

Wattle Grove South Local Water Management Strategy

August 2025



Client: Hesperia Projects Pty Ltd ATF Wattle Grove Trust

Contents

1. Introduction	1
1.1 PLANNING BACKGROUND	1
1.2 KEY REFERENCE DOCUMENTS	2
2. Proposed Development	4
3. Design Criteria	5
4. Pre-Development Environment	7
4.1 SITE CONDITIONS	7
4.2 GEOTECHNICAL	7
4.2.1 Environmental Geology	7
4.2.2 Geotechnical Studies	7
4.2.3 Permeability Testing	9
4.2.4 Acid Sulphate Soils	10
4.2.5 Contaminated Sites	10
4.3 WATER SENSITIVE ECOSYSTEMS	10
4.4 SURFACE WATER	11
4.4.1 Surface Water Quality	12
4.5 GROUNDWATER	14
4.5.1 Regional Groundwater Levels	16
4.5.2 Perched Groundwater	20
4.5.3 Groundwater Quality	20
4.6 RELATIONSHIP TO GREATER BRIXTON ST WETLANDS	22
5. Water Use Sustainability Initiatives	25
5.1 WATER EFFICIENCY MEASURES	25
5.2 WATER SUPPLY	25
5.2.1 Potable Water Supply	25
5.2.2 Irrigation	25
5.3 WASTEWATER MANAGEMENT	26
6. Stormwater Management Strategy	27
6.1 STORMWATER MODELLING	27
6.2 SMALL EVENT WATER QUALITY TREATMENT(15MM)	28
6.3 MAJOR EVENT FLOOD PROTECTION (1% AEP)	30
6.4 MINOR EVENT SERVICEABILITY (20% AEP)	30
6.5 ADAPTIVE MANAGEMENT INFRASTRUCTURE	30
7. Groundwater Management Strategy	36
7.1 GROUNDWATER LEVELS	36
7.2 GROUNDWATER QUALITY	36

8. Urban Water Management Plans	37
9. Monitoring	38
9.1 PRE-DEVELOPMENT	38
9.2 STAGING IMPLICATIONS	38
9.3 POST-DEVELOPMENT	39
10. Implementation	41
10.1 IMPLEMENTATION RESPONSIBILITIES	41
11. References	43

Appendices

- A. LWMS Checklist
- B. Geotech Report (Douglas Partners, 2020 & 2022)
- C. Monitoring Bore Details & Logs
- D. Hyd2o Permeability Testing
- E. Tabulated Monitoring Program Data
- F. Monitoring Protocols & Lab Reports
- G. Surface & Groundwater Quality Data Summary Sheets
- H. Aggregated Monitoring Data Summary Reports
- I. Groundwater Level Hydrographs
- J. Nearby DWER Groundwater Bore Hydrographs
- K. DWER Water Register Extracts & Irrigation Estimates
- L. Epcad Landscape Masterplan
- M. CURRV Runoff Rate Calculator
- N. XP-Storm Stormwater Modelling Outputs
- O. TABEC Engineering Servicing Report & Preliminary Earthworks

Figures

- 1. Location Plan
- 2. Local Structure Plan
- 3. Site Condition Plan
- 4. Geotechnical Plan
- 5. Wetland Plan
- 6. Surface Water Plan
- 7. Surface Water Quality Summary
- 8. Groundwater Plan: AAMGL
- 9. Groundwater Plan: MGL
- 10. Bore Hydrographs in Area of Local Mounding
- 11. Groundwater Quality Summary: Regional Aquifer bores
- 12. Groundwater Quality Summary: Perched Aquifer bores
- 13. Catchment Plan & Proposed Biofilter Area Locations
- 14. a. Stormwater Management Plan: Precinct A, B & C
 b. Stormwater Management Plan: Precinct D, E & F
- 15. Post Development Monitoring Plan

Tables

1. Urban Water Management Process
2. LWMS Design Criteria
3. Insitu Field Permeability Testing (Hyd2o, Douglas Partners)
4. Predevelopment Surface Water Quality Summary
5. Predevelopment Groundwater Monitoring Program
6. AAMGL for DWER Bores & Correction Calculation
7. AAMGL for Regional Groundwater Table
8. Locations & Levels Used for Mapping of Perched Groundwater
9. Pre Development Groundwater Quality Summary
10. BMP Water Quality Performance
11.
 - a. Stormwater Storage Modelling; 1 & 2
 - b. Stormwater Storage Modelling; 3, 4, & 5
 - c. Stormwater Storage Modelling; 6, 7, & 8
 - d. Stormwater Storage Modelling; 9, 10, & 11
12. Water Quality Targets
13. Implementation, Roles and Responsibilities

Disclaimer

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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

This Local Water Management Strategy (LWMS) has been prepared by Hyd2o on behalf of Hesperia to support the proposed Local Structure Plan (LSP) for Wattle Grove South prepared by Element Advisory on behalf of Hesperia.

The site is currently zoned 'Rural' under the Metropolitan Region Scheme (2017). The Western Australian Planning Commission (WAPC) requested an MRS rezoning of the site to Urban, which has recently been assessed by the Environmental Protection Authority (EPA, 2025). EPA (2025) concluded that the amendments are likely to be consistent with the EPA objectives for inland waters, flora and vegetation and terrestrial fauna, and that implementation of the amendment would be unlikely to compromise EPA's environmental objectives provided there is satisfactory implementation of their recommended environmental conditions.

The local structure plan prepared by Element Advisory for the site, considers the predevelopment environment of the site, its existing constraints and opportunities, interfacing with existing development and infrastructure, its proximity and relationship to the Greater Brixton St Wetland (GBSW) area, and outcome of the Hyd2o (2024) DWMS prepared for the MRS amendment process. Seven precincts are identified in the LSP to guide future planning and development.

The proposed development consists of residential lots of various densities, public open spaces (POS) including vegetation retention areas, a school, associated roads and road reserves, and the establishment of the Dampier to Bunbury Natural Gas Pipeline (DBNGP) corridor within landscaped POS.

The site is approximately 126 ha in area. It is located within the suburb of Wattle Grove in the City of Kalamunda approximately 13 km south east of the Perth Central Business District. The site is bound to the north by Crystal Brook Rd and Welshpool Rd East, and bounded to the south and west by the Tonkin Highway, with existing rural landholdings to the east. The site area currently comprises a mix of various rural landholdings and until recently a turf farm. The topography of the site varies between 21 mAHD in the west to a high of 35 mAHD at its eastern boundary, with a general fall from east to west.

The site drains to existing culverts under Tonkin Hwy which connect runoff from the area to downstream stormwater systems.

Regional average annual maximum groundwater level (AAMGL) contours at the site range from approximately 16 mAHD in the northeastern region to approximately 19 mAHD on the western boundary, well below the existing natural surface of the site. Groundwater flow is radial with a mound evident along the central western boundary adjacent to Tonkin Hwy. The groundwater flow direction within the site was found to vary, generally ranging from flowing northwest to flowing southeast and away from the GBSW area.

With regard to water quality management, the development will be required to treat the first 15mm of runoff in biofiltration systems prior to infiltration, and these systems will be distributed throughout the site. The Dampier to Bunbury Natural Gas Pipeline Corridor (DBNGPC) adjacent to Tonkin Hwy is well positioned in terms of location and elevation for potential stormwater management and is proposed to be used for major event flood storage. Its location will also assist in maintaining the sites existing groundwater mound

along the western boundary of the site adjacent to Tonkin Hwy and maintaining post development recharge in this area in accordance with the DWMW (Hyd2o 2025).

The Hyd2o (2024) DWMS identified land use change within the site as having the potential to provide improved future hydrological outcomes for the GBSW area in terms of both water quality and quantity. Nutrient levels are relatively high in the GBSW area as a result of surrounding historical land uses. Nutrient input and export from the Amendment Area will be considerably reduced with land use change and the removal of the existing high nutrient application land uses such as rural and horticultural.

Ongoing monitoring during the pre and post development phases of the project will continue to provide data to build on existing datasets and improve the understanding of the site interaction with GBSW and implementation of an adaptive management approach within the site.

This LWMS has been prepared in accordance with the principles, objectives, and key criteria of Better Urban Water Management (Western Australian Planning Commission, 2008) and reflects the EPA (2025) conditions and requirements for development.

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 precincts and stages of development within the site.

Local Water Management Strategy Summary

Water Supply

- Water Efficiency
- Promotion of 6 star building standards, water efficient fixtures, and fittings.
 - Use of water-wise plantings in POS and landscape rehabilitation areas.

- Water Supply
- Lots: Water Corporation IWSS and rainwater tanks optional.
 - POS: Groundwater irrigation licencing and bores.
 - Construction: Temporary groundwater licencing where/if required.

- Wastewater
- Water Corporation reticulated sewerage.

Stormwater

- Design & Management Approach
- Post development stormwater flows from the Amendment Area consistent with existing conditions and identified opportunities and constraints.
 - Locate stormwater management areas in areas of the existing groundwater mound to maintain the annual predevelopment groundwater recharge and flow direction in that area.
 - Use water quality controls and best management practice to provide improvements relative to current conditions under existing land use and improve downstream ecological conditions.

Local Water Management Strategy Summary

	Implementation of flexible infrastructure arrangements at key locations (Brentwood and Boundary Rd flood storage outlets) to enable future system adjustments to downstream environmental needs if required.
Lot Scale	- Soakwells to be implemented where possible. - Lot connections to be implemented where required based on geotechnical considerations, - Rainwater tanks (optional). - Water-wise landscaping. - Additional lot connections to be considered for implementation in Precinct D at future Precinct scale planning to increase recharge in the area of the existing mound if required.
Street Scale	- Piped drainage. - Bottomless manholes / underground storage cells. - Additional roadside swales and biofiltration/rain gardens to be considered at Precinct scale planning based on individual area subdivision planning and design.
Estate Scale	- Water quality treatment areas to be provided for first 15 mm runoff via biofiltration, with areas located predominately in the location of the existing mound and Tonkin Hwy. A total biofiltration area of 0.73 ha and volume 2925 m³ is required to management the 15mm event (0.6 % of site area). - Flood management areas to attenuate flows in accordance with agency requirements and capacity of downstream infrastructure. Some catchment areas are proposed to retain and infiltrate stormwater onsite. This approach is proposed primarily for staging considerations and to enable individual Precincts to develop independently. - The landscaped Dampier to Bunbury Natural Gas pipeline corridor to be used for the majority of major event stormwater management in accordance with maximising recharge in the area of the existing mound. - The total area required for management of the 20% AEP event is approximately 1.93 ha or 1.5% of the site area with a total flood storage volume of approximately 4,424 m³. - The total area required for management of the 1% AEP event is approximately 3.28 ha or 2.6% of the site area with a total flood storage volume of approximately 16,063 m³. - Implementation of flexible infrastructure arrangements at key locations. - All habitable development levels to have suitable clearance above the 1% AEP flood levels of the local stormwater management system. - Post development performance monitoring and annual reporting.

Local Water Management Strategy Summary

Groundwater

- | | |
|----------------|--|
| Fill & Subsoil | <ul style="list-style-type: none"> • Use of imported fill to be minimised in earthworks design. • Subsoil to control regional groundwater will not be required due to groundwater depth. • Some subsoil control may be necessary in areas of perching subject to detailed geotechnical investigations for individual Precincts. |
|----------------|--|

- | | |
|---------------------|---|
| Acid Sulphate Soils | <ul style="list-style-type: none"> • Acid sulphate soils to be investigated as a separate process (if required) for individual Precincts and reported at later stages of planning. |
|---------------------|---|

Implementation

- | | |
|---------|---|
| Process | <ul style="list-style-type: none"> • Future stages of planning consistent with Better Urban Water Management (WAPC,2008) including preparation of UWMP's for individual Precincts. Documents to reflect the flexible outcomes approach to facilitate adaptive change in this LWMS. • Post development groundwater and surface water monitoring programs and annual assessment reporting to inform water management planning for future stages and iterative adjustment. • Coordination of monitoring outcomes and data sharing with key agencies. • Performance to be assessed in relation to agreed targets. • Monitoring outcomes to inform future planning and decision making and implementation of adaptive management. |
|---------|---|

1. Introduction

This Local Water Management Strategy (LWMS) has been prepared by Hyd2o on behalf of Hesperia to support the proposed Local Structure Plan (LSP) for Wattle Grove South prepared by Element Advisory.

The site is approximately 126 ha in area. It is located within the suburb of Wattle Grove in the City of Kalamunda approximately 13 km south east of the Perth Central Business District (Figure 1). The site is bound to the north by Crystal Brook Rd and Welshpool Rd East, and bounded to the south and west by the Tonkin Highway, with existing rural landholdings to the east (Figure 1).

This document provides an integrated total water cycle management approach to the development, with a detailed assessment of the pre-development environment, development of water use sustainability initiatives, and provision of stormwater and groundwater management strategies. The document also provides a plan for implementation applied within an adaptive management framework suitable for guiding water management toward achieving improved hydrological outcomes for the area.

Importantly the LWMS recognises the sites proximity to the nearby Greater Brixton St Wetland (GBSW) and provides strategies to address and minimise hydrological impacts and risks.

This document has been prepared consistent with the overarching Wattle Grove South District Water Management Strategy, Hyd2o (2024). It has also been prepared in accordance with the principles, objectives, and key criteria of *Better Urban Water Management* (Western Australian Planning Commission (WAPC), 2008).

A completed copy of the WAPC (2008) LWMS Checklist for Developers is included as Appendix A to assist agencies in the review of this document.

1.1 Planning Background

This site is currently zoned Rural under the Metropolitan Region Scheme and was identified as an Urban Expansion area within the North-East Sub-Regional Planning Framework (DPLH, 2018). The Western Australian Planning Commission (WAPC) requested a MRS rezoning of the site to Urban, which has recently been assessed by the Environmental Protection Authority (EPA, 2025).

EPA (2025) concluded that the amendments are likely to be consistent with the EPA objectives for inland waters, flora and vegetation and terrestrial fauna, and that implementation of the amendment would be unlikely to compromise EPA's environmental objectives provided there is satisfactory implementation of their recommended environmental conditions.

A District Water Management Strategy (DWMS) was prepared as part of this process, with the document expanded above typical DWMS requirements to address the Inland Waters scope of the Environmental Protection Authority's, Metropolitan Region Scheme Amendment 1388/57 Wattle Grove South, Instructions for Environmental Review (EPA, 2022).

Consistent with Better Urban Water Management (Western Australian Planning Commission, 2008), the urban water management planning process for the site is shown in Table 1. Following this LWMS, an Urban Water Management Plan (UWMP) will be required to be prepared to facilitate development of the site, as summarised in Table 1.

Given the size of the site and proposed precinct development, several urban water management plans will be required.

Table 1: Urban Water Management Process

Planning Phase	Planning Document	Urban Water Management Documents
MRS Amendment	MRS Amendment Environmental Review	Wattle Grove South District Water Management Strategy (Hyd2o, 2024)
Local Structure Plan/TPS Amendment	Local Structure Plan	Wattle Grove South Local Water Management Strategy THIS DOCUMENT
Subdivision	Subdivision Application	Urban Water Management Plan/s for Individual Precincts FUTURE PREPARATION

1.2 Key Reference Documents

This LWMS uses the following key documents to define its principles, criteria, objectives, and implementation responsibilities:

- Environmental Protection Authority (2025), Metropolitan Region Scheme Amendment 1388/57, Wattle Grove South, Western Australian Planning Commission, Report 1788, July 2025
- Hyd2o (2024), Wattle Grove South District Water Management Strategy, July 2024
- Environmental Values and Pressures for the Greater Brixton St Wetlands on the Swan Coastal Plain, Advice in accordance with section 16(j) of the Environmental Protection Act 1986 (EPA, 2022a)
- Metropolitan Region Scheme Amendment 1388/57 Wattle Grove South Instructions for Environmental Review (EPA, 2022b)
- A Jewel in the Crown of a Global Biodiversity Hotspot (Lambers, 2019)
- A Vision for Conservation and Public Enjoyment of the Greater Brixton Street Wetlands and Eventual Yule Brook Regional Park (The Beeliar Group, 2018)

- Hydrological Function of the Greater Brixton Street Wetlands: Data Sourcing and Review (Bourke, 2017)
- Hydrological Study of the Greater Brixton Street Wetlands (Semeniuk, 2001)
- Stormwater Management Manual for WA (DWER, 2022)
- Decision Process for Stormwater Management in WA (DWER, 2017)
- Interim: Developing a Local Water Management Strategy (Department of Water, 2008)
- Better Urban Water Management (WAPC, 2008)

In addition to these documents, the water management planning process for this document has involved key stakeholders and government agencies at various stages to inform its progress and development since 2020. This input has assisted in identifying key areas of investigation and reporting for this document and the development and refinement of the pre development monitoring program.

2. Proposed Development

The local structure plan prepared by Element Advisory for the site is shown in Figure 2.

The proposed development consists of residential lots of various densities, public open spaces (POS) including vegetation retention areas, a school, associated roads and road reserves, and the establishment of the Dampier to Bunbury Natural Gas Pipeline (DBNGP) corridor within landscaped POS.

Consideration of the predevelopment environment of the site, its existing constraints and opportunities, interfacing with existing development and infrastructure, and its proximity and relationship to the Greater Brixton St Wetland (GBSW) area have guided the development of this plan.

The design also includes consideration of the Hyd2o (2024) DWMS outcomes, intent, and water balance modelling the site, with the location of POS, biofiltration, and the school selected to assist in recharge considerations and an adaptive management approach to maintaining the sites existing groundwater mound.

Details of the sizing and proposed location of the stormwater management areas are presented in Section 6.

3. Design Criteria

Key design criteria for the site have been established consistent with the key reference documents detailed in Section 1.2 and overarching strategy documents for the site. These design criteria are used to develop the LWMS together with the identified constraints and opportunities of the predevelopment environment (Section 4).

