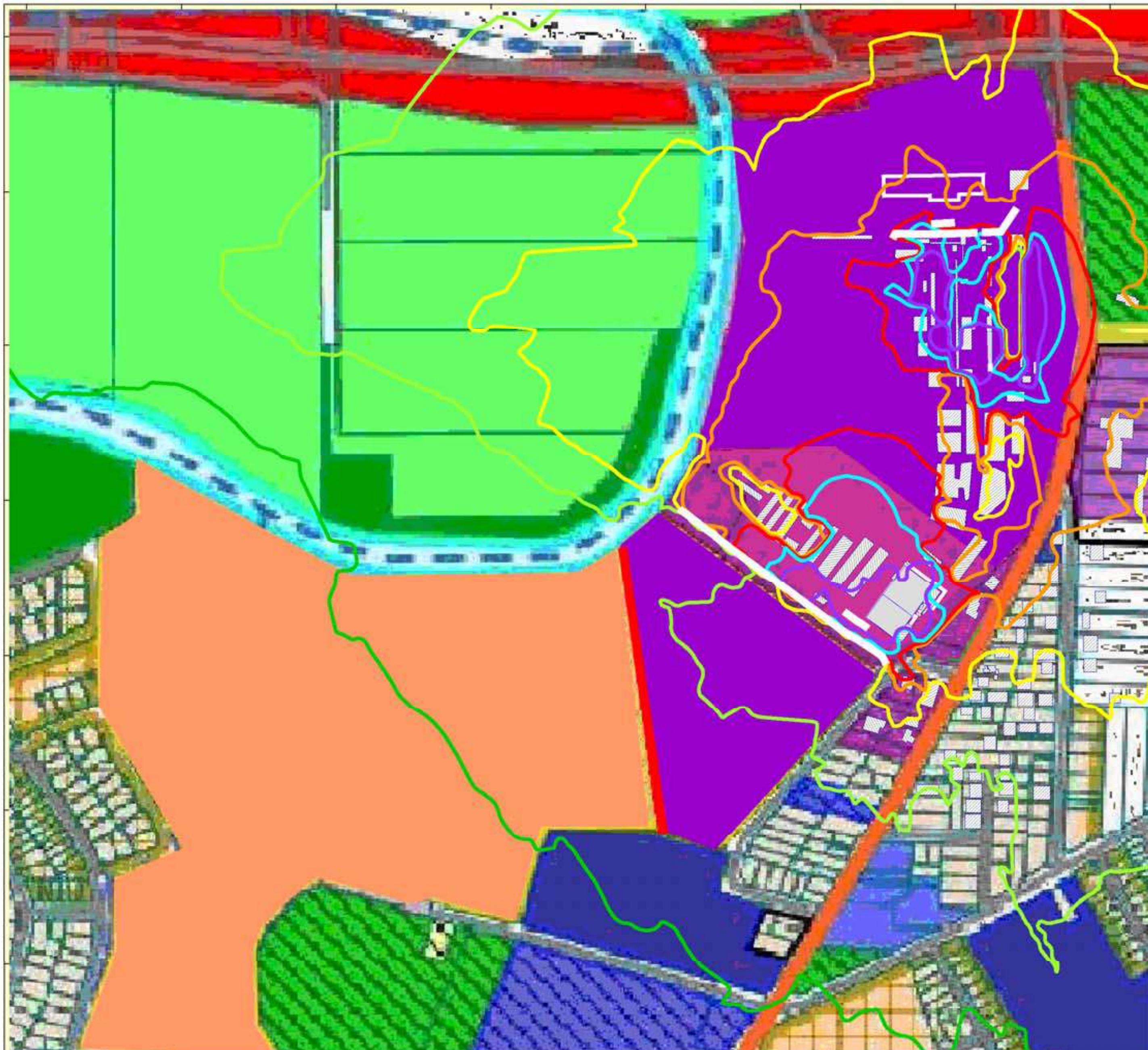
Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No.

Combined Clay and Masonry Night Allwinds Clayshed & Conveyor Removed

Map
299

Scenario B
Result number 299
Calculation in 1.5 m above ground

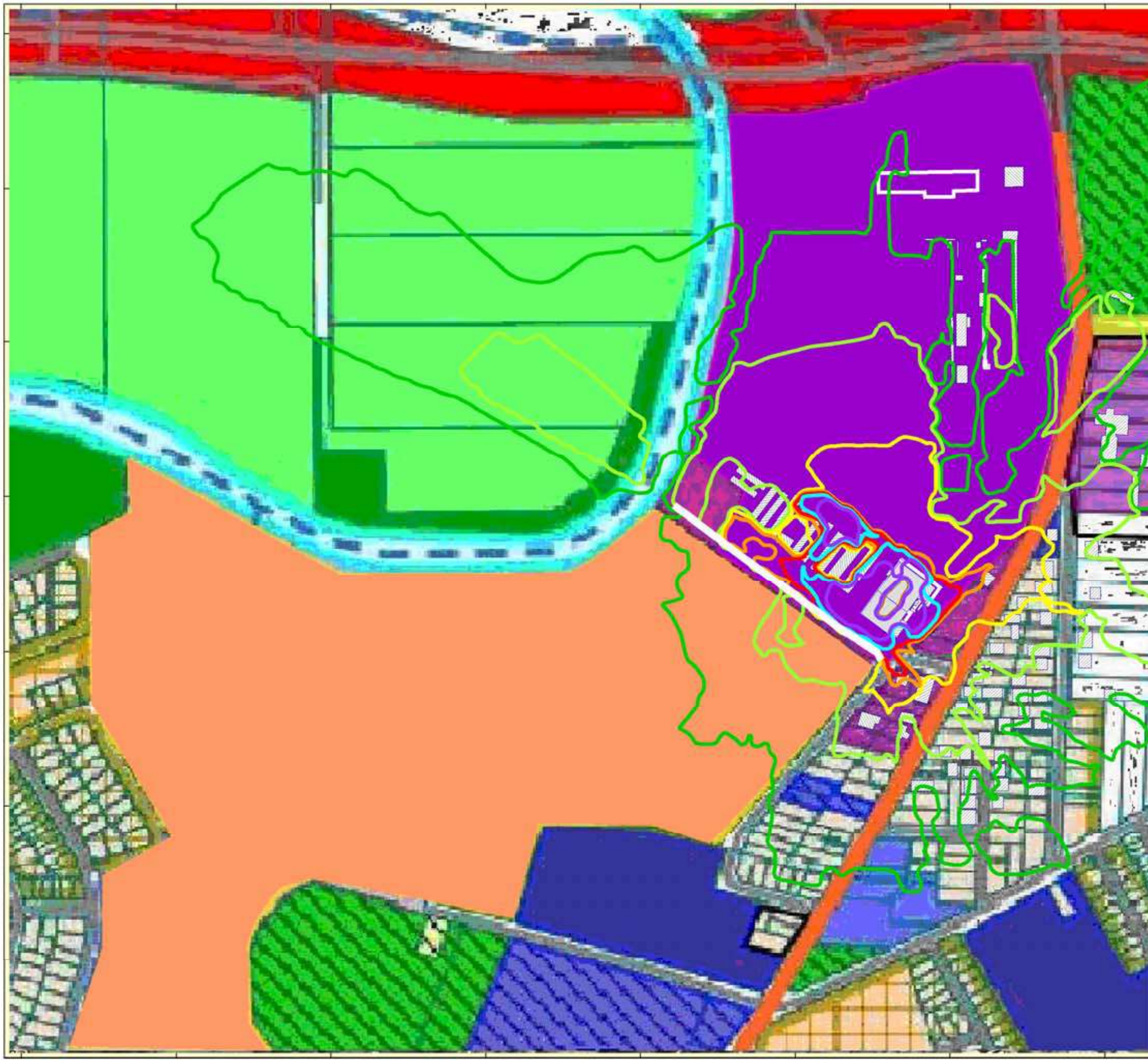
Project engineer: Paul Drew
Created: 22/06/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols
- Wall
- Main building
- Point source
- Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No.

Masonry Only
Night Allwinds

Scenario C

Map
300

Scenario C - Masonry Only
Result number 300
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 24/06/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols
Wall
Main building
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

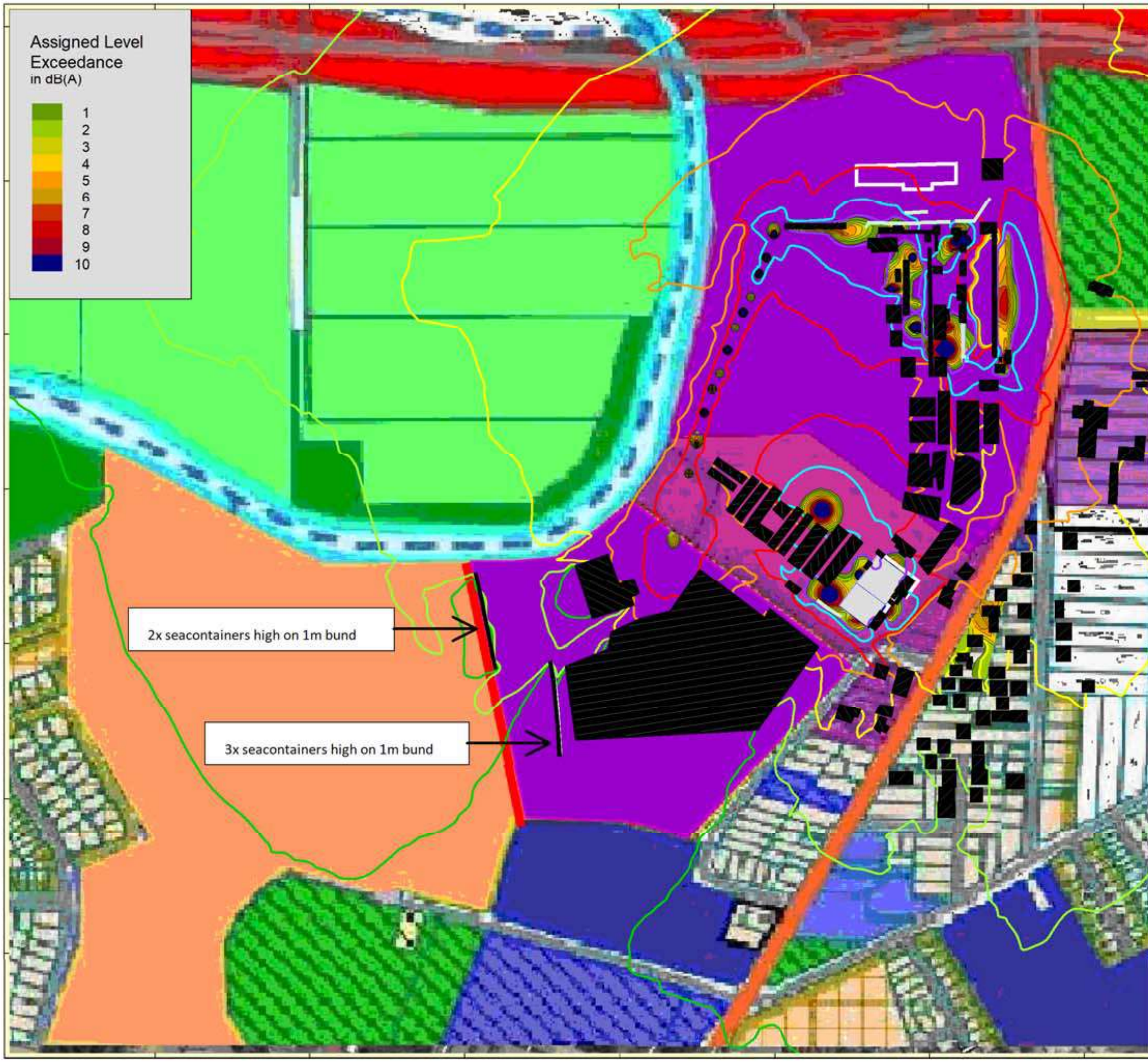
Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS

APPENDIX C

NOISE EMISSION CONFLICT MAPS

(ASSIGNED LEVEL EXCEEDANCE MAPS)



Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02

CONFLICT NOISE MAP
Combined Clay and Masonry,
Night Allwinds
Conveyor Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Night Operations

Map
320
CNMT

Scenario A
Result number 320
Calculation in 1.5 m above ground

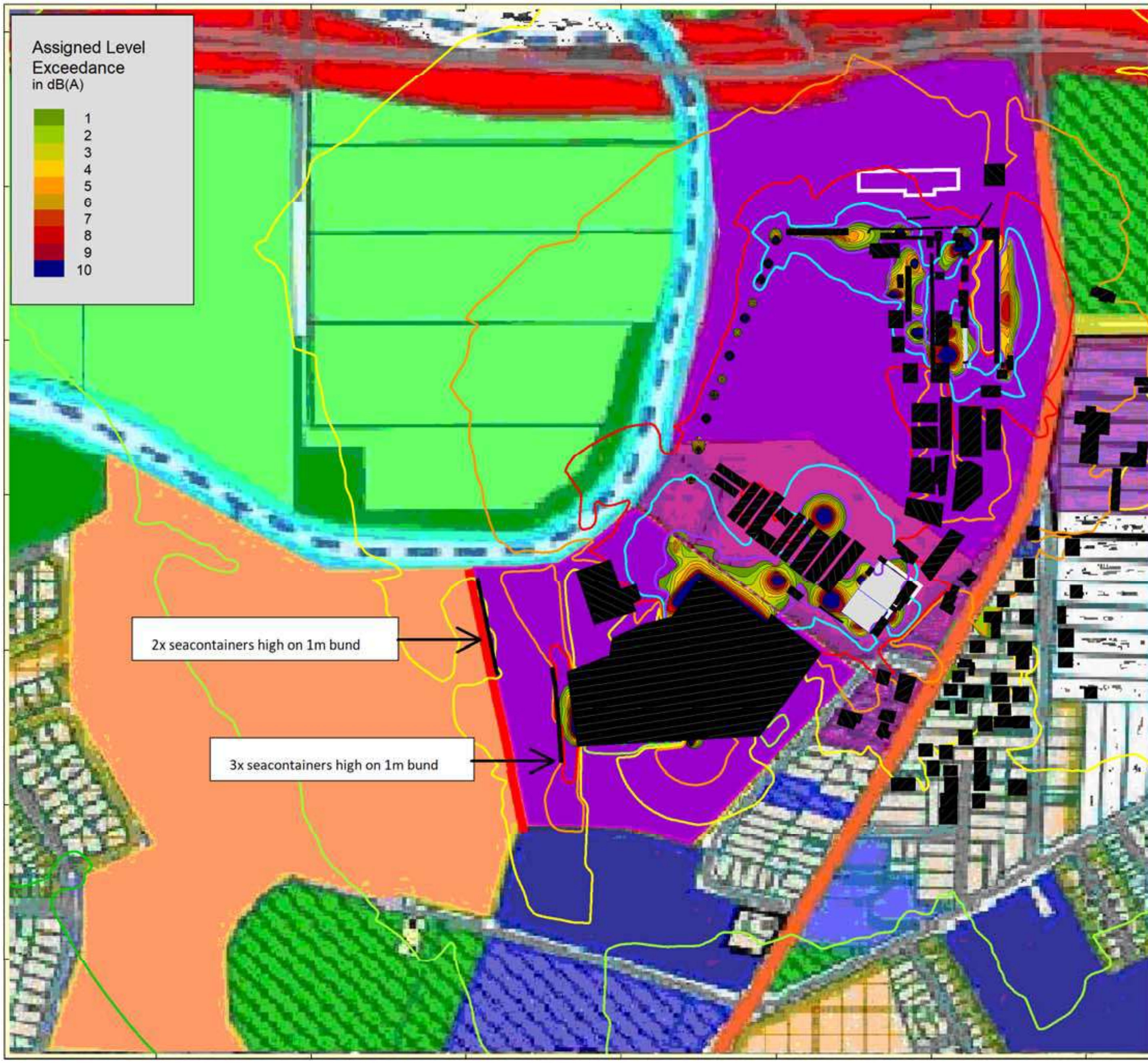
Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS



Customer: Hesparia
Project: Midland Brick Site MRS Submission
Project-No. 20355-02

Combined Clay and Masonry
Evening Allwinds
Conveyor
& Clayshed Operating
3x seacontainer barrier clay
2x seacontainer barrier north
Evening Operations

Map
315
CMET

Scenario A
Result number 315
Calculation in 1.5 m above ground

Day / Evening Operational Scenario

Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

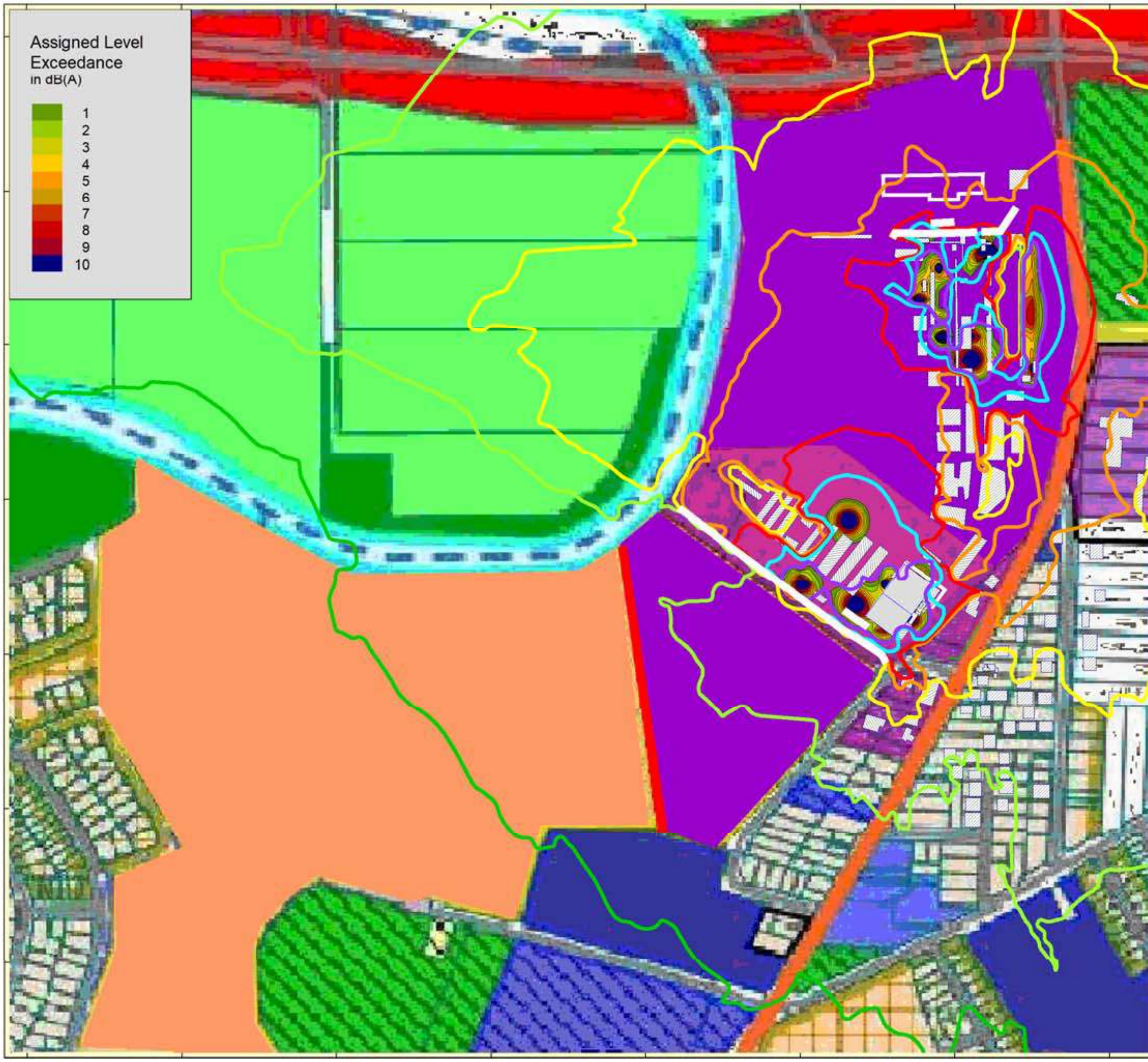
Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

N

Length scale 1:7000
0 40 80 160 240 320
m

HERRING STORER ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No. 20355-02

CONFLICT NOISE MAP
Combined Clay and Masonry
Night Allwinds
Clayshed & Conveyor Removed

Map
299
CNMT

Scenario B
Result number 299
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 7/07/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

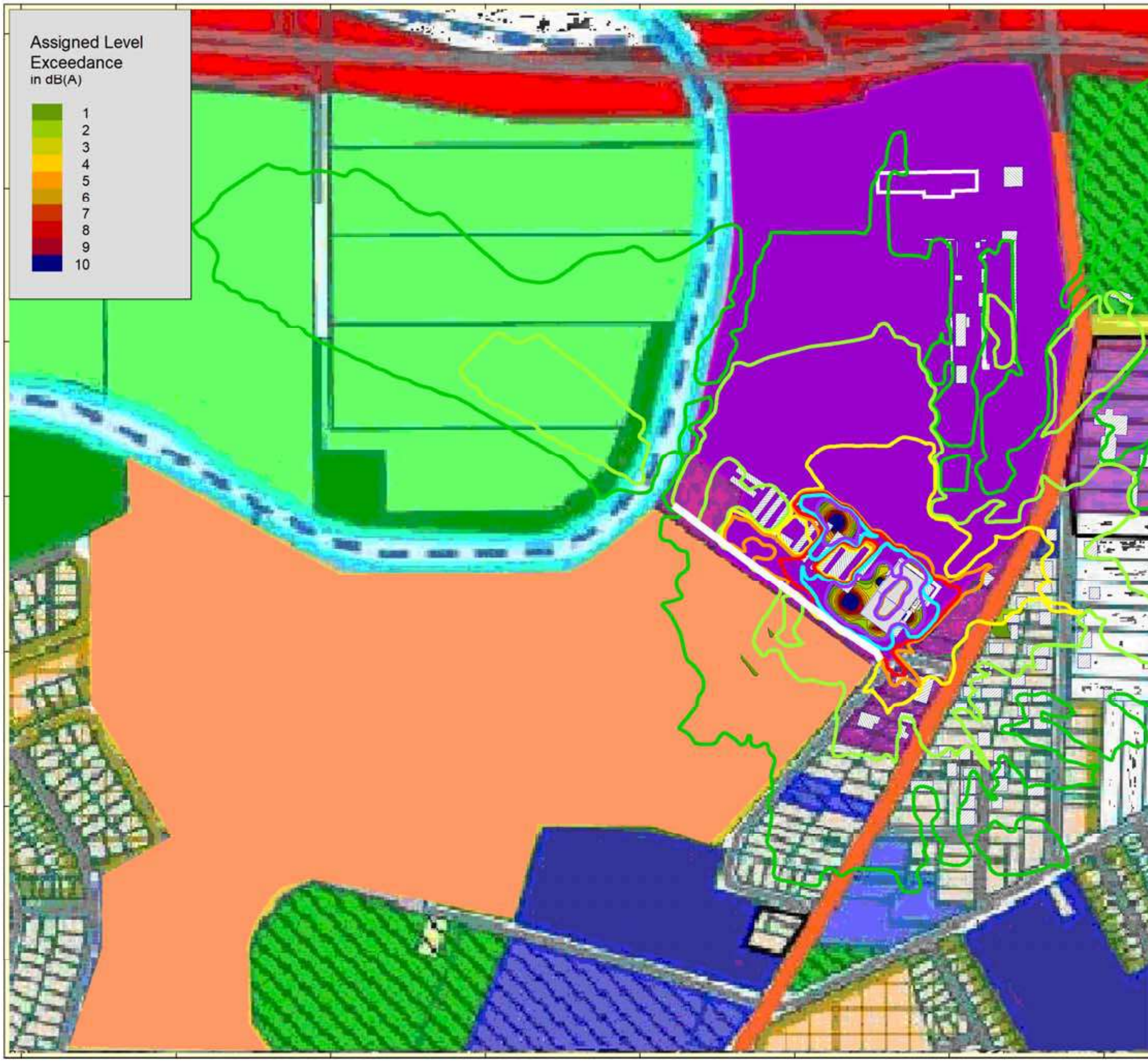
Signs and symbols
Wall
Main building
Point source
Berm

Noise Levels
dB(A)
30
35
40
45
50
55
60

N

Length scale 1:7000
0 40 80 160 240 320
m

HERRING STORER
ACOUSTICS



Customer: BGC & Capitary No.2
Hesperia
Project: Midland Brick Site
Project-No.

CONFLICT MAP - NIGHT
Masonry Only
Night Allwinds

Scenario C

Map
300
CMNT

Scenario C - Masonry Only
Result number 300
Calculation in 1.5 m above ground

Project engineer: Paul Drew
Created: 24/06/2021
Processed with SoundPLAN 8.2, Update 9/06/2021

Signs and symbols	Noise Levels dB(A)
Wall	30
Main building	35
Berm	40
	45
	50
	55
	60

Length scale 1:7000
0 40 80 160 240 320 m

HERRING STORER ACOUSTICS

Appendix B

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)
The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

A-Weighting
An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

L_1
An L_1 level is the noise level which is exceeded for 1 per cent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{10}
An L_{10} level is the noise level which is exceeded for 10 per cent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{90}
An L_{90} level is the noise level which is exceeded for 90 per cent of the measurement period and is considered to represent the "*background*" noise level.

L_{eq}
The L_{eq} level represents the average noise energy during a measurement period.

$L_{A10,18hour}$
The $L_{A10,18\ hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight. The *CoRTN* algorithms were developed to calculate this parameter.

$L_{Aeq,24hour}$
The $L_{Aeq,24\ hour}$ level is the logarithmic average of the hourly L_{Aeq} levels for a full day (from midnight to midnight).

$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$
The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$
The $L_{Aeq\ (Day)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is typically 1-3 dB less than the $L_{A10,18hour}$.

Noise-sensitive land use and/or development
Land-uses or development occupied or designed for occupation or use for residential purposes (including dwellings, residential buildings or short-stay accommodation), caravan park, camping ground, educational establishment, child care premises, hospital, nursing home, corrective institution or place of worship.

About the Term 'Reasonable'

An assessment of reasonableness should demonstrate that efforts have been made to resolve conflicts without comprising on the need to protect noise-sensitive land-use activities. For example, have reasonable efforts been made to design, relocate or vegetate a proposed noise barrier to address community concerns about the noise barrier height? Whether a noise mitigation measure is reasonable might include consideration of:

- The noise reduction benefit provided;
- The number of people protected;
- The relative cost vs benefit of mitigation;
- Road conditions (speed and road surface) significantly differ from noise forecast table assumptions;
- Existing and future noise levels, including changes in noise levels;
- Aesthetic amenity and visual impacts;
- Compatibility with other planning policies;
- Differences between metropolitan and regional situations and whether noise modelling requirements reflect the true nature of transport movements;
- Ability and cost for mobilisation and retrieval of noise monitoring equipment in regional areas;
- Differences between Greenfield and infill development;
- Differences between freight routes and public transport routes and urban corridors;
- The impact on the operational capacity of freight routes;
- The benefits arising from the proposed development;
- Existing or planned strategies to mitigate the noise at source.

About the Term 'Practicable'

'Practicable' considerations for the purposes of the policy normally relate to the engineering aspects of the noise mitigation measures under evaluation. It is defined as "reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge" (*Environmental Protection Act 1986*). These may include:

- Limitations of the different mitigation measures to reduce transport noise;
- Competing planning policies and strategies;
- Safety issues (such as impact on crash zones or restrictions on road vision);
- Topography and site constraints (such as space limitations);
- Engineering and drainage requirements;
- Access requirements (for driveways, pedestrian access and the like);
- Maintenance requirements;
- Bushfire resistance or BAL ratings;
- Suitability of the building for acoustic treatments.

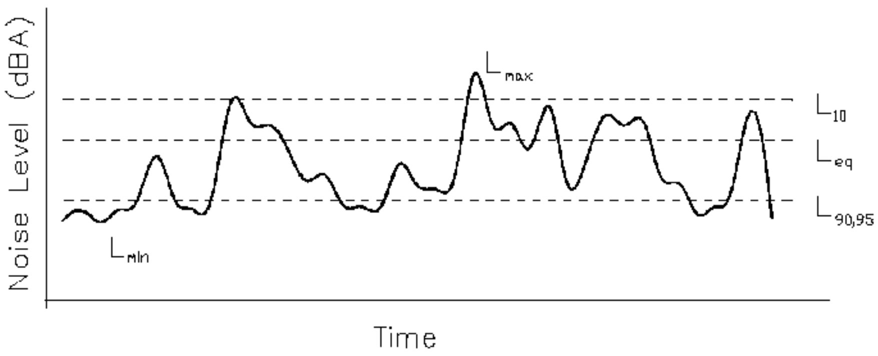
R_w

This is the weighted sound reduction index and is similar to the previously used STC (Sound Transmission Class) value. It is a single number rating determined by moving a grading curve in integral steps against the laboratory measured transmission loss until the sum of the deficiencies at each one-third-octave band, between 100 Hz and 3.15 kHz, does not exceed 32 dB. The higher the R_w value, the better the acoustic performance.

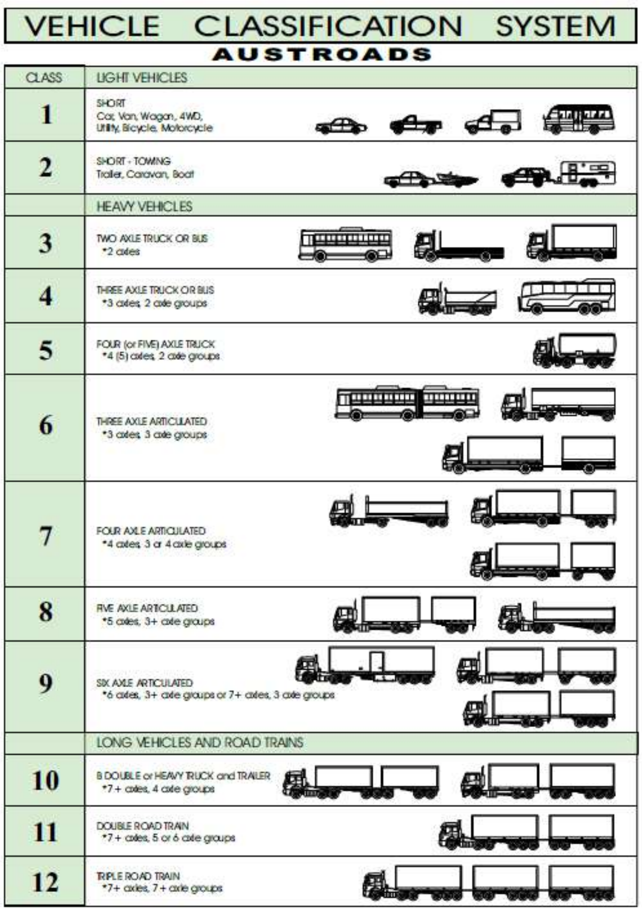
C_{tr}

This is a spectrum adaptation term for airborne noise and provides a correction to the R_w value to suit source sounds with significant low frequency content such as road traffic or home theatre systems. A wall that provides a relatively high level of low frequency attenuation (i.e. masonry) may have a value in the order of –4 dB, whilst a wall with relatively poor attenuation at low frequencies (i.e. stud wall) may have a value in the order of -14 dB.

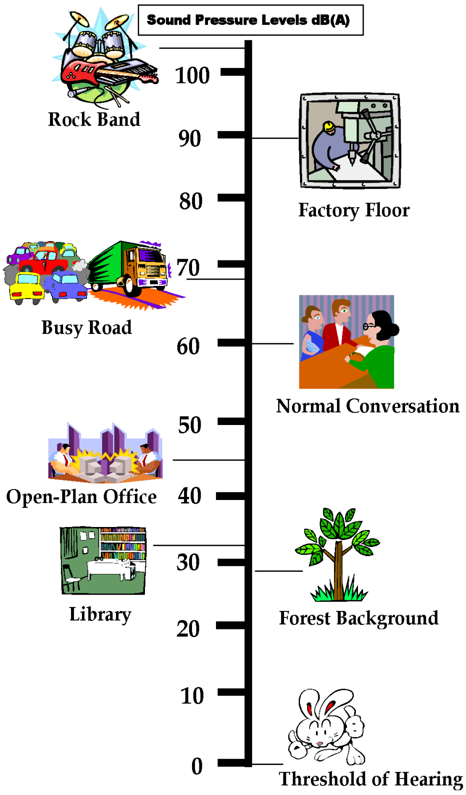
Chart of Noise Level Descriptors



Austroads Vehicle Class



Typical Noise Levels



Appendix D

Transport Impact Assessment

Transport Impact Assessment

Area 3 Local Structure Plan

CW1095800

Prepared for
Hesperia

15 May 2023

Stantec

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Document Information

Prepared for	Hesperia
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Date	15 May 2023
Version Number	C

Author(s):

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Effective Date 15/05/2023

Approved By:

Ray Cook
Business Leader – Traffic & Transport

Date Approved 15/05/2023

Document History

Version	Effective Date	Description of Revision	Prepared by	Reviewed by
A	6/10/2021	For Issue	RR	SGL
B	27/10/2021	Minor Text edit	RR	SGL
C	15/05/2023	Minor Text edit	EH	SGL

Table of Contents

Appendices

Tables

Figures

1 Introduction

1.1 Background

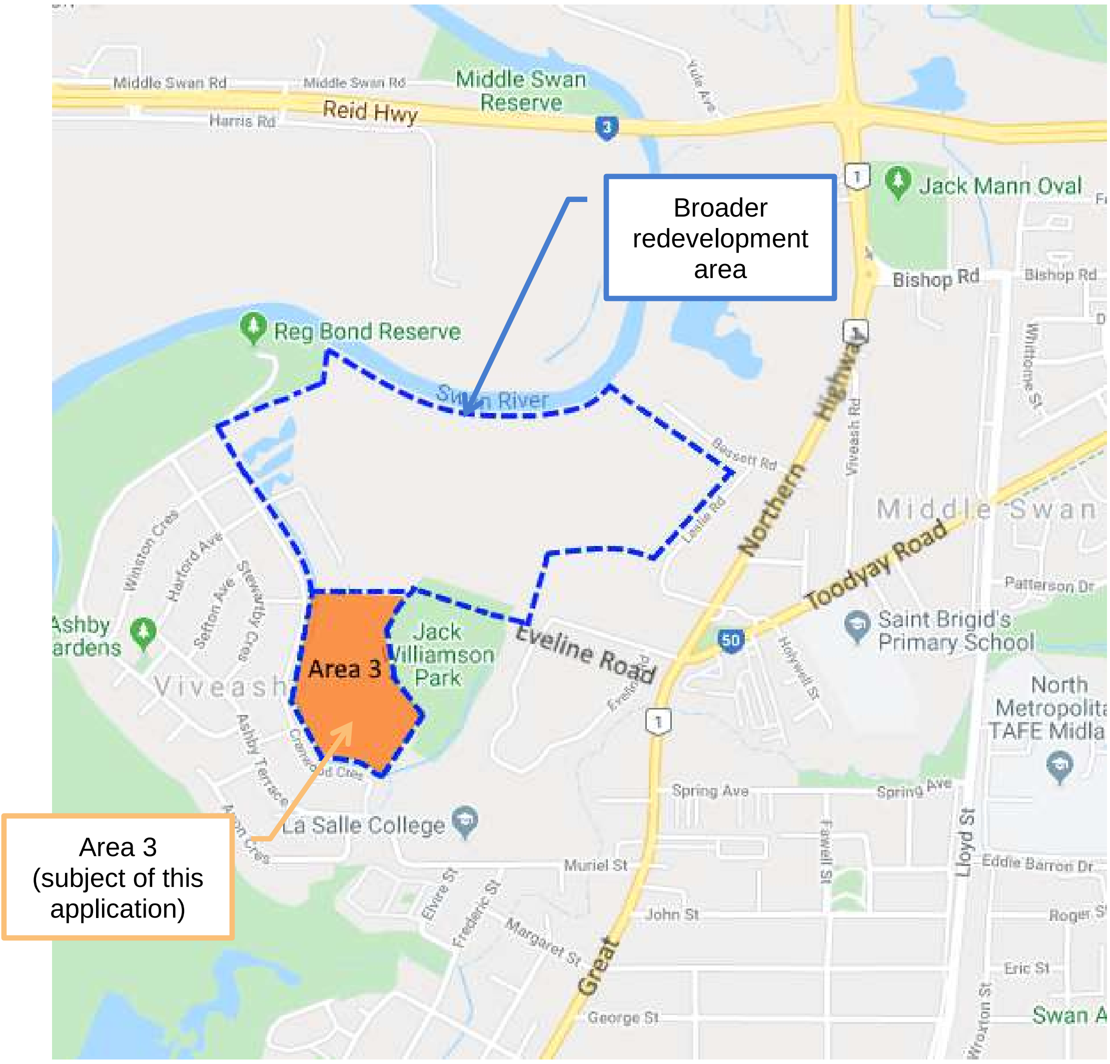
Stantec was commissioned by Hesperia to prepare a Transport Impact Assessment for the Area 3 Local Structure Plan area (‘the Site’, ‘Area 3’). The Site is located within the broader Rivermark (formerly known as Midland Brick) area that is earmarked to be redeveloped to residential area consisting of a planned residential dwelling lots, of which approximately 151 lots are located within Area 3.

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).

1.2 Site Location

The Site (Area 3) is located in the suburb of Middle Swan, City of Swan approximately located 2km north of the Midland Town Centre area. **Figure 1-1** shows the location of Area 3 within the broader redevelopment area, which is currently occupied by Midland Brick. The broader redevelopment area and Area 3 is predominantly zoned as industrial under the City of Swan’s Local Planning Scheme.

Figure 1-1 Location of Area 3



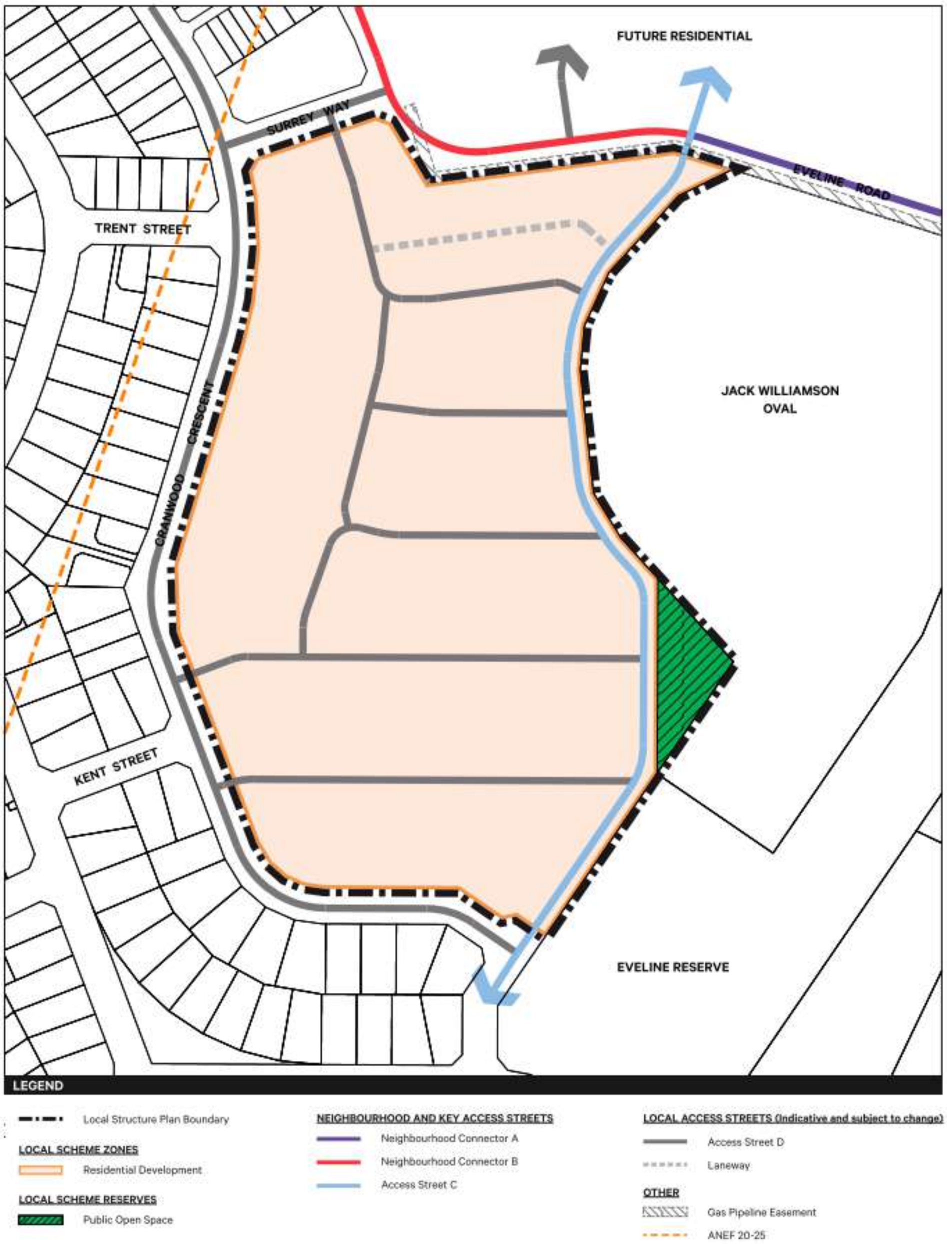
2 Local Structure Plan Proposal

2.1 Proposed Structure Plan

Figure 2-1 shows the extent of the proposed local structure plan consisting of R20 residential dwellings. The estimated yield is 151 dwellings presented in **Table 2-1**.

The broader redevelopment area is proposed to be developed into approximately 545 individual lots, which includes the estimated 151 dwellings located within Area 3.

Figure 2-1 Proposed Structure Plan



Source: Element

Table 2-1 Estimated Dwelling Yield

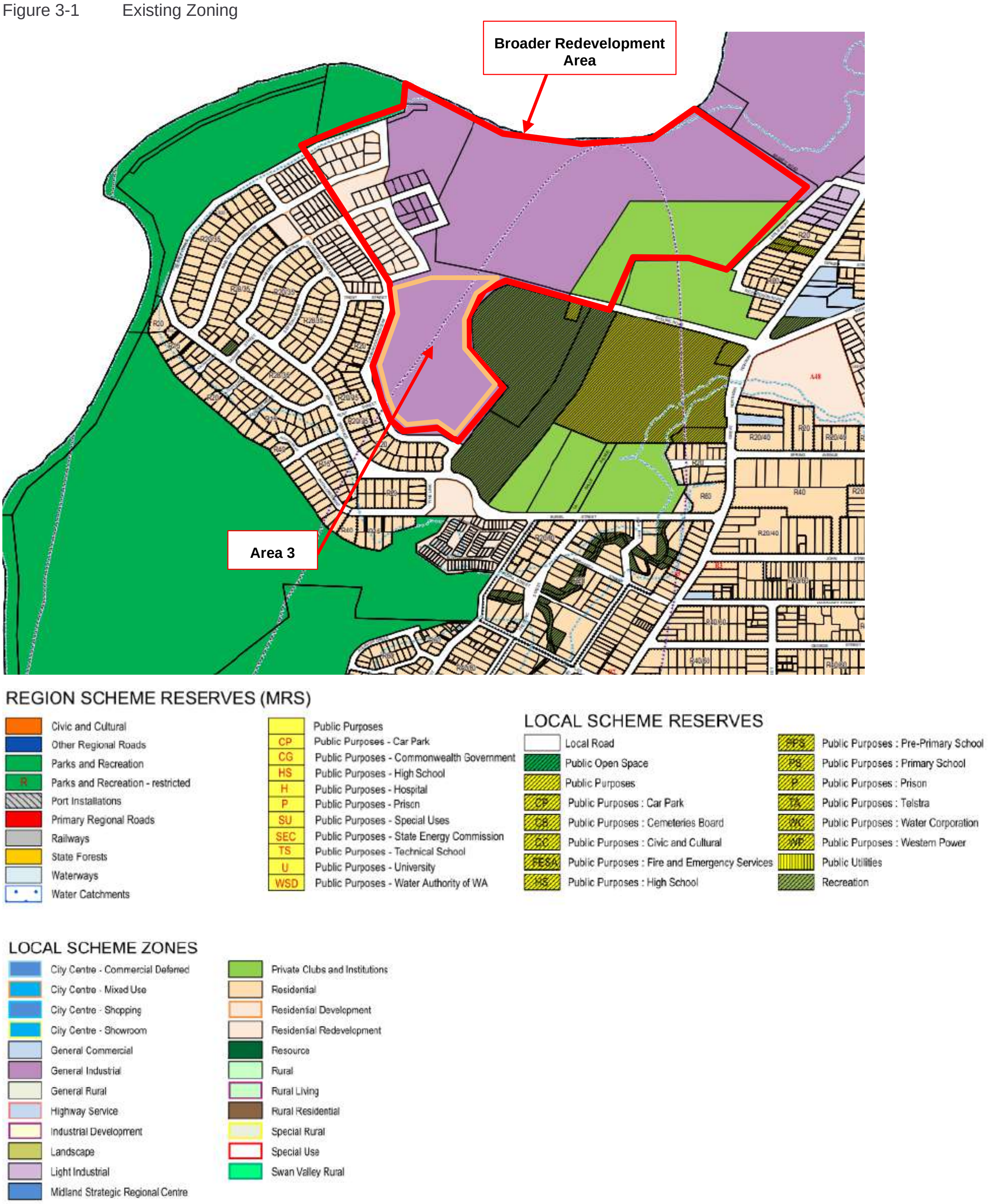
Land Use	Yield
Residential Dwellings (Area 3)	151 dwellings

3 Existing Situation

3.1 Existing Land Uses

The land within the broader redevelopment area, including Area 3 is mostly occupied by Midland Brick and is primarily zoned as "General Industrial", with a small portion to the east zoned as 'Private Club and Institutions'. The western portion of the broader redevelopment area is currently vacant and is zoned as "Residential Development". **Figure 3-1** shows the existing zoning as presented in City of Swan Local Planning Scheme No. 17.

Figure 3-1 Existing Zoning



Source: City of Swan Local Planning Scheme No.17

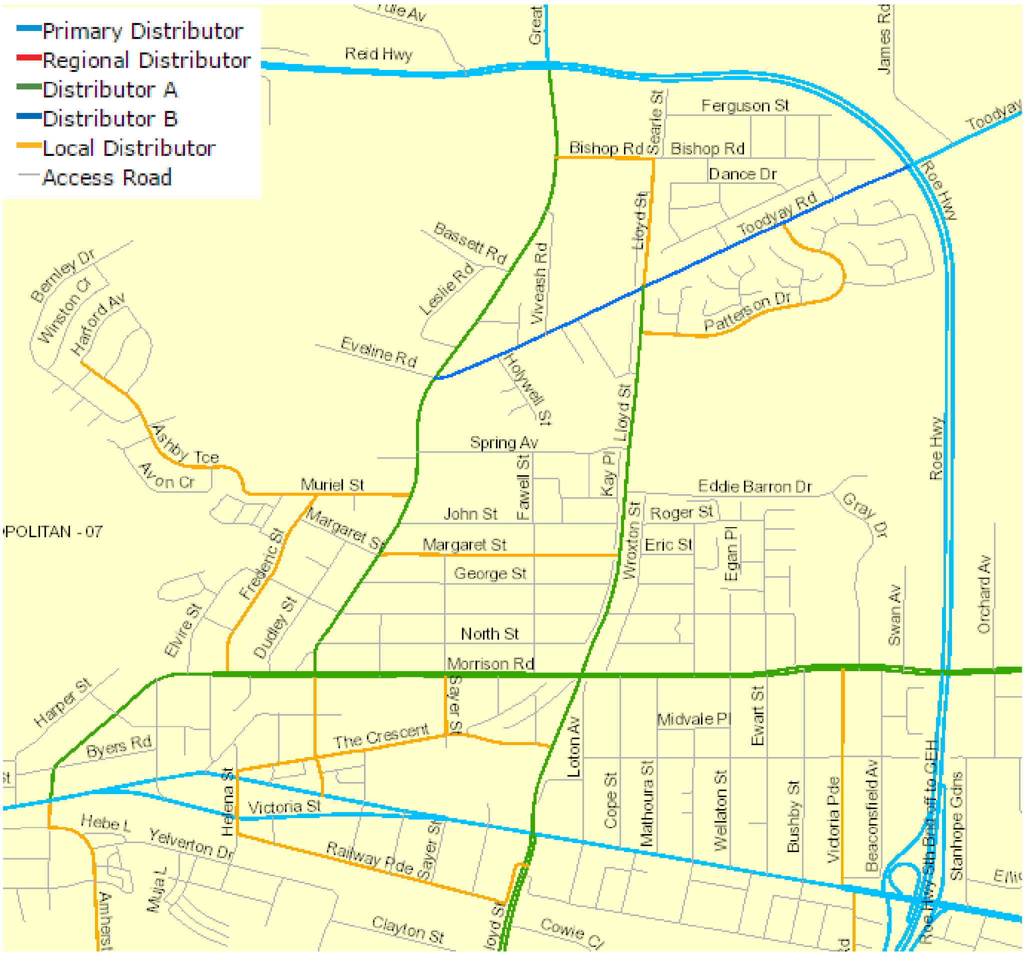
3.2 Existing Road Network

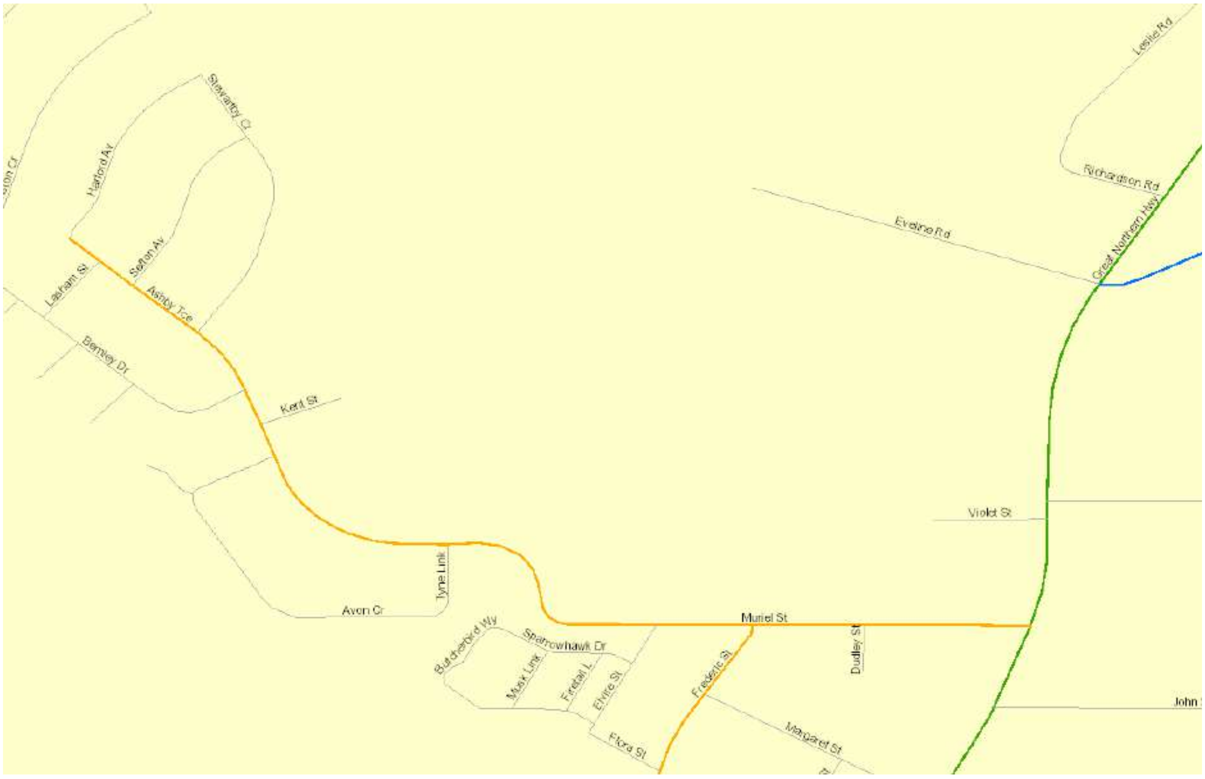
The existing road network hierarchy within and surrounding the Site is shown in **Figure 3-2.** The road classifications are defined in the Main Roads Functional Hierarchy as shown below in **Table 3-1**

Table 3-1 Main Roads WA Road Hierarchy

Road Hierarchy	Description
Primary Distributor	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	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	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	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 Distributor	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 Road	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





Source: Main Roads RIM (Note: RIM has not been updated by MRWA to include Cranwood Crescent)

Table 3-2 below summarises the characteristics of key roads within and surrounding the LSP.

Table 3-2 Key Roads Within and Surrounding the LSP

Road Name	Hierarchy	Jurisdiction	Configuration	Speed Limit (km/h)
Great Northern Highway	▪ Distributor A (south of Reid Highway) ▪ Primary Distributor (North of Reid Highway)	▪ City of Swan (South of Reid Highway) ▪ Main Roads WA (North of Reid Highway)	▪ South of Bishop Road Two-way, two-lane, single carriageway road, with some sections having solid or painted median ▪ North of Bishop Road Two-way, two-lane, dual carriageway road.	60
Reid Highway	Primary Distributor	Main Roads WA	Two-way, four-lane, dual carriageway road	90
Roe Highway	Primary Distributor	Main Roads WA	Two-way, four-lane, dual carriageway road	90
Toodyay Road	Distributor B	City of Swan (East of Roe Highway)	Two-way, two-lane, single carriageway road, with some sections having painted and solid median	60
Muriel Street	Local Distributor	City of Swan	Two-way, two-lane, dual carriageway road with painted median	50
Cranwood Crescent	Not shown (likely Access Road)	City of Swan	Two-way, two-lane, single carriageway road	50
Eveline Road	Access Road	City of Swan	Two-way, two-lane, single carriageway road	50

3.3 Existing Traffic Volume

Existing traffic volumes near the Site were sourced from Main Roads Traffic Map and is shown in **Table 3-3.**

Table 3-3 Existing Traffic Volumes

Location	Year	AM Peak (two-way)	PM Peak (two-way)	Average Weekday Traffic (%HV)	Source
Great Northern Highway (South of Reid Highway)	2015/16	1,484	1,709	19,651 (10.4%)	MRWA Traffic Map
Great Northern Highway (South of Toodyay Road)	2017/18	1,523	1,468	14,694 (6.3%)	MRWA Traffic Map
Great Northern Highway (North of Morrison Road)	2015/16	1,429	1,495	16,845 (6.5%)	MRWA Traffic Map
Toodyay Road (East of Great Northern Highway)	2017/18	547	546	4,229 (8.2%)	MRWA Traffic Map
Eveline Road (West of Great Northern Highway)	2019	34	21	245 (-)	SCATS and Traffic Survey
Muriel Street (West of Great Northern Highway)	2017	460	315	2,550 (7.9%)	City of Swan
Muriel Street (West of Elvire Street)	2017	190	215	2,370 (7.8%)	City of Swan
Frederic Street (North of Charles Street)	2017	480	455	3,115 (3.2%)	City of Swan
Cranwood Crescent (North of Muriel Street)	2020	29	33	344 (5%)	Traffic Survey
Elvire Street	2020	89	89	448 (11%)	Traffic Survey

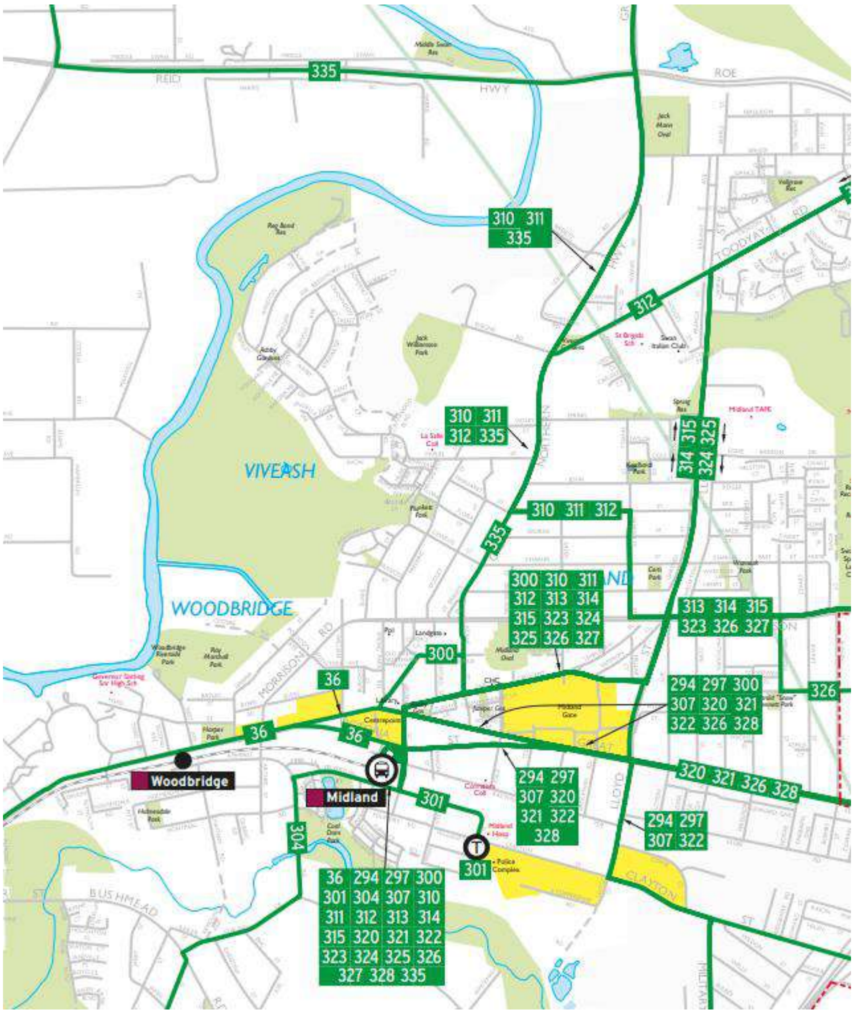
3.4 Existing Public Transport Service

Bus routes within close vicinity of the Site are shown in **Figure 3-3**. The closest bus routes are running along Great Northern Highway as shown in **Figure 3-3**. The bus routes are listed in **Table 3-4**.

Although not shown on the PTA map, some services from Great Northern Highway into Viveash, via Muriel Street, Ashby Terrace, Stewarthy Crescent and Sefton Avenue.

All of the bus routes link to the Midland train station where passengers can switch mode and travel to Perth CBD.

Figure 3-3 Bus Routes in the Vicinity of the Site



Source: Transperth Feb 2019

Table 3-4 Bus Routes

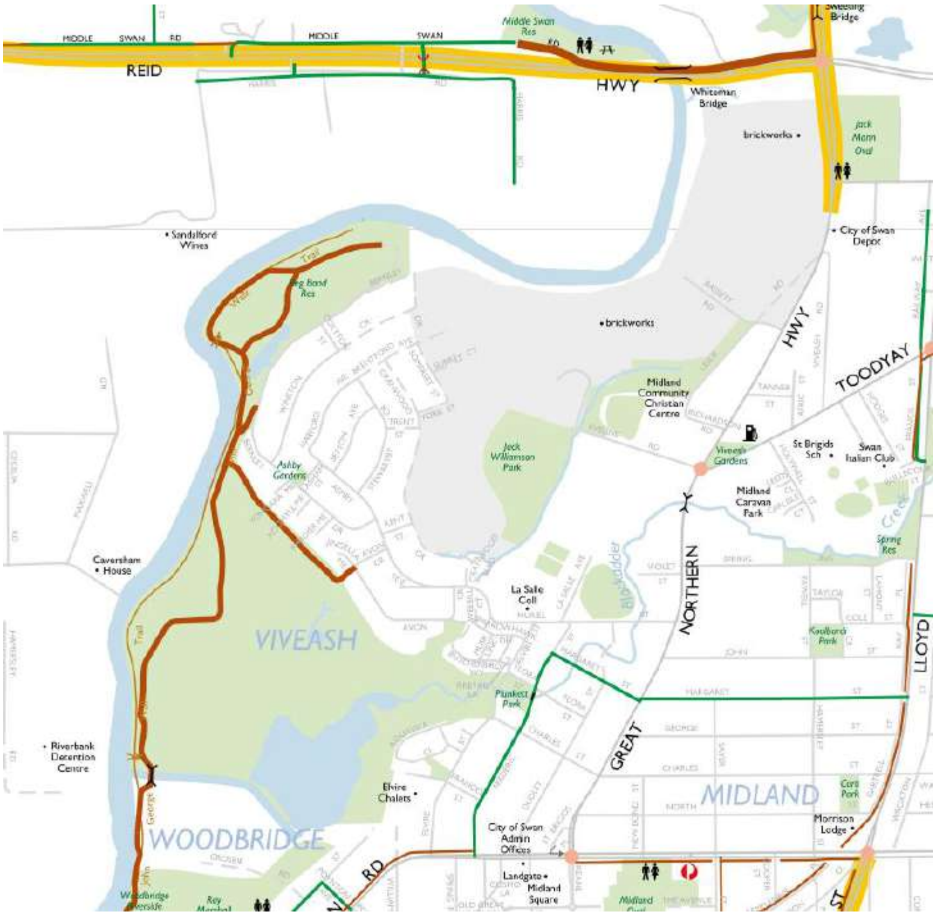
Route No.	Route Description	Service Frequency		
		Weekdays	Saturday	Sunday and Public Holiday
310	Midland Station – Upper Swan	Every 30 - 60 minutes	Every 30 - 60 minutes	Only 3 services per day
311	Midland Station – Bullsbrook	6 services per day	Only 2 services per day	Only 2 services per day
312	Midland Station – Baskerville	4 services per day	No Service	No Service
335	Ellenbrook Town Centre – Midland Station	Every 2 hours	No Service	No Service

3.5 Existing Pedestrian/Cycle Network

Existing pedestrian and cycling facility in the vicinity of the Site are illustrated in **Figure 3-4**. The area is currently not served by dedicated cycling facilities. The nearest cycling facility to the Site are shared paths on the Swan River Foreshore.

In addition, there are 2m wide footpaths available on Cranwood Crescent and Muriel Avenue, providing access to bus stops on Great Northern Highway.

Figure 3-4 Pedestrian and Cycling Facilities



Source: Department of Transport 2016

4 Proposed Changes to Transport Networks

4.1 Road Network

4.1.1 Internal Road Network

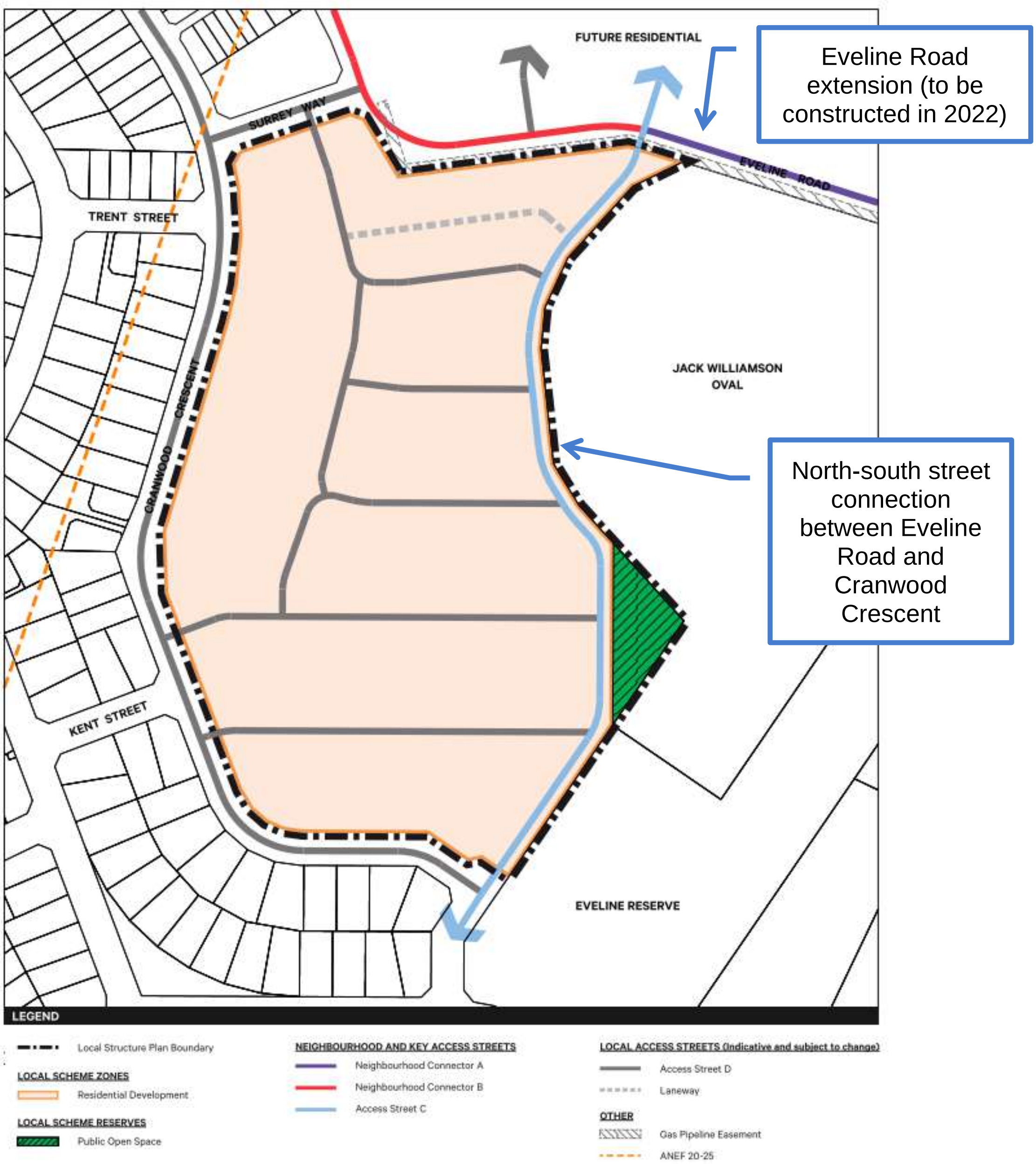
The indicative internal road hierarchy, consistent with the provisions of *Draft Liveable Neighbourhoods 2015*, is shown below in **Figure 4-1.** Changes to the internal road network are summarised as follows:

> Multiple access street connections to Cranwood Crescent

> New north-south street connection (adjacent to Jack Williamson Park/Oval) between Eveline Road extension and Cranwood Crescent

All intersections within the Site is expected to be priority controlled. Further details, e.g. road reserve widths, hierarchies, would be provided at the subdivision stage, generally in accordance with Liveable Neighbourhoods.

Figure 4-1 Indicative Internal Road Network



Source: Element

4.1.2 External Road Network

Known road projects in the vicinity of the Site are listed below:

> **Proposed Great Northern Highway, Reid Highway, and Roe Highway Interchange**

Main Roads are currently in the planning stages of upgrading this intersection to an interchange. This upgrade forms part of the broader Eastlink WA (also known as Orange Route) project where Main Roads is planning to construct a new highway east from Roe Highway towards Northam in order to provide improved access for freight traffic to/from the Wheatbelt region. No detailed plan or funding have been provided, however it is expected that this interchange would be built within 10 years.

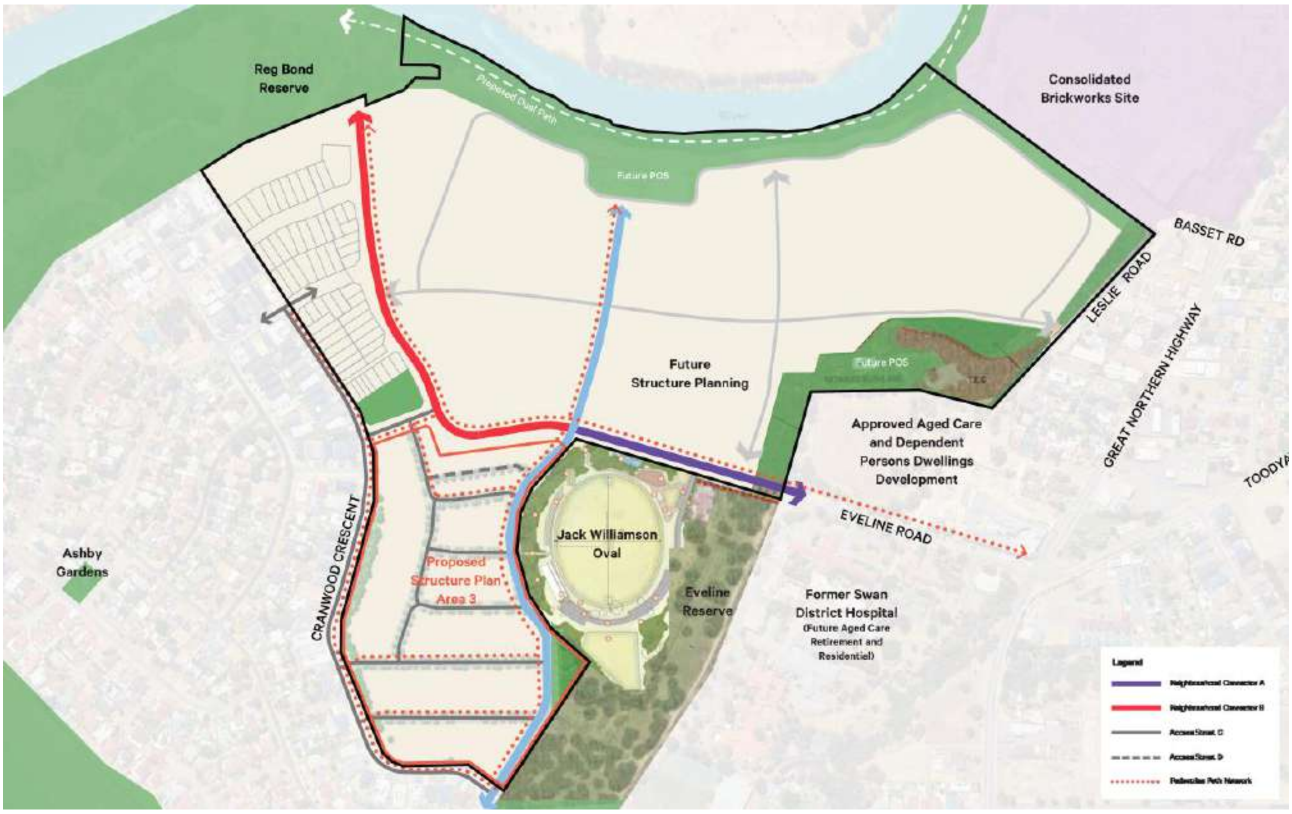
> **Proposed Toodyay Road and Roe Highway Interchange**

As part of the Eastlink WA project, Toodyay Road and Roe Highway intersection is proposed to be upgraded to an interchange. No detailed plan or funding information is available, however this interchange it is expected that this interchange would be built within 10 years.

> **Broader Redevelopment Area**

Figure 4-2 below shows the indicative road network of the broader development area, which includes additional access roads connections from Eveline Road towards Swan River, as well as road connection to Leslie Road. The extension of Eveline Road is to be constructed in 2022.

Figure 4-2 Indicative Road Network within the Broader Redevelopment Area



Source: Element

4.2 Pedestrian Network

To provide good pedestrian and cycling connectivity, footpaths should be provided on at least one side of every street within the Site. A shared path should be provided along the north-south road adjacent to the Jack Williamson Oval, connecting Eveline Road and Cranwood Crescent. These should be included following detailed design at the subdivision stage.

City of Swan have indicated that there will be no changes to the pedestrian network surrounding the proposed Site, other than works related to the approved subdivision to the north. A shared path will be constructed along the Eveline Road extension in 2022.

4.3 Cycling Network

It is understood that the City of Swan has no plans to add or upgrade the cycling network in the vicinity of Area 3, however the Department of Transport (DoT) has long term plans for continuous shared path networks along both sides of the Swan River.

4.4 Public Transport Network

Proposed changes to the surrounding public transport network are as follows:

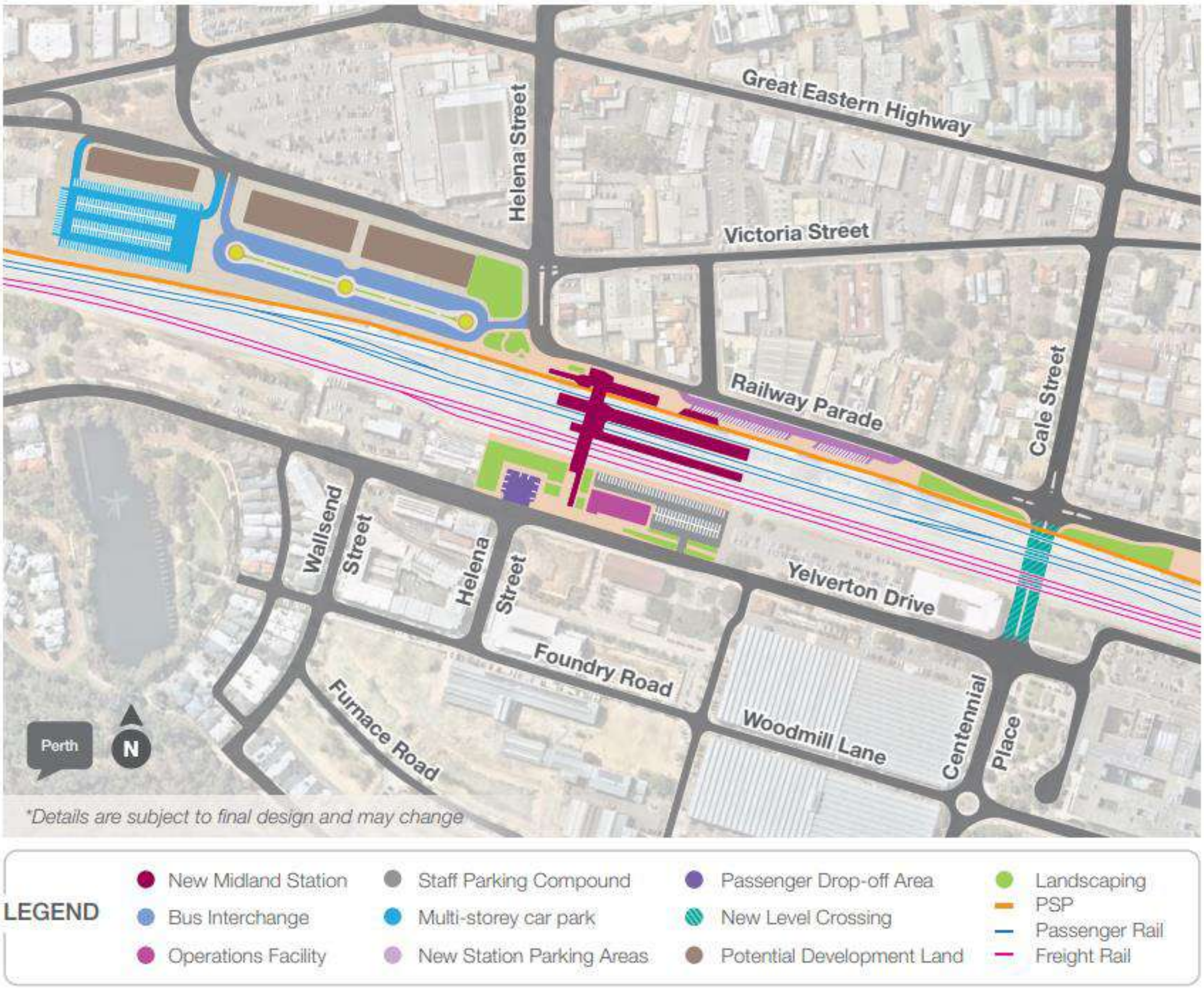
> **Midland Station Relocation**

The State Government has recently announced the relocation of the Midland Station to east of Helena Street as shown below in **Figure 4-3.** The project will also include the following:

- New bus interchange
- Shared path connections
- Cale Street extended to Centennial Place
- Removal of level crossing on Helena Street

The Public Transport Authority also indicates that the bus routes in the surrounding area will undergo changes due to the station relocation, however the details are still to be confirmed.

Figure 4-3 Proposed Midland Station Relocation



Source: https://www.metronet.wa.gov.au

> **Future Bellevue Station**

Following the completion of the Midland Station relocation, the Midland train line is proposed to be extended to the east and a new station to be built in the suburb of Bellevue. The location, design, and timing of construction are still to be determined.

> **Rivermark Broader Redevelopment Area**

Hesperia and Stantec have been consulting with the PTA as part of planning for the Broader Redevelopment Area. Provision has been made in the design of the Eveline Road Extension for the operation of Transperth bus services in the future. The PTA has agreed, in-principle, to the adoption of this route for a bus service but is unable to commit to a timeframe due to funding uncertainty.

5 Integration with Surrounding Area

5.1 Surrounding Attractors and Generators

Major trip generators and attractors in the vicinity Area 3 includes:

> La Salle College (Secondary School)

> TAFE Midland

> Midland City Centre, including Midland Gate shopping centre

> Employment, retail, and educational institutions within Midland Redevelopment Area.

