

Lots 161, 162, 23, 24, 25 & 26 Sawley Close Golden Bay

Local Water Management Strategy

September 2025



Client: Cape Bouvard Investments Pty Ltd

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Executive Summary

Hyd2o was commissioned by Cape Bouvard Investments Pty Ltd to prepare this Local Water Management Strategy (LWMS) to support the proposed the local structure plan process for Lots 161, 162, 23, 24, 25 & 26 Sawley Close, Golden Bay (herein referred to as the site).

The site is located within the City of Rockingham and approximately 16 km south of the Rockingham town centre and 50 km south of the Perth CBD. The site has an approximate area of 16.5 ha and is bound by existing urban development to the west and north, Mandurah Rd and Sawley Close Nature Reserve to the east, and Sawley Close to the south (Figure 1).

The local structure plan for the site has been prepared by Urbis. The proposed residential development consists of residential lots, associated roads, public open space with stormwater management areas, retained bushland and wetland (conservation) reserve. The site includes a total 8.35 ha of POS/parkland reserve area comprising over 50% of the total site area to retain existing areas of Threatened Ecological Community (TEC) and Conservation Category Wetlands (CCW).

The site is currently vacant, with remnant patches of Sedgeland (TEC) which will be retained post development in addition to the CCW. Topography across the site varies between 3 mAHD in low lying wetland areas to 25 mAHD. The sites estimated maximum groundwater level (MGL) is at approximately 2.25 mAHD, with the urban development area having a clearance above MGL ranging from 4 m to 23 m.

Stormwater management within the site post development proposes a mix of detention storage and infiltration storages. Some of the catchment will have their stormwater initially detained prior to be infiltrated to subsequent catchment storages. All stormwater within the site will be infiltrated with no discharge occurring towards TEC and/or wetland areas.

This LWMS provides a total water cycle management approach to development and has been prepared consistent with Better Urban Water Management (Western Australian Planning Commission (WAPC), 2008). This document provides the outcomes of site specific analysis relating to groundwater, surface water and wetland hydrology and provides a clear vision in terms of adopting best management practises to achieve water sensitive design.

Implementation of the strategy will be undertaken in accordance with Better Urban Water

Management through the development and implementation of Urban Water Management Plans for individual stages of development within the site.

1. Introduction

Hyd2o was commissioned by Cape Bouvard Investments Pty Ltd to prepare this Local Water Management Strategy (LWMS) to support the proposed local structure plan process for Lots 161, 162, 23, 24, 25 & 26 Sawley Close, Golden Bay (herein referred to as the site).

The site is located within the City of Rockingham and approximately 16 km south of the Rockingham town centre and 50 km south of the Perth CBD.

The site has an approximate area of 16.5 ha and is bound by existing urban development to the west and north, Mandurah Rd and Sawley Close Nature Reserve to the east, and Sawley Close to the south (Figure 1).

The local structure plan (LSP) for the site has been prepared by Urbis. The proposed residential development consists of residential lots, associated roads, public open space with stormwater management areas, retained bushland and wetland (conservation) reserve. The proposed development for the site has considered the predevelopment environment and uses this information to inform the development of the local structure plan.

This LWMS provides a total water cycle management approach to development and has been prepared consistent with Better Urban Water Management (Western Australian Planning Commission (WAPC), 2008). This document provides the outcomes of site-specific analysis relating to groundwater, surface water and wetland hydrology and provides a clear vision in terms of adopting best management practises to achieve water sensitive design.

A copy of the Better Urban Water Management (WAPC, 2008) LWMS Checklist for Developers is included as Appendix A to assist the Department of Water and Environmental Regulation (DWER) and City of Rockingham (CoR) in review of this document.

1.1 Planning Context

This site is currently zoned 'Rural' under the Metropolitan Region Scheme (2007) and as 'Special Rural' under the City of Rockingham's Local Planning Scheme No. 2 (City of Rockingham, 2025).

The urban water management planning process for the site is shown in Table 1.