Table 2: LWMS Design Criteria

Strategy Elements	Method & Approach
Environmental	
GBSW area	- Land use change to establish a net reduction in nutrient input and export from the Amendment Area relative to existing land use. - Surface water flows to the wetland to retain pre-development rates and volumes, with included flexibility for future modification to address future wetland needs in consultation with agencies if required - Stormwater management area locations to maintain predevelopment groundwater recharge and groundwater flow direction in the area of the existing groundwater mound. - Establish flexible outlet structures and use of engineering design to facilitate adaptive change. - Monitoring of outcomes and use of findings to facilitate/inform adaptive management.
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 Spaces. - Maximise infiltration where practicable.
Water Supply	- Minimise overall use of scheme water for non-drinking purposes. - Water Corporation IWSS for lots plus rainwater tanks (non-mandated). - Use of groundwater for POS irrigation.
Wastewater	Water Corporation reticulated sewerage.
Stormwater	
Ecological Protection	- Combination of lot soakwells (15mm infiltration on site) and lot connection pits to be used. - Establishment of biofiltration areas for treatment and infiltration of first 15 mm road runoff, with area locations selected based on identifying preferred areas of recharge to maintain groundwater levels and flow.
Serviceability	Piped drainage system sized to convey 20% AEP event (1 in 5 year average recurrence interval).

Strategy Elements	Method & Approach
Flood Protection	- Establish minimum habitable floor levels at 0.5m above the 1% AEP flood level of the local stormwater management system. - Overland flow paths within road reserves for safe conveyance of flows exceeding pipe drainage system capacity. 1% average exceedance probability (AEP) events to continue to flow 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. Imported fill to be minimised. Use of subsoil drainage unlikely except in areas of perched groundwater.
Acid Sulphate Soils & Contamination	Management of any Acid Sulphate Soils to be handled as a separate process to the DWMS consistent with DER (2015a) requirements and reported in future water management planning documents.

4. Pre-Development Environment

4.1 Site Conditions

The site located approximately 13 km southeast of the Perth Central Business District within the suburb of Wattle Grove in the City of Kalamunda (Figure 1).

The site is approximately 126 ha in area bound to the north by Crystal Brook Rd and Welshpool Rd East and bounded to the south and west by the Tonkin Highway, with existing rural landholdings to the east (Figure 1).

The topography of the site varies between 21 mAHD in the west to a high of 35 mAHD at its eastern boundary, with a general fall from east to west (Figure 3).

The site area currently comprises a mix of various rural landholdings and until recently, a turf farm. A former poultry farm is located on its south eastern boundary, which has not been in active use for over 10 years.

The Dampier to Bunbury Natural Gas pipeline corridor (DBNGPC) runs within the site along its Tonkin Highway boundary within a 30m easement and is shown in Figure 3.

4.2 Geotechnical

4.2.1 Environmental Geology

The site is predominately located to the west of the Darling Fault (Figure 4).

According to the Armadale 1:50 000 Environmental Geology Series Sheet 2033 I and 2133 IV (Jordan, 1986), the site is characterised from west to east (Figure 4) as follows:

- Thin Bassendean Sand over cohesive materials of the Guildford Formation (S10) – white to pale grey sand at surface, over alluvial deposits of sandy clay to clayey sand of the Guildford Formation.
- Bassendean Sand (S8) – white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to surrounded, of eolian origin.
- Sand (Yoganup Formation) (S12) - yellow, fine grained sand with minor silt and clay, subangular and medium to coarse grained quartz, of colluvial origin.

4.2.2 Geotechnical Studies

Two geotechnical investigations have been undertaken by Douglas Partners within the bounds of the site. The first was conducted in October 2020 and the second in November 2022. Combined, these investigations included excavation of 27 test pits, Perth sand penetrometer (PSP) testing adjacent to each test pit location, installation of 2 groundwater monitoring bores, and infiltration testing at seven locations. Testing locations were subject to property access availability, with sites shown in Figure 4.

Copies of the Douglas Partners geotechnical reports are included in Appendix B. The typical ground conditions as described by Douglas Partners (2020) were similar to the regional mapping as follows:

- **Topsoil** – dark grey-brown and grey-brown, sandy topsoil with silt and roots, between 0.1 m to 0.15 m in thickness. Overlying:
- **Bassendean Sand (light grey sand):**

SAND SP – varying loose to dense, fine to medium grained, light grey and light yellow-brown, with trace silt encountered underlying the topsoil or surficial fill to depths of between 0.5 m and test pit termination depths of 2.5 m at some test locations.

- **Yoganup Formation (yellow-brown sand with various fines content):**

The sand from the Yoganup Formation is yellow-brown and includes a fines content that increases with depth. When described based on its composition in accordance with AS 1726-2017, the sand is logged as ‘Sand trace silt and clay’ (up to 5% fines content) near surface, gradually transitioning with depth to ‘Sand with clay’ (5% to 12% fines content) and then ‘Clayey Sand’ (greater than 12% fines content):

SAND SP-SM – generally medium dense to dense, light brown and yellow-brown sand, with low plasticity to non-plastic fines content of between approximately 5% to 12%, underlying topsoil or surficial fill at some test locations and present below the Bassendean sand at another location from 0.8 m depth. Loose sand was encountered at one location to at least 1.0 m depth. Fines content typically increases with depth.

SAND/Clayey SAND SP-SC/SC – yellow-brown sand with clay/clayey sand (approximately 12% and greater content of low plasticity fines) was encountered from depths of between 0.1 m and 1.6 m extending to depths of between 0.6 m and termination depths of up to 2.5 m in some locations.

Clayey SAND SC – yellow-brown low plasticity clayey sand was encountered from depths of between 0.6 m and 1.5 m extending to termination depths of up to 2.5 m in some locations.

The exceptions to the above profile are some localised areas of gravelly sand, fill and coffee rock. Groundwater was not observed in any test pits excavated on 28 October 2020 or 1 November 2022, to a depth up to 2.9 m.

As property access availability has limited the extent of the geotechnical investigation area to date other sources of data such as bore logs have been used to supplement geotechnical data for this LWMS. Bore locations used to supplement geotechnical data in the north western corner of the site are shown in Figure 4, with lithological logs contained as Appendix C.

In addition, GBG Group carried out two geophysical subsurface investigations across the site in December 2022 and October 2023, which included conducting Electrical Resistivity Tomography (ERT) across thirteen transects totalling 7 km. The objective of the investigation was to obtain subsurface electrical resistivity models for the assessment of interpreted material porosity and permeability pertaining to geological units acting as aquifers and aquitards. The target depth of the investigation was 50m below ground level.

Details of the GBG Group outcomes are provided in the DWMS (Hyd2o, 2024). The investigation found sections were generally non-uniform, indicating the complex geology in proximity to the scarp. A number of transects showed large areas of very high resistivity (low conductivity) below the groundwater table, and these were interpreted to represent low permeability areas, typically at 10-15 mAHd. Along Crystal Brook Rd, these large areas of very high resistivity (low conductivity) were largely absent.

4.2.3 Permeability Testing

Seven in situ infiltration tests were conducted by Douglas Partners at depths between 0.5 m and 1.3m. In addition, Hyd2o conducted further tests to improve coverage and distribution over the remainder of the site. Tests were carried out 27 October 2022 at three locations via a constant head method using a borehole permeameter.

Insitu testing locations are shown in Figure 4 with results summarised in Table 3. Douglas Partners soil permeability values ranged from 2.4 m/day to 34 m/day, with the higher rates associated with Bassendean Sands, and lower rates with the Yoganup Formation. Hyd2o tested areas ranged from approximately 12 to 29 m/day, similarly with areas of Bassendean Sands with higher rates.

Douglas Partners anticipate permeabilities will decrease following densification of the soils during earthworks. The Yoganup sand is anticipated to have a generally lower permeability following compaction, and may not form a suitably drained material for stormwater disposal without additional drainage provisions being adopted. Douglas Partners recommended that if soakwells are adopted, the provision of measures such as overflow outlets should be considered.

Hyd2o permeability calculations for test sites HTS1 to HTS3 are contained in Appendix D.

Table 3: Insitu Field Permeability Testing (Hyd2o, Douglas Partners)

Test Site	Test Date	Depth (m)	Soil Description	K _s m/day
Hyd2o				
HTS1	27/10/2022	0.5	Fine to Medium Light Grey Sand	12
HTS2	27/10/2022	0.5	Fine White Sand	29
HTS3	27/10/2022	0.5	Fine to Medium Grey Sand	21
Douglas Partners				
TP3	28/10/2020	0.55	Sand, light grey trace silt, dense	25
TP4	28/10/2020	1.0	Sand, yellow-brown with clay/Clayey Sand (fines content increasing with depth), medium dense	6
TP9	28/10/2020	1.0	Sand, light grey, trace silt, dense	34
TP11	28/10/2020	1.0	Sand, with clay (fines content increasing with depth), dense	7
TP103	1/11/2022	1.0	SAND SP, trace silt, medium dense, pale grey	>20
TP108	1/11/2022	1.0	SAND SP-SM, with silt, loose to medium dense, yellow-brown	7.1
TP111	1/11/2022	1.3	Silty SAND SM, loose to medium dense, orange-brown	2.4

4.2.4 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.

The presence of ASS has been a recognised issue of concern in Western Australia since 2003. The Department of Environment and Conservation and the WAPC have released guidance notes on ASS, covering the requirement for assessing sites and the management of sites where ASS is identified. ASS investigations are commonly required as part of the conditions of subdivision or as a requirement for a dewatering license application.

The WAPC's Bulletin 64 (WAPC, 2003) ASS risk mapping for the site indicates it is located within an area of moderate to low risk of acid sulfate soils occurring within 3.0 m of natural soil surface. Notwithstanding, following preparation of detailed engineering plans, further investigation will be undertaken to determine if there is the presence (and any likelihood of disturbance) of ASS and if so, an appropriate management plan will be prepared and implemented in accordance with agency requirements.

4.2.5 Contaminated Sites

There are no listed contaminated sites in the Department of Environment Regulation's Contaminated Site Database as occurring within the site.

4.3 Water Sensitive Ecosystems

The site contains two mapped resource enhancement wetlands located adjacent to Tonkin Hwy (Figure 5). These wetlands are largely cleared, with one historically filled and currently grassed as part of a turf farm. Immediately adjacent to the north western corner of the site at the Welshpool Rd and Tonkin Hwy intersection are several conservation category wetlands.

Based on A Methodology for the Evaluation of Wetlands on the Swan Coastal Plain, Western Australia (DBCA, 2017), a wetland assessment found the values for both resource enhancement wetlands to be commensurate with that of a multiple use wetland. An application to DBCA to amend the Geomorphic Wetlands Swan Coastal Plain dataset will be required to change this classification.

The main environmentally significant feature in proximity to the site is the conservation category Greater Brixton St Wetland (GBSW) area located on the western side of Tonkin Hwy. The GBSW area is one of the most important wetlands on the Swan Coastal Plain, recognised for its botanical biodiversity attributed to unique geological, geomorphic and hydrological characteristics (Lambers 2019, EPA 2022a).

The GBSW area is of international, national, and regional environmental significance and is listed on the Directory of Important Wetlands in Australia (Environment Australia 2001) and the Department of Climate Change, Energy, the Environment and Water's Register of the National Estate.

The GBSW comprises a series of seasonally inundated or seasonally waterlogged areas, with various areas mapped as either Conservation Category, Resource Enhancement or Multiple Use wetlands. The GBSW was previously spatially defined by the cadastral boundary of Bush Forever site BF387 and has recently been expanded (EPA, 2022a). The extent of the revised GBSW area is shown in Figure 6. The wetland is situated at the foot slopes of the Darling Scarp within the geomorphological unit known as the Pinjarra Plain.

Bush Forever site BF387 is approximately 181 ha in size and has been identified as one of the most important conservation areas on the Swan Coastal Plain, containing more than 550 native plant taxa, Declared Rare Flora, Priority Flora and Threatened Ecological Communities (Bourke, 2017).

Further details of the site relationship to the GBSW area is discussed in Section 4.6.

4.4 Surface Water

The site is located within the catchment of Yule Brook (Figure 6).

Yule Brook is a natural watercourse in its upper reaches which transition to a network of drains in its lower reaches that form part of the Water Corporation's Yule Brook Main Drain system. The Yule Brook has a total catchment area of 56 km², most of which is highly modified and includes existing urban uses such as light to medium industry and high-density residential developments, as well as agricultural uses such as horticulture and poultry farming.

The catchment is estimated to be more than 75% cleared (DWER & DBCA, 2016).

Yule Brook includes Woodlupine Brook, Lesmurdie Brook and Whistlepipe Gully among its tributaries, ultimately flowing to the Canning River in Beckenham. Crystal Brook is also a tributary which previously flowed through the GBSW but was modified to connect to Yule Brook north of the site over 70 years ago (Lambers, 2019)

Water quality within Yule Brook varies both seasonally and annually (DWER & DBCA, 2016). Between 2006 and 2016, TN median concentrations annually were estimated to range between 0.66 mg/L and 1.10 mg/L, while median TP ranged from 0.07 mg/L and 0.16 mg/L.

Figure 6 delineates the site sub catchments relative to the location of the GBSW area and Yule Brook, showing the key topographic catchment boundaries and existing stormwater pipes and open drains in the vicinity.

The site represents approximately 2% of the total Yule Brook catchment area and 15% of the GBSW area subcatchment. The site has three key outlets which drain under Tonkin Hwy located at the southern ends of Boundary Rd (2 x 900 mm dia), Brentwood Rd (2 x 350mm dia) and Victoria Rd (375 mm dia). All of these outlets ultimately direct flow toward the GBSW area, albeit via different routes, and in many cases indirectly via constructed roadside trapezoidal drains.

The existing drainage within the site consists mainly of open roadside swales and crossovers/culverts, with limited piped drainage.

The majority of the site is located in the catchment of the Brentwood Rd culverts. These culverts flow to open road side drains on the southern side of Tonkin Hwy before entering the GBSW approximately 1.8 km downstream of the site.

The site does not appear to have any formal external drainage entering its boundary, with an open swale running along the sites northern boundary of Crystal Brook Road which acts as a cutoff for flow from any catchment to its north.

With respect to pre-development flow rates from the site across Tonkin Hwy these have been estimated on consideration of the following:

- MKSEA modelling conducted by Emerge Associates estimated the total flow from Catchment B (Figure 6) from the site of approximately 1.23 m³/s in the 1% AEP event, corresponding to a pro rata flow rate of approximately 10 l/s/ha from the catchment. Note Catchment A flows were provided in MKSEA reporting.
- The rate for Catchment B however appears to exceed the culvert capacities under Tonkin Hwy for this catchment, with the exception of the portion of this catchment draining to the Victoria Rd 375 mm dia culvert under Tonkin Hwy. Hyd2o also notes the 375mm and 450mm dia culverts between Brentwood and Victoria discharge into private property and do not currently appear to have a clear flow path downstream of the Tonkin Hwy.
- XP-Storm modelling by Hyd2o provides a lower pro rata flow rate estimate for Catchments A and B of approximately 7 l/s/ha, equating to overall flow rates of Catchments A and B of 0.92 m³/s and 0.90 m³/s respectively for the 1% AEP event.

On the basis of the above assessment, Hyd2o have utilised existing culvert capacities under the Tonkin Hwy and flow paths as the limiting factor for determining allowable downstream flow rate for Catchment B. Given culvert capacity is not a constraint for Catchment A an allowable pro rata discharge rate of 7 l/s/ha for post development modelling has been adopted.

In relation to external flows into the site, Catchment B has an area of 38 ha which interfaces with the Precinct E boundary. There is no defined flow path entering the site at this boundary indicating any flows would be diffuse and overland. Detailed engineering design for Precinct E will need to accommodate potential inflows from the upstream area in due course.

4.4.1 Surface Water Quality

Surface water quality monitoring has been conducted by Hyd2o since winter 2021, with sampling occurring at 9 locations when sites were observed to be flowing and water not stagnant. Sampling was inclusive of locations upstream of the site (SW1), outlets to cross Tonkin Hwy (SW2 to SW4) and locations downstream (west of Tonkin Hwy) to capture drainage flow paths across the GBSW area towards Yule Brook (SW5 to SW9). The majority of these sites are roadside open drains.

Sampling locations are shown in Figure 7 along with a general monitoring summary for each individual site shown spatially.

Data to July 2025 is summarised below in Table 4 and is aggregated to reflect surface quality upstream of the site, leaving the site, or downstream west of Tonkin Hwy in proximity to GBSW. Data has also been supplemented with historical Endemic (2012) data collected from 2009 to 2010 as well as Urbaqua (2020) data collected from 2019 to 2020. Note that where longer term data via previous monitoring programs also exists, data summaries for only the most recent 2021-2025 monitoring conducted by Hyd2o is also provided in Table 4 and Figure 7.

All tabulated monitoring data collected is provided in Appendix E, inclusive of relevant data from other previous programs where sites in common have been used. Laboratory reports are contained as Appendix F. Summary results via Hyd2o's FIELD AE database are provided in Appendix G for individual sites, with aggregated reporting (upstream, site, downstream) detailed in Appendix H. These results are used to inform the water quality targets for the site in Section 9.1.

General comparison to ANZECC (2000) for lowland river ecosystems in south-west Australia and freshwater ecosystem trigger values is as follows:

- Median EC at upstream sites fell within the ANZECC guideline range (0.12 – 0.3 mS/cm). Median EC at locations downstream was next highest with a value of 0.66 mS/cm and site outlets recorded the highest median with a value of 1.130 mS/cm.
- Median pH across all sampling groups fell within the ANZECC guideline range (6.5 – 8).
- Median TN values for both the site outlets (2.30 mg/L) and the locations west of Tonkin Hwy (1.90 mg/L) exceeded the ANZECC guideline (1.2 mg/L). Outlet SW2 had a high exceedance value of 18.00 mg/L while SW9 recorded the highest reading for a downstream location (4.90 mg/L).
- The median value for NO_x-N across the site outlets (1.09 mg/L) exceeded the ANZECC guideline (0.15 mg/L) with the highest reading recorded at SW2 (5.4 mg/L). The highest reading downstream was 1.30 mg/L at SW7.
- Median NH₃-N values across all sampling groups fell within the ANZECC guideline (0.9 mg/L). The highest site outlet recording was at SW3 (0.77 mg/L) while the highest downstream reading was at SW7 (2.70 mg/L).
- Median TP across the site outlets and downstream locations were 0.14 mg/L, which exceed the ANZECC guideline (0.065 mg/L). The highest reading across the outlets was taken at SW3 (5.6 mg/L) which was a large exceedance while the highest reading downstream was taken at SW9 (0.32 mg/L).
- Median FRP across locations downstream of the site (0.09 mg/L) exceeded the ANZECC guideline (0.04 mg/L). The highest value recorded across the site outlets occurred at SW2 (0.51 mg/L) while the highest value across the downstream locations occurred at SW9 (0.32 mg/L).
- Medians for heavy metals across all sampling groups fell within the 95% trigger value for freshwater species with the exception of Cu and Zn. Metal levels were generally consistent across sampling groups.
- The highest metals readings were most common at SW2 and SW4 for site outlets while SW7 recorded the highest readings for across locations downstream.