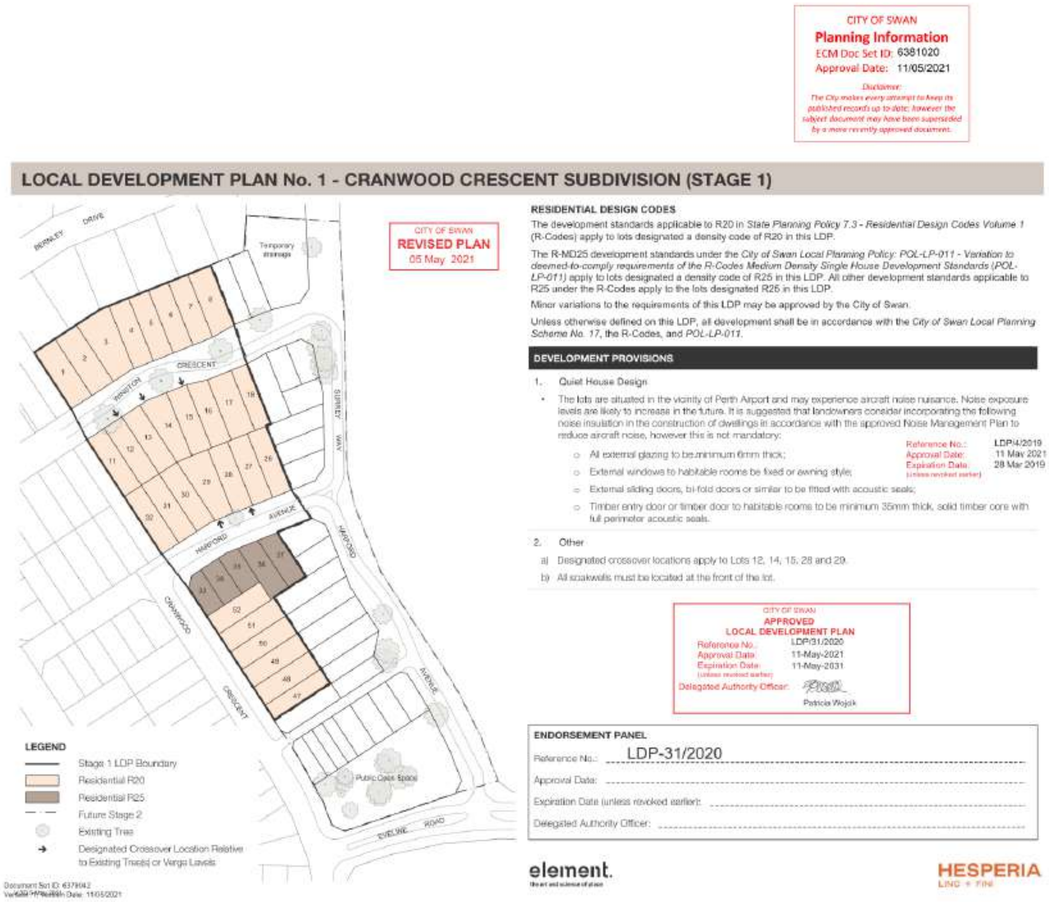
5.2 Proposed Changes to Surrounding Land Uses

Below is a list of known changes to the areas in the vicinity of Area 3:

> **Area 1 & 2 of the Broader Redevelopment Area (Approved Cranwood Crescent Subdivision LDP/31/2020)**

The applicant is also currently in the process of developing a residential subdivision to the north of Area 3. The proposed subdivision is planned to yield 60 dwellings and includes the extension of Eveline Road to connect into Cranwood Crescent. **Figure 5-1** below shows the approved subdivision layout, with Stage 1 construction consisting of 34 lots.

Figure 5-1 Approved Residential Subdivision



> **Old Swan District Hospital site**

With the opening of the new Midland Public Hospital, the Swan District Hospital has been decommissioned. Currently, the area is still zoned as 'Public Purposes' and the City of Swan is currently in the process of amending the zoning. Meeting minutes from the Ordinary Meeting of Council dated 13 November 2019, indicate that the former hospital is being proposed to be zoned as 'Special Use', and The City of Swan indicated to Stantec that a small portion of the site would likely be zoned R20 with a minimal number of dwellings being created at this stage.

> **Future Retirement Village and Aged Care Centre**

A retirement village and an aged care facility is being built in the corner of Great Northern Highway and Eveline Road as shown in **Figure 5-2.**

The facility, as currently proposed, will consist of:

- Aged care facility: 124 licensed beds
- Retirement village: 69 individual dwellings, 72 apartment units, and supporting amenities.

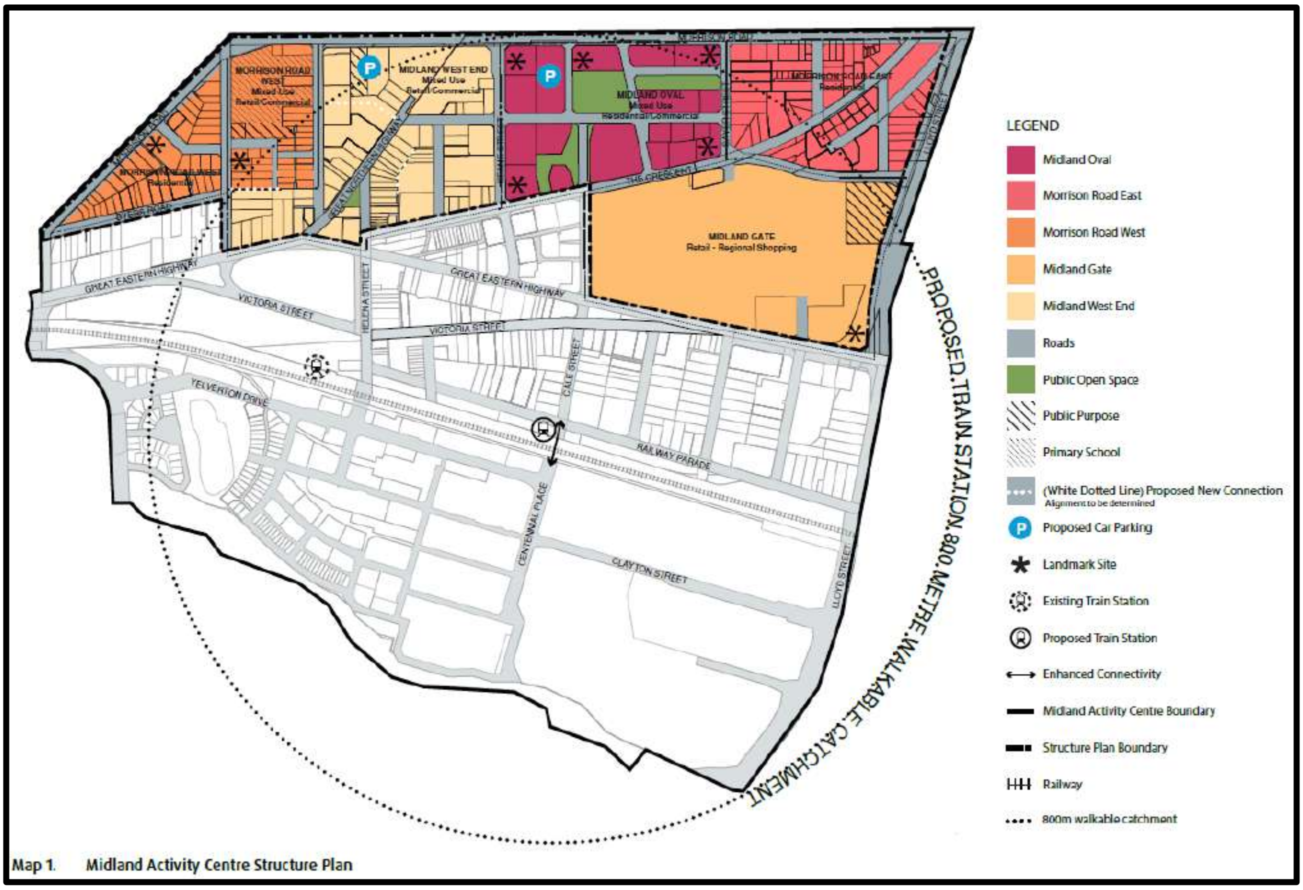
The aged-care facility part of the development has been approved by the Metro East JDAP on 28 February 2019, while the retirement village is part of a future development application.

Figure 5-2 Future Retirement Village and Aged Care Facility

> **Midland Activity Centre Structure Plan**

The Midland Activity Centre Structure Plan (MACSP) was approved by the Western Australian Planning Commission on January 30, 2018. It provides for the long-term growth and development of Midland, addressing key activity centre considerations. MACSP details land use and infrastructure requirements as well as environmental assets, residential density and plot ratios, built form, and movement arrangements for all modes of transport and pedestrian accessibility. **Figure 5-3** below illustrates the Midland Activity Centre Structure Plan boundary.

Figure 5-3 Midland Activity Centre Structure Plan



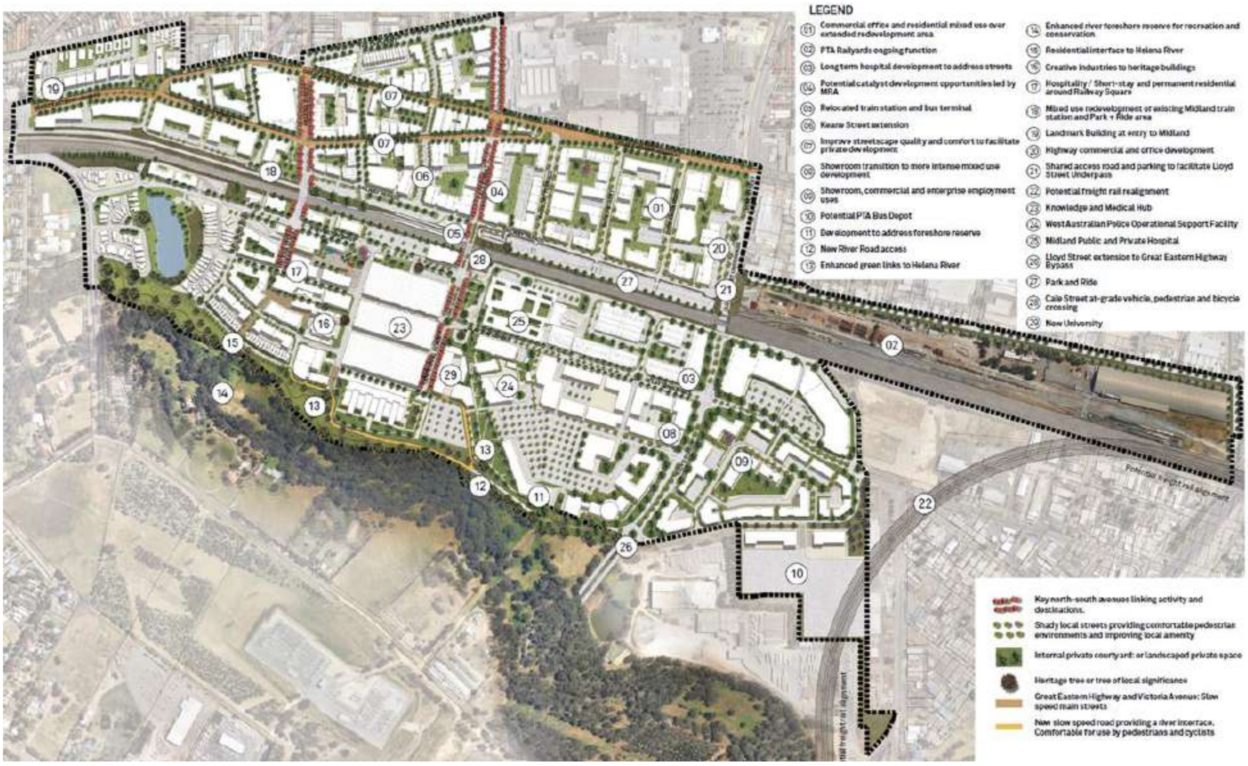
Source: City of Swan

> **Midland Redevelopment Project**

The redevelopment area is defined in the Midland Master Plan (2015) and is shown below in **Figure 5-4**. The redevelopment is still ongoing with some significant milestones achieved on the southern side of the rail line, such as the new Midland Public Hospital, new dwellings and a new university.

The redevelopment will continue with additional residential/office mixed used development in the vicinity of the Midland Town Centre. Additional residential are planned in the vicinity of the former railway workshops area and a more commercial and showrooms are planned in the south east section of the area, adjacent to Lloyd Street.

Figure 5-4 Midland Master Plan



Source: Development WA

5.3 Transport Connectivity to Surrounding Areas

The surrounding road network provides adequate connectivity between the Site and the major attractors in the area such as Midland Town Centre. The proposed Eveline Road extension will significantly improve connectivity for the existing Viveash residential area, providing a second access routes to the surrounding road network.

Bus stops are located on Great Northern Highway, which provide connectivity to the Midland Gate shopping centre and the Midland train station, which connects the wider Midland area to the Perth CBD and beyond. Selected bus services do divert into Viveash and the stops along Ashby Terrace and Stewarthy Crescent will be comfortable walking distance for many of the future residents of the Site. With the extension of Eveline Road to Cranwood Crescent, there is the opportunity for these diverted services to use Eveline Road instead of doubling back along Muriel Street. Similarly, the additional residential catchment provided by Area 3 and the broader redevelopment area may warrant at least one service diverting through Viveash and Eveline Road on a full-time basis.

The Eveline Road extension would also provide additional entry or exit point for school buses, particularly for La Salle College, where currently extensive queuing was observed on Muriel Street as a result of buses having difficulty negotiating traffic gaps on Great Northern Highway. The signalised intersection of Great Northern Highway and Eveline Road would greatly assists the buses serving the area.

Pedestrian and cycling links to the wider network would be provided via a future shared path along Eveline Road and connections to the existing path on Muriel Street. These paths would link with existing paths along Great Northern Highway and Frederic Street.

6 Analysis of Transport Network

6.1 Introduction

This Section will cover the analysis of not just the impact of Area 3, but also includes the broader redevelopment area which is assumed to be completed in 2031. The traffic assessment was originally undertaken in early 2020, before the first COVID lockdown in Western Australia.

The analysis will be undertaken for the assumed Area 3 completion year of 2023. The impact of the broader area will be analysed for the year 2031, which is the assumed year that it is completed.

6.2 Area 3 Traffic Generation

Trip generation for the proposed residential subdivision has been calculated using the *Institute of Transportation Engineers (ITE) "Trip Generation" 10th Edition* guideline document. The trip rates adopted are shown **Table 6-1**. The estimated trip generated are shown in **Table 6-2.**

For the purpose of the assessment it is assumed that the Site will be opened and completed in the year 2023.

Table 6-1 Trip Rates

Land Use	ITE Code	AM Peak	PM Peak	Daily	AM Distribution		PM Distribution		Daily	
					IN	OUT	IN	OUT	IN	OUT
Detached Dwelling	210	0.76 per dwelling	1.00 per dwelling	9.44 per dwelling	26%	74%	64%	36%	50%	50%

Table 6-2 Estimated Trip Generation

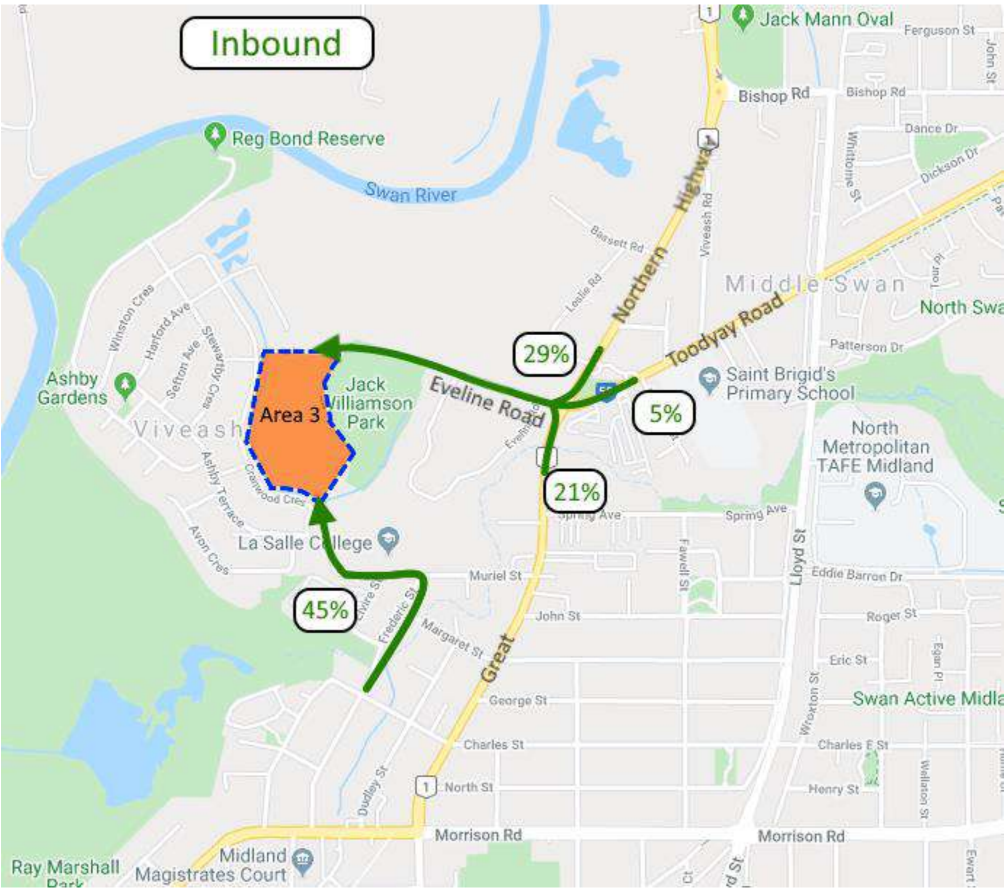
Land Use	Yield	AM Peak		PM Peak		Daily	
		IN	OUT	IN	OUT	IN	OUT
Detached Dwelling	151 Dwellings	30	85	97	55	713	713
	Total	**115**		**151**		**1426**	

6.3 Area 3 Traffic Distribution

Overall traffic distribution was derived from the sub-area matrix extracted from Main Roads WA ROM 24 strategic model (job no. #41335) and then allocated to the network. The adopted traffic distribution is shown in **Figure 6-1** and **Figure 6-2.**

Figure 6-1 Area 3 Outbound Traffic Distribution

Figure 6-2 Area 3 Inbound Traffic Distribution



6.4 Background Traffic

Background traffic flow for the existing condition was sourced from traffic counts undertaken in October 2019. Background traffic for future years were obtained by applying a compound growth factor of 1.5% per annum, as derived from Main Roads WA ROM 24 strategic model outputs (job no. #41335).

6.4.1 Other Developments

As mentioned in **Section 5.2**, a residential subdivision on Cranwood Crescent, retirement village and aged care facility on Eveline Road are being planned, and the former Swan District Hospital site is in the process of being rezoned. These future developments will be included in the future year 2023 and 2031 analyses.

The yield of these proposed developments and the traffic generation are as follows and summarised in **Table 6-3** and **Table 6-4**:

> **Area 1 & 2 (Approved Cranwood Crescent Subdivision) - 2023**
  - 60 residential dwellings
  - Extension of Eveline Road to Cranwood Crescent
  - Assumed to be completed by 2023

> **Remainder of the Broader Redevelopment Area - 2031**
  - The total yield for the broader redevelopment area is estimated to be 545 dwellings (which includes the 151 dwellings in Area 3) however, for the purpose of the assessment, 700 dwellings will be considered for the whole of the broader redevelopment area. This is a conservative assumption, which accounts for possible density increase in the future.

> **Retirement village and aged care facility - 2031**
  - Aged care facility: 124 licensed beds
  - Retirement village: 69 individual dwellings, 72 apartment units, and supporting amenities.
  - Assumed to be completed by 2031

> **Former Swan District Hospital - 2031**

As discussed previously in **Section 5.2**, the rezoning of the former hospital is still ongoing and no firm details are available regarding the likely development yield of the site. For the purpose of this assessment, it is assumed that the hospital will be developed into residential dwellings with similar density as the existing residential dwellings in Viveash. Based on the zoning changes being proposed by the City of Swan, the total development area is approximately 8.1ha and applying similar density to Viveash, it would yield approximately 100 dwellings. This redevelopment is assumed to be completed by 2031.

Table 6-3 Other Developments

Land Use	Yield	Notes
Cranwood Crescent Subdivision	▪ 60 dwellings	Assumed completion in 2023
Broader Redevelopment Area (Residential)	▪ Assumed to be 545 dwellings. This will add up to a conservative 700 total dwellings for the broader redevelopment area which considers the potential for increased density in the future.	Assumed completion in 2031
Retirement Village and Aged Care Facility	▪ Aged care facility: 124 licensed beds Retirement village: 69 individual dwellings, 72 apartment units, and supporting amenities.	Assumed completion in 2031
Swan District Hospital Redevelopment (Residential Dwellings)	100 dwellings	Assumed completion in 2031

Table 6-4 Other Developments Trip Generation

Year of Completion	Land Use	AM Peak		PM Peak		Daily	
		IN	OUT	IN	OUT	IN	OUT
2023	Cranwood Subdivision	12	34	38	22	284	284
2031	Broader redevelopment area (545 dwellings)	108	307	349	196	2574	2574
2031	Retirement Village and Aged Care Facility	25	29	35	36	444	444
2031	Swan District Hospital Redevelopment (Residential Dwellings)	20	56	64	36	472	472

6.5 Daily Traffic Flows

The estimated daily traffic flow at key roads within Area 3 at opening year 2023 is shown below in **Figure 6-4.** The traffic flow forecast is at year 2031 with the broader redevelopment area as well as other developments previously listed in **Section 6.4.1** is shown in **Figure 6-4.**

Figure 6-3 Estimated Two-way Daily Traffic Flow at 2023 with Area 3

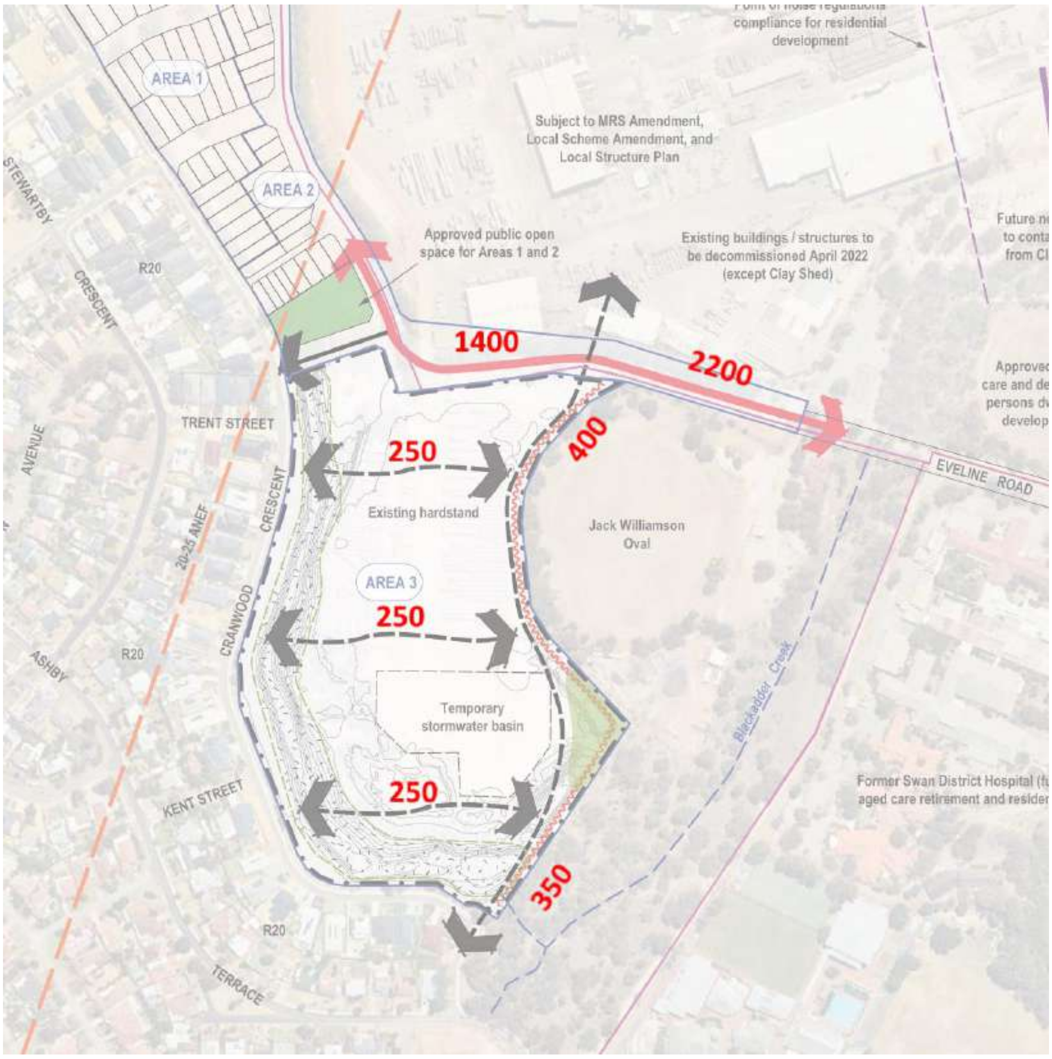


Figure 6-4 Estimated Two-way Daily Traffic Flow at 2031 with the Broader Development Area Included

6.6 Key Intersections Analysis

6.6.1 Subject Intersections

The intersection(s) listed below have been analysed using SIDRA intersection analysis software.

> Great Northern Highway / Reid Highway / Roe Highway
> Great Northern Highway / Bishop Road.
> Great Northern Highway / Eveline Road / Toodyay Road.
> Great Northern Highway / Morrison Road / Keane Street
> Morrison Road / Frederic Street

Great Northern Highway and Muriel Street intersection would not be assessed as it is unlikely that this intersection would be used by the LSP traffic due to alternative routes and the Eveline Road extension as would likely reduce traffic on Muriel at this intersection

Muriel Street and Frederic Street would also not be analysed as the primary congestion at this intersection is caused by the school traffic, which only lasts for a short amount of time the peak hours and the PM peak of the LSP does not coincide with the school peak.

6.6.2 Assessment Years

The assessment years are assumed as follows:

> Year 2020 – Existing traffic condition
> Year 2023 – Assumed opening year of Area 3
> Year 2031 – Sensitivity analysis to assess impact of the full build-out of the broader redevelopment area

6.6.3 Time Period

The peak hour assessed will be at the following AM and PM peak hours, which is the surrounding road network peak.

> AM Peak: 7:45 – 8:45
> PM Peak: 15:00 – 16:00

The peak hours were determined from aggregating SCATS data of 3 different signalised intersections along Great Northern Highway at Reid Highway and Roe Highway, Toodyay and Eveline Road, and Morrison and Keane Street.

Note that the Site (a residential development) PM peak does not typically occur at 15:00 – 16:00, but assumed to be for the purpose of robust assessment.

6.6.4 Peak Hour Total Traffic Flow

Peak hour traffic volumes are presented in **Appendix B.**

6.6.5 Analysis Scenario Summary

The subject intersections will be analysed under the analysis scenarios listed in **Table 6-5.**

Table 6-5 Scenario Summary

	Year	Description
Scenario 1	Existing Year 2020	Existing background traffic only to establish a baseline.
Scenario 2	Opening Year 2023	To assess traffic impact at the completion year of Area 3 ▪ Background compound annual traffic growth of 1.5% to year 2021 ▪ Area 3 is assumed to be completed ▪ Cranwood Crescent Subdivision is completed ▪ Eveline Road is extended and connected Cranwood Crescent
Scenario 3	Future Year 2031	To assess traffic impact at the completion of Area 3 and with other planned developments completed. ▪ Background compound annual traffic growth of 1.5% to year 2031 ▪ Area 3 completed ▪ Cranwood Crescent Subdivision is completed ▪ Former Swan District Hospital site redeveloped into residential area ▪ Future retirement village and aged care complete
Scenario 4	Future Year 2031	To assess traffic impact of the broader redevelopment area with other planned developments completed. ▪ As per Scenario 3 ▪ Full development of the broader redevelopment area

6.6.6 SIDRA Results Definition

The subject intersections have been analysed using the SIDRA analysis program. This program calculates the performance of intersections based on input parameters, including geometry and traffic volumes. As an output SIDRA provides values for the Degree of Saturation (DOS), queue lengths, delays, level of service, and 95th Percentile Queue. These parameters are defined as follows:

> Degree of Saturation (DOS) is the ratio of the arrival traffic flow to the capacity of the approach during the same period. The theoretical intersection capacity is exceeded for an un-signalized intersection where DOS > 0.80;

> 95% Queue is the statistical estimate of the queue length up to or below which 95% of all observed queues would be expected;

> Average Delay is the average of all travel time delays for vehicles through the intersection. An unsignalised intersection can be considered to be operating at capacity where the average delay exceeds 55 seconds for any movement; and

> Level of Service (LOS) is the qualitative measure describing operational conditions within a traffic stream and the perception by motorists and/or passengers. The different levels of service can generally be described as shown in **Table 6-6.**

Table 6-6 Level of Service (LoS) Performance Criteria

LOS	Description	Signalised Intersection	Unsignalised Intersection
A	Free-flow operations (best condition)	≤10 sec	≤10 sec
B	Reasonable free-flow operations	10-20 sec	10-15 sec
C	At or near free-flow operations	20-35 sec	15-25 sec
D	Decreasing free-flow levels	35-55 sec	25-35 sec
E	Operations at capacity	55-80 sec	35-50 sec
F	A breakdown in vehicular flow (worst condition)	≥80 sec	≥50 sec

A LOS exceeding these values indicates that the road section is exceeding its practical capacity. Above these values, users of the intersection are likely to experience unsatisfactory queueing and delays during the peak hour periods.

6.6.7 Great Northern Highway, Reid Highway, and Roe Highway

The SIDRA layout of Great Northern Highway / Reid Highway / Roe Highway is shown in **Figure 6-5** and the analysis results for intersection are presented in **Table 6-7** to **Table 6-10.**

The results show that the intersection would operate at a similar overall performance to the existing condition at the year 2023 with Area 3 development traffic added. No upgrades are required to cater for Area 3 development.

Observing and comparing results from Scenario 3 and Scenario 4 indicates that the intersection would reach its capacity and require upgrades even before the completion of the broader redevelopment area. This indicates that the intersection would reach its capacity before 2031, if the assumed traffic growth scenario is realised.

As mentioned in **Section 4.1.2,** Main Roads WA is planning to upgrade this intersection into a grade-separated interchange which would result in significant increase in capacity. As this work is envisaged within 10 years, an interim upgrade would not be warranted.

Figure 6-5 Great Northern Highway / Reid Highway / Roe Highway SIDRA Layout

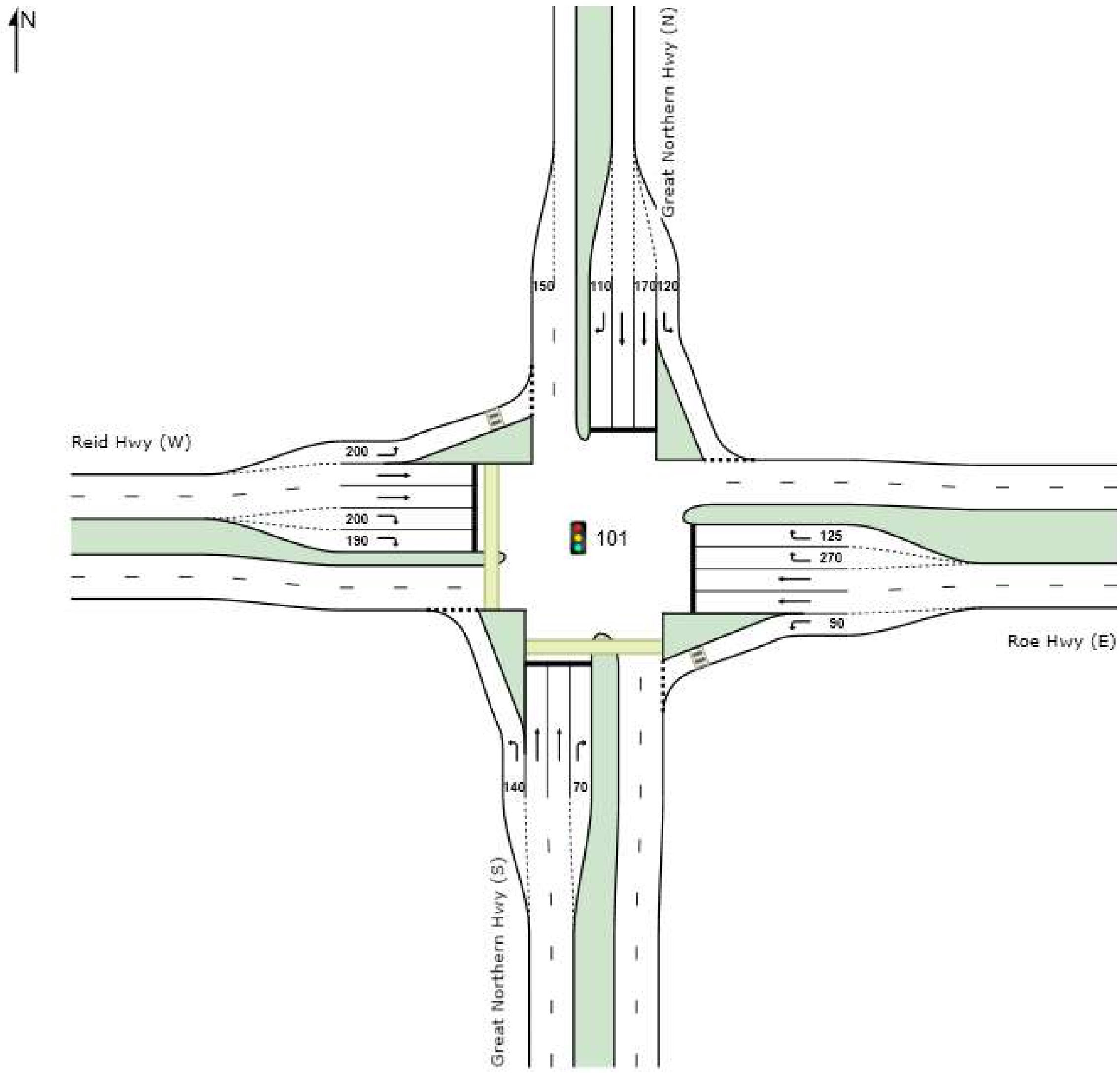


Table 6-7 Scenario 1 Results – Great Northern Highway / Reid Highway / Roe Highway

Intersection Approach		Great Northern Highway / Reid Highway / Roe Highway Scenario 1 – Existing Year 2020							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	L	0.395	13.2	B	96.2	0.827	27.1	C	299.3
	T	0.880	72.4	E	74.9	0.758	30.1	C	93.6
	R	0.488	108	F	21.2	0.276	93.1	F	11.5
Roe Highway – E	L	0.037	12.5	B	5.7	0.022	12	B	3
	T	0.855	16.6	B	180.1	0.793	12.1	B	131
	R	0.511	52	D	132.7	0.703	32.1	C	104.9
Great Northern Highway – N	L	0.54	12.9	B	106.1	0.382	11.6	B	69.5
	T	0.721	19.4	B	81.9	0.297	37.3	D	56.5
	R	0.859	17.5	B	77.2	0.820	19.7	B	73.4
Reid Highway – W	L	0.306	12.5	B	48.5	0.201	13.6	B	31.6
	T	0.64	26.5	C	164	0.698	52.9	D	182.9
	R	0.849	16.5	B	155.2	0.789	77.5	E	157.5
All vehicles		**0.88**	**22.8**	**C**	**180.1**	**0.827**	**32.5**	**C**	**299.3**

Table 6-8 Scenario 2 Results – Great Northern Highway / Reid Highway / Roe Highway

Intersection Approach		Great Northern Highway / Reid Highway / Roe Highway Scenario 2 – 2023 with Area 3							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	L	0.459	16.3	B	131.5	0.907	44.2	D	375.5
	T	0.923	73.7	E	87.5	0.781	31.2	C	103.6
	R	0.668	110.2	F	29.5	0.321	91.7	F	15.5
Roe Highway – E	L	0.048	15.4	B	9.2	0.049	13.2	B	7.7
	T	0.900	18.9	B	223.3	0.846	13.5	B	162.6
	R	0.534	52.4	D	140.8	0.735	33.4	C	115
Great Northern Highway – N	L	0.57	13.9	B	105.8	0.405	12.2	B	75.5
	T	0.741	19.5	B	90	0.339	38.1	D	64.4
	R	0.897	19.1	B	96.2	0.892	22	C	98.5
Reid Highway – W	L	0.326	13.7	B	56.2	0.561	18.7	B	119.9
	T	0.679	27.1	C	179.8	0.73	53.6	D	194.8
	R	0.909	19.7	B	221	0.840	81	F	180.3
All vehicles		**0.923**	**24.7**	**C**	**223.3**	**0.907**	**35.9**	**D**	**375.5**

Table 6-9 Scenario 3 Results – Great Northern Highway / Reid Highway / Roe Highway

Intersection Approach		Great Northern Highway / Reid Highway / Roe Highway Scenario 3 – Future Year 2031 with Area 3							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	L	0.667	35.1	D	251.5	1.161	193.4	F	977.9
	T	1.047	99.4	F	125	0.821	31.2	C	124.3
	R	0.848	115.8	F	38.8	0.405	92.3	F	19.7
Roe Highway – E	L	0.063	32	C	20.9	0.073	15.2	B	12.8
	T	1.054	77.1	E	495.2	0.961	24.2	C	314.7
	R	0.614	53.9	D	166.5	0.806	33.8	C	145.7
Great Northern Highway – N	L	0.671	16.1	B	118.6	0.467	13.4	B	93.3
	T	0.863	22.1	C	136	0.394	38.9	D	75.3
	R	1.050	72.6	E	257.3	1.142	151.1	F	287
Reid Highway – W	L	0.384	16.2	B	78.3	0.258	17.2	B	41.1
	T	0.741	27.7	C	219.3	0.822	58.5	E	240.6
	R	1.044	71.4	E	459.2	0.956	105.6	F	243.7
All vehicles		**1.054**	**49.8**	**D**	**495.2**	**1.161**	**74.4**	**E**	**977.9**

Table 6-10 Scenario 4 Results – Great Northern Highway / Reid Highway / Roe Highway

Intersection Approach		Great Northern Highway / Reid Highway / Roe Highway Scenario 4 – 2031 with the broader redevelopment area							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	L	0.727	36.4	D	287.3	1.252	271.1	F	1200.5
	T	1.038	95.8	F	130.2	0.927	34.6	C	141.9
	R	0.925	122.3	F	58.4	0.446	89.7	F	27.4
Roe Highway – E	L	0.087	32.9	C	29.6	0.144	16.4	B	27.3
	T	1.063	84.3	F	511.5	0.986	32.5	C	379.5
	R	0.614	54	D	166.5	0.806	33.9	C	145.7
Great Northern Highway – N	L	0.682	16.3	B	117.1	0.477	13.7	B	94.9
	T	0.898	23.7	C	152.3	0.444	40.2	D	81.2
	R	1.050	72.6	E	257.3	1.092	108.8	F	254.6
Reid Highway – W	L	0.387	16.7	B	80.5	0.257	18.5	B	41.2
	T	0.753	28	C	222.9	0.804	57	E	235.2
	R	1.067	89.1	F	502.8	0.980	115.7	F	272
All vehicles		**1.067**	**54.8**	**D**	**511.5**	**1.252**	**89.1**	**F**	**1200.5**

6.6.8 Great Northern Highway and Bishop Road

The SIDRA layout of Great Northern Highway / Bishop Road is shown in **Figure 6-6** and the analysis results for intersection are presented in **Table 6-11** to **Table 6-10.**

The results show that the intersection would operate satisfactorily in the opening year 2023 with Area 3 traffic added.

Results for Scenario 3 and 4 indicates that the intersection can cater for the assumed background traffic growth as well as the broader redevelopment area traffic.

Figure 6-6 Great Northern Highway / Bishop Road SIDRA Layout

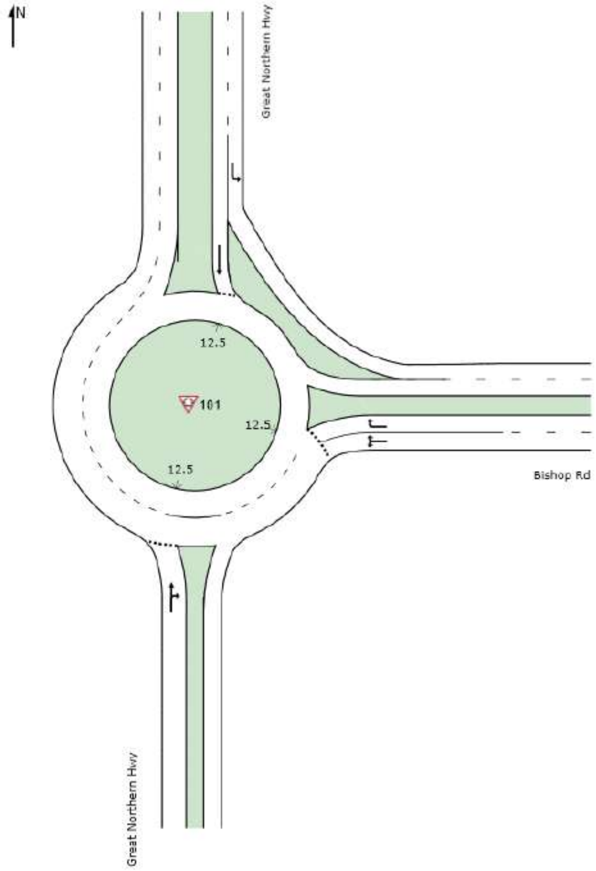


Table 6-11 Scenario 1 Results – Great Northern Highway / Bishop Road

Intersection Approach		Great Northern Highway / Bishop Road Scenario 1 – Existing Year 2020							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	T	0.35	5.3	A	10.6	0.69	7.6	A	32.3
	R	0.35	8.8	A	10.6	0.69	11.3	B	32.3
Bishop Road – E	L	0.167	9.9	A	8.1	0.276	6.3	A	12.1
	R	0.167	14.1	B	8.1	0.276	9.8	A	12.1
Great Northern Highway – N	L	0.276	3.7	A	0	0.193	3.8	A	0
	T	0.51	4.6	A	36	0.28	4.6	A	16.7
All Vehicles		**0.51**	**5.5**	**A**	**36**	**0.69**	**6.8**	**A**	**32.3**

Table 6-12 Scenario 2 Results – Great Northern Highway / Bishop Road

Intersection Approach		Great Northern Highway / Bishop Road Scenario 2 – 2023 with Area 3							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	T	0.414	5.3	A	13.7	0.772	8.6	A	43.5
	R	0.414	8.9	A	13.7	0.772	12.2	B	43.5
Bishop Road – E	L	0.187	10.9	B	9.4	0.31	7	A	14.2
	R	0.187	15.3	B	9.4	0.31	10.5	B	14.2
Great Northern Highway – N	L	0.289	3.7	A	0	0.202	3.8	A	0
	T	0.545	4.6	A	41.2	0.331	4.6	A	21.6
All Vehicles		**0.545**	**5.6**	**A**	**41.2**	**0.772**	**7.3**	**A**	**43.5**

Table 6-13 Scenario 3 Results – Great Northern Highway / Bishop Road

Intersection Approach		Great Northern Highway / Bishop Road Scenario 3 – 2031 with Area 3							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	T	0.488	5.5	A	18.1	0.927	14.1	B	90.3
	R	0.488	9	A	18.1	0.927	17.7	B	90.3
Bishop Road – E	L	0.251	13.7	B	13.6	0.379	7.9	A	18.7
	R	0.251	18.5	B	13.6	0.379	11.6	B	18.7
Great Northern Highway – N	L	0.326	3.8	A	0	0.227	3.8	A	0
	T	0.62	4.6	A	54.9	0.387	4.6	A	28.6
All Vehicles		**0.62**	**6**	**A**	**54.9**	**0.927**	**9.3**	**A**	**90.3**

Table 6-14 Scenario 4 Results – Great Northern Highway / Bishop Road

Intersection Approach		Great Northern Highway / Bishop Road Scenario 4 – 2031 with the broader redevelopment area							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	T	0.559	5.5	A	24.4	0.993	27.2	C	178.5
	R	0.559	9.1	A	24.4	0.993	30.8	C	178.5
Bishop Road – E	L	0.263	14.6	B	15.4	0.418	9.2	A	23.2
	R	0.263	19.5	B	15.4	0.418	13.2	B	23.2
Great Northern Highway – N	L	0.326	3.8	A	0	0.227	3.8	A	0
	T	0.638	4.6	A	63.2	0.448	4.6	A	38.8
All Vehicles		**0.638**	**6**	**A**	**63.2**	**0.993**	**13.9**	**B**	**178.5**

6.6.9 Great Northern Highway, Eveline Road and Toodyay Road

The SIDRA layout of Great Northern Highway / Eveline Road / Toodyay Road is shown in **Figure 6-7** and the analysis results for intersection are presented in **Table 6-15** to **Table 6-18**.

The results show that the intersection would operate satisfactorily in 2023 when Area 3 is completed. No upgrades are required for this intersection to cater for increased traffic due to Area 3.

In the year 2031, the intersection would start to approach its capacity, as shown in Scenario 3 results, particularly the PM peak results for Great Northern Highway south leg. The addition of the broader redevelopment traffic (Scenario 4) results in the right turn out of Eveline Road performing poorly in the AM peak. Therefore, a modification is required to cater for the broader redevelopment area, which will be further discussed in **Section 6.7.1.**

Figure 6-7 Great Northern Highway / Eveline Road / Toodyay Road SIDRA Layout

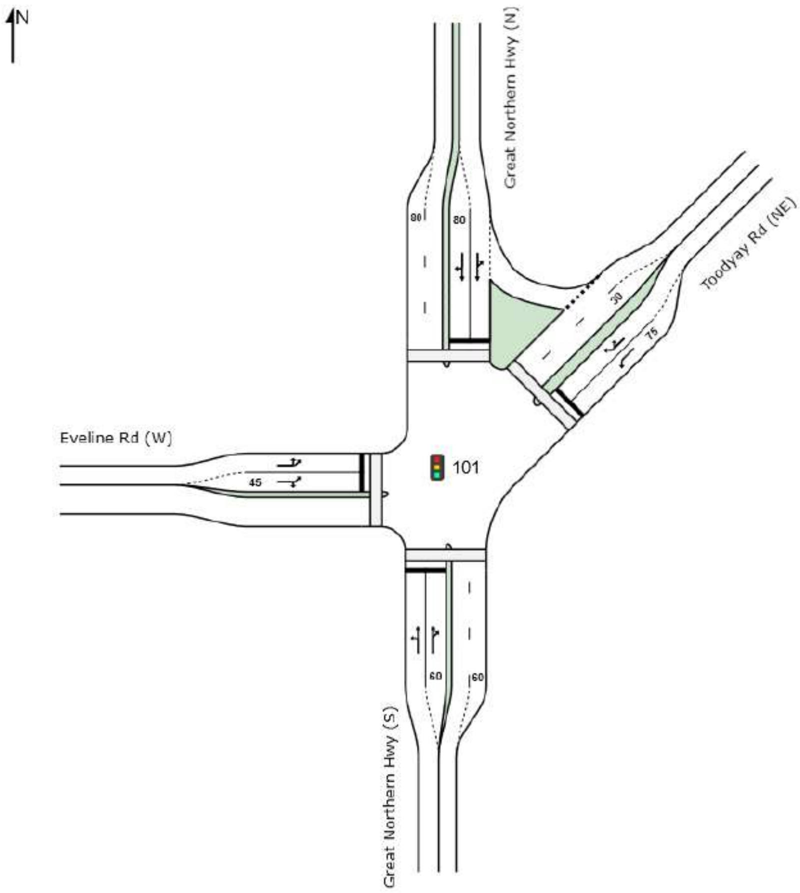


Table 6-15 Scenario 1 Results – Great Northern Highway / Eveline Road / Toodyay Road

Intersection Approach		Great Northern Highway / Eveline Road / Toodyay Road Scenario 1 – Existing Year 2020							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	L	0.327	16.2	B	52.2	0.455	15.5	B	69.2
	T	0.547	11.1	B	52.2	0.613	10.6	B	69.2
	R	0.547	17.3	B	33.5	0.613	16.3	B	51.4
Toodyay Road – E	L	0.429	24.7	C	64.3	0.364	25.3	C	38.5
	T	0.175	28.7	C	12.4	0.204	27.1	C	11.9
	R	0.175	30.7	C	12.4	0.204	29.2	C	11.9
Great Northern Highway – N	L	0.561	15.2	B	54.6	0.326	18.5	B	34.7
	T	0.676	9.5	A	73.6	0.357	13.8	B	46.2
	R	0.676	14.1	B	73.6	0.357	20.4	C	46.2
Eveline Road – W	L	0.009	27.4	C	1	0.031	25.2	C	2.4
	T	0.009	24.3	C	1	0.031	23.5	C	2.4
	R	0.023	34.5	C	1.2	0.043	36.2	D	1.4
All Vehicles		**0.676**	**14.1**	**B**	**73.6**	**0.613**	**15.3**	**B**	**69.2**

Table 6-16 Scenario 2 Results – Great Northern Highway / Eveline Road / Toodyay Road

Intersection Approach		Great Northern Highway / Eveline Road / Toodyay Road Scenario 2 – 2023 with Area 3							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	L	0.365	16.5	B	59.8	0.534	16.1	B	85.8
	T	0.611	11.4	B	59.8	0.719	11.9	B	85.8
	R	0.611	18.6	B	35	0.719	19.9	B	58.6
Toodyay Road – E	L	0.448	25.5	C	68	0.38	25.3	C	40.4
	T	0.232	30.1	C	15.8	0.298	27.7	C	19.1
	R	0.232	32.1	C	15.8	0.298	29.7	C	19.1
Great Northern Highway – N	L	0.634	15.7	B	68.2	0.51	22.2	C	67.3
	T	0.763	11.4	B	91.7	0.559	17.5	B	67.3
	R	0.763	16.5	B	91.7	0.559	26.8	C	45.6
Eveline Road – W	L	0.193	28.1	C	19.6	0.161	26.3	C	13.1
	T	0.193	26.6	C	19.6	0.161	24.5	C	13.1
	R	0.275	35.2	D	15.1	0.262	36.5	D	10.1
All Vehicles		**0.763**	**16.5**	**B**	**91.7**	**0.719**	**18.5**	**B**	**85.8**

Table 6-17 Scenario 3 Results – Great Northern Highway / Eveline Road / Toodyay Road

Intersection Approach		Great Northern Highway / Eveline Road / Toodyay Road Scenario 3 – Future Year 2031 with Area 3							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	L	0.456	16.1	B	79.6	0.794	18.5	B	128
	T	0.763	10.9	B	79.6	1.068	27.7	C	160.3
	R	0.763	24.7	C	37	1.068	106.9	F	160.3
Toodyay Road – E	L	0.561	30.9	C	84.4	0.544	29.5	C	51
	T	0.307	33.3	C	19.2	0.435	31.3	C	24
	R	0.307	35.3	D	19.2	0.435	33.4	C	24
Great Northern Highway – N	L	0.717	16	B	95.7	0.681	22	C	111.9
	T	0.863	14.3	B	119.3	0.747	15.7	B	111.9
	R	0.863	19.5	B	119.3	0.747	41.4	D	27.7
Eveline Road – W	L	0.28	31.2	C	26.9	0.278	30.6	C	19.7
	T	0.28	29.7	C	26.9	0.278	28.8	C	19.7
	R	0.630	41.4	D	35	0.416	31.5	C	21.8
All Vehicles		**0.863**	**19.9**	**B**	**119.3**	**1.068**	**34**	**C**	**160.3**

Table 6-18 Scenario 4 Results – Great Northern Highway / Eveline Road / Toodyay Road

Intersection Approach		Great Northern Highway / Eveline Road / Toodyay Road Scenario 4 – 2031 with the broader redevelopment area							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	L	0.511	16.5	B	92.8	0.776	16.2	B	114.1
	T	0.856	11.6	B	92.8	1.045	46.7	D	247
	R	0.856	31.4	C	41.4	1.045	95.2	F	247
Toodyay Road – E	L	0.561	35.3	D	84.4	0.679	34.3	C	56.2
	T	0.351	35.4	D	21.3	0.541	33	C	28.9
	R	0.351	37.3	D	21.3	0.541	35	C	28.9
Great Northern Highway – N	L	0.791	18	B	126.2	0.634	19.6	B	105
	T	0.953	22.2	C	152.4	0.634	13.6	B	105
	R	0.953	29.5	C	152.4	0.874	49.4	D	43.2
Eveline Road – W	L	0.383	31.9	C	38	0.395	32.7	C	26.9
	T	0.383	30.4	C	38	0.395	30.4	C	26.9
	R	1.236	260.5	F	273.5	0.978	69	E	80.3
All Vehicles		**1.236**	**49**	**D**	**273.5**	**1.045**	**39.9**	**D**	**247**

6.6.10 Great Northern Highway, Morrison Road, and Keane Street

The SIDRA layout of Great Northern Highway / Morrison Road / Keane Street is shown in **Figure 6-8** and the analysis results for intersection are presented in **Table 6-19** to **Table 6-22.**

The results show that the intersection at the opening year of Area 3 in 2023 would operate similarly to existing conditions, indicating that Area 3 development would have a low impact at opening year. Keane Street is experiencing poor performance, however this is an existing condition and as a result of its low traffic volume which results in SCATS not allocating significant green phase for Keane Street.

Scenario 3 results shows that the intersection is approaching its capacity due to the growth of background traffic, particularly the AM peak, even before the addition of the broader redevelopment traffic in Scenario 4.

Refer to **Section 6.7.2** for potential mitigation measure for this intersection, which should be considered prior to 2031 in order to accommodate background growth.

Figure 6-8 Great Northern Highway / Morrison Road / Keane Street SIDRA Layout

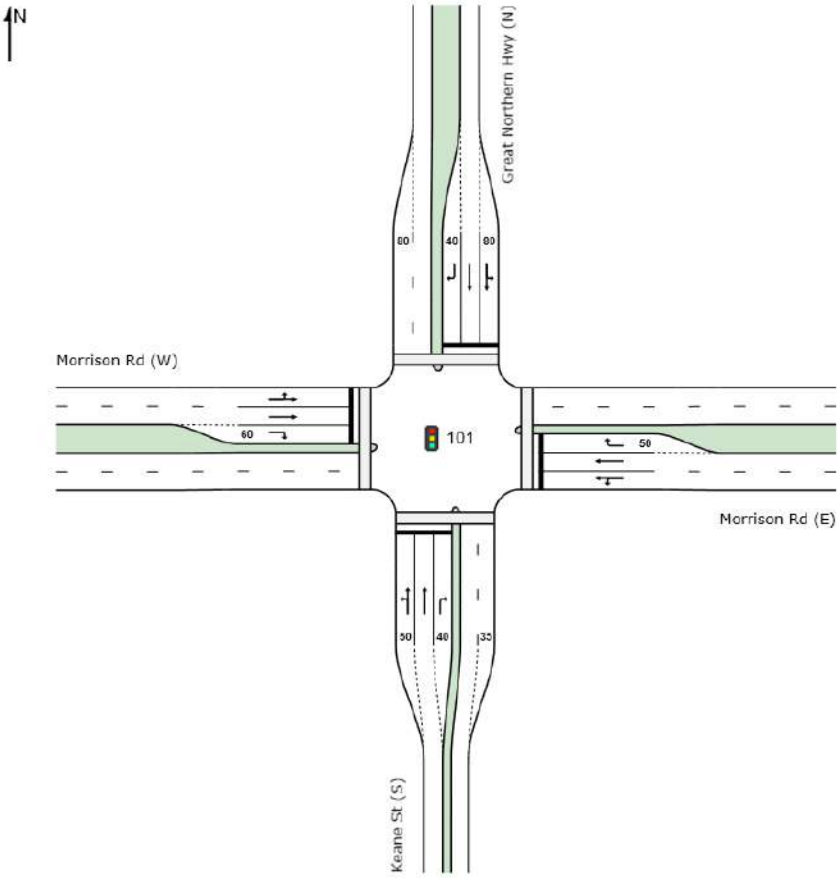


Table 6-19 Scenario 1 Results – Great Northern Highway / Morrison Road / Keane Street

Intersection Approach		Great Northern Highway / Morrison Road / Keane Street Scenario 1 – Existing Year 2020							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Keane Street – S	L	0.041	59.6	E	3.2	0.084	61.3	E	6.9
	T	0.087	62.4	E	3.7	0.176	65.6	E	7.5
	R	0.227	69.7	E	9.3	0.336	73.2	E	13.9
Morrison Road – E	L	0.599	28.9	C	56.5	0.315	27.1	C	44.7
	T	0.599	11.1	B	56.5	0.315	14.1	B	44.7
	R	0.677	39	D	60.1	0.583	31.2	C	62.9
Great Northern Highway – N	L	0.153	22.6	C	28.3	0.16	30.9	C	32.5
	T	0.548	9.4	A	53.4	0.574	16.7	B	60.4
	R	0.684	18.2	B	74.8	0.418	28.6	C	50.6
Morrison Road – W	L	0.616	19.9	B	62.6	0.572	14.5	B	69.6
	T	0.616	12.5	B	62.6	0.572	7.1	A	69.6
	R	0.632	68.4	E	42.7	0.315	42.2	D	33.4
All vehicles		**0.684**	**19.2**	**B**	**74.8**	**0.583**	**20.5**	**C**	**69.6**

Table 6-20 Scenario 2 Results – Great Northern Highway / Morrison Road / Keane Street

Intersection Approach		Great Northern Highway / Morrison Road / Keane Street Scenario 2 – 2023 with Area 3							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Keane Street – S	L	0.062	61.2	E	4.3	0.149	65.3	E	10.2
	T	0.131	62.8	E	5.6	0.315	66.9	E	13.6
	R	0.239	69.7	E	9.8	0.349	73.3	E	14.4
Morrison Road – E	L	0.738	31.9	C	68.1	0.338	27.1	C	48.2
	T	0.738	12.5	B	68.1	0.338	14.1	B	48.2
	R	0.783	40.4	D	72	0.625	31.2	C	75.3
Great Northern Highway – N	L	0.154	20	B	30.2	0.177	33.7	C	42.3
	T	0.551	8.9	A	59.2	0.633	17.4	B	66.9
	R	0.770	18.8	B	83.9	0.456	28.9	C	56.9
Morrison Road – W	L	0.768	21.5	C	88.6	0.638	15.2	B	86.4
	T	0.768	13.9	B	88.6	0.638	7.4	A	86.4
	R	0.703	69.5	E	48.3	0.341	42.4	D	36.6
All Vehicles		**0.783**	**20.1**	**C**	**88.6**	**0.638**	**21.4**	**C**	**86.4**

Table 6-21 Scenario 3 Results – Great Northern Highway / Morrison Road / Keane Street

Intersection Approach		Great Northern Highway / Morrison Road / Keane Street Scenario 3 – Future Year 2031 with Area 3							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Keane Street – S	L	0.075	62.4	E	5.1	0.175	65.7	E	11.4
	T	0.159	63.2	E	6.8	0.369	67.3	E	16.1
	R	0.263	69.9	E	10.8	0.398	73.5	E	16.6
Morrison Road – E	L	0.804	31.2	C	94.6	0.371	27.1	C	54.9
	T	0.804	13.8	B	94.6	0.371	14.1	B	54.9
	R	1.030	80.7	F	125.8	0.852	34	C	101.1
Great Northern Highway – N	L	0.183	18.3	B	34.3	0.238	31.3	C	49
	T	0.655	8.9	A	76.7	0.850	19.6	B	90.2
	R	1.020	78.6	E	257.8	0.714	29.4	C	76.7
Morrison Road – W	L	0.983	38.7	D	203.5	0.809	17.6	B	150.9
	T	0.983	29.9	C	203.5	0.809	9	A	150.9
	R	0.789	71.4	E	55.6	0.44	44	D	43.4
All Vehicles		**1.03**	**37.3**	**D**	**257.8**	**0.852**	**22.8**	**C**	**150.9**

Table 6-22 Scenario 4 Results – Great Northern Highway / Morrison Road / Keane Street

Intersection Approach		Great Northern Highway / Morrison Road / Keane Street Scenario 4 – 2031 with the broader redevelopment area							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Keane Street – S	L	0.087	62.7	E	5.5	0.226	67.4	E	13.6
	T	0.184	63.4	E	7.9	0.475	68.1	E	20.8
	R	0.263	69.9	E	10.8	0.398	73.5	E	16.6
Morrison Road – E	L	0.835	32.8	C	101.8	0.548	33.8	C	67.1
	T	0.835	14.9	B	101.8	0.548	17.8	B	67.1
	R	1.103	137.4	F	177.9	1.020	72	E	194.3
Great Northern Highway – N	L	0.252	20.2	C	58.9	0.268	30.9	C	61.9
	T	0.902	19.3	B	103.6	0.959	29.8	C	116.7
	R	1.136	165.4	F	444.7	0.971	47.2	D	123.9
Morrison Road – W	L	1.106	123.9	F	337.3	0.969	31.9	C	389.8
	T	1.106	115.1	F	337.3	0.969	21.4	C	389.8
	R	0.796	71.7	E	56.2	0.269	38.8	D	39.6
All Vehicles		**1.136**	**79.9**	**E**	**444.7**	**1.02**	**36.1**	**D**	**389.8**

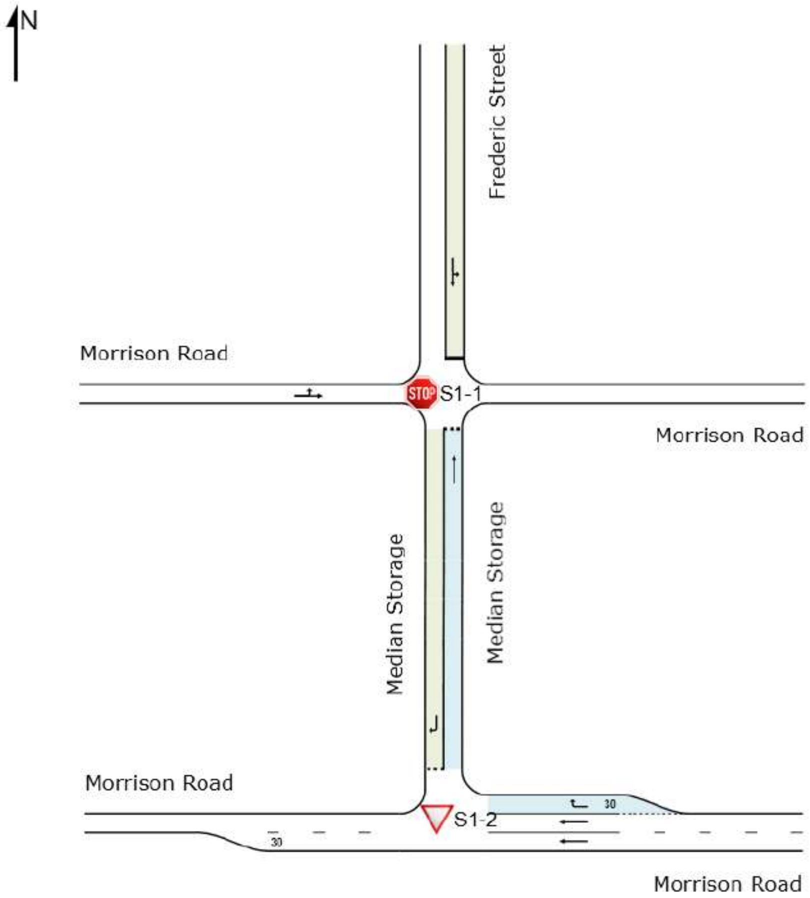
6.6.11 Morrison Road and Frederic Street

The SIDRA layout of Morrison Road / Frederic Street is shown in **Figure 6-9** and the analysis results for intersection are presented in **Table 6-23** to **Table 6-26.**

Scenario 2 results shows that the intersection is expected to be able to cater for Area 3 traffic in opening year 2023 and no upgrades are warranted.

The results show that the intersection would operate satisfactorily up until year 2031 with the broader redevelopment traffic added (Scenario 4). In Scenario 4, performance of right turn out of Frederic Street decreases to LOS E due to increased delay, however no extensive queue was observed from the modelling. Refer to **Section 6.7.2** for potential mitigation measure for this intersection

Figure 6-9 Morrison Road / Frederic Street SIDRA Layout



Note: The above image is a SIDRA representation of the existing intersection layout. The 'on the ground' layout will differ from this representation.

Table 6-23 Scenario 1 Results – Morrison Road / Frederic Street

Intersection Approach		Morrison Road / Frederic Street Scenario 1 – Existing Year 2020							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Morrison Road – E	T	0.313	0.2	A	0	0.24	0.1	A	0
	R	0.124	8.8	A	3.1	0.143	10	A	0.61
Frederic Street – N	L	0.348	11.2	B	12.7	0.273	12.2	B	0.65
	R	0.348	17.3	C	12.7	0.273	16.8	C	8.4
Morrison Road – W	L	0.34	5.6	A	0	0.395	5.7	A	0
	T	0.34	0.1	A	0	0.395	0.1	A	0

Table 6-24 Scenario 2 Results – Morrison Road / Frederic Street

Intersection Approach		Morrison Road / Frederic Street Scenario 2 – 2023 with Area 3							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Morrison Road – E	T	0.334	0.2	A	0	0.254	0.1	A	0
	R	0.145	9.2	A	3.6	0.2	11.4	A	0.68
Frederic Street – N	L	0.461	12.4	B	19.2	0.379	13.7	B	0.73
	R	0.461	19.8	C	19.2	0.379	19.6	C	12.9
Morrison Road – W	L	0.366	5.7	A	0	0.445	5.7	A	0
	T	0.366	0.1	A	0	0.445	0.2	A	0

Table 6-25 Scenario 3 Results – Morrison Road / Frederic Street

Intersection Approach		Morrison Road / Frederic Street Scenario 3 – Future Year 2031 with Area 3							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Morrison Road – E	T	0.389	0.3	A	0	0.298	0.2	A	0
	R	0.191	10.4	B	4.7	0.292	14.6	A	0.79
Frederic Street – N	L	0.635	15.8	C	29.2	0.542	18.2	C	0.84
	R	0.635	26.1	D	29.2	0.542	26.2	D	20
Morrison Road – W	L	0.42	5.7	A	0	0.518	5.7	A	0
	T	0.42	0.2	A	0	0.518	0.2	A	0

Table 6-26 Scenario 4 Results – Great Northern Highway / Morrison Road / Keane Street

Intersection Approach		Morrison Road / Frederic Street Scenario 4 – Future Year 2031 with the broader redevelopment area							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Morrison Road – E	T	0.424	0.4	A	0	0.32	0.2	A	0
	R	0.208	11.1	B	5.2	0.424	20.6	B	0.88
Frederic Street – N	L	0.866	26.2	D	56.2	0.786	30.4	D	0.94
	R	0.866	39.2	E	56.2	0.786	41.1	E	36.7
Morrison Road – W	L	0.444	5.7	A	0	0.595	5.8	A	0
	T	0.444	0.2	A	0	0.595	0.3	A	0

6.6.12 Summary

Based on the SIDRA analysis above, all of the key intersections would be able to cater for Area 3 traffic in the opening year 2023, hence no upgrades are recommended.

In 2031, with the completion of the remainder of the Broader Development Area, mitigation measure should be considered for the following intersections:

> **Great Northern Highway / Reid Highway / Roe Highway**

Results from the analysis shows that in 2031 the intersection would require an upgrade due to background traffic growth. This intersection is currently being planned to be upgraded to an interchange by Main Roads WA within 10 years.

> **Great Northern Highway / Eveline Road / Toodyay Road**

In 2031, the intersection is approaching its capacity and the addition of the Broader Redevelopment area would result in poor performance.

> **Great Northern Highway / Morrison Road / Keane Street**

Analysis shows that even without the Broader Redevelopment Area, the intersection would reach its capacity in 2031 if the assumed background traffic growth is realised.

> **Morrison Road / Frederic Street**

The analysis shows that in 2031, the addition of the Broader Redevelopment Area traffic would result poor performance, particularly the right out from Frederic Street.

6.7 Potential Mitigation Measures for 2031 Scenarios

The potential mitigation discussed below are for the year 2031 with development scenarios where the whole of the Broader Redevelopment Area is completed. The existing intersection is sufficient in accommodating Area 3 alone in 2023.

6.7.1 Great Northern Highway, Eveline Road, and Toodyay Road Intersection

The SIDRA analysis presented previously shows that in 2031 the Eveline Road right turn movement would experience poor performance in the AM peak under existing phasing and layout. This poor performance is due to a combination of increased background traffic volumes, and the high left turn movement from Toodyay Road, which the right turn movement from Eveline Road must give way to.

Several different phasing options were tested with a view to achieving satisfactory performance with the existing layout, including a Leading Right Turn phase for Eveline Road. However, none of the tested phasing options were able to sufficiently improve the operation of the intersection.

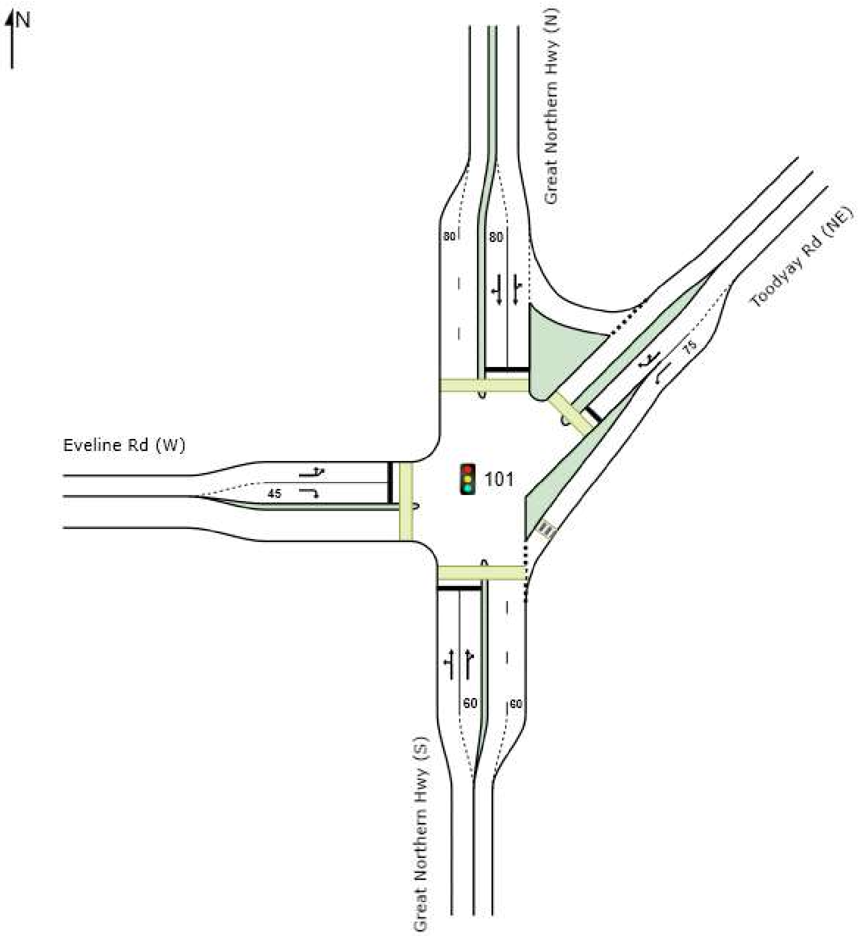
As such, it is proposed that the following modification to be applied to the intersection in order to allow better performance for right turn from Eveline Road (Refer to **Figure 6-10**):

> Provide a left turn slip lane with splitter island on Toodyay Road.

> On Eveline Road, the median side lane is reallocated for right turn movement only.

> Signal phasings and timing are not modified from existing.

Figure 6-10 Proposed Layout - Great Northern Highway / Eveline Road / Toodyay Road



The SIDRA analysis for the proposed intersection layout is shown in **Table 6-27**. The results show that the proposed layout improves the right turn movement from Eveline Road, without having detrimental impact to the performance on other intersection legs. Therefore, it is proposed that the modified layout be considered as a potential long-term intersection upgrade to accommodate increased traffic from Viveash due to developments such as the hospital redevelopment, aged care and retirement village development, and the broader redevelopment area.

Table 6-27 Great Northern Highway / Eveline Road / Toodyay Road - Existing and Mitigated Layout Results Comparison

Intersection Approach		Great Northern Highway / Eveline Road / Toodyay Road Scenario 4 – Existing Layout							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Great Northern Highway – S	L	0.511	16.5	B	92.8	0.776	16.2	B	114.1
	T	0.856	11.6	B	92.8	1.045	46.7	D	247
	R	0.856	31.4	C	41.4	1.045	95.2	F	247
Toodyay Road – E	L	0.561	35.3	D	84.4	0.679	34.3	C	56.2
	T	0.351	35.4	D	21.3	0.541	33	C	28.9
	R	0.351	37.3	D	21.3	0.541	35	C	28.9
Great Northern Highway – N	L	0.791	18	B	126.2	0.634	19.6	B	105
	T	0.953	22.2	C	152.4	0.634	13.6	B	105
	R	0.953	29.5	C	152.4	0.874	49.4	D	43.2
Eveline Road – W	L	0.383	31.9	C	38	0.395	32.7	C	26.9
	T	0.383	30.4	C	38	0.395	30.4	C	26.9
	R	1.236	260.5	F	273.5	0.978	69	E	80.3
All Vehicles		**1.236**	**49**	**D**	**273.5**	**1.045**	**39.9**	**D**	**247**
Intersection Approach		**Great Northern Highway / Eveline Road / Toodyay Road Scenario 4 – Mitigated Layout**							
		AM Peak				**PM Peak**			
		DOS	**Delay**	**LOS**	**95% Queue (m)**	**DOS**	**Delay**	**LOS**	**95% Queue (m)**
Great Northern Highway – S	L	0.478	15.1	B	84.5	0.562	13	B	91.2
	T	0.800	10.4	B	84.5	0.941	25.3	C	178.1
	R	0.800	26.3	C	40.1	0.941	46.3	D	178.1
Toodyay Road – E	L	0.753	37.9	D	68.4	0.307	9.2	A	14.9
	T	0.375	36.5	D	21.7	0.541	33	C	28.9
	R	0.375	38.3	D	21.7	0.541	34.9	C	28.9
Great Northern Highway – N	L	0.74	16.2	B	109.3	0.637	14.8	B	72.5
	T	0.891	22.5	C	135.4	0.637	8.8	A	72.5
	R	0.891	22.1	C	135.4	0.818	42.3	D	39.9
Eveline Road – W	L	0.407	33	C	38.8	0.395	32.9	C	26.9
	T	0.407	31.5	C	38.8	0.395	30.4	C	26.9
	R	0.799	38	D	87.6	0.777	36.7	D	54.3
All Vehicles		**0.891**	**25.3**	**C**	**135.4**	**0.941**	**23.3**	**C**	**178.1**

6.7.2 Great Northern Highway/Morrison Road/Keane Street Intersection

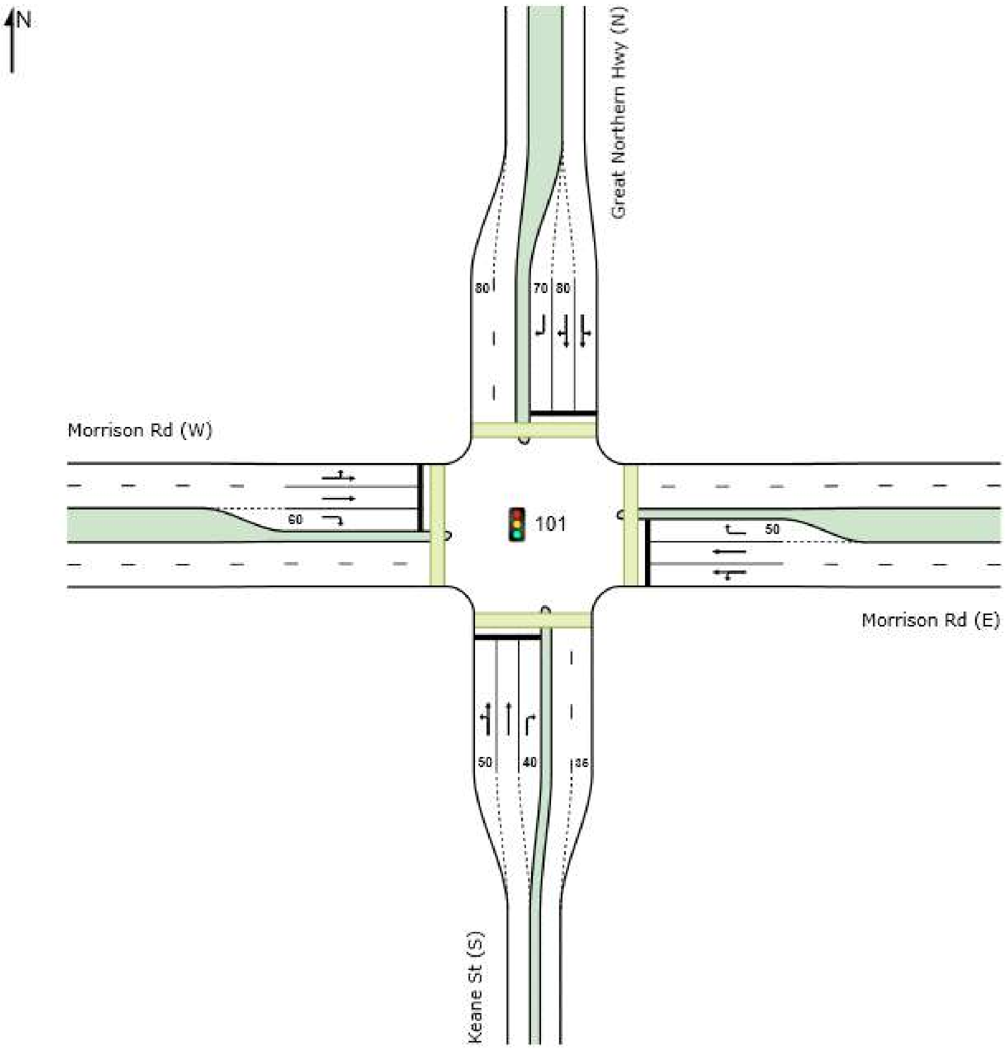
The SIDRA analysis presented previously shows that in 2031 the intersection of Great Northern Highway / Morrison Road / Keane Street would experience poor performance, particularly for Great Northern Highway and Morrison Road east legs. As the Great Northern Highway approach has the highest traffic volume, it is proposed that the following long-term modification to be applied (Refer to **Figure 6-11**) to allow more throughput from the Great Northern Highway leg of the intersection:

> Lengthen the existing right turn lane on Great Northern Highway north leg to 70m long.