A DWMS for the site has been previously prepared (Hyd2o,2025) and approved to support the TPS and MRS Amendment process as follows:

- MRS Rezoning to 'Urban' and 'Parks and Recreation'
- TPS rezoning to 'Development' and 'Parks and Recreation'

This LWMS supports the proposed LSP of the area for residential development.



Table 1: Urban Water Management Process

Planning Phase	Planning Document	Urban Water Management Documents
MRS Amendment	MRS Amendment	Various Lots Sawley Close Golden Bay District Water Management Strategy (DWMS) APPROVED
Local Structure Plan	Local Structure Plan	Local Water Management Strategy (LWMS) THIS DOCUMENT
Subdivision	Subdivision Application	Urban Water Management Plan (UWMP) FUTURE PREPARATION

1.2 Key Documents

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

- Various Lots, Sawley Close, Golden Bay District Water Management Strategy (Hyd2o, 2025)
- Stormwater Management Manual for Western Australia (DWER,2022)
- Draft State Planning Policy 2.9 Planning for Water (WAPC, 2021a)
- Draft State Planning Policy 2.9: Planning for Water Guidelines for the implementation of State Planning Policy 2.9 Planning for Water (WAPC, 2021b)
- Planning Policy No.3.4.3 Urban Water Management (City of Rockingham, 2019a)
- Planning Procedure No.1.8 Urban Water Management (City of Rockingham, 2019b)
- Decision Process for Stormwater Management in WA (DoW, 2017)
- Guidelines for District Water Management Strategies (Department of Water, 2013)
- Better Urban Water Management (Western Australian Planning Commission, 2008)

2. Proposed Development

The proposed local structure plan is shown in Figure 2a with the development concept plan shown in Figure 2b.

It consists of residential lots, associated roads, public open space with stormwater management areas, retained bushland and wetland (conservation) reserve.

This LWMS has been designed to ensure that the pre-development hydrological regime of the adjacent Conservation Category Wetlands (CCWs) is maintained.

To achieve this, a 50 m buffer has been provided around the CCWs, with all drainage infrastructure located outside this buffer and within designated public open space.

Similarly, the buffer surrounding the existing SCP 19 Threatened Ecological Community (TEC) will ensure that future development does not adversely impact the integrity or ongoing maintenance of this ecological community.

3. Design Criteria

Key design criteria for the site are shown in Table 2 and have been established consistent with criteria specified in the key reference documents previously detailed in Section 1.2.

These design criteria are used to formulate the water management strategy for the site within the identified constraints and opportunities of the pre-development environment.

Table 2: Design Criteria

Strategy Elements	LWMS Method & Approach
Water Use Sustainability	
Water Efficiency	 Water efficiency requirements consistent with Building Codes of Australia Maximising infiltration /retention of all stormwater on site "Waterwise" Public Open Space Aim for less than 100 kL/person/year
Water Supply	 Water Corporation IWSS for lots, rainwater tanks (non-mandated) Minimise use of scheme water for non-drinking purposes Use of groundwater for POS irrigation
Wastewater	Water Corporation reticulated sewerage
Stormwater	
Flood Protection	 Overland flow paths within road reserves for safe conveyance of flows exceeding pipe drainage system capacity. 1%AEP event to be retained and fully infiltrated within POS area. Establish minimum habitable floor levels at 0.5m above the 1%AEP flood level. All stormwater to be infiltrated within a period not exceeding 96hrs to prevent mosquito and midge breeding.
Serviceability	 Piped drainage system sized to convey 20% annual exceedance probability (AEP) event. 20%AEP event to be infiltrated within POS area.
Ecological Protection	 Use of infiltration systems at lot scale to infiltrate 15mm on site. Establishment of biofiltration area for treatment and infiltration of first 15mm road runoff within POS and road reserves.
Groundwater	
Fill Requirement & Subsoil Drainage	Large clearance to groundwater - no fill importation or subsoil required.
Acid Sulphate Soils & Contamination	 If required, any management of Acid Sulphate Soils to be handled as a separate process consistent with DoE (2004) requirements and reported in future water management documents.