Surface flow upstream of the site represented by SW1 generally had the best quality with the least ANZECC guideline exceedances.

For locations downstream, the highest nutrient and metal concentrations were at SW7, downstream of the GBSW area and prior to discharge to Yule Brook.

4.5 Groundwater

The sites groundwater monitoring program commenced with the installation of bores in October 2020 and has extended over a period of almost 5 years. This monitoring program was commissioned by Hesperia in recognition of the site's proximity to the GBSW area.

The monitoring program was developed by Hyd2o in consultation with DBCA and DWER based on a review of previous reporting and data. The program considered where possible to use historically monitored sites so existing datasets could be built on and used to assist analysis and interpretation. DBCA and Main Roads provided data to assist this process. DWER data was obtained from the Water Information Reporting (WIR) database.

The program has included sampling groundwater quality and levels within, upstream, and downstream of the site, with the selection of sites to enable a review of data in the context of groundwater quality closer to the GBSW area.

Monitoring locations are shown in Figure 8. A total of 12 bores were installed in July 2022 and a further 4 bores in October 2022 to build on the initial 3 bores installed in 2020.

Paired deep and shallow bores exist at 8 locations. Deep bores were typically drilled to 12-14 mAHd into the top of the superficial aquifer. Sites for paired bores were based on a review of a deeper bore soil log which indicated the possibility that perching may occur at higher levels, or following a review of the historical hydrograph from a shallow bore which indicated it may be reporting a perched level and not representing the regional water table in that area.

Bore logs for all installed bores are included as Appendix C, together with tabulated construction details for all bores including screen intervals at each bore and drill depths.

Across the site and its surrounds, the program monitored 23 bores monthly for water levels, and quarterly for water quality at 20 of these. A further 3 nearby DWER bores (SCC 05/08, SCC 06/08, SCC 09/08) were also monitored monthly for water levels for correlation of results to longer term data.

Table 4: Predevelopment Surface Water Quality Summary

Parameter	ANZECC Guide (2000)	Upstream SW1			Site Outlets SW2, SW3, SW4			Downstream SW5, SW6, SW7, SW8, SW9		
		n	Med.	Max.	n	Med.	Max.	n	Med.	Max.
EC (mS/cm)	0.120 – 0.300 ¹	2	0.260	0.352	33	1.130	1.872 (SW2)	37	0.66	5.200 (SW7)
					16	0.501 ³	1.872 ³ (SW2)	27	0.578 ³	5.200 ³ (SW7)
pH	6.5 – 8.0 ¹	2	7.90	8.19	33	7.60	9.01 (SW2)	37	7.30	7.90 (SW7)
					16	7.53 ³	8.29 ³ (SW2)	27	7.26 ³	7.89 ³ (SW5)
TN (mg/L)	1.20 ¹	2	0.60	0.90	33	2.30	18.00 (SW2)	37	1.90	4.90 (SW9)
					16	2.10 ³	18.00 ³ (SW2)	27	1.80 ³	4.90 ³ (SW9)
NO _x -N (mg/L)	0.15 ¹	2	0.017	0.017	32	1.09	5.40 (SW2)	36	0.059	1.30 (SW7)
					16	0.98 ³	5.40 ³ (SW2)	27	0.036 ³	1.10 ³ (SW9)
NH ₃ -N (mg/L)	0.900 ²	2	0.01	0.02	16	0.03	0.77 (SW3)	27	0.02	2.70 (SW7)
					16	0.03 ³	0.77 ³ (SW3)	27	0.02 ³	2.70 ³ (SW7)
TP (mg/L)	0.065 ¹	2	0.05	0.05	33	0.14	5.60 (SW3)	37	0.14	0.32 (SW9)
					16	0.14 ³	5.60 ³ (SW3)	27	0.16 ³	0.32 ³ (SW9)
FRP (mg/L)	0.04 ¹	2	0.01	0.01	33	0.03	0.51 (SW2)	37	0.09	0.32 (SW9)
					16	0.06 ³	0.31 ³ (SW2)	27	0.09 ³	0.32 ³ (SW9)
As (mg/L)	0.024 ²	2	0.0015	0.002	19	0.001	0.0047 (SW3)	30	0.0018	0.004 (SW7)
					16	0.001 ³	0.0047 ³ (SW3)	27	0.0017 ³	0.003 ³ (SW9)
Cd (mg/L)	0.0002 ²	2	0.0001	0.0001	19	0.0001	0.0001	30	0.0001	0.0003 (SW7)
					16	0.0001 ³	0.0001 ³	27	0.0001 ³	0.0003 ³ (SW7)
Cr (mg/L)	0.001 ²	2	0.001	0.001	19	0.001	0.006 (SW2)	30	0.001	0.006 (SW7)
					16	0.001 ³	0.001 ³	27	0.001 ³	0.002 ³ (SW7)
Cu (mg/L)	0.0014 ²	2	0.0035	0.004	19	0.005	0.100 (SW4)	30	0.0024	0.013 (SW7)
					16	0.0049 ³	0.100 ³ (SW4)	27	0.0022 ³	0.0042 ³ (SW9)
Pb (mg/L)	0.0034 ²	2	0.001	0.001	19	0.001	0.005 (SW2)	30	0.001	0.001
					16	0.001 ³	0.003 ³ (SW4)	27	0.001 ³	0.001 ³
Ni (mg/L)	0.011 ²	2	0.001	0.001	19	0.001	0.006 (SW4)	30	0.002	0.019 (SW7)
					16	0.001 ³	0.006 ³ (SW4)	27	0.002 ³	0.019 ³ (SW7)
Hg (mg/L)	0.0006 ²	2	0.00005	0.00005	19	0.00005	0.0001 (SW2)	30	0.00005	0.0001 (SW7)
					16	0.00005 ³	0.00005 ³	27	0.00005 ³	0.00005 ³
Zn (mg/L)	0.008 ²	2	0.0135	0.017	19	0.015	0.078 (SW4)	30	0.012	0.360 (SW7)
					16	0.013 ³	0.078 ³ (SW4)	27	0.011 ³	0.360 ³ (SW7)

1. ANZECC (2000) default trigger values for lowland river ecosystems in south-west Australia
2. ANZECC (2000) trigger values for 95% level of species protection
3. Most recent years of monitoring period (2021-2025) is shown in italics where longer term data via previous monitoring programs also exists
4. Med. – Median, Max. – Maximum, n - Number of samples

Table 5 provides a summary of the site's predevelopment monitoring program. All monitoring data collected during the programme was managed in Hyd2o's FIELDAE monitoring database. All laboratory testing was conducted by NATA approved MPL Laboratories. Hyd2o sampling protocols are detailed in Appendix F.

With respect to water quality monitoring parameters, in addition to nutrients and heavy metals, monitoring for traces of common herbicides and pesticides was also undertaken for a short period at DBCA's request. All herbicide and pesticide monitoring results were below the limit of detection. Laboratory results of this testing are contained in Appendix F.

Further full analysis suite testing was performed for the site at DWER's request on four occasions in February 2023, September 2024, March 2025, and June 2025, which included additional parameters such as Bicarbonate, Total Dissolved Solids, Total Hardness, Total Alkalinity, and Ions. Summary tables of this testing are contained in Appendix E with laboratory results in Appendix F.

Table 5: Predevelopment Groundwater Monitoring Program

Monitoring	Parameter	Location	Method	Frequency and Timing
Groundwater Level	Water Level (mAHD)	23 bores within and in proximity to the site plus 3 DWER bores	Electrical probe or similar	Monthly
Groundwater Quality	Physical parameters, Nutrients, Heavy Metals	20 bores within and in proximity to the site	Pumped bore sample	Quarterly (Aug 2022 to Apr 2023 Bimonthly)
	Full Analysis Suite*			* Periodic

4.5.1 Regional Groundwater Levels

Groundwater level hydrographs and data for all Hyd2o bores monitored during the pre development monitoring period are contained as Appendix H. Relevant data from other previous programs where sites in common have been used are also included.

The calculation of average annual maximum groundwater level (AAMGL) contours and maximum groundwater level (MGL) contours for a site represents standard practice for land development projects to normalise recorded data and consider the variability in groundwater levels which occur across wet and dry periods.

The Hyd2o bores together with the following additional sites were used to map the AAMGL and MGL for superficial aquifer groundwater levels in proximity to the site:

- Main Roads bores along Tonkin Hwy (BH001, BH007, BH014, BH010)
- Closest DWER bores (SCC 06-08, SCC 05-8, SCC 09-08, 675B)

- DBCA bores in the GBSW area (WAN01, WAN02, WAN03)
- MKSEA Precinct 1 Bores (MW201S, MW202D, MW203D, MW205D, MW208D)
- Douglas Partners bore within the site (Mbb).

Construction details and logs for these additional bores are included in Appendix C.

Recorded levels on 27 October 2022 were used for AAMGL and MGL calculations which reflect a peak end of winter condition. Online data from two regional DWER bores (SCC 05-08 and SCC 09-08) were used to derive a correction factor to apply to the monitored data and determine the AAMGL and MGL for the site. This correction factor is used to normalise short term site data to expected longer term annual groundwater level variations based on nearby bores with longer term record.

DWER bore hydrographs as monitored by Hyd2o are contained as Appendix I, with longer term hydrographs based on DWER recorded data contained in Appendix J.

Correction factor calculations are shown in Table 6 with the resulting AAMGL values for the site bores shown in Table 7. It should be noted that peak winter water levels in 2022 exceeded the AAMGL condition at the DWER bores, which was a common occurrence across many areas of the Swan Coastal Plain during that winter.

Mapped AAMGL groundwater contours and depth to groundwater mapping are shown in Figure 8 in the immediate vicinity of the site. AAMGL contours at the site range from approximately 16 mAHD in the northeastern region to approximately 19 mAHD on the western boundary. Groundwater flow was found to be radial with a mound evident along the central western boundary adjacent to Tonkin Hwy.

The groundwater flow direction within the site was found to vary, generally ranging from flowing northwest to flowing southeast and away from the GBSW area. Monthly monitoring has shown that the seasonal variation in water table across the site varies considerably. Bores WG1, WG2 and WG3 which have been part of the monitoring program since November 2020 have had an average seasonal fluctuation of 0.8m, 1.4m and 2.4m respectively. Depth to AAMGL at the site was found to be more than 3m across the site, with the majority of the site having a clearance in excess of 9m.

The MGL was estimated to be 0.62 m higher than the AAMGL based on DWER bore correlation. MGL groundwater contours are shown in Figure 9.

With respect to the mound evident along the central western boundary adjacent to Tonkin Hwy, this was found to be likely a result of the following factors:

- Geology
The local variability in sub surface geology and existence of localised high and low permeability areas is likely to be a major factor influencing local groundwater flow directions and levels within the site, which is broadly observed in monitoring data as occurring toward more permeable soil types.
- Irrigation
Groundwater mounding in the vicinity of the turf farm indicates the application of water from a source such as the deeper Leederville aquifer rather than the superficial aquifer in this area is likely to have been occurring.

Since April 2023, the turf production and its irrigation have ceased and groundwater levels in its immediate vicinity have been observed to reduce. Figure 10 shows the recent

hydrographs at the nearest bores to the turf farm, in comparison to other nearby bores within and downstream of the site. The falling hydrographs at bores WG6 and WG9 in comparison to other locations highlight the local impact of the previous irrigation on groundwater levels. The decline in groundwater levels however have been observed to be greater at the near turf farm bores within the site compared to those south of Tonkin Hwy which is interpreted as being representative of more permeable soils in the Amendment Area and groundwater flow more readily moving and normalising in this direction. Interpretation of this data however is complicated by a Water Corporation main leak in August 2024 in this area. The mound however appears to still be persisting 2 ½ years since the turf farm pumping ceased.

The DWMS (Hyd2o, 2025) acknowledged EPA's objective of maintaining the existing hydrological regime, and considered the environment under turf farm irrigation to represent the baseline condition for assessment as this is representative of the local hydrological conditions in proximity to GBSW over many years.

Table 6: AAMGL for DWER Bores & Site Correction Calculation

Bores	Period of Record	Groundwater Level (mAHD) Oct-22	AAMGL 2000-2022 (mAHD)	Correction Factor (m)
SCC 05-08	2010 - 2022	23.09	22.74	-0.35
SCC 09-08	2010 - 2022	11.20	10.77	-0.43
Correction Factor for site Bores (Based on SCC 05-08 & SCC09-8)				-0.39
Other Nearby DWER Bores				
675B	2000 - 2022	-	15.90	-
SCC 06-08	2010 - 2022	-	6.55	-

Table 7: AAMGL for Regional Groundwater Table

Bore	Installed	Natural Surface (mAHD)	Monitored Date	Water Level (mAHD)	AAMGL (mAHD)	Depth to AAMGL Below Natural Surface (m)
site Bores						
WG1	Hyd2o	31.45	Oct-22	16.81	16.42	15.03
WG2D	Hyd2o	25.47	Oct-22	17.98	17.59	7.88
WG3	Hyd2o	22.32	Oct-22	17.76	17.37	4.95
WG4D	Hyd2o	25.11	Oct-22	16.37	15.98	9.13
WG5D	Hyd2o	34.55	Oct-22	16.61	16.22	18.33

Bore	Installed	Natural Surface (mAHD)	Monitored Date	Water Level (mAHD)	AAMGL (mAHD)	Depth to AAMGL Below Natural Surface (m)
WG6	Hyd2o	24.64	Oct-22	18.80	18.41	6.23
WG7D	Hyd2o	22.90	Oct-22	17.43	17.04	5.86
WG9	Hyd2o	23.23	Oct-22	19.51	19.12	4.11
WG10D	Hyd2o	22.88	Oct-22	18.13	17.74	5.14
Mbb	Douglas Partners	31.25	Oct-22	17.61	17.22	14.03
Nearby Bores External to the site						
WG8	Hyd2o	41.08	Oct-22	16.64	16.25	24.83
GW5D	Hyd2o	18.81	Oct-22	16.72	16.33	2.48
GW8D	Hyd2o	24.00	Oct-22	18.09	17.70	6.30
GW9D	Hyd2o	21.20	Oct-22	19.10	18.71	2.49
Other Monitoring Program Bores						
BH001	Main Roads	27.71	Nov-20	17.49	17.84 ²	9.87
BH007	Main Roads	21.42	Nov-20	14.35	14.70 ²	6.72
BH010	Main Roads	23.41	Nov-20	18.71	19.06 ²	4.35
BH014	Main Roads	20.00	Nov-20	14.86	15.21 ²	4.79
WAN01	DBCA	7.10	Oct-21	7.25	7.00 ¹	0.10
WAN02	DBCA	6.30	Oct-21	5.99	5.74 ¹	0.56
WAN03	DBCA	5.70	Oct-21	5.48	5.23 ¹	0.47
MW201S	MKSEA	23.14	Oct-22	18.98	18.59	4.55
MW202D	MKSEA	20.37	Oct-22	17.85	17.46	2.91
MW203D	MKSEA	26.90	Oct-22	18.50	18.11	8.79
MW205D	MKSEA	16.48	Oct-22	14.97	14.58	1.90
MW208D	MKSEA	15.15	Oct-22	12.59	12.20	2.95

1. Correction factor of -0.25m applied to 14 October 2021 reading for AAMGL based on SCC05-08 and SCC 09-08.

2. Correction factor of +0.35m applied to 26 November 2020 reading for AAMGL based on SCC05-08 and SCC 09-08.

4.5.2 Perched Groundwater

The maximum recorded levels during the monitoring period at shallow bores within and in close proximity to the site are shown on Figure 8 in relation to regional groundwater contours. Maximum readings recorded at each bore are summarised in Table 8.

In areas along the southern side of Tonkin Hwy adjacent to the site boundary perching was found to occur 1m to 3m above the regional water table, while in some of the central and southern areas of the GBSW, the regional water table and perching were found to be closer in elevation. This finding was consistent with the hydrological behaviour of the GBSW area described in Semeniuk (2001).

While some perching was evident in groundwater levels in the north western corner of the site near Tonkin Hwy, no perching was evident at most bores within the site.

There are a small number of unlined drains in the site on Brentwood Rd near Crystal Brook Rd which are located below the perched water table in that area and drain toward the culvert under Tonkin Hwy and the GBSW area.

It is noted anecdotal evidence from landholders in the site have suggested groundwater levels in proximity to the Dampier to Bunbury Natural Gas Pipeline Corridor (DBNGPC) adjacent to Tonkin Hwy reduced following excavation for the pipeline.

Table 8: Site Shallow Bores & Maximum Recorded Groundwater Levels

Bore	Installed By	Natural Surface (mAHD)	Date of Maximum Level	Water Level (mAHD)	Depth Below Natural Surface (m)
WG2S	Hyd2o	25.21	-	22.50 (Dry)	2.71
WG4S	Hyd2o	25.11	16/8/2023	24.78	0.33
WG5S	Hyd2o	34.54	-	29.33 (Dry)	5.21
WG7S	Hyd2o	22.85	-	19.82 (Dry)	3.03
WG10S	Hyd2o	22.80	21/08/2024	21.06	1.74

4.5.3 Groundwater Quality

Groundwater quality monitoring by Hyd2o to inform the predevelopment environment baseline commenced in May 2021 with the number of bore locations expanded over time to include additional site bores and external sites in proximity to the GBSW area.

A total of 20 bores within and in proximity to the site were monitored for water quality. Locations are shown in Figure 11. General monitoring summaries of each individual site are shown spatially for regional aquifer bores and shallow perched aquifer bores in Figures 11 and 12 respectively.