> The central lane of Great Northern Highway approach to be reallocated for combined through and right turn movement.

To operate safely with the revised lane configuration, the filter right turns from Great Northern Highway and Keane Street legs are removed and the phasing changed to operate with split phasings on these legs. Lane allocations and phasing on Morrison Road legs remain unchanged.

Figure 6-11 Proposed Layout - Great Northern Highway / Morrison Road / Keane Street



The SIDRA analysis for the proposed layout is shown in **Table 6-28** and it shows that the proposed layout would be a significant improvement for the right turn from Great Northern Highway and Morrison Road west leg. Other legs also experience some improvement in level of service. Therefore, the proposed upgrade should be considered to accommodate the increased background traffic volumes.

Table 6-28 Great Northern Highway / Morrison Road / Keane Street - Existing and Mitigated Layout Results Comparison

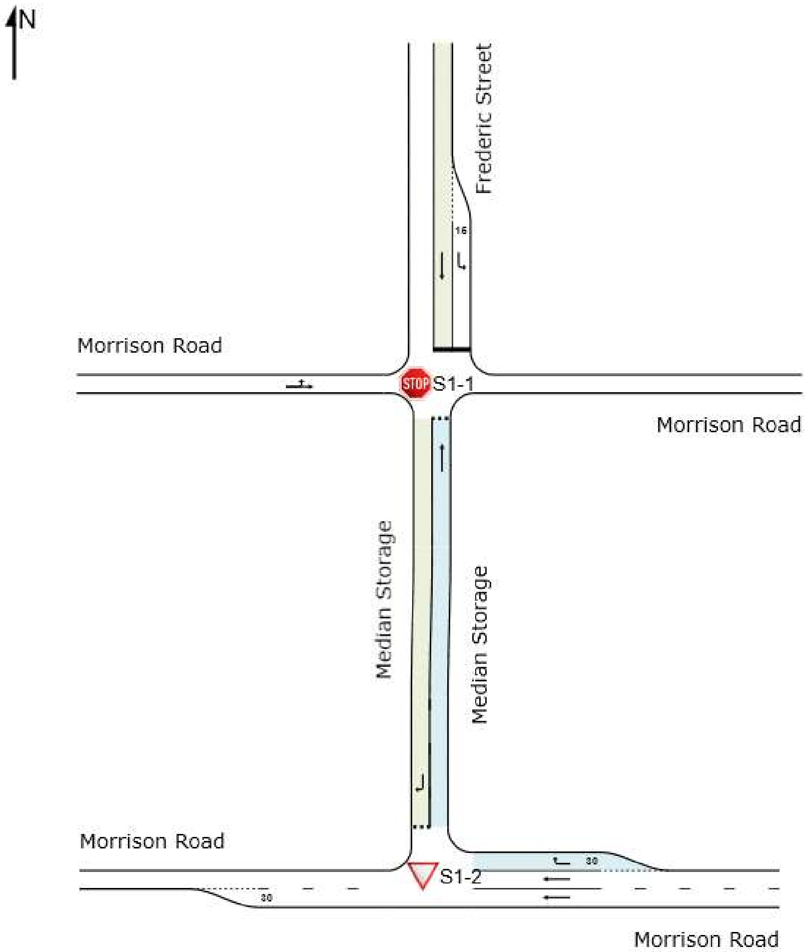
Intersection Approach		Great Northern Highway / Morrison Road / Keane Street Scenario 4 – Existing Layout							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Keane Street – S	L	0.087	62.7	E	5.5	0.226	67.4	E	13.6
	T	0.184	63.4	E	7.9	0.475	68.1	E	20.8
	R	0.263	69.9	E	10.8	0.398	73.5	E	16.6
Morrison Road – E	L	0.835	32.8	C	101.8	0.548	33.8	C	67.1
	T	0.835	14.9	B	101.8	0.548	17.8	B	67.1
	R	1.103	137.4	F	177.9	1.020	72	E	194.3
Great Northern Highway – N	L	0.252	20.2	C	58.9	0.268	30.9	C	61.9
	T	0.902	19.3	B	103.6	0.959	29.8	C	116.7
	R	1.136	165.4	F	444.7	0.971	47.2	D	123.9
Morrison Road – W	L	1.106	123.9	F	337.3	0.969	31.9	C	389.8
	T	1.106	115.1	F	337.3	0.969	21.4	C	389.8
	R	0.796	71.7	E	56.2	0.269	38.8	D	39.6
All Vehicles		**1.136**	**79.9**	**E**	**444.7**	**1.02**	**36.1**	**D**	**389.8**
Intersection Approach		**Great Northern Highway / Morrison Road / Keane Street Scenario 4 – Modified Layout**							
		AM Peak				**PM Peak**			
		DOS	**Delay**	**LOS**	**95% Queue (m)**	**DOS**	**Delay**	**LOS**	**95% Queue (m)**
Keane Street – S	L	0.072	50.4	D	4.4	0.147	47.9	D	9.5
	T	0.151	50.8	D	6.4	0.311	48	D	15.3
	R	0.217	57.1	E	8.8	0.257	53.2	D	12
Morrison Road – E	L	0.996	59.7	E	167.6	0.540	22.8	C	37.6
	T	0.996	36.3	D	167.6	0.540	9	A	37.6
	R	0.958	43.3	D	99.1	0.981	48.1	D	139.4
Great Northern Highway – N	L	0.233	12.5	B	25.1	0.266	19.7	B	37.3
	T	0.833	10.2	B	123.8	0.954	17.6	B	124.6
	R	0.833	20.4	C	143	0.867	20.9	C	89
Morrison Road – W	L	0.920	24.3	C	139.1	0.943	34.3	C	269.8
	T	0.920	16.1	B	139.1	0.943	18.2	B	269.8
	R	0.467	50.8	D	42.6	0.278	43.9	D	41.5
All Vehicles		**0.996**	**25.4**	**C**	**167.6**	**0.981**	**26.6**	**C**	**269.8**

6.7.3 Morrison Road / Frederic Street Intersection

The SIDRA analysis presented previously shows that the right turn movement out of Frederic Street would operate at LOS E in both the AM and PM peak in 2031 with development. To mitigate this, an additional short left turn lane is added to Frederic Street as shown in **Figure 6-12.**

The results of the mitigated layout are shown in **Table 6-29.** The proposed layout would improve the performance of both left and right turn movements from Frederic Street.

Figure 6-12 Proposed Layout - Morrison Road / Frederic Street



Note: The above image is a SIDRA representation of the existing intersection layout. The 'on the ground' layout will differ from this representation.

Table 6-29 Morrison Road / Frederic Street – Existing and Mitigated Layout Results Comparison

Intersection Approach		Morrison Road / Frederic Street Scenario 4 – Existing Layout							
		AM Peak				PM Peak			
		DOS	Delay	LOS	95% Queue (m)	DOS	Delay	LOS	95% Queue (m)
Morrison Road – E	T	0.424	0.4	A	0	0.32	0.2	A	0
	R	0.208	11.1	B	5.2	0.424	20.6	B	0.88
Frederic Street – N	L	0.866	26.2	D	56.2	0.786	30.4	D	0.94
	R	0.866	39.2	E	56.2	0.786	41.1	E	36.7
Morrison Road – W	L	0.444	5.7	A	0	0.595	5.8	A	0
	T	0.444	0.2	A	0	0.595	0.3	A	0
Intersection Approach		**Morrison Road / Frederic Street Scenario 4 – Mitigated Layout**							
		AM Peak				**PM Peak**			
		DOS	**Delay**	**LOS**	**95% Queue (m)**	**DOS**	**Delay**	**LOS**	**95% Queue (m)**
Morrison Road – E	T	0.424	0.9	A	0	0.32	0.2	A	0
	R	0.208	11.1	B	5.2	0.424	20.6	B	0.88
Frederic Street – N	L	0.269	12.2	B	8.3	0.285	17.1	C	0.79
	R	0.659	30.6	D	19.2	0.502	31.1	D	15.3
Morrison Road – W	L	0.444	5.7	A	0	0.595	5.8	A	0
	T	0.444	0.2	A	0	0.595	0.3	A	0

6.8 Pedestrian and Cycling Network

The pedestrian and cycling networks are described in **Section 4.2** and **Section 4.3.** In addition, provision should be made in the development plan for a 3m wide red asphalt shared path to be provided along the river frontage between Reg Bond Reserve and Bassett Road.

Footpaths and/or shared paths will likely be required on streets within Area 3, with appropriate linkages between the residential and industrial components to facilitate walking and cycling.

6.9 Safe Walk and Cycling to School

The closest school within walking distance are Saint Brigid's Primary School on Toodyay Road and La Salle College on Muriel Street.

Students would be able to walk or cycle to Saint Brigid's Primary School via future footpaths along Eveline Road. A pedestrian crossing facility is located at the intersection of Great Northern Highway /Eveline Road / Toodyay Road, which would assist students to cross the intersection towards Toodyay Road. La Salle College can be accessed via internal roads within Area 3 adjacent to Jack Williamson Oval linking into Cranwood Crescent and Muriel Street.

6.10 Public Transport Access

Bus stops are located on Great Northern Highway, which provide connectivity to the Midland Gate shopping centre and the Midland train station, which connects the wider Midland area to the Perth CBD and beyond. The bus stops would be accessible from Area 3 by new paths linking into the extension of Eveline Road or Muriel Street.

As noted in **Section 5.3**, selected bus services divert into the Viveash residential area to serve school children and the general residential catchment. With the extension of Eveline Road, there is the potential for these services to take a much more efficient route without having to double back along Muriel Street. Furthermore, the additional residential catchment provided by the Area 3 or the broader redevelopment area may warrant the full-time diversion of at least one bus route through Viveash, significantly improving public transport accessibility for the area.

Access to La Salle College for school buses would also be improved with the Eveline Road extension. It was observed that 'School Special' bus services approach the College via a range of routes, including Margaret Street and Elvire Street (refer to **Figure 6-13**), which can be difficult to negotiate due to parked vehicles and general congestion. As a result of the Eveline Road extension, these services could circulate via Eveline Road, Ashby Crescent and Muriel Street to access the College bus stops.

Figure 6-13 Bus manoeuvring tight corner on Elvire Street

7 Conclusion

This Transport Impact Assessment (TIA) outlines the transport aspects of the proposed development focusing on traffic operations, access, pedestrian, cycle parking and public transport. This assessment has been prepared in accordance with the WAPC Transport Impact Assessment Guidelines Volume 2: Planning Schemes, Structure Plans & Activity Centre Plans (2016) for lodgement with the development application.

The following conclusions have been made in regards to the proposed development:

Summary of Area 3 Assessment

> The proposed development of Area 3 (the subject of this structure plan) consists of 151 dwellings. This is envisaged to form part of a broader redevelopment area consisting a total of 545 residential dwellings. For the purpose of the analysis however, a total yield of 700 dwellings is adopted for robustness.

> Area 3 is estimated to generate 115 trips in the AM Peak Hour, 151 trips in the PM Peak Hour, and 1,426 daily trips.

> To support the proposed structure plan, a north-south road connection (adjacent to Jack Williamson Oval) between the extension of Eveline Road and Cranwood Crescent is proposed. Additional east-west access roads connection to Cranwood Crescent are also proposed.

> The Eveline Road extension (to be constructed in 2022) will provide improved connectivity for the Site and the existing Viveash suburb and present possibility for bus service to be routed through or adjacent the Site and Viveash, therefore improving public transport access.

> SIDRA analysis for the year 2023 with the completion of Area 3 shows that all intersection analysed will be operating satisfactorily and no upgrades are required. Therefore, Area 3 is expected to have no material impact to the surrounding road network.

Summary of the Broader Redevelopment Area Assessment

This report also assessed a scenario where the broader redevelopment area is completed. The assessment concluded that in 2031 some intersection would be operating poorly and may need upgrades.

> SIDRA analysis results show that the intersection of Great Northern Highway/Reid Highway/Roe Highway would perform poorly in 2031. This is caused by the background traffic growth and will perform poorly regardless of whether the broader redevelopment area is included. Main Roads WA is planning to grade separate the intersection within 10 years as part of the Eastlink WA project which would significantly increase the capacity. As such, it is expected that this intersection would performed adequately when the grade separation is completed.

> SIDRA analysis results show that the intersection of Great Northern Highway/Toodyay Road/Eveline Road generally operates satisfactorily in 2031 with the broader redevelopment area, however during the AM Peak the right turn from Eveline Road should be improved. The recommended mitigation measure is to amend the signal phasing and construct a left turn slip lane with splitter island for the Toodyay Road approach in order to reduce the amount of opposing traffic for the right turn from Eveline Road. This mitigation measure results in satisfactory performance in all scenarios.

> SIDRA analysis results for Great Northern Highway/Morrison Road/Keane Street intersection indicates that the intersection is likely to require upgrades prior to 2031 to accommodate background traffic growth (i.e. before the broader redevelopment area is added). A potential mitigation measure is to modify the lane allocations and phasing to allow a dual right turn from Great Northern Highway into Morrison Road (west). This mitigation measure results in satisfactory performance in all scenarios.

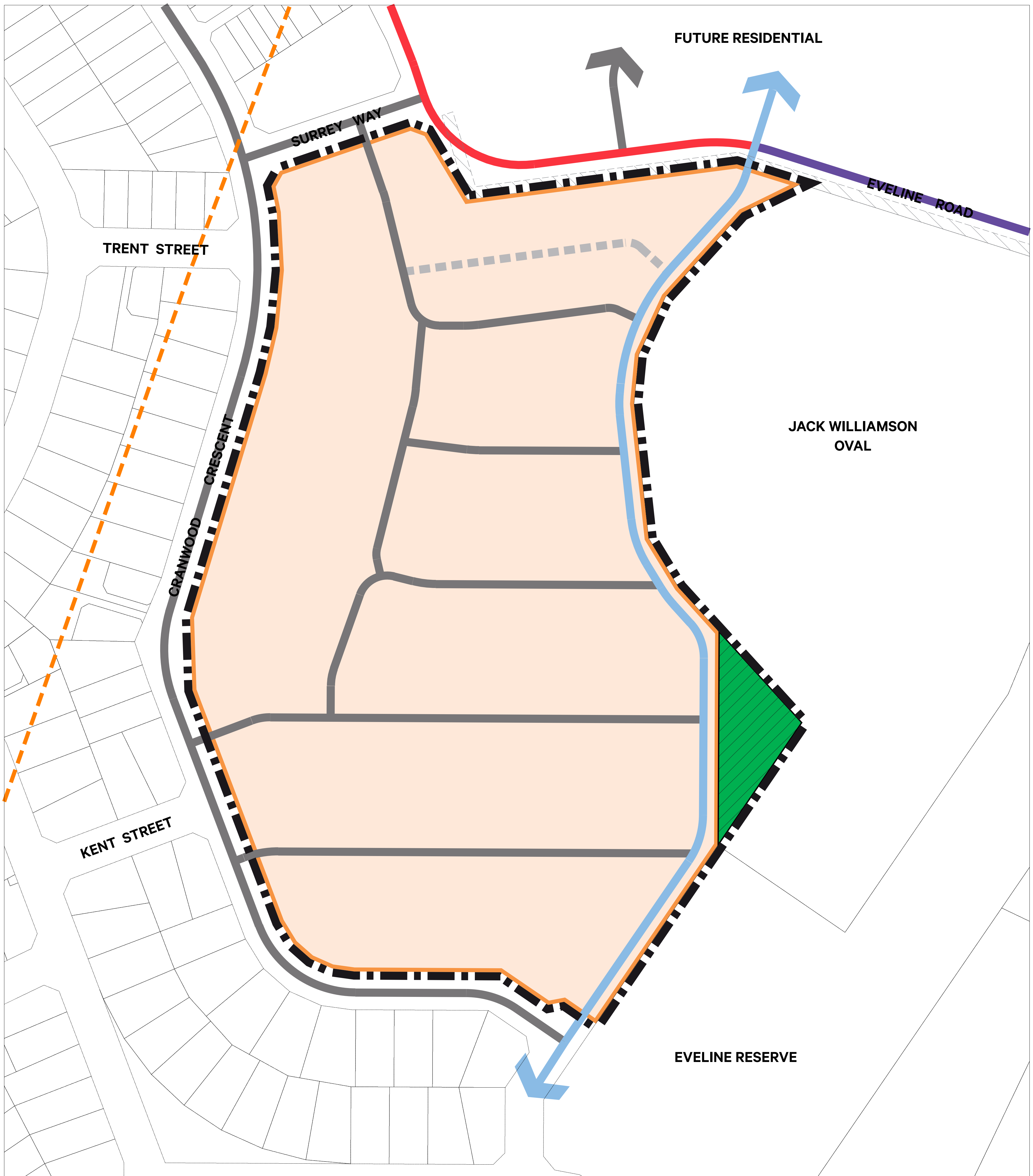
> Morrison Road/Frederic Street SIDRA results show that some delays are expected on Frederic Street in the year 2031. Providing a short left turn lane in Frederic Street results in satisfactory level of service for Frederic Street and improved right turn and left turn performance.

> In conclusion, the broader redevelopment area can be catered by the road network with the mitigation measures identified.

APPENDIX

A

AREA 3 DESIGN FRAMEWORK



LEGEND

Local Structure Plan Boundary

LOCAL SCHEME ZONES

Residential Development

LOCAL SCHEME RESERVES

Public Open Space

NEIGHBOURHOOD AND KEY ACCESS STREETS

Neighbourhood Connector A

Neighbourhood Connector B

Access Street C

LOCAL ACCESS STREETS (Indicative and subject to change)

Access Street D

Laneway

OTHER

Gas Pipeline Easement

ANEF 20-25

Area 3 Local Structure Plan

Lot 9000 Eveline Road, Viveash

N

0 20 40m

Date: 4 May 2023
File: **21-742 ST1 1**
Revision: A — Initial issue 24.05.22
B — Amended 04.05.23
- -

Scale: 1:2000 @ A3
Staff: LC CW
Checked: MR

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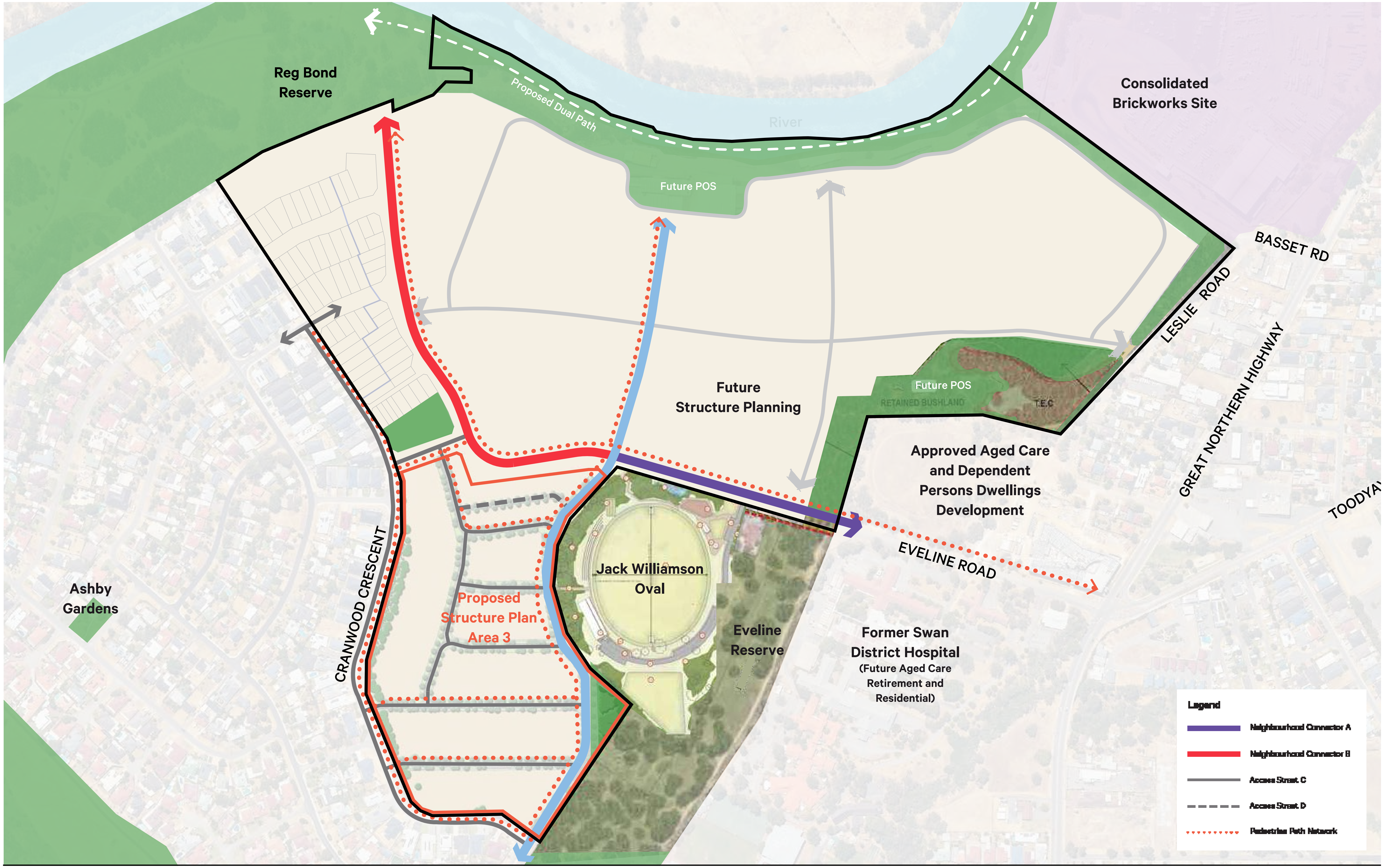

Movement Network

Rivermark, Viveash

Date: 8 May 2023 Scale: NTS @ A3 NTS @ A1 File: **19-402 CP-2-B** Staff: MR GW Checked: MR

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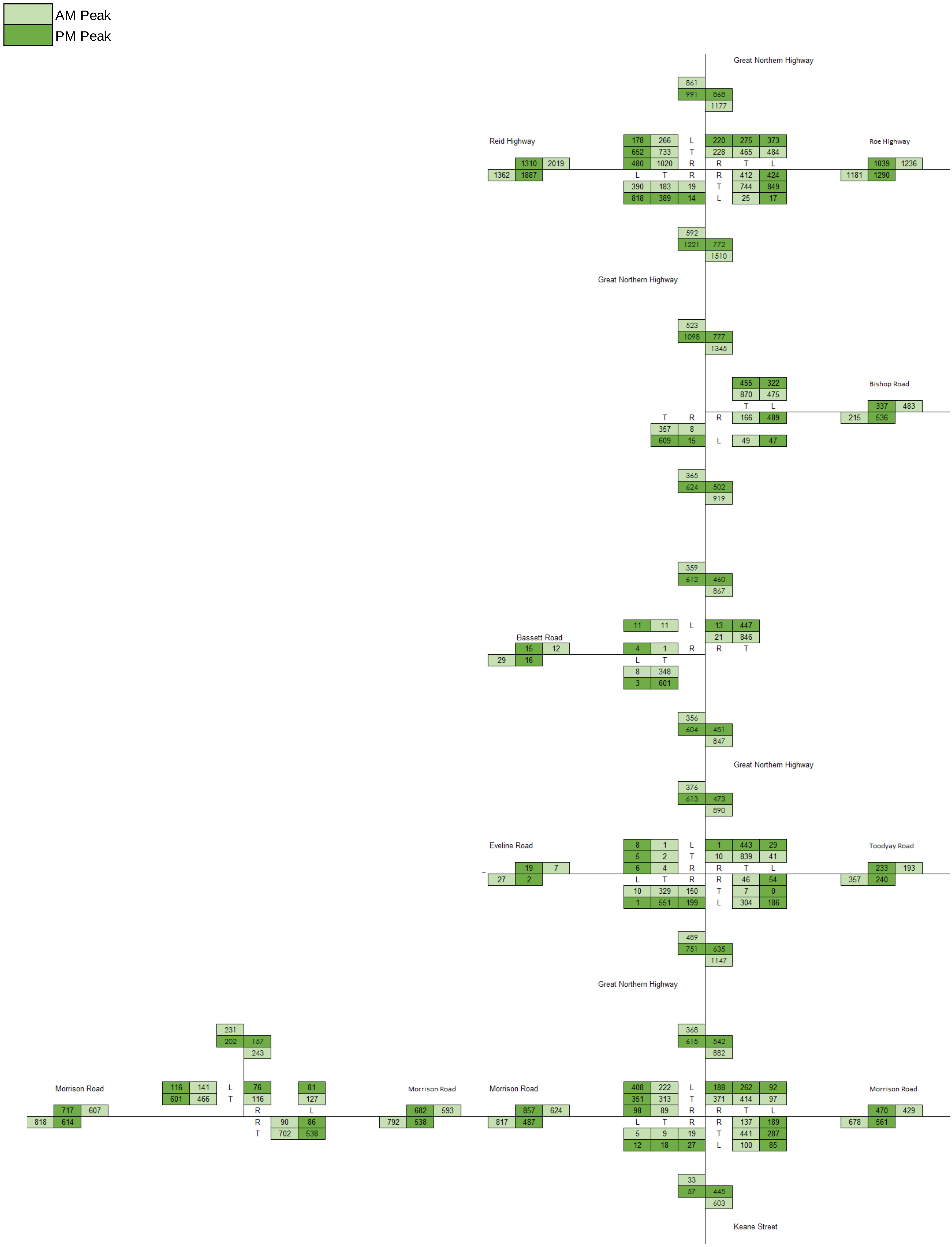
Area 3 Local Structure Plan

APPENDIX

B

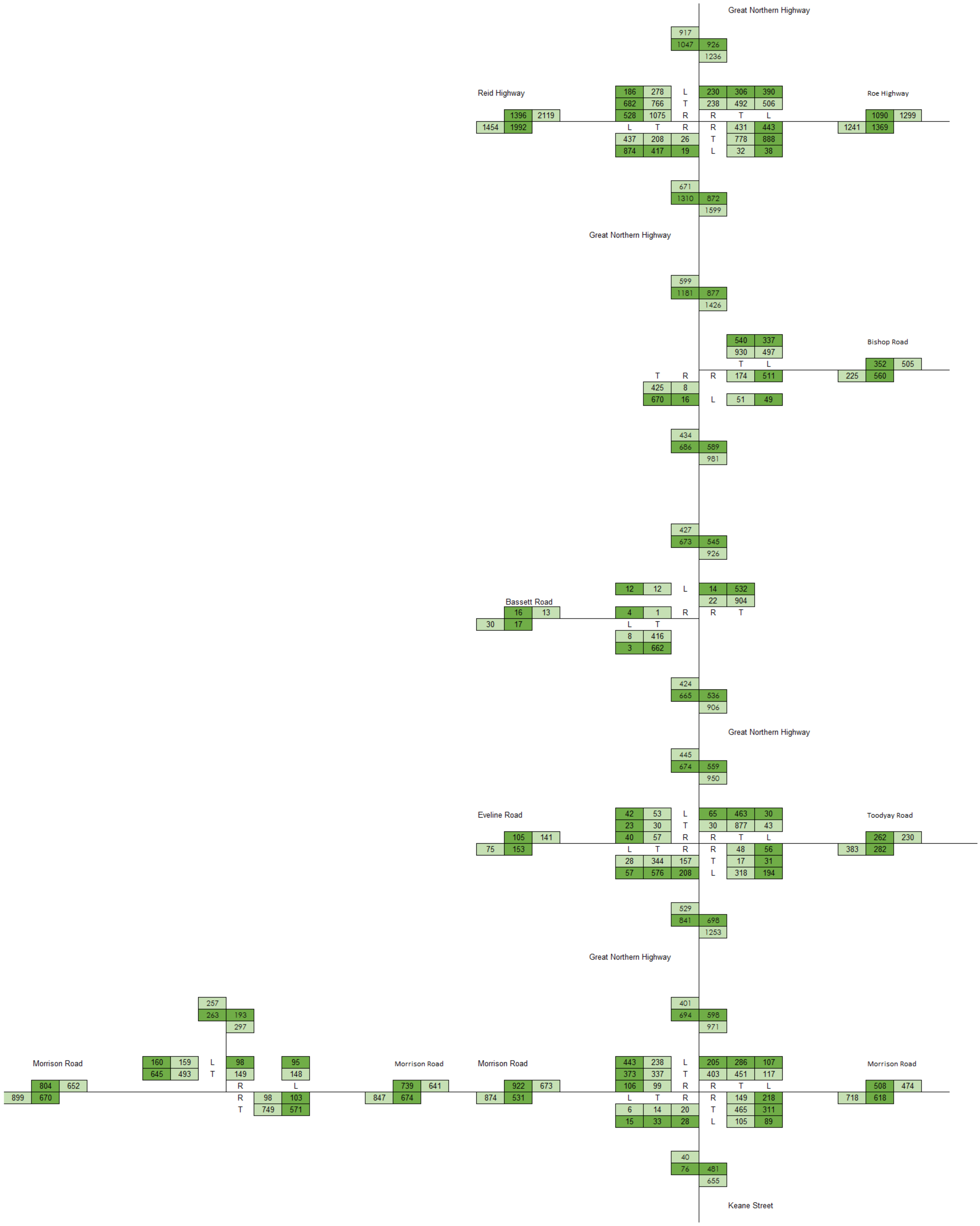
TRAFFIC VOLUME

Background 2020



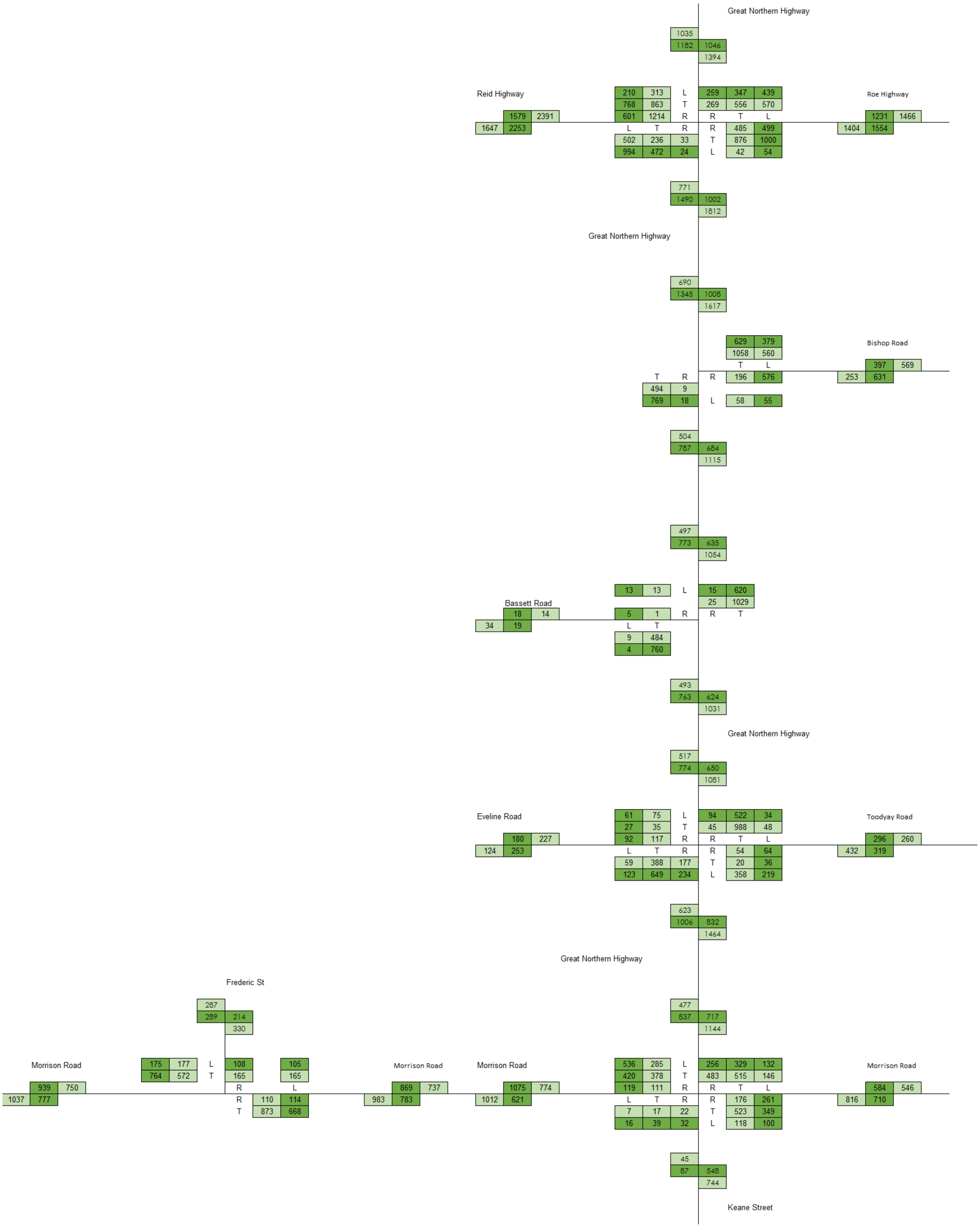
Background 2023+Area 3

AM Peak
PM Peak



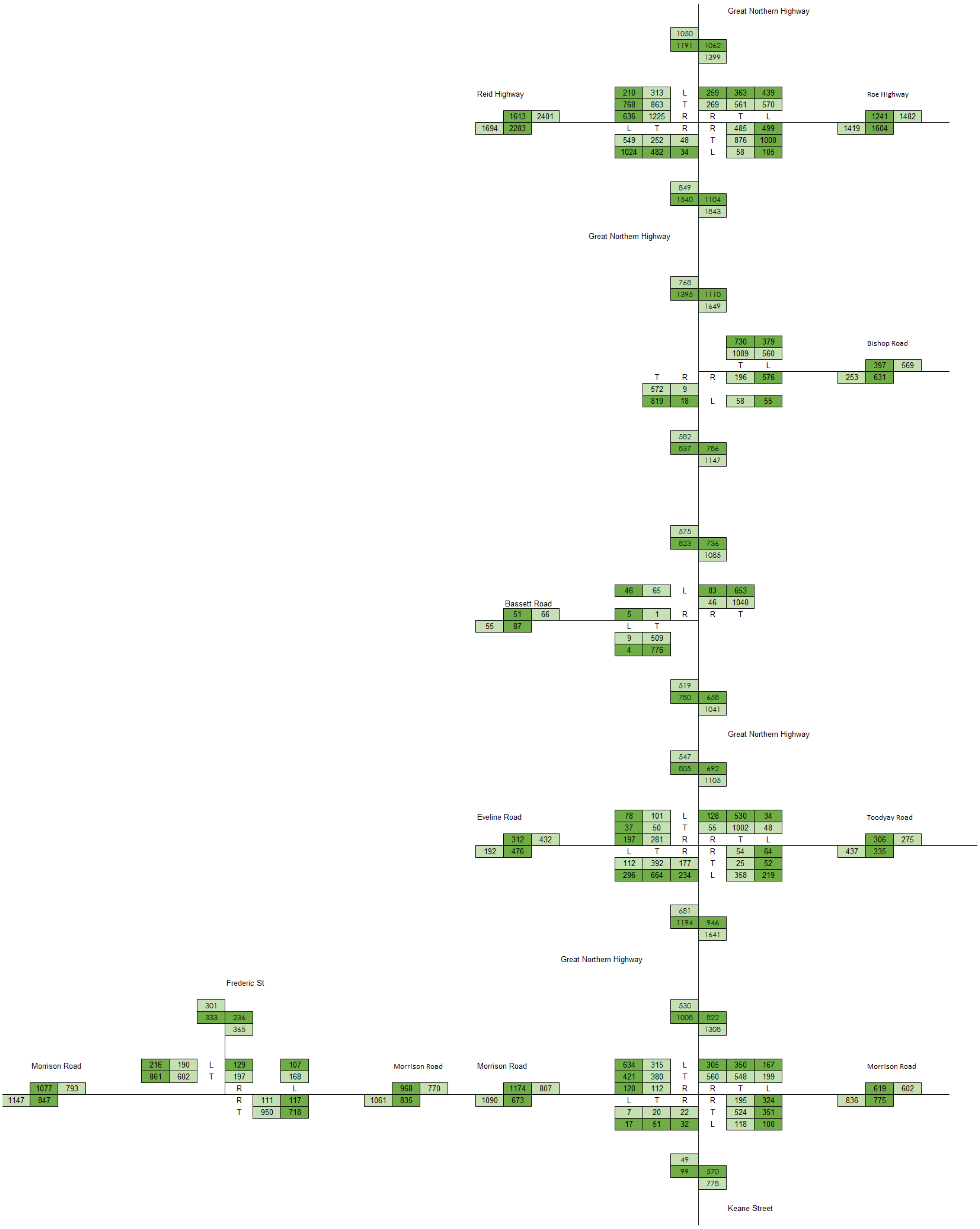
Background 2031 (Area 3 included)

AM Peak
PM Peak



Background 2031+Broader Redevelopment Area

AM Peak
PM Peak



Contact

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Appendix E

Local Water Management Strategy

Rivermark Area 3

Local Water Management Strategy

February 2024

Client: HESPERIA

Contents

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Figures

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Disclaimer

Executive Summary

Hyd2o was commissioned by Hesperia to prepare this Local Water Management Strategy (LWMS) to support the proposed Rivermark Area 3 local structure plan (LSP) within the existing Midland Brick site in Middle Swan.

The LSP area is approximately 10 ha in size and located approximately 20 km north east of the Perth central business district within the City of Swan. The proposed urban development, subject to a future subdivision application, will consist of residential lots, roads, and public open space creating public amenity in connectivity to a Blackadder Creek tributary.

This LWMS presents stormwater management in the context of the whole of the Midland Brick site including areas outside of the LSP area to provide a comprehensive overall assessment of the existing water management system of the area and its performance and how this will be modified to improve water sensitive urban design outcomes as a result of the proposed land use change.

Understanding key hydrological considerations has informed the development of the LWMS. The Midland Brick site has been a brickworks since 1946 with operations and brick sales currently operating. The LSP area is generally characterised as having low permeability soils, good clearance to groundwater, and no ASS risk. It is part of a larger existing stormwater system which operates via a pumped system to transfer water from the Midland Brick site to the Blackadder Creek Tributary, with larger events also flowing to the Swan River.

The environmental considerations and values of the Blackadder Creek tributary and the Eveline Reserve have guided the hydrological design for the LSP area.

This document has been prepared in accordance with the principles and objectives of Better Urban Water Management (Western Australian Planning Commission, 2008) and its overarching District Water Management Strategy (DWMS) (Hyd2o, 2020a). Key agencies ultimately involved with its implementation including the City of Swan, (CoS), Department of Biodiversity, Conservation, and Attractions (DBCA) and Department of Water and Environmental Regulation (DWER), have been widely consulted during the planning process.

Implementation of the strategy will be undertaken in accordance with Better Urban Water Management through the development and implementation of Urban Water Management Plans for individual stages of development within the LSP area.

The Better Urban Water Management LWMS checklist is included as Appendix A.

Local Water Management Strategy Summary

Water Use Sustainability	
Water Efficiency	• Promotion of 6 star building standards (water efficient fixtures and fittings). • Use of water-wise plantings in POS and landscape rehabilitation areas. • Maximise infiltration of residential stormwater runoff.
Water Supply	• Construction: Temporary DWER groundwater licence and use of brickworks stormwater • Lots: Water Corporation IWSS and rainwater tanks (optional). • POS: Groundwater irrigation. • Retained industrial outside of LSP area to continue with Water Corporation IWSS and stormwater harvesting via Clay Basin/Swale storage for dust suppression.
Wastewater	• Water Corporation reticulated sewerage.
Stormwater	
Design & Management Principles	• Habitable development levels have suitable clearance above the 1% AEP flood level of the Swan River (5.7-6.0 mAHD) and Blackadder Creek (5.46 mAHD at Muriel St). • Water quality to be managed through biofiltration treatment of runoff generated by first 15mm of rainfall prior to discharge to Blackadder Creek tributary. • Maintain the overall water balance at Muriel St and maintain the peak discharge at the existing southern outlet of the Midland Brick site to existing flows. • For the remaining industrial area and its upstream external catchment, continue to provide a flow path and operation consistent with existing practice.
Lot Scale Measures	• Soakwells sized to retain and infiltrate first 15 mm rainfall on lots within sand fill. • Rainwater tanks (optional). • Water-wise landscaping to retain stormwater and minimise runoff
Street Scale Measures	• Biofiltration as specified in POS, with additional areas identified at UWMP scale as necessary if required • Piped drainage, with opportunities for localised swales in road reserves to be reviewed at UWMP stage. • GPT's
Estate Scale Measures	• Water quality treatment areas for treatment of runoff from first 15mm rainfall via biolfitration. Estimated area and volume required of 0.076 ha and 227 m³, based on assumed 0.3m depth. • Flood management storage areas within POS areas to attenuate flows in accordance with agency requirements. • Post development groundwater, surface water, and system performance monitoring and annual reporting.
Groundwater	
Fill & Subsoil	• Use of imported fill, with subsoil to be implemented to control perched water levels within the imported fill.
Acid Sulphate Soils	▪ Development area has no known risk of ASS.
Implementation	
Process	• Predevelopment groundwater and surface water monitoring program complete. • Future stages of planning consistent with BUWM including preparation of UWMP's. • Staging of stormwater changes to be detailed in the relevant UWMP's and implemented to ensure key hydrological performance criteria for the receiving environment are maintained during the transitional process.

1. Introduction

Hyd2o was commissioned by Hesperia to prepare this Local Water Management Strategy (LWMS) to support the proposed Rivermark Area 3 local structure plan (LSP) for land within the existing Midland Brick site in Middle Swan.

The LSP area is approximately 10 ha in size and located approximately 20 km north east of the Perth central business district within the City of Swan (Figure 1). The proposed urban development, subject to a future subdivision application, will consist of residential lots, roads, and public open space creating public amenity in connectivity to a Blackadder Creek tributary.

Note this LWMS considers the whole of the Midland Brick site including areas outside of the LSP area to provide a comprehensive overall assessment of the existing water management system of the area and its performance and how this will ultimately be modified to improve water sensitive urban design outcomes as a result of the proposed land use change.

This LWMS provides a total water cycle management approach to development. It has been prepared in accordance with the principles and objectives of Better Urban Water Management (Western Australian Planning Commission, 2008) and the overarching District Water Management Strategy (DWMS) (Hyd2o, 2020a).

This document provides the outcomes of detailed site specific analysis relating to groundwater and surface water and provides a clear vision in terms of adopting best management practices to achieve water sensitive design.

A copy of the Better Urban Water Management (WAPC, 2008) LWMS Checklist for Developers is included as Appendix A to assist the Department of Water and Environmental Regulation (DWER) and City of Swan in review of this document.

Key stakeholders involved with its implementation of this strategy including the City of Swan, (CoS), Department of Biodiversity, Conservation, and Attractions (DBCA) and Department of Water and Environmental Regulation (DWER), have been widely consulted during the planning process.

1.1 Planning Background

The LSP area is zoned General Industrial under the City of Swan Local Planning Scheme 17 and urban under the Metropolitan Region Scheme.

The urban water management planning process is shown in Table 1. This LWMS supports the proposed development of the LSP area of the Midland Brick site to urban development.

Table 1: Integrated Planning and Urban Water Management Process

Planning Phase	Planning Document	Urban Water Management Documents
MRS Amendment	MRS Amendment	Midland Brick District Water Management Strategy (Hyd2o, 2020a)
Local Structure Plan/TPS Amendment	Local Structure Plan/ Local Scheme Amendment	Rivermark Area 3 Local Water Management Strategy **THIS DOCUMENT**
Subdivision	Subdivision Application	Urban Water Management Plan **FUTURE PREPARATION**

1.2 Key Documents and Previous Studies

This LWMS uses the following key documents to define its principles, criteria, objectives, and implementation responsibilities:

- Midland Brick District Water Management Strategy (Hyd2o, 2020a)
- Decision Process for Stormwater Management in WA (DWER, 2017)
- Planning for Land Use, Development and Permitting Affecting the Swan Canning Development Control Area (Department of Parks and Wildlife/Swan River Trust, 2016a)
- Planning for Stormwater Management Affecting the Swan Canning Development Control Area (Department of Parks and Wildlife/Swan River Trust, 2016b)
- Handbook of Stormwater Drainage Design, City of Swan (2012)
- Swan Canning Water Quality Improvement Plan (Swan River Trust 2009)
- Better Urban Water Management (WAPC, 2008)
- Stormwater Management Manual for WA (Department of Water, 2007)

2. Proposed Development

The proposed local structure plan is shown in Figure 2, providing a unique opportunity for urban infill in close proximity to the Midland town centre.

The LSP area covers approximately 10 ha. The concept layout consists of replacing existing industrial hardstand with residential lots, roads, and public open space, adjacent to existing developed areas of Viveash, Jack Williamson Park, and the Blackadder Creek Tributary.

From a stormwater management perspective, the development will seek to provide improvements in local water management and interaction with adjacent watercourses and seek to improve existing water quality management outcomes as the area transitions from its current industrial use.

3. Existing Environment

3.1 Site Conditions

The 10 ha LSP area is located in the suburb of Middle Swan in the City of Swan.

The Midland Brick site in which the LSP area is located is bound to the north by Reid Hwy, to the west by the Swan River, to the south and east by existing urban development and Eveline Reserve (Figure 1). It has been used for brick making purposes since 1946 and is currently operational and operates under a DWER Part V Licence.

The LSP area is currently utilised by Midland Brick for brick storage and contains some sedimentation storage ponds. Topography across the LSP area varies between 6 mAHD and 16 mAHD. The area has been modified for industrial use to have flat areas at 9 mAHD for brick storage, falling to 6 mAHD in some storage areas. Bunds to heights of 16 mAHD are adjacent to external development along the western and southern boundaries.

Figure 3 shows an aerial photograph with existing land use and topography.

3.2 Geotechnical

According to the Perth Metropolitan Region 1:50 000 Environmental Geology Series Perth Sheet 2034 II and Part of 2034 III and 2134 III, the LSP area is characterised by Pebbly Silt (Mgs1) (Gozzard, 1986). The Pebbly Silt is described as strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weather granite pebble, some fine to medium grained quartz sand of alluvial origin.

A geotechnical investigation for the wider Midland Brick site was undertaken by Douglas Partners in June 2019. The geotechnical report is included as Appendix B. This investigation included excavation of 11 test pits and 8 cone penetration tests. A dynamic cone penetrometer (DCP) test was also undertaken at each test pit location.

Test locations within the LSP area are shown on Figure 4. The encountered ground conditions at the test locations generally comprised uncontrolled fill, generally clayey although some granular fill was also encountered, overlying variable, though generally clayey, natural soils. The typical soil profile as described by Douglas Partners (2019) is as follows:

- ***Clayey Fill (Sandy Clay, Clayey Sand, Gravelly Clay, Clayey Gravel, Clay, Bricks and Sand with Clay)*** *– generally stiff to hard, encountered at all test pit locations, generally forming most of the encountered fill depth. Loose silty or clayey gravel, inferred as possible fill, was encountered between depths of 1.5 m and 4.0 m at test location 7. Firm to very stiff clay fill was encountered to a depth of approximately 5.5 m at test location 6. The clayey fill general contained brick fragments and/or bricks, and occasionally fragments of plastic, rubber, wood, wire, fabric, carpet and concrete.*
- ***Granular Fill (Sand, Gravelly Sand, Sandy Gravel)*** *– generally medium dense to very dense, granular fill, generally encountered from the surface to depths of less than 0.5 m. Granular fill (i.e. fill with no clay content) was encountered at test pit locations 11, 12, 13, 15, 16 and 17 and cone penetration locations 2 and 3. A granular fill layer was encountered at test location 13, underlying clayey fill from a depth of approximately 0.4 m to the termination depth of the test pit at 1.6 m. The fill generally contained brick*

fragments and/or unbroken bricks. Inferred granular fill or disturbed ground was encountered to a depth of approximately 9.8 m at test location 3, with loose silty sand being encountered between depths of approximately 3.0 m and 8.0 m.

- *Natural Soils – generally clayey soils from the Guildford Formation, including:*
  - ***Clayey Sand** – hard / very dense orange-brown mottled red-brown and grey, fine to medium grained clayey sand, encountered underlying the fill from a depth of 0.75 m at test location 11. Sand with sand clay was encountered from the surface at test location 5.*
  - ***Clay** – stiff to hard clay, encountered underlying the fill from a depth of approximately 0.75 m at test location 14 and cone penetration test locations 1, 3, and 6.*
  - ***Sand and Silty Sand** – generally medium dense to dense, orange-brown fine to medium grained sand, sometimes with clay, encountered underlying the clayey sand at test pit location 11 and cone penetration test location 5*

Groundwater was not observed in any test pit locations on 24 June 2019 however groundwater was measured within some of the cone penetration test locations at levels ranging between -1.3 mAHD and 2.9 mAHD (interpolated levels only, not surveyed).

3.2.1 Acid Sulphate Soils

Acid Sulphate Soil (ASS) is the common name given to naturally occurring soil and sediment containing iron sulfides. These naturally occurring iron sulfides are generally found in a layer of waterlogged soil or sediment and are benign in their natural state. When disturbed and exposed to air, however, they oxidise and produce sulfuric acid, iron precipitates, and concentrations of dissolved heavy metals such as aluminium, iron and arsenic. Release of acid and metals as a result of the disturbance of ASS can cause significant harm to the environment and infrastructure.

WAPC's Bulletin 64 (WAPC, 2003) ASS risk mapping indicates that the LSP area is classified as no known risk (Figure 4).

3.2.2 Contaminated Sites

Contaminated site investigations have been undertaken over part of the Midland Brick site due to localised areas of elevated petroleum hydrocarbon concentrations in soil and water in several isolated areas. Remediation will be required for residential land use in these areas and are likely to include the excavation and treatment of affected soils and groundwater remediation. These areas will be remediated prior to any subdivision application being made, consistent with Contaminated Sites Act (2003) processes.

3.3 Wetlands and Waterways

The LSP area contains no mapped wetlands.

The Midland Brick site is however located adjacent to the Swan River and associated Swan River Regional Park. The Swan River is classified as a conservation category wetland as shown in Figure 5.

The foreshore area adjacent to the Midland Brick site is largely occupied by the brickworks with industrial development abutting the banks of the river. The banks are relatively steep and vegetated, and act as a bund to protect the brickworks from flooding during major events in the Swan River. It is not clear if the bunds were constructed for such purposes or represent a remnant outcome of site excavation over time (or combination of both).

On the western side of the Midland Brick site there is an established foreshore reserve adjacent to the Swan River. A foreshore area study has recently been undertaken by Emerge Associates including an assessment of biophysical characteristics for the portion of the Midland Brick site adjacent to the Swan River to guide future planning of that area.

A tributary of Blackadder Creek which flows into a piped drainage system downstream of Muriel St is located to the south east of the LSP area.

This tributary is located in a public reserve fully outside of the LSP area, and is under management of the City of Swan. This tributary currently receives flow from the LSP area near its southern end at Muriel St. These flows are quantified and described in further detail in Section 4.

A biophysical assessment of the tributary in proximity to the LSP area conducted by Emerge Associates is contained as Appendix C and summarised in Section 3.3.1 below.

3.3.1 Blackadder Creek Tributary Biophysical Assessment

A biophysical assessment of the Blackadder Creek Tributary was undertaken by Emerge Associates to determine the location and extent of any required foreshore area to protect the waterway adjacent to the LSP area from potential development impacts, with outcomes used to inform the development of the LSP.

Biophysical criteria were considered against known existing environmental conditions including observations and data from on-site assessments. On site assessment included a detailed flora and vegetation assessment in 2019 and a basic fauna and targeted black cockatoo assessment for the LSP area in 2019 and 2021. Emerge Associates undertook additional vegetation survey of the public reserve within which the Blackadder Creek tributary is situated to inform this biophysical assessment in Spring 2022.

A copy of the biophysical assessment is contained as Appendix C. In relation to key biophysical considerations for the Blackadder Creek tributary the assessment found:

- There is no riparian vegetation or riparian wetlands that extend into the LSP area.
- The 1% AEP floodplain for the Blackadder Creek tributary does not extend into the LSP area.
- The landform and soils within the LSP area have been substantially modified associated with historic industrial uses associated with the operation of the brickworks
- The closest the Blackadder Creek tributary is situated to the LSP area is 43 m and ranges up to 91 m at the south-eastern boundary.
- The Blackadder Creek tributary is located in a vegetated corridor that provides separation from the LSP area and the proposed change in land use.

- Redevelopment of the LSP area provides opportunities to improve the existing interface and relationship with the Blackadder Creek tributary from an existing operational industrial site.

The assessment found the proposed LSP does not pose any risk of impacts to the Blackadder Creek tributary, and that based on existing and available information there is an adequate setback given the relevant biophysical considerations, including the presence of confirmed Threatened Ecological Community (TEC) occurrences outside of the LSP area. Further discussion regarding the TEC is contained in Sections 3.3.2 and Section 6.4.

The biophysical assessment proposed the following to define the foreshore area required to protect the tributary:

- The foreshore should include the full extent of the land included in the public reserve that includes the Blackadder Creek tributary.
- The foreshore area will include the outermost extent of 1% AEP flooding.
- Given the proposed public road reserve and public open space interface within the proposed LSP, there is no requirement for additional management interfaces or separations to the existing public reserve.
- Stormwater flows from the LSP area should be managed (in terms of location, rates and volumes) to take into consideration the location of known TEC occurrences.
- The public reserve incorporating the Blackadder Creek tributary should be managed so as to maintain and ideally enhance waterway, vegetation and fauna habitat values, and to ensure that the implementation of the LSP does not require any impact to the public reserve (including for stormwater conveyance and bushfire management purposes).

3.3.2 Threatened Ecological Community Assessment

Vegetation surveys undertaken within the LSP area have found there are limited flora and vegetation values that occur within the LSP area.

Vegetation survey of the public reserve surrounding the Blackadder Creek tributary has indicated that a number of TECs occur within the public reserve.

The extent of the mapped TECs in proximity to the LSP area is shown in Figure 6.

No TEC occurs in the LSP area, with the majority of the identified TEC occurrences located on the southern side of the Blackadder Creek tributary, the opposite side to the LSP area.

A hydrological assessment of the TECs relationship with the Blackadder Creek Tributary and discharges from the LSP area is provided in Section 6.4

3.4 Surface Water

3.4.1 Swan River & Blackadder Creek Tributary Flood Levels

The Swan River 1% Annual Exceedance Probability (AEP) levels adjacent to Midland Brick range from 5.7 mAHD near the downstream boundary to 6.0 mAHD at the northern boundary (Table 2 and Appendix D). These levels have been recently updated by DWER based on an updated flood study of the Swan River (BMT WBM Pty Ltd, 2017). These levels supersede previous estimates and are approximately 1m lower than those of the previous 1985 flood study.

The Midland Brick site is predominately located outside the 1% AEP floodplain of the Swan River with only a minor area (outside the LSP area) classified as floodway and flood fringe.

The time of concentration for peak flows in the River is very different to that of the local catchment and not coincident. This suggests non-attenuated rather than attenuated flows from the Midland Brick site during major events to be beneficial from a flood management perspective.

Development that is located in the floodway and is considered obstructive to major flows is not permitted, and no new buildings are considered acceptable within the floodway. Proposed development that is located outside of the floodway is considered acceptable with respect to major flooding. However, a minimum habitable floor level of 0.5 m above the appropriate 1 % AEP flood level is recommended to ensure adequate flood protection.

With respect to the Blackadder Creek Tributary, the 1% AEP level is also shown in Table 2 and Appendix D. The 1% AEP level value at the confluence of the Blackadder Creek and the Blackadder Creek Tributary near the LSP area is shown as 5.46 mAHD.

Table 2: Watercourse Flood Levels

Watercourse	Location	1% AEP Flood Level (mAHD)
Swan River	Downstream near Bernley Drive and Colyton St intersection	5.7 mAHD
Swan River	Upstream of Midland Brick near Reid Hwy	6.0 mAHD
Blackadder Creek	At confluence of Blackadder Creek Tributary	5.46 mAHD

3.4.2 Existing Stormwater Management for Midland Brick site

The Midland Brick site has no specific Environmental Protection Act licence conditions for water control, however objectives for stormwater management are detailed in Boral (2011) and Hyd2o (2021) as follows:

- All industrial surface runoff water is to be treated in an appropriate manner prior to discharge to the Swan River.
- Maximise the storage and reuse of industrial surface runoff water for dust suppression and industrial purposes on site.
- Freshwater runoff may be discharged from site without further treatment if it is segregated from other site water management.

Figure 7 details a map of the key existing stormwater infrastructure and system of the Midland Brock site in the proximity of the LSP area, with plates of key locations shown in Appendix E. A plan showing the wider Midland Brick site stormwater management system reproduced from the DWMS is contained in Appendix D. The function of the existing Midland Brick stormwater management system is summarised as follows:

- The site lies between two watercourses which receive stormwater runoff from the site; the Swan River to the north and a tributary of Blackadder Creek to the south.
- Due to clay soils onsite infiltration is limited and stormwater is managed through offsite discharge. The current stormwater system on site comprises of various storage ponds for attenuation and settlement of stormwater and a series of outlets to the Swan River and Blackadder Creek tributary. In general terms, for the majority of the site minor event flows are discharged to the Blackadder Creek tributary, while more major events have an outlet to the Swan River.
- The majority of stormwater from the site flows to an existing sump located abutting Kiln 8 (herein called the main site pump), where it is then pumped to the northern storage ponds in the north west of the site. Hyd2o understand this pumped system was installed in approximately 2000 to divert flows from the site to the Blackadder Creek Tributary and prior to this flows from the site discharged to the Swan River. Pump capacities as reported in SKM (2003) are 170 l/s for the main electric pump and 125 l/s for the diesel pump.
- This water then flows south along the western boundary of the site before entering a further series of storages (southern storage ponds) and discharging to the Blackadder Creek Tributary.
- Flows from the Clay Shed roof area represent a separate stormwater system which discharge into a storage area to the south of the Clay Shed and then into the top of the Blackadder Creek tributary.

The total catchment draining to the Swan River and Blackadder Creek Tributary in this area is estimated to be 116.6 ha. Subcatchments are shown in Figure 7 and Appendix E and were mapped based on site inspections, Boral (2011) and available pipe survey data. This includes an external local authority catchment of approximately 16 ha associated with Great Northern Hwy, Richardson Rd, and Leslie Rd which drains into and is managed within the Midland Brick site.

With respect to the Clay Basin, the total catchment draining to basin is estimated to be 31.7 ha, with an estimated equivalent impervious area (EIA) of 19.5 ha during major events. The external local authority catchment contributing flow to the Clay Basin is 10.7 ha (EIA 6.4 ha) and is estimated to contribute 33% of the runoff which currently flows to this storage.

3.4.3 Modelling of Existing System

Stormwater modelling for the existing system using XP-Storm has been reported in detail in a range of various documents prepared by Hyd2o including the following:

- Midland Brick, Middle Swan District Water Management Strategy (Hyd2o, 2020a)
- Midland Brick, Middle Swan Brickworks Kiln 10 Hardstand Expansion Stormwater Management: Updated Report (Hyd2o, 2020b).
- Midland Brick, Middle Swan Local Water Management Strategy Bridging Document, (Hyd2o, 2020c).

- Midland Brick, Middle Swan Brickworks: Southern Replacement Storage Design (Hyd2o (2020d)
- Midland Brick, Middle Swan Brickworks: Masonry Site Stormwater Management, (Hyd2o, 2020e)
- Cranwood Crescent Viveash Stages 1a & 1b Urban Water Management Plan (Hyd2o, 2020f)

Key modelling outcomes and extracts from these studies used to inform this LWMS are contained in Appendix E, with design flows at key locations within the Midland Brick site summarised in Table 3. Note that recent updates to Australian Rainfall and Runoff (Ball et al, 2016) have resulted in changes in terminology being recommended to describe design rainfalls. Annual Exceedance Probability (AEP, %) terminology has therefore been adopted to replace Average Rainfall Interval (ARI) terminology in this report as follows:

- Frequent Events : previously 1 Year ARI, replaced with 63% AEP
- Minor Events : previously 5 Year ARI, replaced with 20% AEP
- Major Events : previously 100 Year ARI, replaced with 1% AEP

Table 3: Existing Midland Brick Site Stormwater Management Flow Summary

Location	Flows (m^3/s)		
	63% AEP	20% AEP	1% AEP
Clay Basin	0.05	0.06	0.07
Swan River Outflow	-	0.08	0.27
Blackadder Creek Tributary at Southern Outlet	0.20	0.21	0.26
Clay Shed Flow	0.33	0.53	1.02
Flow in Blackadder Creek Tributary at Eveline St	0.19	0.24	0.27
Blackadder Creek Tributary at Muriel St culvert	0.28	0.45	0.67

3.4.4 Surface Water Quality

Hyd2o undertook a pre development surface water quality monitoring program over the wider Midland Brick site from September 2019 to September 2020. Sampling locations are shown in Appendix F. This program was supplemented by data previously collected by Midland Brick as part of broader environmental monitoring within the site over a 15 year period.

Parameters analysed for this LWMS include physical parameters (temperature, electrical conductivity, pH, and turbidity), nutrients, and metals. Surface water quality results are summarised in Table 4 for physical parameters and nutrients compared to ANZECC (2000) guideline trigger values for freshwater lowland river ecosystems and the Swan River Trust's Swan Canning Water Quality Improvement Plan (2009) long term targets.

Full results are contained in Appendix F for locations considered relevant to the LSP area, including metals. Key results are summarised as follows:

- Mean pH at all sites are within the ANZECC guideline range (6.5 – 8) except for the Clay Basin where the mean pH (8.31) was marginally higher than the upper limit.
- Mean EC (µS/cm) at the Swan River downstream site was higher (15455 µS/cm) than at the upstream site (14012 µS/cm). Swan River sites were well outside the ANZECC guideline range (120 - 300 µS/cm) but this is typical of the Upper Swan Catchment of the Swan-Canning River system (DoW, 2009). Mean EC (µS/cm) at the locations within the Midland Brick site were well below the levels within the Swan River but outside the ANZECC guideline range.
- Mean TN at Swan River sites were slightly higher downstream (1.31 mg/L) than upstream (1.24 mg/L), and both locations were only marginally above the ANZECC guideline value of 1.2 mg/L and the SCWQIP long term target of 1.0 mg/L. Mean TN at the monitoring locations within the Midland Brick site were all within the ANZECC guideline value and long term SCWQIP target.
- Mean TP at Swan River sites were slightly higher downstream (0.09 mg/L) than upstream (0.08 mg/L), and both were slightly above the ANZECC guideline value of 0.065 mg/L but were both consistent with the SCWQIP long term target of 0.1 mg/L. Mean TP at the monitoring locations within the Midland Brick site were all within the ANZECC guideline value and long term SCWQIP target.

With respect to metals, mean results were as follows relative to ANZECC guideline values:

- Arsenic was within the 95% protection limit for all sites.
- Cadmium was outside the 80% protection limit for all sites except SW4 (Site Outlet) and SW5 (Blackadder Creek Tributary at Muriel) which are within the 95% protection limit.
- Chromium was within the 80% protection limit for all sites.
- Copper was outside the 80% protection limit at all sites, except SW4 (Site Outlet), which was within the 99% protection limit.
- Lead was within the 80% protection limit for all sites, except SW10 (Southern Storage) which was outside the 80% protection limit.
- Nickel was within the 95% protection limit for all sites, except SW10 (Southern Storage) which was outside the 80% protection limit.
- Zinc was within the 80% protection limit for all sites, except SW5 (Blackadder Creek Tributary at Muriel) and SW10 (Southern Storage) which were outside the 80% protection limit.
- Mercury was within the 95% protection limit for all sites, except SW6 (Clay Basin) which fell within the 90% protection limit.

Table 4: Existing Surface Water Quality

	Mean of Parameter Values							
Parameter	Swan River Upstrm	Swan River Dnstrm	Clay Basin	Southern Storage Area	Site Outlet	Blackadder Trib @ Muriel	ANZECC	Long term SCWQIP
EC	14012	15455	718	384	516	1170	120-300	-
pH	7.56	7.52	8.31	7.70	7.30	7.59	6.5-8.0	-
TN (mg/L)	1.24	1.31	0.72	0.70	0.50	2.40	1.2	1.0
Ammonia (mg/L)	0.12	0.13	0.05	0.05	0.01	0.01	0.32 – 2.3 (99% - 80%)	-
TP (mg/L)	0.08	0.09	0.03	0.04	0.05	0.05	0.065	0.1
FRP (mg/L)	0.02	0.03	0.00	0.00	0.01	0.01	0.04	-
Nitrate (mg/L)	0.43	0.48	0.17	0.59	0.01	2.30	0.017 – 17 (99% - 80%)	-
Nitrite (mg/L)	0.05	0.06	0.03	0.05	0.01	0.01	-	-

3.4.5 Additional Surface Water Monitoring 2021

Hyd2o undertook further surface water quality monitoring at selected sites in 2021 to reflect water quality during a transitional period following recent changes to the site, including creation of the southern storages and re-configuration of the Clay Basin.

Sites monitoring during this period included SW3 (Blackadder Tributary at Eveline St), SW6 (Clay Basin) and SW15 (Site Inlet from Great Northern Highway). Sampling locations are shown in Appendix F.

Parameters analysed included those measured in the predevelopment monitoring program (EC, pH, turbidity, nutrients, and metals) with additional analysis conducted for total recoverable hydrocarbons (TRH's) at the Clay Basin.

Surface water quality results are summarised in Table 5 for physical parameters and nutrients compared to ANZECC (2000) guideline trigger values for freshwater lowland river ecosystems and the Swan River Trust's Swan Canning Water Quality Improvement Plan (2009) long term targets.

Full results are contained in Appendix F, including metals and TRH's. Key results are summarised as follows:

- Mean pH at all sites were within the ANZECC guideline range (6.5 – 8).
- Mean EC (µS/cm) at all sites were within the ANZECC guideline range (120 - 300 µS/cm).
- Mean TN at all sites were within the ANZECC guideline value of 1.2 mg/L and the SCWQIP long term target of 1.0 mg/L.

- Mean TP at all sites were within the ANZECC guideline value of 0.065 mg/L and the SCWQIP long term target of 0.1 mg/L.

With respect to metals, mean results were as follows relative to ANZECC guideline values:

- Arsenic, Lead, Nickel and Mercury were within the 99% protection limit for all sites.
- Cadmium and Chromium were within the 95% protection limit for all sites.
- Copper was within the 80% protection limit at all sites, with SW3 (Blackadder Tributary at Eveline St) also within the 90% limit.
- Zinc was outside the 80% protection limit for all sites, with the exception of the SW6 (Clay Basin) which was within the 80% protection.

TPH's were below the detectable limit at SW6 (Clay Basin) on all three monitoring occasions.

While water quality generally aligned well with guideline values across the sites, water quality within the Midland Brick site (SW3 and SW6) was better in comparison to that entering the site (SW15).

In particular water quality within the Clay Basin has considerably improved from previous monitoring prior to its redevelopment. Water quality within and entering the Midland Brick site (SW3 and SW6) was notably better than water quality in the Swan River.

Table 5: Surface Water Monitoring 2021

Mean of Parameter Values					
Parameter	**Blackadder Tributary @ Eveline**	**Clay Basin**	**Site Inlet @ Swan Offices**	**ANZECC**	**Long term SCWQIP targets**
EC (µS/cm)	145	220	300	120-300	-
pH	6.80	7.73	7.45	6.5-8.0	-
TN (mg/L)	0.85	0.43	1.05	1.2	1.0
Ammonia (mg/L)	0.03	0.01	0.01	0.32 – 2.3 (99% - 80%)	-
TP (mg/L)	0.06	0.05	0.05	0.065	0.1
FRP (mg/L)	0.01	0.01	0.01	0.04	-
Nitrate (mg/L)	0.01	0.02	0.50	0.017 – 17 (99% - 80%)	-
Nitrite (mg/L)	0.01	0.01	0.01	-	-

3.5 Groundwater

3.5.1 Groundwater Levels

The Perth Groundwater Map (DWER, online) indicates the superficial aquifer base at the LSP area is approximately -20 mAHD and has a saturated thickness of approximately 21 m.

Groundwater levels in the Perth Groundwater Map are representative of typical end of summer groundwater levels and estimate groundwater levels of less than 1 mAHD for the LSP area, with groundwater flow in an easterly direction towards the Swan River.

Emerge Associates installed 10 groundwater monitoring bores within the wider Midland Brick site on 20 August, 2018. Lithological logs for the two bores in proximity to LSP area are included as Appendix G.

Water levels in all bores were measured monthly from Sept 2018 to Feb 2019 with further monitoring over 2 winters then undertaken by Hyd2o from September 2019.

The estimated average annual maximum groundwater levels (AAMGL) across the Midland Brick site are shown in Figure 8 based on this data. Hyd2o have calculated the AAMGL by adjusting levels at the bores based on the recorded level in DWER bores MM38 and GD8 referenced to their long term historical data (Table 5). DWER bores MM38 and GD8 long-term hydrographs are provided in Appendix H. The data considered for the calculation is from the year 2000, which is considered representative of current climate conditions

The AAMGL and MGL for each groundwater bore based on this analysis is shown in Table 6. Perching of groundwater appears to be occurring at some bores due to their proximity to existing stormwater storage areas.

For the LSP area, the mapping indicates an AAMGL of approximately 2 mAHD in this area.

It is important to note this LWMS only uses the terminology AAMGL to represent a valid statistical property of groundwater in the area, and not as a concept as per previous DWER policies. This LWMS presents details of the groundwater's seasonal variation, AAMGL, and MGL all as measures of its seasonal, annual, and interannual behaviour. Simply presenting an MGL is not considered adequate to represent the groundwater characteristics and behaviour of a site.

Table 5: AAMGL and MGL for DWER Bores

Bore	Period of Record	Groundwater Level (mAHD) 21/10/2019	AAMGL 2000-2020 (mAHD)	Correction Factor (m)	MGL (mAHD)	Correction Factor (m)
MM38	1974 – 2020	20.23	20.29	+0.06	20.64	+0.41
GD8	1978-2020	4.01	4.07	+0.06	4.94	+0.94
Correction Factors for Midland Brick Site Bores				+0.06		+0.67

Table 6: AAMGL and MGL for Midland Brick Site Bores

Bore	Natural Surface (mAHD)	AAMGL (mAHD)	MGL (mAHD)	Depth to AAMGL Below Natural Surface (m)
EMW01	5.60	0.67	1.28	4.93
EMW02	9.55	1.26	1.87	8.29
EMW03	10.82	1.42	2.03	9.40
EMW04	9.29	2.14	2.75	7.15
EMW05	10.96	7.38*	7.99	3.58*
EMW06	5.57	4.09	4.70	1.48
EMW07	8.37	6.36	6.97	2.01
EMW08	8.58	3.30	3.91	5.28
EMW09	7.00	1.76	2.37	5.24
EMW10	10.35	5.86	6.47	4.49

- EMW05 calculated AAMGL level above considered to be possibly perched due to comparison which other previously installed and monitored bores in close proximity to this area. Possibly due to stormwater ponding in the area behind the Clay Shed.

3.5.2 Groundwater Quality

Groundwater quality was monitored at the 10 groundwater bores by Emerge on a single occasion in September 2018 and by Hyd2o quarterly from September 2019 to September 2020. Groundwater bore locations are shown in Figure 8 and Appendix F.

Physical parameters (temperature, electrical conductivity, and pH) were measured in situ. Samples were sent to the NATA approved MPL Laboratory for total nitrogen, ammonia, nitrate, nitrite, total phosphorus, filterable reactive phosphorus, and heavy metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury, and zinc).

Groundwater water quality results for the two bores within the LSP area are outlined in Table 7 compared to ANZECC (2000) guideline trigger values for freshwater lowland river ecosystems. Full results are contained in Appendix F. Results are summarised as follows:

- Mean pH ranged from 6.61 to 6.74, within the ANZECC guideline range.
- Mean EC ranged from 668 µs/cm to 1896 µs/cm across all groundwater samples, above the ANZECC guideline range for freshwater, indicating that the groundwater is fresh to marginal.
- Mean values for total nitrogen (TN) ranged from 0.82 mg/L to 1.20 mg/L, at or below the ANZECC guideline value of 1.2 mg/L.
- Mean total phosphorous ranged from 0.53 mg/L to 0.60 mg/L across all bores, above the ANZECC guideline value of 0.065 mg/L.

With respect to metals, mean results were as follows relative to ANZECC guideline values:

- Arsenic, Lead, and Nickel were within the 99% protection limit.
- Cadmium, Chromium, and Mercury were within the 95% protection limit.
- Copper was within the 95% protection limit at EMW3, but outside 80% at EMW4.
- Zinc was within the 90% protection limit.

- **Table 7: Existing Groundwater Quality**

Groundwater Bore	Parameters							
	EC (µS/cm)	pH	TN (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	TP (mg/L)	FRP (mg/L)
ANZECC	120-300	6.5-8.0	1.2	0.32 – 2.3 (99% - 80% protection)	0.017 – 17 (99% - 80% protection)	-	0.065	0.04
EMW03	1896	6.74	1.20	0.03	0.01	0.01	0.60	0.15
EMW04	668	6.61	0.82	0.01	0.04	0.01	0.53	0.01

3.6 Constraints and Opportunities

Based on the LSP area existing environment, the following key constraints and opportunities are identified to guide the development of the water management strategy:

- The area is outside the floodplain of the Swan River and Blackadder Creek.
- There is good clearance to regional groundwater across the area.
- Underlying clay soils limit opportunities for stormwater management via infiltration.
- There are existing flow paths to the Blackadder Creek tributary.
- Re-development of the area provides opportunities to improve the existing interface and relationship with the Blackadder Creek tributary.

4. Design Criteria & Objectives

Key design principles and criteria for the LSP area are shown in Table 8 and have been established consistent with the key reference documents previously detailed in Section 1.2, and reflect the site constraints and opportunities identified in Section 3.

These principles and criteria are used to formulate the water management strategy for the LSP area to remain within the identified constraints and opportunities of the existing environment.

Table 8: Design Principles & Criteria

Strategy Elements	Method & Approach
Water Use Sustainability	
Water Efficiency	• Water efficiency implementation to be consistent with Building Codes of Australia requirements. • Aim for less than 100 kL/person/year water use. • Establish "Waterwise" Public Open Space. • Maximise infiltration and reuse of stormwater .
Water Supply	• Minimise overall use of scheme water for non-drinking purposes • Water Corporation IWSS for lots plus use of rainwater tanks (non mandated). • Use of groundwater for POS irrigation.
Wastewater	• Water Corporation reticulated sewerage.
Stormwater	
Ecological Protection	• Stormwater design to manage small event discharge (63% AEP) to the Blackadder Creek Tributary at acceptable rates consistent with predevelopment flows (DWER, 2017) • Lot soakwells (15mm event infiltration on lot) to be used to maintain the overall required ecological water balance for receiving environments post development. • Establishment of biofiltration areas within POS for treatment of first 15mm road runoff and subsoil.
Serviceability	• Piped drainage system sized to convey 20% AEP event.
Flood Protection	• Establish minimum habitable floor levels at 0.5m above the 1% AEP flood level of the Swan River and Blackadder Creek. • Overland flow paths within road reserves for safe conveyance of flows exceeding pipe drainage system capacity • 1% average exceedance probability (AEP) events to be discharged offsite at acceptable rates consistent with downstream ecological and infrastructure constraints.
Groundwater	
Fill Requirement & Subsoil Drainage	• Development levels to establish an acceptable clearance to groundwater systems via the use of a combination of subsoil drainage and sand fill above less permeable soils.
Acid Sulphate Soils & Contamination	• No known risk of ASS.

5. Water Use Sustainability

5.1 Water Efficiency Measures

Development of the LSP area will lead to an increased demand of potable water for residential use as irrigation of gardens and POS areas. Water conservation measures will be implemented to reduce scheme water consumption within the development will be consistent with Water Corporation's "Waterwise" land development criteria including:

- Promotion of use of waterwise practices including water efficient fixtures and fittings (taps, showerheads, toilets, rainwater tanks, waterwise landscaping).
- All houses to be built to 6 star building standards (water efficient fixtures and fittings).
- Use of water wise plantings in POS areas.
- Maximising onsite retention and reuse of stormwater.
- Use of high density residential zoning to reduce garden (ex-house) use of water and minimise fertiliser nutrient inputs.

5.2 Water Supply

The Water Corporation's Integrated Water Supply System (IWSS) will supply potable water to future homes within the LSP area.

Rainwater tanks will not be implemented/mandated at estate scale to supplement the domestic water supply scheme. Residents who wish to supplement scheme water supply with rainwater tanks will be provided for by individual builders during the building application process.