4. Pre-Development Environment

4.1 Site Conditions

The 16.5 ha site is located within the City of Rockingham and approximately 16 km south of the Rockingham town centre and 50 km south of the Perth CBD. The site is bound by existing urban development to the west and north, Mandurah Rd and Sawley Close Nature Reserve to the east, and Sawley Close to the south (Figure 1).

Figure 3 shows an aerial photograph with existing land use and topography.

The site has existing urban development along its northern and western boundaries. The site currently uncleared apart from a series of track and firebreaks and is characterised by native vegetation. DWER 1m LiDAR data indicates the site has a maximum elevation of 25 mAHD in the north ranging to a minimum of approximately to 3 mAHD in the lowest lying southern area along Sawley Close.

4.2 Geotechnical

Environmental geology mapping of the 1:50,000 Rockingham Sheets 2033 II and 2033 III (Gozzard, 1983) is shown in Figure 4. The site is characterised as:

- **\$**₇: Sand, Pale and olive yellow, medium to coarse grained, sub angular to sub rounded quartz, trace of feldspar, moderated sorted, of residual origin.
- **\$**₂: Calcerous Sand white fine to medium-grained sub-rounded quartz and shell debris of eolian origin.
- LS1: Tamala Limestone Pale yellowish brown, fine to coarse-grained, sub-angular to well-rounded quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin.
- S_{cp}: Clayey Sand black fine to medium-grained quartz sand with clay matrix variable organic matter of lacustrine origin

Strategen-JBS&G conducted a soil testing at six locations at central and northern portions of the site in January 2020. Test locations are shown on Figure 4 with report extracts contained as Appendix B. Using a hand auger, six bore holes with depth of 1.5 – 2.0 m were excavated. The site was characterised as follows:

• Sand: light brown, very loose, poorly sorted and poorly graded. Dry.

Bore logs for groundwater monitoring bores installed within the site by Strategen in September 2016 are included as Appendix C with locations shown on Figure 4. Bore were installed by drill rig to depths 4.5 – 5.0 m below natural surface. Bore where typically installed in lower areas of the site and near wetland area. These soil profile showed predominately sand profiles with some clayey sand and silty sand present at depth.

Strategen-JBS&G (2020) also provided estimates of the soils Phosphorus Retention Index (PRI) and permeability. Results are shown in Table 3 indicating permeabilities ranging from 3 m/day to 17 m/day.

Table 3: Permeability and PRI Estimates (Strategen-JBS&G, 2020)

Test Location	Estimated Permeability (m/day)	Estimated PRI Range
SB01	3.2	275-1680
SB02	3.6	9-28
SB03	7.1	9-28
SB04	3.8	9-28
SB05	9.7	28-87
SB06	17.3	9-28

On 9 July 2025, Hyd2o conducted a further six permeability tests at proposed stormwater management areas. Testing was replicated until results were consistent at each location to an average depth of 0.6 m using a borehole permeameter. Field recorded saturated hydraulic conductivities ranged from 2.9 m/day to 10.7 m/day, with calculations based on Erick and Reynolds Method (Table 4).

Permeability test locations are shown in Figure 4 and calculations details in Appendix D.

Hyd2o permeability testing results were broadly similar to Strategen (2020) indicating lower infiltration rates than typically would be expected for coastal sands. The presence of finergrained sand fractions and organic matter in the lower lying areas as observed during auger investigations likely contribute to the reduced rates. Higher rates are to be expected in elevated dunal area of the site and will be confirmed via geotechnical studies in due course.

Table 4: Permeability Tests (Hyd2o, 2025)

Test Location	Estimated Permeability (m/day)
PT1	8.2
PT2	10.7
PT3	2.9
PT4	5.1
PT5	3.7
PT6	3.2

4.3 Acid Sulphate Soils

Acid Sulphate Soil (ASS) is the common name given to naturally occurring soil and sediment containing iron sulphides. These naturally occurring iron sulphides 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 are identified. ASS investigations are commonly required as part of the conditions of subdivision or as a requirement for a dewatering license application.