Data to July 2025 is summarised in Table 9 and is aggregated to reflect groundwater quality at either shallow or deep bores within the site or west of Tonkin Hwy in proximity to the GBSW area. Data has also been supplemented with historical Endemic (2012) data collected from 2009 to 2011. Note that where longer term data via previous monitoring programs also exists, data summaries for only the most recent 2021-2025 monitoring conducted by Hyd2o are also provided in Table 9 and Figures 11 & 12.

All tabulated monitoring data collected is provided in Appendix E, inclusive of relevant data from other previous programs where sites in common have been used. Laboratory reports are contained as Appendix F.

Summary results via the FIELDAE database are provided in Appendix G for individual sites, with aggregated reporting at various scales (i.e. shallow/deep bores, site/West of Tonkin Hwy) detailed in Appendix H.

General comparison to ANZECC (2000) guidelines for wetland ecosystems in south-west Australia and freshwater ecosystem trigger values is as follows:

- Median EC at both shallow and deep bores within the site are higher than the respective medians of shallow and deep bores west of Tonkin Hwy. Only the median for shallow bores within the site (2.133 mS/cm) fell outside the ANZECC guideline range (0.3 – 1.5 mS/cm).
- Median pH's for all bore groups, except for shallow bores west of Tonkin Hwy (7.02), have indicated some acidity and fall outside the ANZECC guideline range (7.0 – 8.5).
- Median TN readings at deep site bores (3.50 mg/L) and shallow bores west of Tonkin Hwy (2.75 mg/L) exceeded the ANZECC guideline (1.50 mg/L). Within these aggregations WG9 and GW12 have reported high exceedances of 52.0 mg/L and 8.4 mg/L respectively during the monitoring period. GW5D reported the highest reading across the deep bores west of Tonkin Hwy (5.50 mg/L).
- The median NO_x-N values for deep (2.20 mg/L) site bores and shallow (0.54 mg/L) bores west of Tonkin Hwy exceeded the ANZECC guideline (0.1 mg/L). Within their aggregations, WG9 and GW3 have reported high readings of 44.0 mg/L and 7.55 mg/L respectively during the monitoring period. Medians for all aggregations fell within the ANZECC guideline for NH₃-N (0.9 mg/L).
- Medians for all aggregations fell within the ANZECC guideline for TP (0.06 mg/L) except for the shallow bores west of Tonkin Hwy (0.15 mg/L). Within their aggregations WG9, GW12 and GW5D all reported the highest readings of 4.00 mg/L, 1.50 mg/L and 0.42 mg/L respectively.
- Medians for all aggregations fell within the ANZECC guideline for FRP (0.03 mg/L) except for the shallow bores west of Tonkin Hwy (0.04 mg/L). Within their aggregations WG9, GW12 and GW9D all reported the highest readings of 4.60 mg/L, 0.68 mg/L and 0.09 mg/L respectively.
- Generally, medians for heavy metals across the bore sets fell within the 95% protection trigger value for wetland ecosystems. The exceptions were median values for Cu for shallow bores west of Tonkin Hwy.
- Metal readings across the aggregations were generally higher across the bores west of Tonkin Hwy with notably high readings taken at GW5S, GW8S and GW12 (all shallow)

as shown in Table 9. The highest metal readings across the deep bores west of Tonkin Hwy were generally reported at GW5D and GW9D.

Based on groundwater quality monitoring to date nutrient levels in the regional water table appear highest around the previous Turf Farm area and mounding on the sites western boundary to which WG9 (internal) and GW9D (external) are associated. Nutrient levels were also generally highest at GW5D which is notably downstream of GW9D in a northwest direction. Generally metal levels within the regional table fall within ANZECC trigger values however concentrations are most apparent at GW9D. GW9D is in the vicinity of the Turf Farm at a cul-de-sac on Brentwood Rd enclosed by an elevated Tonkin Hwy and surrounding private properties.

For perched groundwater, nutrient levels have generally been highest at GW3 and GW12. These bores are located furthest away from the site and adjacent to the GBSW area with GW3 located in a road reserve and GW12 located within a rural property on Brook Rd. Metal concentrations have generally recorded highest at bore GW8S and GW12. Both GW8S and GW12 are located in areas slightly lower to an adjacent long existing road and levels may be a result of road runoff over time.

With respect to the poultry farm and disused chicken sheds near the site's eastern boundary, water quality sampling at nearby bore WG2 and MBb did not indicate elevated nutrient levels relative to other bores, with median TN levels considerably lower than the site median across all sites. The chicken sheds will be subject to separate soil and groundwater investigations in due course as planning progresses to determine if any remediation works are required.

With respect to ASS, while WAPC's Bulletin 64 (WAPC, 2003) ASS risk mapping for the site indicates it is located within an area of moderate to low risk of acid sulfate soils occurring within 3.0 m of natural soil surface, DWER's review of February 2023 monitoring's full analysis suite data indicated the likely presence of ASS within the groundwater fluctuation zone around bore GW5D located approximately 200 m west of the site on the southern side of Tonkin Hwy. Further investigation of ASS will be required as planning progresses to determine the presence and extent of any ASS, and an appropriate management response and plan prepared and implemented in accordance with agency requirements.

4.6 Relationship to Greater Brixton St Wetlands

EPA (2022a) identifies that a high level of protection and coordinated management is critical for the GBSW area, and future activities and development is to be compatible with the protection of environmental values of the GBSW area. The DWMS (Hyd20, 2024) provided the following key findings of the sites relationship to the GBSW area to inform its strategy:

- The key hydrological mechanisms supporting the GBSW area are broadly agreed across previous studies which identify the GBSW area as reliant largely on incident rainfall and surface water inflow.
- The site specific data collected since November 2020 enabled refinement of local regional groundwater mapping which indicates groundwater flow within the site as predominately away from the GBSW area. Groundwater flow was found to be radial with mounding evident along the central western boundary adjacent to Tonkin Hwy. The groundwater flow direction within the site was found to vary, generally ranging from flowing northwest to flowing south east and away from the GBSW area.

Table 9: Predevelopment Groundwater Quality Summary

Parameter	ANZECC Guide (2000)	Site Bores						Bores West of Tonkin Hwy					
		Shallow			Deep			Shallow			Deep		
		<i>n</i>	<i>Med.</i>	<i>Max.</i>	<i>n</i>	<i>Med.</i>	<i>Max.</i>	<i>n</i>	<i>Med.</i>	<i>Max.</i>	<i>n</i>	<i>Med.</i>	<i>Max.</i>
EC (mS/cm)	0.300 – 1.50 ¹	15	2.133	3.622 (WG4S)	148	1.242	12.939 (WG3)	44 28	0.666 0.550 ³	26.60 (GW12) 4.92 ³ (GW3)	36	0.560	1.496 (GW9D)
pH	7.0 – 8.5 ¹	15	5.61	6.95 (WG4S)	149	5.75	6.95 (MBb)	44 28	7.02 6.69 ³	8.18 (GW12) 7.44 ³ (GW3)	36	5.49	6.60 (GW9D)
TN (mg/L)	1.50 ¹	13	0.33	14.0 (WG4S)	140	3.50	52.0 (WG9)	36 25	2.75 2.50 ³	8.40 (GW12) 8.20 ³ (GW9S)	33	0.62	5.50 (GW5D)
NO _x -N (mg/L)	0.1 ¹	13	0.04	3.30 (WG10S)	140	2.20	44.0 (WG9)	35 25	0.54 0.93 ³	7.55 (GW3) 6.50 ³ (GW9S)	33	0.01	1.40 (GW9D)
NH ₃ -N (mg/L)	0.900 ²	14	0.01	0.32 (WG4S)	149	0.01	3.40 (MBb)	26 26	0.02 0.02 ³	0.18 (GW3) 0.18 ³ (GW3)	36	0.04	0.27 (GW5D)
TP (mg/L)	0.06 ¹	13	0.05	0.25 (WG4S)	140	0.05	4.00 (WG9)	39 25	0.15 0.15 ³	1.50 (GW12) 1.40 ³ (GW9S)	33	0.05	0.42 (GW5D)
FRP (mg/L)	0.03 ¹	14	0.01	0.07 (WG4S)	149	0.01	4.60 (WG9)	40 26	0.04 0.06 ³	0.68 (GW12) 0.31 ³ (GW9S)	36	0.01	0.09 (GW9D)
As (mg/L)	0.024 ²	14	0.001	0.0011 (WG4S)	149	0.001	0.0058 (MBb)	39 26	0.0033 0.0018 ³	0.05 (GW12) 0.016 ³ (GW9S)	36	0.001	0.0062 (GW9D)
Cd (mg/L)	0.0002 ²	13	0.0001	0.00082 (WG4S)	140	0.0001	0.00045 (WG1)	38 25	0.0001 0.0001 ³	0.0034 (GW8S) 0.0001 ³	33	0.0001	0.00011 (GW5D)
Cr (mg/L)	0.001 ²	13	0.001	0.0042 (WG10S)	140	0.001	0.013 (WG9)	38 25	0.001 0.001 ³	1.70 (GW12) 0.0018 ³ (GW9S)	33	0.001	0.0023 (GW9D)
Cu (mg/L)	0.0014 ²	13	0.001	0.002 (WG10S)	140	0.001	0.019 (WG9)	38 25	0.0038 0.0027 ³	0.48 (GW12) 0.006 ³ (GW9S)	33	0.001	0.018 (GW9D)
Pb (mg/L)	0.0034 ²	13	0.001	0.0018 (WG10S)	140	0.001	0.060 (WG6)	38 25	0.001 0.001 ³	0.19 (GW5S) 0.001 ³	33	0.001	0.01 (GW5D)
Ni (mg/L)	0.011 ²	13	0.0013	0.0038 (WG4S)	140	0.0029	0.096 (WG3)	38 25	0.0053 0.0045 ³	0.98 (GW8S) 0.023 ³ (GW9S)	33	0.0085	0.039 (GW5D)
Hg (mg/L)	0.0006 ²	13	0.00005	0.00005 (WG4S)	140	0.00005	0.0007 (WG9)	38 25	0.00005 0.00005 ³	0.0006 (GW8S) 0.00005 ³	33	0.00005	0.00005
Zn (mg/L)	0.008 ²	13	0.0030	0.047 (WG4S)	140	0.0068	0.061 (MBb)	38 25	0.0073 0.0043 ³	1.90 (GW12) 0.019 ³ (GW3)	33	0.0043	0.021 (GW5D)

1. ANZECC (2000) default trigger values for wetland ecosystems in south-west Australia
2. ANZECC (2000) trigger values for 95% level of species protection
3. Most recent years of monitoring period (2021-2025) is shown in *italics* where longer term data via previous monitoring programs also exists
4. Med. – Median, Max. – Maximum, n - Number of samples

- The site has a high clearance to the regional groundwater table and generally permeable soils at surface, which differs considerably from the shallow groundwater area on the southern side of Tonkin Hwy.
- There are no unlined open drains within the site which drain regional groundwater and affect the hydrological behaviour of downstream environments.
- Paired groundwater bores have shown a general absence of perching across the majority of the site, with the exception of some areas near Tonkin Highway and its Welshpool Road intersection, where clayey soils are present closer to surface.
- Recent changes in local irrigation within the site due to cessation of turf farm irrigation have impacted groundwater levels locally and requires ongoing consideration to ensure no adverse impacts on the GBSW area. The mound however appears to still be persisting 2 ½ years since the turf farm pumping ceased.

Based on these findings, key constraints and opportunities were identified to assist and guide the development of the DWMS and the approach adopted for this LWMS:

- While the site contributes a relatively small component of surface water inflow to the GBSW area compared to its other sources, surface flows are recognised as a key component of the wetlands hydrological water balance and the principle of maintaining pre and post development flow rates and volumes to the GBSW area will be used to inform the water management strategy and design.
- The existing groundwater mound along Tonkin Hwy is recognised to represent the baseline condition for considering historical hydrological conditions of the site in proximity to GBSW. Maintaining groundwater recharge and groundwater flow direction for this area was therefore considered a key principle to inform the water management strategy.
- Nutrient levels are relatively high in the GBSW area as a result of the adjacent historical rural and horticultural land uses. Nutrient input and export from the site itself is also considered high under existing land use, which included a turf farm.
- The site currently has no water sensitive measures or controls actively applied to improve and manage water prior to its discharge under existing land use to receiving environments.
- Declining rainfall in south west WA of the last 30 years has likely already resulted in changes to the hydrological cycle of the GBSW area and will continue to do so in future. No agency based management strategies are currently known to exist for managing the impacts of future reduced inflow to the GBSW area.

Ongoing monitoring and the use of adaptive management techniques were identified as key required elements of the strategy.

Land use change was viewed as an opportunity to provide an improved interface of surface and groundwater flows from the site to GBSW, improve water quality, and to provide potential measures to assist in countering the future effects of climate change and future rainfall decline on the wetlands.

5. Water Use Sustainability Initiatives

5.1 Water Efficiency Measures

Water conservation measures will be implemented within the development and will be consistent with Water Corporation's "Waterwise" land development criteria, and include:

- Promotion of use of waterwise practices including water efficient fixtures and fittings (taps, showerheads, toilets and appliances, rainwater tanks, waterwise landscaping).
- Water efficiency consistent with Building Codes of Australia.
- Establish Waterwise Public Open Space and retention of existing vegetation and significant trees.
- Maximising on site retention and reuse of stormwater.

More specific details on measures and approaches to be adopted to achieve water use efficiency objectives will be appropriately presented for individual precinct planning within the UWMP.

5.2 Water Supply

5.2.1 Potable Water Supply

The Water Corporation's Integrated Water Supply System (IWSS) will supply potable water to future homes in the site, via the extension of existing water supply infrastructure located in proximity.

5.2.2 Irrigation

The site is located within the Shire of Kalamunda Groundwater Management Subarea. Water in the superficial is still available for allocation in this area, however deeper aquifers such as the Leederville and Yarragadee are fully allocated.

With regard to Public Open Space (POS) irrigation, use of local groundwater is proposed.

Current licencing within the Amendment Area totals an allocation of approximately 255,350 kL/yr, including 176,000 kL/yr for the existing turf farm. Extracts from DWER's Water Register are included in Appendix K showing the spatial distribution of existing licences.

Landscape planning for the site has been undertaken by EPCAD. Plans for individual precincts and POS areas extracted from the Landscape Masterplan are presented in Appendix L, showing the integration of required stormwater management areas within POS. Stormwater area calculations used to inform landscape planning are detailed in Chapter 6.

Appendix K details estimated POS water requirements for individual precincts on the basis of a required allocation provision of 6,750 kL/ha/yr for non-conservation POS inclusive of DBNGP irrigation, but excluding school requirements.

The total POS irrigation requirement on this basis is estimated to be 88,828 kL/yr, well below existing licencing within the site.

While several precincts individual POS irrigation licence requirements exceed existing licences within their individual boundary, other areas have more than sufficient allocation. Given water is also still available for allocation in this sub area, water availability is not considered a constraint for the development.

With respect to construction water requirements depending on ultimate staging considerations, some temporary licencing allocation from local groundwater may also be required.

5.3 Wastewater Management

Wastewater will be deep sewerage (reticulated) with management by Water Corporation.

6. Stormwater Management Strategy

Stormwater management is proposed to be undertaken consistent with DWER water sensitive design practices, via a combination of lot soakwells, biofiltration areas, and multiple use flood storage areas to manage events within the site up to the 1% AEP event.

The overall key components of stormwater management within the site are as follows:

- Land use densities to reduce nutrient application and export relative to existing use.
- Lots to have soakwells to provide 15mm infiltration of stormwater at source, with lot connections to be considered at future Precinct scale planning where required based on subdivision design and geotechnical considerations.
- Road runoff to be conveyed using piped drainage with bottomless manholes to reduce bottom end infrastructure requirements.
- Treatment of first 15mm of road runoff within each catchment via specified biofiltration areas for water quality within POS areas. Locations of biofiltration areas have been identified with the key consideration being groundwater recharge and flow direction in the area of the existing groundwater mound. Biofiltration areas are therefore located predominately in the location of the existing mound and Tonkin Hwy
- Flood management areas to attenuate flows in accordance with agency requirements and capacity of downstream infrastructure. Some catchment areas are proposed to retain and infiltrate stormwater onsite. This approach is proposed primarily for staged development considerations and to enable individual Precincts to develop independently.
- The landscaped Dampier to Bunbury Natural Gas pipeline corridor (DBNGPC) to be used for the majority of major event stormwater management in accordance with maximising recharge in the area of the existing mound.
- Flow rates and flowpaths to be maintained post development, with flow from the site to continue to be directed towards existing outlets under Tonkin Hwy.
- Implementation of flexible infrastructure arrangements at key locations (Brentwood and Boundary Rd flood storage outlets) to enable future system adjustments to downstream environmental needs if required

Post development catchments for the site for stormwater modelling are shown in Figure 13, based on the proposed LSP and existing topography, and considering Precinct boundaries to reduce cross boundary considerations for future planning.

A total of eleven catchments were identified. Catchments 1 to 8 are assumed to discharge events in excess of the 15mm event to the DBNGPC, while Catchments 9 to 11 are proposed to infiltrate stormwater on site in POS areas up to the 1% AEP event.

Note no stormwater storage within conservation POS areas is proposed.

6.1 Stormwater Modelling

Stormwater modelling for the site was performed using XP-Storm to determine stormwater flood storage requirements. The design storms modelled by XP-Storm were based on methodology in Australian Rainfall & Runoff (AR&R) and the Bureau of Meteorology

Computerised Design IFD Rainfall System. The rainfall temporal pattern was assumed to be spatially uniform across the catchment. Storms modelled ranged from 30 mins to 72 hrs.