The LSP area is located within the Perth (Superficial-Swan) Groundwater Management Area (GMA), Shire of Swan South groundwater sub area. DWER's online Water Register for Licence and Water Availability Information indicates that the superficial aquifer is fully allocated within this sub area. The deeper Leederville aquifer is also fully allocated.

With respect to construction water requirements, discussions with DWER's Swan Avon region indicate temporary licences are still issued in this groundwater sub area. To this end the developer has already acquired a groundwater licence of 30,000 kl/yr valid until May 2025 for dust suppression for earthworks and construction purposes (Appendix I).

With respect to POS irrigation, the extent of POS area within the LSP area is minor and a small volume of water will be required. Water is regularly available within this groundwater area for purchase and transfer within this subarea, and the developer is currently negotiating opportunities for transfers. Obtaining POS water via licencing will be undertaken via a commercial transaction to facilitate development.

Upon handover of POS areas groundwater licences will be handed over to the City of Swan.

Landscape masterplanning prepared by Plan E is contained as Appendix J. Landscaping will be designed with recognition of the generally low availability of water in the area, with local species incorporated to minimise water use.

Preparation and agency approval of final landscape plans will be undertaken at UMWP stage based on final stormwater design requirements. The UWMP will also include detailed irrigation usage tables demonstrating water use and distribution at local scale.

Note the stormwater areas shown in Appendix J should be considered indicative only, with the final form of this area undertaken at UWMP stage based on refined stormwater modelling and landscape design.

5.3 Wastewater Management

Wastewater will be reticulated sewerage with management by the Water Corporation.

6. Stormwater Management Strategy

Stormwater management has been designed in accordance with Better Urban Water Management (WAPC, 2008), City of Swan's principles for water quality and quantity management, DBCA and DWER requirements, Stormwater Management Manual for Western Australia (DoW, 2007), and overarching DWMS (Hyd2o,2020).

Post development, annual stormwater discharge volumes and peak flows are typically required to be maintained relative to pre development conditions and water quality maintained and/or improved with the aim of maintaining and restoring ecological systems. These principles are the key guiding principles applied to the Blackadder Creek tributary to maintain its existing hydrology.

A summary of the overarching ultimate stormwater management strategy for the Midland Brick site as modelled and detailed in Hyd2o (2020a) is provided as Appendix K. Key elements of the proposed stormwater management system to facilitate the land use change for Area 3 are shown in Figure 9, with the aim of providing stormwater quantity and quality management, and staged land use transition.

In broad terms the system will comprise the following:

- For Blackadder Creek tributary, the stormwater management area will be required to provide stormwater storage to attenuate flows to existing levels for events up to the 1% AEP. This storage area will be integrated within the landscaped POS, with opportunities for smaller scale distributed storage considered at UWMP stage.
- For the existing brickworks site and its external contributing local authority catchment, the strategy will be to continue to provide a functioning stormwater management system in accordance with existing environmental requirements. This will require the continued use of a pumped stormwater management system. Additional staging works will be required in due course, including relocation of the existing southern storage area once development proceeds.

Staging of stormwater works will be required to maintain a functioning stormwater management system for the existing brickworks and external council drainage system which drains into Midland Brick throughout the development transition period.

Staging details will be appropriately documented in the UWMP.

6.1 Stormwater Event Modelling

Post development stormwater modelling for the LSP area was performed using XP-Storm.

Post development catchment areas and runoff rates are detailed in Appendix L. Runoff coefficients adopted for modelling purposes for various events and durations were calculated in detail using Hyd2o's CURRV runoff rate estimator based on various individual land use characteristics. Lots are proposed to infiltrate stormwater runoff from constructed impervious surfaces via soakwells sized to retain the 15 mm rainfall event at source.

The LSP Area catchment is proposed to flow to a biofilter and flood storage area located in POS adjacent to Jack Williamson Oval. The design of this area has been undertaken based on ensuring the 1% AEP discharge from this area is similar to the existing flow from southern area which currently occurs. It is estimated the biofiltation area will be 760 m^2 in size at 0.3m depth to provide 227 m^3 of storage, while the1% AEP area will be 1688 m^2 (1186 m^3 volume).

The proposed stormwater management system post development is shown in Figure 10, showing catchment areas, flows paths, and key infrastructure details based on modelling outcomes using XP-Storm for various AEP events. Table 9 summarises the stormwater management sizing details for individual areas, with more detailed modelling results provided in Appendix M.

Note that the extent of inundation in the POS area shown in Figure 10 for various flood management events are shown to scale. The storage shapes however should be considered indicative only for determination of area requirements and as a representation of storage areas required in relation to POS areas allocated in the concept layout.

The final flood attenuation area configuration (side slopes etc), locations, and elevations will be documented in future UWMPs and will be dependent on final earthworks, drainage, and road design levels for the development. Minor refinements to catchment areas shown in this report are considered likely to occur as detailed design proceeds, and stormwater modelling will be updated accordingly during the UWMP process.

The maximum water depth for the flood attenuation area for the 1% AEP event is proposed to be only 0.8m above the 0.,3m deep biofilter (1.1m total), with shallow batters being adopted in design to integrate with the wider POS area. The biofilter is proposed to be nested within the flood storage area to reduce the overall footprint of stormwater within the POS area and increase overall amenity/useability. Detailed landscape design of POS areas will be undertaken as part of the UWMP to achieve aesthetic and useability outcomes and will be negotiated with various agencies to suitably integrate with the surrounding environment.

Note that opportunities for further distribution of stormwater storage to reduce downstream POS stormwater requirements will be undertaken at UWMP stage as more detailed civil engineering is progressed. Key areas for these opportunities include the road reserve adjacent to Jack Williamson Oval and downstream of the proposed stormwater storage area. Th use of tree pits and bottomless manholes will also be included at UWMP stage to further disaggregate flows within the site.

Based on modelling refinements as detailed design proceeds, outlet structures will be modified at UWMP stage to refine outflows and meet predevelopment flow rates for various AEP events.

Table 9: Area 3 Stormwater Management

Catchment	Area 3 Catchment D	Stage 2 Catchment F
Lots (ha)	4.91	2.64
POS (ha)	0.23	0.46
Road Reserve (ha)	2.39	1.87
Total Area (ha)	7.54	4.97
Equivalent Impervious Area (15mm event) ha to Area 3 Basin (no Catchment F contribution)	1.51	
Equivalent Impervious Area (20% &1% AEP) ha To Area 3 Basin (with Catchment F contribution)	6.71	
Storage Characteristics		
Side Slopes (v:h) Biofilter Flood Storage	 0 6	
System Component and Design Approach	Biofilter and flood storage in POS discharge to Blackadder Creek Tributary	
Water Quality (15 mm Event) & Ecological Protection (63% AEP)		
Invert (mAHD)	7.1	
Flood Rise (m)	0.3	
TWL (mAHD)	7.4	
Volume (m^3)	227	
TWL Area (m^2)	760	
63% AEP Event Discharge (l/s)	0.16 (3 hr critical)	
Flood Storage: 20% AEP Event		
Invert (mAHD)	7.1	
Flood Rise (m)	0.57	
TWL (mAHD)	7.67	
Volume (m^3)	468	
TWL Area (m^2)	1056	
Flood Storage: 1% AEP Event		
Flood Rise (m)	1.10	
TWL (mAHD)	8.20	
Volume (m^3)	1186	
TWL Area (m^2)	1688	

6.2 Ecological Protection

This LWMS proposes a treatment train approach to water quality management which includes non- structural as well as structural controls:

- **Non-Structural Controls**
  Planning: POS location, lot product and subdivision layout.
  Maintenance: regular stormwater system maintenance including POS biofilter area.
  Monitoring: Post development program and performance review.
- **Structural Controls**
  Catchment Scale Infrastructure: bioretention in POS, integration with living streams.
  Local Scale Infrastructure: soakwells, GPT's.
  Landscape: Native plantings, integration of POS and downstream environment

Measures adopted represent known best management practice as detailed in the Stormwater Management Manual for Western Australia (DoW, 2007). Table 10 details a summary from the Stormwater Management Manual for Western Australia (DoW, 2007) of expected pollutant removal efficiencies for various WSUD measures in relation to water quality design criteria.

While DoW (2007) does not provide expected pollutant removal efficiencies for all BMP's, application of a treatment train approach using a combination of the non-structural and structural measures will therefore clearly achieve the design objectives for water quality as detailed in Better Urban Water Management (WAPC, 2008).

Stormwater volumes for ecological protection based on water quality treatment of the 15mm event are provided in Table 9 and Figure 10. The total area required is approximately 0.076ha. This provides approximately 227 m^3 of storage at 0.3 m depth.

For the critical duration 63% AEP event, discharge to Blackadder Creek Tributary will be xx l/s, consistent with predevelopment flows.

Figure 11 provides an indicative cross section of the POS biofilter. Biofiltration systems will be designed at the UWMP stage consistent with the Adoption Guidelines for Stormwater Biofiltration Systems (CRC for Water Sensitive Cities, 2015).

Table 10: BMP Water Quality Performance In Relation to Design Criteria

Parameter	Design Criteria via (WAPC, 2008) (required removal as compared to a development with no WSUD)	Structural Controls Nutrient Output Reduction [1]	
		Vegetated Swales/ Bioretention Systems	Detention/ Retention Storages
Total Suspended Solids	80%	60-80%	65-99%
Total Phosphorus	60%	30-50%	40-80%
Total Nitrogen	45%	25-40%	50-70%
Gross Pollutants	70%	-	>90%

1. Typical Performance Efficiencies via DoW (2007)

6.3 Water Balance Modelling

An existing monthly water balance was established for the site and used to provide estimates of annual flows and water volume movements across the site at key locations.

Modelling results are presented in Appendix N. These estimates are based on the original water balance model developed and reported in the DWMS (Hyd2o, 2020a), with some further refinements based on an improved calibration using Landgate's Map Viewer historical site photographs showing water inundation timeframes in various storages.

The water balance modelling estimated that prior to the recent changes to water management at the site (clay basin changes, and new southern storage construction) on average 172,000 kL/yr of water was lost from the site due to evaporation and other infiltration losses. These losses occurred at the existing open water storages on site, including approximately 78,000 kL/yr at the Clay Basin alone, and equated to approximately 56 % of the water from the catchments contributing flow within the site.

Based on the proposed post development stormwater management system, the site's existing system monthly water balance model was refined and used to model the post development case. This model provided estimates of post development annual and seasonal flows and water volume movements across the site at key locations. Modelling results are summarised in Figure 12 compared to the existing site water balance, with more detailed extracts from the model contained in Appendix N.

The total flows considered in the predevelopment water balance model was 306,000 m^3/yr, and while a minor difference in the post development flows to the Blackadder Creek Tributary is reported (4,000 m^3/yr) this difference is considered within the accuracy of the modelling, and effectively represents a similar pre to post development outcome. At the location of the 4000 m^3/yr change, this flow change represents a 3% predevelopment to post development flow difference, which is considerably less than existing interannual flow variability.

At detailed design phase, as part of an adaptive management approach, a flexible outlet arrangement (such as an adjustable orifice plate configuration) could be considered to provide flexibility to modify outflows to the receiving environment at this location.

The modelling shows that both the annual and monthly seasonal distribution of flow for the Blackadder Creek Tributary at Muriel St post development can be maintained similar to the existing condition. Further consultation with DBCA and DWER will be undertaken as planning for the site progresses to assess opportunities the development provides for enhancement of the Blackadder Creek tributary and its environment.

6.4 Assessment of Potential TEC Impact in Proximity to Site

As previously discussed in Section 3.3.2, no TEC occurs in the LSP area, with the majority of the identified TEC occurrences located on the southern side of the Blackadder Creek tributary, the opposite side to the LSP area.

Notwithstanding this, hydrological modelling of the relationship of the Blackadder Creek Tributary and LSP area discharge to the TEC was undertaken to assess any potential impacts or changes that may result due to the proposed LSP and its water management strategy.

In particular the assessment was focussed on the relationship between the LSP area discharge and potential inundation (or any change of inundation) of the TEC which may result due to land use change. Storms were modelled up to the 1% AEP event, and included consideration of flood levels and tailwater conditions which may result from Blackadder Creek flood levels during major events.

Modelling was performed using XP-Storm, with results shown on Figure 13 and more detailed modelling outputs contained in Appendix O. Results on Figure 13 show the extent of inundation within the Blackadder Creek Tributary adjacent to the LSP area and its relationship to the TEC.

Summarising the key findings of the modelling and assessment:

- The existing 375mm diameter outlet location from the site is proposed to be used post development for the LSP area. This location is shown on Figure 13. The principle of post development flows not exceeding pre-development flow rates up to the 1% AEP event has been applied to protect the downstream environments. Peak flow rates leaving the site at this location will therefore not change post development.
- Given the location of the outlet to the mapped TEC, any discharges from the LSP area can only potentially affect the most southern area of mapped TEC adjacent to Muriel St and the school. Upstream flows in the Blackadder Creek tributary do not change as a result of development within the LSP area, and its hydrology remains the same.
- The Muriel St culvert has a diameter of 900 mm (invert 4.27 mAHD). The capacity of this culvert far exceeds any existing and proposed flows from LSP area (0.36 m^3/s).
- Based on MNG LiDAR contours, the lowest elevation of the mapped TEC adjacent to the LSP area discharge point corresponds approximately with the 6.25 mAHD contour. This elevation is approximately 2m above the Muriel Rd culvert invert and similar to the lowest elevation of Muriel St in this location. This indicates that the TEC would only start to be inundated at this location once the water in the tributary reaches the elevation of the road.
- Modelling conducted for the 1% AEP event, confirms the TEC is located well outside the 1% AEP event inundation for the Blackadder Creek Tributary near the LSP area outlet. This modelling was performed considering both site flows (0.36 m^3/s) and flows from its upstream catchment (0.52 m^3/s).
- Further modelling was conducted to consider inundation areas should the 1% AEP event for the catchment be coincident with a 1% AEP event of the Swan River and Blackadder Creek. The results indicate that levels immediately upstream of Muriel St Creek would rise 0.12 m above the 5.46 mAHD Blackadder Creek tailwater condition and be 0.16m higher at the location of the LSP Area outflow (5.59m AHD). The extent of this inundation is shown in Figure 13. This level similarly would not inundate the TEC (6.25mAHD).
- Given the capacity of the 900mm diameter culverts at Muriel St relative to its catchment flows to this location, inundation of the TEC adjacent to the site outlet will not occur. Based on sensitive analysis, flows far in excess of current flows in the tributary (more than 3x larger) would be required before the TEC would be inundated at this location.

In summary the results show that the TEC in proximity to the proposed LSP area outlet is located well outside the area of inundation that would occur along the Blackadder Creek Tributary even during a 1% AEP event, and this status will not change following development within the LSP area.

Given the water management approach of maintaining flow rates at predevelopment levels, the areas of the inundation pre and flow development in this area will remain similar.

Similar investigations will be undertaken for TEC communities upstream of Area 3 in due course to support LSP planning and inform the development of future water management strategies of that area. A separate local structure plan and LWMS will be prepared for the area north-east of Eveline Road (referred to as Area 4) to address the management of that particular area.

7. Groundwater Management Strategy

7.1 Post Development Groundwater Levels

Development levels within the LSP area are not dominated by fill requirements to achieve adequate separation to regional groundwater, given the proximity of groundwater levels to natural surface.

Due to the underlying impermeable soils however, it is envisaged that subsoil drainage will be required within the development to control water rise within imported fill above less permeable soils. Subsoil drainage is a widely used practice across the Swan Coastal Plain.

7.2 Earthworks, Fill and Subsoil Drainage

Development will require the removal of all brick and clay stock, as well as the demolition of any existing structures, pavements and services. Site works will then generally comprise the clearing of existing vegetation (where necessary), stripping of topsoil, earthworking of the existing surface, compaction to areas of existing fill, and importing fill with a top sand layer to facilitate the proposed form of development.

The clayey subgrade surface will be earthworked and shaped, before the sand is placed, to ensure drainage of perched water. Following the subgrade works, a layer of clean sand fill will be imported and placed above the clayey material to achieve the proposed finished levels and desired site classification. The imported material used for sand fill will be a free draining clean sand material with a fines content less than 5% and permeability of greater than 5m/day.

Preliminary earthwork levels prepared by TABEC are detailed in Appendix P on the basis of the following considerations:

- Fill requirement to achieve the required site classification.
- The minimum level required to ensure adequate separation from perched groundwater within sand fill.
- Interfacing levels with the adjacent development and existing infrastructure.
- Ensuring finished floor levels for buildings are a minimum 500mm above estimated 1% AEP flood levels of adjacent watercourses.

These earthwork levels have informed the establishment of catchment boundaries for stormwater modelling previous detailed in the DMWS (Hyd2o, 2020a) and Section 6.

As previously discussed, development levels are generally not dominated by fill requirements to achieve adequate separation to regional groundwater, given the proximity of groundwater levels to natural surface. However, due to the underlying impermeable soils, it is envisaged that subsoil drainage will be required within the development to control the perching of groundwater from rainfall.

Subsoil drainage is proposed to be located within road reserves. All subsoil drainage will have free outfalls and discharge to the biofiltration area for treatment. Ongoing management of subsoil drainage will be required to ensure its ongoing performance in accordance with design.

Groundwater/subsoil modelling will be performed at the UWMP stage in accordance with the IPWEA (2016) Draft Specification on Separation Distances for Groundwater Controlled Urban Development. This guideline recommends the establishment of development levels on the basis of detailed modelling of subsoil drainage utilising a 30 year daily rainfall record obtained from DWER based on a future median rainfall scenario as outlined in Selection of Future Climate Projections for Western Australia (DoW, 2015).

IPWEA (2016) requires the provision of a minimum 0.3 m of coarse sand in the rear of lots above the 50% AEP phreatic surface for residential lots of size 400-800m^2, and a 0.15m clearance for lots <400 m^2. This criteria will be used as the initial basis for establishing fill requirements for the LSP area, in consultation with City of Swan.

Final design lot levels and fill specification are a detailed design issue to be addressed during the preparation of detailed engineering design drawings and preparation of the UWMP and will be ultimately submitted for council approval at that stage.

In situ permeability testing is recommended to be undertaken once the LSP area has been filled to confirm that permeability rates meet those used in detailed design. The testing will be detailed in the UWMP and undertaken by the developer in consultation with the City of Swan.

7.3 Acid Sulphate Soils

Acid sulphate soil mapping has been previously discussed in Section 3.2.1 as no known risk.

8. Urban Water Management Plans

Consistent with processes defined in WAPC (2008), Urban Water Management Plans (UWMPs) will be developed and submitted to support subdivision applications for various stages of development within the LSP area.

Preparation of the UWMP will be the responsibility of the developer. UWMPs will address:

- Demonstrated compliance with LWMS criteria and objectives to the satisfaction of the City of Swan, DBCA and DWER.
- Agreed/approved measures to achieve water conservation and efficiencies of water use, including provision of POS irrigation water use distribution details.
- Detailed stormwater management design including the size, location and design of public open space areas, integrating major and minor flood management capability.
- Management of groundwater levels including proposed cut/fill levels.
- Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, expected performance and agreed ongoing management arrangements.
- Management of subdivisional works including development of a strategy for sediment control during construction.
- Implementation plan including roles, responsibilities, funding and maintenance arrangements.
- Specific monitoring and reporting to be undertaken for each UWMP area consistent with the monitoring program defined in the LWMS.
- Contingency plans (where necessary).

Further detail of the integration of stormwater within POS areas and any improvements to the Blackadder Creek Tributary area adjacent to the LSP area will be provided during the development of the relevant UWMP's covering those specific areas. This will include the refinement of stormwater modelling, preparation of detailed landscape plans (species selection and treatments), and detailed engineering design drawings.

Staging of stormwater changes will be detailed in the relevant UWMP's and implemented to ensure key hydrological performance criteria in relation to the receiving environment and key design objectives are maintained during the transition process.

9. Monitoring

9.1 Pre Development

Baseline surface and groundwater monitoring of existing conditions commenced in winter 2019 and was completed in winter 2020 as detailed in Chapter 3. Some additional monitoring was also undertaken in 2021 to monitor the performance of the Midland Brick site following recent changes to its overall system. No further specific monitoring is considered to be required to inform development of the Stage 3 area.

9.2 Post Development

Department of Water (2012) indicates a minimum of 3 years post development monitoring is required, and defines post development as "from completion of first subdivision to five years after 80 per cent of the development (by land area) has been completed".

The post development monitoring program is summarised in Table 11. Post development groundwater monitoring is proposed in 2 groundwater monitoring bores and 4 surface water monitoring sites as shown in Figure 14. Locations have been selected based on maintaining existing sampling locations where possible.

The following frequency of monitoring is proposed:

- Monthly groundwater level measurements.
- Quarterly groundwater quality measurements.

Groundwater levels will also be measured in DWER bores MM38 and GD8 consistent with pre development monitoring. Groundwater quality will be monitored quarterly (typically January, April, July, October) for physical parameters (pH, electrical conductivity), nutrients (total nitrogen, total Kjeldahl nitrogen, ammonia, nitrate, nitrite, total phosphorus, and filterable reactive phosphorus) and heavy metals.

Surface water samples will be taken in the Swan River upstream and downstream of the LSP area as well as within the Blackadder Creek Tributary at Muriel St. Samples will be taken on up to four occasions over each winter monitoring period, when water is flowing, via a collected grab sample. Samples of the stormwater outflow from the main stormwater basin and biofilter area will be taken when/if water is present. Visual assessment of these areas will also be undertaken on a quarterly basis via a standardised proforma, to assess performance in relation to design.

All water quality samples will be analysed at a NATA approved laboratory.

The monitoring schedule will be undertaken for a three year period consistent with DWER requirements. An annual report will be prepared summarising the results of the program, with results compared to predevelopment monitoring data. The program may need to be modified as data is collected to increase or decrease the monitoring effort in a particular area, or to alter the scope of the program itself. This will require the agreement of all parties.

If required, contingency actions will include a review of all monitoring data to determine the likely cause of any significant changes in water quality, consideration of additional monitoring required to assist a determination, and consideration of remedial actions.

A contingency plan including targets estimated on the basis of predevelopment monitoring is presented in Table 12. Implementation of the post development monitoring program is the responsibility of the developer. Where any staging aspects require specific additional monitoring to be conducted, this will be appropriately detailed at UWMP stage.

Table 11: Post Development Monitoring Program

Monitoring	Parameter	Location	Method	Frequency and Timing
Groundwater level	Water level (m AHD)	2 bores within LSP area and 2 DWER bores	Electrical depth probe or similar	Monthly (12x annually)
Groundwater quality	Physical, nutrients and heavy metals	2 bores within LSP area	Pumped bore sample	Quarterly (4x annually)
Surface water /Stormwater quality	Physical, nutrients and heavy metals	Blackadder Creek Tributary @ Muriel Rd, 2 locations Swan River, Site Storage	Collected grab samples	Maximum four occasions during each annual winter monitoring period
System performance	Profroma	Site storage, Blackadder Creek Tributary @ Muriel Rd	Visual Assessment	Maximum four occasions during each annual winter monitoring period

Table 12: Contingency Planning

Type	Criteria for Assessment	Frequency	Process & Possible Actions
Water Quality	Surface and groundwater quality significantly worse than: a) predevelopment water quality; and/or b) typical urban stormwater quality on the Swan Coastal Plain (Martens et al 2005) TN : 1.1 mg/l TP : 0.21 mg/l with reference to ANZECC guidelines [1]	Ongoing assessment following monitoring with annual review	**Process** 1. Assess spatial extent of occurrence. 2. Determine if due to development or other factors. 3. Perform appropriate action as required (refer below) 4. Record and report any breach and action taken. 5. If necessary, inform residents of any required works. 6. Inform and provide monitoring data to DWER/ City of Swan. **Possible Actions** 1. Resample location to determine if it is a false reading. 2. Identify and remove point sources of pollution. 3. Review operational and maintenance practices. 4. Consider alterations to POS areas including landscape regimes and soil amendment. 5. Consider modifications to the stormwater system. 6. Consider initiation of community based projects.

1. ANZECC guidelines to be used as a reference point only. ANZECC guidelines state that guidelines values are not intended to be directly applied to stormwater quality, however are applicable where the stormwater system are regarded as having conservation value. ANZECC guideline values are derived for unmodified or slightly modified ecosystems. ANZECC recommends the values only be applied where site specific values do not exist, or site specific targets cannot be derived.

10. Implementation

Table 13 details the roles, responsibilities, and funding to implement the LWMS.

Monitoring outcomes will be used in a continual improvement capacity to review the implemented WSUD within the LSP area and inform the planning and design approaches for subsequent stages of development.

Details of construction and maintenance activities and responsibilities will be appropriately detailed at UWMP stage, and will include details of any specific staging considerations, and the need for ongoing management of subsoil drainage to ensure its ongoing performance in accordance with design.

Monitoring outcomes will also be used to inform continual design and planning improvements as the development proceeds, particularly in relation to maintaining and improving the hydrology of the Blackadder Creek Tributary.

Table 13: Implementation, Roles and Responsibilities

Implementation Action	Responsibility		
	Developer	DWER / DBCA	City of Swan
Review and approval of this LWMS		✓	✓
Preparation of a UWMP for individual development stages	✓		
Review and approval of UWMP		✓	✓
Construction of stormwater system and maintenance post construction until council handover	✓		
Long term stormwater system operation and maintenance			✓
Conduct post development monitoring program and annual reporting	✓		
Review of monitoring data and annual reports		✓	✓

11. References

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FIGURES

Midland Brick

Local Structure Plan Area (LWMS Site)

0 125 250 375 500 Meters

hyd2o

Rivermark Area 3 Local Water Management Strategy

Location Plan

Figure 1

hyd2o
Rivermark Area 3 Local Water Management Strategy
Local Structure Plan
Figure 2

Date: 7/05/2023 Job No. H22039

Site

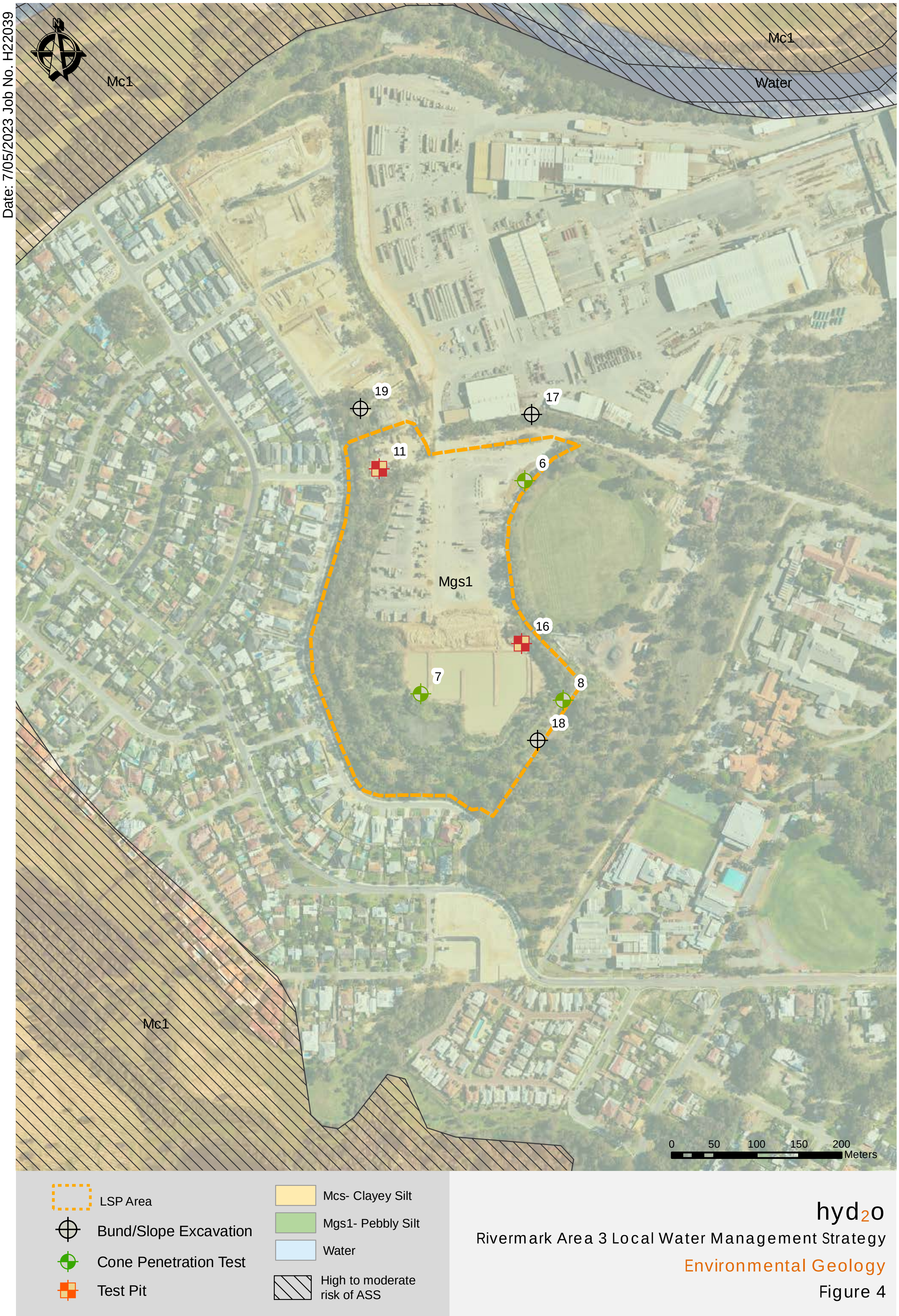
Topography (mAHD)

hyd2o

Rivermark Area 3 Local Water Management Strategy

Site Conditions Plan

Figure 3



hyd2o

Rivermark Area 3 Local Water Management Strategy

Environmental Geology

Figure 4

Date: 7/05/2023 Job No. H22039

LSP Area

SCP Wetlands

Conservation

Multiple Use

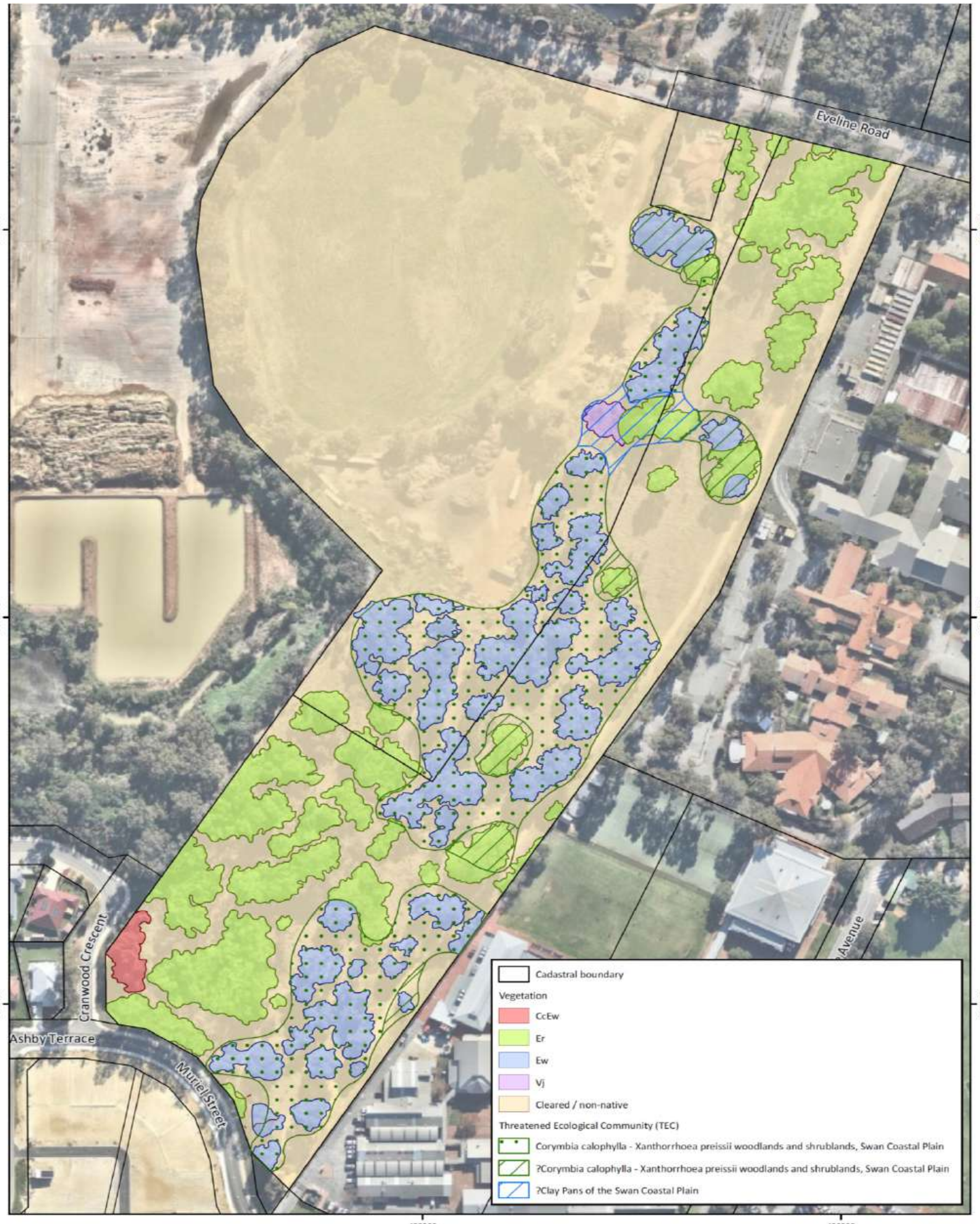
hyd2o

Rivermark Area 3 Local Water Management Strategy

Environmental Plan

Figure 5

Date: 7/5/2023 Job No. H22039



WD:	Vegetation and Threatened Ecological Communities (TECs)
Project:	TEC Assessment Eveline Road
Client:	Hesperia Pty Ltd

Plan Number: EP19-105(50)--WD314a
Drawn: GAR
Date: 29/09/2022
Checked: TAA
Approved: TAA
Date: 26/10/2022

N

0 20 40 60
Metres
Scale: 1:2,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used.
©Landgate (2021). Nearmap Imagery date: XX/XX/XXXX

Source : Emerge Associates (2022)

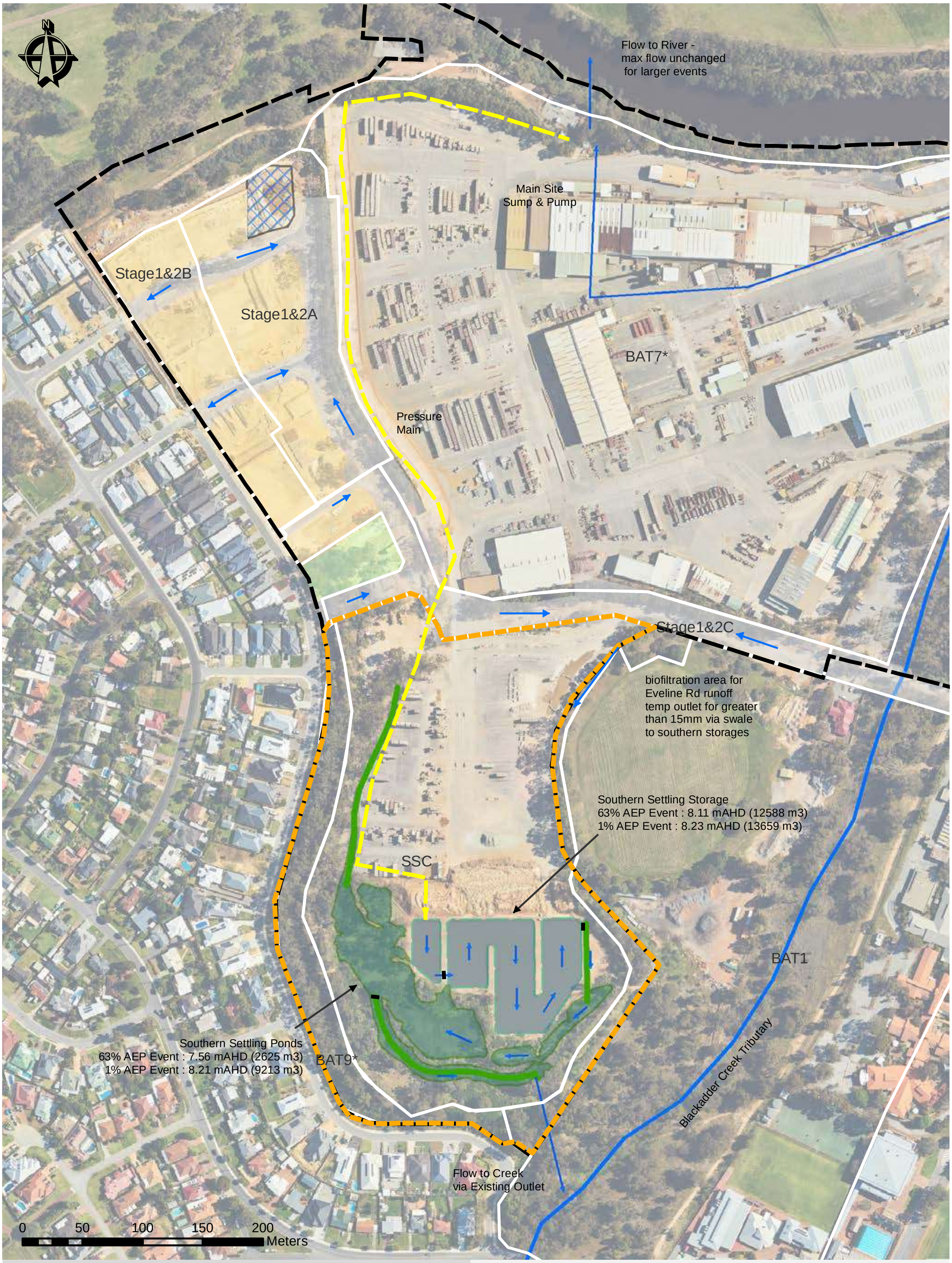
hyd2o

Rivermark Area 3 Local Water Management Strategy

Vegetation & TEC in Proximity to Site

Figure 6

Date: 7/05/2023 Job No. H22039



Midland Brick Site
LSP Area
Subcatchments
Open Drain/Swale
Pressure Main
Southern Settling Ponds
Southern Settling Storage
Lots
Road
POS
Temp Storage

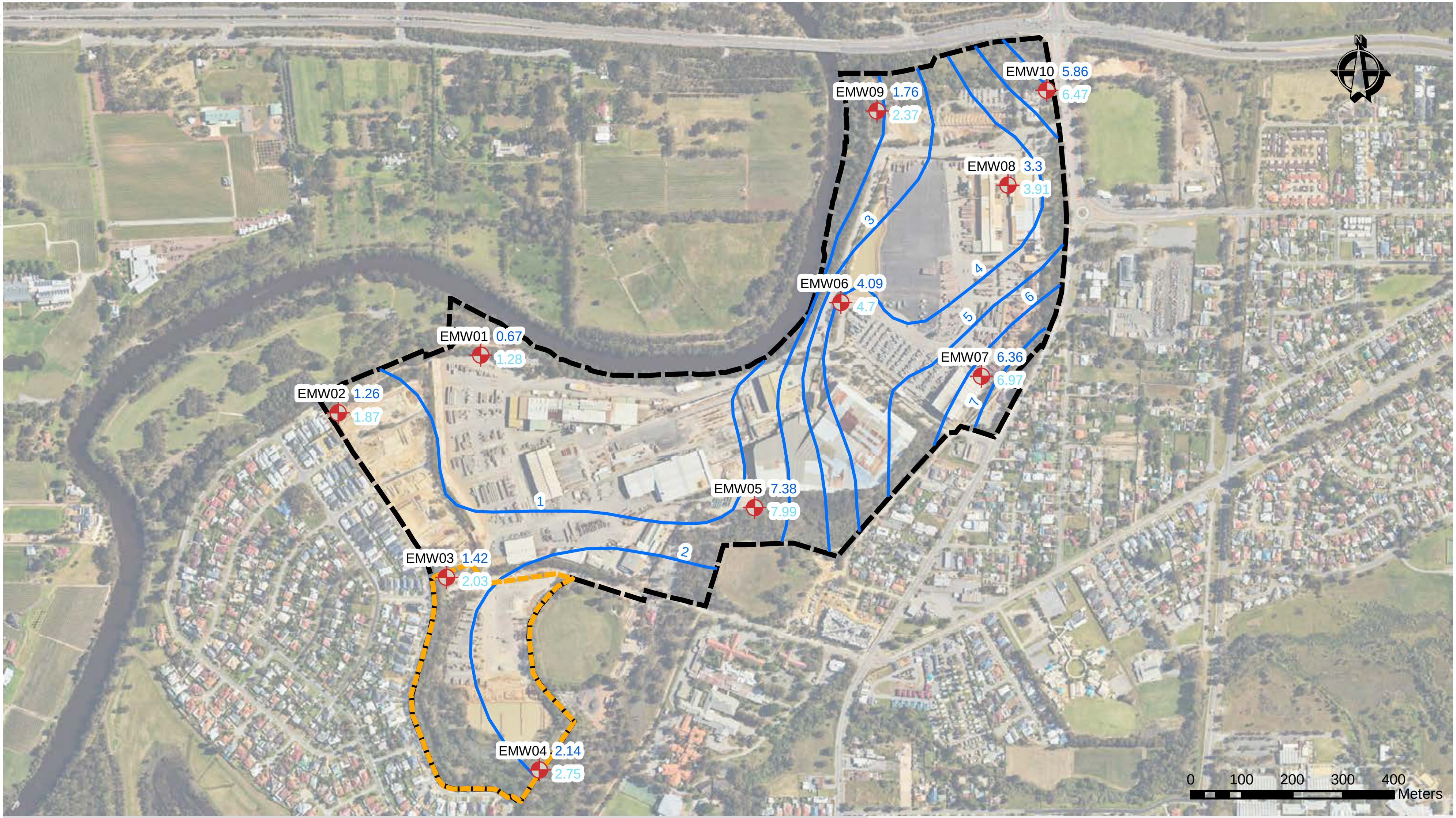
hyd2o

Rivermark Area 3 Local Water Management Strategy

Surface Water Plan

Figure 7

Date: 7/05/2023 Job No. H22039



Midland Brick Site

LSP Area

Groundwater Bores

AAMGL mAHD

MGL mAHD

AAMGL Contour (mAHD)

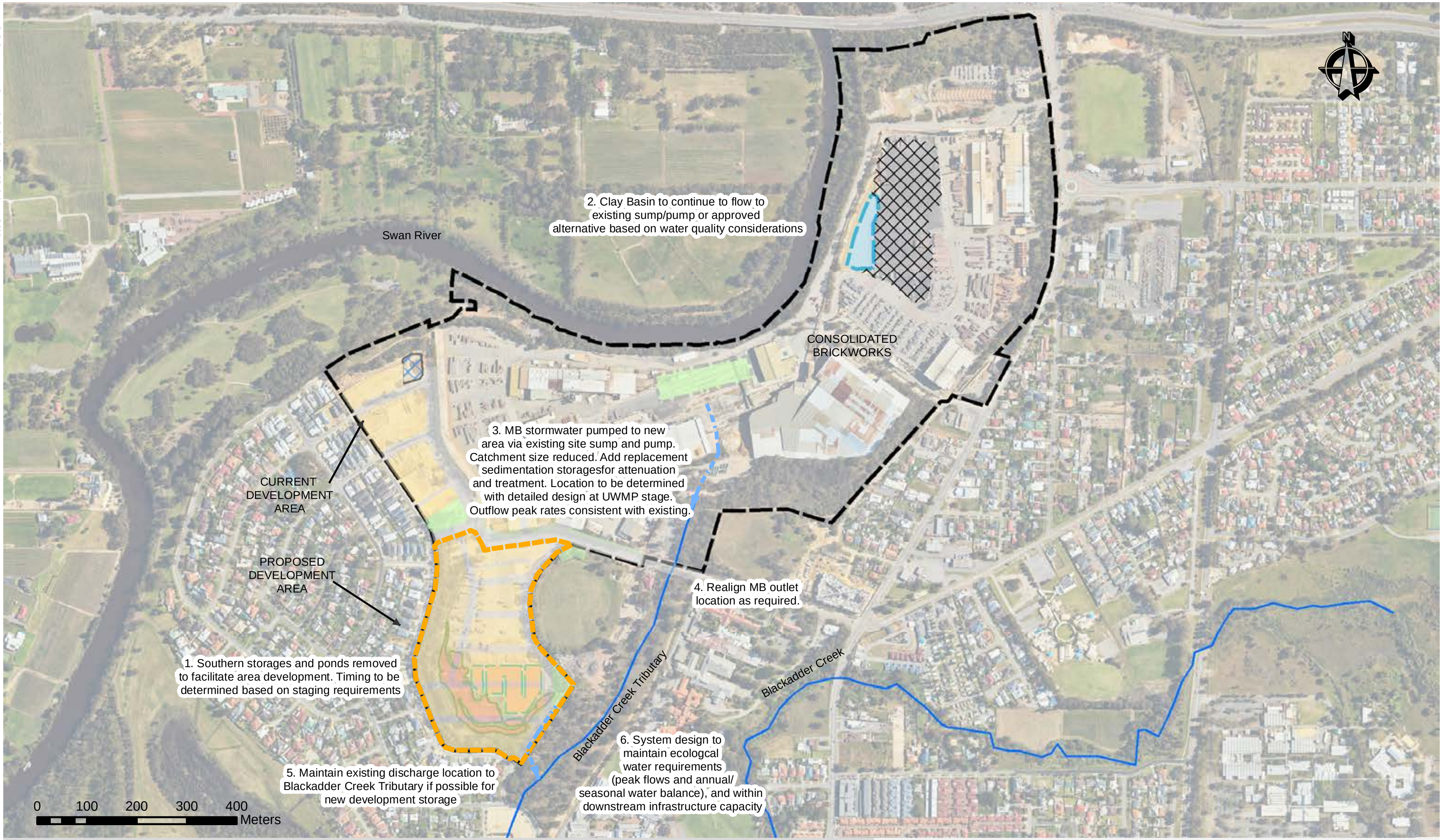
hyd2o

Rivermark Area 3 Local Water Management Strategy

Groundwater Plan

Figure 8

Date: 7/05/2023 Job No. H22039



Midland Brick Site

LSP Area

Existing Storages

Temporary Additional Storages

Hardstand Expansion

Revised Clay Basin

Stormwater Flow Paths

Blackadder Creek & Tributary

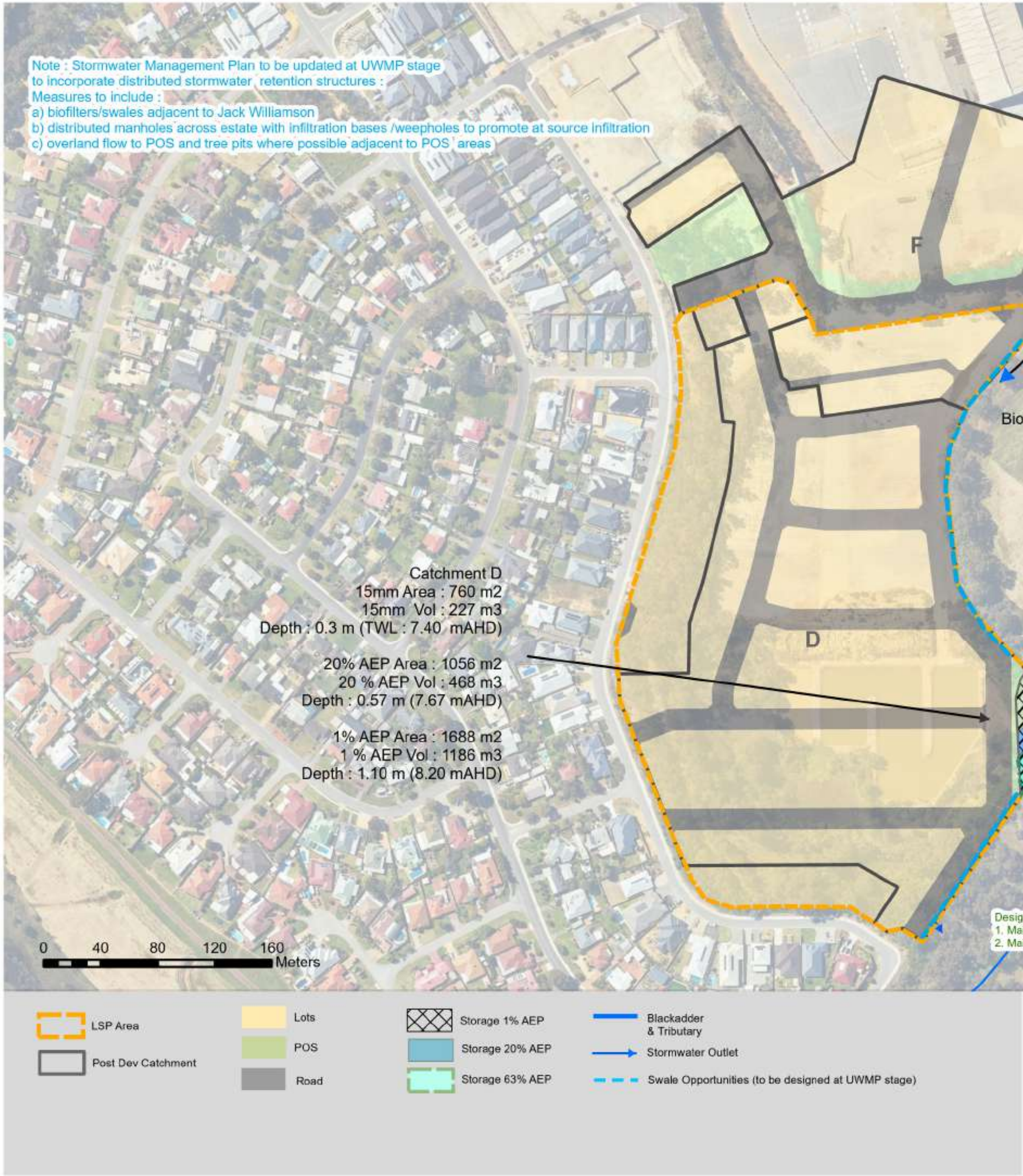
hyd2o

Rivermark Area 3 Local Water Management Strategy

Stormwater Management Changes Overview

Figure 9

Date: 7/05/2023 Job No. H22039



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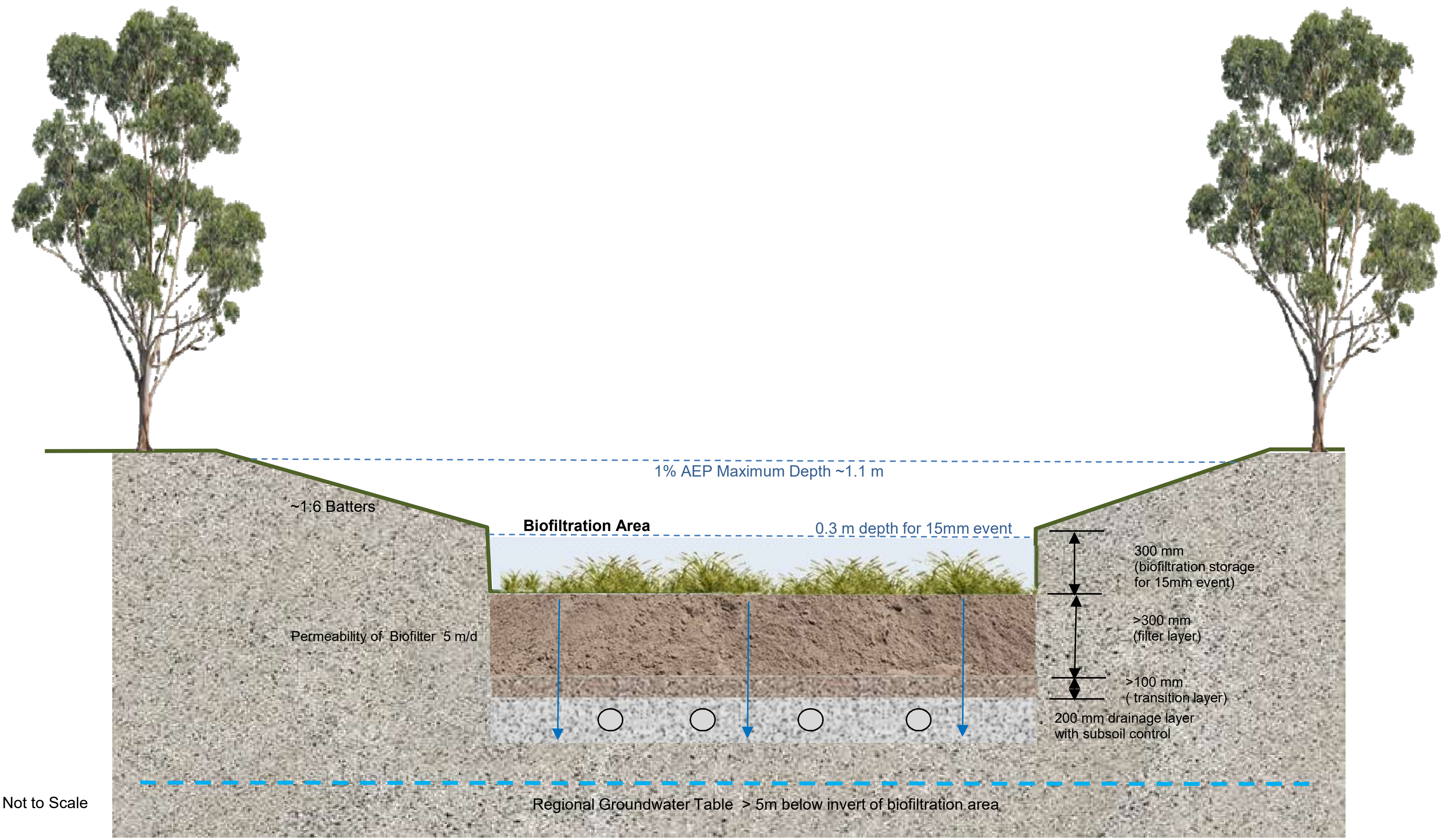
Rivermark Area 3 Local Water Management Strategy

Stormwater Management Event Plan

Figure 10

Date: 7/5/2023 Job No H22039



Not to Scale

Basin cross section shown indicative only
Actual depth and width to vary based on individual detailed design requirements at UWMP stage

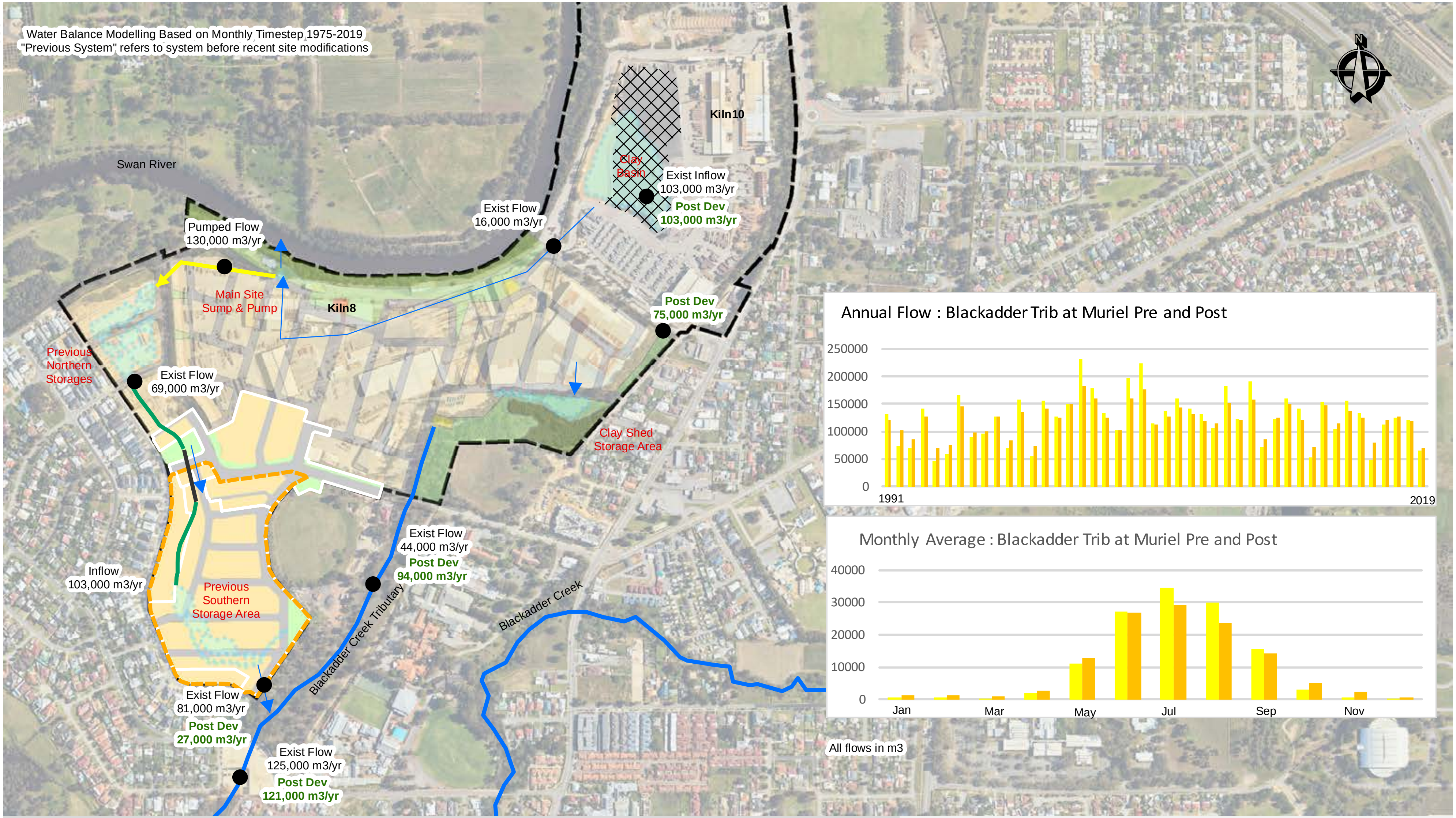
hyd2o

Rivermark Area 3 Local Water Management Strategy

Indicative Biofiltration System

Figure 11

Date: 7/5/2023 Job No. H22039



Midland Brick

Site

Subcatchment Boundaries

Existing Storages

Blackadder Creek & Tributary

Open_Drain

Pipe Drain

Previously Existing System Flows

Post Development Flow at Same Locations

Previous Stormwater Flow Path (Gravity)

Previous Stormwater Flow Path (Pumped)

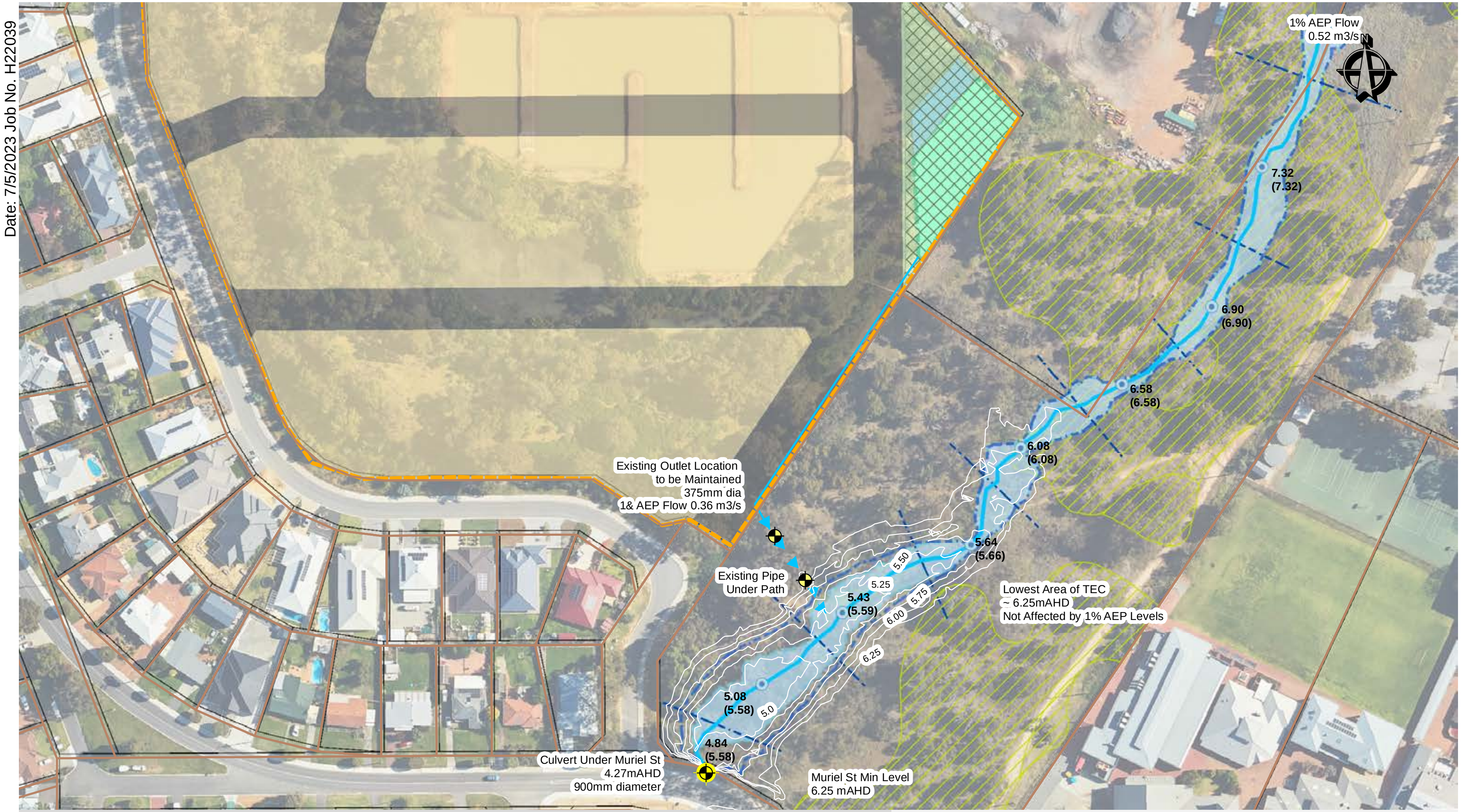
0 80 160 240 320 Meters

hyd2o

Rivermark Area 3 Local Water Management Strategy

Water Balance Modelling Summary

Figure 12



LSP Site
Mapped TEC
MNG LiDAR Data (0.25m)
Area 3 Outflow Flowpath
Piped Outlets
1% AEP Event Inundation Area
1% AEP Event Inundation Area with Blackadder Creek 1% AEP Tailwater (5.46 mAHD)
Modelled Sections
Blackadder Creek Tributary (& Modelled Nodes)
x.xx 1% AEP Flood Level (mAHD)
(x.xx) (with Blackadder Tailwater shown in parenthesis)

0 10 20 30 40 Meters

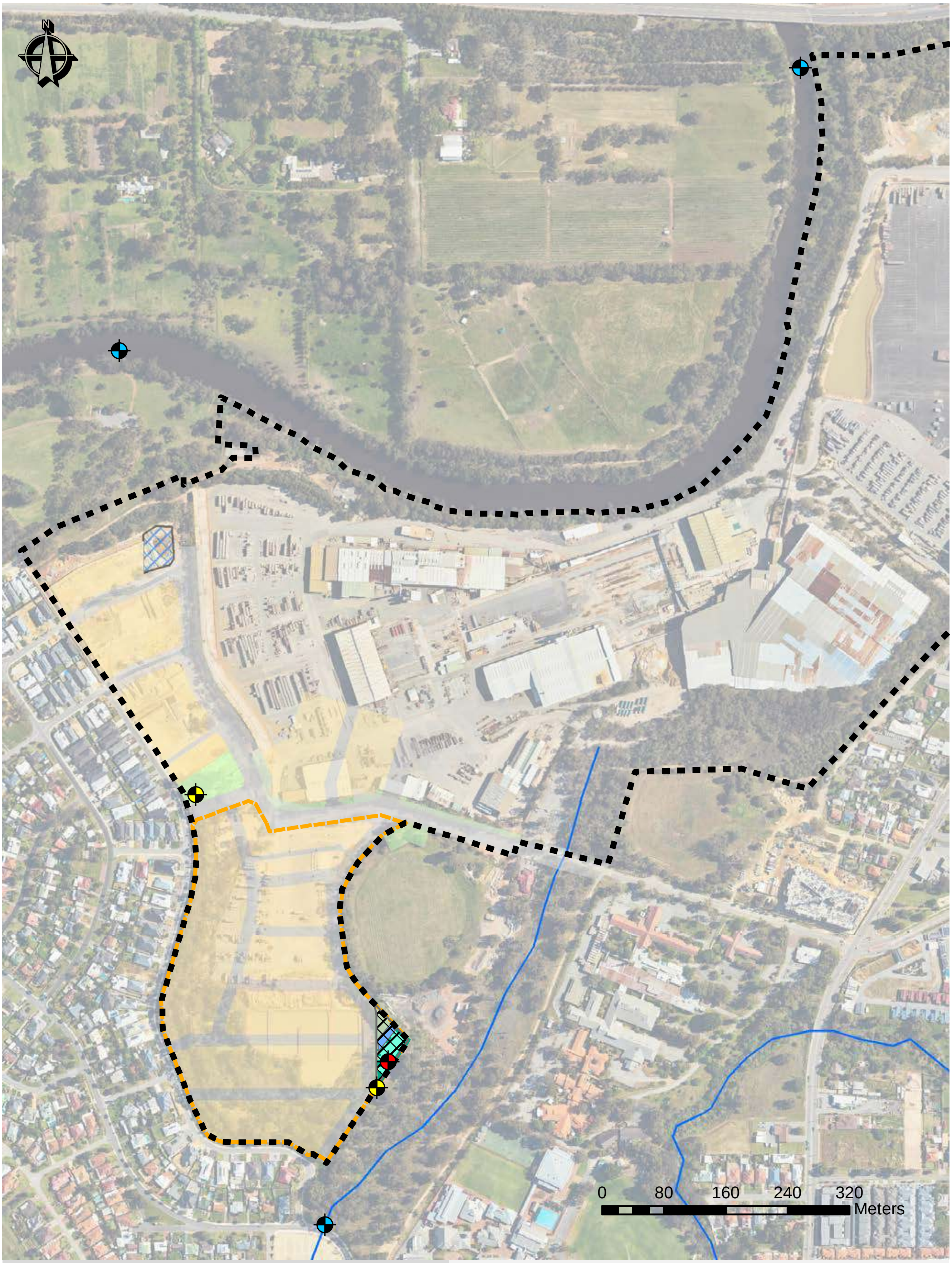
hyd$_2$o

Rivermark Area 3 Local Water Management Strategy

TEC Area Inundation Modelling for Various AEP Events

Figure 13

Date: 7/05/2023 Job No. H22039



LSP Area
Midland Brick Site
Groundwater
Stormwater
Surface Water

hyd₂o

Rivermark Area 3 Local Water Management Strategy

Post Development Monitoring

Figure 14

APPENDIX A
Better Urban Water Management Checklist

Better Urban Water Management LWMS Checklist

Local Water Management Strategy Item	Deliverable	✓	Comments
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: design elements and requirements for BMP's and critical control points	☑	Executive Summary
Introduction			
Total water cycle management - principles and objectives Planning background Previous studies		☑	Chapter 1, Figure 1
Proposed development			
Structure plan, zoning and land use Key landscape features Previous land use	Site Context Plan Structure Plan	☑	Section 1.1, Section 2, Figure 2
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape plan	☑	Section 5.2, Appendix I
Design criteria			
Agreed design objective and source of objective		☑	Section 4, Table 8
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☑	Section 3, Figures 3-8
Site conditions- existing topography/ contours, aerial photo underlay, major physical features	Site Condition plan	☑	Section 3.1, Figure 3
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	☑	Section 3.2, Figure 4, Appendix B
Environmental- areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental plan plus supporting data where appropriate	☑	Sections 3.3, Figures 5 & 6, Appendix C
Surface water- topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface water plan	☑	Section 3.4, Figure 7, Appendix D & E
Groundwater - topography, pre development groundwater levels and water quality, test bore locations	Groundwater plan plus details of groundwater monitoring and testing	☑	Section 3.5, Figure 8, Appendices E-H
Water use sustainability initiatives			
Water efficiency measures- private and public open spaces including method of enforcement		☑	Section 5.1
Water supply (fit- for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		☑	Section 5.2, Section 6.3, Appendix I, J, & N
Wastewater management		☑	Section 5.3
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points, 100 year flow paths and 100 year detentions storage areas	100yr event plan Long section of critical points	☑	Section 6.1, Table 9, Figures 9 & 10, Appendix K-O
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5yr event plan	☑	Section 6.1, Table 9, Figures 9 &10, Appendix K-O
Protect ecology - detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1 yr event plan Typical cross sections	☑	Section 6.2 -6.4 Table 9 & 10, Figures 9 - 13, Appendix C, N & O

Local Water Management Strategy Item	Deliverable	✓	Comments
Groundwater management strategy			
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoil areas/exclusion zones	Groundwater/subsoil plan	☑	Section 7.1 & 7.2, Appendix P
Actions to address acid sulphate soils or contamination		☑	Section 7.3
The next stage - subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design		☑	Section 8
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		☑	Section 9, Figure 14, Table 11 & 12
Implementation			
Developer commitments		☑	Section 10, Table 13
Roles, responsibilities, funding for implementation		☑	Section 10, Table 13
Review		☑	Section 10, Table 13

APPENDIX B
Geotechnical Report

Douglas Partners
Geotechnics | Environment | Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Project Texas
102 Great Northern Highway, Middle Swan, WA

Prepared for
Linc Property Pty Ltd

Project 96584.01
June 2019

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	96584.01	Document No.	R.001.Rev0
Document title	Report on Geotechnical Investigation Project Texas		
Site address	102 Great Northern Highway, Middle Swan, WA		
Report prepared for	Linc Property Pty Ltd		
File name	96584.01.R.001.Rev0.MIDDLE SWAN, 102 Great Northern Highway		

Document status and review

Status	Prepared by	Reviewed by	Date issued
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Distribution of copies

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Revision 0	1	-	Judd Dyer, Linc Property Pty Ltd

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		26 JUNE 2019
Reviewer		26 June 2019

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Table of Contents

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Report on Geotechnical Investigation
Project Texas
102 Great Northern Highway, Middle Swan, WA

1. Introduction

This report presents the results of a geotechnical investigation undertaken for Project Texas at 102 Great Northern Highway, Middle Swan, WA. The investigation was commissioned on 20 June 2019 by Judd Dyer of Linc Property Pty Ltd and was undertaken in accordance with Douglas Partners' proposal PER190248 dated 11 June 2019.

It is understood that the proposed development comprises a residential subdivision development in the western part of the site and an industrial development in the eastern part. Preliminary site formation earthworks design includes cutting below existing surface levels in the western and central parts of the site and filling elsewhere. It is understood that finished levels are proposed to be achieved, following bulk earthworks, by placing approximately 1.2 m of clean granular fill over the existing soils underlying the site in the proposed residential development area (western part of the site) and 0.5 m of clean, granular fill in the industrial (eastern) part of the site.

A desktop study of the site has been previously undertaken by Douglas Partners and is presented in Douglas Partners report 96584.00.R.001.

The aim of the investigation was to assess the subsurface soil and groundwater conditions across the site in order to provide preliminary information on:

- the geotechnical suitability of the site for the proposed development;
- the thickness, consistency, strength and density of uncontrolled fill, including in the areas of former clay pits;
- site classification in accordance with AS 2870-2011 following recommended site preparation works;
- the suitability of the encountered existing fill to be left in place below the proposed development, and advice on ground improvement of existing uncontrolled fill if required;
- suitability of encountered uncontrolled fill for reuse as structural fill, and recommendations to improve unsuitable fill to make it suitable for reuse; and
- site preparation, earthworks and ground improvement requirements, if any, required to remediate the existing deep basin in the northern part of the site.

The investigation included the excavation of eleven test pits and the supervision of eight cone penetration tests. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

2. Site Description

The site is approximately 82 ha in size. It is mostly developed as a brick manufacturing facility, with numerous large industrial buildings scattered across the site, and associated areas of hardstand for storage. There are undeveloped areas around the edges of the site, particularly the western and south western side. A bund of soil has been constructed around the western end of the site. A relatively large water body (approximately 250 m by 175 m maximum dimensions) occupies an inferred former clay pit in the northern part of the site. Most of the site is currently covered with hardstand pavement, apart from the undeveloped fringes which are vegetated.

It is understood that brick making operations have been present on the site since the late nineteenth century. Historical photographs indicate that clay quarrying has been undertaken on parts of the site, notably in the south eastern area and northern part of the site. As previously noted, one relatively deep excavation is partially filled with water in the northern part of the site but the other clay pits have been backfilled.

Douglas Partners has previously undertaken a desktop study of the site. The findings of the desktop study are presented in Douglas Partners repot 96584.00.R.001.

3. Field Work Methods

Field work was carried out on 21 June 2019 and comprised:

- Eight cone penetration tests;
- Eleven test pits; and
- A dynamic cone penetrometer (DCP) test at each test pit location.

The cone penetration tests (test locations 1 to 8) were carried out using a 36 mm diameter instrumented cone with a following 130 mm long friction sleeve attached to rods of the same diameter, pushed continuously at a rate of 20 mm/sec into the soil by hydraulic thrust from a ballasted 12 tonne tracked rig. Strain gauges in the cone and sleeve measure resistance to penetration and this data allows assessment of the type and condition of the materials penetrated. The cone penetration tests were undertaken to depths of up to approximately 12.9 m, though several tests encountered refusal at shallower depth and three encountered refusal at depths of less than 1 m.

Test pits at test locations 9 to 16 were excavated using a 5 tonne excavator with a 450 mm wide toothed bucket to depths of up to 2.8 m. Several test pits encountered refusal at shallower depths due to slow digging. The pits in the side of the western bund (test locations 17 to 19) were excavated using the same excavator to a depth of 0.4 m and 0.5 m respectively.

Ground conditions were logged in general accordance with AS1726-2017 by a suitably experienced geotechnical engineer from Douglas Partners. Soil samples were recovered for subsequent geotechnical laboratory testing. Laboratory testing had not commenced at time of issue of this report due to timing constraints.

Dynamic cone penetrometer testing was carried out in accordance with AS 1289.6.3.2, adjacent to each test pit, to assess the in situ density of the shallow soils. The results of these penetrometer tests are presented on the test pit log sheets in Appendix B.

Test locations were determined with reference to existing site features, and are presented on Drawing 1 in Appendix A. Surface elevations at each test location were interpolated from publicly available LiDAR data.

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing carried out on 21 June 2019 are presented in Appendix B, with notes defining descriptive terms and classification methods provided in Appendix A.

The encountered ground conditions at the test locations generally comprised uncontrolled fill, generally clayey although some granular fill was also encountered, overlying variable, though generally clayey, natural soils.

A summary of the general ground conditions encountered at the test locations is given below:

- **Clayey Fill (Sandy Clay, Clayey Sand, Gravelly Clay, Clayey Gravel, Clay, Bricks and Sand with Clay)** – generally stiff to hard, encountered at all test pit locations, generally forming most of the encountered fill depth. Loose silty or clayey gravel, inferred as possible fill, was encountered between depths of 1.5 m and 4.0 m at test location 7. Firm to very stiff clay fill was encountered to a depth of approximately 5.5 m at test location 6. The clayey fill general contained brick fragments and/or bricks, and occasionally fragments of plastic, rubber, wood, wire, fabric, carpet and concrete.
- **Granular Fill (Sand, Gravelly Sand, Sandy Gravel)** – generally medium dense to very dense, granular fill, generally encountered from the surface to depths of less than 0.5 m. Granular fill (i.e. fill with no clay content) was encountered at test pit locations 11, 12, 13, 15, 16 and 17 and cone penetration locations 2 and 3. A granular fill layer was encountered at test location 13, underlying clayey fill from a depth of approximately 0.4 m to the termination depth of the test pit at 1.6 m. The fill generally contained brick fragments and/or unbroken bricks.

  Inferred granular fill or disturbed ground was encountered to a depth of approximately 9.8 m at test location 3, with loose silty sand being encountered between depths of approximately 3.0 m and 8.0 m.
- Natural Soils – generally clayey soils from the Guildford Formation, including:
  - **Clayey Sand** – hard / very dense orange-brown mottled red-brown and grey, fine to medium grained clayey sand, encountered underlying the fill from a depth of 0.75 m at test location 11. Sand with sand clay was encountered from the surface at test location 5.
  - **Clay** – stiff to hard clay, encountered underlying the fill from a depth of approximately 0.75 m at test location 14 and cone penetration test locations 1, 3, and 6.

- **Sand and Silty Sand** – generally medium dense to dense, orange-brown fine to medium grained sand, sometimes with clay, encountered underlying the clayey sand at test pit location 11 and cone penetration test location 5.

4.2 Groundwater

Free groundwater was not observed in test pit locations undertaken on 24 June 2019.

Groundwater was measured within some of the cone penetration test locations, as summarised in Table 1 below, and are indicated on the logs in Appendix B. Some of the cone penetration test holes collapsed prior to dipping for groundwater, precluding measurement of groundwater levels.

Table 1: Summary of Groundwater Observations

Test Location	Surface Level [1] (m AHD)	Groundwater Depth (m)	Groundwater Level (RL m AHD)
1	5.9	7.2	-1.3
3	5.8	2.9	2.9
5	9.2	9.1	0.1
6	9.2	8.0	1.2
7	8.3	9.9	1.6

Notes: [1]: Interpolated from publicly available LiDAR data

The Perth Groundwater Atlas (2004) indicates that the level of the regional superficial aquifer beneath the site was at approximately RL 2 m AHD in May 2003 in the north eastern corner of the site but generally below RL 1 m AHD, which is from approximately 3 m to more than 10 m below the estimated current surface elevation of the site. Desktop information and our general experience in the area indicates that perched groundwater may be present at higher elevations (see Douglas Partners report 96584.00.R.001).