WAPC (2003) mapping indicate some areas in the south of the site mapped as wetland have a high to moderate risk of acid sulphate soils within 3m of natural soil surface.

The remainder of the site proposed for development is classified as having no mapped risk.

4.4 Contaminated Sites

A search of the Department of Water and Environmental Regulation's Contaminated Sites Database (accessed June 26, 2025) indicates no known contaminated sites within the site or in 0.5 km radius.

4.5 Wetlands

Wetland mapping is shown in Figure 5. Conservation and multiple use type wetlands are observed along the east and southern portions of the site. The lower lying areas along Sawley Close are mapped as Multiple Use, with a Conservation Category Wetland (Anstey Swamp) located between the site and Mandurah Rd.

A threatened ecological community (TEC) has been identified within the southern boundary. The TEC covers part of lots 23, 25, 26, 28, 161 and 162.

Mapping is shown in Figure 5. According to the TEC List (DBCA, 2023), the community is Sedgelands in Holocene dune swales of the southern Swan Coastal Plain – SCP19 and it is considered critically endangered.

The previous MRS rezoning of the site considered the TEC and provided a buffer for its protection within the specified Parks and Recreation Reserve.

4.6 Surface Water

There are no existing natural or constructed watercourses within the site, and no external catchments drain into the site (Figure 6). All rainfall would currently infiltrate on site through the sandy subsurface profile.

4.7 Groundwater

4.7.1 Groundwater Levels

According to Perth Groundwater Atlas Second Edition (Department of Environment, 2004) the site's groundwater is mapped as being approximately 1mAHD based on May 2003 water table contours

In mid 2023, DWER revised the groundwater information reported on their Perth Groundwater Map (online) to report the Gnangara Jandakot maximum and minimum water table contours for 2019. Advice from DWER indicates these revised contours account for the declines and rises in water tables in recent decades and the impacts of current climate trends. These contours are understood to be based on the contouring of the actual recorded maximum and minimum groundwater levels at DWER bores in 2019.

These 2019 maximum contours however do not cover the site.

To refine site groundwater levels, Strategen conducted a 13-month baseline groundwater investigation encompassing 4 site bores and one DWER bore (T480) from October 2016 – October 2017, capturing two peak groundwater flows. Extracts from the study including recorded water level data are contained in Appendix E.

Results from the investigation showed similar groundwater fluctuations among the monitored bores over this period, with groundwater generally flowing in a southerly direction. The groundwater gradient however was very low with only a several centimetre difference in water level between all site bores indicating a very low velocity of groundwater flow. The seasonal groundwater variation was approximately 1m.

In April 2024, Hyd2o conducted an additional investigation including 3 extra DWER bores (T490, T530(I) and T540A) and 2 existing private bores located further west of the site (Golden Bay Estate bores MB05R2 and MB06R). These two additional bores located approximately 300m west of the site and the DWER bores located approximately 1.2 to 3.5 km of the site.

Groundwater levels in the general area have been recorded by DWER since 1975 (T480 and T490), 1977 (T530(I)), and 2010 (T540A), with the DWER bores long term historical hydrographs shown in Appendix F. The average annual maximum groundwater levels (AAMGL) and Maximum Groundwater Levels (MGL) for DWER bores are shown in Table 5 calculated across the period from 2000 – 2023, considered more representative of recent levels and climate.

Recorded levels at site and nearby bores were used and a correction factor applied based on DWER bore levels relative to its calculated AAMGL (2000-2023) to determine the sites AAMGL & MGL. Site AAMGL's are shown in Table 6 and contoured on Figure 7. It should be noted that the sites MGL is approximately 0.52m above the AAMGL.