The following key parameters were used for modelling:

- Land use adopted as per the LSP, with catchment slopes based on existing natural topography.
- 1:0 side slopes for biofiltration areas to a maximum depth of 0.4 m, with overflow spillways established at these levels for managing larger events.
- Minimum side slopes of 1 in 6 for minor/major event flood storage in general POS areas, to a maximum depth of approximately 1.0 m (1% AEP Event). Storages were assumed to be nested above the 15 mm biofiltration areas in these locations.
- Within the DBNGPC, minor/major event storages are to be formed via bunding on the edges of the corridor above the existing natural surface. DWER's LiDAR DEM data has been used for this assessment. Side slopes of 1:6 have been assumed on the northern side of the DBNGPC adjacent to the development area with 1:3 on the Tonkin Highway side. A total of five storage areas in the corridor are proposed. A maximum flood depth of 0.9m in the DBNGPC was assumed to reduce required bund heights.
- A saturated hydraulic conductivity adopted for flood storage modelling of 2.5 m/day for biofiltration areas, 2.5 m/day for flood storage areas within in Yoganup sands, and 5 m/day in Bassendean sand areas within the DBNGPC adjacent to Tonkin Hwy.
- Allowable discharges under Tonkin Highway have been determined by a combination of considering predevelopment flow rate estimates (at Boundary Rd, 0.23 m³/s for 1% AEP), previous Maddington Kenwick Strategic Employment Area planning report allowable discharges (at Victoria Rd, 0.15 m³/s), and the existing hydraulic capacity of the existing Tonkin Hwy culverts (at Brentwood Rd, 0.30 m³/s). These flows have defined the allowable 1% AEP discharge rates from the site post development.

Various runoff coefficients applied to different land uses for each of the events modelled are shown in Table 11. These have been determined using Hyd2o's CURRV runoff rate calculator with detailed calculations included as Appendix M. Hyd2o's CURRV runoff calculator is a standardised approach used by Hyd2o across all development projects to estimate runoff rates. In estimating runoff rates CURRV considers rainfall IFD's, land use breakdown, percentages of impervious and pervious areas within land use type and likely initial and continuing loss of soil types. Modelling has assumed all residential lots with greater than a 10m street frontage will have soakwells sized to retain a 15 mm event on site, and the proposed school will be required to manage its stormwater on site.

Modelling results for the POS storages are provided in Table 11 and Figure 14, with modelling outputs shown in Appendix N. Note that storage shapes shown in Figure 14 are indicative only for determination of POS area requirements in the local structure plan.

Landscape plans in Appendix L should be referenced for more detailed information regarding the integration of required storage volumes within POS.

6.2 Small Event Water Quality Treatment(15mm)

This LWMS proposes a treatment train approach to water quality management which includes non- structural as well as structural controls:

- **Non-Structural Controls**

Planning: Lot product and sizing, POS and storage locations and configuration

Landscape: Native plantings, Conservation area establishment, WSUD integration

Maintenance: Storage areas, street sweeping, manhole education

Monitoring: Post development program and performance review

- **Structural Controls**

Catchment Scale Infrastructure: Bioretention & Flood Storage areas

Local Scale Infrastructure: Soakwells at lot scale, bottomless manholes in roads

Measures adopted represent known best management practice as detailed in the Stormwater Management Manual for Western Australia (DWER, 2022).

Table 10 details a summary from the Stormwater Management Manual for Western Australia (DWER, 2022) of expected pollutant removal efficiencies for various WSUD measures in relation to water quality design criteria. While DWER (2022) 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 achieve the design objectives for water quality as detailed in WAPC (2008).

Bioretention areas will be sized to retain treat and infiltrate 15mm in accordance with agency requirements. Biofiltration systems will be designed consistent with the Adoption Guidelines for Stormwater Biofiltration Systems (CRC for Water Sensitive Cities, 2015).

Storm volumes for ecological protection based on the 63% AEP (15mm) event are provided in Table 11 and Figure 14 to provide a guide for storage requirements and areas for water quality treatment consistent with DWER (2022) and DWER (2017).

The total area estimated for biofiltration is approximately 0.73 ha (volume 2925 m³).

With respect to disease vector and nuisance insect management, modelling shows stormwater management areas will have a maximum duration for standing water following small events (<15mm) of less than 6 hours, well within WAPC (2008) requirement of 96 hours.

Table 10: BMP Water Quality Performance

Water Quality Parameter	Design Criteria via WAPC (2008) (required removal as compared to a development with no WSUD)	Structural Controls Nutrient Output Reduction ¹	
		Biofiltration Areas/ Swales	Detention/ Retention Storages
Total Suspended Solids	80%	60-80%	65-99%
Total Phosphorus	60%	30-60%	40-80%
Total Nitrogen	45%	25-50%	50-70%
Gross Pollutants	70%	>90%	>90%

1. Typical Performance Efficiencies via DWER (2022)

6.3 Major Event Flood Protection (1% AEP)

Modelled flood protection storage volumes, areas, and flood rises are detailed in Table 11 and Figure 14 which shows the extent of inundation of POS area for various flood management events.

The total area within the site required for flood storage up to the 1% AEP event is approximately 3.28 ha or 2.6% of the total site area, with a total detention storage volume of approximately 16,063 m³ (inclusive of biofiltration areas/volumes).

The final storage area configuration (side slopes, treatments etc), location, and elevations will be documented in the UWMP and will be dependent on final earthworks, drainage, and road design levels for the development of individual Precincts.

Refinements to catchment areas shown in this report may occur as detailed design proceeds, and stormwater modelling will be updated accordingly if required during the Precinct UWMP process. Opportunities for additional distributed storage and treatment throughout the site will also be reviewed at Precinct level during later stages of planning.

All building floor levels will comply with requirements for a 0.3 m clearance above the 1% AEP flood level within the street drainage system and 0.5 m above the flood level within stormwater storage areas.

6.4 Minor Event Serviceability (20% AEP)

Modelled storage volumes, areas, flood rise and inverts are detailed in Table 11 and Figure 14 for the 20% AEP flood event, showing the extent of inundation of POS area.

The total area within the site required for flood storage up to the 20% AEP event is approximately 1.93 ha or 1.5% of the total site area, with a total detention storage volume of approximately 4,424 m³ (inclusive of biofiltration areas/volumes).

6.5 Adaptive Management Infrastructure

The DWMS (Hyd2o, 2024) detailed an adaptive management approach for the site to be managed within the processes of Better Urban Water Management (WAPC, 2008).

The key to implementation of the approach was the implementation of a comprehensive monitoring program and the provision of a framework which enabled outcomes from monitoring to influence planning outcomes on an ongoing basis. This framework is provided by this LWMS establishing clear performance targets, EPA (2025) requiring WAPC to prepare annual environmental compliance reporting, and the proposed establishment of a working group and GBSW management body by EPA (2025).

The approach will require active participation of key agencies and stakeholders and ensure a feedback loop of outcomes into the planning and implementation process.

To achieve this, flexibility will need to be embedded in stormwater infrastructure for Precincts A and B during design and construction to enable future adjustments to the system to be made to increase flows to GBSW if required. This will include:

- Providing an alternative outflow path for Storage PS-D to flow north to PS-E along the DBNGPC. This would entail providing a means to divert flows from PS-D toward the Tonkin Hwy culverts to flow to PS-E. A flexible orifice plate arrangement on the outlet would be considered an appropriate means of achieving this outcome. Some

additional bunding along the DBNGPC downstream of PS-D is also likely to be required to facilitate this outcome.

- Providing a flexible size outlet structure on storage PS-E to enable increase outflows at this location in future if required. An orifice plate arrangement on the outlet would be considered an appropriate means of achieving this outcome.

These requirements are associated with Precincts A and B and should be reflected in the UWMP's and engineering drawings prepared in support of development of these areas.

Opportunities for use of the Leederville Aquifer for school oval and Precinct B POS irrigation should be considered in future planning on the basis of monitoring outcomes.

Table 11a: Stormwater Storage Modelling – Catchments 1 & 2

Site Characteristics	Catch 1	Catch 2
Lots (Soakwells) (ha) (RO: 15mm 0%,20% AEP 16%,1% AEP 35%)	8.89	3.94
Lots (Lot Connection) (ha) (RO: 15mm 54%,20% AEP 59%,1% AEP 64%)	0.00	0.00
Road Reserve (ha) (RO: 15mm 63%,20% AEP 69%,1% AEP 79%)	3.92	1.73
POS & Conservation (ha) (ex DBNGP Corridor) (RO: 15mm 0%,20% AEP 1%,1% AEP 11%)	1.22	0.00
School (ha) (Managed On Site)	0.00	0.00
Total Catchment Area (ha)	14.04	5.67
15mm EIA (ha)	2.47	1.09
20%AEP EIA (ha)	4.14	1.83
1%AEP EIA (ha)	6.35	2.75
Biofiltration Design Parameters (15mm Event)		
Invert (mAHD)	21.6	24.8
Base Area (m ²)	928	412
Side Slopes (1:v)	0	0
Volume (m ³)	371	164
Maximum Depth (m)	0.40	0.40
Outlet & Elevation (mAHD)	Spillway @ 24.4 Overflow to Bunded Storage PS-E	Spillway @ 25.2 Overflow to Catch 1
Infiltration Rate for Flood Storage Design (m/d)	2.5	2.5
Flood Storage Design Parameters (20% & 1% AEP Event)		
Invert (mAHD)	21.0	-
Base Area	600(12x50)	-
Side Slopes (1:v)	1:6 development side 1:3 highway side 1:50,1:50 longitudinal	-
Design Top of Bund (mAHD)	22.35	-
Outlet & Elevation (mAHD)	400mm dia @21.0 Flow to 2x900mm dia under Tonkin Hwy	-
Infiltration Rate for Flood Storage Design (m/d)	5.0	-
20% AEP Event		
Flood Rise (m)	0.22	-
Top Water Level (mAHD)	21.22	-
Top Water Level Surface Area (m ²)	1007	-
Volume (m ³)	179	-
Outflow (m ³ /s)	0.11	-
Critical Storm (hr)	3	-
1% AEP Event		
Flood Rise (m)	0.93	-
Top Water Level (mAHD)	21.93	-
Top Water Level Surface Area (m ²)	2913	-
Volume (m ³)	1504	-
Outflow (m ³ /s)	0.23	-
Critical Storm (hr)	3	-

Table 11b: Stormwater Storage Modelling – Catchments 3, 4 & 5

Site Characteristics	Catch 3	Catch 4	Catch 5
Lots (Soakwells) (ha) (RO: 15mm 0%,20% AEP 16%,1% AEP 35%)	9.81	9.61	6.74
Lots (Lot Connection) (ha) (RO: 15mm 54%,20% AEP 59%,1% AEP 64%)	0.00	0.00	0.29
Road Reserve (ha) (RO: 15mm 63%,20% AEP 69%,1% AEP 79%)	4.97	4.37	3.59
POS & Conservation (ha) (ex DBNGP Corridor) (RO: 15mm 0%,20% AEP 1%,1% AEP 11%)	2.35	0.71	0.88
School (ha) (Managed On Site)	4.32	0.00	0.00
Total Catchment Area (ha)	21.44	14.68	11.50
15mm EIA (ha)	3.13	2.75	2.41
20%AEP EIA (ha)	5.02	4.56	3.74
1%AEP EIA (ha)	7.62	6.89	5.48
Biofiltration Design Parameters (15mm)			
Invert (mAHD)	23.3	23.8	24.8
Base Area (m ²)	1176	1035	906
Side Slopes (1:v)	0	0	0
Volume (m ³)	469	413	362
Maximum Depth (m)	0.40	0.40	0.40
Outlet & Elevation (mAHD)	Spillway @ 24.7 Overflow to Bunded Storage PS-D	Spillway @ 25.2 Overflow to Bunded Storage PS-C	Spillway @ 25.2 Overflow to Catch 4
Infiltration for Flood Storage Design (m/d)	2.5	2.5	2.5
Flood Storage Design Parameters (20% & 1% AEP Event)	Gas Pipeline Corridor Bunded Storage PS-D	Gas Pipeline Corridor Bunded Storage PS-C	
Invert (mAHD)	22.1	23.1	
Base Area (m ²)	960 (12x80)	1200 (12*100)	
Side Slopes (1:v)	1:6 development side 1:3 highway side 1:6,1:200 longitudinal	1:6 development side 1:3 highway side 1:6, 1:150 longitudinal	
Desing Top of Bund	23.4	24.2	
Outlet & Elevation (mAHD)	22.10 2x350mm Dia connect to existing Tonkin Hwy culverts	23.7 Weir for flow to Bunded Storage PS-D	
Infiltration for Flood Storage Design (m/d)	5.0	5.0	
20% AEP Event			
Flood Rise (m)	0.12	0.32	
Top Water Level (mAHD)	22.22	23.42	
Top Water Level Surface Area (m ²)	1370	2231	
Volume (m ³)	133	547	
Outflow (m ³ /s)	0.05	0.00 to B	
Critical Storm (hr)	3	3	
1% AEP Event			
Flood Rise (m)	0.92	0.74	
Top Water Level (mAHD)	23.02	23.84	
Top Water Level Surface Area (m ²)	5466	4020	
Volume (m ³)	2718	1845	
Outflow (m ³ /s)	0.30	0.68 to B	
Critical Storm (hr)	3	3	

Table 11c: Stormwater Storage Modelling – Catchments 6, 7 & 8

Site Characteristics	Catch 6	Catch 7	Catch 8
Lots (Soakwells) (ha) (RO: 15mm 0%,20% AEP 16%,1% AEP 35%)	5.71	1.00	1.49
Lots (Lot Connection) (ha) (RO: 15mm 54%,20% AEP 59%,1% AEP 64%)	0.00	0.00	0.00
Road Reserve (ha) (RO: 15mm 63%,20% AEP 69%,1% AEP 79%)	2.58	0.65	0.95
POS & Conservation (ha) (ex DBNGP Corridor) (RO: 15mm 0%,20% AEP 1%,1% AEP 11%)	0.22	0.61	1.13
School (ha) (Managed On Site)	0.00	0.00	0.00
Total Catchment Area (ha)	8.51	2.26	3.57
15mm EIA (ha)	1.63	0.41	0.60
20%AEP EIA (ha)	2.70	0.62	0.91
1%AEP EIA (ha)	4.06	0.93	1.40
Biofiltration Design Parameters (15mm)			
Invert (mAHD)	24.7	28.8	29.3
Base Area (m ²)	610	155	225
Side Slopes (1:v)	0	0	0
Volume (m ³)	244	62	90
Maximum Depth (m)	0.40	0.40	0.40
Outlet & Elevation (mAHD)	Spillway @ 25.1 Overflow to Bunded Storage PS-A + Overflow @ 25.1 to 375mm Pipe Dia connected to Tonkin Hwy culvert (1% AEP flow : 0.13 m3/s)	Spillway @ 29.2 Overflow to Catch 6	Spillway @ 29.7 Overflow to Catch 6
Infiltration for Flood Storage Design (m/d)	2.5	2.5	2.5
Flood Storage Design Parameters (20% & 1% AEP Event)	Gas Pipeline Corridor Bunded Storage PS-A	Gas Pipeline Corridor Bunded Storage PS-B	
Invert (mAHD)	24.0	23.5	
Base Area (m ²)	12 (1x12)	600 (12x50)	
Side Slopes (1:v)	1:6 development side 1:3 highway side 1:6,1:00 longitudinal	1:6 development side 1:3 highway side 1:100, 1:100 longitudinal	
Design Top of Bund (mAHD)	25.15	24.3	
Outlet & Elevation (mAHD)	24.75 Weir for flow to Bunded Storage PS-B	No Outlet	
Infiltration for Flood Storage Design (m/d)	5.0	5.0	
20% AEP Event			
Flood Rise (m)	0.55	-	
Top Water Level (mAHD)	24.55	-	
Top Water Level Surface Area (m ²)	1005	-	
Volume (m ³)	247	-	
Outflow (m ³ /s)	0.00 to PS-B	-	
Critical Storm (hr)	3	-	
1% AEP Event			
Flood Rise (m)	0.85	0.50	
Top Water Level (mAHD)	24.85	24.0	
Top Water Level Surface Area (m ²)	1790	2475	
Volume (m ³)	654	719	
Outflow (m ³ /s)	0.45 to PS-B	-	
Critical Storm (hr)	1	3	

Table 11d: Stormwater Storage Modelling – Catchments 9, 10 & 11

Site Characteristics	Catch 9	Catch 10	Catch 11
Lots (Soakwells) (ha) (RO: 15mm 0%,20% AEP 16%,1% AEP 35%)	6.60	3.60	10.12
Lots (Lot Connection) (ha) (RO: 15mm 54%,20% AEP 59%,1% AEP 64%)	0.00	0.00	0.00
Road Reserve (ha) (RO: 15mm 63%,20% AEP 69%,1% AEP 79%)	3.56	1.15	3.22
POS & Conservation (ha) (ex DBNGP Corridor) (RO: 15mm 0%,20% AEP 1%,1% AEP 11%)	2.73	0.81	4.90
School (ha) (Managed On Site)	0.00	0.00	0.00
Total Catchment Area (ha)	12.90	5.56	18.23
15mm EIA (ha)	2.25	0.72	2.03
20%AEP EIA (ha)	3.54	1.38	3.89
1%AEP EIA (ha)	5.43	2.26	6.62
Biofiltration Design Parameters (15mm)			
Bio Invert (mAHD)	26.5	32.5	28.0
Base Area (m ²)	843	275	765
Side Slopes (1:v)	0	0	0
Volume (m ³)	337	109	304
Maximum Depth (m)	0.40	0.40	0.40
Infiltration Rate Adopted for Flood Storage Design (m/d)	2.5	2.5	2.5
Storage Design Parameters (20% & 1% AEP Event) Nested Storage			
Flood Storage Invert (mAHD)	26.9	32.9	28.4
Base Area (m ²)	3080	1110	3800
Side Slopes (1:v)	6	6	6
Infiltration Rate Adopted for Flood Storage Design (m/d)	2.5	2.5	2.5
20% AEP Event (inclusive of biofilter)			
Flood Rise (m) inclusive of biofilter	0.46	0.48	0.44
Top Water Level (mAHD)	26.96	32.98	28.44
Top Water Level Surface Area (m ²) inclusive of biofilter	3165	1196	3865
Volume (m ³) inclusive of biofilter	509	194	440
Critical Storm (hr)	3	3	3
1% AEP Event			
Flood Rise (m) inclusive of biofilter	1.02	1.03	1.02
Top Water Level (mAHD)	27.52	33.53	29.02
Top Water Level Surface Area (m ²) inclusive of biofilter	4006	1840	4860
Volume (m ³) inclusive of biofilter	2494	1018	2936
Critical Storm (hr)	6	6	6

7. Groundwater Management Strategy

7.1 Groundwater Levels

Future development levels for the Amendment Area are generally not dominated by fill requirements to achieve adequate separation to groundwater, given the distance of groundwater levels to natural surface over much of the site.