It should be noted that groundwater levels are affected by climatic conditions and soil permeability, and will therefore vary with time.

5. Proposed Development

It is understood that the proposed development comprises a residential subdivision development in the western part of the site and an industrial development in the eastern part. Preliminary site formation earthworks design includes cutting below existing surface levels in the western and central parts of the site and filling elsewhere. It is understood that finished levels will be achieved, following bulk earthworks, by placing approximately 1.2 m of clean granular fill over the existing soils in the proposed residential development area (western part of the site) and 0.5 m of clean, granular fill in the industrial (eastern) part of the site.

6. Comments

6.1 Site Suitability

Results of the investigation indicate that the site is generally underlain by generally clayey fill overlying clayey natural soils. Granular fill and natural sand (with some clay content) are present in some locations.

The fill is generally stiff to hard, or medium dense to very dense. Loose inferred fill and disturbed ground was encountered to a depth of approximately 8 m at test location 3, adjacent to the existing large pit in the northern part of the site. Loose and firm soils, interpreted to be possible fill, were identified to depths of between 4 m and 5.5 m at test locations 6 and 7. The fill across the site generally contains brick fragments or bricks, and occasionally contains traces of other materials such as wood, fabric, wire, plastic, rubber and concrete.

It is considered that, from a geotechnical perspective, the site is considered suitable for the proposed redevelopment, as evidenced by existing facilities on the site. The following should be considered:

- The site is underlain by variable, uncontrolled fill of generally unknown thickness. Much of the fill is clayey in nature and commonly contains brick fragments and bricks. In current encountered condition, the fill appears to generally form a suitable foundation material without the requirement of full depth removal of the fill, although partial removal to a given depth to ensure a minimum thickness of engineered ground beneath proposed founding levels should be considered to reduce geotechnical risk, as discussed in Section 6.2. Removal, screening/crushing and replacement of the uncontrolled fill such that a layer of controlled fill with a thickness of at least 1.2 m below the proposed layer of imported sand is suggested at this stage of the study. Following removal of the 1.2 m layer of uncontrolled fill, the exposed surface should be heavily compacted by an impact roller or similar. Given the size of the site, the duration of industrial activity and the limited extent of current investigation, it is considered likely that some areas of unsuitable fill that do not form a suitable foundation layer and require removal, deep ground improvement or soil reinforcement may be encountered.
- The site classification of the site in accordance with AS 2870-2011 in existing condition is considered to be "Class P" due to presence of uncontrolled filling. The site classification of the natural clayey soils underlying the site is indicated to be "Class M" by previous investigations and corroborates Douglas Partners' general experience in the Midland area. Laboratory testing on the clayey fill to further define site classification was outside the scope of this report owing to timing requirements. The following equivalent site classifications are considered likely appropriate following proposed earthworks:
    - An equivalent site classification of "Class S" is considered to be likely suitable for the residential development in the western part of the site, following placement of 1.2 m of imported clean, granular fill as described in Section 5 and suitable preparation of the existing soils.
    - An equivalent site classification of either "Class S" or "Class M" is considered to be likely suitable for the industrial development in the eastern part of the site, following placement of 0.5 m of imported clean, granular fill as described in Section 5 and suitable preparation of existing soils. Increasing the proposed thickness of granular fill to at least, say, 0.8 m would reduce the risk of areas of the site being "Class M" in finished condition. Additionally, AS2870-2011 requires placement of at least 0.8 m of

non-reactive, structural fill to change the site classification from that applying to the previous condition.

- To achieve a site classification of "Class A", all of the existing fill would need to be removed and replaced by at least 1.8 m of compacted granular fill.

- It is considered that the encountered fill, including the fill in the bund around the western part of the site, could generally be reused as fill elsewhere on the site. Given the abundance of bricks and brick fragments, fill excavated from within the site should be fed through a crusher, or screened and the oversized particles crushed, to reduce the size of the bricks and brick fragments (and over oversized particles such as concrete, to be less than 50 mm in size. However, as discussed above, the presence of unsuitable fill material in some locations may be anticipated and close supervision and testing of fill material excavated on the site will be necessary prior to its reuse elsewhere within the development.
- Remediation of the existing basin in the northern part of the site may require dewatering, removal of soft deposits from within the inundated area, excavation of loose fill and over-steepened slopes (if present) around the basin, and backfilling in a controlled, engineered manner. It is recommended that clayey fill is used to backfill the basin to create ground conditions similar to the natural ground and avoid creation of a 'swimming pool' effect.
- Desktop information (see Douglas Partners report 96584.00.R.001) indicates that shallow groundwater may be present in some western areas of the site, particularly adjacent to the Swan River, and perched groundwater is anticipated to form, at least during the wet months of the year, on the surface of clayey soils (i.e. Guildford Formation and some of the uncontrolled fill).

6.2 Suitability of the Existing Fill to be Left in Place

The encountered existing fill was generally clayey in nature, with granular fill present in some locations, generally as a thick surface layer. The encountered fill was generally in a stiff to hard, or medium denser or denser condition at the test locations.

Based on the encountered fill, and the current land use of the site as an active industrial development, it is considered that some ground improvement provisions are required to ensure that a minimum thickness of controlled soils exists beneath founding levels.

The degree of ground improvement provisions will be proportionate to the level of project risk considered acceptable for the proposed structures. The following alternative scenarios may be considered to address geotechnical risks:

- To fully mitigate the geotechnical risk associated with the existing uncontrolled fill, undertake full depth excavation, screening/crushing and replacement of the uncontrolled fill;

  or alternatively, with potentially some residual risk;

- Partial excavation and reinstatement of the uncontrolled fill to form a controlled, engineer foundation layer, as follows:
  - Excavation of the uncontrolled fill to a depth of 1.2 m. The suggested depth can possibly be adjusted (say to 1.0 m) depending on detailed investigation results and compaction details;
  - Heavy compaction of the uncontrolled fill left in place using an impact roller or possibly heavy (18 tonne) roller (compaction details subject to findings of detailed investigation and may differ across the site depending on uncontrolled fill thickness);
  - Treatment of the excavated controlled fill by screening and crushing as described in Section 6.4; and
  - Replacement of the excavated uncontrolled fill in an engineering manner.

The above methodology for partial excavation of the uncontrolled fill is considered a reasonable level of mitigation to address most of the geotechnical risks associated with the uncontrolled fill material. The proposed compacted sand layer could then be constructed above the improved uncontrolled fill platform. It is possible that soil reinforcement (e.g. geogrids) may be required within the foundation layer to reduce differential settlements in areas of poor filling, where encountered, if this approach is adopted.

Notwithstanding the above, given the large size of the site, the duration of industrial developments within the site and the limited scope of investigations undertaken at this stage, it may be anticipated that areas of unsuitable fill may be encountered during redevelopment of the site. Areas of the site requiring full depth fill replacement, deep ground improvement or exclusion from development of the site cannot be precluded at this stage of the study. Detailed investigations should be undertaken during design development to address this matter. Earthworks should be supervised during construction, particularly exposures of fill, so that unsuitable material, if present, can be identified and removed.

6.3 Site Classification

The site is generally underlain by generally clayey, with some sandy, uncontrolled fill to various, and generally unknown, depths.

The site classification of the site in its current condition is “Class P” in accordance AS2870-2011 because of the presence of uncontrolled fill.

The encountered fill was generally in a medium dense or denser or stiff to hard condition, except at test location 3, located adjacent to the existing flooded excavation (see Section 6.5 for a discussion of this area).

It is understood that it is proposed to place a layer of compacted, granular fill over the site to achieve finished levels. The proposed thickness of the granular fill layer is understood to be approximately 1.2 m for the proposed residential development in the western part of the site and 0.5 m for the industrial eastern part of the site.

At this stage, soil reactivity testing has not been undertaken on samples of existing clayey uncontrolled fill.

However, based on Douglas Partners experience, it is anticipated that an equivalent site classification of “Class S” will likely apply to most of the proposed residential area, following placement of a 1.2 m thick layer of compacted, non-reactive, granular fill and following some provisions regarding site preparation as discussed in previous sections to ensure a minimum thickness of controlled founding materials beneath proposed founding levels.

In the proposed industrial area, where a reduced thickness of 0.5 m of compacted granular fill is proposed, a site classification of either “Class S” or Class M” may apply the zones within the area, depending on the reactivity of the existing uncontrolled fill and following site preparation as discussed in previous sections. Increasing the thickness of the proposed fill layer to, say, 0.8 m would reduce the risk of a “Class M” site in finished condition. It should be noted that, in strict accordance to AS-2870-2011, a controlled fill layer thickness of at least 0.8 m is required to change the site classification from the existing condition prior to filling.

Existing information suggests that the natural clayey soils underlying the site may have a site classification of “Class M”. Therefore, if required, a site classification of “Class M” should be assumed for footings founded in natural clayey soils.

In order to achieve a site classification of “Class A”, which assumes no surface movement, it would be necessary to remove the full depth of uncontrolled fill and replace with a layer of controlled, non-reactive granular at least 1.8 m thick. Although the encountered existing fill is generally stiff to hard, the potential variability in the fill material and the possibility of creep within the fill material precludes the application of a site classification of “Class A” unless the uncontrolled fill is removed.

Loose sandy soils were encountered at test locations 3 and 7. The density of loose sand underlying the site would need to be increased to medium dense or denser to achieve the site classifications given above.

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.

6.4 Geotechnical Suitability for Re-Use of Uncontrolled Fill

The encountered uncontrolled fill was generally clayey in nature, though granular fill was encountered in some locations, mostly as a thin surface layer. Two pits excavated into the bund located around the western end of the site also encountered clayey fill.

Occurrence of brick fragments and bricks within the fill was frequent. A trace of other materials, such as rubber, wood, fabric, wire and carpet was encountered at some locations.

It is considered that existing fill excavated from the site could be generally suitable for reuse as fill below the proposed surface layer of granular, non-reactive fill, provided that the material is put through a crusher to reduce oversized particles such as bricks and concrete to be less than 50 mm in size, or screened if the soil is suitable for screening. Following screening, oversized fragments such as bricks and concrete could be crushed and remixed with the fill material.

Notwithstanding the above, as discussed in Section 6.2, it is possible that fill that is not suitable for reuse will be encountered. Close supervision and frequent testing of fill material excavated from the site will be required prior to reuse as fill elsewhere on the site.

It should be noted that this geotechnical study does not assess whether unacceptable levels of contaminants (including asbestos) exist within the fill material as this was outside the scope of the geotechnical investigation. Such levels, if they occur, may limit or prevent the use of this material.

6.5 Remediation of the Flooded Excavation

A deep excavation, partially filled with water, is located in the northern part of the site in an area indicated by historical aerial maps to have been part of a former clay pit. The depth of the pit and ground conditions within the inundated area were not known to Douglas Partners at the time of writing this report.

Test locations around the basin by Douglas Partners and others encountered clayey fill on the northern side of the basin and deep granular fill on the southern side. Test location 3 encountered inferred fill or disturbed ground to a depth of approximately 9.8 m at test location 3, with loose silty sand encountered between depths of approximately 1.5 m and 8 m. It is possible that the encountered loose granular soil is material that has been pushed into the former clay pit to form the existing ground elevation at the test location.

Remediation of the basin and backfilling to design surface levels may require the following:

- Dewatering of the basin;
- Removal of anticipated soft deposits from within the inundated area, which will likely require removal from site;
- Excavation of loose material where present around the edges of the basin, such as at test location three, and to make the area within the basin safe for workers to enter;
- Backfilling of the basin to the required elevation in a controlled manner. It is suggested that clayey fill excavated from elsewhere on the site is used to backfill the basin to avoid creating a 'swimming pool' effect that may occur if granular fill is used; and
- Finish the site to design levels with the proposed layer of granular, non-reactive fill.

7. References

1. Australian Standard AS2870-2011, 'Residential Slabs and Footings', April 2011, Standards Australia
2. Australian Standard AS 1289-2000, Methods of Testing Soils for Engineering Purposes.
3. Australian Standard AS 1289.6.3.2-1999, Soil Strength and Consolidation Tests- Determination of the Penetration Resistance of a Soil – Dynamic Cone Penetrometer Test.
4. Australian Standard AS 1726-2017, Geotechnical Site Investigation.
5. Australian Standard AS 3798-2007, Guidelines on Earthworks for Commercial and Residential Developments.
6. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004

8. Limitations

Douglas Partners (DP) has prepared this report for this project at in accordance with DP's proposal dated 11 June 2019 and acceptance received from Linc Property Pty Ltd dated 20 June 2019. The work was carried out under a Professional Services Agreement, with amended terms and conditions. This report is provided for the exclusive use of Linc Property Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. 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 on the site only at the specific sampling and/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 human 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 affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing 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 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 stated 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 scope for work for this investigation/report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. Should evidence of filling of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such filling may contain contaminants and hazardous building materials.

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 / environmental / groundwater) 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
Drawing

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.

Copyright

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.

Cone Penetration Tests

Douglas Partners

Introduction

The Cone Penetration Test (CPT) is a sophisticated soil profiling test carried out in-situ. A special cone shaped probe is used which is connected to a digital data acquisition system. The cone and adjoining sleeve section contain a series of strain gauges and other transducers which continuously monitor and record various soil parameters as the cone penetrates the soils.

The soil parameters measured depend on the type of cone being used, however they always include the following basic measurements

- Cone tip resistance q_c
- Sleeve friction f_s
- Inclination (from vertical) i
- Depth below ground z

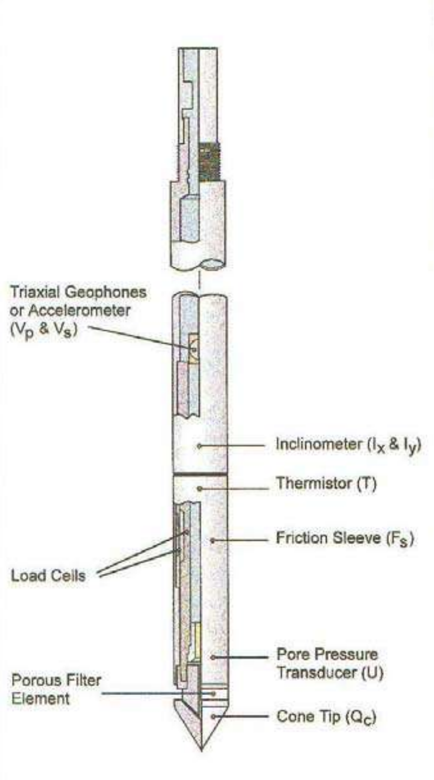


Figure 1: Cone Diagram

The inclinometer in the cone enables the verticality of the test to be confirmed and, if required, the vertical depth can be corrected.

The cone is thrust into the ground at a steady rate of about 20 mm/sec, usually using the hydraulic rams of a purpose built CPT rig, or a drilling rig. The testing is carried out in accordance with the Australian Standard AS1289 Test 6.5.1.

Figure 2: Purpose built CPT rig

The CPT can penetrate most soil types and is particularly suited to alluvial soils, being able to detect fine layering and strength variations. With sufficient thrust the cone can often penetrate a short distance into weathered rock. The cone will usually reach refusal in coarse filling, medium to coarse gravel and on very low strength or better rock. Tests have been successfully completed to more than 60 m.

Types of CPTs

Douglas Partners (and its subsidiary GroundTest) owns and operates the following types of CPT cones:

Type	Measures
Standard	Basic parameters (q_c, f_s, i & z)
Piezocone	Dynamic pore pressure (u) plus basic parameters. Dissipation tests estimate consolidation parameters
Conductivity	Bulk soil electrical conductivity (σ) plus basic parameters
Seismic	Shear wave velocity (V_s), compression wave velocity (V_p), plus basic parameters

Strata Interpretation

The CPT parameters can be used to infer the Soil Behaviour Type (SBT), based on normalised values of cone resistance (Qt) and friction ratio (Fr). These are used in conjunction with soil classification charts, such as the one below (after Robertson 1990)

Cone Penetration Tests

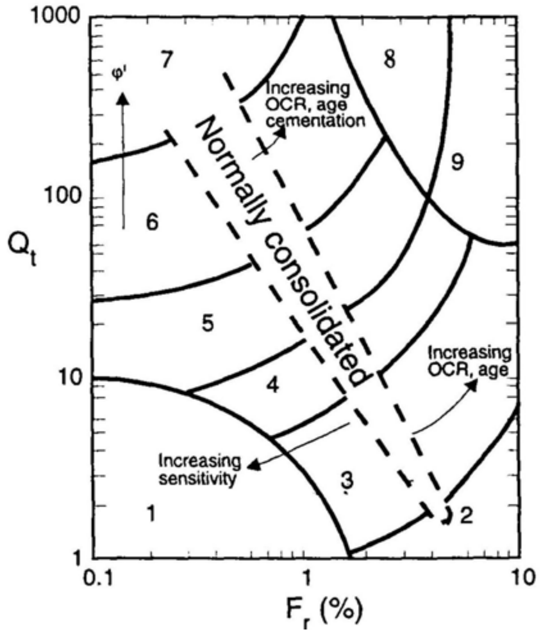


Figure 3: Soil Classification Chart

DP's in-house CPT software provides computer aided interpretation of soil strata, generating soil descriptions and strengths for each layer. The software can also produce plots of estimated soil parameters, including modulus, friction angle, relative density, shear strength and over consolidation ratio.

DP's CPT software helps our engineers quickly evaluate the critical soil layers and then focus on developing practical solutions for the client's project.

Engineering Applications

There are many uses for CPT data. The main applications are briefly introduced below:

Settlement

CPT provides a continuous profile of soil type and strength, providing an excellent basis for settlement analysis. Soil compressibility can be estimated from cone derived moduli, or known consolidation parameters for the critical layers (eg. from laboratory testing). Further, if pore pressure dissipation tests are undertaken using a piezocone, in-situ consolidation coefficients can be estimated to aid analysis.

Pile Capacity

The cone is, in effect, a small scale pile and, therefore, ideal for direct estimation of pile capacity. DP's in-house program ConePile can analyse most pile types and produces pile capacity versus depth plots. The analysis methods are based on proven static theory and empirical studies, taking account of scale effects, pile materials and method of installation. The results are expressed in limit state format, consistent with the Piling Code AS2159.

Dynamic or Earthquake Analysis

CPT and, in particular, Seismic CPT are suitable for dynamic foundation studies and earthquake response analyses, by profiling the low strain shear modulus G_0. Techniques have also been developed relating CPT results to the risk of soil liquefaction.

Other Applications

Other applications of CPT include ground improvement monitoring (testing before and after works), salinity and contaminant plume mapping (conductivity cone), preloading studies and verification of strength gain.

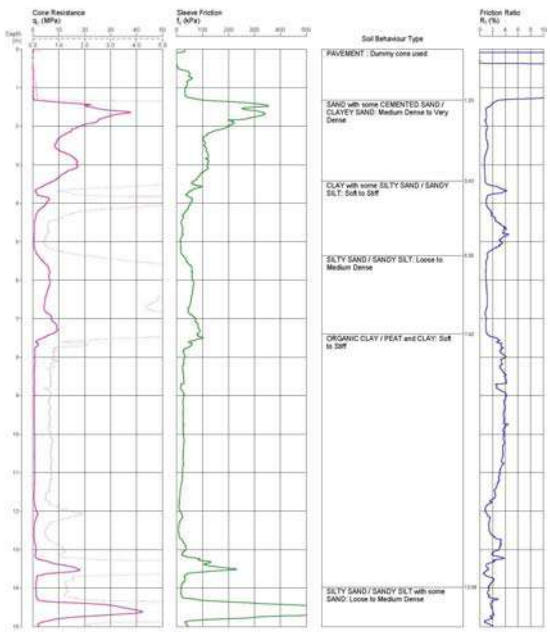


Figure 4: Sample Cone Plot

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. 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	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

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

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with ‘Mix of Soil and Cobbles/Boulders’ with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

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
Friable	Fr	-

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	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

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;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) Non-cohesive and free-running.
- Moist (M) Soil feels cool, darkened in colour.

  Soil tends to stick together.

  Sand forms weak ball but breaks easily.
- Wet (W) Soil feels cool, darkened in colour.

  Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- 'Moist, dry of plastic limit' or 'w <PL' (i.e. hard and friable or powdery).
- 'Moist, near plastic limit' or 'w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- 'Moist, wet of plastic limit' or 'w >PL' (i.e. soils usually weakened and free water forms on the hands when handling).
- 'Wet' or 'w ≈LL' (i.e. near the liquid limit).
- 'Wet' or 'w >LL' (i.e. wet of the liquid limit).

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
$\underline{\nabla}$	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

Test Location	Easting (m)	Northing (m)
1	406463	6473965
2A	406483	6473872
3	406403	6473637
4	406120	6473251
5	405343	6473459
6	405713	6473064
7	405590	6472813
8	405758	6472805
9	406393	6474041
10	406457	6473795
11	405541	6473078
12	406038	6473420
13	405523	6473542
14	405522	6473154
15	405898	6473062
16	405709	6472872
17	405721	6473142
18	405728	6472758
19	405519	6473149

Easting and Northing in MGA Zone 50

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Linc Property Pty Ltd	**Location of Tests**		PROJECT No:	96584.01
OFFICE: Perth	**Proposed Residential & Industrial Development**		DRAWING No:	1
DATE: 25 June 2019	**102 Great Northern Highway, Middle Swan, WA**		REVISION:	A

Appendix B

Results of Field Work

CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan, WA

REDUCED LEVEL: 5.9 m AHD

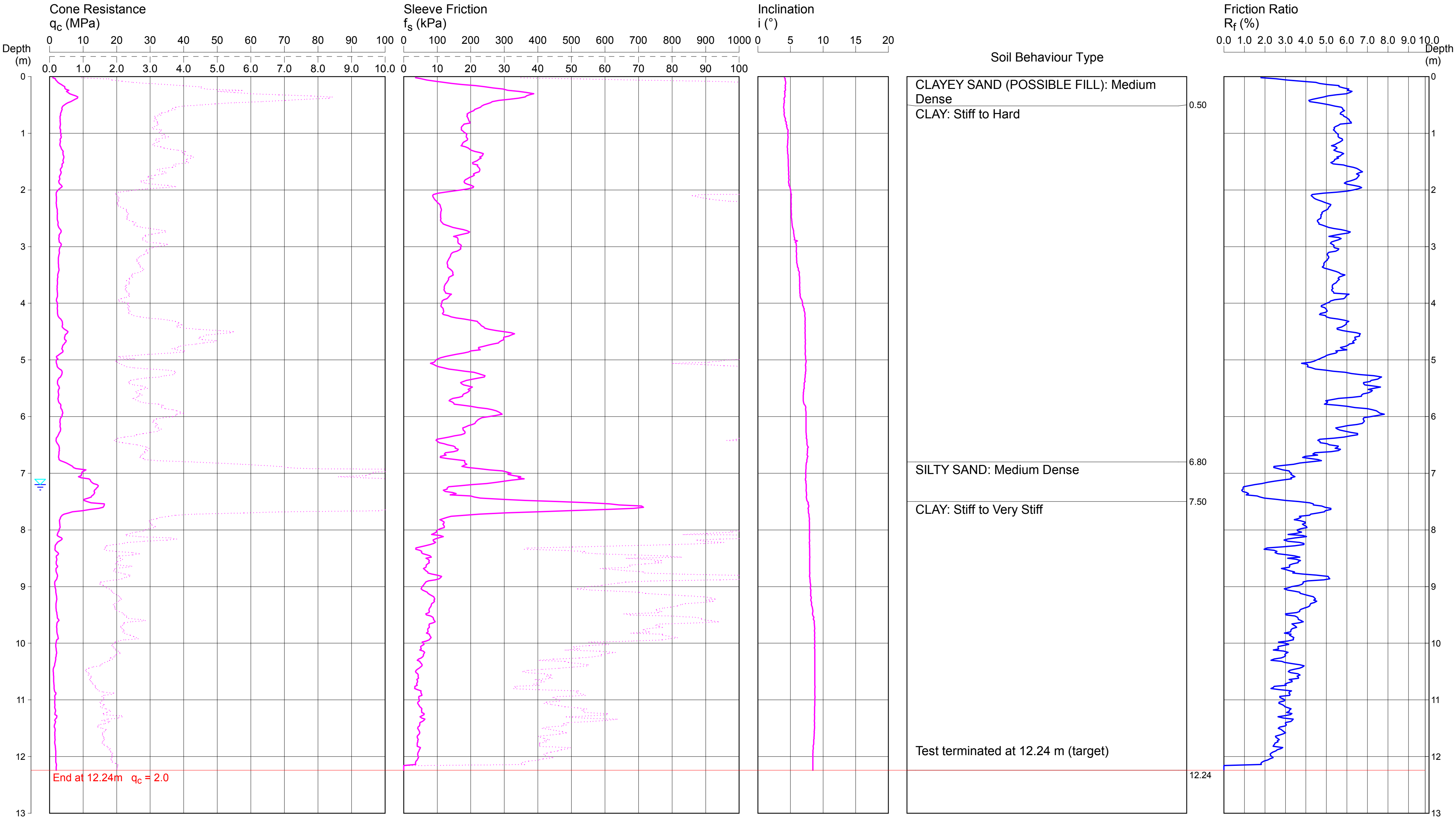
COORDINATES: 406463E 6473965N MGA Zone 50

CPT1

Page 1 of 1

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly availble LiDAR data.

Water depth after test: 7.20m depth (measured)

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT1.CP5

Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

REDUCED LEVEL: 5.5 m AHD

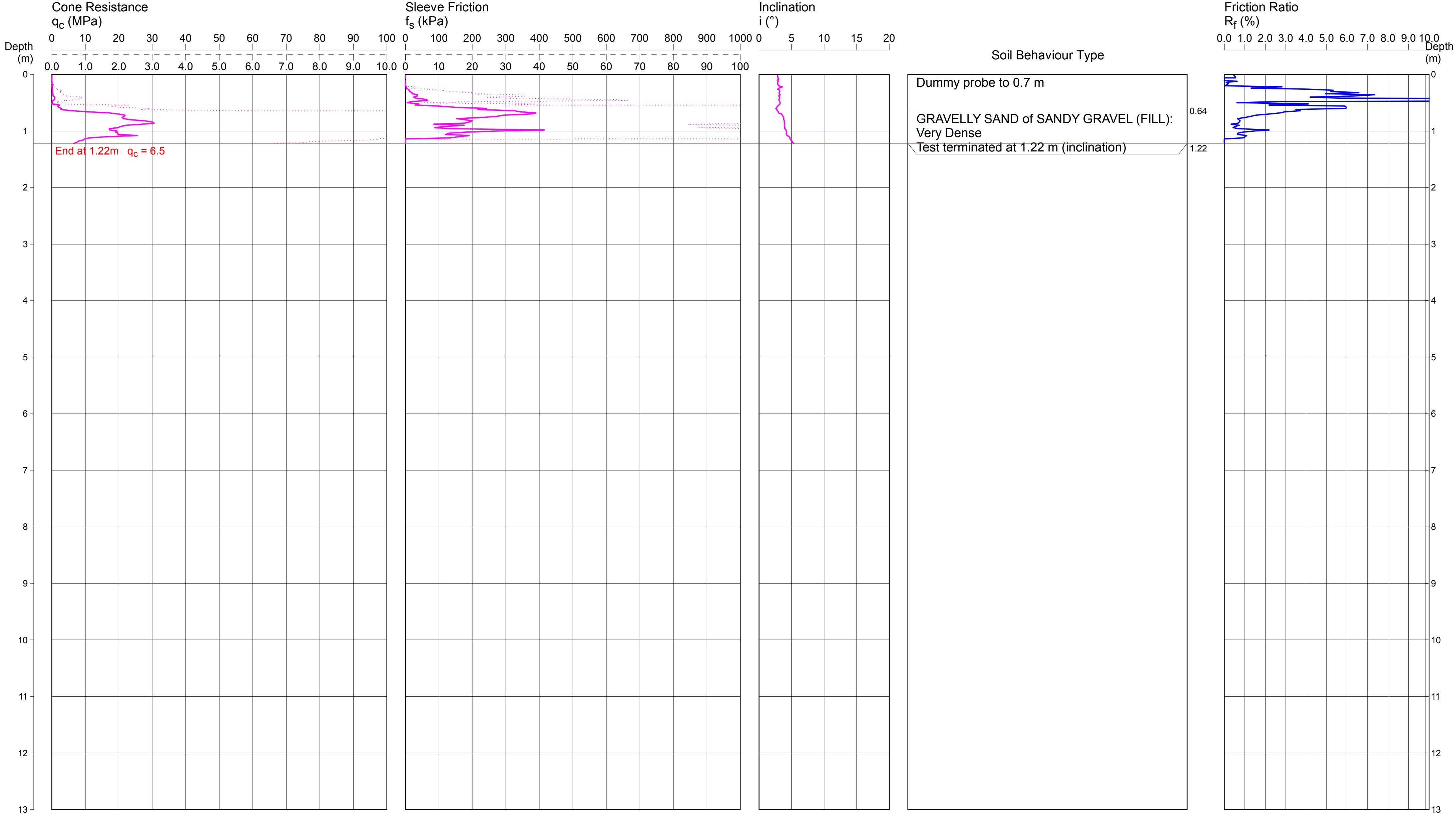
COORDINATES: 406483E 6473872N MGA Zone 50

CPT2A

Page 1 of 1

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels estimated from publicly available LiDAR data and site observations.

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT2A.CP5

Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

REDUCED LEVEL: 5.8 m AHD

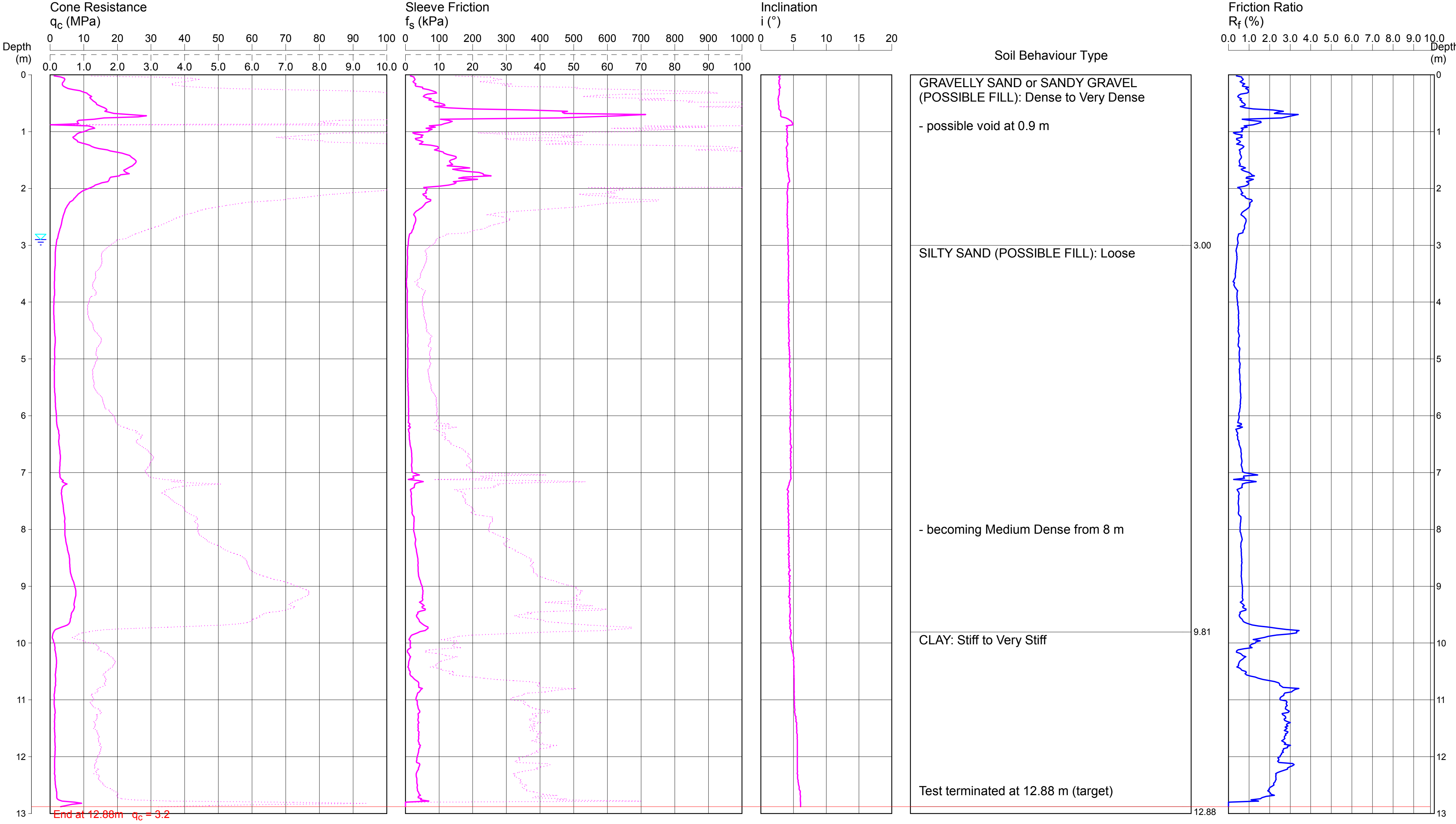
COORDINATES: 406403E 6473637N MGA Zone 50

CPT3

Page 1 of 1

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

Water depth after test: 2.90m depth (measured)

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT3.CP5
Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

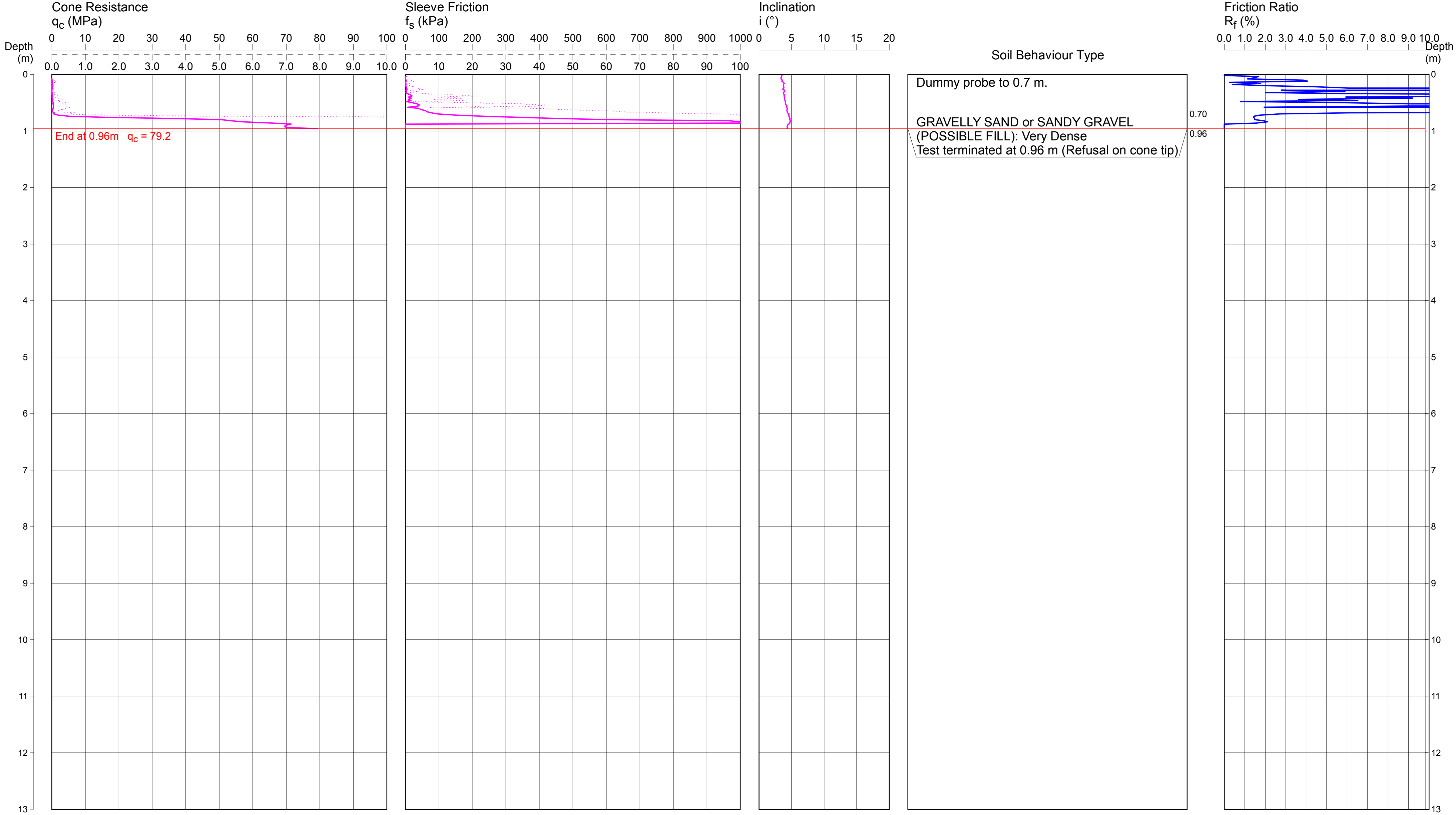
REDUCED LEVEL: 11.7 m AHD

COORDINATES: 406120E 6473251N MGA Zone 50

CPT4

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT4.CP5
Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

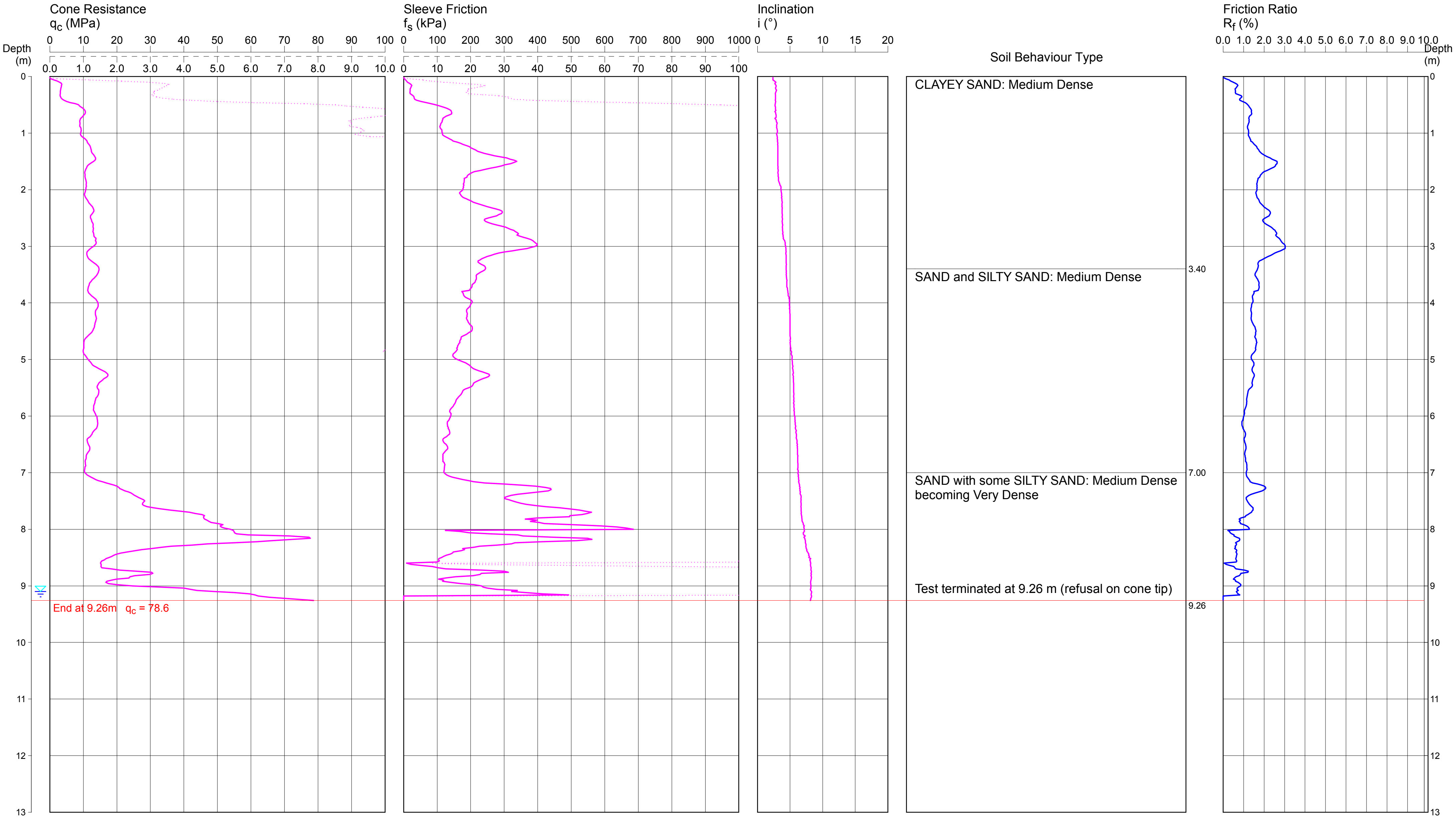
REDUCED LEVEL: 9.2 m AHD

COORDINATES: 405343E 6473459N MGA Zone 50

CPT5

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

Water depth after test: 9.10m depth (measured)

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT5.CP5
Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

Douglas Partners
Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

REDUCED LEVEL: 9.2 m AHD

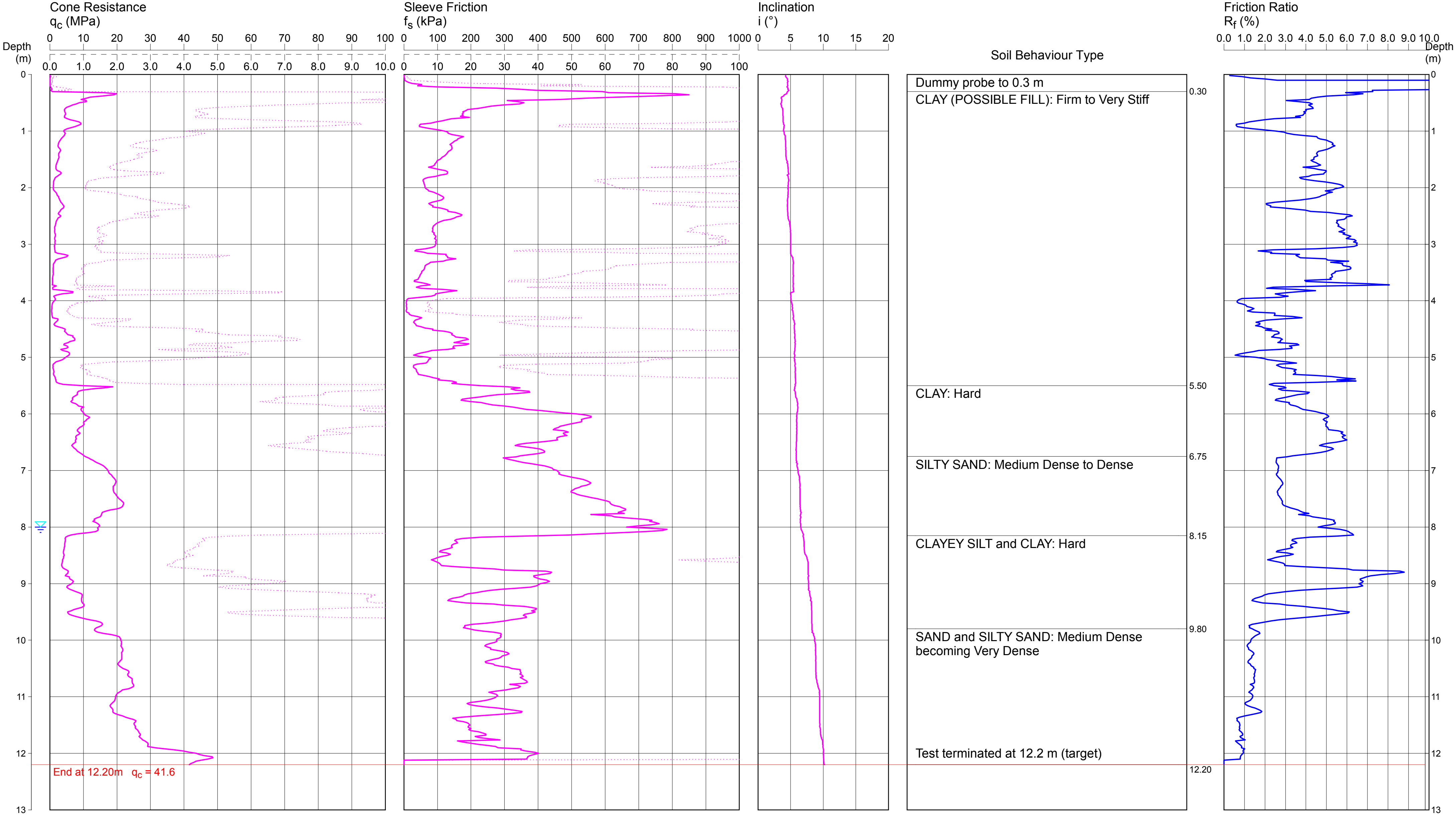
COORDINATES: 405713E 405713N MGA Zone 50

CPT6

Page 1 of 1

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

Water depth after test: 8.00m depth (measured)

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT6.CP5

Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

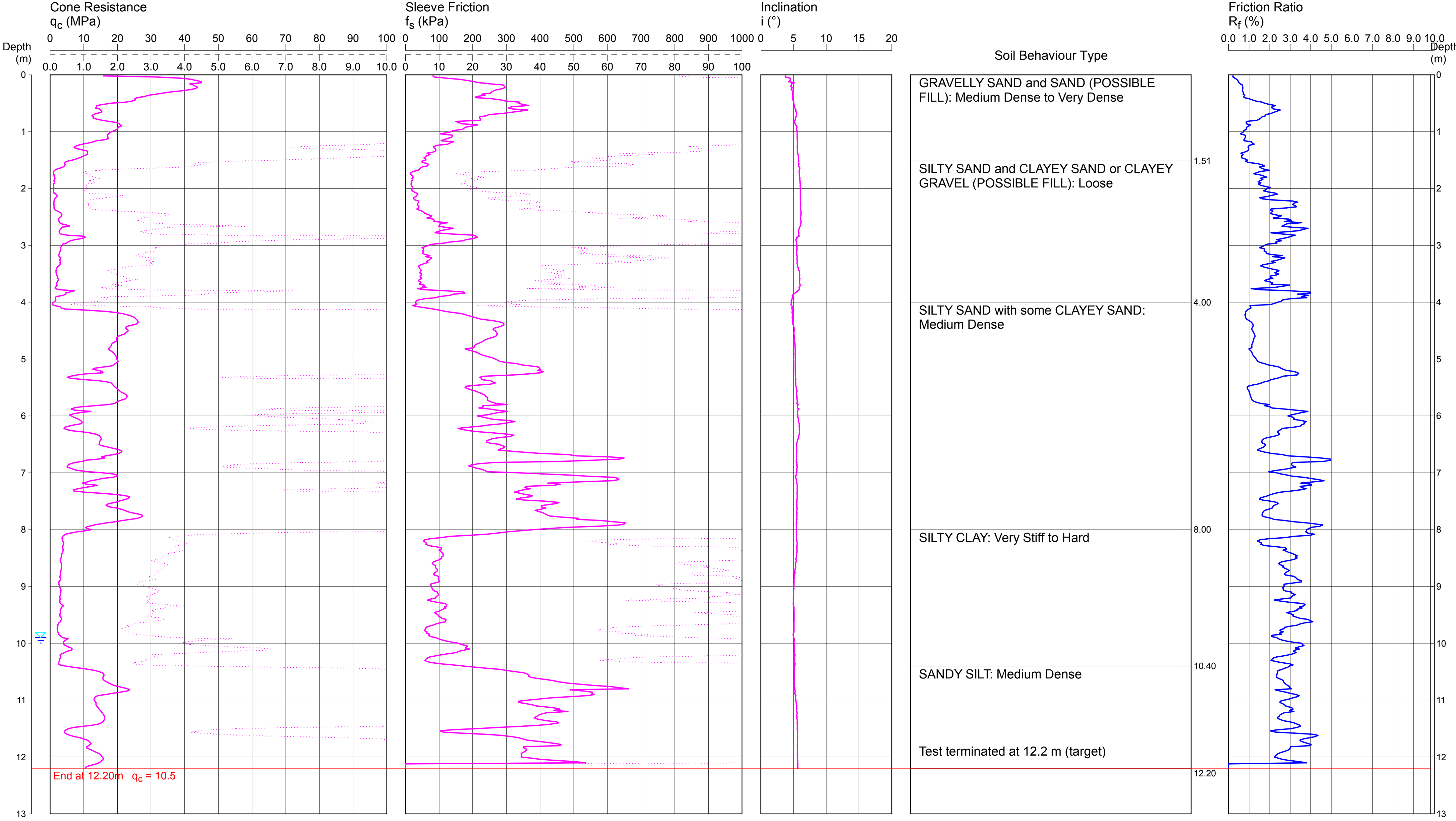
REDUCED LEVEL: 8.3

COORDINATES: 405590E 6472813N MGA Zone 50

CPT7

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

Water depth after test: 9.90m depth (measured)

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT7.CP5

Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: Linc Property Pty Ltd

PROJECT: Proposed Residential & Industrial Development

LOCATION: 102 Great Northern Highway, Middle Swan

REDUCED LEVEL: 9.5 m AHD

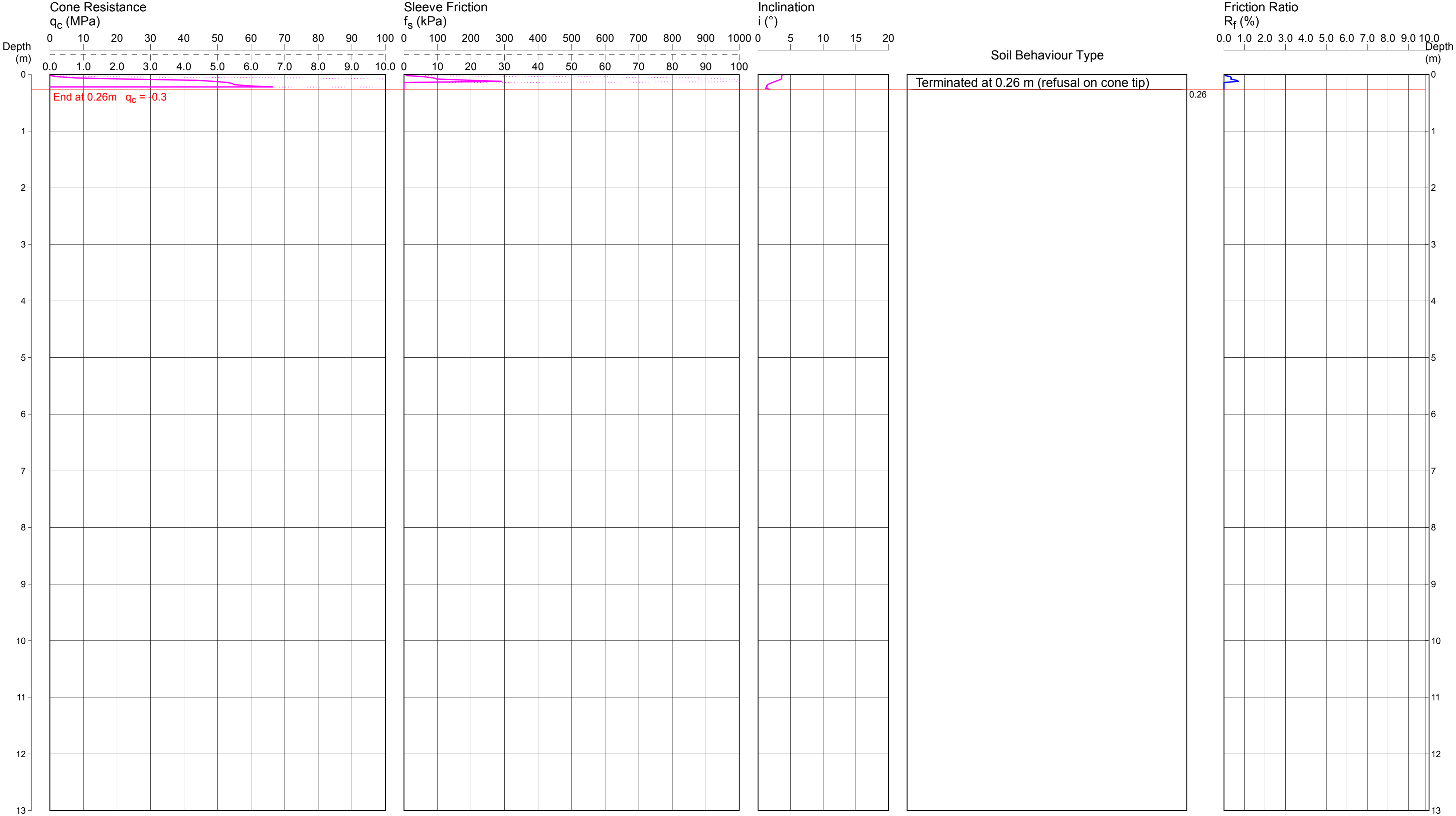
COORDINATES: 405758E 6472805N MGA Zone 50

CPT8

Page 1 of 1

DATE 21/06/2019

PROJECT No: 96584.01



REMARKS: Surface levels interpolated from publicly available LiDAR data.

File: P:\96584.01 - MIDDLE SWAN, 102 Gt Northern Highway\4.0 Field Work\CPTs\DP\96584.01 - CPT8.CP5
Cone ID: Probedrill **Type:** EC26

ConePlot Version 5.9.2

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TEST PIT LOG

CLIENT: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 10.2 m AHD*
EASTING: 406393
NORTHING: 6474041

PIT No: 9
PROJECT No: 96584.01
DATE: 24/6/2019
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) 5 10 15 20
10		FILL (SANDY CLAY, CI) - stiff, brown sandy clay, trace gravel and brick fragments and full sized bricks, moist. Sand is fine grained. Gravel is angular, fine to medium sized quartz).							
		- becoming hard from 0.45 m		B	0.6				>>
		- with brick fragments from 0.8 m to 1.0 m							
9	1	- slow digging and dry from 1.0 m							1
	1.3	Pit discontinued at 1.3m (slow digging)							
8	2								

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 5.7 m AHD*
EASTING: 406457
NORTHING: 6473795

PIT No: 10
PROJECT No: 96584.01
DATE: 24/6/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		FILL (GRAVELLY CLAY, CI) - hard, red-brown gravelly clay with sand, moist. Sand is fine to medium grained. Gravel is fine to coarse brick fragments). - red-brown mottled white and with cobble sized brick fragments from 0.25 m			0.3		PP >600 kPa		>>
	0.55			B	0.5		PP >600 kPa		
5		FILL (SANDY CLAY, CI) - hard, brown mottled red-brown sandy clay, trace gravel and brick fragments, moist. Sand is fine to medium grained.			0.7		PP >600 kPa		
					0.9		PP >600 kPa		
	1								1
	1.15				1.1		PP >600 kPa		
		Pit discontinued at 1.15m (slow digging)							
4	2								
3									

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 11.0 m AHD*
EASTING: 405541
NORTHING: 6473078

PIT No: 11
PROJECT No: 96584.01
DATE: 24/6/2019
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) 5 10 15 20
11		FILL (BRICK and GRAVELLY SAND, SP-SM) - bricks and red-brown mottled brown, fine to coarse grained gravelly sand, dry. Gravelly sand is crushed brick. Plastic and fabric observed.							>>
	0.55	FILL (SANDY GRAVEL, GP-GM) - yellow-brown, fine to coarse sized sandy gravel, dry. Gravel is lateritic.							
	0.75	CLAYEY SAND (CS) - hard/very dense, orange-brown mottled red-brown and grey, fine to medium grained clayey sand, dry. Hard digging.							
10	1			B	1.0				1
	1.1	SAND (SP-SC) - estimated dense, orange-brown, fine to medium grained sand with clay, dry.							
	1.5	Pit discontinued at 1.5m (slow digging)							
9	2								

RIG: 5 tonne excavator with 450 mm wide toothed bucket **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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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TEST PIT LOG

CLIENT: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 11.5 m AHD*
EASTING: 406038
NORTHING: 6473420

PIT No: 12
PROJECT No: 96584.01
DATE: 24/6/2019
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) 5 10 15 20
	0.15	FILL (SANDY GRAVEL, GS) - very dense, grey-brown, fine to coarse sized sandy gravel with cobbles, moist. Gravel and cobbles are concrete. Possible demolition debris.							>>
11		Pit discontinued at 0.15m (refusal on concrete)							
	1								
10									
	2								
9									

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 5.7 m AHD*
EASTING: 405523
NORTHING: 6473542

PIT No: 13
PROJECT No: 96584.01
DATE: 24/6/2019
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	FILL (TOPSOIL, SM) - dark brown, fine to medium grained silty sand, with organics, moist.							
	0.2 – 0.25	FILL (SANDY GRAVEL, GS) - very dense, red-brown, fine to coarse sized gravel, trace cobbles, moist. Gravel and cobbles are brick fragments.							>>
	0.4 – 0.45	FILL (GRAVELLY SAND, SP-SM) - pale brown, fine to coarse grained gravelly sand, moist. Gravel is fine to medium sized brick fragments.							
5	1	FILL (GRAVELLY CLAY, CI) - red-brown gravelly clay, moist. Gravel is fine to coarse sized ferricrete and brick fragments.							
		FILL (SANDY GRAVEL, GM) - grey, fine to coarse sandy gravel, moist. Crushed rock roadbase.							
4	1.6	FILL (BRICKS and SANDY GRAVEL, GS) - brick cobbles and fine to coarse sandy gravel (crushed bricks), dry. Occasional pieces of plastic, rubber, wood and wire observed.							
		Pit discontinued at 1.6m (bricks collapsing)							
3	2								

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 11.8 m AHD*
EASTING: 405522
NORTHING: 6473154

PIT No: 14
PROJECT No: 96584.01
DATE: 24/6/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		FILL (CLAYEY SAND, CS) - very stiff becoming hard, red-brown and brown, fine to medium grained clayey sand, with pockets of silty sand, moist. Concrete boulder and fabric observed.							
11	0.75 / 1	CLAY (CL) - red clay with sand, dry, low plasticity. Hard digging. - tree root approx. 5 cm diamter at 1 m deep.		B	1.2				>>
10 / 9	1.85 / 2	Pit discontinued at 1.85m (slow digging)							

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 11.2 m AHD*
EASTING: 405898
NORTHING: 6473062

PIT No: 15
PROJECT No: 96584.01
DATE: 24/6/2019
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)
11		FILL (SANDY GRAVEL, GS) - very dense, red-brown, fine to coarse sized gravel, trace cobbles and boulders, moist. Gravel and cobbles are ferricrete.		B	0.4				>>
10	0.45	FILL (SANDY CLAY, CI) - stiff, brown sandy clay, trace gravel and brick fragments and full sized bricks, moist. Sand is fine grained. Gravel is angular, fine to medium sized quartz). Hard digging. - increasing sand content from 0.9 m deep		D	0.8				
9	1.6	FILL (CLAYEY GRAVELLY SAND, SC) - estimated dense, red-brown mottled light brown clayey gravelly sand, dry to moist. Gravel is fine to coarse sized brick fragments. - carpet, wood and fabric pieces from 1.8 m deep - trace brick fragments and with ferricrete cobbles and occasionale boulders from 2.2 m		B	2.5				
	2.5	Pit discontinued at 2.5m (maximum excavator reach)							

RIG: 5 tonne excavator with 450 mm wide toothed bucket **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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

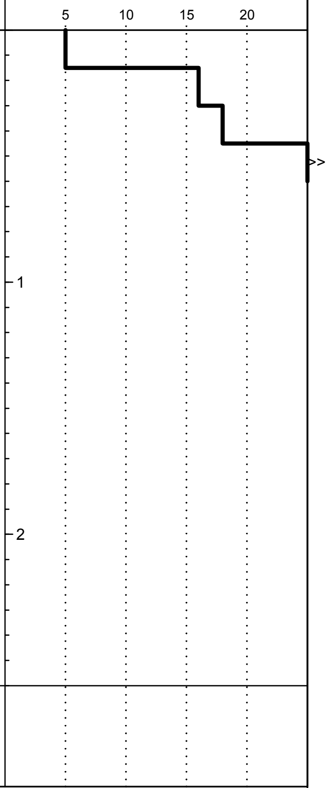
CLIENT: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 8.3 m AHD*
EASTING: 405709
NORTHING: 6472872

PIT No: 16
PROJECT No: 96584.01
DATE: 24/6/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		FILL (SANDY GRAVEL, GS) - very dense, red-brown, fine to coarse sized gravel, trace cobbles, moist. Gravel and cobbles are brick fragments.						
8	0.3	FILL (SAND, SP-SM) - blue-grey, fine to coarse grained sand with silt, moist.						
	0.4							
	0.6	FILL (SANDY CLAYEY GRAVEL, GC) - very dense, orange-brown, fine to coarse sized sandy clayey gravel, moist. Gravel is ferricrete. Sand is fine to coarse grained.						
	1	FILL (BRICKS and SAND, SP-SC) - estimated dense, brown, fine to medium grained sand with clay and bricks, moist.						
	1.2	FILL (CLAYEY GRAVEL, GC) - blue-grey, fine to medium sized clayey gravel, moist to wet. Gravel is subangular crushed granite aggregate.						
7	1.35							
	1.6	FILL (BRICKS and SAND, SP-SC) - estimated dense, brown, fine to medium grained sand with clay and bricks, moist.						
	2	FILL (GRAVELLY SANDY CLAY, CI) - grey-brown gravelly sandy clay, moist. Sand is fine to coarse grained. Gravel is fine to medium sized. - mottled red-brown and with brick fragments up to cobble size, moist to wet from 2.0 m						
6				B	2.5			
	2.6	Pit discontinued at 2.6m (maximum excavator reach)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 6.0 m AHD*
EASTING: 405721
NORTHING: 6473142

PIT No: 17
PROJECT No: 96584.01
DATE: 24/6/2019
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 mm) 5 10 15 20
6		FILL (SANDY GRAVEL, GP-SM) - grey-brown, fine to coarse sandy gravel, moist. Gravel is brick fragments, ferricrete and granitic. Plastic tape observed.							
	0.4	Pit discontinued at 0.4m (target depth)							
5	1								
4	2								

RIG: 5 tonne excavator with 450 mm wide toothed bucket **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 11.0 m AHD*
EASTING: 405728
NORTHING: 6472758

PIT No: 18
PROJECT No: 96584.01
DATE: 24/6/2019
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 mm) 5 10 15 20
11		FILL (SANDY CLAY, CI) - brown sandy clay with gravel, brick fragments and bricks, moist. Sand is fine to medium grained.							
	0.4	Pit discontinued at 0.4m (target depth)							
10	1								
9	2								

RIG: 5 tonne excavator with 450 mm wide toothed bucket
LOGGED: DJB
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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: Linc Property Pty Ltd
PROJECT: Proposed Residential & Industrial Development
LOCATION: 102 Great Northern Highway, Middle Swan

SURFACE LEVEL: 13.2 m AHD*
EASTING: 405519
NORTHING: 6473149

PIT No: 19
PROJECT No: 96584.01
DATE: 24/6/2019
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 mm) 5 10 15 20
13		FILL (CLAY, CI) - grey clay with sand, trace gravel, moist to wet.							
	0.2	FILL (SANDY CLAY, CL) - red-brown sandy clay, trace gravel, moist, low plasticity. Sand is fine grained.							
	0.5	Pit discontinued at 0.5m (target depth)							
12	1								
11	2								

RIG: 5 tonne excavator with 450 mm wide toothed bucket **LOGGED:** DJB **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater

REMARKS: *surface levels interpolated from publicly available LiDAR

☐ 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
Emerge Biophysical Assessment

TECHNICAL MEMORANDUM

Blackadder Creek Tributary Biophysical Assessment
Area 3 Middle Swan Brickworks Local Planning Scheme Amendment

PROJECT NUMBER	EP19-105(44)	**DOC. NUMBER**	EP19-105(44)--106 JDH
PROJECT NAME	Middle Swan Area 3	**CLIENT**	Hesperia
AUTHOR	JDH	**REVIEWER**	JDH
VERSION	1	**DATE**	18/11/2022

1 INTRODUCTION

1.1 Background

Hesperia Pty Ltd (the proponent) is supporting a Local Planning Scheme amendment to rezone Lot 9000 Cranwood Crescent, Viveash (the site) from 'General Industrial' to 'Residential (R20)' under the City of Swan (CoS) Local Planning Scheme (LPS) No.17 (referred to herein as 'the amendment'). The amendment is to facilitate future residential development following the decommissioning of a portion of the Middle Swan Brickworks land uses within the site. Following the progression of the amendment, a Local Structure Plan (LSP) will be prepared for the site which will guide the structure and layout of residential development to be progressed across the site.

The site is approximately 10 hectares (ha) in area and located within the CoS, approximately 17 km north-east from Perth Central Business District. The site currently comprises existing brickworks infrastructure, stormwater settlement ponds, hardstand areas and areas of degraded native and planted vegetation. The site is bound by the Cranwood Crescent residential development (WAPC subdivision approval reference #158848) and Eveline Road to the north, the Midland Brickworks operational areas to the north-east, Jack Williamson Park and La Salle College to the east and Cranwood Crescent and Ashby Gardens residential estate to the south and west. The site is currently zoned 'Urban' under the Metropolitan Region Scheme (MRS) and 'Industrial' under the CoS LPS No.17, as shown in **Plate 1** below. The location and extent of the site is also shown in **Figure 1**.

No natural surface water features have been identified within the site. However, the Swan River is located approximately 450 m to the north of the site and a tributary of the Blackadder Creek (referred to herein as 'the Blackadder Creek tributary') is located immediately to the south of the site within a public reserve incorporating Jack Williamson Park. The Blackadder Creek is a tributary of the Swan River, with its confluence to the west of the site.

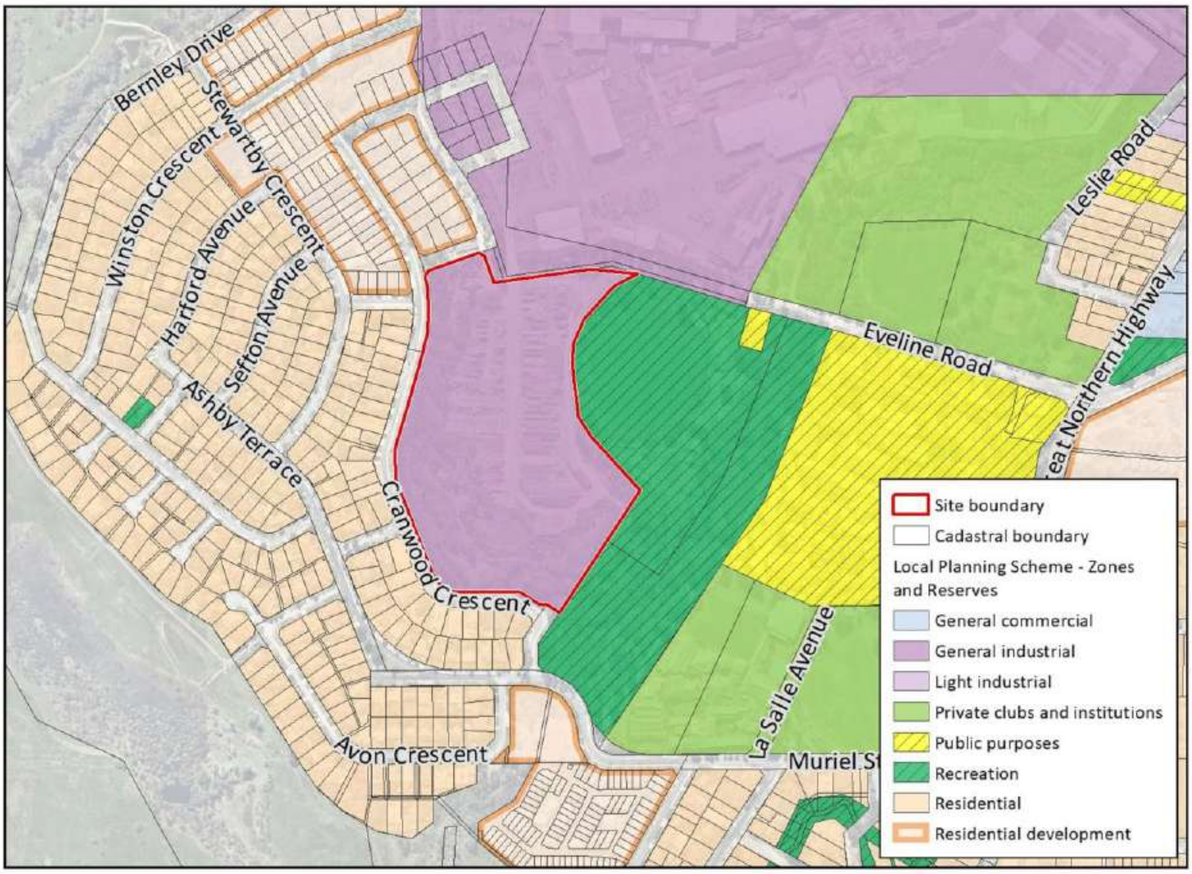

Plate 1: City of Swan LPS 17 zones and reserves within and surrounding the site (DPLH 2018)

The amendment was referred to the Environmental Protection Authority (EPA) pursuant to section 48A of the *Environmental Protection Act 1986*. As part of the amendment referral process, queries were raised regarding the Blackadder Creek tributary and the extent to which an adequate foreshore area would be provided for during the future land use planning processes.

1.2 Purpose of this document

The purpose of this document is to outline a biophysical assessment undertaken for the Blackadder Creek tributary to be considered as part of the future land use planning processes, and in particular the preparation of the LSP and the subsequent subdivision stages. Specifically, this biophysical assessment for the Blackadder Creek tributary will inform both the LSP layout and the associated Local Water Management Strategy (LWMS) that is being prepared to support the LSP.

2 SUMMARY OF SITE CONTEXT

A minor waterway that is a tributary of the Blackadder Creek is situated to the southeast of the LSP area, the location of which is shown in **Figure 2**. The amendment was supported by a LWMS (Hyd2O 2021), which has been subsequently updated to also support the preparation of the LSP (Hyd20 2022).

The LWMS (Hyd20 2022) acknowledges the presence of the Blackadder Creek tributary and identifies that there is a surface water transfer from the LSP area to the Blackadder Creek tributary at the southern extent of the LSP area. In addition, the LWMS considers the 1% Annual Exceedance

Probability (AEP) flood flows and confirms that these are external to the LSP area (i.e. the flood flows do not extend into the LSP area).

The stormwater management approach for the LSP area, as documented in the LWMS, seeks to maintain pre and post development hydrological regimes. This has been considered from both a flow rate and volumetric (i.e. water balance) viewpoint, and a stormwater retention area has been provided for within public open space within the LSP layout to accommodate this.

In terms of on-site assessments, Emerge Associates undertook a detailed flora and vegetation assessment in 2019 (Emerge Associates 2020) and a basic fauna and targeted black cockatoo assessment for the Local Structure Plan area in 2019 and 2021 (Emerge Associates 2022). Vegetation communities, vegetation condition and large tree locations are shown on **Figure 3** and **Figure 4**. Emerge Associates also undertook additional site inspection and vegetation survey of the public reserve adjacent to the LSP area within which the Blackadder Creek tributary is situated to inform this biophysical assessment in Spring (i.e. October) 2022 (see **Figure 5**).

In regard to the key biophysical considerations for the Blackadder Creek tributary as relevant for the LSP area:

- There is no riparian vegetation or riparian wetlands that extend into the LSP area, which has been confirmed by the investigations undertaken to support the amendment. There are very limited flora and vegetation values that occurs within the LSP area.
- The 1% AEP floodplain for the Blackadder Creek tributary does not extend into the LSP area.
- The landform and soils within the LSP area have been substantially modified associated with historic industrial uses associated with the operation of the brickworks as shown in **Figure 1** and **Figure 8**.
- The closest the Blackadder Creek tributary is situated to the LSP area is 43 m and extends up to 91 m from the south-eastern boundary, which is shown in **Figure 6**.
- The Blackadder Creek tributary is situated within a vegetated corridor that provides separation from the LSP area and the proposed change in land use. Notwithstanding this, redevelopment of the LSP area provides opportunities to improve the interface and relationship of the existing industrial area with the Blackadder Creek tributary.

Therefore, in summary the implementation of the proposed LSP does not pose any risk of impacts to the Blackadder Creek tributary and based on existing and available information there is an adequate setback given the relevant biophysical considerations, including the presence of confirmed Threatened Ecological Community (TEC) occurrences located outside of the LSP area.

3 POLICY FRAMEWORK

Government policy and guidance relating to waterways foreshore areas is primarily administered by the Department of Water and Environmental Regulation (DWER). A number of guidance documents assist with the determination of appropriate foreshore areas, and these include:

- *Operation Policy 4.3: Identifying and establishing waterways foreshore areas* (DoW 2012)
- *Guidance Note 6: Identifying and establishing waterways foreshore areas* (DoW 2013)
- *Water Note 23: Determining foreshore reserves* (WRC 2001).

The following biophysical criteria require consideration when identifying a foreshore area (WRC 2001):

- Vegetation – the extent of the riparian vegetation
- Hydrology – the extent of the floodway/floodplain
- Soil type – soil types that typically support riparian vegetation
- Erosion – soil types that are prone to erosion
- Topography – landscape features
- Function – foreshore function
- Habitat – valuable habitat areas
- Land use – areas that might be harmed by adjacent land use pressures.

4 BIOPHYSICAL ASSESSMENT

A biophysical assessment has been undertaken to determine the location and extent of any required foreshore area (i.e. the area required to protect the waterway that occurs adjacent to the site from potential development impacts) for the Blackadder Creek tributary, to confirm whether this extends into the LSP area. The biophysical assessment informs spatial planning for the LSP.

The biophysical criteria listed in **Section 3** have been considered against the known existing environmental conditions and includes observations and data from on-site assessments as well as existing background information. The biophysical assessment is summarised below in **Table 1**.

In the context of the following criteria and their application for the purposes of the assessment, it is important to note that the Blackadder Creek tributary is situated entirely outside of the LSP area, upon land that has already been ceded to and under the management of CoS. This area is referred to as the 'public reserve' in the assessment below and is already in place from both a spatial and management perspective regardless of the proposed LSP. Therefore, the focus of this assessment has been the section of the Blackadder Creek tributary immediately adjacent to the LSP area, and to determine the extent to which any additional foreshore area beyond the existing public reserve is required (or not) to be accommodated within the LSP area.

Table 1: Biophysical criteria and assessment

Biophysical factor	Assessment of biophysical factor	Spatial implications of biophysical factor
Vegetation	Vegetation surveys have been undertaken within the LSP area which have confirmed that there are limited flora and vegetation values that occur within the LSP area (see **Figure 3** and **Figure 4**). Vegetation survey of the public reserve surrounding the Blackadder Creek tributary has indicated that a number of TECs occur within the public reserve. The extent of these are shown on **Figure 5**, which have been refined from Department of Biodiversity Conservation and Attractions (DBCA) known occurrence mapping by Emerge Associates based on recent vegetation survey.	The majority of the identified TEC occurrences occur on the southern side of the Blackadder Creek tributary, which is the opposite side to the LSP area. Where the known extent of a TEC occurs in closer proximity to the LSP area, an area of public open space is provided for in the LSP layout. The entire known extent of the TECs occur within the existing public reserve adjacent to the LSP area, and none occur within the LSP area itself.
Hydrology	The existing waterway is aligned adjacent to but external to the LSP area. The ephemeral tributary conveys surface water to the Blackadder Creek, which ultimately discharges to the Swan River.	All areas inundated in a 1% AEP event are included in the existing public reserve area and do not extend into the LSP area.

Biophysical factor	Assessment of biophysical factor	Spatial implications of biophysical factor
	The inundated areas have been delineated using surveyed contours of the waterway corridor and 1% AEP flood depths from 1D modelling analysis. The spatial extent of the 1% AEP inundated area is shown on **Figure 7**.	
Topography	The topography surrounding and including the Blackadder Creek tributary involves gentle slopes, and the channel of the waterway is minor and not significantly incised. The waterway channel and associated banks are fully contained within the public reserve within which the Blackadder Creek tributary is situated. The land associated with the LSP has been subject to substantial historic modification, and in particular large earthen bunds along its western and southern boundaries as shown in **Figure 1**. The existing topographic contours are shown in **Figure 8**.	Given the gentle topography of the waterway and its channel and banks, there is no spatial consideration or topographical limitation that extends from the public reserve into the LSP area. The development of the LSP area will involve the rectification of the modified landform and the provision of a managed interface (i.e. a public road reserve and public open space) immediately adjacent to the existing public reserve within which the Blackadder Creek tributary is situated.
Soil Type	Both the public reserve within which the Blackadder Creek tributary is situated, and the LSP area are generally underlain by pebbly silt (described as strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin (DMIRS 2018)).	There is no clear delineation of soils associated with riparian vegetation that would need to be accommodated by a foreshore area/reserve, as the soils are the same across the existing public reserve and the LSP area.
Erosion	The generally gently inclined nature of the waterway and its banks means there is a low potential for channel changes to occur.	Any development adjacent to the existing public reserve containing the Blackadder Creek tributary (i.e. within the LSP area) will need to ensure that sufficient flow mitigation and erosion protection is incorporated, however there are no immediate spatial limitations or considerations.
Function	Historical function of the waterway is flood conveyance to the Blackadder Creek and the retention of riparian vegetation, TECs and fauna habitat.	The future function of the foreshore area within the public reserve will be flood detention and conveyance and retention of existing vegetation including riparian, TEC and fauna habitat values.
Habitat	No detailed fauna surveys have been undertaken across the existing public reserve within which the Blackadder Creek tributary is situated. Notwithstanding this, it is expected that the riparian vegetation aligning the Blackadder Creek tributary will provide foraging and potential breeding habitat for black cockatoos. The vegetation within the public reserve forms a corridor of native vegetation that would enable the movement of a range of fauna species. The fauna habitat value of the adjacent areas within the LSP area are limited given the extent of historic clearing and the lack of native vegetation within the LSP area.	Existing vegetation (including riparian vegetation) within the public reserve is likely to provides some measure of fauna habitat and all vegetation within and immediately surrounding the waterway within the public reserve should be retained. There are limited fauna habitat values within the adjacent LSP area, therefore there is no requirement for an additional foreshore area extending into the LSP area.
Land Use	The areas immediately adjacent to the Blackadder Creek tributary form part of an existing public reserve. Within the LSP area, the	The areas immediately adjacent to the Blackadder Creek tributary will continue to fall within a City of Swan managed public

Biophysical factor	Assessment of biophysical factor	Spatial implications of biophysical factor
	land has historically been used for industrial purposes associated with the long-term operation of the Middle Swan Brickworks.	reserve. The areas within the adjacent LSP will be subject to residential development, but with a public road reserve interface/boundary and an area of public open space situated immediately adjoining the public reserve. There would be no requirement to alter or modify any of the vegetation within the public reserve to implement the LSP, including for bushfire management purposes.