Depth to groundwater currently varies within the site from approximately 4 m to 22 m below the existing natural surface (depth to AAMGL).

Subsoil drainage is considered unlikely to be required, however should any be needed in limited areas (for example due to impermeable underlying soils and localised perching), all flows would be treated via use of biofiltration systems prior to any off site discharge.

Finished lot levels and fill requirements are a detailed design issue to be addressed during the preparation of detailed engineering design drawings at UWMP stage and will be ultimately submitted for further agency approvals at that stage.

7.2 Groundwater Quality

Groundwater quality will be maintained relative to predevelopment conditions with the intent to improve water quality through a change in land use and through application of best practice water sensitive urban design measures as outlined in Chapter 6.

Post development monitoring and reporting will be implemented across the site (discussed further in Section 9.2) to compare water quality with predevelopment conditions and ensure compliance.

Acid sulphate soil mapping has been previously discussed in Sections 2.3.5 and 4.5.3. Management of acid sulphate soils (ASS) will be addressed in separate studies at Precinct level if required depending on possible disturbance and excavation depths for engineering services. Lower lying precincts closer to Tonkin highway are more likely than elevated precincts to require further ASS consideration.

All assessment and management of ASS will be undertaken in accordance with the Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes Guideline (Department of Environment Regulation, 2015a) to better characterise ASS at the site.

Should any ASS Management Plan be required for ground disturbing works this will be prepared in accordance with the Treatment and Management of Soil and Water in Acid Sulfate Soils Landscapes Guideline (Department of Environment Regulation, 2015b). Details regarding the outcomes of any ASS studies will be included as part of later water management planning documents for individual precincts.

8. Urban Water Management Plans

Consistent with processes defined in WAPC (2008), Urban Water Management Plans (UWMP's) will be required to be developed to support development for individual precincts and submitted to support individual development applications within the site.

The UWMP's will be required to address:

- Demonstrated compliance with LWMS criteria, subdivision conditions, and objectives to the satisfaction of the City of Kalamunda.
- Results of detailed geotechnical investigation undertaken at individual precinct level.
- Agreed/approved measures to achieve water conservation and efficiencies of water use.
- Ensure groundwater licencing requirements to meet POS area requirements at precinct level.
- Refined stormwater management design including updated stormwater modelling based on the approach detailed in this LWMS.
- Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, expected performance and agreed on going management arrangements.
- Management of construction works, including staging considerations.
- Implementation plan including roles, responsibilities, funding and ongoing maintenance needs and arrangements.
- Precinct scale monitoring requirements to meet the intent of the LWMS and annual compliance reporting to be undertaken consistent with the monitoring program defined in this LWMS.
- Contingency plans (where necessary).

More detail of stormwater storage integration with POS and the DBNGP corridor will be provided during the development of individual UWMP's, including refinement of stormwater modelling, preparation of detailed landscape plans (species selection and treatments), and detailed engineering design drawings.

Preparation of the individual precinct UWMP's will be the individual developer's responsibility.

9. Monitoring

9.1 Pre-Development

An initial predevelopment monitoring program was previously undertaken by Urbaqua for the Water Grove South area and accepted by DWER as satisfying their requirements for pre-development monitoring. Although no further predevelopment monitoring was necessary to meet DWER requirements at that time, due to the site proximity to the GBSW area, Hyd2o commenced additional monitoring for the site in November 2020.

Across the site and its immediate surrounds, there are currently 23 bores which are being monitored monthly for water levels, with 20 of these monitored quarterly for quality. A further 3 nearby DWER bores are monitored monthly for water levels for correlation of results to longer term data. Nine surface water sites are also monitored.

Monitoring locations are shown in Figure 15. The pre-development program is due for completion at the end of winter 2025 and has provided:

- groundwater levels to inform the setting of future infrastructure.
- groundwater quality upstream and downstream of the site for review in the context of groundwater quality closer to the wetland.
- surface water quality upstream and downstream of the site, and within the wetland where stormwater inflows occur.
- data to establish post development assessment targets.

A summary of data collected to date is provided in Chapter 4 and Appendices E to I.

The predevelopment program has been coordinated with DWER and DBCA and opportunities for synergies and data sharing assessed to maximise its overall benefit.

Ongoing monitoring during the post development phase of the project will continue to provide an opportunity to build on existing datasets and improve understanding of the GBSW area and its behaviour in its changing environment.

9.2 Staging Implications

Staging of stormwater works to maintain a functioning stormwater management system for the Amendment Area and the existing council drainage systems will be required during the development staging process.

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

A key consideration during staging will be the management of the existing groundwater mound during the transition phase and ensuring any changes in land use and recharge are carefully managed. While not development related, the effects of the recent cessation of groundwater irrigation at the turf farm will be monitored and this data used to inform the transition process and future planning.

EPA(2025) recommends collaboration on information and a coordinated management approach in relation to the GBSW area and requires WAPC to submit an environmental performance report which is inclusive of all subdivisions within the Amendment Area to

DWER within three months after the end of the Initial Report Year and subsequently within three months after the end of each Report Period, until DWER confirms in writing that reports are no longer required.

The establishment of key common post development monitoring sites and parameters in Section 9.3 to be monitored by all precinct developers as part of individual programs will ensure a robust dataset across the staged development process for evaluation of overall strategy performance and need for adaptive management.

9.3 Post-Development

Department of Water (2012) indicates a minimum of 3 years post development monitoring is required.

Programs for individual precinct areas within the site will be required. The extent of these individual programs will be determined in consultation with agencies at the appropriate stage of planning for individual precincts. Individual programs will be designed to operate over three year post development periods, with the timing for commencement of the program to be negotiated at UWMP stage with DWER and the City of Kalamunda. Given the staged process of development a considerably longer rolling monitoring program will ultimately result with a focus on the current development stage outcomes in the context of assessing whole of development performance outcomes.

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 based on its outcomes and reporting.

At precinct level, locations for groundwater monitoring at a minimum will be based on predevelopment locations (including areas south of Tonkin Hwy near GBSW), with surface water monitoring based on key outlets from the site and the performance of key stormwater infrastructure.

Key post development assessment sites for common monitoring are based on protection of the GBSW area and assessing the existing groundwater mound. Sites are shown in Figure 15, with updated targets based on predevelopment monitoring outcomea to July 2025 shown in Table 12.

Note that while the nutrient targets are variable and at some locations exceed DWER & DBCA (2016) overall long term TN and TP targets of 1.0 mg/L and 0.1 mg/L for the Yule Brook catchment, the current targets reflect the site's existing condition due to legacy land uses. Improvement in water quality is expected with land use change as development progresses.

With respect to water level targets, levels at the existing mound are considered to still be in transition following the cessation of irrigation at the former turf farm. The key indicator is to demonstrate existing groundwater flow directions are maintained. In addition to the four bores identified for water quality monitoring Hyd2o therefore recommend monitoring bore WG5D levels be also taken to assess groundwater flow direction and mound persistence.

Annual reporting will be required to be provided for individual precincts, detailing the previous 12 months of monitoring and assessing performance in the context of established targets, and providing recommendations for future monitoring, planning and development implications, and on any corrective actions (if required).

Data from annual reporting will also be provided to WAPC to assist in the preparation of the overall annual environmental performance reporting for the site. This will ensure post development monitoring program outcomes will provide a feedback loop to inform later stages of planning using adaptive management.

Table 12: Water Quality Targets

Parameter	Site	Targets			
		pH	EC (mS/cm)	TN (mg/L)	TP (mg/L)
Surface Water Quality	ANZECC (2000) ¹	6.5-8.0	0.12-0.30	1.20	0.065
	SW2	7.69	1.14	3.50	0.13
	SW3	7.38	0.23	1.80	2.90
	SW4	7.62	0.17	0.45	0.08
Groundwater Quality	ANZECC (2000) ²	7.0-8.5	0.30-1.50	1.50	0.06
	GW5D	4.43	0.68	0.61	0.05
	GW9D	6.43	0.60	1.40	0.05
	WG8D	5.33	0.85	1.50	0.28
	WG10D	6.11	0.15	4.20	0.05
Levels	GW5D, GW9D, WG8D, WG 10D WG5D	Comparison of relative levels at bores to determine level trends, flow direction, and persistence of groundwater mound.			

1. ANZECC (2000) default trigger values for lowland river ecosystems in south-west Australia
2. ANZECC (2000) default trigger values for wetland ecosystems in south-west Australia

10. Implementation

10.1 Implementation Responsibilities

A summary of roles, responsibilities and funding to implement the LWMS is provided in Table 13. Monitoring outcomes will be used in a continual improvement capacity to review the performance of implemented WSUD within the site with outcomes to enable implementation of an adaptive management approach.

Responsibilities will be further appropriately refined at UWMP stage for individual Precincts, including maintenance tasks and responsibilities.

It is important to note that EPA (2025) provided additional advice for consideration by the Minister during its assessment of the MRS Amendment for Wattle Grove South. These recommendations included collaboration on information and the development of a coordinated management approach between government agencies.

EPA (2025) found that the disparate land management of the GBSW area and surrounds has resulted in monitoring related to the GBSW being undertaken by different stakeholders, and it considered:

- o *that a coordinated approach to the collection and analysis of hydrological data across the GBSW and surrounds would inform a better understanding of the hydrology and hydrogeology supporting the GBSW*
- o *the consolidation of all recent monitoring datasets in the GBSW region and building of a single regional groundwater surface map is likely to assist in defining the GBSW groundwater catchment*
- o *development of models (such as conceptual/numerical surface water/groundwater) would allow better understanding of the GBSW processes and function*
- o *State government agencies should be custodians of hydrological datasets in a consolidated database*
- o *a working group is established for the analysis of the data and its application to the understanding of, protection and enhancement of the GBSW*
- o *a GBSW management body to be established with all relevant stakeholders, including Traditional Owners, with a government agency as a support coordinator of the management body MRS Amendment 1388/57- Wattle Grove South 38 Environmental Protection Authority*

While this management body is yet to be formed, the intent of the EPA in the above statements is reflected in the implementation actions for the LWMS in Table 13 via assigning relevant government agencies responsibilities in the review and actioning of adaptive management recommendations for the site implemented in relation to potential GBSW impacts.

Table 13: Implementation, Roles and Responsibilities

Implementation Action	Responsibility					
	Developer	DWER	City of Kalamunda	DBCA	WAPC	EPA
Preparation of UWMP's to support in individual precinct developments	✓					
Review and approval of UWMP's		✓	✓	✓		
Construction of water management system and maintenance post construction until council handover	✓					
Conduct post development monitoring program and annual reporting for individual precincts	✓					
Monitoring data provision to WAPC for collation and use in annual environmental performance reporting	✓					
Review of annual reporting for individual precincts including adaptive management recommendations		✓	✓	✓		
Preparation of annual environmental performance reporting					✓	
Review of annual environmental compliance reporting						✓
Review and actioning of adaptive management recommendations		✓	✓	✓	✓	✓
Long term water management system operation and maintenance			✓			

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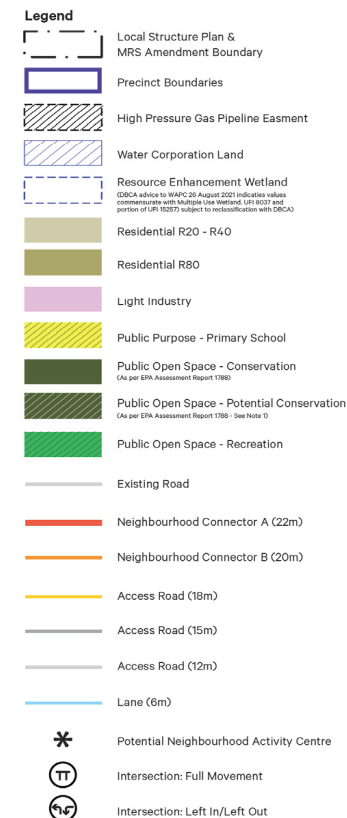
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FIGURES



- Site Boundary
- Precinct Areas
- Urban Expansion Area
- Urban Investigation Area

0 210 420 630 840 Meters



Notes

- Potential Conservation areas to be investigated further and determined by proponents as part of Local Structure Plan Amendments.
- Landowners are not forced to redevelop their land. It is their individual choice whether they wish to proceed to develop or remain as-is.
- The location of Public Open Space can potentially be modified by a proponent as part of their final design solution, subject to justification being provided through a Structure Plan amendment and/or subdivision application.
- Upgrades to Welshpool Road intersection will be required in the future in accordance with the Transport Impact Assessment (PTG 2025) - proposed roundabout, subject to detailed design with City of Kalamunda and Main Roads WA.
- Opportunity for Neighbourhood Activity Centre in Precinct A - subject to further investigations undertaken by Precinct A landowners.

Source : element, 2025



Site Boundary



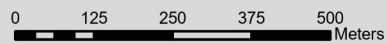
Precinct Areas

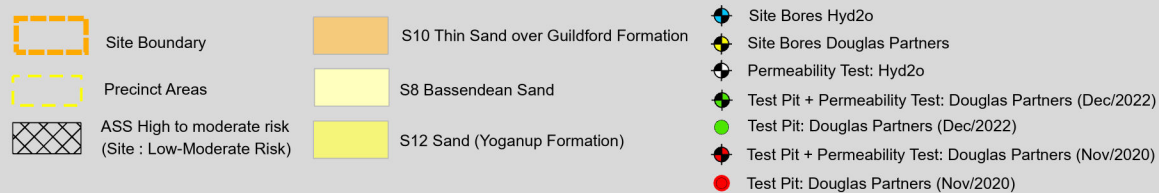
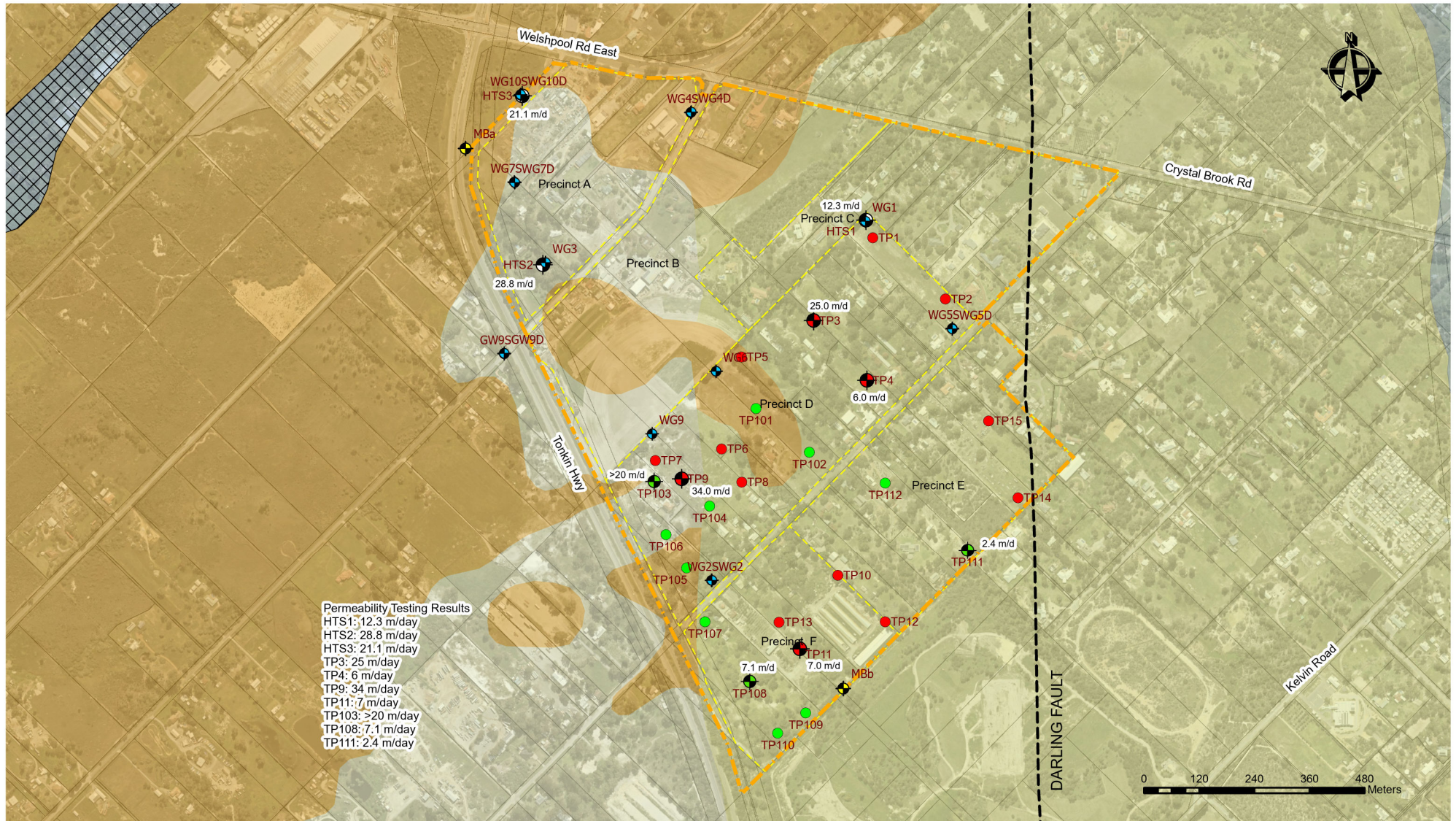


DWER LiDAR Topography (mAHD)

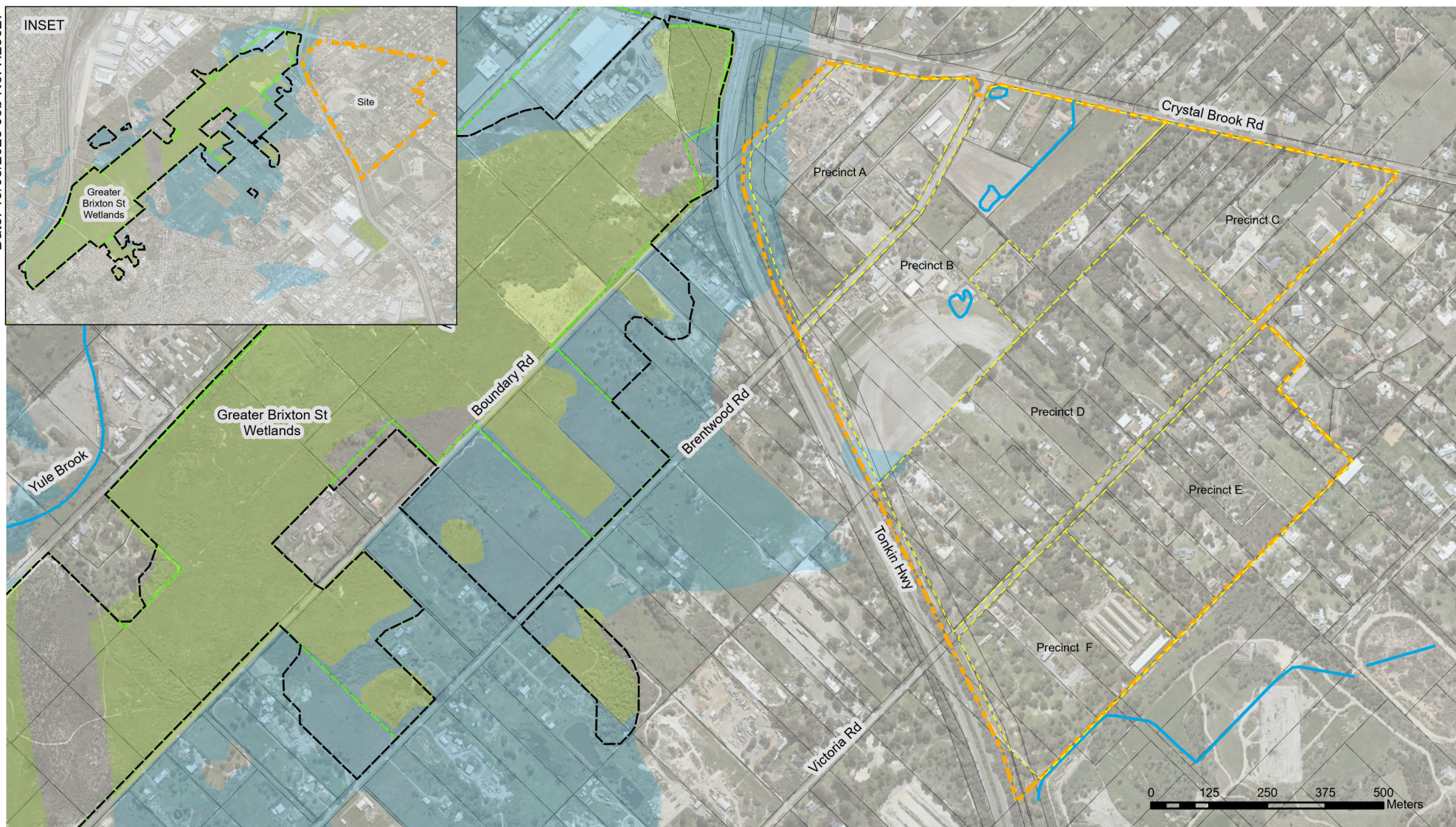


Dampier to Bunbury Natural Gas Pipeline



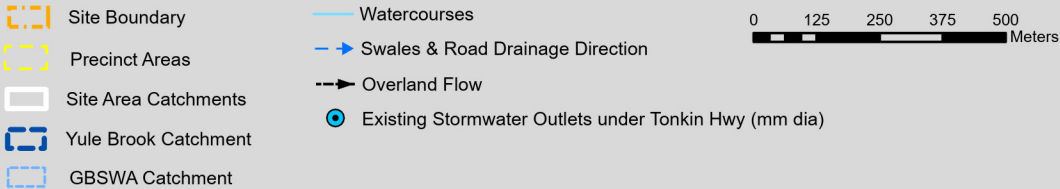
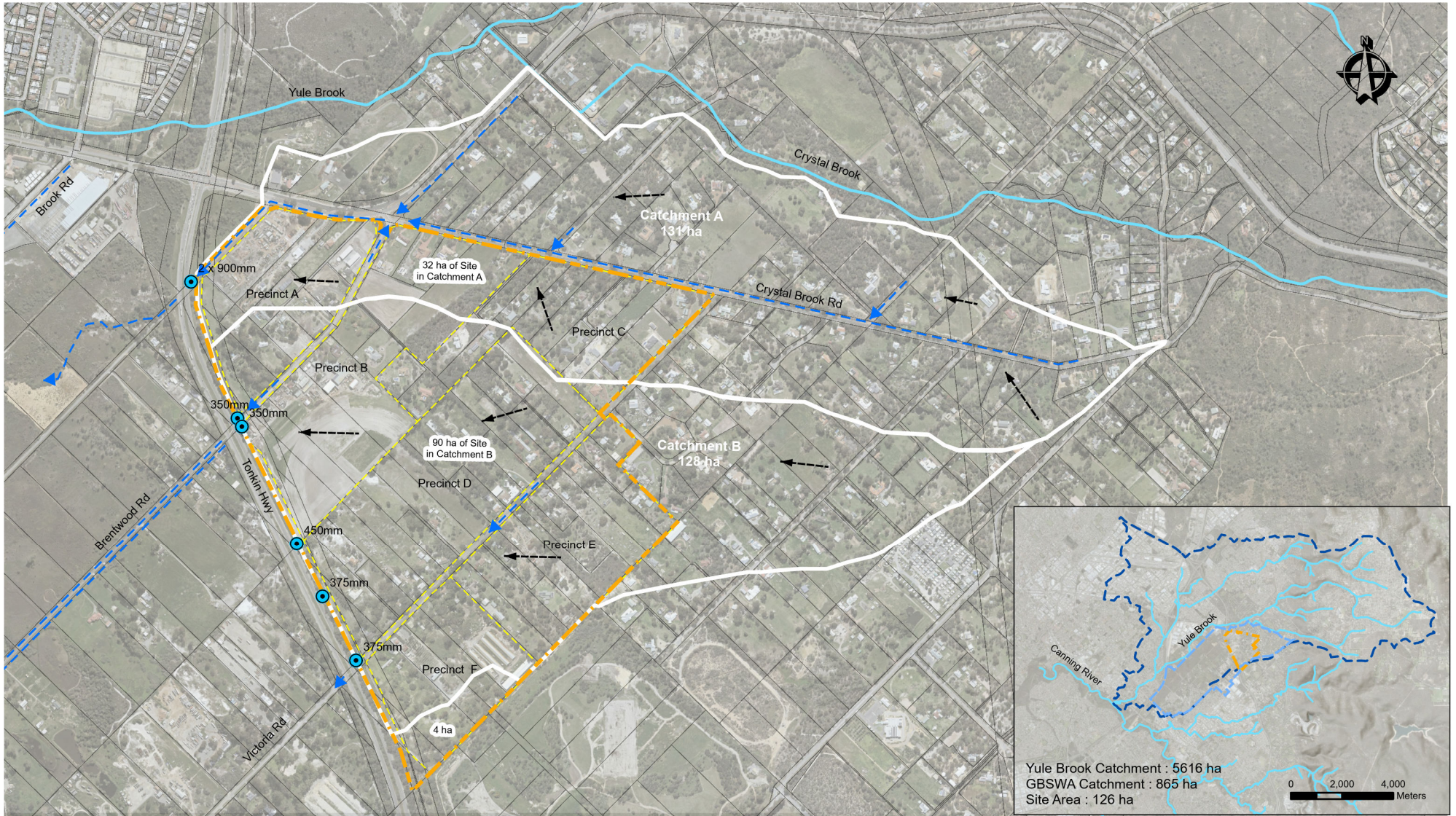


hyd2o
Wattle Grove South Local Water Management Strategy
Geotechnical Plan
Figure 4



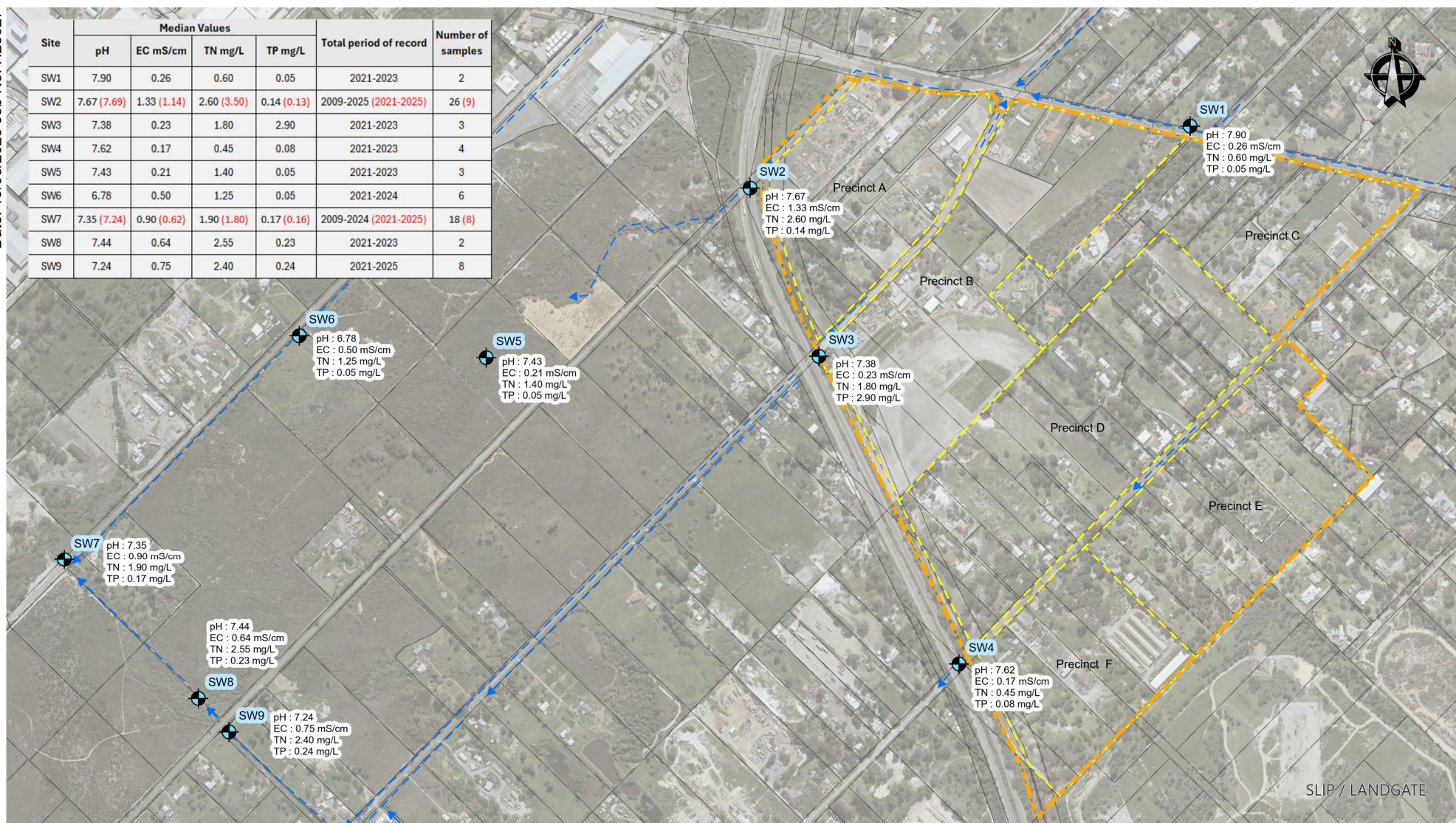
- Site Boundary
- Precinct Areas
- Bush Forever Site 387
- Greater Brixton Street Wetland Area (EPA, 2022)

- Conservation Category Wetland
- Resource Enhancement Wetland
- DWER Hydrography



hyd2o
Wattle Grove South Local Water Management Strategy
Surface Water Plan
Figure 6

Site	Median Values				Total period of record	Number of samples
	pH	EC mS/cm	TN mg/L	TP mg/L		
SW1	7.90	0.26	0.60	0.05	2021-2023	2
SW2	7.67 (7.69)	1.33 (1.14)	2.60 (3.50)	0.14 (0.13)	2009-2025 (2021-2025)	26 (9)
SW3	7.38	0.23	1.80	2.90	2021-2023	3
SW4	7.62	0.17	0.45	0.08	2021-2023	4
SW5	7.43	0.21	1.40	0.05	2021-2023	3
SW6	6.78	0.50	1.25	0.05	2021-2024	6
SW7	7.35 (7.24)	0.90 (0.62)	1.90 (1.80)	0.17 (0.16)	2009-2024 (2021-2025)	18 (8)
SW8	7.44	0.64	2.55	0.23	2021-2023	2
SW9	7.24	0.75	2.40	0.24	2021-2025	8



Site Precinct Areas

Surface Water Monitoring Sites

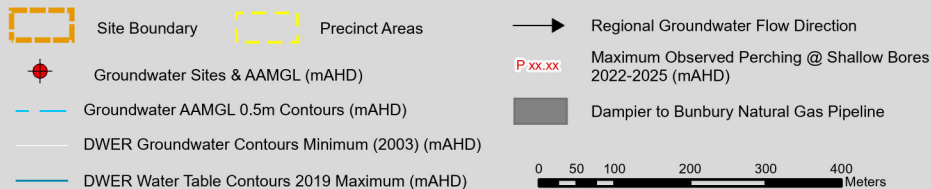
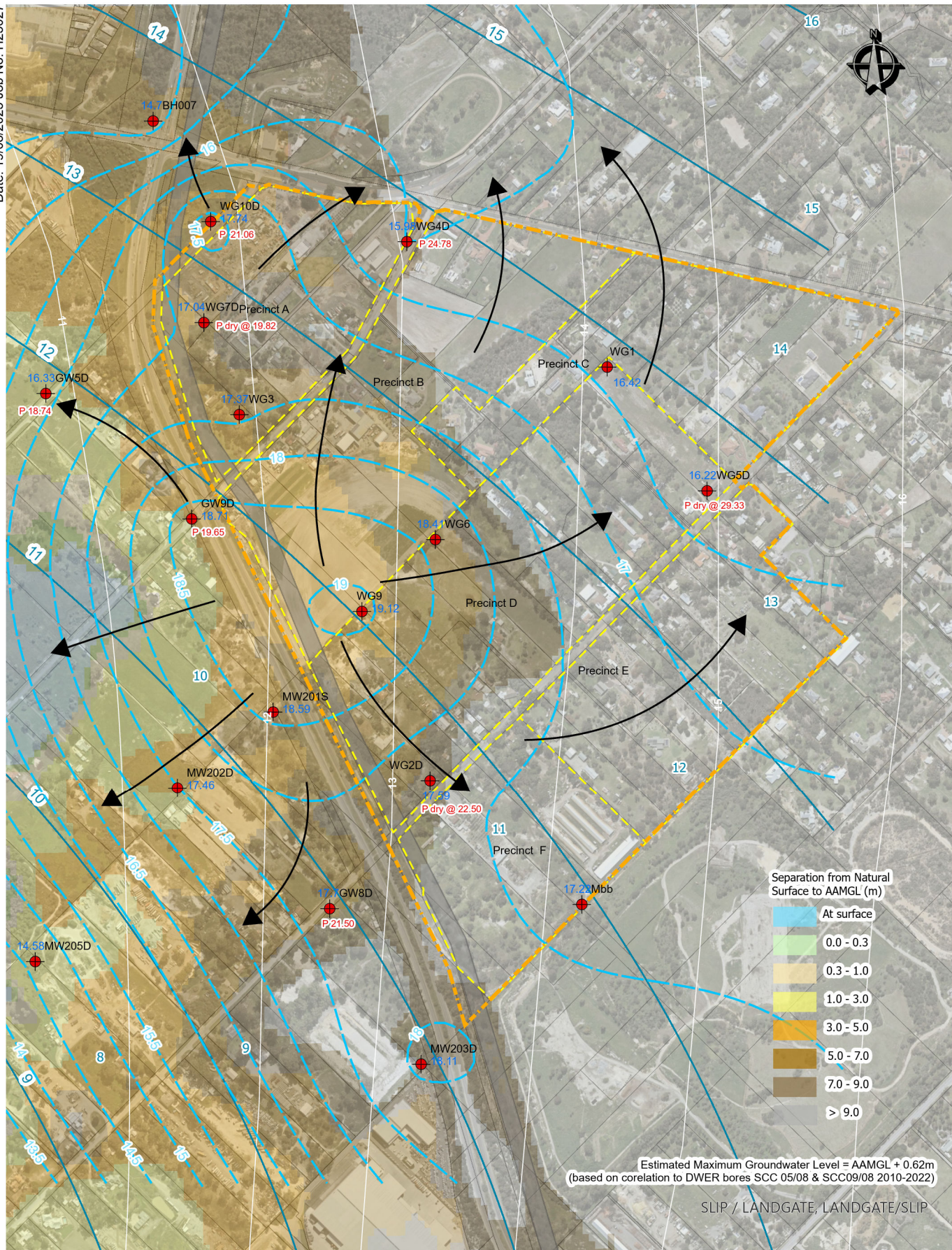
Swales & Road Drainage Direction