5 PROPOSED FORESHORE AREA RECOMMENDATIONS

Based on the information provided in **Table 1**, and in relation to the protection and management of the Blackadder Creek tributary and the any considerations within the LSP, the following is recommendations are provided:

- The foreshore area should include the full extent of the land included in the existing public reserve that includes the Blackadder Creek tributary.
- The existing public reserve will include the outermost extent of 1% AEP flooding as shown in **Figure 7**.
- Given the proposed public road reserve and public open space interface within the proposed LSP as shown in **Figure 6**, there would be no requirement for additional management interfaces or separations for the Blackadder Creek tributary beyond the existing public reserve.
- Stormwater flows from the LSP area should be managed (in terms of location, rates and volumes) to take into consideration the waterway, riparian vegetation and the location of known TEC occurrences as shown in **Figure 5**.
- The public reserve incorporating the Blackadder Creek tributary should be managed so as to maintain and enhance the waterway, inclusive of vegetation and fauna habitat values, and to ensure that the implementation of the LSP does not require any impact to the public reserve (including for stormwater conveyance and bushfire management purposes).
- The LSP should include the requirement for the preparation of a Foreshore Management Plan (FMP) for the section of the public reservation aligning the LSP area to ensure that the delivery of subdivision works (including landscape works) do not impact on the Blackadder Creek tributary and its associated foreshore area. The extent of this area is shown in **Figure 9**.

6 REFERENCES

6.1 General references

Department of Mines Industry Regulation and Safety (DMIRS) 2018, *1:50,000 Geological Series Map* - Fremantle (2033 IV).

Department of Water (DoW) 2012, *Operational policy 4.3: Identifying and establishing waterways foreshore areas*, Perth.

Department of Water (DoW) 2013, *Guidance Note 6: Identifying and establishing waterways foreshore areas*, Perth, Western Australia.

Emerge Associates 2020, *Technical Memorandum - Flora and Vegetation Assessment Part Lots 23 Winston Crescent and 73 Eveline Road, Middle Swan*, EP19-105(07)--035 RAW, Version 1.

Emerge Associates 2022, *Technical Memorandum - Fauna Assessment Part Lots 23 Winston Crescent and 73 Eveline Road, Middle Swan*, EP19-105(26)--036A RAW, Version A.

Hyd2o Hydrology 2021, *Local Water Management Strategy - Watermark Area 3*

Hyd2o Hydrology 2022, *Rivermark Area 3 Local Water Management Strategy*

Water and Rivers Commission (WRC) 2001, *Water Note 23: Determining Foreshore Reserves*, East Perth.

Figures

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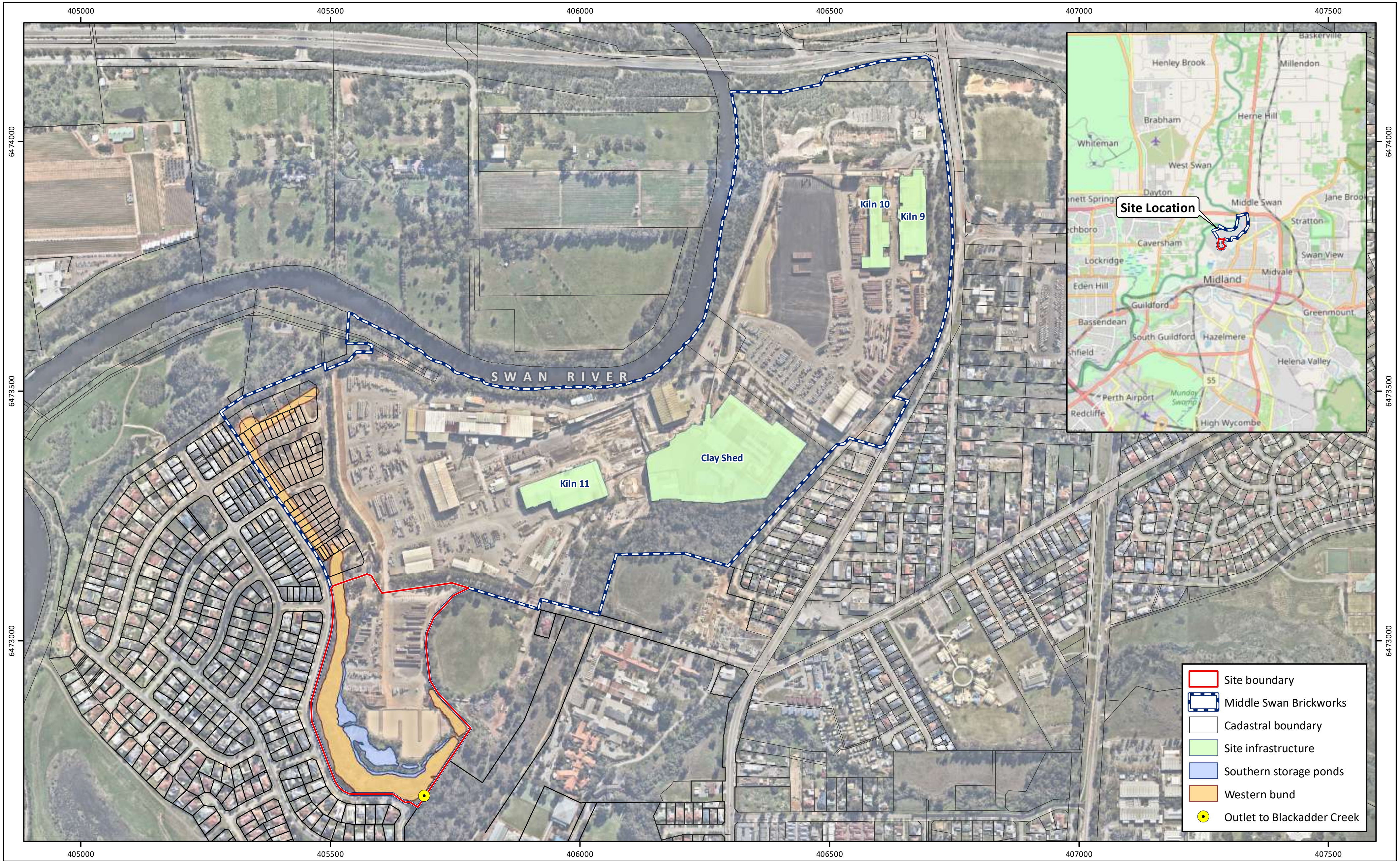

Figure 1: Location Plan

Scale: 1:10,000@A4

GDA 1994 MGA Zone 50

Project:	Middle Swan Area 3 Amendment Support
Client:	Hesperia Pty Ltd

Plan Number:
EP19-105(44)--F317

Drawn:	GAR
Date:	18/11/2022
Checked:	JDH
Approved:	JDH
Date:	18/11/2022

emerge ASSOCIATES

Figure 2:	**Location of Blackadder Creek Tributary**	**Plan Number: EP19-105(44)--F318** Drawn: GAR Date: 18/11/2022 Checked: JDH Approved: JDH Date: 18/11/2022	0 50 100 Metres Scale: 1:3,750@A4 GDA 1994 MGA Zone 50	emerge ASSOCIATES
Project:	Middle Swan Area 3 Amendment Support			
Client:	Hesperia			

Figure 3:	**Plant Communities and Trees within the LSP Area**
Project:	Middle Swan Area 3 Amendment Support
Client:	Hesperia

Plan Number:
EP19-105(44)--F319
Drawn: GAR
Date: 18/11/2022
Checked: JDH
Approved: JDH
Date: 18/11/2022

N

0 50 100
Metres
Scale: 1:3,750@A4
GDA 1994 MGA Zone 50

emerge
ASSOCIATES

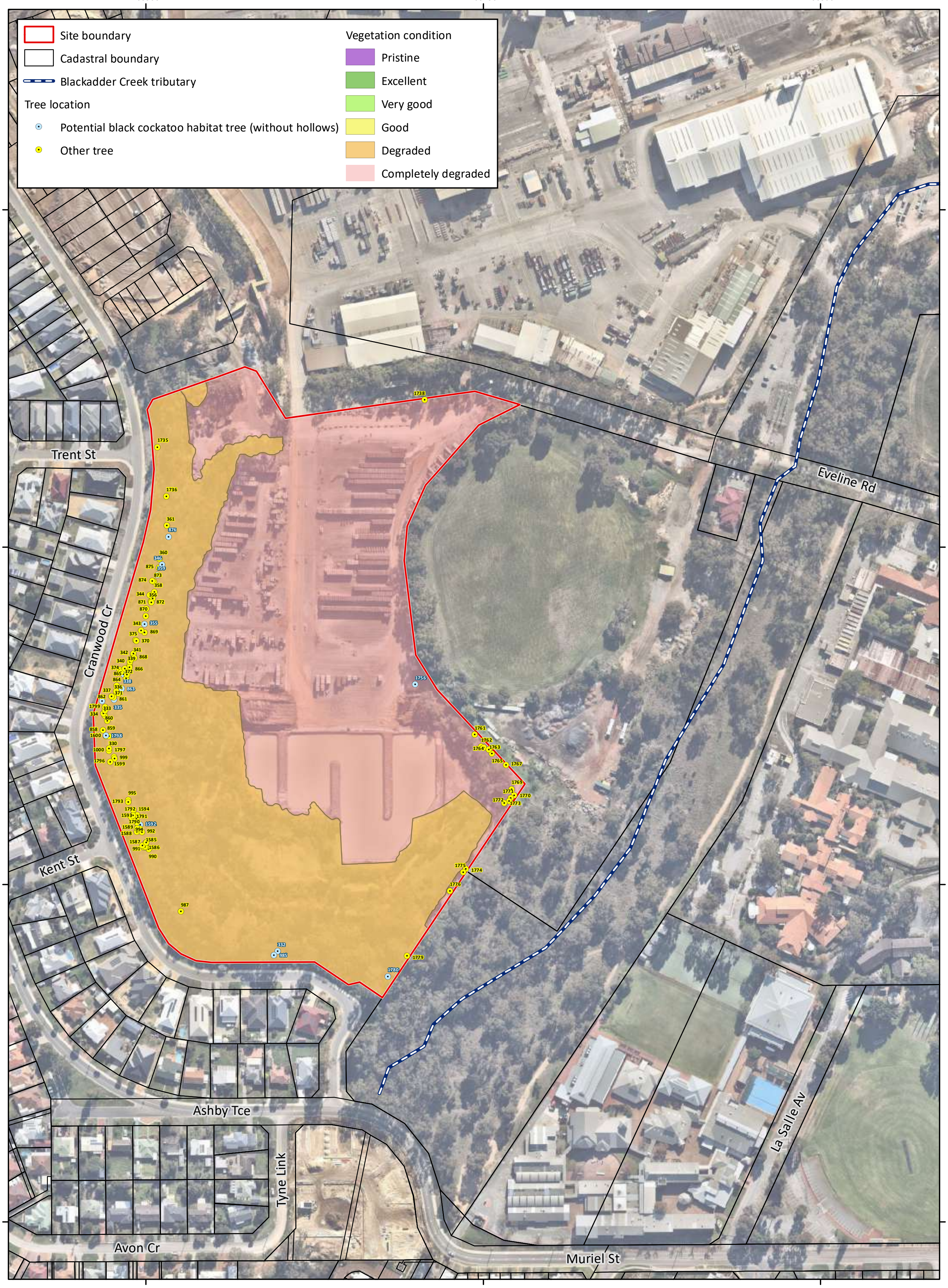

Figure 4: **Vegetation Condition and Trees within the LSP Area**

Project: Middle Swan Area 3 Amendment Support

Client: Hesperia

Plan Number: EP19-105(44)--F320
Drawn: GAR
Date: 18/11/2022
Checked: JDH
Approved: JDH
Date: 18/11/2022

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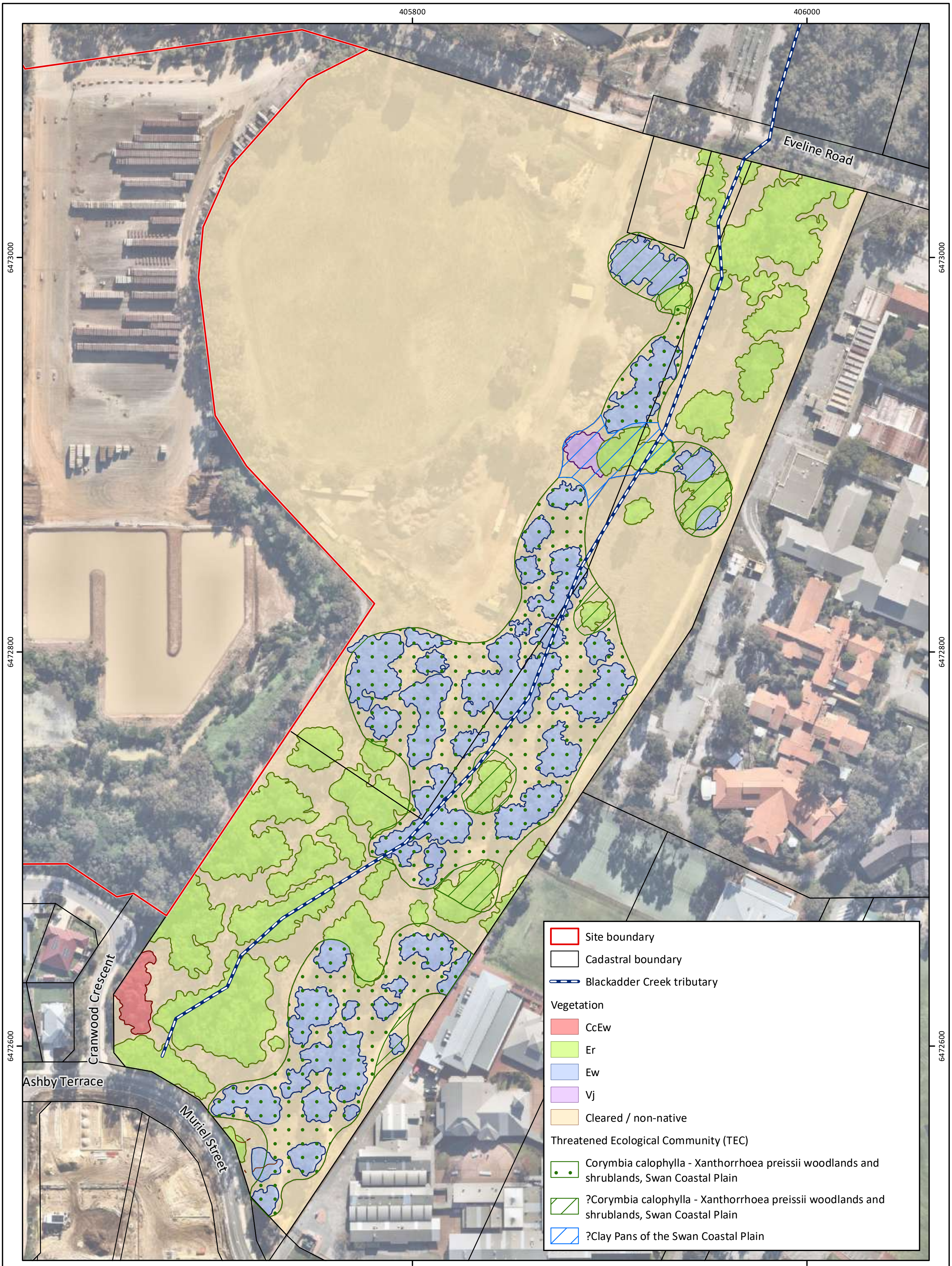

Figure 5: **Known TEC Occurrences within Public Reserve**

Project: Middle Swan Area 3 Amendment Support

Client: Hesperia

Plan Number: **EP19-105(44)--F321**
Drawn: GAR
Date: 18/11/2022
Checked: JDH
Approved: JDH
Date: 18/11/2022

emerge ASSOCIATES

Figure 6:	**Proposed LSP Layout and Separation from Blackadder Creek Tributary**
Project:	Middle Swan Area 3 Amendment Support
Client:	Hesperia

Plan Number:
EP19-105(44)--F322
Drawn: GAR
Date: 18/11/2022
Checked: JDH
Approved: JDH
Date: 18/11/2022

N

0 50 100
Metres
Scale: 1:3,750@A4
GDA 1994 MGA Zone 50

emerge
ASSOCIATES

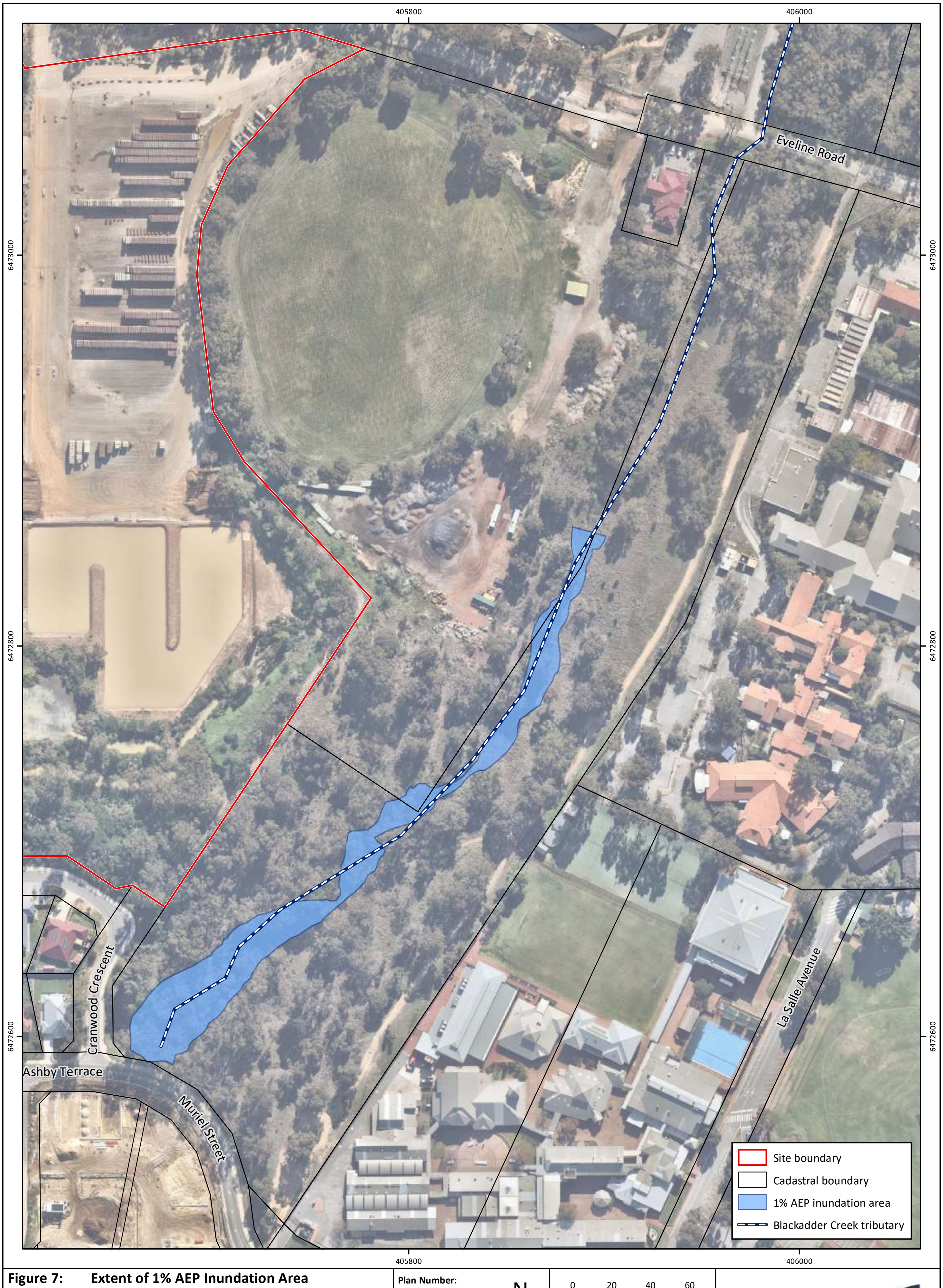

Figure 7: **Extent of 1% AEP Inundation Area**

Project: Middle Swan Area 3 Amendment Support

Client: Hesperia

Plan Number:
EP19-105(44)--F323
Drawn: GAR
Date: 18/11/2022
Checked: JDH
Approved: JDH
Date: 18/11/2022

N

0 20 40 60
Metres
Scale: 1:2,500@A4
GDA 1994 MGA Zone 50

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While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used.

Figure 8:	**Topographic Contours**	**Plan Number:** EP19-105(44)--F324	Scale: 1:2,500@A4
Project:	Middle Swan Area 3 Amendment Support	Drawn: GAR Date: 18/11/2022 Checked: JDH Approved: JDH Date: 18/11/2022	GDA 1994 MGA Zone 50
Client:	Hesperia		

emerge ASSOCIATES

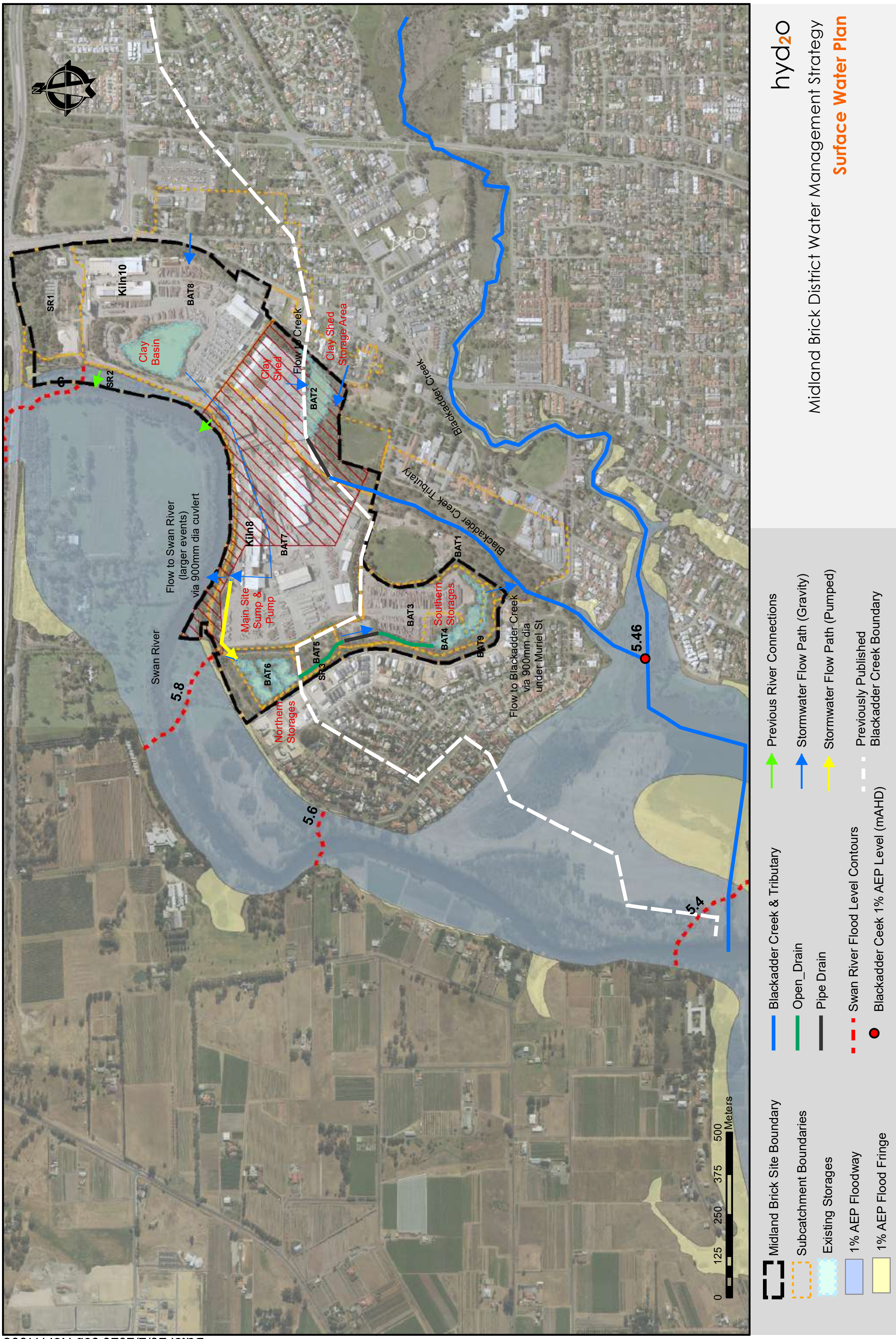
Figure 9:	**Proposed Extent of Foreshore Management Plan**	**Plan Number:** **EP19-105(44)--F325** Drawn: GAR Date: 18/11/2022 Checked: JDH Approved: JDH Date: 18/11/2022	
Project:	Middle Swan Area 3 Amendment Support		
Client:	Hesperia		

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used.

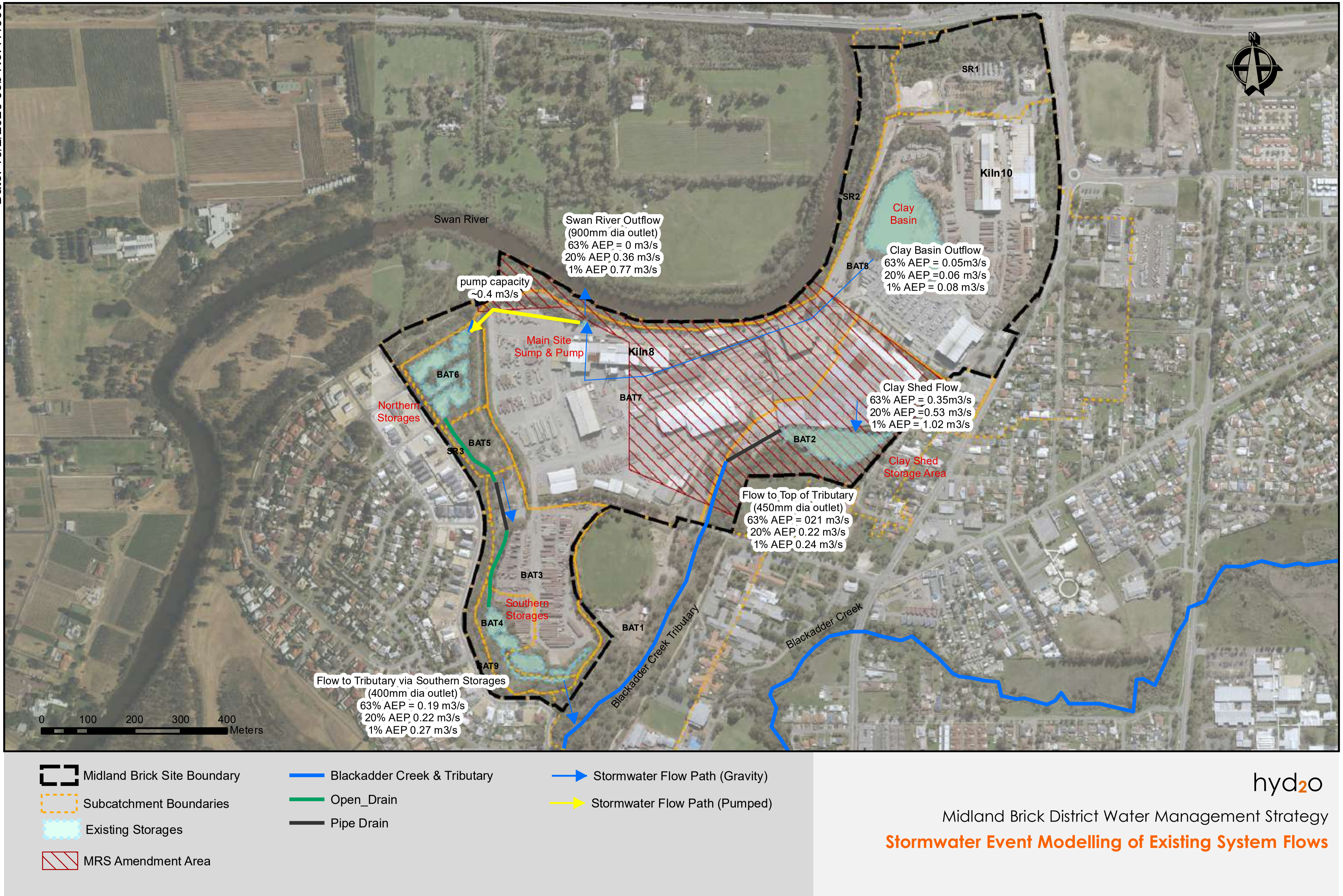
APPENDIX D
Existing System Stormwater Modelling Extracts
(Hyd2o 2020a, 2020b, 2020c, 2020d)

DWMS EXISTING SYSTEM & FLOODPLAIN MAPPING



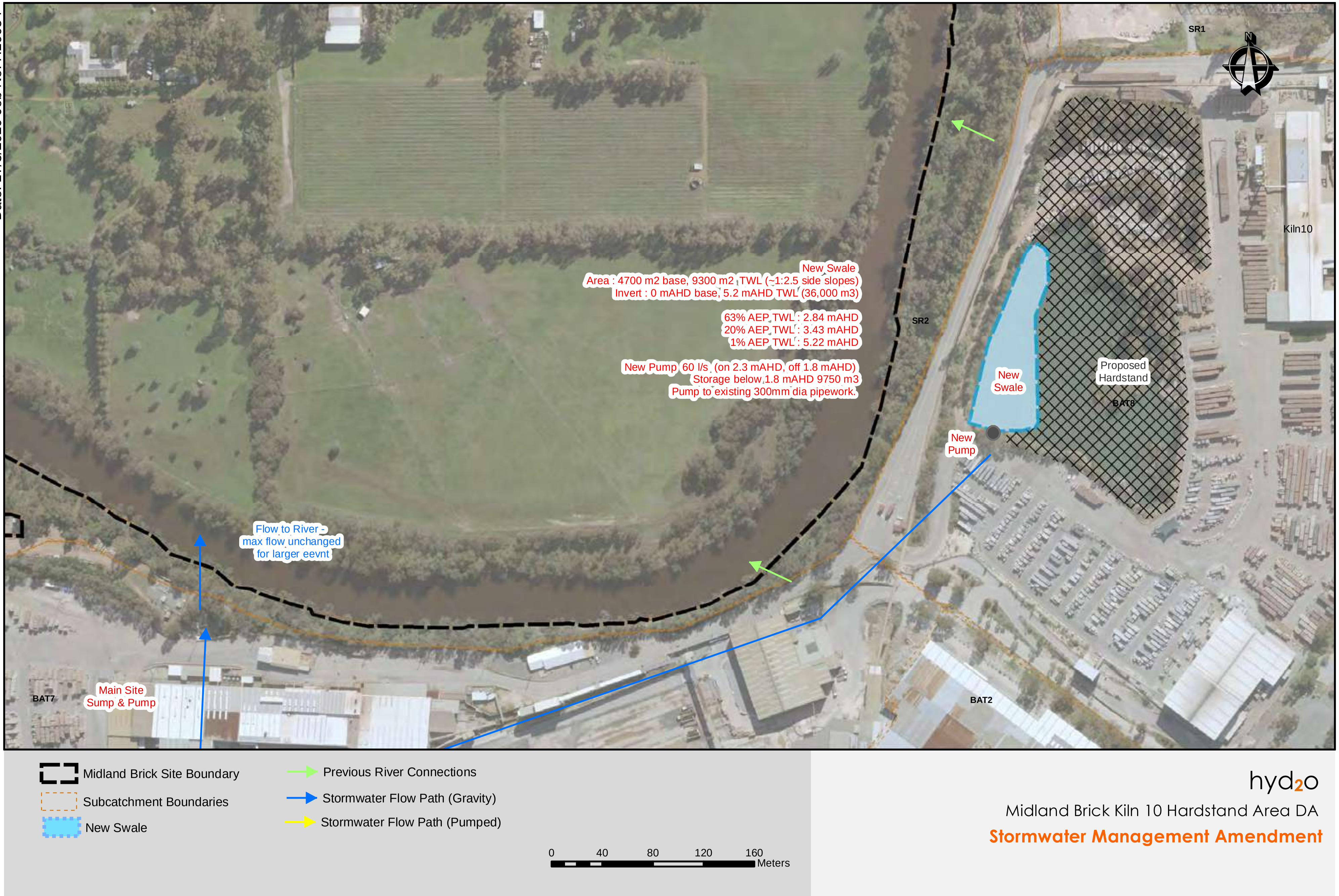
Date: 26/2/2020 Job No. H19054

DWMS EXISTING SYSTEM MODELLING



Date: 10/2/2020 Job No. H19054

Date: 17/3/2020 Job No. H19054

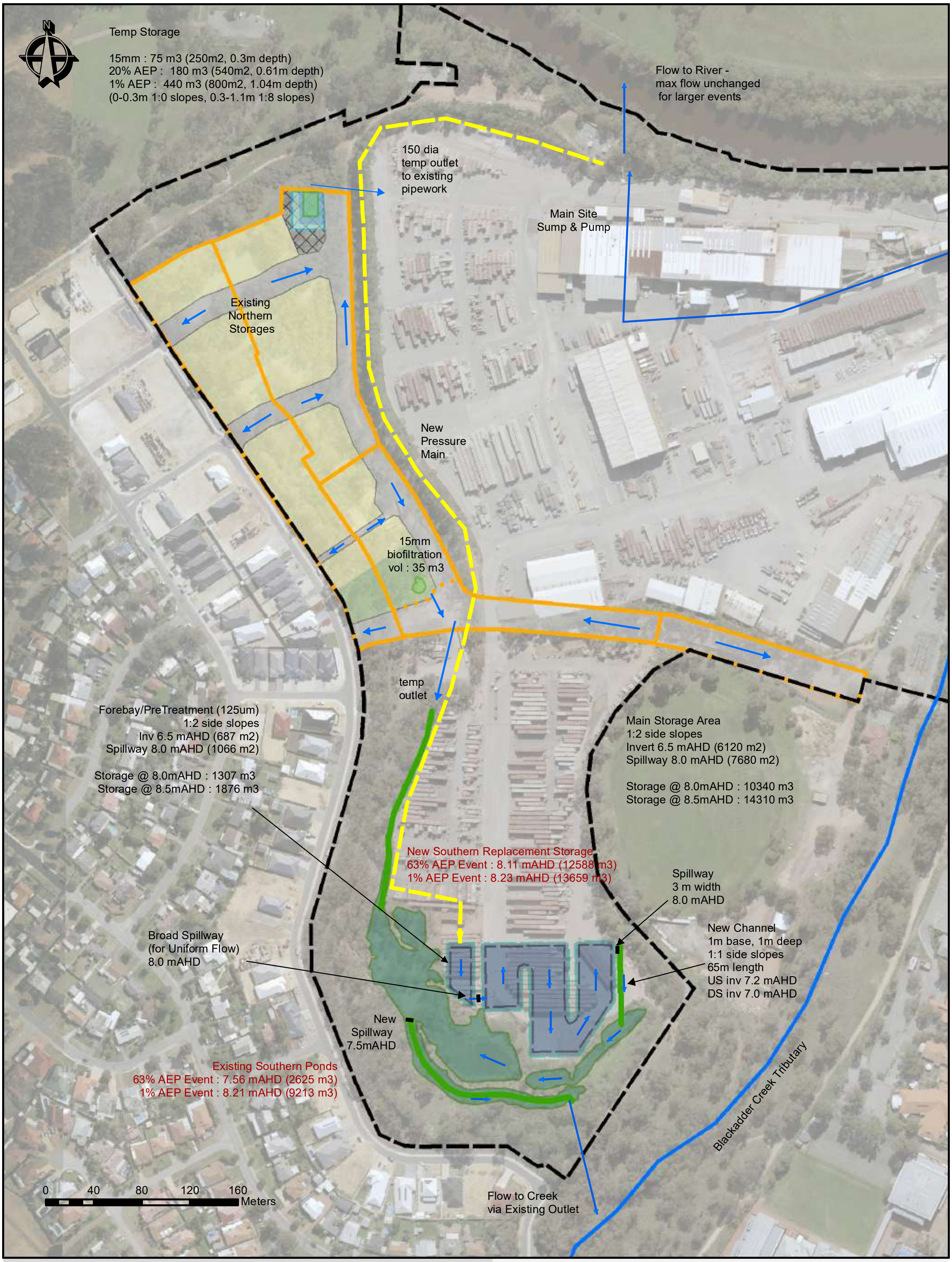


hyd2o

Midland Brick Kiln 10 Hardstand Area DA

Stormwater Management Amendment

Date: 27/5/2020 Job No. H19054



- Site
- Temp Storage
- 63% AEP
- 20% AEP
- 1% AEP
- Lots
- POS
- Road
- Existing Southern Ponds (area @ 8mAHD)
- Replacement Southern Storage (area @ 8mAHD)
- Open Drain/Swale
- New Pressure Main
- Subcatchments

hyd2o

Midland Brick Southern Replacement Storage Design

Stage 1 & Southern Storage Design

MASONRY PLANT NEW STORAGE MODELLING

Date: 12/5/2020 Job No. H19054

APPENDIX E
Existing Stormwater System Plates

PLATES

PLATE 1: Southern sedimentation storage area, main storage

PLATE 2: Southern sedimentation storage area, forebay

PLATE 3: Additional southern storage area downstream of Southern Sedimentation Storagea

PLATE 4: Existing open drain from southern storage areas to southern outlet

PLATE 5 : Southern outlet in concrete tomb at end of open drain

PLATE 6: 400 mm dia southern outlet

PLATE 7: Culvert under Muriel St at low point (approx. opposite vehicle location).
Blackadder Creek Tributary is piped under development area immediately downstream of Muriel St.

PLATE 8: 900 mm dia pipe under Muriel St. Invert of pipe is several metres below road level.

PLATE 9: Recently upgraded Clay Basin storage area in Midland Brick following construction

PLATE 10: Recently upgraded Clay Basin storage area commences filling following construction

PLATE 11 : Existing site outlet to Blackadder Creek Tributary

APPENDIX F
Predevelopment Site Monitoring Data

Date: 16/11/2022 Job No. H22039

Midland Brick Site

Groundwater Monitoring Bores

Surface Water Monitoring Locations

hyd2o

Rivermark Area 3 Local Water Management Strategy

Groundwater and Surface Water Monitoring Locations

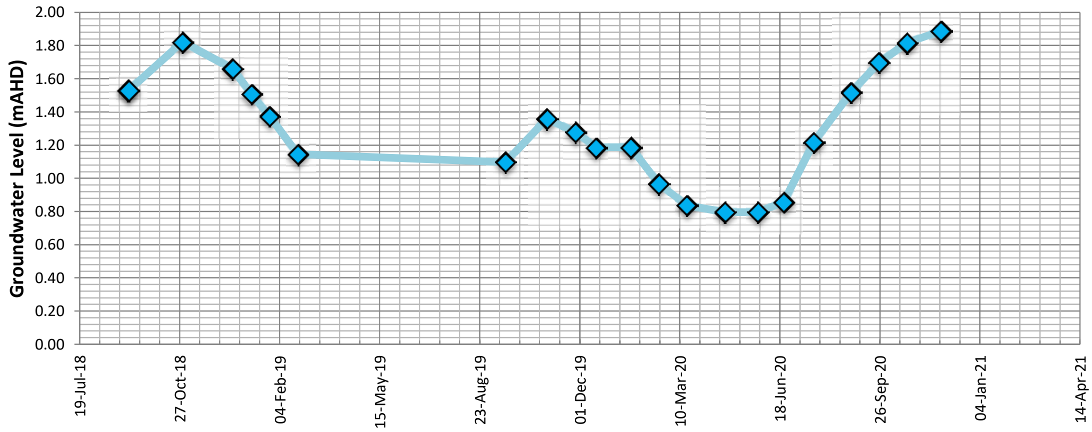
Appendix F

H21087 Rivermark Area 3

EMW03 Groundwater Bore 3
Oval Storage Area East Bore

				Natural Surface (mAHD)	10.82
Data Analysis Period Start Date	01-01-04	Easting	405530	Top of Casing (m AHD)	11.34
Data Analysis Period End Date	31-12-20	Northing	6473108	End of Hole (mAHD)	-2.88

Report Date : 01-09-21



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
05-09-18	9.81	1.53	9.29
06-09-18	9.81	1.53	9.29
30-10-18	9.52	1.82	9.00
19-12-18	9.68	1.66	9.16
07-01-19	9.83	1.51	9.31
25-01-19	9.96	1.38	9.45
22-02-19	10.19	1.15	9.67
18-09-19	10.24	1.10	9.72
29-10-19	9.98	1.36	9.46
27-11-19	10.06	1.28	9.54
17-12-19	10.15	1.19	9.63
21-01-20	10.15	1.19	9.63
18-02-20	10.37	0.97	9.85
17-03-20	10.50	0.84	9.98
24-04-20	10.54	0.80	10.02
27-05-20	10.54	0.80	10.02
22-06-20	10.48	0.86	9.96
22-07-20	10.12	1.22	9.60
28-08-20	9.82	1.52	9.30
25-09-20	9.64	1.70	9.12
23-10-20	9.52	1.82	9.00
26-11-20	9.45	1.89	8.93

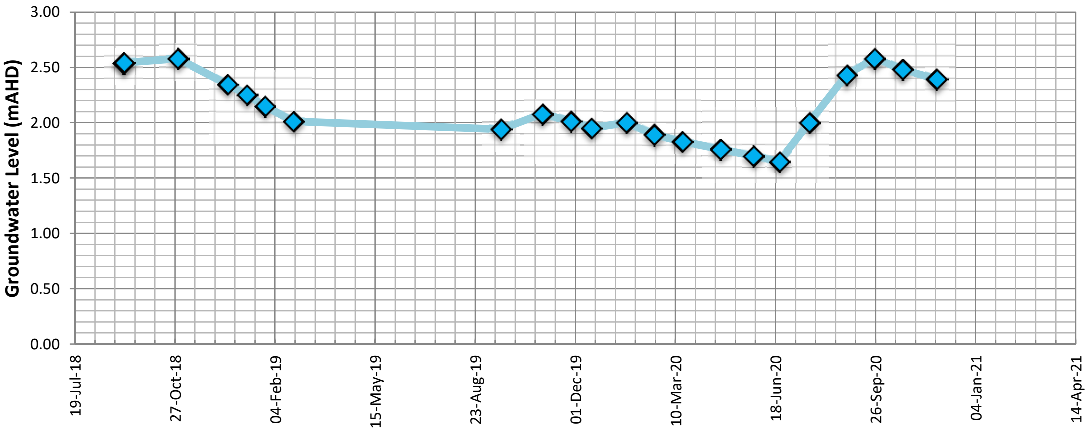
Minimum Recorded Level (mAHD)	0.797
Maximum Recorded Level (mAHD)	1.887

H21087 Rivermark Area 3

EMW04 Groundwater Bore 4
Oval Storage Area South Bore

				Natural Surface (mAHD)	9.29
Data Analysis Period Start Date	01-01-04	Easting	405712	Top of Casing (m AHD)	9.75
Data Analysis Period End Date	31-12-20	Northing	6472730	End of Hole (mAHD)	0.49

Report Date : 01-09-21



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
05-09-18	7.21	2.54	6.75
06-09-18	7.21	2.54	6.75
30-10-18	7.17	2.58	6.71
19-12-18	7.41	2.35	6.94
07-01-19	7.50	2.25	7.04
25-01-19	7.60	2.15	7.14
22-02-19	7.74	2.01	7.28
18-09-19	7.81	1.94	7.35
29-10-19	7.67	2.08	7.21
27-11-19	7.74	2.01	7.28
17-12-19	7.80	1.95	7.34
21-01-20	7.75	2.00	7.29
18-02-20	7.86	1.89	7.40
17-03-20	7.92	1.83	7.46
24-04-20	7.99	1.76	7.53
27-05-20	8.05	1.70	7.59
22-06-20	8.10	1.65	7.64
22-07-20	7.75	2.00	7.29
28-08-20	7.32	2.43	6.86
25-09-20	7.17	2.58	6.71
23-10-20	7.27	2.48	6.81
26-11-20	7.36	2.39	6.90

Minimum Recorded Level (mAHD)	1.651
Maximum Recorded Level (mAHD)	2.581

H21087 Rivermark Area 3

EMW03 Groundwater Bore 3

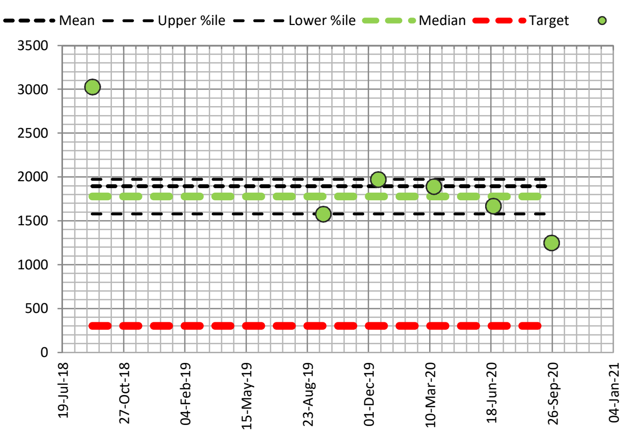
Oval Storage Area East Bore

Easting	405530	Data Analysis Period Start Date	01-01-04
Northing	6473108	Data Analysis Period End Date	31-12-20

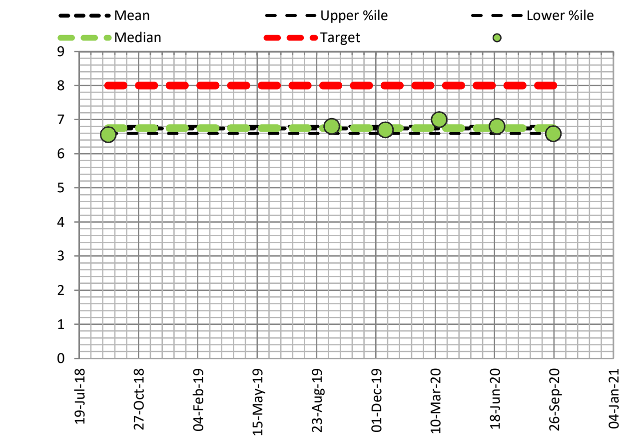
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	22	9.45	9.70	10.02	**10.02**	10.34	10.54		0
GWL mAHD	Groundwater Level	mAHD	22	0.80	0.99	1.32	**1.32**	1.63	1.89		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	6	20.40	21.60	22.68	**21.95**	22.90	27.30		0
EC	Electrical Conductivity	uS/cm	6	1247.00	1576.00	1896.17	**1777.50**	1972.00	3027.00	300.00	6
DO	Dissolved Oxygen	mg/L	2	2.04	2.12	2.25	**2.25**	2.38	2.46		0
DO %	Dissolved Oxygen	%	6	14.20	17.90	28.19	**25.97**	36.00	49.10	80.00	0
pH	pH	pH	6	6.56	6.59	6.74	**6.75**	6.80	7.00	8.00	0
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	6	0.10	0.40	1.20	**0.75**	1.20	4.00	1.20	1
TKN	Total Kjeldahl Nitrogen	mg/L	3	0.10	0.22	0.33	**0.40**	0.46	0.50		0
NH3-N	Ammonia as N	mg/L	6	0.01	0.01	0.03	**0.02**	0.04	0.11	1.43	0
NO_3-N	Nitrate as N	mg/L	6	0.01	0.01	0.01	**0.01**	0.01	0.05	3.40	0
NO_2-N	Nitrite as N	mg/L	6	0.01	0.01	0.01	**0.01**	0.01	0.01		0
TP	Total Phosphorous	mg/L	6	0.35	0.42	0.60	**0.53**	0.68	1.10	0.07	6
FRP	Filterable Reactive Phosphorous	mg/L	6	0.05	0.08	0.15	**0.09**	0.20	0.37	0.04	6
As	Arsenic	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.09400	0
Cd	Cadmium	mg/L	6	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010	0.00040	0
Cr	Chromium	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		0
Cu	Copper	mg/L	6	0.00100	0.00100	0.00133	**0.00100**	0.00100	0.00300	0.00180	1
Pb	Lead	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.00560	0
Ni	Nickel	mg/L	6	0.00100	0.00100	0.00267	**0.00150**	0.00500	0.00600	0.01300	0
Zn	Zinc	mg/L	6	0.00200	0.00200	0.00483	**0.00200**	0.00300	0.01800	0.01500	1
Hg	Mercury	mg/L	6	0.00005	0.00005	0.00006	**0.00005**	0.00005	0.00010	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0
Nox as N	Nox as N	mg/L	1	0.01	0.00500	0.01	**0.01**	0.00500	0.01		0

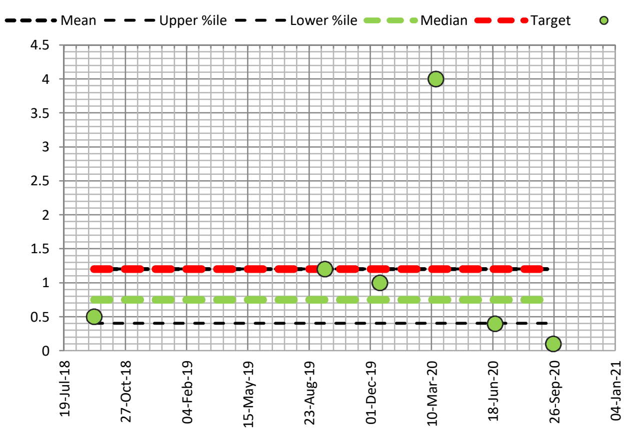
Electrical Conductivity



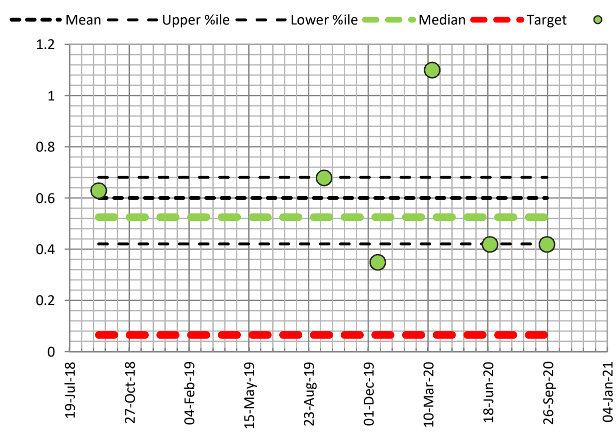
pH



Total Nitrogen



Total Phosphorous



FieldDAE
Field Data Analysis & Evaluation System

H21087 Rivermark Area 3

EMW04 Groundwater Bore 4

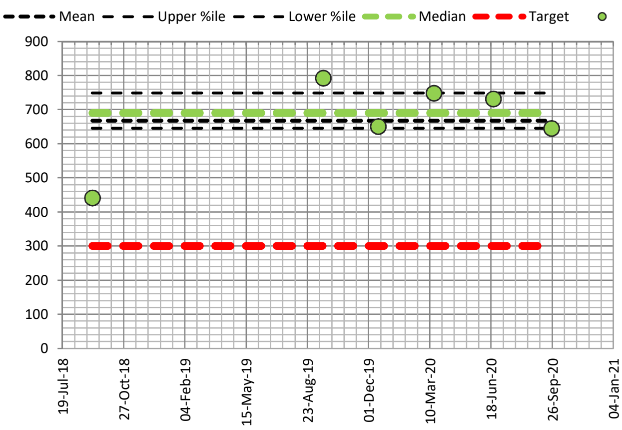
Oval Storage Area South Bore

Easting	405712	Data Analysis Period Start Date	01-01-04
Northing	6472730	Data Analysis Period End Date	31-12-20

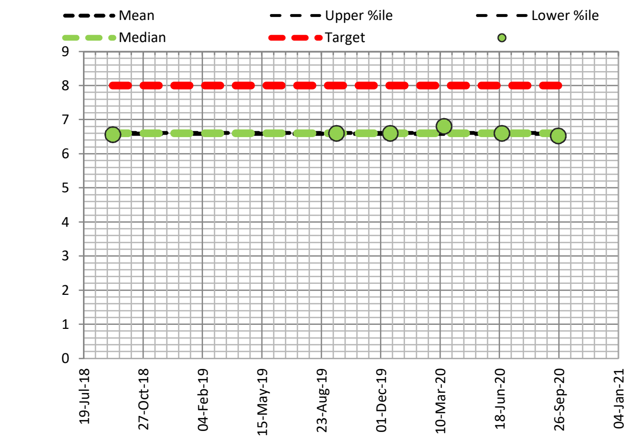
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	22	7.17	7.28	7.61	**7.70**	7.85	8.10		0
GWL mAHD	Groundwater Level	mAHD	22	1.65	1.90	2.14	**2.05**	2.47	2.58		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	6	20.60	20.60	22.17	**21.00**	23.30	26.50		0
EC	Electrical Conductivity	uS/cm	6	441.00	645.00	667.83	**690.50**	748.00	792.00	300.00	6
DO	Dissolved Oxygen	mg/L	2	2.32	2.41	2.55	**2.55**	2.69	2.78		0
DO %	Dissolved Oxygen	%	6	8.50	17.50	20.46	**19.25**	26.30	31.96	80.00	0
pH	pH	pH	6	6.52	6.56	6.61	**6.60**	6.60	6.80	8.00	0
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	6	0.10	0.20	0.82	**0.60**	1.10	2.30	1.20	1
TKN	Total Kjeldahl Nitrogen	mg/L	3	0.10	0.14	0.27	**0.20**	0.38	0.50		0
NH3-N	Ammonia as N	mg/L	6	0.01	0.01	0.01	**0.01**	0.02	0.04	1.43	0
NO_3-N	Nitrate as N	mg/L	6	0.01	0.01	0.04	**0.02**	0.09	0.10	3.40	0
NO_2-N	Nitrite as N	mg/L	6	0.01	0.01	0.01	**0.01**	0.01	0.01		0
TP	Total Phosphorous	mg/L	6	0.05	0.11	0.53	**0.19**	0.41	2.20	0.07	5
FRP	Filterable Reactive Phosphorous	mg/L	6	0.01	0.01	0.01	**0.01**	0.01	0.01	0.04	0
As	Arsenic	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.09400	0
Cd	Cadmium	mg/L	6	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010	0.00040	0
Cr	Chromium	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		0
Cu	Copper	mg/L	6	0.00100	0.00100	0.00350	**0.00100**	0.00200	0.01500	0.00180	2
Pb	Lead	mg/L	6	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.00560	0
Ni	Nickel	mg/L	6	0.00100	0.00100	0.00217	**0.00100**	0.00300	0.00600	0.01300	0
Zn	Zinc	mg/L	6	0.00200	0.00200	0.00883	**0.00350**	0.01500	0.02700	0.01500	1
Hg	Mercury	mg/L	6	0.00005	0.00005	0.00006	**0.00005**	0.00005	0.00010	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0
Nox as N	Nox as N	mg/L	1	0.01	0.00500	0.01	**0.01**	0.00500	0.01		0

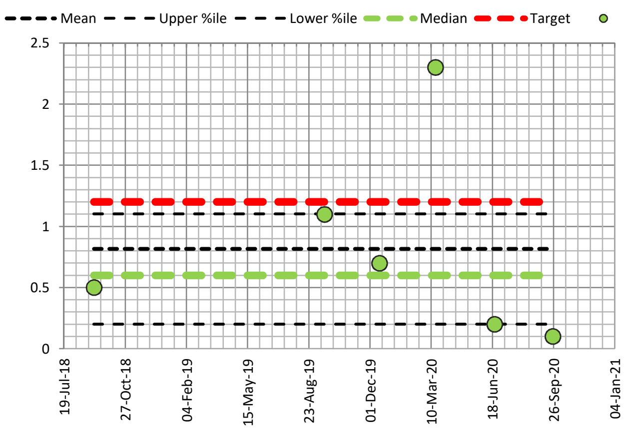
Electrical Conductivity



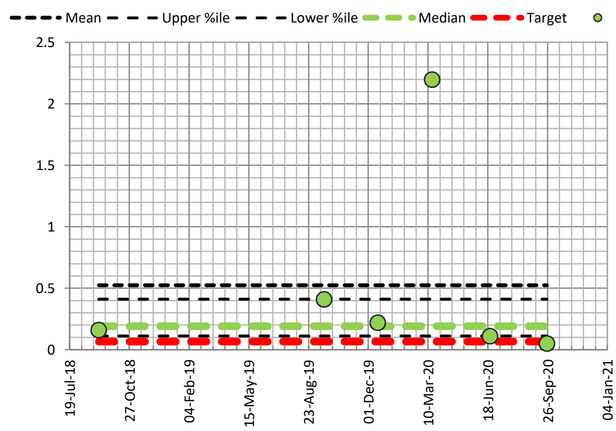
pH



Total Nitrogen



Total Phosphorous



H21087 Rivermark Area 3

SW4 Surface Water Site 4

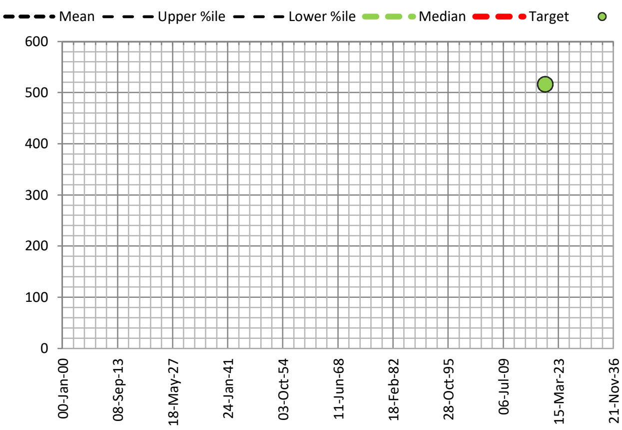
Site Outlet

Easting		Data Analysis Period Start Date	01-01-04
Northing		Data Analysis Period End Date	31-12-20

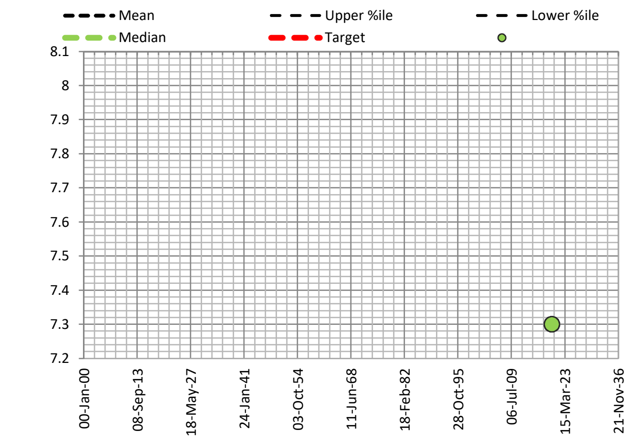
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	1	26.60	26.60	26.60	**26.60**	26.60	26.60		0
EC	Electrical Conductivity	uS/cm	1	516.00	516.00	516.00	**516.00**	516.00	516.00	300.00	1
DO	Dissolved Oxygen	mg/L	1	5.16	5.16	5.16	**5.16**	5.16	5.16		0
DO %	Dissolved Oxygen	%	1	64.70	64.70	64.70	**64.70**	64.70	64.70	80.00	0
pH	pH	pH	1	7.30	7.30	7.30	**7.30**	7.30	7.30	8.00	0
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	1	0.68	0.68	0.68	**0.68**	0.68	0.68	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	1	0.50	0.50	0.50	**0.50**	0.50	0.50	1.20	0
TKN	Total Kjeldahl Nitrogen	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
NH3-N	Ammonia as N	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01	1.43	0
NO_3-N	Nitrate as N	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01	3.40	0
NO_2-N	Nitrite as N	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01		0
TP	Total Phosphorous	mg/L	1	0.05	0.05	0.05	**0.05**	0.05	0.05	0.07	0
FRP	Filterable Reactive Phosphorous	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01	0.04	0
As	Arsenic	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.09400	0
Cd	Cadmium	mg/L	1	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010	0.00040	0
Cr	Chromium	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		0
Cu	Copper	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.00180	0
Pb	Lead	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.00560	0
Ni	Nickel	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.01300	0
Zn	Zinc	mg/L	1	0.00600	0.00600	0.00600	**0.00600**	0.00600	0.00600	0.01500	0
Hg	Mercury	mg/L	1	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005	0.00190	0
TDS	Total Dissolved Solids	mg/L	1	336.00	336.00000	336.00	**336.00**	336.00000	336.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0

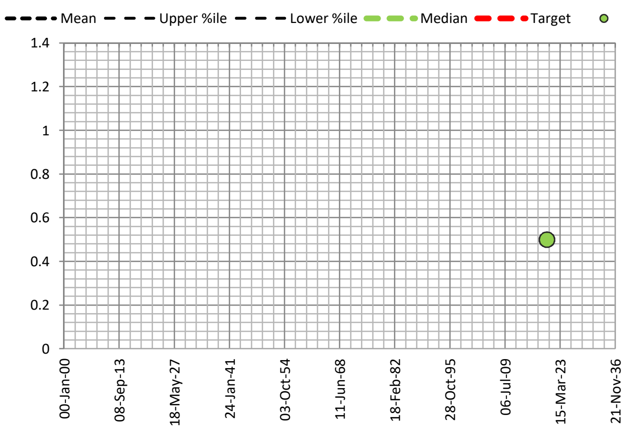
Electrical Conductivity



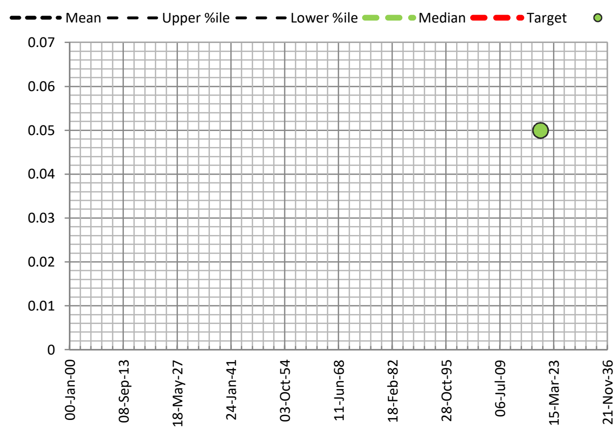
pH



Total Nitrogen



Total Phosphorous



H21087 Rivermark Area 3

SW5 Surface Water Site 5

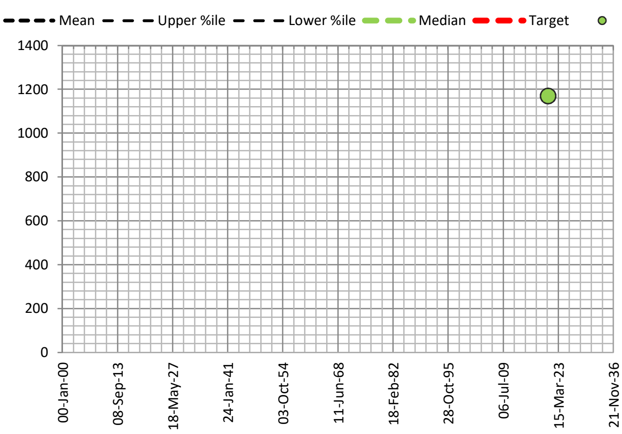
Blackadder Tributary : Muriel St

Easting		Data Analysis Period Start Date	01-01-04
Northing		Data Analysis Period End Date	31-12-20

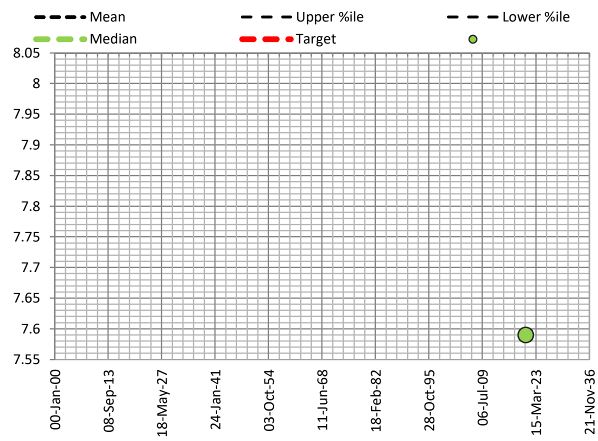
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	1	17.70	17.70	17.70	**17.70**	17.70	17.70		0
EC	Electrical Conductivity	uS/cm	1	1170.00	1170.00	1170.00	**1170.00**	1170.00	1170.00	300.00	1
DO	Dissolved Oxygen	mg/L	1	7.31	7.31	7.31	**7.31**	7.31	7.31		0
DO %	Dissolved Oxygen	%	1	77.30	77.30	77.30	**77.30**	77.30	77.30	80.00	0
pH	pH	pH	1	7.59	7.59	7.59	**7.59**	7.59	7.59	8.00	0
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	1	2.40	2.40	2.40	**2.40**	2.40	2.40	1.20	1
TKN	Total Kjeldahl Nitrogen	mg/L	1	0.10	0.10	0.10	**0.10**	0.10	0.10		0
NH3-N	Ammonia as N	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01	1.43	0
NO_3-N	Nitrate as N	mg/L	1	2.30	2.30	2.30	**2.30**	2.30	2.30	3.40	0
NO_2-N	Nitrite as N	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01		0
TP	Total Phosphorous	mg/L	1	0.05	0.05	0.05	**0.05**	0.05	0.05	0.07	0
FRP	Filterable Reactive Phosphorous	mg/L	1	0.01	0.01	0.01	**0.01**	0.01	0.01	0.04	0
As	Arsenic	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.09400	0
Cd	Cadmium	mg/L	1	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010	0.00040	0
Cr	Chromium	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		0
Cu	Copper	mg/L	1	0.08200	0.08200	0.08200	**0.08200**	0.08200	0.08200	0.00180	1
Pb	Lead	mg/L	1	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100	0.00560	0
Ni	Nickel	mg/L	1	0.00600	0.00600	0.00600	**0.00600**	0.00600	0.00600	0.01300	0
Zn	Zinc	mg/L	1	0.06000	0.06000	0.06000	**0.06000**	0.06000	0.06000	0.01500	1
Hg	Mercury	mg/L	1	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0

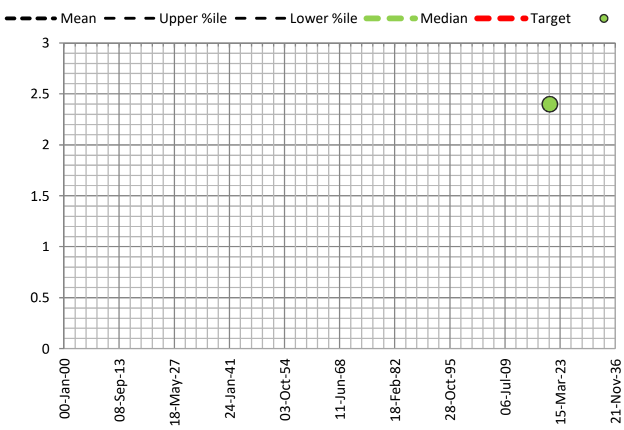
Electrical Conductivity



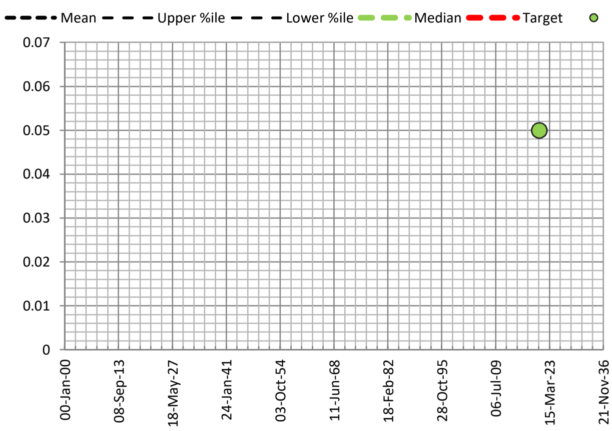
pH



Total Nitrogen



Total Phosphorous



H21087 Rivermark Area 3

SW6 Surface Water Site 6

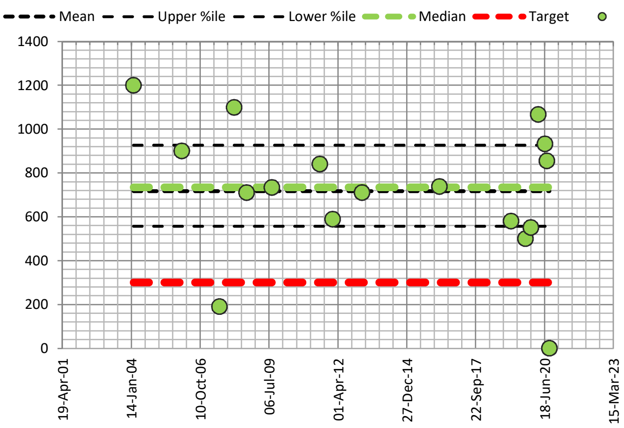
MB : Clay Basin

Easting		Data Analysis Period Start Date	01-01-04
Northing		Data Analysis Period End Date	31-12-20

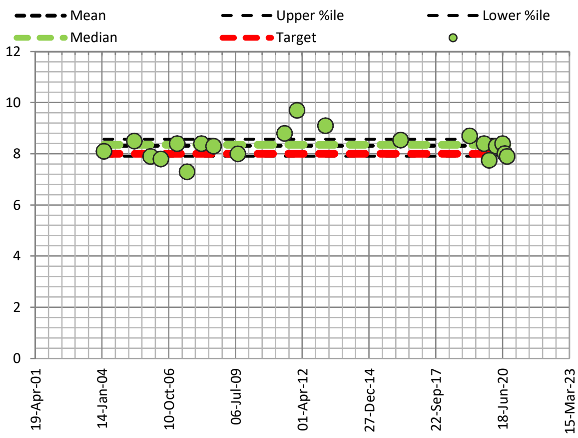
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	5	16.70	17.74	21.60	**20.40**	25.22	28.50		0
EC	Electrical Conductivity	uS/cm	17	1.23	556.80	717.60	**734.00**	926.40	1200.00	300.00	15
DO	Dissolved Oxygen	mg/L	15	6.10	7.53	8.51	**8.50**	9.39	11.20		0
DO %	Dissolved Oxygen	%	5	60.40	76.48	87.20	**84.00**	98.08	118.00	80.00	4
pH	pH	pH	20	7.30	7.90	8.31	**8.35**	8.56	9.70	8.00	14
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	1	8.07	8.07	8.07	**8.07**	8.07	8.07	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	18	0.30	0.46	0.72	**0.66**	0.94	1.30	1.20	2
TKN	Total Kjeldahl Nitrogen	mg/L	9	0.53	0.56	0.77	**0.70**	0.89	1.30		0
NH3-N	Ammonia as N	mg/L	15	0.01	0.01	0.05	**0.02**	0.08	0.26	1.43	0
NO_3-N	Nitrate as N	mg/L	19	0.01	0.01	0.17	**0.05**	0.20	1.60	3.40	0
NO_2-N	Nitrite as N	mg/L	10	0.01	0.01	0.03	**0.03**	0.05	0.06		0
TP	Total Phosphorous	mg/L	20	0.01	0.01	0.03	**0.03**	0.05	0.09	0.07	3
FRP	Filterable Reactive Phosphorous	mg/L	8	0.00	0.01	0.00	**0.01**	0.01	0.01	0.04	0
As	Arsenic	mg/L	23	0.00100	0.00100	0.00174	**0.00100**	0.00200	0.00500	0.09400	0
Cd	Cadmium	mg/L	23	0.00010	0.00010	0.00136	**0.00010**	0.00340	0.00500	0.00040	10
Cr	Chromium	mg/L	22	0.00010	0.00100	0.01387	**0.00200**	0.04480	0.05000		0
Cu	Copper	mg/L	23	0.00010	0.00100	0.01283	**0.00100**	0.03400	0.05000	0.00180	10
Pb	Lead	mg/L	23	0.00010	0.00100	0.00840	**0.00100**	0.00500	0.05000	0.00560	3
Ni	Nickel	mg/L	23	0.00100	0.00100	0.00874	**0.00100**	0.00500	0.05000	0.01300	3
Zn	Zinc	mg/L	23	0.00100	0.00500	0.02013	**0.00900**	0.05000	0.11000	0.01500	6
Hg	Mercury	mg/L	21	0.00005	0.00005	0.00009	**0.00005**	0.00005	0.00080	0.00190	0
TDS	Total Dissolved Solids	mg/L	1	358.00	358.00000	358.00	**358.00**	358.00000	358.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0

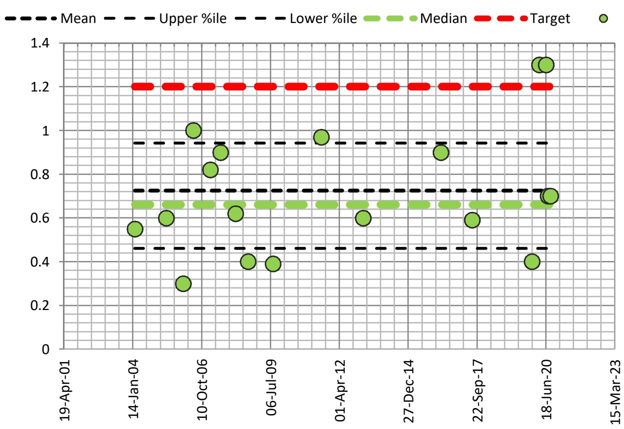
Electrical Conductivity



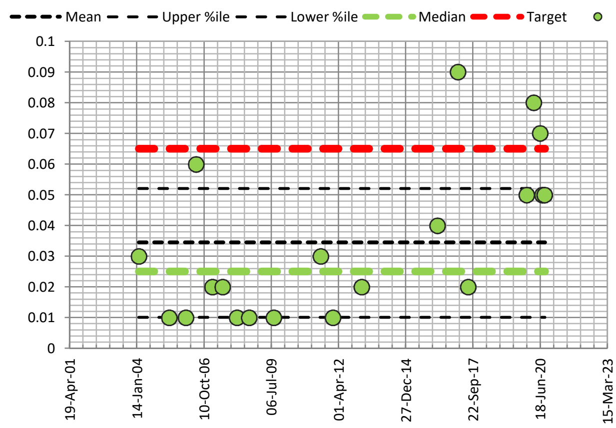
pH



Total Nitrogen



Total Phosphorous



FieldDAE

Field Data Analysis & Evaluation System

H21087 Rivermark Area 3

SW10 Surface Water Site 10

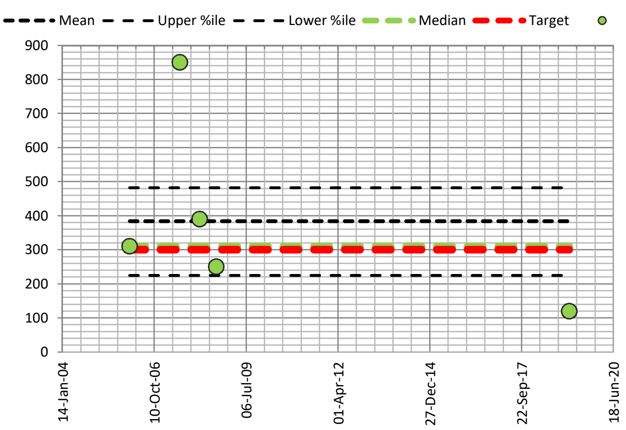
MB : Southern Storage Area

Easting		Data Analysis Period Start Date	01-01-04
Northing		Data Analysis Period End Date	31-12-20