Watercourses

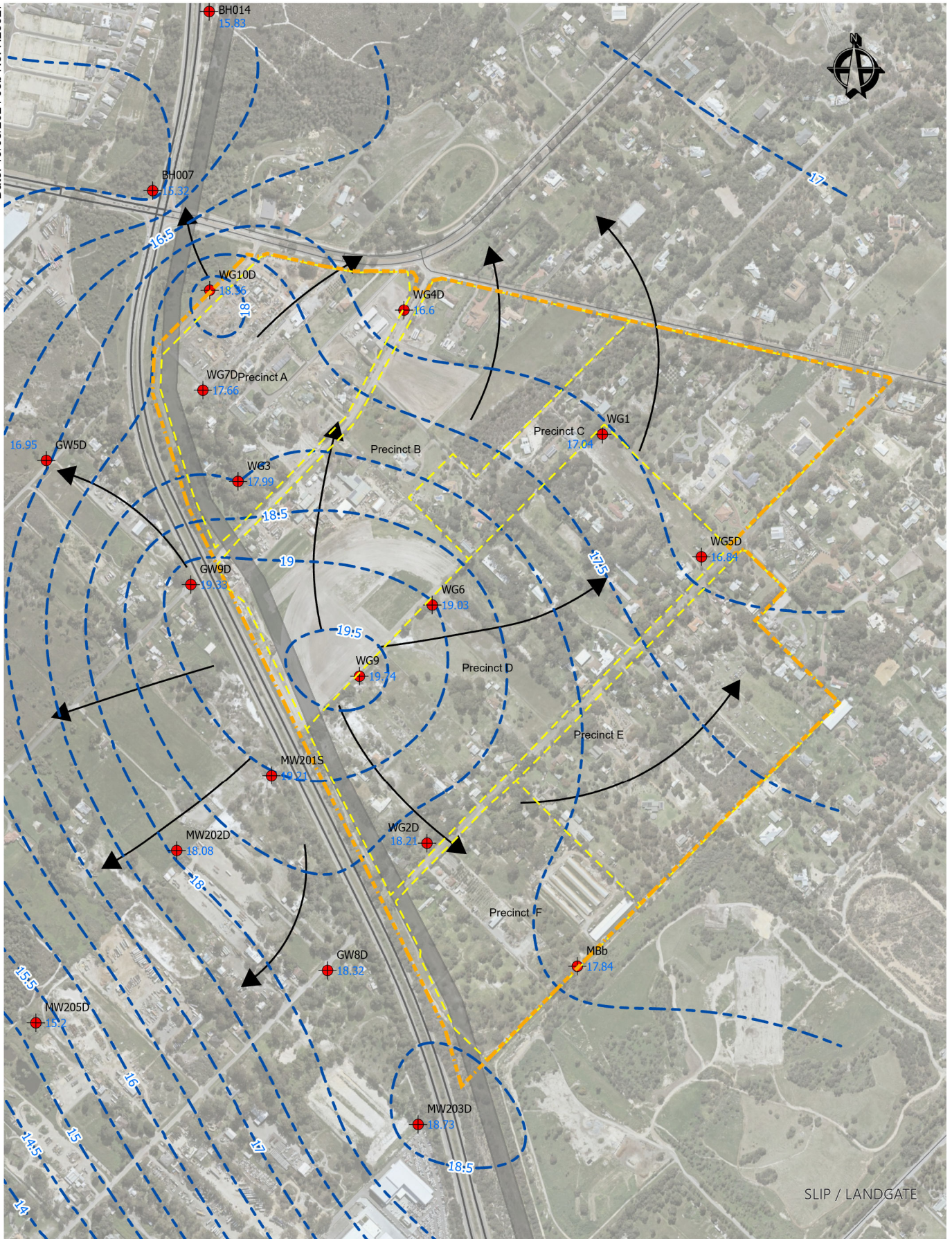
0 125 250 375 500 Meters

* Medians shown are for total period of available record
Recent 2021-2025 median is shown in red where longer term record at the site exists

hyd2o
Wattle Grove South Local Water Management Strategy
Water Quality Summary: Surface Water
Figure 7



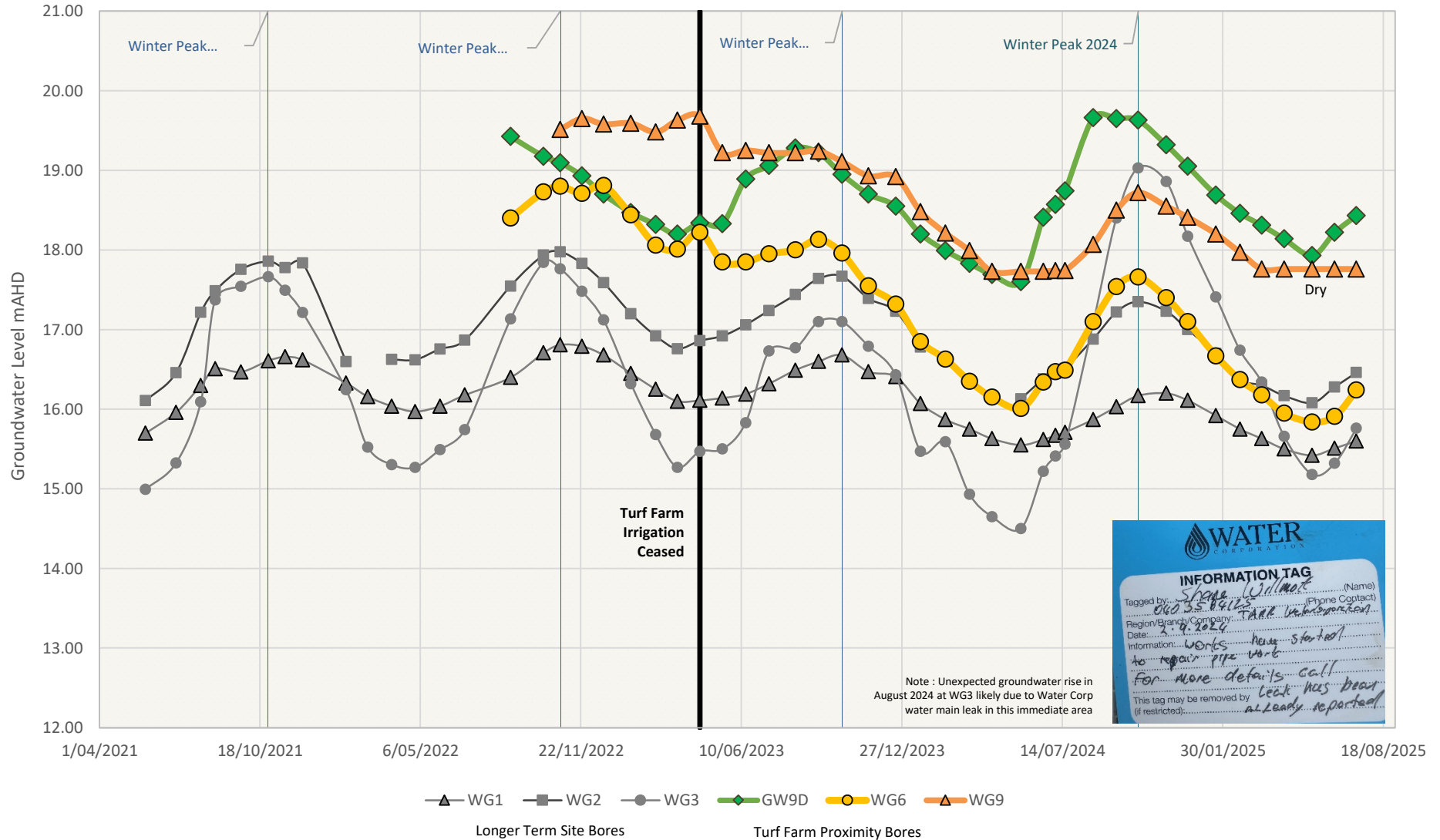
hyd2o
Wattle Grove South LWMS
Groundwater Plan : AAMGL
Figure 8

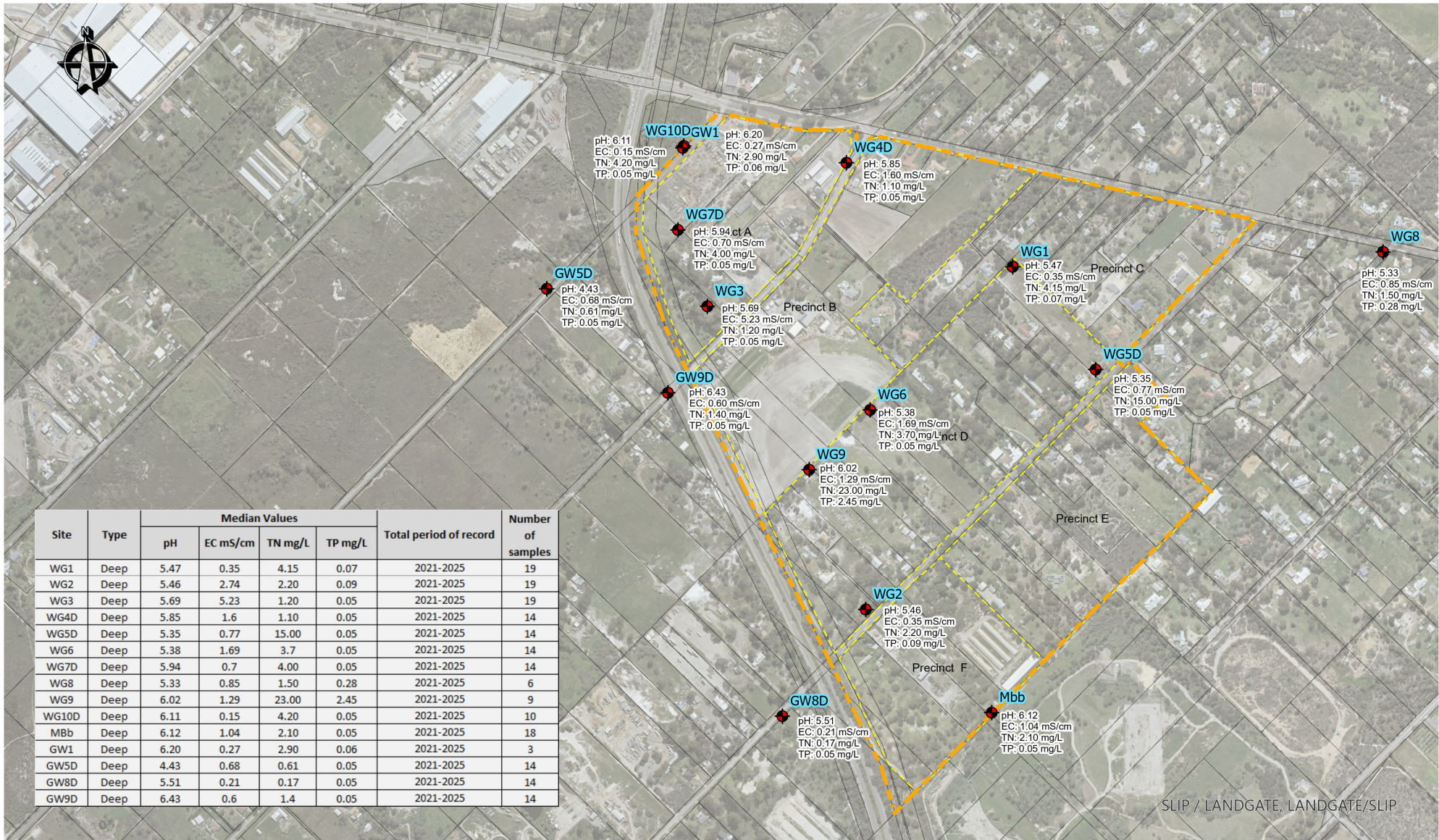


SLIP / LANDGATE

- Site Boundary
- Precinct Areas
- Groundwater Sites & MGL (mAHD)
- Groundwater MGL 0.5m Contours (mAHD)
- Regional Groundwater Flow Direction
- Dampier to Bunbury Natural Gas Pipeline

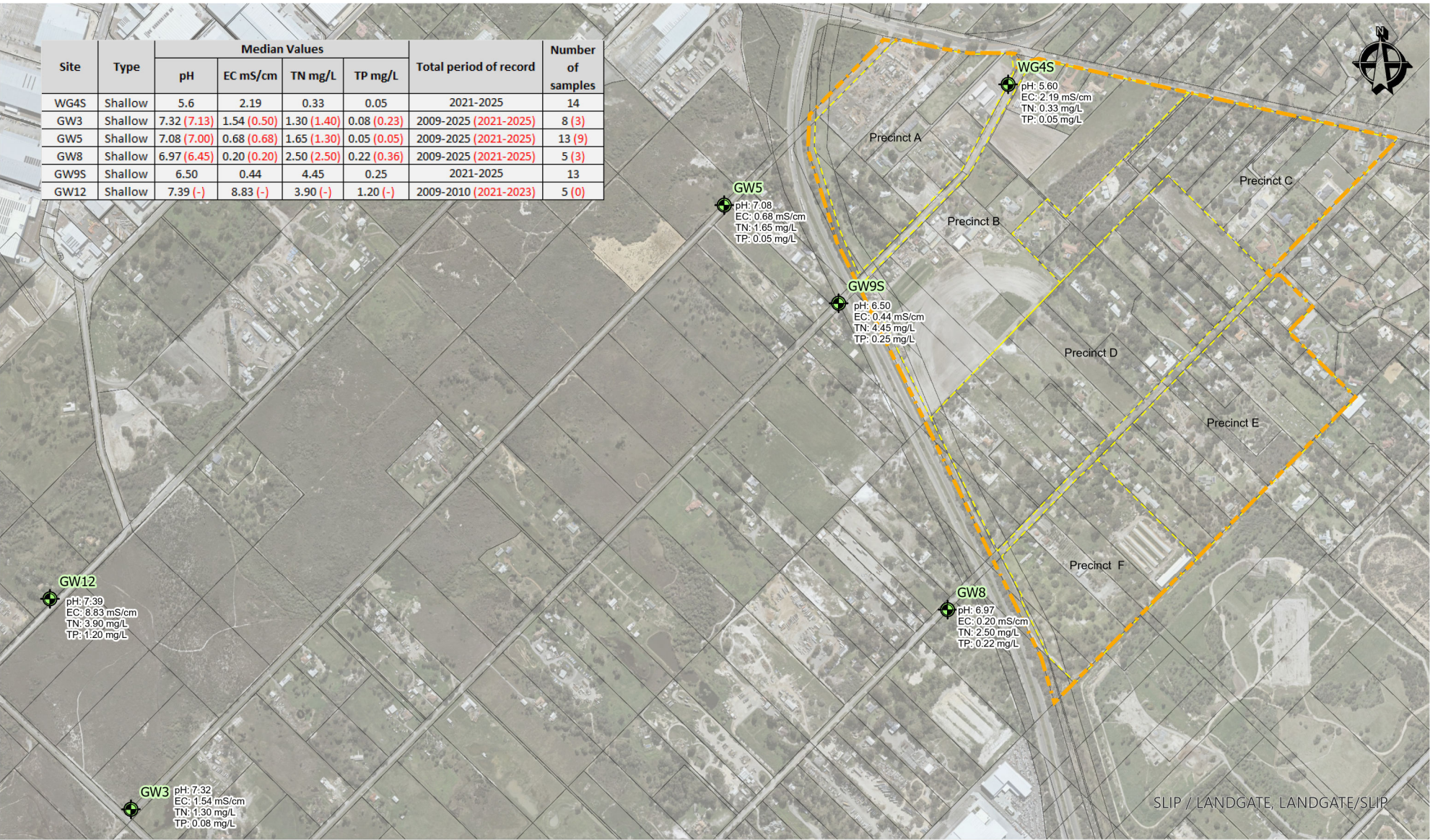
0 50 100 200 300 400 Meters





Site	Type	Median Values				Total period of record	Number of samples
		pH	EC mS/cm	TN mg/L	TP mg/L		
WG1	Deep	5.47	0.35	4.15	0.07	2021-2025	19
WG2	Deep	5.46	2.74	2.20	0.09	2021-2025	19
WG3	Deep	5.69	5.23	1.20	0.05	2021-2025	19
WG4D	Deep	5.85	1.6	1.10	0.05	2021-2025	14
WG5D	Deep	5.35	0.77	15.00	0.05	2021-2025	14
WG6	Deep	5.38	1.69	3.7	0.05	2021-2025	14
WG7D	Deep	5.94	0.7	4.00	0.05	2021-2025	14
WG8	Deep	5.33	0.85	1.50	0.28	2021-2025	6
WG9	Deep	6.02	1.29	23.00	2.45	2021-2025	9
WG10D	Deep	6.11	0.15	4.20	0.05	2021-2025	10
MBb	Deep	6.12	1.04	2.10	0.05	2021-2025	18
GW1	Deep	6.20	0.27	2.90	0.06	2021-2025	3
GW5D	Deep	4.43	0.68	0.61	0.05	2021-2025	14
GW8D	Deep	5.51	0.21	0.17	0.05	2021-2025	14
GW9D	Deep	6.43	0.6	1.4	0.05	2021-2025	14

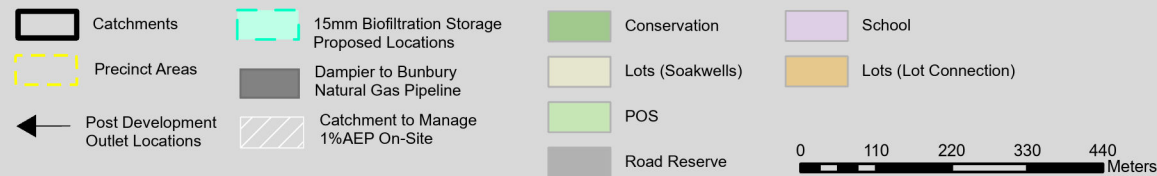
Site	Type	Median Values				Total period of record	Number of samples
		pH	EC mS/cm	TN mg/L	TP mg/L		
WG4S	Shallow	5.6	2.19	0.33	0.05	2021-2025	14
GW3	Shallow	7.32 (7.13)	1.54 (0.50)	1.30 (1.40)	0.08 (0.23)	2009-2025 (2021-2025)	8 (3)
GW5	Shallow	7.08 (7.00)	0.68 (0.68)	1.65 (1.30)	0.05 (0.05)	2009-2025 (2021-2025)	13 (9)
GW8	Shallow	6.97 (6.45)	0.20 (0.20)	2.50 (2.50)	0.22 (0.36)	2009-2025 (2021-2025)	5 (3)
GW9S	Shallow	6.50	0.44	4.45	0.25	2021-2025	13
GW12	Shallow	7.39 (-)	8.83 (-)	3.90 (-)	1.20 (-)	2009-2010 (2021-2023)	5 (0)



Site Boundary Precinct Areas

Groundwater Monitoring Bores

* Medians shown are for total period of available record
Recent 2021-2025 median is shown in red where longer term record at the site exists



hydo
Wattle Grove South Local Water Management Strategy
Catchment Plan + Proposed Biofilter Area Locations
Figure 13