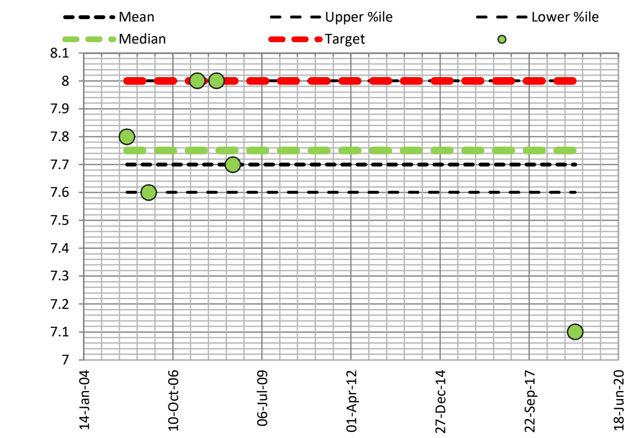
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.000	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
EC	Electrical Conductivity	uS/cm	5	120.00	224.00	384.00	**310.00**	482.00	850.00	300.00	3
DO	Dissolved Oxygen	mg/L	4	7.00	7.66	8.58	**8.55**	9.48	10.20		0
DO %	Dissolved Oxygen	%	0	0.00	0.00	0.00	**0.00**	0.00	0.00	80.00	0
pH	pH	pH	6	7.10	7.60	7.70	**7.75**	8.00	8.00	8.00	0
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	5	0.18	0.44	0.70	**0.71**	1.02	1.10	1.20	0
TKN	Total Kjeldahl Nitrogen	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
NH3-N	Ammonia as N	mg/L	5	0.01	0.01	0.05	**0.06**	0.07	0.10	1.43	0
NO_3-N	Nitrate as N	mg/L	5	0.05	0.05	0.59	**0.05**	0.63	2.70	3.40	0
NO_2-N	Nitrite as N	mg/L	2	0.05	0.05	0.05	**0.05**	0.05	0.05		0
TP	Total Phosphorous	mg/L	5	0.02	0.02	0.04	**0.04**	0.05	0.06	0.07	0
FRP	Filterable Reactive Phosphorous	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00	0.04	0
As	Arsenic	mg/L	6	0.00100	0.00100	0.00183	**0.00100**	0.00200	0.00500	0.09400	0
Cd	Cadmium	mg/L	6	0.00010	0.00100	0.00218	**0.00100**	0.00500	0.00500	0.00040	5
Cr	Chromium	mg/L	5	0.00500	0.00500	0.02760	**0.02800**	0.05000	0.05000		0
Cu	Copper	mg/L	6	0.00100	0.00500	0.02100	**0.01000**	0.05000	0.05000	0.00180	5
Pb	Lead	mg/L	6	0.00100	0.00500	0.01933	**0.00500**	0.05000	0.05000	0.00560	2
Ni	Nickel	mg/L	6	0.00100	0.00500	0.01933	**0.00500**	0.05000	0.05000	0.01300	2
Zn	Zinc	mg/L	6	0.00900	0.01300	0.03850	**0.02950**	0.05000	0.10000	0.01500	4
Hg	Mercury	mg/L	6	0.00005	0.00005	0.00006	**0.00005**	0.00005	0.00010	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00000	0.00	**0.00**	0.00000	0.00		0

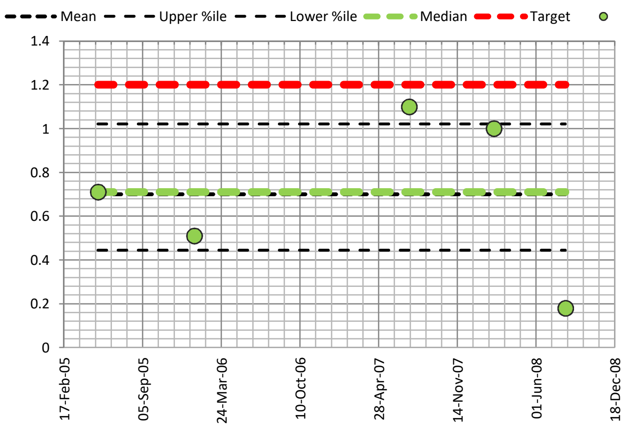
Electrical Conductivity



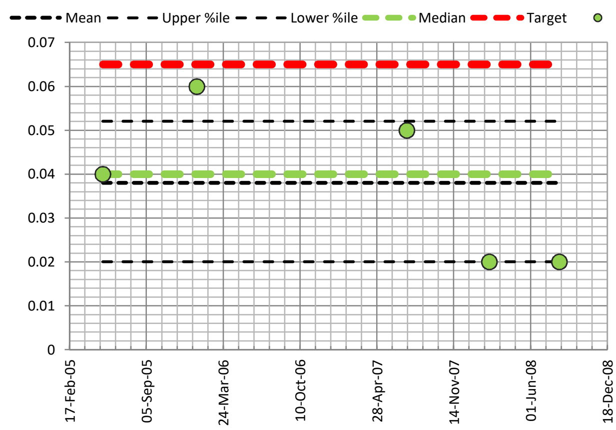
pH



Total Nitrogen



Total Phosphorous



H21087 Rivermark Area 3

Swan River Sites

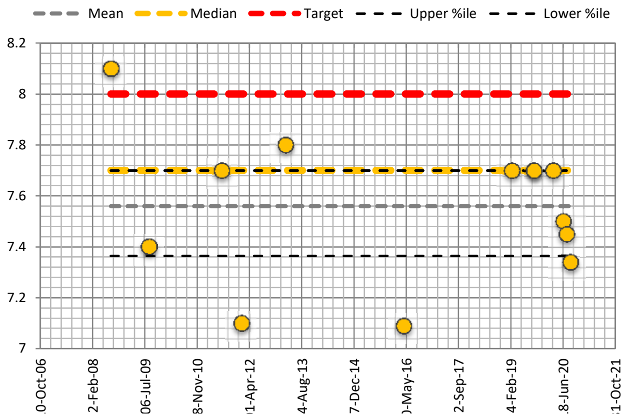
Swan River Upstream Site

Data Analysis Period Start Date	01-01-04
Data Analysis Period End Date	31-12-20

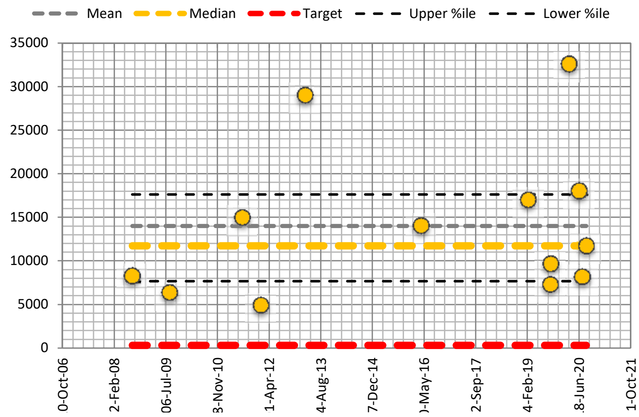
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.00	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.00	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	5	15.20	16.16	18.52	**17.30**	20.86	23.50		0
EC	Electrical Conductivity	uS/cm	13	4900.00	7656.00	14012.08	**11720.00**	17631.80	32612.00	300.00	13
DO	Dissolved Oxygen	mg/L	9	3.16	4.72	6.51	**5.74**	9.08	10.30		0
DO %	Dissolved Oxygen	%	5	46.30	47.74	53.03	**53.20**	56.45	62.65	80.00	0
pH	pH	pH	13	7.09	7.36	7.56	**7.70**	7.70	8.10	8.00	1
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	11	0.80	0.90	1.24	**1.10**	1.54	2.20	1.20	4
TKN	Total Kjeldahl Nitrogen	mg/L	9	0.80	0.86	1.49	**1.10**	2.16	2.70		0
NH3-N	Ammonia as N	mg/L	9	0.01	0.03	0.12	**0.06**	0.20	0.40	1.43	0
NO_3-N	Nitrate as N	mg/L	12	0.01	0.04	0.43	**0.10**	0.41	2.25	3.40	0
NO_2-N	Nitrite as N	mg/L	9	0.01	0.01	0.05	**0.01**	0.07	0.25		0
TP	Total Phosphorous	mg/L	13	0.01	0.04	0.08	**0.06**	0.10	0.23	0.07	6
FRP	Filterable Reactive Phosphorous	mg/L	8	0.01	0.01	0.02	**0.01**	0.03	0.08	0.04	2
As	Arsenic	mg/L	15	0.00100	0.00100	0.00340	**0.00400**	0.00500	0.01000	0.09400	0
Cd	Cadmium	mg/L	15	0.00010	0.00010	0.00092	**0.00010**	0.00060	0.00500	0.00040	7
Cr	Chromium	mg/L	14	0.00050	0.00100	0.00411	**0.00100**	0.00500	0.02500		0
Cu	Copper	mg/L	15	0.00050	0.00100	0.00437	**0.00300**	0.00500	0.02500	0.00180	10
Pb	Lead	mg/L	15	0.00050	0.00100	0.00250	**0.00100**	0.00500	0.00500	0.00560	0
Ni	Nickel	mg/L	15	0.00100	0.00100	0.00467	**0.00300**	0.00500	0.02500	0.01300	1
Zn	Zinc	mg/L	15	0.00100	0.00460	0.01600	**0.01300**	0.02500	0.05000	0.01500	6
Hg	Mercury	mg/L	13	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0

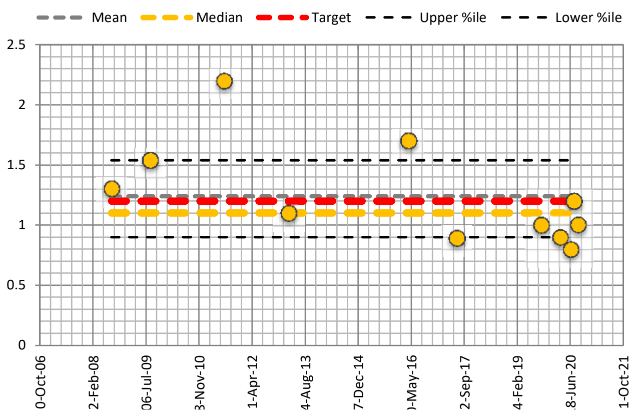
pH



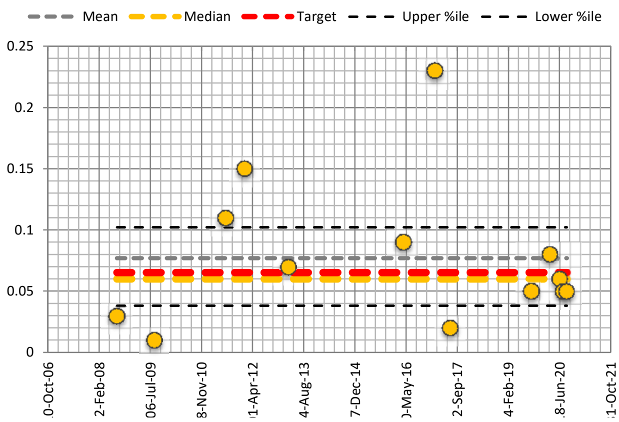
Electrical Conductivity



Total Nitrogen



Total Phosphorous



FieldDAE

Field Data Analysis & Evaluation System

H21087 Rivermark Area 3

Swan River Sites

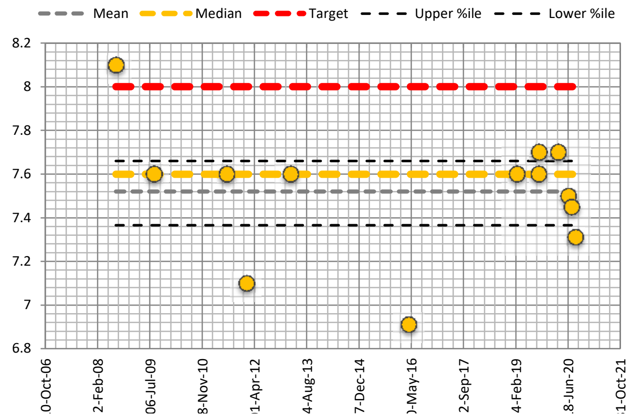
Swan River Downstream Site

Data Analysis Period Start Date	01-01-04
Data Analysis Period End Date	31-12-20

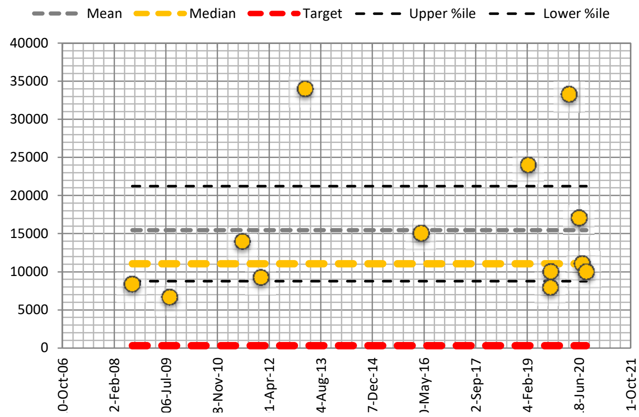
Report Date : 01-09-21

Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC 90%	Times Exceeded
GWL bToC	Groundwater Level	mBToC	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
GWL mAHD	Groundwater Level	mAHD	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
SWL	Surface Water Level	m	0	0.00	0.00	0.000	**0.000**	0.000	0.000		0
SWF	Flow Estimate	m³/s	0	0.00	0.00	0.000	**0.000**	0.000	0.000		0
T	Temperature	°C	5	15.70	15.78	18.48	**17.80**	20.38	23.50		0
EC	Electrical Conductivity	uS/cm	13	6675.00	8760.00	15455.31	**11061.00**	21227.60	34000.00	300.00	13
DO	Dissolved Oxygen	mg/L	9	2.85	4.86	6.42	**5.82**	8.80	10.20		0
DO %	Dissolved Oxygen	%	5	37.50	42.30	53.85	**62.30**	62.69	63.47	80.00	0
pH	pH	pH	13	6.91	7.37	7.52	**7.60**	7.66	8.10	8.00	1
ORP	Oxidation Reduction Potential	mV	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TUR	Turbidity	NTU	0	0.00	0.00	0.00	**0.00**	0.00	0.00	20.00	0
TSS	Total Suspended Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
TN	Total Nitrogen	mg/L	11	0.80	0.90	1.31	**1.10**	1.69	2.30	1.20	5
TKN	Total Kjeldahl Nitrogen	mg/L	9	0.70	0.83	1.57	**1.40**	2.26	3.00		0
NH3-N	Ammonia as N	mg/L	9	0.01	0.02	0.13	**0.07**	0.22	0.43	1.43	0
NO_3-N	Nitrate as N	mg/L	12	0.01	0.05	0.48	**0.12**	0.39	2.68	3.40	0
NO_2-N	Nitrite as N	mg/L	9	0.01	0.01	0.06	**0.01**	0.08	0.30		0
TP	Total Phosphorous	mg/L	13	0.03	0.04	0.09	**0.06**	0.12	0.23	0.07	6
FRP	Filterable Reactive Phosphorous	mg/L	8	0.01	0.01	0.03	**0.01**	0.06	0.08	0.04	3
As	Arsenic	mg/L	15	0.00100	0.00100	0.00320	**0.00200**	0.00500	0.01000	0.09400	0
Cd	Cadmium	mg/L	15	0.00010	0.00010	0.00092	**0.00010**	0.00060	0.00500	0.00040	7
Cr	Chromium	mg/L	14	0.00050	0.00100	0.00411	**0.00100**	0.00500	0.02500		0
Cu	Copper	mg/L	15	0.00050	0.00180	0.00510	**0.00500**	0.00500	0.02500	0.00180	12
Pb	Lead	mg/L	15	0.00050	0.00100	0.00257	**0.00100**	0.00500	0.00500	0.00560	0
Ni	Nickel	mg/L	15	0.00100	0.00100	0.00547	**0.00500**	0.00560	0.02500	0.01300	1
Zn	Zinc	mg/L	15	0.00100	0.00500	0.01853	**0.02100**	0.02560	0.05000	0.01500	8
Hg	Mercury	mg/L	13	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005	0.00190	0
TDS	Total Dissolved Solids	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0
Nox as N	Nox as N	mg/L	0	0.00	0.00	0.00	**0.00**	0.00	0.00		0

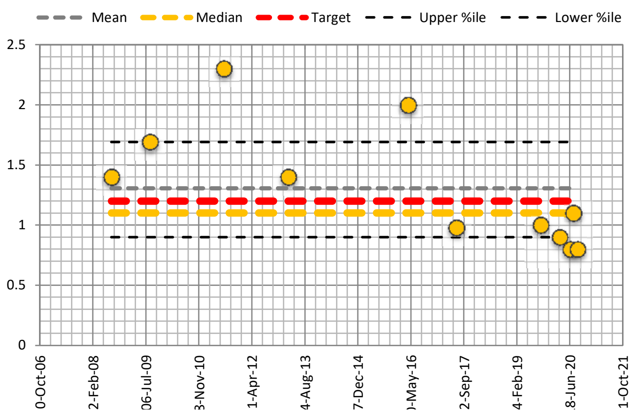
pH



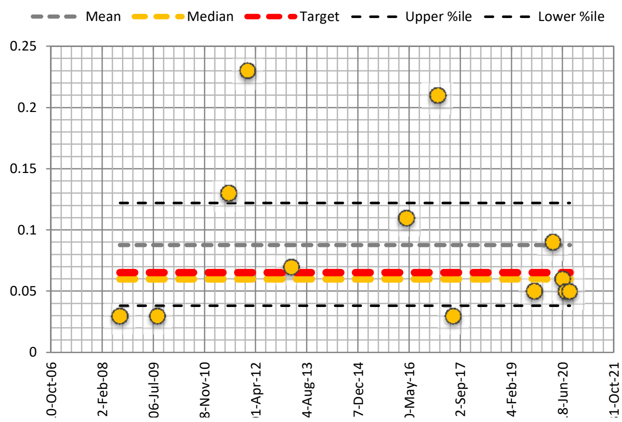
Electrical Conductivity



Total Nitrogen



Total Phosphorous



FieldDAE
Field Data Analysis & Evaluation System

APPENDIX G
Lithological Logs

emerge ASSOCIATES
Integrated Science & Design

Well ID: EMW03

PROJECT NUMBER: EP18-062(01)
CLIENT: Boral Limited

PROJECT NAME: Boral Midland Groundwater Assessment
PROJECT LOCATION: 102 Great Northern Highway Midvale

DATE INSTALLED: 20/08/2018
DRILLING CONTRACTOR: Strataprobe
DRILLING METHOD: Auger
LOGGED BY: MM

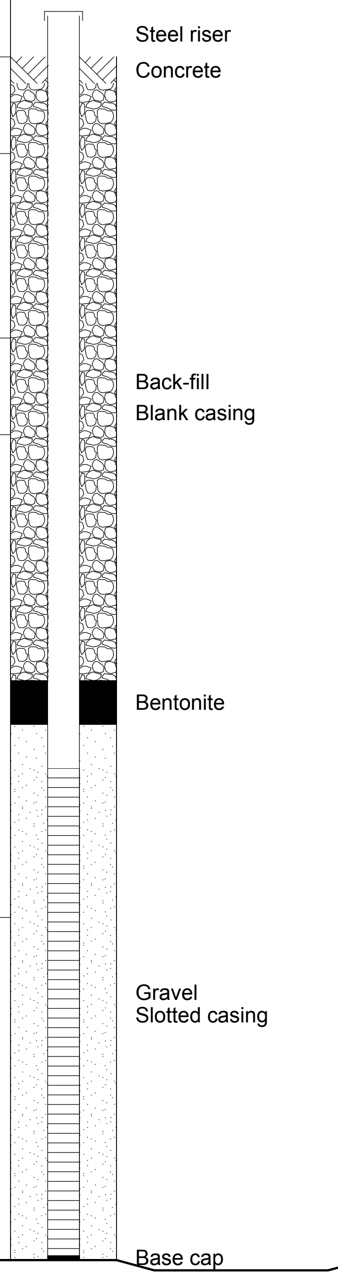
SURVEY SOURCE: Surveyed
EASTING: 405529.696
NORTHING: 6473108.240
PROJECTION: MGA, GDA94

ELEVATION (GROUND): 10.8 mAHD
ELEVATION (TOP OF CASING): 11.3 mAHD
CASING DIAMETER: 50 mm

DEPTH (mBGL)	MATERIAL DESCRIPTION	MOISTURE CONTENT
0.0m	UNCONTROLLED FILL: dark grey, plastic, brick, bluemetal.	
1.1m	SANDY CLAY: dark red/brown, fine to medium grained, low plasticity, orange mottling.	Dry To Moist
3.2m	CLAYEY SAND: dark red/brown, fine grained, low plasticity, fine sands with charcoal fines.	Moist
4.3m	SANDY CLAY: light brown, fine grained, low plasticity, firm to stiff layer, slow penetration.	Dry
9.8m	CLAYEY SAND: light brown, fine to coarse grained, medium plasticity, soft to firm, water bearing layer encountered .	Wet

Total drilled depth: 13.7 mBGL

WELL CONSTRUCTION



COMMENTS: Water was observed at 10.00 mBGL during well install. Standing water level recorded in September 2018 was 9.291 mBGL

Well ID: EMW04

PROJECT NUMBER: EP18-062(01)
CLIENT: Boral Limited

PROJECT NAME: Boral Midland Groundwater Assessment
PROJECT LOCATION: 102 Great Northern Highway Midvale

DATE INSTALLED: 20/08/2018
DRILLING CONTRACTOR: Strataprobe
DRILLING METHOD: Sonic
LOGGED BY: MM

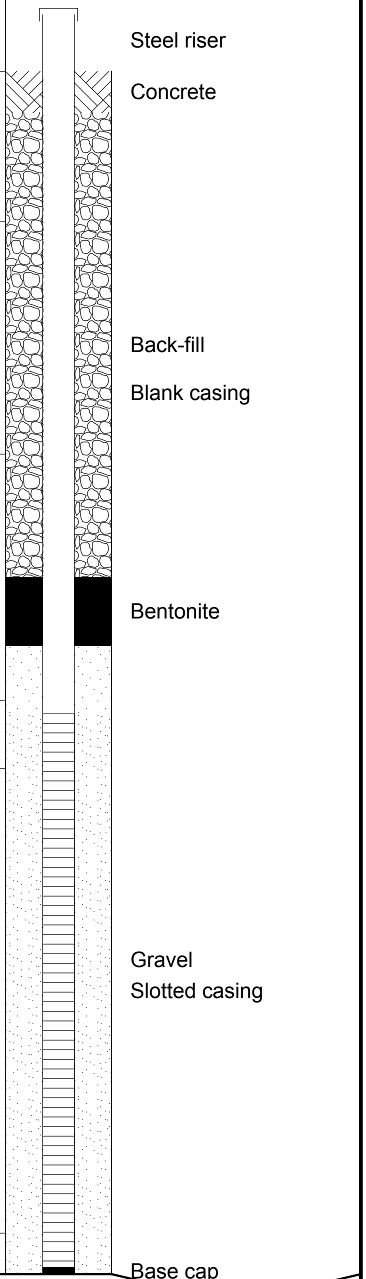
SURVEY SOURCE: Surveyed
EASTING: 405712.103
NORTHING: 6472730.410
PROJECTION: MGA, GDA94

ELEVATION (GROUND): 9.3 mAHD
ELEVATION (TOP OF CASING): 9.8 mAHD
CASING DIAMETER: 50 mm

DEPTH (mBGL)	DEPTH (mAHD)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONTENT
0	9		0.0m: SANDY CLAYEY UNCONTROLLED FILL: dark brown/grey, brick and bitumen rubble, plastics, unable to sonic core due to rubble.	Dry To Moist
1	8		1.1m: CLAY: dark brown, medium plasticity.	Moist
2	7			
3	6		2.8m: SANDY CLAY: light brown, low plasticity, firm to stiff layer, slow to gradual penetration.	Dry
4	5			
5	4		4.6m: GRAVELLY CLAY: dark brown/purple, medium plasticity, purple mottling.	Moist
6	3		5.1m: CLAYEY SAND: light brown, fine to coarse grained, low plasticity, water bearing layer.	Wet
7	2			
8	1		8.5m: SANDY CLAY: light brown/red, medium plasticity, more clays at depth.	Wet

Total drilled depth: 8.8 mBGL

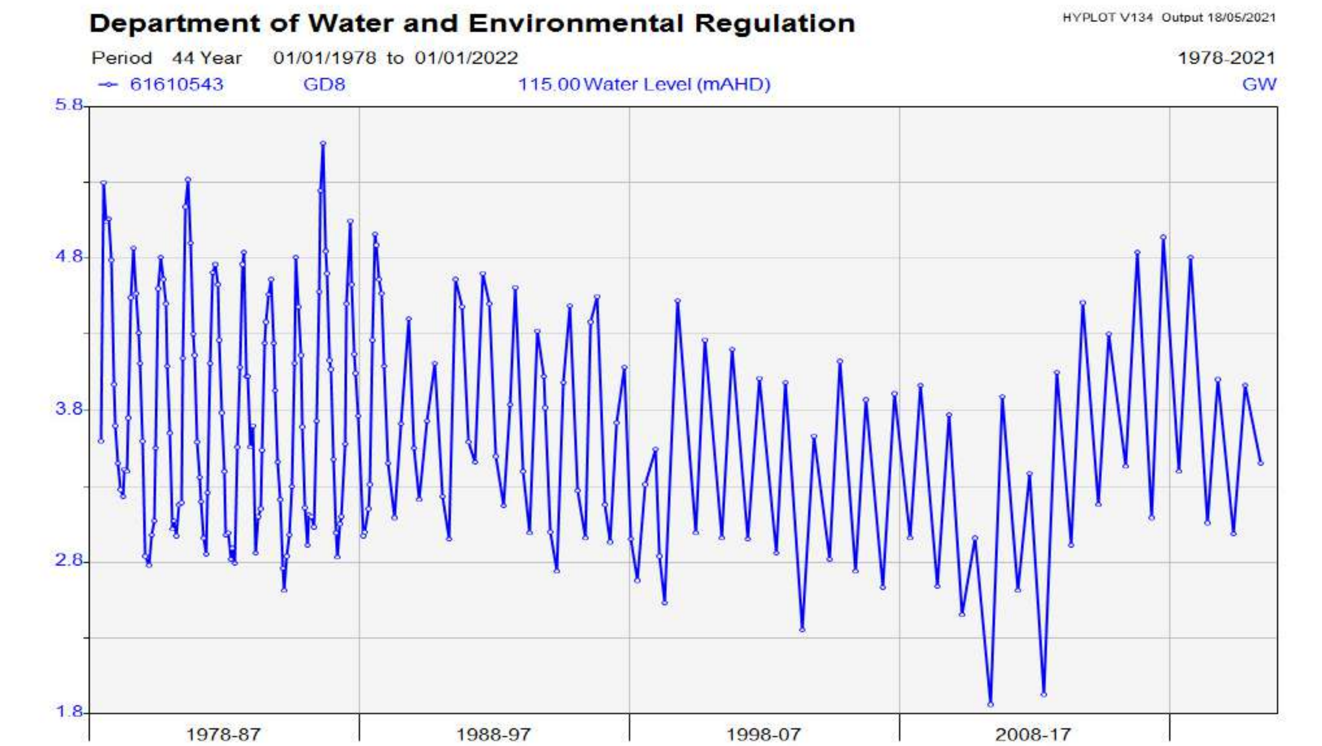
WELL CONSTRUCTION

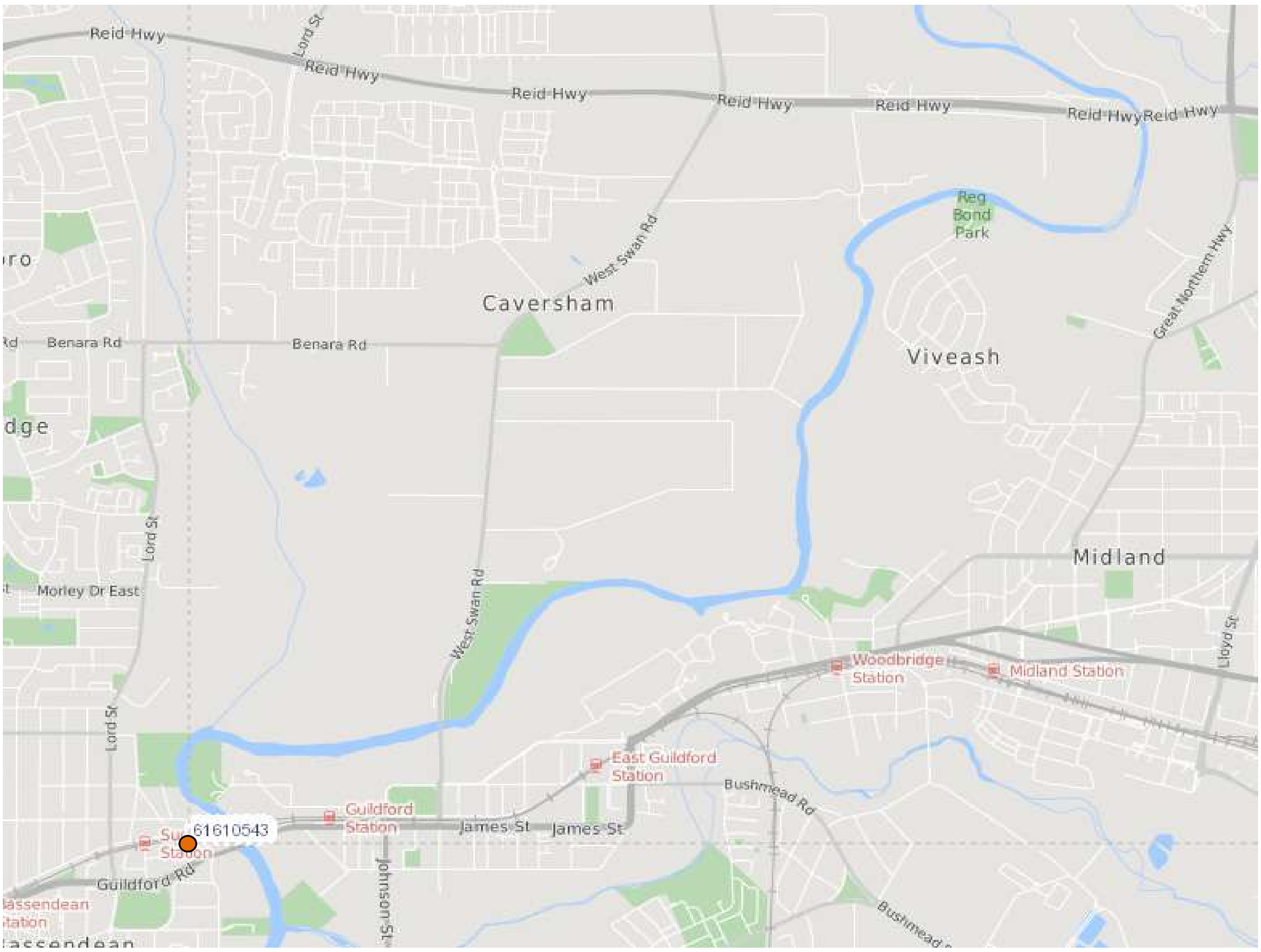


COMMENTS: water was observed at 5.10 mBGL during well install. Standing water level recorded in September 2018 was 6.808 mBGL.

APPENDIX H
DWER Groundwater Monitoring Data

Date :16/11/2022 Job No. H22039





Source: Department of Water and Environmental Regulation (2021)

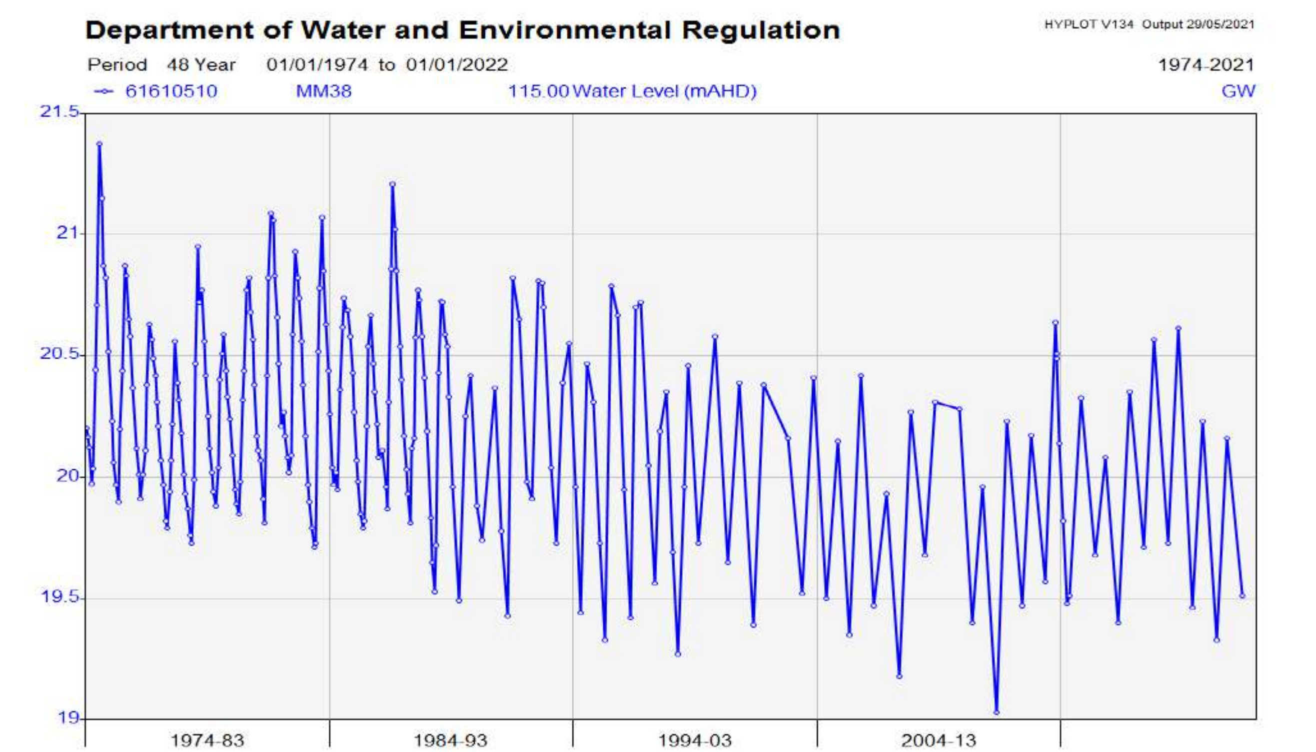
hyd2o

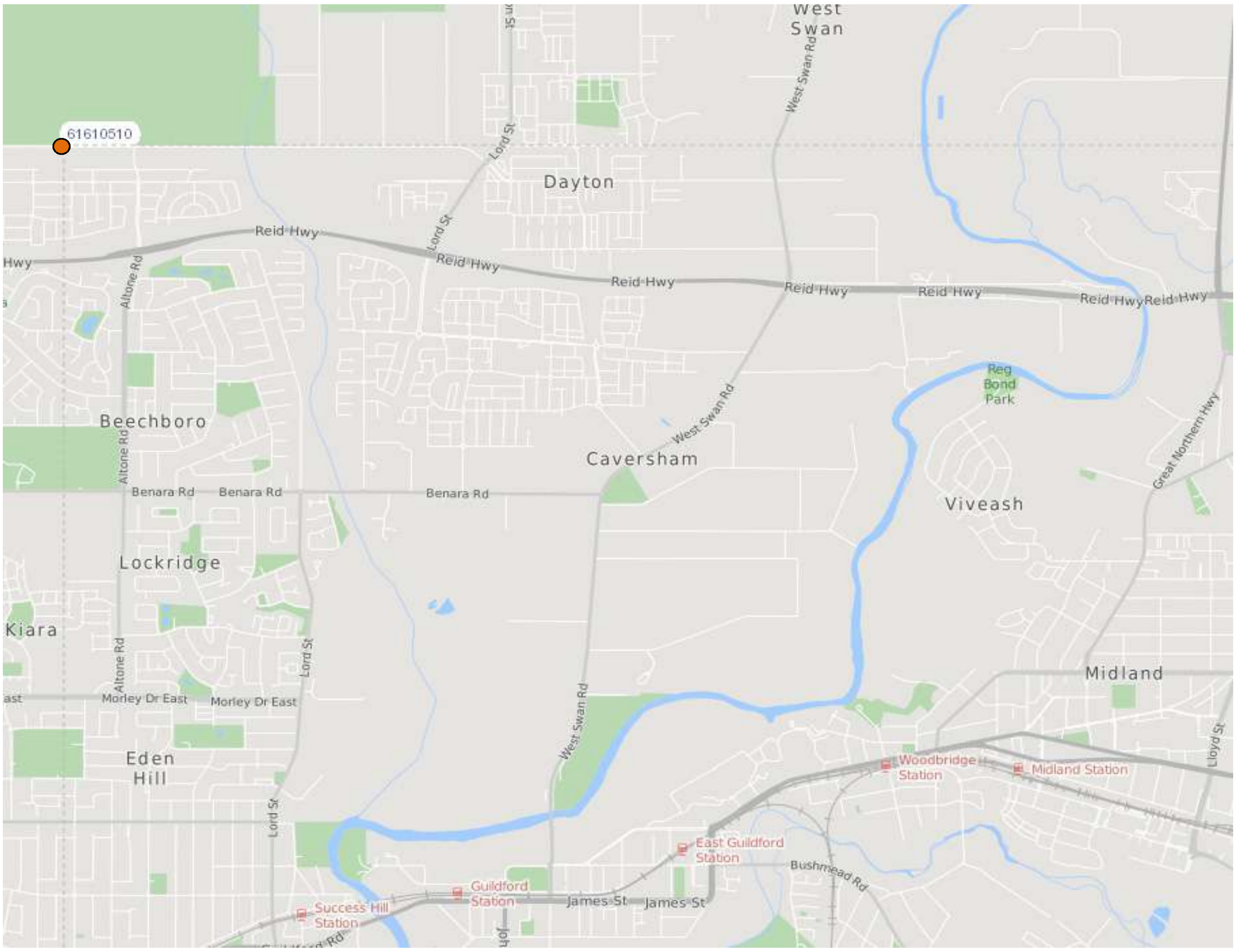
Rivermark Area 3 Local Water Management Strategy

DWER Bore Hydrographs : GD8

Appendix H1

Date :16/11/2022 Job No. H22039





Source: Department of Water and Environmental Regulation (2021)

hyd2o

Rivermark Area 3 Local Water Management Strategy

DWER Bore Hydrographs : MM388

Appendix H2

APPENDIX I
Groundwater Licence

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	Linc Property Pty Ltd		
Description of Water Resource	Perth Perth - Superficial Swan	**Annual Water Entitlement**	30,000kL
Location of Water Source	LOT 72 ON DEPOSITED PLAN 408605 - Volume/Folio 2916/634 - Lot 72 EVELINE RD MIDDLE SWAN		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Dust suppression for earthworks and construction purposes	LOT 72 ON DEPOSITED PLAN 408605 - Volume/Folio 2916/634 - Lot 72 EVELINE RD MIDDLE SWAN
Duration of Licence	From 8 May 2020 to 7 May 2025	

This Licence is subject to the following terms, conditions and restrictions:

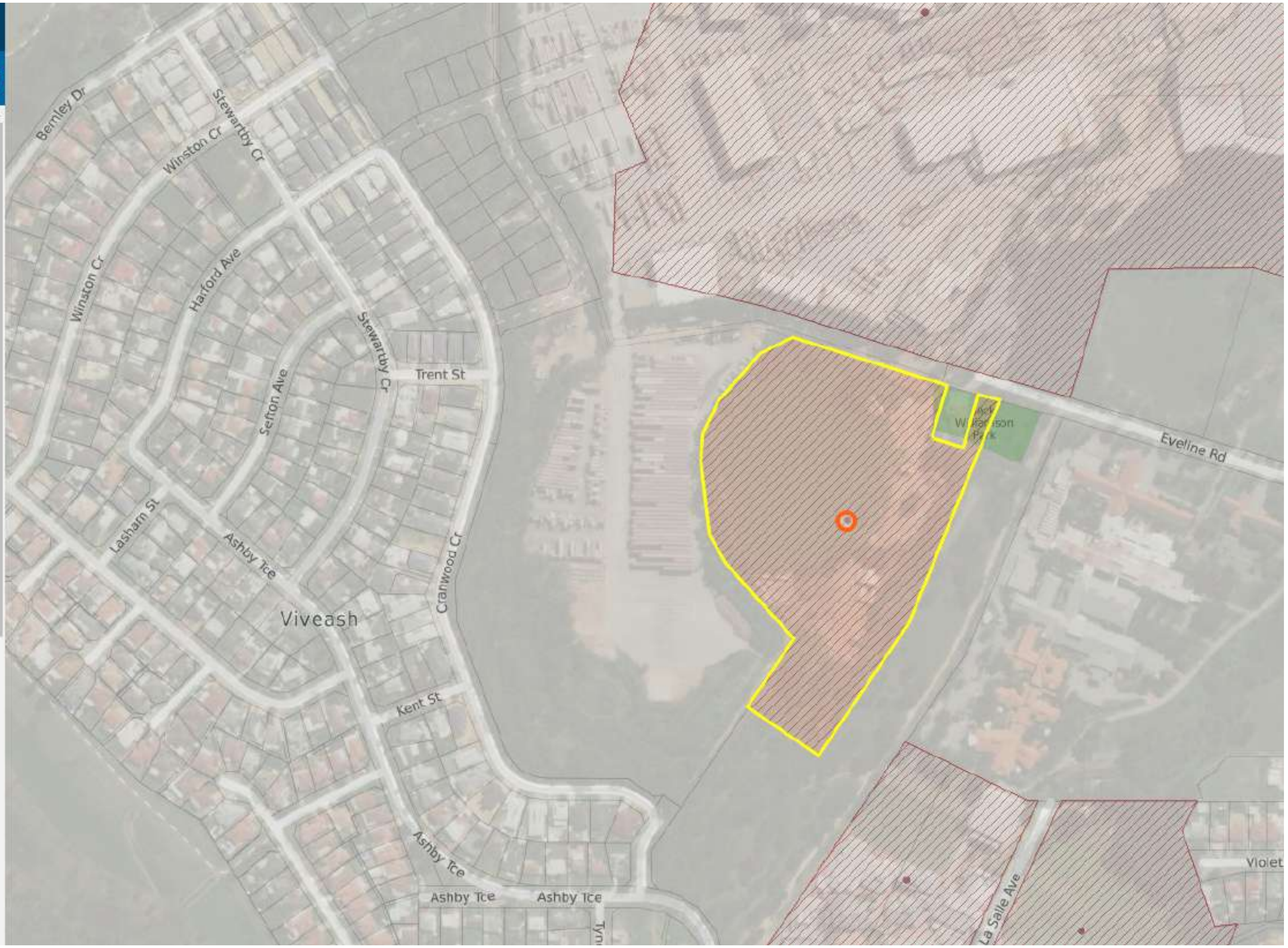
1. The annual water year for water taken under this licence is defined as 1 November to 31 October.
2. This licence is not renewable.
3. This licence is not transferable.

End of terms, conditions and restrictions

← Licence details

Selected   1 of 1

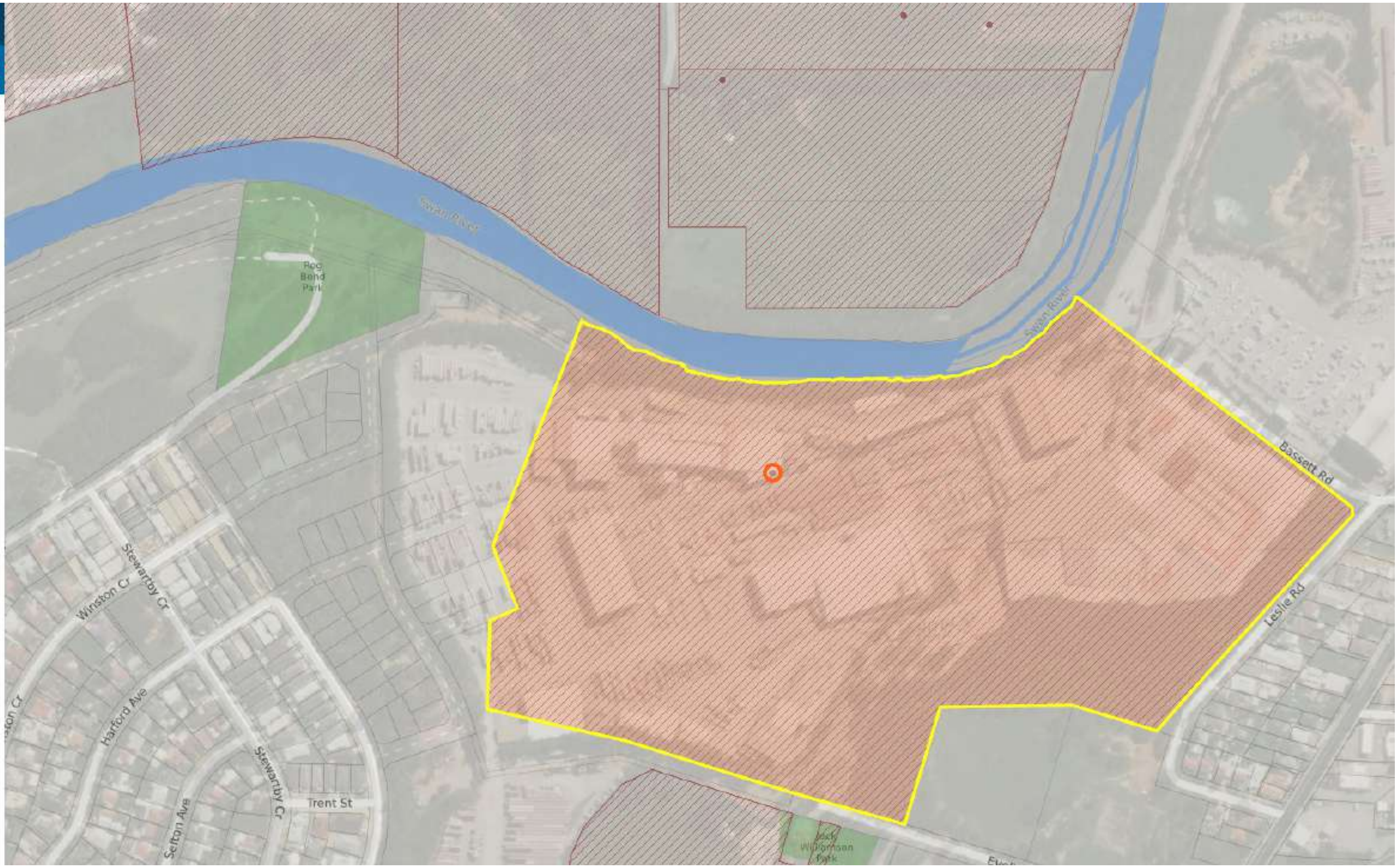
Licence Number:	168139
Licence Type:	Groundwater Licence
Issue Date:	29/8/2019
Expiry Date:	28/8/2029
Licence Allocation:	280775 KL
Parties:	City of Swan
Postal Address:	PO BOX 196 Midland DC WA 6936 Australia
Groundwater Area:	Perth
Groundwater Subarea:	Perth South Confined
Aquifer:	Perth - Leederville.
Surface Water Area:	
Surface Water Subarea:	
Surface Water Resource:	
Licence Address:	Lot 234 On Plan 188150 Volume/Folio Lr3041/230 Lot 234 Helena St Guildford Kings Meadow Polo Grou; Lot 191 On Plan 222550 Volume/Folio 199/195 Lot 191 Meadow St Guildford Stirling Square And Meado; Crown Reserve 35349 Lot 9803 Blackadder Rd Swan View Swan View Park; Lot 98 Harper Street Woodbridge Ray Marshall Park; Lot 13421 On Plan 220279 Volume/Folio Lr3114/605 Lot 13421 Eddie Barron Dr Middle Swan Velodrome; Lot 9808 On Plan 215911 Volume/Folio Lr3011/723 Lot 9808 The Quarry Swan View The Quarry; Lot 5 On Diagram 48300 Volume/Folio 1406/686 Lot 5 Great Northern Hwy Middle Swan Lot 56 On Plan ; Lot 144 On Plan 222536 Volume/Folio 1228/232 Lot 144 Helena St Guildford Spring Reserve; Lot 216 On Plan 3298 Volume/Folio 2156/710 Lot 216 The



← Licence details

Selected 1 of 2

Licence Number:	204304
Licence Type:	Groundwater Licence
Issue Date:	8/5/2020
Expiry Date:	7/5/2025
Licence Allocation:	30000 KL
Parties:	Linc Property Pty Ltd
Postal Address:	PO Box 782 Subiaco WA 6904 Australia
Groundwater Area:	Perth
Groundwater Subarea:	Shire of Swan South
Aquifer:	Perth - Superficial Swan
Surface Water Area:	
Surface Water Subarea:	
Surface Water Resource:	
Licence Address:	LOT 72 EVELINE ROAD MIDDLE SWAN 6056
Security Interests:	No
Convictions:	No
Agreements:	No
Notations:	No
Directions:	No



APPENDIX J
Landscape Masterplan

STRATEGIC MASTER PLAN

LEGEND

1. FORESHORE BUSH FOREVER
RETAIN, PROTECT AND ENHANCE RIVER FORESHORE
2. FORESHORE P.O.S 1
LOCAL FUTSAL/EXERCISE PRECINCT
3. FORESHORE P.O.S 2
COMMUNITY FACILITIES AND GATHERING SPACE WITH INFORMATION NODE & STORM
4. FORESHORE P.O.S 3
PASSIVE RECREATION, COMMUNITY GATHERING & STORM WATER MANAGEMENT
5. BUSH FOREVER
PROTECTION AND ENHANCEMENT OF EXISTING CONSERVATION RESERVE
6. CONSERVATION P.O.S 1
PROTECTION OF EXISTING VEGETATION, WITH PATHS, MINOR SEATING NODES, INTERPRETIVE SIGNAGE & DRAINAGE SWALE IN ROAD
7. CONSERVATION P.O.S 2
PROTECTION OF EXISTING VEGETATION, WITH PATHS, MINOR SEATING NODES AND INTERPRETIVE SIGNAGE
8. LOCAL P.O.S 2
PASSIVE RECREATION AND DRAINAGE INFRASTRUCTURE USING LOCAL SPECIES
9. YORK STREET P.O.S 1
SMALL NEIGHBOURHOOD POS WITH PASSIVE RECREATION OPPORTUNITIES FOR ADJACENT RESIDENTS & DRAINAGE BASIN
10. FORESHORE CONNECTOR WITH HABITAT TREES AND SHADED PEDESTRIAN ACCESS
11. EVELINE ROAD , WEST CONNECTOR
A VEGETATED LINEAR GREEN LINK THAT RETAINS EXISTING HEALTHY TREES AND REINFORCES WITH LOCAL SPECIES THAT SUPPORT NORTH/ SOUTH FAUNA MOVEMENT
12. NORTHERN CONNECTOR
A STRONG TREE LINED VEGETATED LINEAR CONNECTION, REINFORCED WITH LOCAL SPECIES THAT SUPPORT NORTH/SOUTH FAUNA
13. JACK WILLIAMSON PARK REGIONAL RECREATION RESERVE
14. EVELINE ROAD , EAST CONNECTOR
A VEGETATED LINEAR GREEN LINK THAT RETAINS EXISTING HEALTHY TREES AND REINFORCES WITH LOCAL SPECIES THAT SUPPORT EAST/WEST FAUNA MOVEMENT
15. ENTRY STATEMENT AND INFORMATION NODE
16. PUBLIC ACCESS WAY 1 WITH SHADED PEDESTRIAN ACCESS
17. PUBLIC ACCESS WAY 2 WITH SHADED PEDESTRIAN ACCESS
18. SOUTHERN CONNECTOR
A STRONG TREE LINED AND VEGETATED LINEAR CONNECTION, REINFORCED WITH LOCAL SPECIES THAT SUPPORT NORTH/SOUTH FAUNA MOVEMENT
19. FORESHORE/CONSERVATION CONNECTOR WITH HABITAT TREES AND SHADED PEDESTRIAN ACCESS
20. DRAINAGE SWALES IN ROAD RESERVES
21. DRAINAGE BIOFILTER ON NORTHEN SIDE OF JACK WILLIAMSON OVAL
22. MATURE EXISTING TREES RETAINED WITHIN PROPOSED 'LANDSCAPE LOTS'
23. FUTURE PSP CONNECTION TO REG BOND RESERVE

RIVERMARK RIVERSIDE VILLAGE

PREPARED FOR HESPERIA

STRATEGIC LANDSCAPE MASTER PLAN

MAY 2023

JOB NO. 2105501 | C1.101 | REV F

0 40 80 120 200m

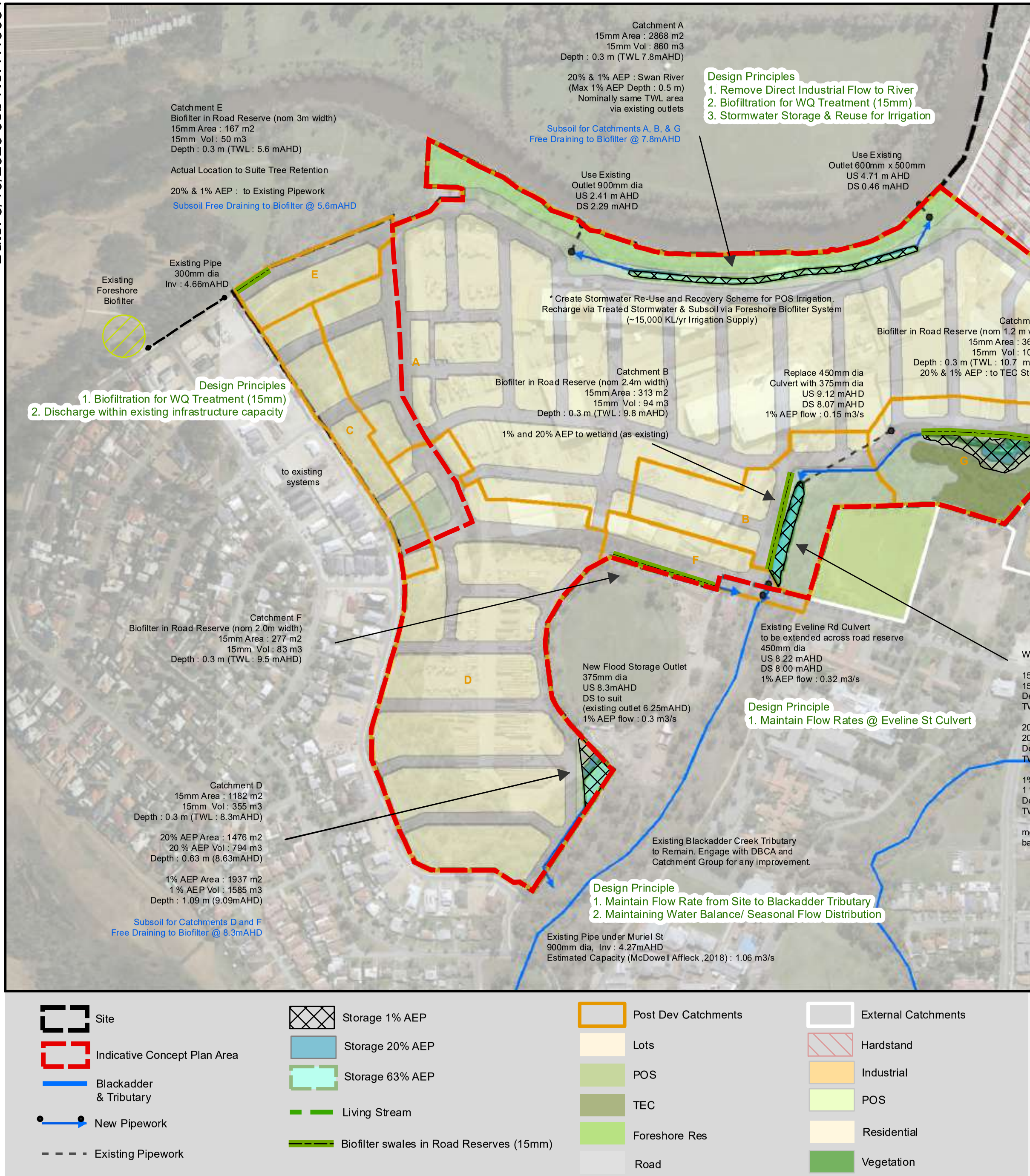
RIVERMARK
· VIVEASH ·

PLAN E

LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au

APPENDIX K
Post Development Stormwater Modelling Extracts
(Hyd2o, 2020a)

DWMS POST DEVELOPMENT SYSTEM MODELLING



hyd2o

Midland Brick District Water Management Strategy

Indicative Stormwater Management Event Plan

Date: 5/10/2020 Job No. H19054

APPENDIX L
Post Development Runoff Rate Estimation

CURRV

Calculator for Urban Runoff Rates & Volumes
11/05/2023

AR&R

Project Rivermark Area 3 Post Development Model : Southern POS Catchment (15mm Event)

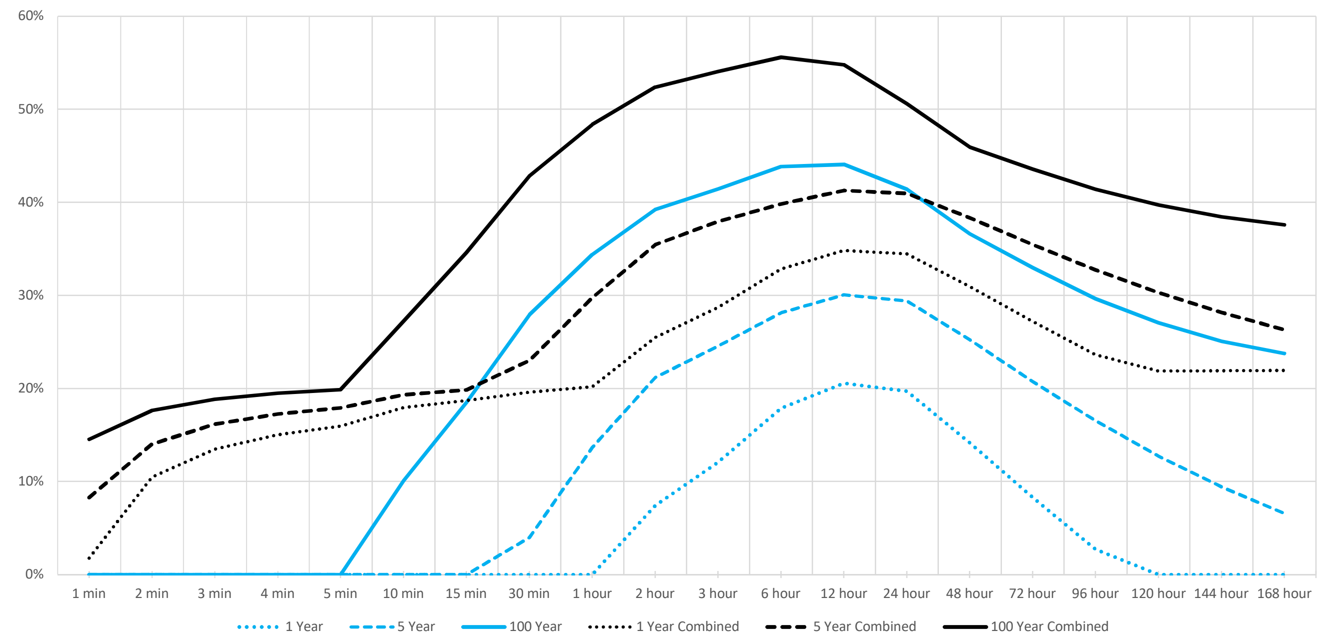
	Land Use Description	Area (ha)	Use in Calc	Imperv Initial Loss mm	Perv Initial Loss mm	Perv Continue Loss mm/hr	On Site Soak (mm)	Empty (days)	AR&R EIA/TIA System Connect Ratio	Roof %	Ext Imp %	Ext Perv %	Comment
1	Residential Lots	4.91	Yes	1.5	20.0	4.0	15.0	1.00	60%	65	22	13	excluding Catchment F
2	Roads	2.39	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	excluding Catchment F
3	POS	0.23	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	excluding Catchment F
4				1.5	20.0	4.0		1.00					
5				1.5	20.0	4.0		1.00					
6				1.5	20.0	4.0		1.00					
7				1.5	20.0	4.0		1.00					
8				1.5	20.0	4.0		1.00					
9				1.5	20.0	4.0		1.00					
10				0.0	20.0	4.0		1.00					

EIA : Effective Impervious Area, TIA : Total Impervious Area

Land Use Graph Selector	1

(11 - combined total)

Residential Lots



hyd2o HYDROLOGY

Rainfall IFD Data
Annual Exceedence Probability

	Duration	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
1	1 min	1.6	1.8	2.4	2.8	3.2	3.8	4.3
2	2 min	2.8	3.1	4.1	4.7	5.4	6.4	7.2
3	3 min	3.8	4.2	5.5	6.4	7.3	8.7	9.8
4	4 min	4.6	5.1	6.7	7.8	9.0	10.7	12.1
5	5 min	5.3	5.9	7.7	9.1	10.4	12.4	14.0
6	10 min	7.8	8.6	11.4	13.4	15.5	18.3	20.6
7	15 min	9.4	10.4	13.8	16.2	18.7	22.1	24.9
8	30 min	12.5	13.8	18.2	21.3	24.6	29.0	32.7
9	1 hour	16.1	17.8	23.2	27.2	31.4	37.3	42.2
10	2 hour	20.7	22.7	29.5	34.7	40.2	48.3	55.2
11	3 hour	23.9	26.2	34.1	40.2	46.8	56.6	65.1
12	6 hour	30.8	33.7	43.9	52.0	61.0	74.7	86.7
13	12 hour	39.6	43.3	56.6	67.1	78.8	96.7	112.0
14	24 hour	50.6	55.4	72.1	84.7	98.3	119.0	137.0
15	48 hour	63.8	70.1	90.0	104.0	118.0	139.0	156.0
16	72 hour	73.1	80.2	102.0	116.0	130.0	151.0	167.0
17	96 hour	80.7	88.5	112.0	127.0	141.0	162.0	177.0
18	120 hour	87.6	96.0	121.0	137.0	152.0	174.0	190.0
19	144 hour	94.1	103.0	130.0	148.0	164.0	187.0	205.0
20	168 hour	101.0	110.0	139.0	158.0	177.0	203.0	223.0

Estimated Runoff Rates
Annual Exceedence Probability

Maximum of All Events	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
Residential Lots	21%	23%	30%	34%	37%	42%	44%
Roads	69%	69%	69%	74%	77%	81%	84%
POS	1%	1%	3%	7%	10%	14%	16%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	35%	37%	41%	45%	49%	53%	56%

Event Selector	9	1 hour					
Residential Lots	0%	2%	14%	20%	26%	31%	34%
Roads	63%	64%	65%	70%	74%	78%	80%
POS	1%	1%	1%	5%	8%	12%	14%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	20%	22%	30%	35%	40%	45%	48%

CURRV

Calculator for Urban Runoff Rates & Volumes

11/05/2023

Project: Rivermark Area 3 Post Development Model : Southern POS Catchment (20% & 1% AEP)

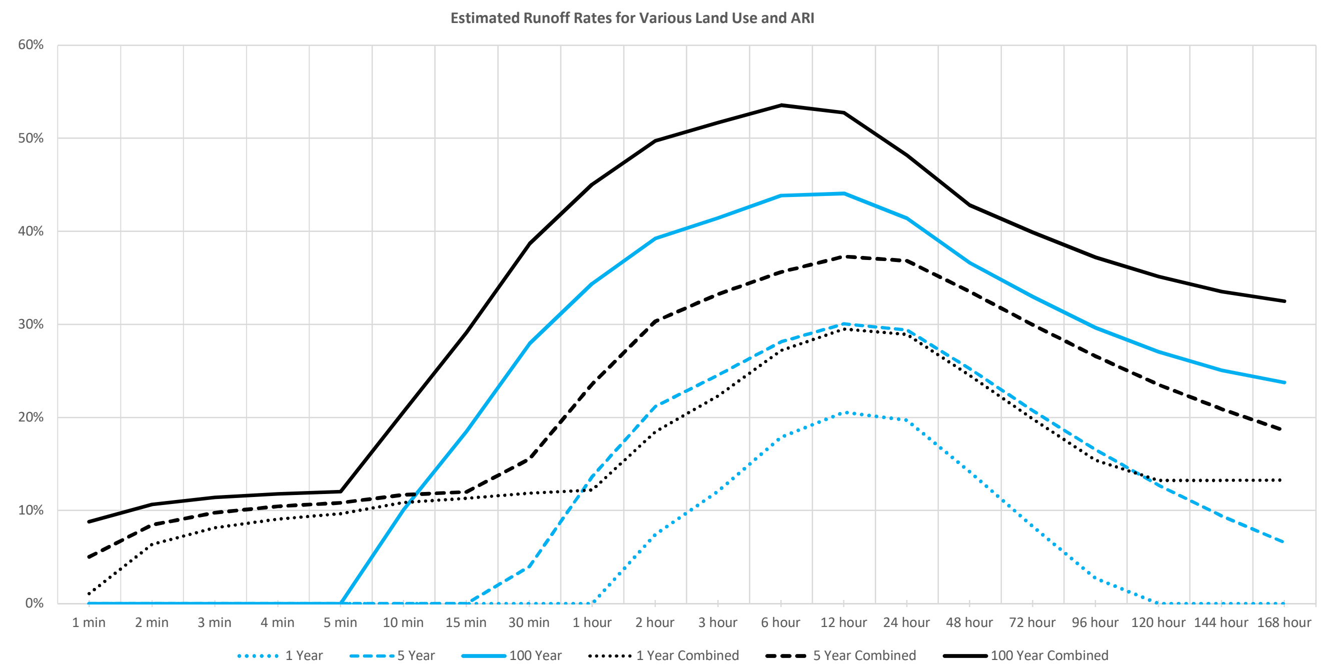
	Land Use Description	Area (ha)	Use in Calc	Imperv Initial Loss mm	Perv Initial Loss mm	Perv Continue Loss mm/hr	On Site Soak (mm)	Empty (days)	AR&R EIA/TIA System Connect Ratio	Roof %	Ext Imp %	Ext Perv %	Comment
1	Residential Lots	7.55	Yes	1.5	20.0	4.0	15.0	1.00	60%	65	22	13	including Catchment F
2	Roads (Catchment F)	1.87	Yes	1.5	20.0	4.0	15.0	1.00	100%	0	70	30	15mm into Catchment F Biofilter
3	POS	0.69	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	including Catchment F
4	Roads (Catchment D)	2.39	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	
5				1.5	20.0	4.0		1.00					
6				1.5	20.0	4.0		1.00					
7				1.5	20.0	4.0		1.00					
8				1.5	20.0	4.0		1.00					
9				1.5	20.0	4.0		1.00					
10				0.0	20.0	4.0		1.00					

EIA : Effective Impervious Area, TIA : Total Impervious Area

Land Use Graph Selector	1

(11 - combined total)

Residential Lots



Rainfall IFD Data

Annual Exceedence Probability

	Duration	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
1	1 min	1.6	1.8	2.4	2.8	3.2	3.8	4.3
2	2 min	2.8	3.1	4.1	4.7	5.4	6.4	7.2
3	3 min	3.8	4.2	5.5	6.4	7.3	8.7	9.8
4	4 min	4.6	5.1	6.7	7.8	9.0	10.7	12.1
5	5 min	5.3	5.9	7.7	9.1	10.4	12.4	14.0
6	10 min	7.8	8.6	11.4	13.4	15.5	18.3	20.6
7	15 min	9.4	10.4	13.8	16.2	18.7	22.1	24.9
8	30 min	12.5	13.8	18.2	21.3	24.6	29.0	32.7
9	1 hour	16.1	17.8	23.2	27.2	31.4	37.3	42.2
10	2 hour	20.7	22.7	29.5	34.7	40.2	48.3	55.2
11	3 hour	23.9	26.2	34.1	40.2	46.8	56.6	65.1
12	6 hour	30.8	33.7	43.9	52.0	61.0	74.7	86.7
13	12 hour	39.6	43.3	56.6	67.1	78.8	96.7	112.0
14	24 hour	50.6	55.4	72.1	84.7	98.3	119.0	137.0
15	48 hour	63.8	70.1	90.0	104.0	118.0	139.0	156.0
16	72 hour	73.1	80.2	102.0	116.0	130.0	151.0	167.0
17	96 hour	80.7	88.5	112.0	127.0	141.0	162.0	177.0
18	120 hour	87.6	96.0	121.0	137.0	152.0	174.0	190.0
19	144 hour	94.1	103.0	130.0	148.0	164.0	187.0	205.0
20	168 hour	101.0	110.0	139.0	158.0	177.0	203.0	223.0

Estimated Runoff Rates

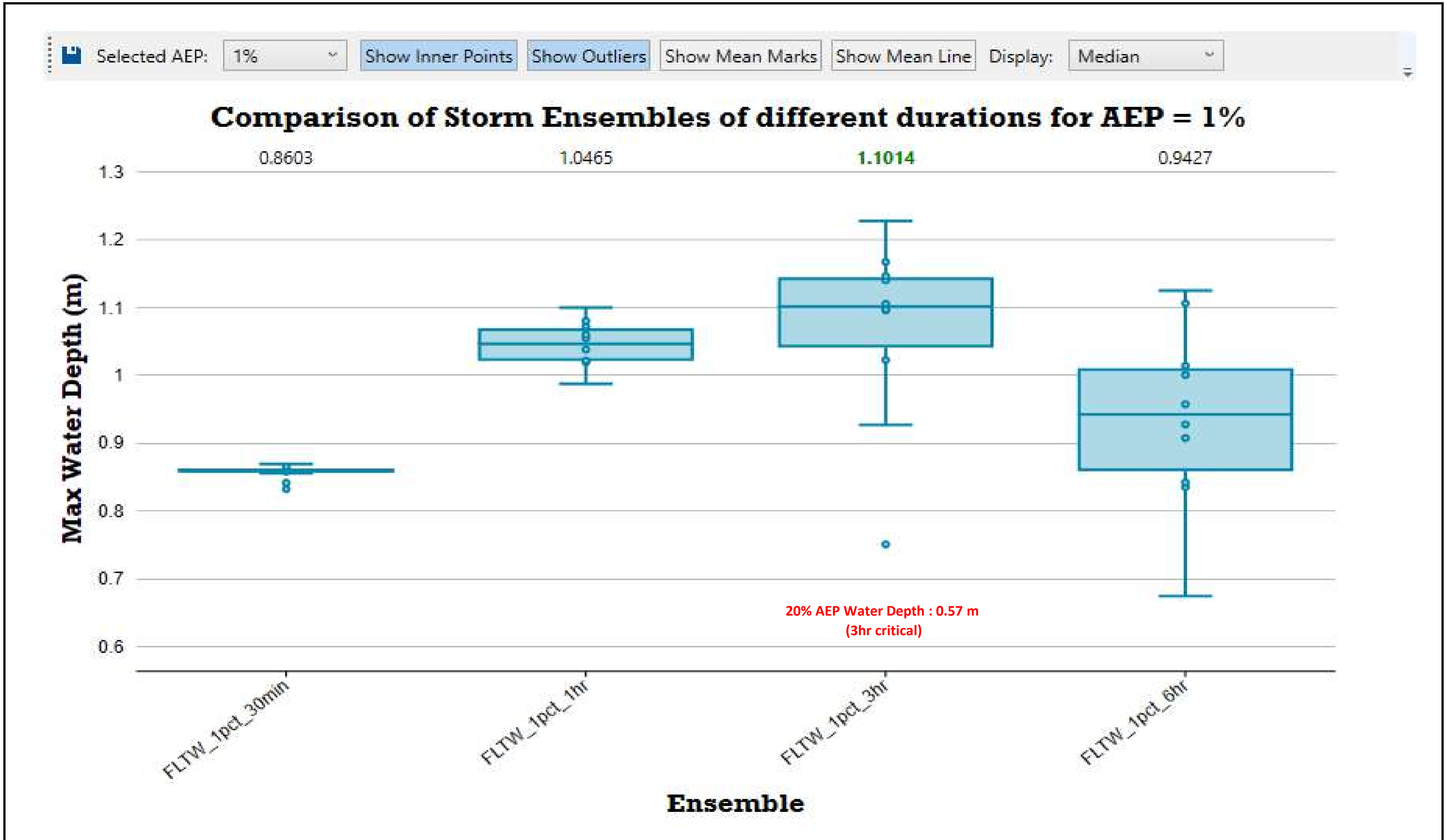
Annual Exceedence Probability

Maximum of All Events	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
Residential Lots	21%	23%	30%	34%	37%	42%	44%
Roads (Catchment F)	28%	31%	40%	47%	55%	63%	68%
POS	1%	1%	3%	7%	10%	14%	16%
Roads (Catchment D)	69%	69%	69%	74%	77%	81%	84%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**30%**	32%	**37%**	**41%**	46%	51%	**54%**

Event Selector	9	1 hour					
Residential Lots	0%	2%	14%	20%	26%	31%	34%
Roads (Catchment F)	0%	3%	18%	29%	39%	49%	55%
POS	1%	1%	1%	5%	8%	12%	14%
Roads (Catchment D)	63%	64%	65%	70%	74%	78%	80%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**12%**	14%	**24%**	**30%**	36%	42%	**45%**

APPENDIX M
LSP Area Stormwater Modelling Outputs

Date: 15/05/2023 Job No H22039

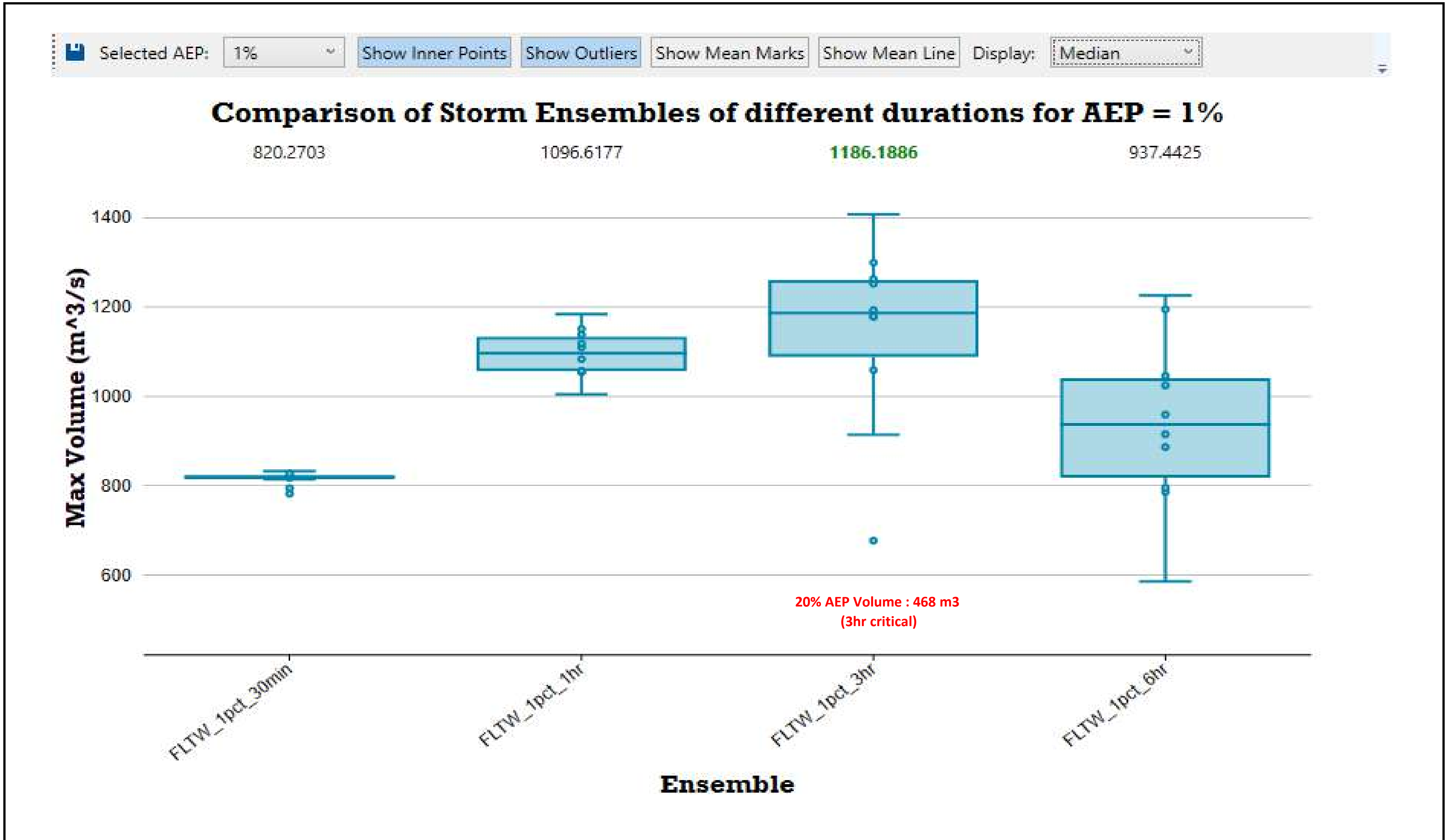


hyd$_2$o

Rivermark Area 3 Local Water Mangement Strategy

Post Development System : Modelling Results at POS Basin Outlet (Box & Whisker)

Appendix M

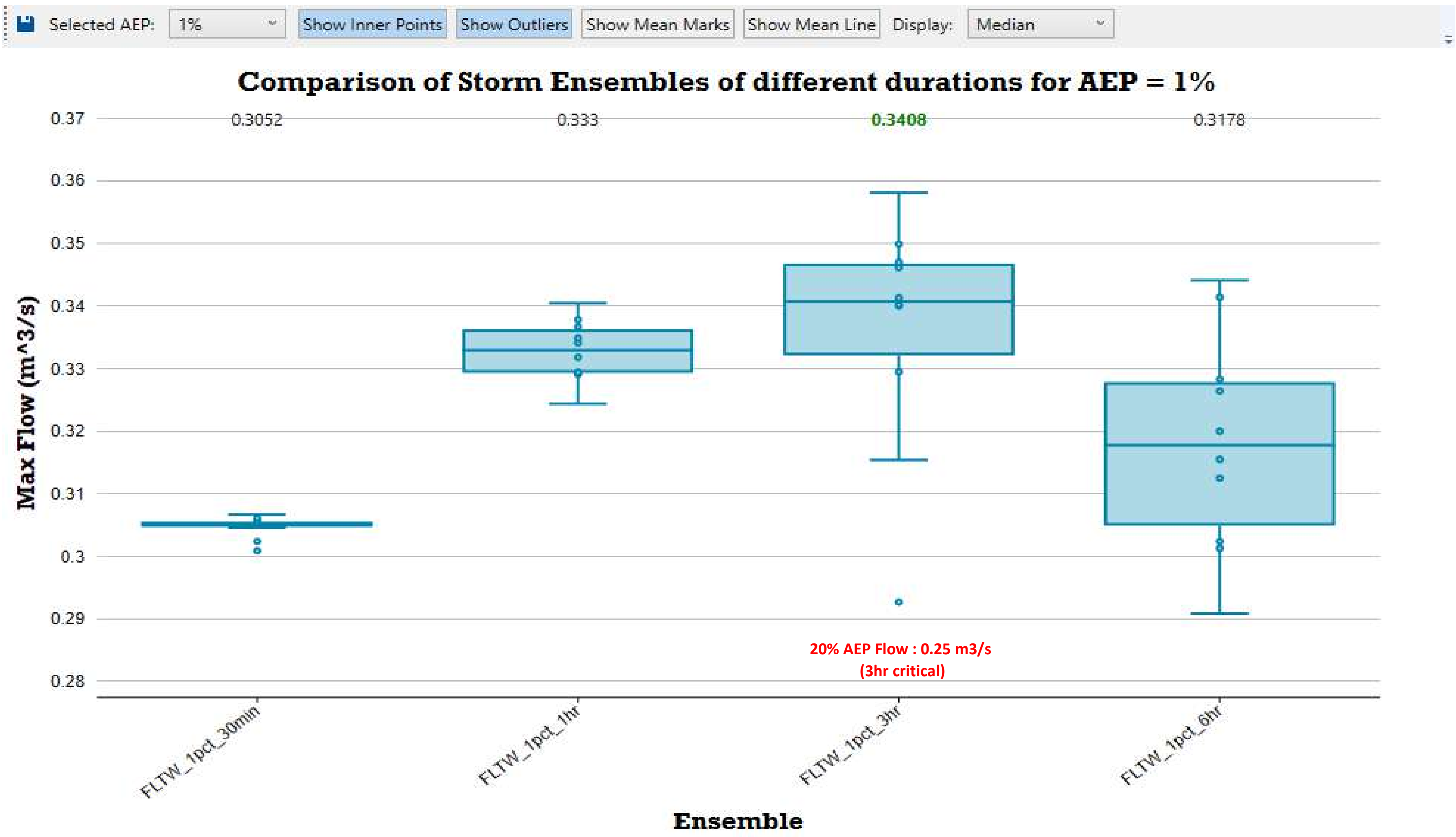


hyd2o

Rivermark Area 3 Local Water Mangement Strategy

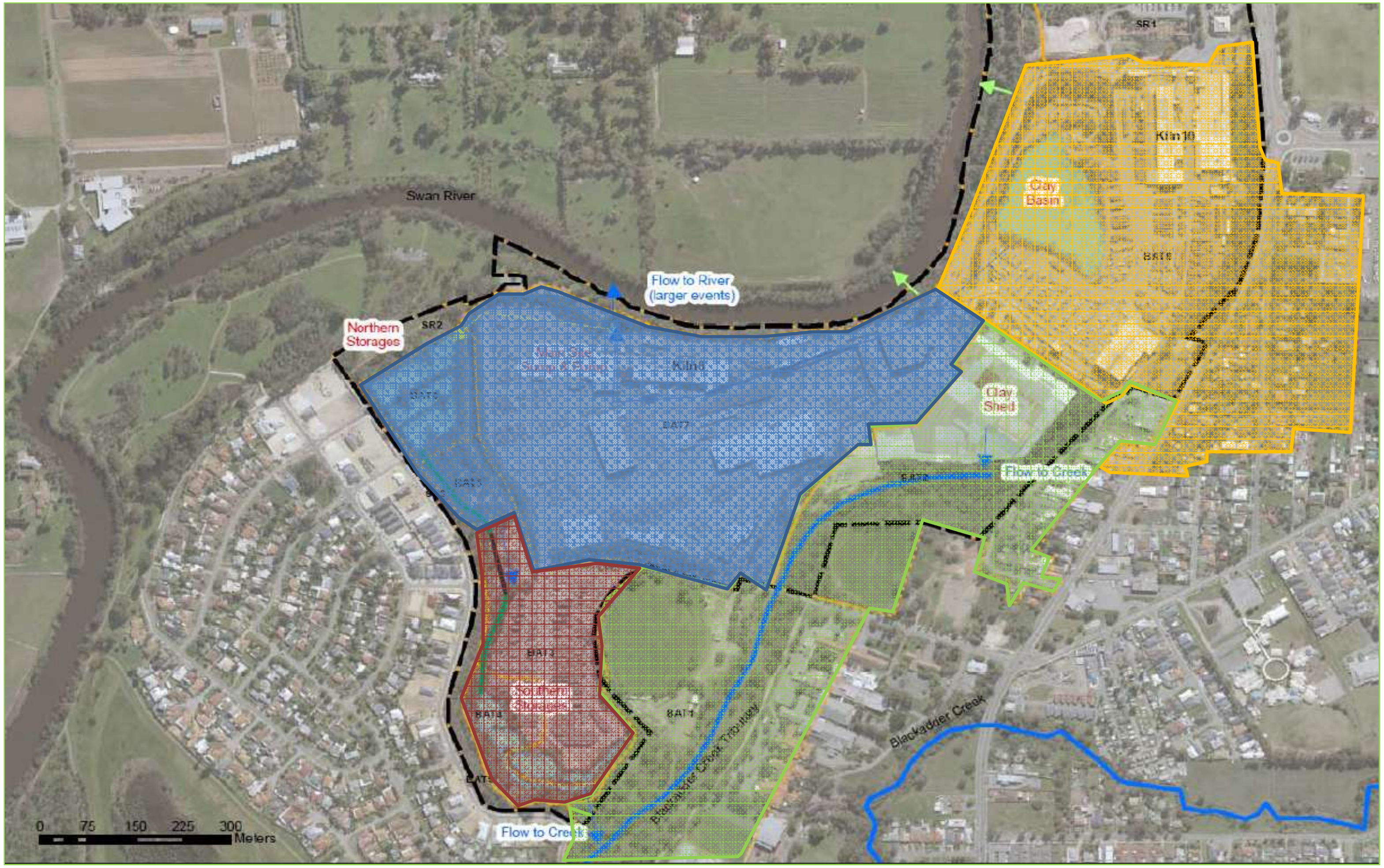
Post Development System : Modelling Results at POS Basin Outlet (Box & Whisker)

Appendix M


Selected AEP: 1%
Show Inner Points
Show Outliers
Show Mean Marks
Show Mean Line
Display: Median
Comparison of Storm Ensembles of different durations for AEP = 1%
0.3052
0.333
0.3408
0.3178
Max Flow (m^3/s)
0.37
0.36
0.35
0.34
0.33
0.32
0.31
0.3
0.29
0.28
20% AEP Flow : 0.25 m3/s
(3hr critical)
FLTW_1pct_30min
FLTW_1pct_1hr
FLTW_1pct_3hr
FLTW_1pct_6hr
Ensemble

APPENDIX N
Water Balance Modelling

Midland Brick Water Balance : Existing System - Conceptual Model



Catchment 1 : Midland Brick
Water In : Catchment Runoff (31.74 ha)
Water Use : Dust Suppression
Water Use : Evaporation
Water Out : To Catchment 2
Post Dev - Same Area

Catchment 2 : Northern
Water In : from Catchment 1
Water In : Catchment Runoff (29.88 ha)
Water Use : Evaporation
Water Out : to Catchment 3
Post Dev - Catchments A,E and C

Catchment 3 : Southern
Water In : from Catchment 2
Water In : Catchment Runoff (9.00 ha)
Water Use : Evaporation
Water Out : to Blackadder
Post Dev - Catchments D,F

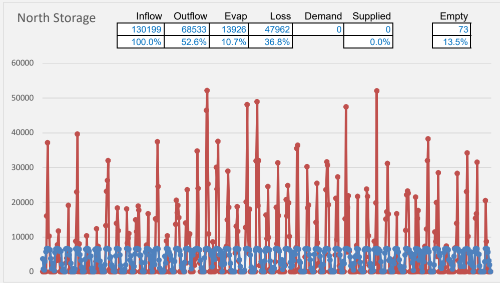
Catchment 4 : Clay Shed
Water In : Catchment Runoff (31.15 ha)
Water Use : Evaporation
Water Out : to Blackadder
Post Dev - Catchments B,G, Same External

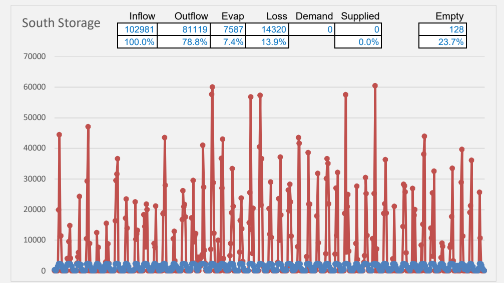
Midland Brick

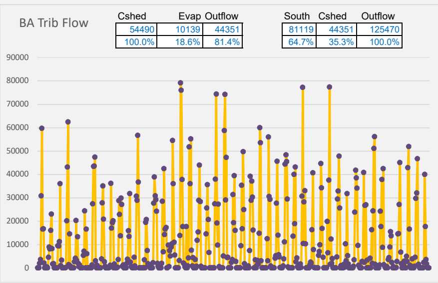
Existing Water Balance Model

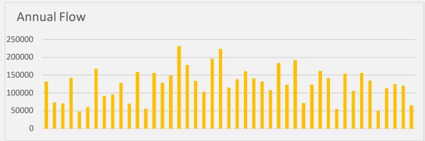
(note : system prior to recent upgrades)

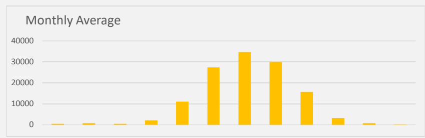
Modelling Start Year	1975	
Modelling Start Month	1	
Rainfall Multiplier	1.00	
Total Flow (kL/yr)	306132	
Catchment 1 (kL/yr)	102752	33.6%
Catchment 2 (kL/yr)	114443	37.4%
Catchment 3 (kL/yr)	34448	11.3%
Catchment 4 (kL/yr)	54490	17.8%
Total Evaporation	67889	22.2%
Total Demand	9768	3.2%
Total Loss	103915	33.9%
BA Trib Outflow	125470	41.0%
Average Outflow l/s	4.0	











Year	Mth	Rain (mm)	Adj Rain (mm)	Evap (mm)	Dust Supp kL	Recycl Plant kL	Resid /POS kL	Constr kL	Catch 1 Hstand ha	Catch 1 Roof ha	Catch 1 External ha	Catch 2 Indust ha	Catch 2 Resid ha	Catch 3 Indust ha	Catch 3 Resid ha	Catch 4 Local/ CShed ha	Catch 4 Other ha	Extra Bore kL	Catch 1 Hstand kL	Catch 1 Roof kL	Catch 1 External kL
					1.00	0.00	0.00	0.00										0	6124	887	1551
									55%	85%	25%	55%	30%	55%	30%	85%	15%				
1975	1	0.0	0.0	274.7	1107	3986	6333	833	19.2	1.8	10.7	29.9	0.0	9.0	0.0	4.5	26.7	0	0	0	0
1975	2	0.0	0.0	236.0	1000	3600	6333	833	19.2	1.8	10.7	29.9	0.0	9.0	0.0	4.5	26.7	0	0	0	0
1975	3	12.8	12.8	202.4	1107	3986	6333	833	19.2	1.8	10.7	29.9	0.0	9.0	0.0	4.5	26.7	0	1352	196	342
1975	4	39.4	39.4	114.2	536	1286	0	0	19.2	1.8	10.7	29.9	0.0	9.0	0.0	4.5	26.7	0	4161	603	1054
1975	5	55.6	55.6	74.8	554	1329	0	0	19.2	1.8	10.7	29.9	0.0	9.0	0.0	4.5	26.7	0	5871	851	1487
1975	6	146.8	146.8	52.9	536	1286	0	0	19.2	1.8	10.7	29.9	0.0	9.0	0.0	4.5	26.7	0	15502	2246	3927
1975	7	201.2	201.2	50.4	554	1329	0	0	19.2	1.8	10.7	29.9	0.0	9.0	0.0	4.5	26.7	0	21247	3078	5382
1975	8	76.8	76.8	73.1	554	1329	0	0	19.2	1.8	10.7	29.9	0.0	9.0	0.0	4.5	26.7	0	8110	1175	2054
1975	9	79.0	79.0	92.4	536	1286	0	0	19.2	1.8	10.7	29.9	0.0	9.0	0.0	4.5	26.7	0	8342	1209	2113
1975	10	44.0	44.0	135.2	1107	3986	6333	833	19.2	1.8	10.7	29.9	0.0	9.0	0.0	4.5	26.7	0	4646	673	1177

Midland Brick

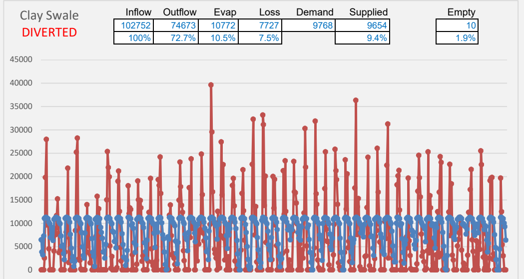
Water Balance Model Ultimate

Add New Northern Storage, Remove Southern Storage
Catchments 2&3 & Clay Shed to Residential
Clay Swale Outflow to BA Trib

Modelling Start Year	1975	
Modelling Start Month	1	
Rainfall Multiplier	1.00	
Total Flow (kL/yr)	221648	
Catchment 1 (kL/yr)	102752	46.4%
Catchment 2 (kL/yr)	53029	23.9%
Catchment 3 (kL/yr)	27141	12.2%
Catchment 4 (kL/yr)	38728	17.5%
Total Evaporation	23798	10.7%
Total Demand	9768	4.4%
Total Loss	9997	4.5%
BA Trib Outflow	120930	54.6%
Average Outflow l/s	3.8	

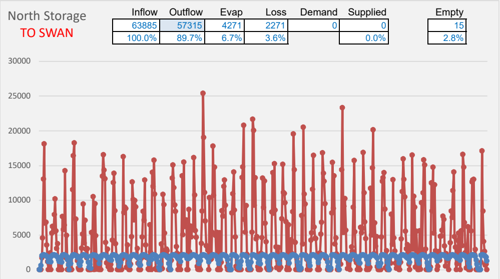
Clay Swale DIVERTED

Inflow	Outflow	Evap	Loss	Demand	Supplied	Empty
102752	74673	10772	7727	9768	9654	10
100%	72.7%	10.5%	7.5%		9.4%	1.9%



North Storage TO SWAN

Inflow	Outflow	Evap	Loss	Demand	Supplied	Empty
63885	57315	4271	2271	0	0	15
100.0%	89.7%	6.7%	3.6%		0.0%	2.8%

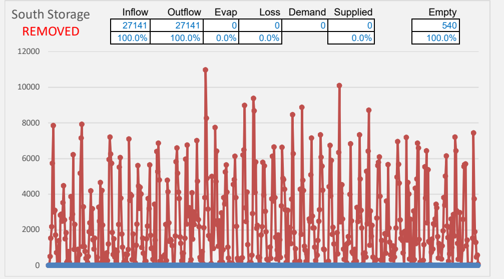


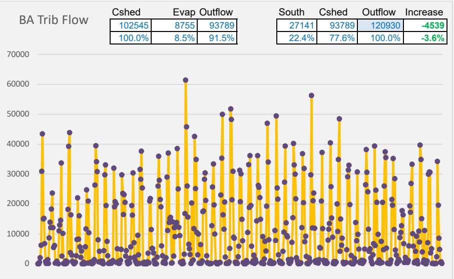
South Storage REMOVED

Inflow	Outflow	Evap	Loss	Demand	Supplied	Empty
27141	27141	0	0	0	0	540
100.0%	100.0%	0.0%	0.0%		0.0%	100.0%

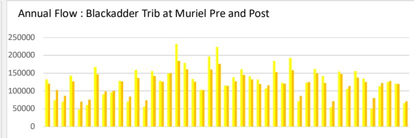
BA Trib Flow

Cshed	Evap	Outflow	South	Cshed	Outflow	Increase
102545	8755	93789	27141	93789	120930	-4539
100.0%	8.5%	91.5%	22.4%	77.6%	100.0%	-3.6%

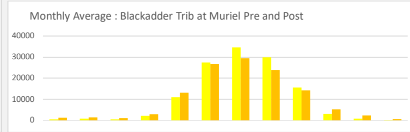




Annual Flow : Blackadder Trib at Muriel Pre and Post

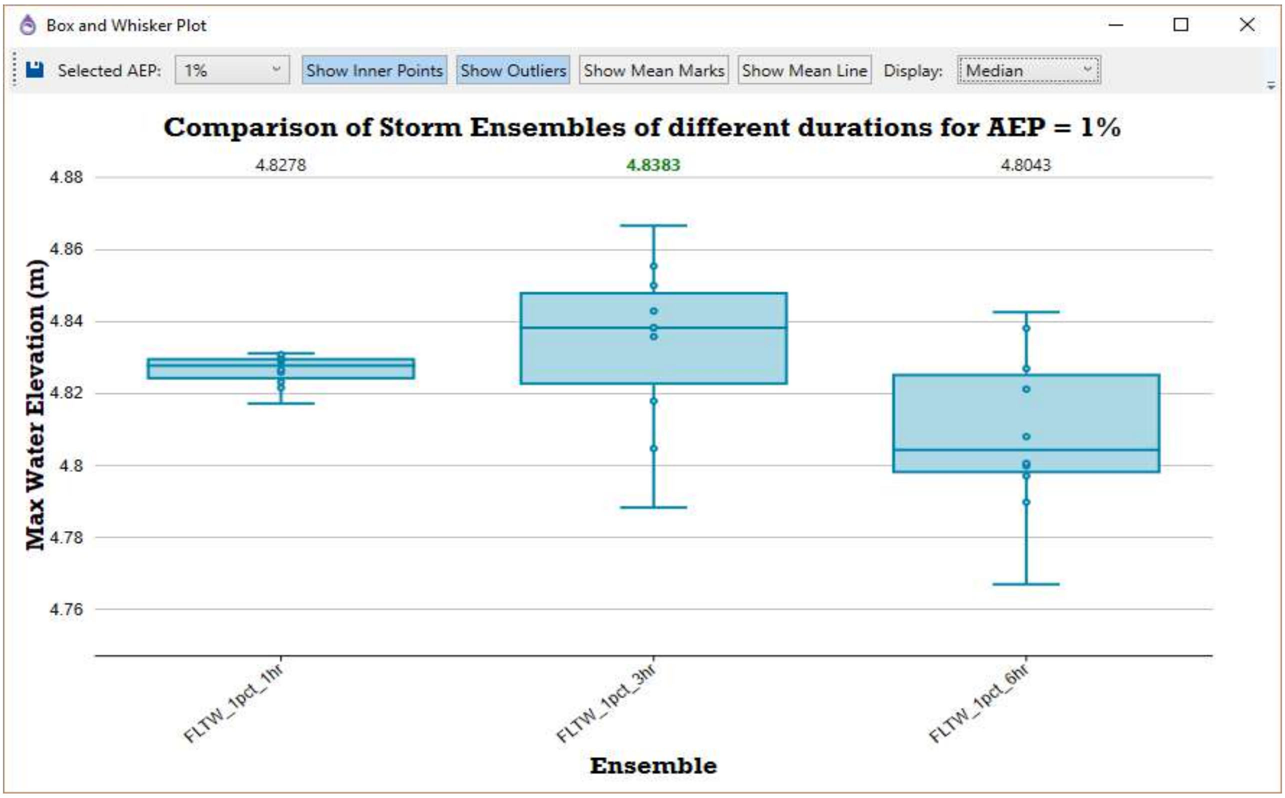


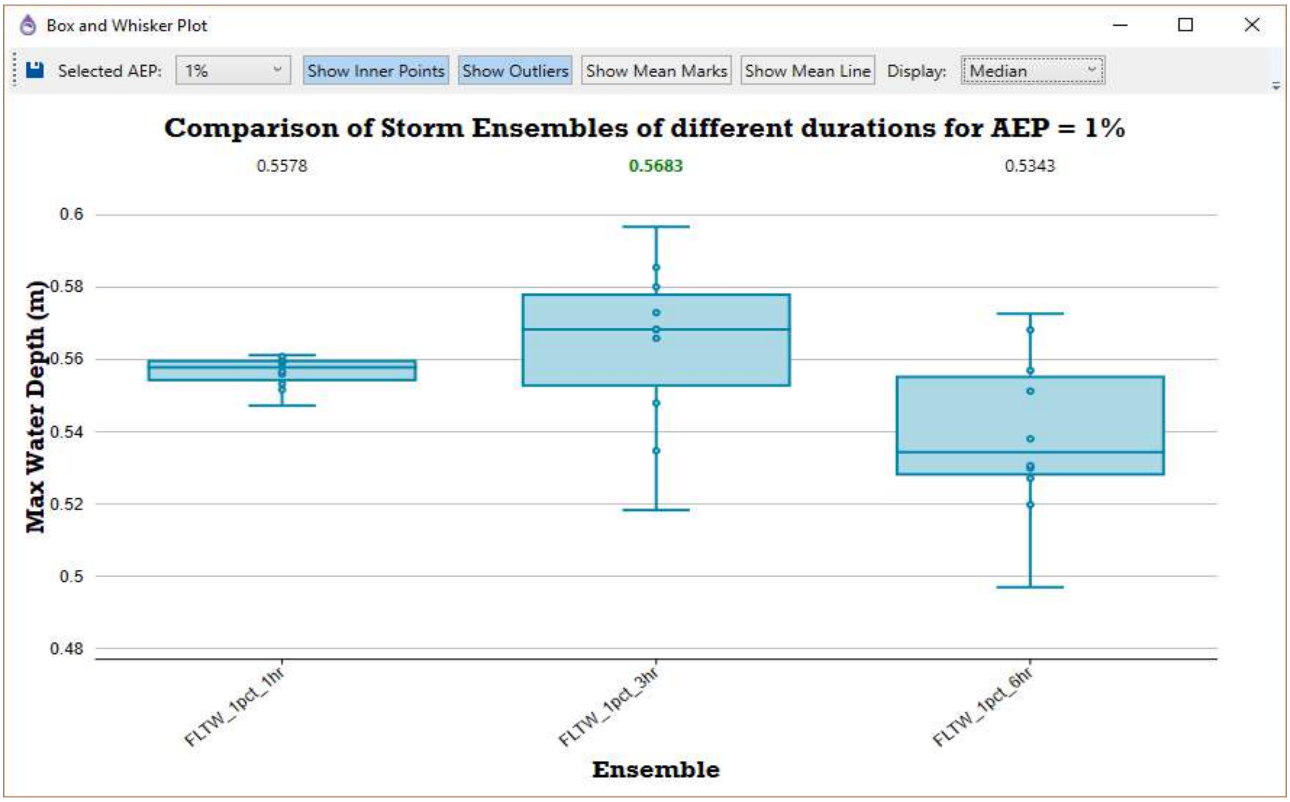
Monthly Average : Blackadder Trib at Muriel Pre and Post

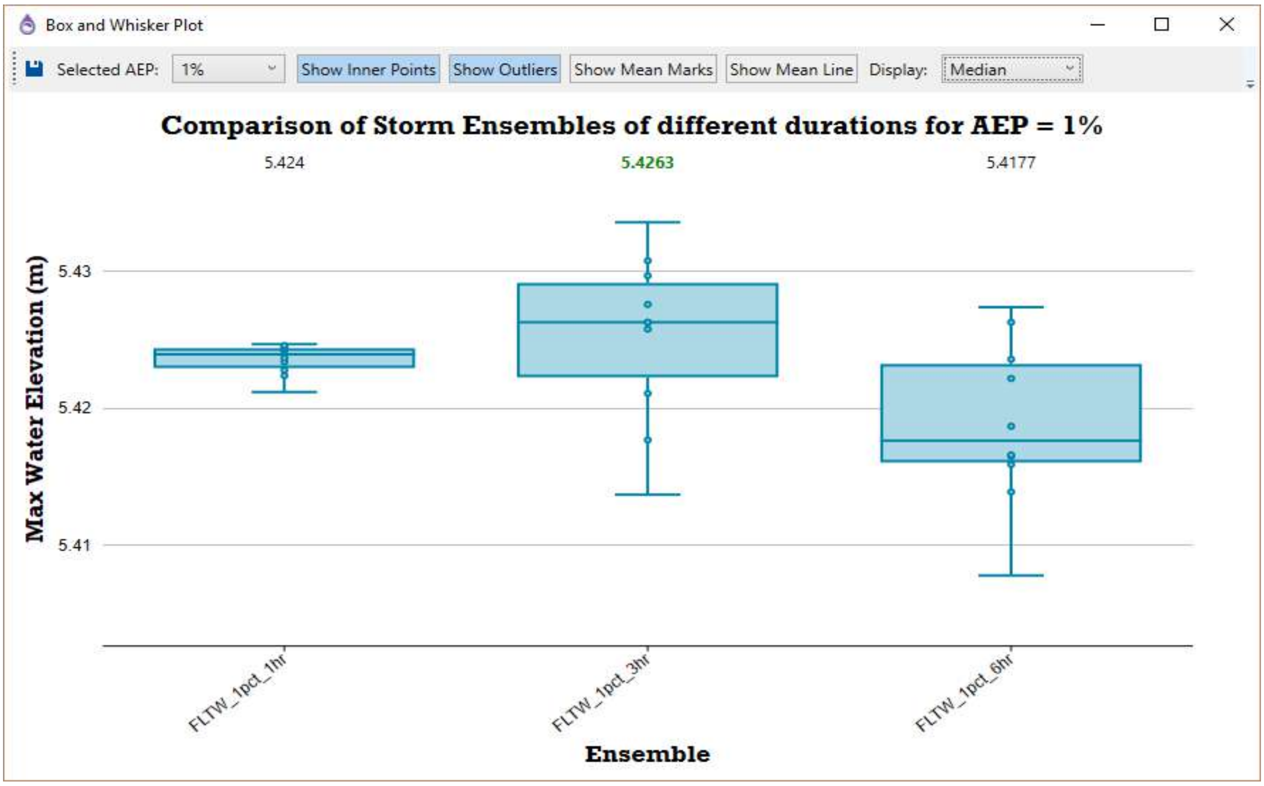


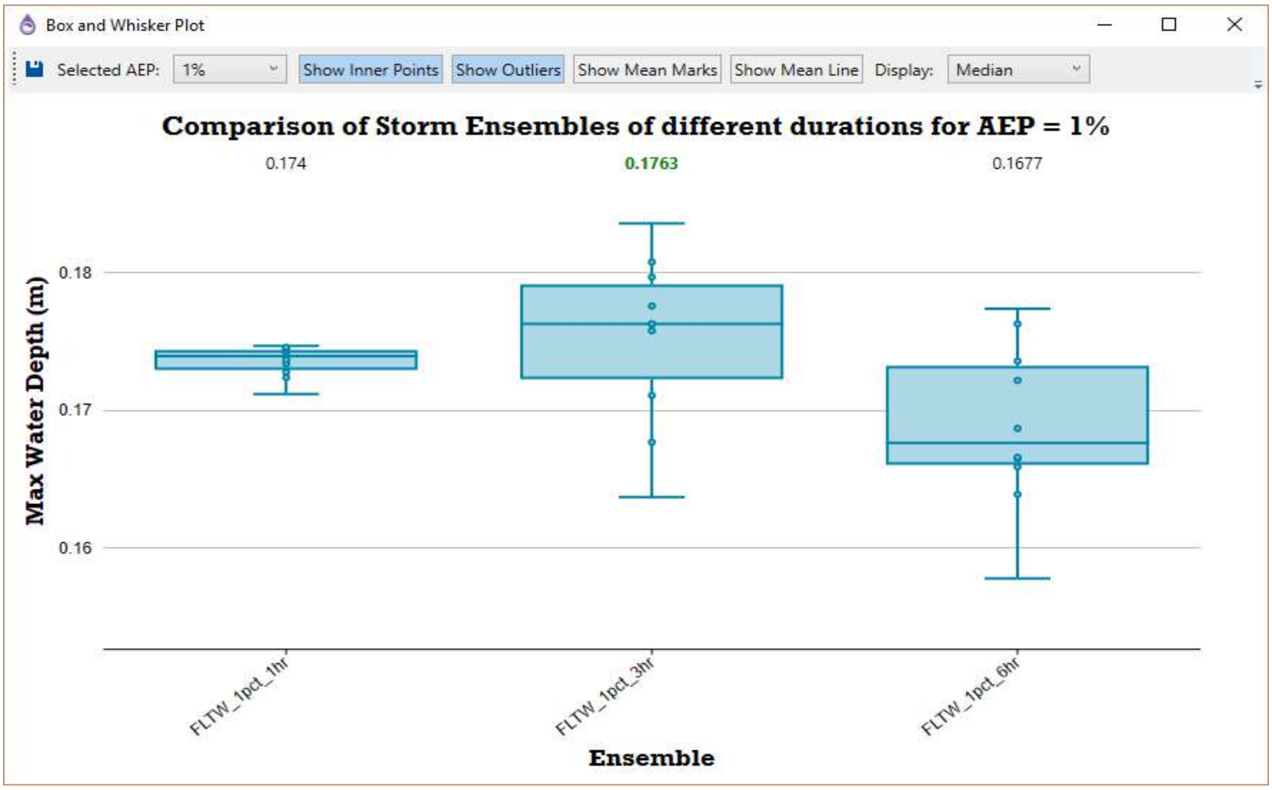
Year	Mth	Rain (mm)	Adj Rain (mm)	Evap (mm)	Dust Supp kL	Recycl Plant kL	Resid /POS kL	Constr kL	Catch 1 Hstand ha	Catch 1 Roof ha	Catch 1 External ha	Catch 2 Indust ha	Catch 2 Resid ha	Catch 3 Indust ha	Catch 3 Resid ha	Catch 4 Local/ CShed ha	Catch 4 Other ha	Extra Bore kL	Catch 1 Hstand kL	Catch 1 Roof kL	Catch 1 External kL
					1.00	0.00	0.00	0.00										Vol 0	6124	887	1551
					Demands			0	Water Sources, Catchment Areas, & Runoff												
									55%	85%	25%	55%	30%	55%	30%	30%	15%				
1975	1	0.0	0.0	274.7	1107	3986	6333	833	19.2	1.8	10.7	0.0	25.4	0.0	13.0	5.2	26.7	0	0	0	0
1975	2	0.0	0.0	236.0	1000	3600	6333	833	19.2	1.8	10.7	0.0	25.4	0.0	13.0	5.2	26.7	0	0	0	0
1975	3	12.8	12.8	202.4	1107	3986	6333	833	19.2	1.8	10.7	0.0	25.4	0.0	13.0	5.2	26.7	0	1352	196	342
1975	4	39.4	39.4	114.2	536	1286	0	0	19.2	1.8	10.7	0.0	25.4	0.0	13.0	5.2	26.7	0	4161	603	1054
1975	5	55.6	55.6	74.8	554	1329	0	0	19.2	1.8	10.7	0.0	25.4	0.0	13.0	5.2	26.7	0	5871	851	1487
1975	6	146.8	146.8	52.9	536	1286	0	0	19.2	1.8	10.7	0.0	25.4	0.0	13.0	5.2	26.7	0	15502	2246	3927
1975	7	201.2	201.2	50.4	554	1329	0	0	19.2	1.8	10.7	0.0	25.4	0.0	13.0	5.2	26.7	0	21247	3078	5382
1975	8	76.8	76.8	73.1	554	1329	0	0	19.2	1.8	10.7	0.0	25.4	0.0	13.0	5.2	26.7	0	8110	1175	2054
1975	9	79.0	79.0	92.4	536	1286	0	0	19.2	1.8	10.7	0.0	25.4	0.0	13.0	5.2	26.7	0	8342	1209	2113
1975	10	44.0	44.0	135.2	1107	3986	6333	833	19.2	1.8	10.7	0.0	25.4	0.0	13.0	5.2	26.7	0	4646	673	1177
1975	11	18.6	18.6	185.6	1071	3857	6333	833	19.2	1.8	10.7	0.0	25.4	0.0	13.0	5.2	26.7	0	1964	285	498

APPENDIX O
TEC Stormwater Modelling Outputs

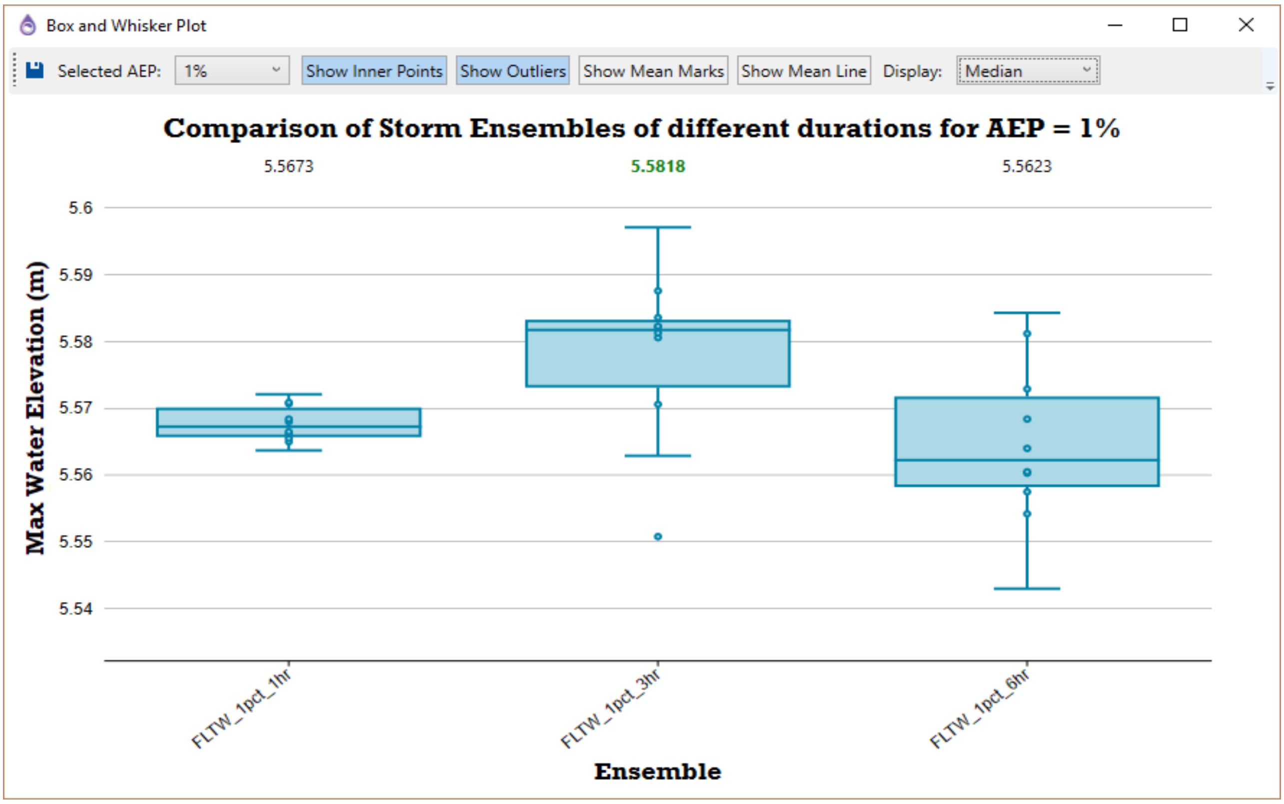

Box and Whisker Plot
Selected AEP: 1%
Show Inner Points
Show Outliers
Show Mean Marks
Show Mean Line
Display: Median
Comparison of Storm Ensembles of different durations for AEP = 1%
4.8278
4.8383
4.8043
Max Water Elevation (m)
4.88
4.86
4.84
4.82
4.8
4.78
4.76
FLTW_1pct_1hr
FLTW_1pct_3hr
FLTW_1pct_6hr
Ensemble

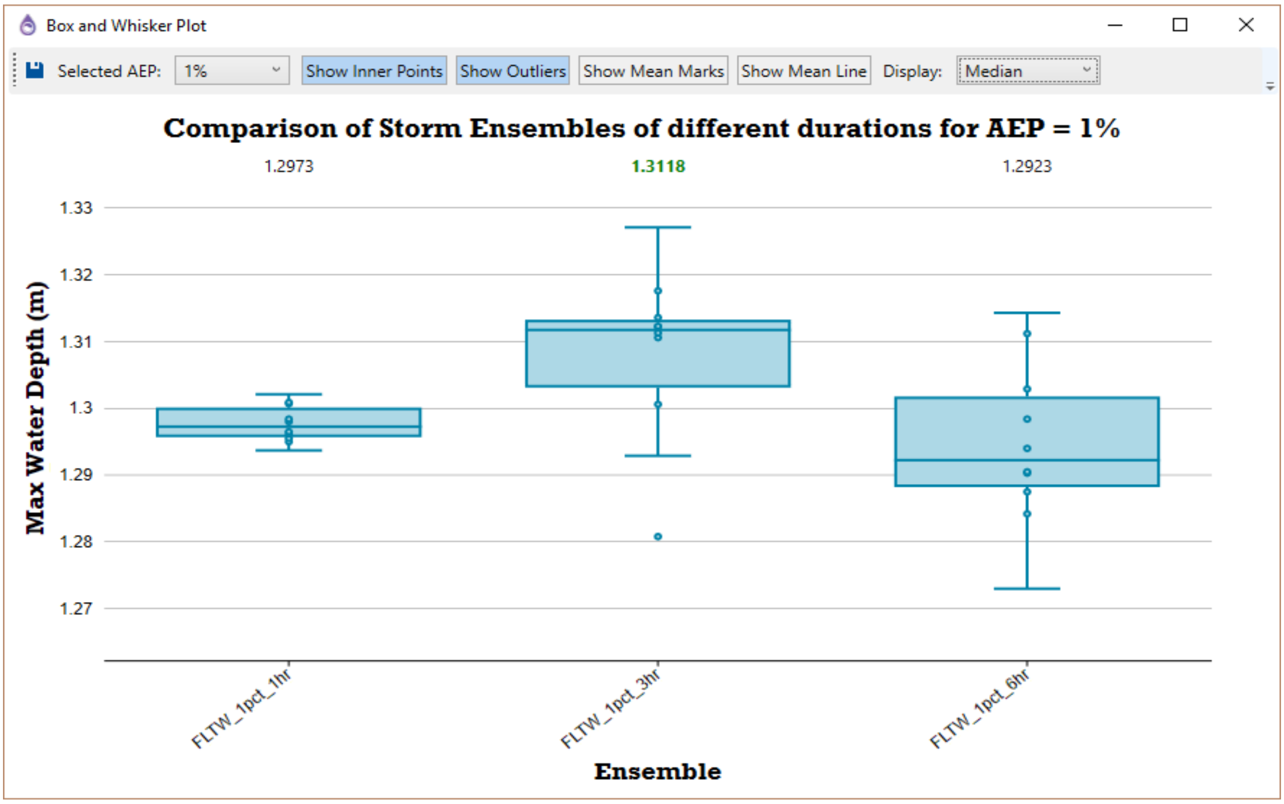

Box and Whisker Plot
Selected AEP: 1%
Show Inner Points
Show Outliers
Show Mean Marks
Show Mean Line
Display: Median
Comparison of Storm Ensembles of different durations for AEP = 1%
0.5578
0.5683
0.5343
Max Water Depth (m)
0.6
0.58
0.56
0.54
0.52
0.5
0.48
FLTW_1pct_1hr
FLTW_1pct_3hr
FLTW_1pct_6hr
Ensemble


Box and Whisker Plot
Selected AEP: 1%
Show Inner Points
Show Outliers
Show Mean Marks
Show Mean Line
Display: Median
Comparison of Storm Ensembles of different durations for AEP = 1%
5.424
5.4263
5.4177
Max Water Elevation (m)
5.43
5.42
5.41
FLTW_1pct_1hr
FLTW_1pct_3hr
FLTW_1pct_6hr
Ensemble


Box and Whisker Plot
Selected AEP: 1%
Show Inner Points
Show Outliers
Show Mean Marks
Show Mean Line
Display: Median
Comparison of Storm Ensembles of different durations for AEP = 1%
0.174
0.1763
0.1677
Max Water Depth (m)
0.18
0.17
0.16
FLTW_1pct_1hr
FLTW_1pct_3hr
FLTW_1pct_6hr
Ensemble

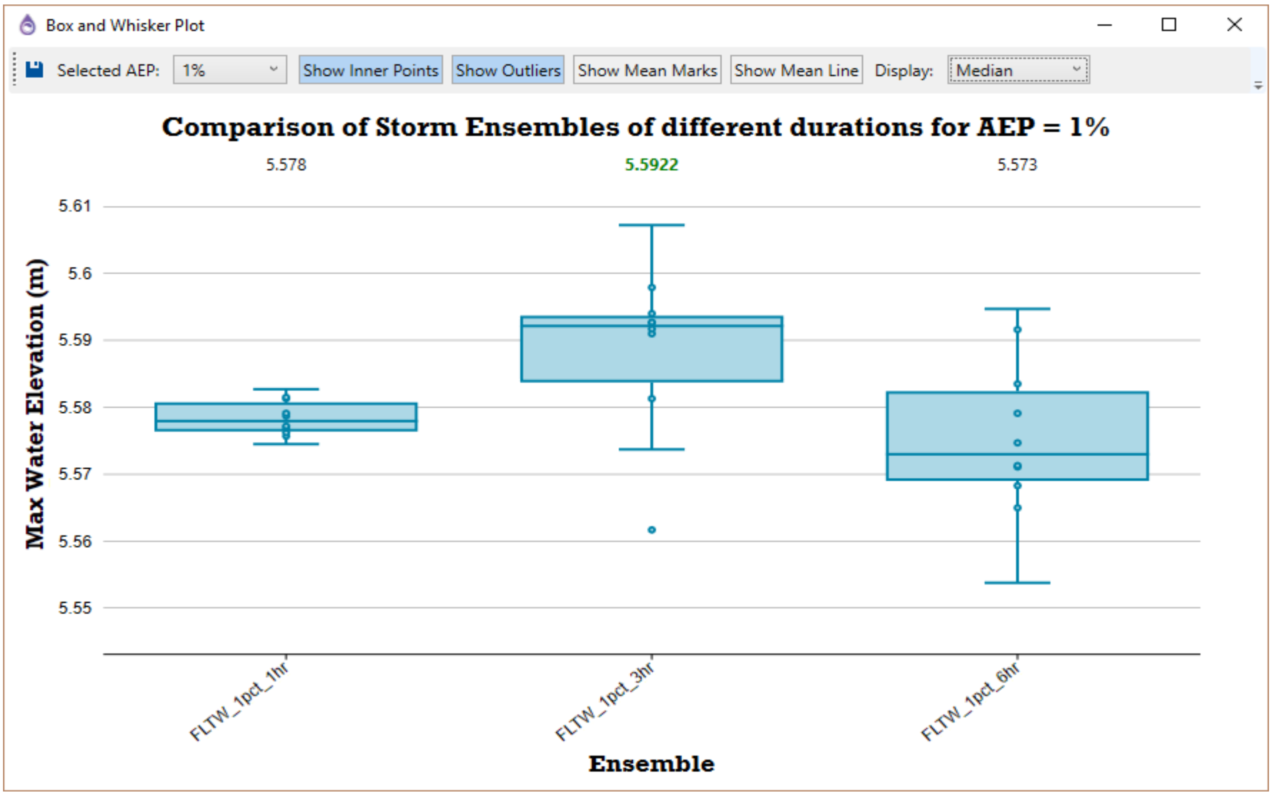
Date :16/11/2022 Job No. H22039

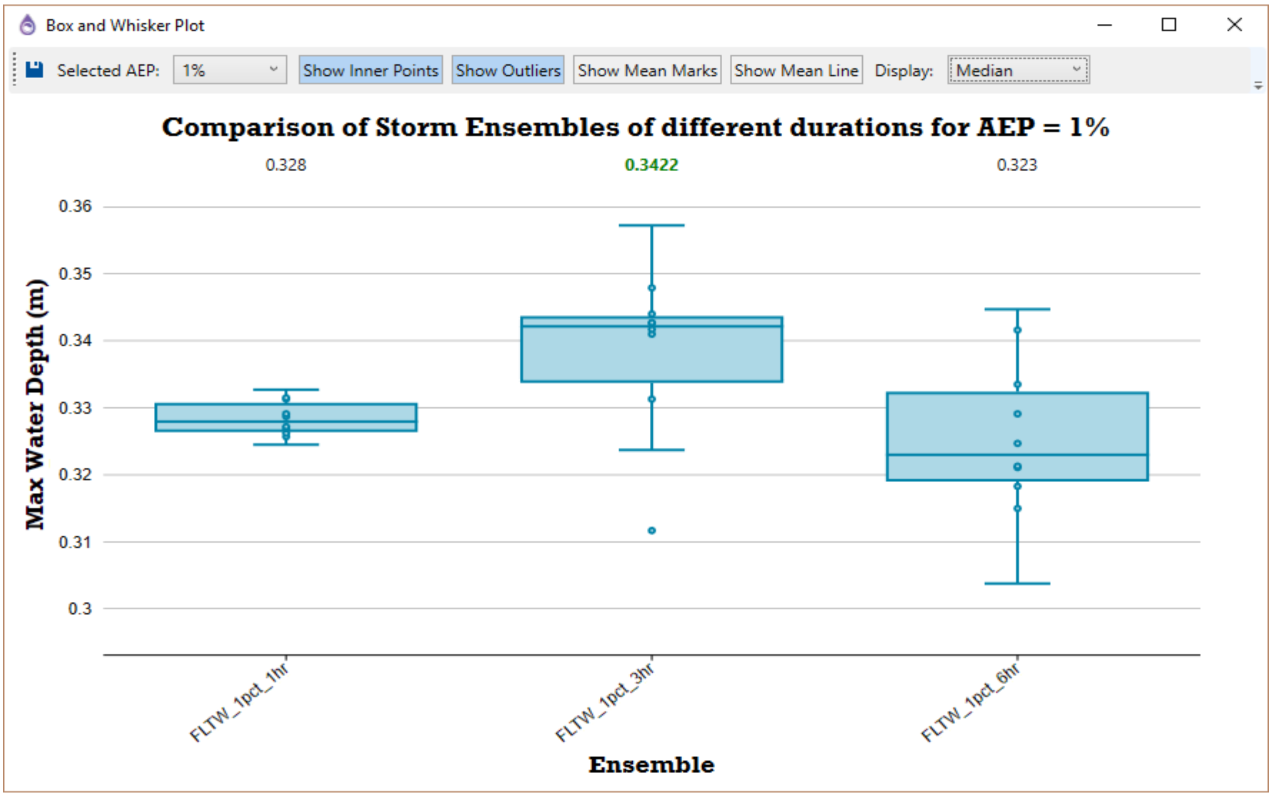




1% AEP Tailwater for Blackadder Creek : 5.46m AHD

Date :16/11/2022 Job No. H22039





1% AEP Tailwater for Blackadder Creek : 5.46m AHD

APPENDIX P
Engineering Drawings

3 SITEWORKS AND EARTHWORKS

Siteworks to support residential urban development will generally comprise the clearing of existing vegetation, stripping of topsoil, earthworking of the existing ground surface, compaction to areas of existing fill and import of a sand topping to facilitate the proposed form of development.

While the majority of the site is utilised for the manufacture of bricks and masonry product, there are some stands of vegetation which may ultimately impact on the concept design. One of these is along the Swan River foreshore within an area identified as Bush Forever and the other is near the Leslie Road frontage.

Given the existing soils within the site consist of material unsuitable for residential development in its current state and the geotechnical requirement for imported sand fill, limited vegetation will be able to be retained during site preparation. However, some of the more significant trees have been identified with the planning and conceptual earthworks design taking in to account these trees for retention.

Development of the site will require removal of all brick and clay stock on site as well as the demolition of existing buildings, pavements and services prior to undertaking site earthworks, servicing and roadworks to produce the desired development form. Following demolition of existing infrastructure, earthworking will take place to provide for a desired development form while addressing the engineering constraints of the site.

The clayey subgrade surface will be earthworked and shaped, before the sand is placed, to ensure no ponding of perched water occurs. Following the subgrade works, a layer of clean sand fill will be imported and placed above the clayey material to achieve the proposed finished levels and desired site classification. Earthworking of the site is also required to ensure the positive drainage of the allotments to the road and drainage reserves for disposal.

The Douglas Partners geotechnical review recommends that there is a minimum depth zone of at least 1.2m of compacted clay fill that sits below the sand topping layer. Therefore, areas where there is less than 1.2m of clay filling required below the sand layer will need to be over-excavated and recompacted. Where the excavated material has brick or other deleterious inclusions, a screening and crushing process will be required to downsize material to less than 50mm to ensure there are no voids in the future structural fill matrix.

The imported material used for filling should be a free drainage clean sand material having a fines content less than 5% and permeability greater than 5m/day to avoid the imported material having a negative impact on site drainage.

Once an appropriate level of site preparation is undertaken to address the geotechnical risk from the existing fill, compaction of the clayey subgrade and depending on the thickness of the proposed sand fill layer over the clayey soils, it is expected that the post development site classification will be “A” or “S”, in accordance with AS2870.

It is anticipated that the final levels across the site will be dictated by either the fill required for improvement of the AS2870 site classification or the minimum level required to ensure adequate separation from the Guildford formation and groundwater levels. Additionally, final levels will need to accommodate interface levels with the adjacent developments and existing infrastructure. Furthermore, finished floor levels for the buildings will need to be at least 500mm above the estimated 1% average exceedance probability (AEP) flood levels.

In accordance with current market expectations flat residential allotments will generally be created. Due to the proposed earthworks strategy, stepping between allotments is likely to be achieved with the minimal use of retaining.

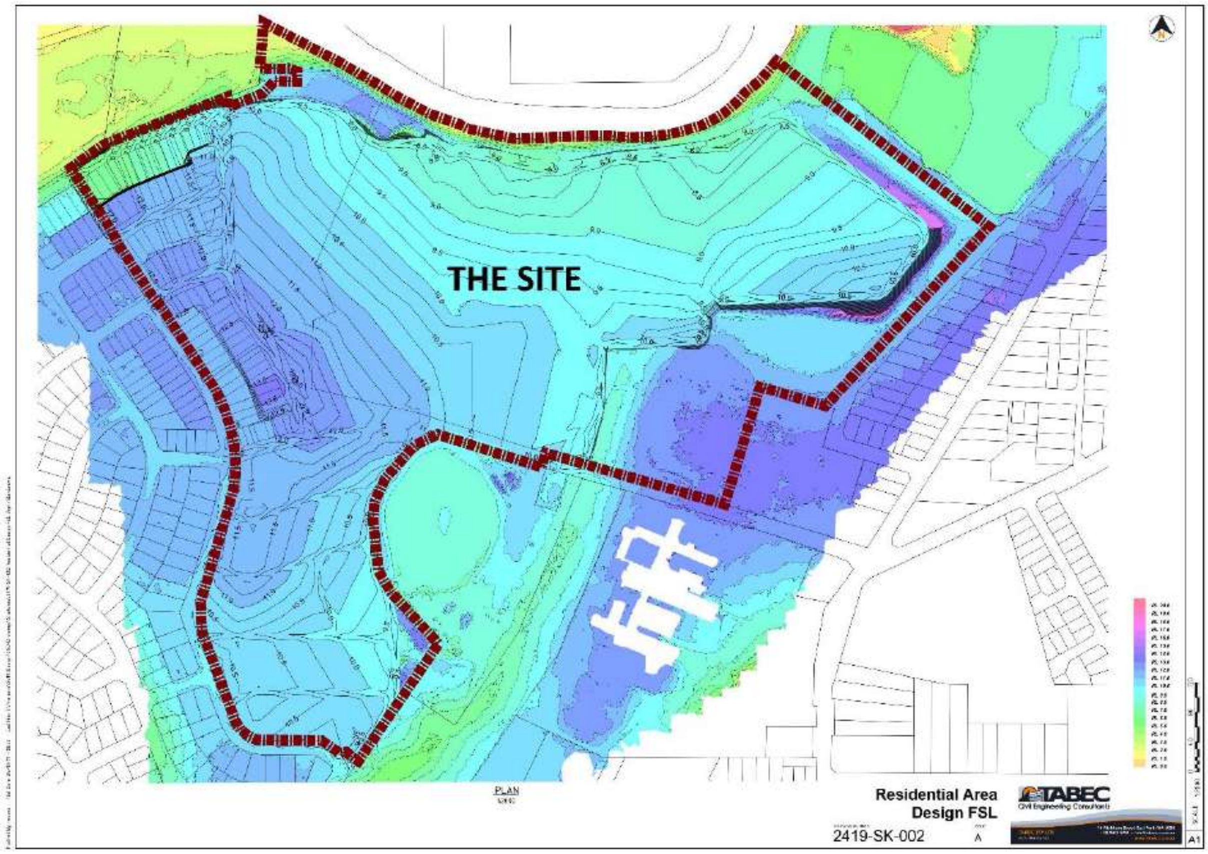
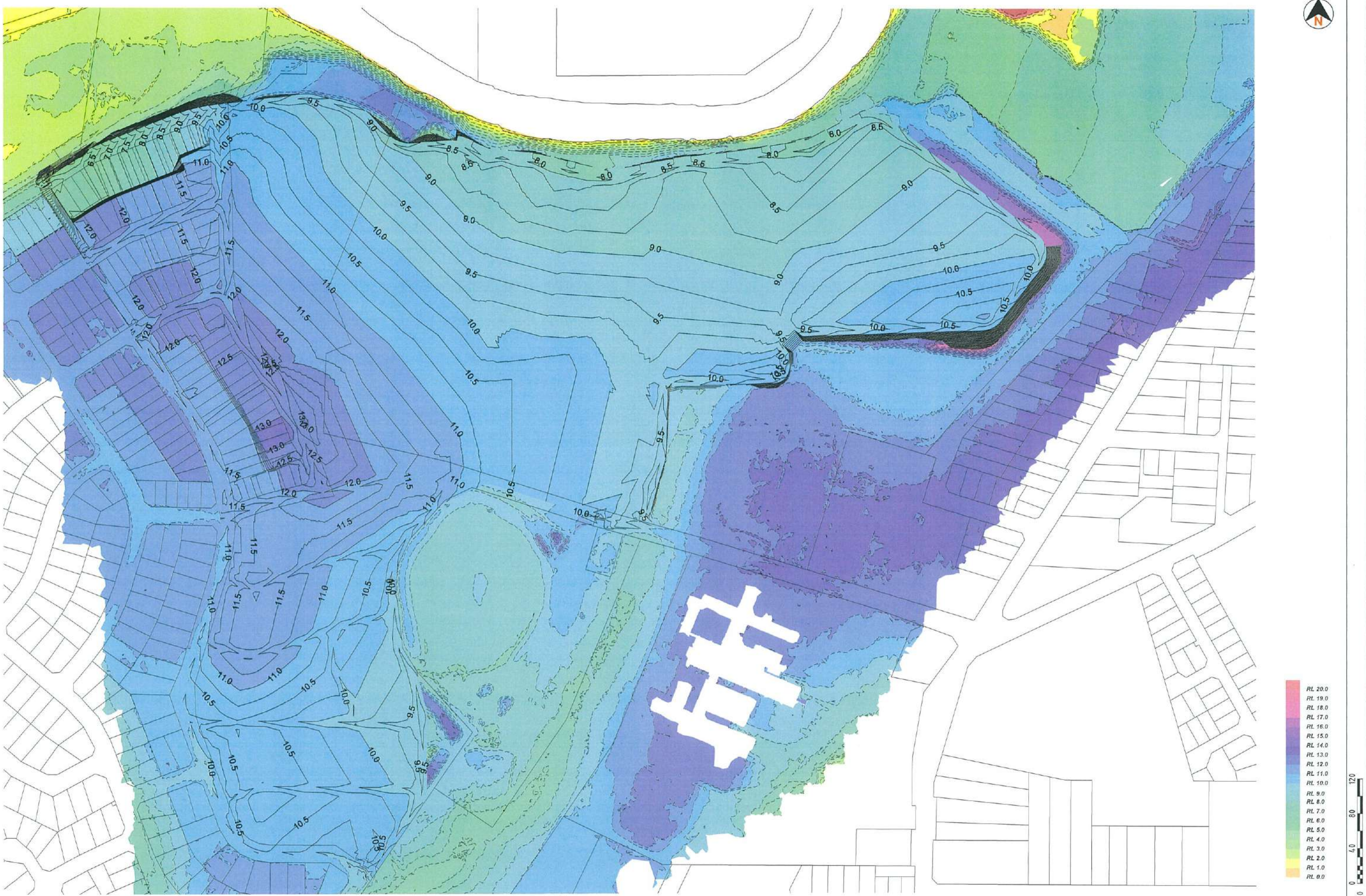


Figure 7 – Concept Bulk Earthworks Design (TABEC, July 2019)



PLAN
1:2000

Residential Area Design FSL

DRAWING NUMBER
2419-SK-002

ISSUE
A

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SCALE 1:2000

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Plotted By: revans Plot Date: 24/10/19 - 08:31 Cad File: T:\Projects\2419\Design\CAD\Drawings\Sketches\2419-SK-002 Residential Design FSL Depth Bands.dwg

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Appendix F

Engineering Infrastructure Report

Civil Engineering Consultants

HESPERIA PTY LTD

RIVERMARK

Engineering Infrastructure Report

MAY 2023

CLIENT: HESPERIA PTY LTD

PROJECT: 2419 – RIVERMARK

TITLE: ENGINEERING INFRASTRUCTURE REPORT

DOCUMENT REVIEW				
Revision	Date Issued	Written By	Reviewed By	Approved By
0	26 August 2021	CB	CB	CB
1	21 October 2021	CB	CB	CB
2	27 October 2021	CB	CB	CB
3	18 May 2023	CB	CB	CB

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1 INTRODUCTION

Hesperia, on behalf of Lot 9000 Middle Swan Pty. Ltd. is proposing to redevelop part of the Midland Brick landholding in Viveash / Middle Swan (the Site). The following report provides a broad overview of the existing conditions and engineering advice on the capability and possible future infrastructure requirements of the site to support the proposed development.

To facilitate future development, the Brickworks facility is being consolidated within the northern portion of the broader Midland Brick landholding, north of Eveline Road in the short term and north of Bassett Road in the medium term. The reduction in footprint of the brickworks operation will, in part, be dictated by the rate of residential development which is referred to as Rivermark.

The investigation and preparation of the report is mainly based on preliminary advice from the various service authorities. The information is current as of May 2023 and is subject to change as development proceeds around the site.

2 THE SITE

2.1 Site Description

The approximately 9.98ha total LSP area represents the very southern portion of Midland Brick landholding and is located about 17km northeast of the Perth CBD within the City of Swan and has operated for nearly 75 years as a clay extraction and brick manufacturing facility.

The portion of the Midland Brick landholding subject to the LSP is generally bounded by the Cranwood Crescent to the south and west, Jack Williamson oval to the east and an extension of Eveline Road to the north. It is depicted inside the red boundary line in Figure 2.

Figure 1 – LSP area (MNG Aerial Image, June 2021)

The site is zoned General Industrial under City of Swan Local Planning Scheme No. 17.

Most of the site is currently utilised for storage of the manufactured bricks and masonry product and associated works and hence has been cleared of vegetation. At the southern end of the LSP area, a temporary drainage basin has been constructed to facilitate removal of sediments in site generated stormwater. A border of mostly regrowth vegetation generally extends around the perimeter of the site.

2.2 Landform / Topography

Over the many years the Midland Brick facility has operated, the natural topography across the site has been heavily modified.

The majority of the site is relatively level and has an elevation of 9.0 to 10.0mAHD. The exception to this is a previously constructed bund adjacent to the Cranwood Crescent boundary which has a top elevation ranging from 14.0m to 17.0mAHD. Regrowth vegetation is evident throughout the bund and in some areas at the margins of the site.

Existing levels outside of the bund are generally consistent with Cranwood Crescent levels and the lots which abut the west and south edges of Cranwood Crescent.

Topographic contours for the site are provided in the image below.

Figure 2 – Topographic Survey (MNG, June 2021)

2.3 Ground Conditions

During the earlier days of brick manufacture, clay was sourced from within the site and over the years, much of the previous excavation has been backfilled and formed the subgrade for extensive hardstand areas across the site.

Much of the site is covered by hardstand. Several geotechnical investigations have been undertaken across the Midland Brick landholding and the site, the most recent, completed by Douglas Partners.

Results of the Douglas Partners investigation are generally consistent with previous investigations that indicate that the site is generally underlain by clayey soils (both fill and natural material).

The existing fill and bund is not formally controlled, albeit where encountered, was generally medium dense or very stiff to hard. The fill generally contains some minor brick fragments, and occasionally contains traces of other materials such as wood, fabric, wire, plastic, rubber and concrete.

In its present state the previously filled portions of the site would be classified as 'P' and the natural areas classified as 'M' in accordance with AS 2870-2011.

2.4 Groundwater

The Perth Groundwater Atlas (2004) indicates that the groundwater levels beneath the site ranges from 1m to 2m AHD, with groundwater flow generally in a westerly direction towards the Swan River. Groundwater levels in the Atlas are representative of typical end of summer groundwater levels and are subject to variation due to the influence of rainfall, temperature, tides, local drainage and the seasons.

Emerge Associates installed 10 groundwater monitoring bores within the Midland Brick landholding including parts of the site. Water levels in all bores were measured monthly from September 2018 to February 2019 with monitoring recommencing in September 2019 and ongoing on a monthly basis.

Based on the existing data, Consultant Hydrologist, hyd2o have calculated the estimated average annual maximum groundwater levels (AAMGL) for the Midland Brick landholding and site which are shown below. Hyd2o also noted that perching of groundwater appears to be occurring at some bores due to their proximity to existing stormwater attenuation areas.

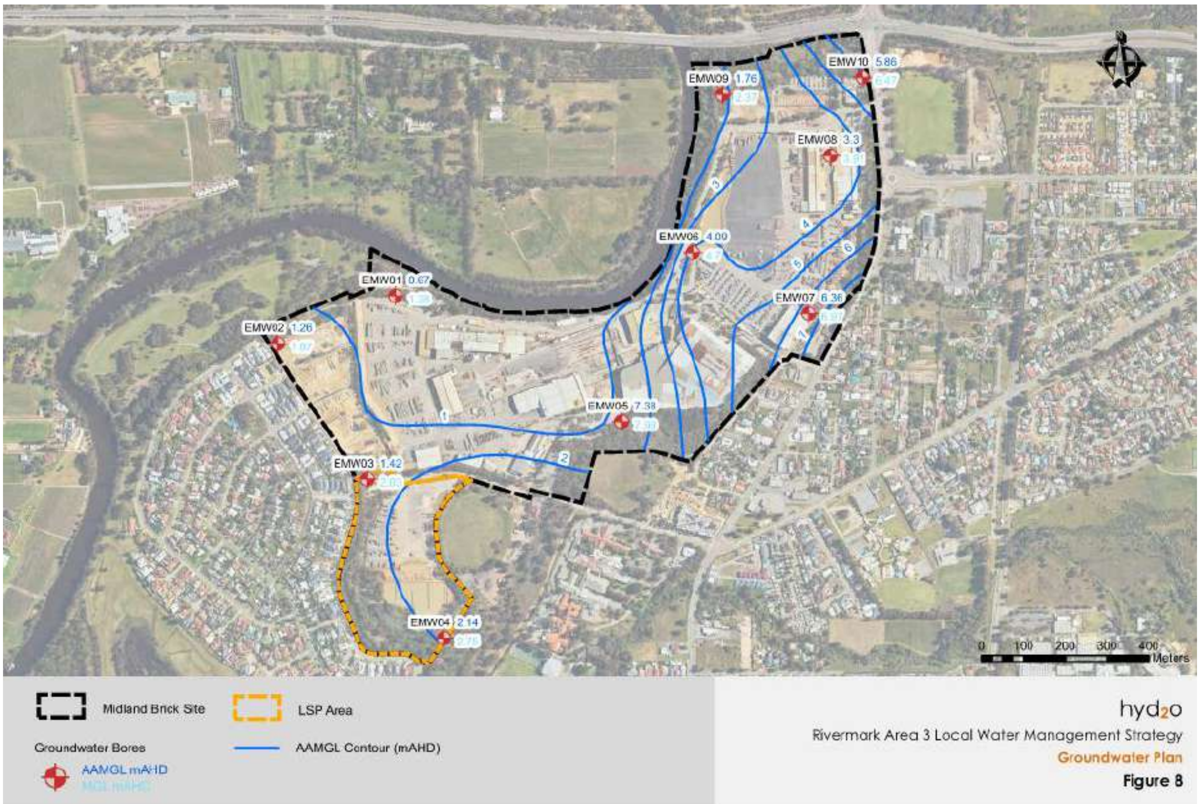

Figure 3 – Estimate AAMGL Groundwater Levels (hyd2o, May 2023)

2.5 Acid Sulfate Soils

A review of the DWER Acid Sulfate Soils (ASS) mapping indicates that the site is located in an area as having "no known risk" of ASS, however it is adjacent to an area of "high to moderate ASS disturbance risk" that is associated with the Swan River foreshore. The ASS risk mapping is provided below.

If ASS is to be disturbed, a suitably qualified environmental consultant will be engaged to conduct an investigation of the area and if necessary, prepare an ASS Management Plan. The ASS Management Plan will detail the actions to minimise and mitigate potential adverse environmental effects during the works.

3 SITEWORKS AND EARTHWORKS

Siteworks to support residential urban development will generally comprise the clearing of existing vegetation, stripping of topsoil, earthworking of the existing ground surface, compaction to areas of existing fill and import of a sand topping to facilitate the proposed form of development.

Given the existing soils within the site consist of material unsuitable for residential development in its current state and the geotechnical requirement for imported sand fill, limited vegetation will be able to be retained during site preparation. However, some of the more significant trees have been identified with the planning and conceptual earthworks design taking in to account these trees for retention where possible. This is likely to provide a similar outcome to Stage 1 where some trees within road reserve have been retained, and future roads and services are designed to minimise impact on the retained trees. Future detailed design at subdivision stage will dictate what trees can be retained.

Development of the site will require removal of all brick and clay stock on site as well as the demolition of existing pavements and services prior to undertaking site earthworks, servicing and roadworks to produce the desired development form. Following demolition of existing infrastructure, earthworking will take place to provide for a desired development form while addressing the engineering constraints of the site.

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In accordance with current market expectations flat residential allotments will generally be created. Due to the proposed earthworks strategy, stepping between allotments is likely to be achieved with the minimal use of retaining.

4 ROADS AND TRAFFIC

Access to the site is proposed via the extension of Eveline Road presently being constructed under subdivision approval 158848, and at various locations along Cranwood Crescent.

The internal road network will be in accordance with the current IPWEA Subdivision Guidelines, Liveable Neighbourhoods and City of Swan standards. Roadworks will generally consist of kerbed and asphalted pavement. Where possible, there is a desire to maximise the use of (approved) recycled products in the construction of new roads and for feature threshold treatments at key locations.

A network of pedestrian paths will also be constructed as part of the subdivision to facilitate pedestrian movement throughout the development.

5 STORMWATER MANAGEMENT

Hyd2o, on behalf of Hesperia, has prepared Local Water Management Strategy (LWMS) to support the LSP.

The LWMS have been prepared in accordance with the principles and objectives of Better Urban Water Management (WAPC, 2008) and following discussions with key agencies ultimately involved with its implementation including the City of Swan, Department of Biodiversity, Conservation, and Attractions (DBCA) and Department of Water and Environmental Regulation (DWER). Implementation of the strategies will be undertaken through the development and implementation of an Urban Water Management Plan(s) for stages of subdivision development within the site.

The broader Midland Brick site lies between two watercourses which receive stormwater runoff from the Midland Brick landholding, the Swan River to the north and a tributary of Blackadder Creek to the south. The Midland Brick landholding also receives inflow from an approximate 10-hectare external catchment to the east of Great Northern Highway, adjacent to the proposed consolidated brickworks.

The Swan River 1% Annual Exceedance Probability (AEP) levels adjacent to the site range from 5.8m AHD at the western margin of the site rising to 6.0m AHD at the northern boundary of the Midland Brick landholding. The site is predominantly located outside the 1% AEP floodplain of the adjacent Swan River with only a minor area within the site classified as floodway and flood fringe.

Due to the presence of clay soils, infiltration is limited and stormwater is managed through offsite discharge. The Midland Brick landholding’s current stormwater system comprises various storage ponds for attenuation and settlement of stormwater and a series of outlets to the Swan River and Blackadder Creek tributary.

The majority of stormwater from the Midland Brick landholding flows to an existing sump, via a 1.8-hectare open water body, where it is then pumped to the storage ponds in the north west of the site and Midland Brick landholding. Water then flows south along the western boundary of the site, entering a further series of storage ponds and ultimately discharging to a tributary of Blackadder Creek, in the southwest corner of the site and landholding. Major events have an outlet to the Swan River.

Flows from the roof area of the Clay Shed at the eastern extent of the site represent a separate stormwater system which discharge into a vegetated storage area behind the Clay Shed (including the TEC) and then into the Blackadder Creek tributary.

Post development, stormwater management will be in accordance with the aim of Better Urban Water Management and the requirements of the Australian Rainfall and Runoff Guide and the City of Swan.

In general, stormwater discharge volumes and peak flows are typically required to be maintained relative to predevelopment conditions.

Residential lots will capture the first 15mm of rainfall for infiltration at source via soakwells or landscaped areas.

Runoff from road reserves will be managed via a piped stormwater drainage system, with the first 15mm of rainfall being treated prior to any discharge offsite. The stormwater drainage system will be designed and constructed in accordance with Local Authority requirements.

Major event overland flow paths within the development will be directed towards the Blackadder Creek tributary or Swan River.

For areas draining to the Blackadder Creek tributary, such as the LSP 1A area, the stormwater management areas will be required to provide stormwater storage to attenuate flows to existing levels for events up to the 1% AEP. These storage areas will be integrated with landscaped POS.

These storage areas and volumes will be determined at UWMP stage based on more detailed modelling in parallel with the engineering design.

The conceptual hyd2o stormwater management for the broader landholding is shown below. The concept demonstrates that all of LSP 1A discharges towards Blackadder Creek Tributary.

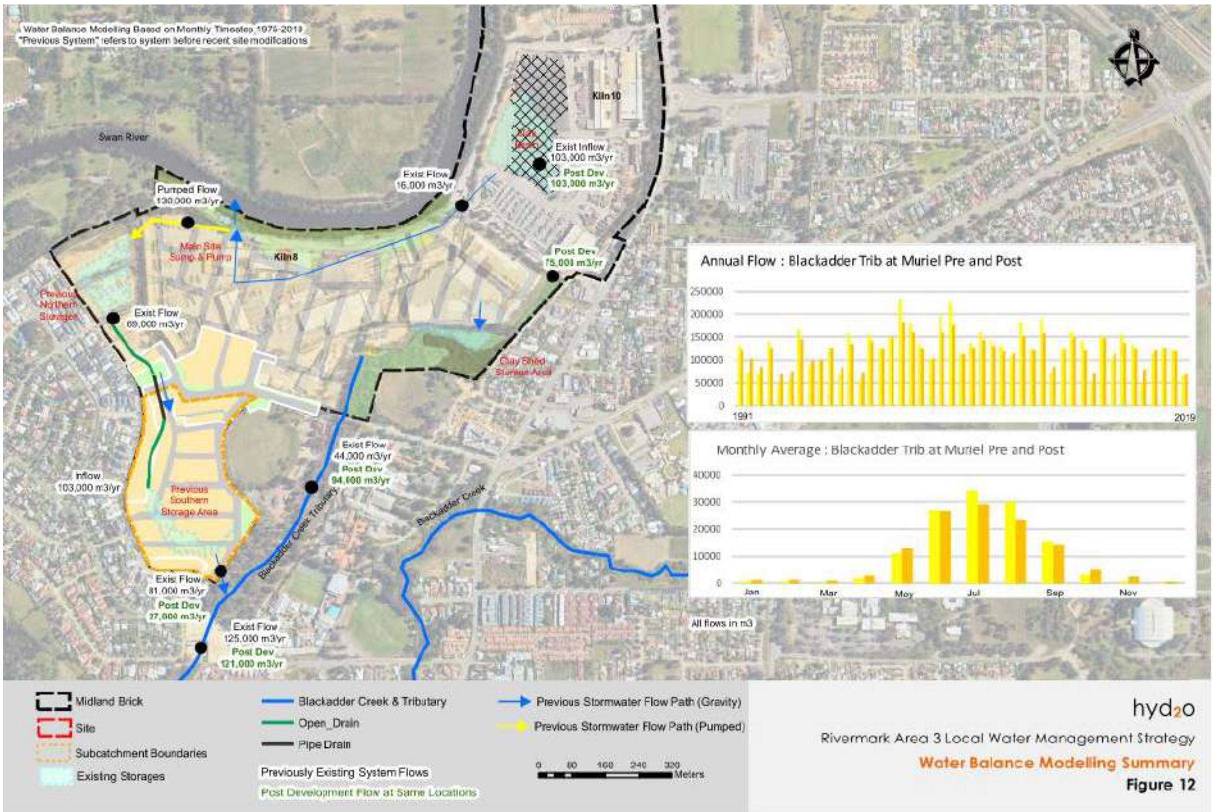

Figure 4 – Water Balance Modelling Summary (hyd2o, Mary 2023)

Development levels are generally not dominated by fill requirements to achieve adequate separation to groundwater, given the proximity of groundwater levels to natural surface. However, due to the underlying impermeable soils, it is envisaged that subsoil drainage may be required within the development to alleviate the perching of groundwater from rainfall.

Subsoil drains will require a free outfall and will be treated prior to any off site discharge. The subsoil drainage network will be integrated with the piped stormwater drainage network.

6 WASTEWATER

The proposed development is within the Water Corporation license area and all lots created will be connected to the Water Corporation sewer. The site sits within Eden Hill Sewer District 024.

Figure 5 – Wastewater Catchment Plan (Water Corporation, 2020)

Based on a review of existing sewer infrastructure, it is likely that lots directly abutting Cranwood Crescent will connect to the existing sewer in Cranwood Crescent. However, as Cranwood sewer Crescent sewer is relatively shallow, it is likely that the majority of the LSP 1A area will need to outfall to the existing network near the intersection of Ashby Terrace and Kent Street.

From a development perspective, providing the site with a reticulated sewer system will be achieved through the orderly development of the site. Wastewater infrastructure will be designed and constructed in accordance with Water Corporation standards and requirements. Standard Water Corporation wastewater headworks are applicable in this area.

7 WATER SUPPLY

The site is within the Water Corporation license area and can be served via connections to and extensions of the existing water mains adjacent to the landholding.

Existing Water Corporation infrastructure in the vicinity of the site includes a 250mm diameter main in Eveline Road, 100mm diameter main in Cranwood Crescent and a 200mm diameter main traversing the site between Eveline Road and Cranwood Crescent, just north of Trent Street.

The existing Midland Brick water and fire supply network within the site is intended to be removed in a progressive manner as part of the proposed staged demolition works.

The extension of the existing water mains surrounding the site will provide the internal reticulation network. An internal water reticulation network will be constructed within the site to provide a service to all lots in accordance with the Water Corporation requirements. Standard Water Corporation water headworks are applicable in this area.

8 POWER SUPPLY

There is currently capacity within Western Power's (WP) broader network to service the development with their network mapping tool indicating that there is in excess of 25MVa capacity in the area which is serviced from Hadfields WP-009 substation.

In this instance, it is also noteworthy that the reduction in area and capacity of the brick making facilities will free up capacity in the existing network.

Street lighting will also be required as part of the development in accordance with Western Power and City of Swan guidelines.

9 TELECOMMUNICATIONS

The site is within the NBN fibre to the node fixed line footprint and therefore can be serviced.

The NBN network is located adjacent to the site, within the existing residential subdivision in Cranwood Crescent and provides a connection point for an NBN compliant pit and pipe network to be extended within the proposed development.

The site would enter into an agreement with NBN (or other service provider). NBN is required to recover part of the cost of deploying the NBN network infrastructure by applying a Developer contribution charge per premises.

10 GAS

Atco Gas also have a steel high-pressure gas pipeline within and in near proximity to the site, along with a PRS located north of the site near Swan River shoreline. Unlike the Parmelia 'single user' supply, the Atco Gas infrastructure forms part of a broader network. The Atco Gas pipes traverse the site through the future development and along Eveline Road and Leslie Street.

The LSP concept plan and subsequent conceptual earthworks modelling has taken into consideration the existing Atco Gas steel high-pressure pipeline such that it can remain in situ. However, it is an Atco requirement that no sensitive land uses such as aged care, child care etc. are located immediately adjacent to any HP gas pipes located within future road reserves.

11 SUMMARY

All required utilities are available and can be extended to service the proposed development.

Based on the engineering servicing review, there would appear to be no engineering or servicing constraints to the development of the site that cannot be resolved through orderly standard engineering design and construction. Significant planning has already been undertaken by the relevant authorities to support existing developments within the vicinity of the site.

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