Based on DWER LiDAR topographic contours the natural surface clearance above MGL at the site ranges from approximately 1m to 23 m. Within the area of proposed Urban rezoning the clearance to MGL ranges from in excess of 4 m to 23 m.

Table 5: DWER Monitoring Bore AAMGL & MGL

Bore	Period of Record	Period for AAMGL Calc	2000-2023 AAMGL (mAHD)	2000-2023 MGL (mAHD)	Oct 2017 Reading (mAHD)	Difference to AAMGL (m)		
T480	1975 – 2023	2000 – 2023	1.80	2.33	2.00	-0.20		
T490	1975 – 2023	2000 – 2023	1.73	2.14	1.90	-0.17		
T530(I)	1977 – 2023	2000 – 2023	1.55	2.08	1.75	-0.20		
T540A	2010 - 2023	2010 - 2023	1.53	2.13	1.68	-0.15		
Correction Factor to Apply to Site Bore for AAMGL (m) -0.18								
Correction	Correction Factor to Apply to Site Bore for MGL (m) +0.34							

Table 6: Site AAMGL & MGL

Bore	Recorded Level October 2017 (mAHD)	AAMGL Correction Factor (m)	AAMGL (mAHD)	MGL Correction Factor (m)	MGL (mAHD)
MW01	1.91	- 0.18	1.73	+0.34	2.25
MW02	1.96	- 0.18	1.78	+0.34	2.30
MW03	1.94	- 0.18	1.76	+0.34	2.28
MW04	1.88	- 0.18	1.70	+0.34	2.22

4.7.2 Groundwater Quality

To establish a groundwater quality baseline, Strategen (2018) performed quarterly water quality monitoring, where samples were analysed for physiochemical parameters and nutrients. Analysis of eight heavy metals were included in samples retrieved in October 2016. Results are summarised in Tables 7 and 8 with all data contained in Appendix E.

The water quality monitoring revealed characteristics of neutral to slightly alkaline pH. EC and TDS values indicate properties of fresh to slightly brackish water, consistent with proximity to the ocean and wetland environments.

Mean nutrient levels for TN ranged from 0.4 to 1.0 mg/L while TP ranged between 0.05 to 0.14 mg/L. These values are within the range of expected values or nutrients on the Swan Coastal Plain given current site and surrounding land use.

Metals exceedances for chromium at bore MW04 and zinc at bores MW01, MW02 and MW03 were observed based on ANZECC (2000) freshwater and marine water guidelines.

Table 7: Groundwater Physiochemical and Nutrients Summary

Parameters		Во	re	
	MW01	MW02	MW03	MW04
		Mean	values	
рН	7.13	7.20	7.30	7.40
Electrical Conductivity (µS/cm)	1,283	1,850	1,975	1,950
TDS (mg/L)	745	1,135	1,125	1,138
Total Nitrogen (mg/L)	0.60	0.40	0.70	1.00
TKN (mg/L)	0.60	0.40	0.70	0.90
NOx (as N) (mg/L)	0.01	<0.01	<0.01	0.08
Total Phosphorus (mg/L)	0.09	0.05	0.06	0.14
Phosphate as P (mg/L)	0.01	<0.01	<0.01	0.04
Nitrate-N (mg/L)	0.01	<0.01	<0.01	0.07
Nitrite-N (mg/L)	<0.01	<0.01	<0.01	0.01
Ammonia as NH ₃ -N (mg/L)	0.15	0.13	0.21	0.35

Table 8: Groundwater Metals Summary

Parameters		Вс	re	
	MW01	MW02	MW03	MW04
		m	g/L	
Arsenic	0.016	0.014	0.002	0.002
Cadmium	<0.0001	<0.0001	< 0.0001	<0.0001
Chromium	<0.001	<0.001	<0.001	0.003
Copper	<0.001	<0.001	<0.001	<0.001
Lead	<0.001	<0.001	<0.001	<0.001
Mercury (Total)	<0.00005	<0.00005	<0.00005	<0.00005
Nickel	<0.001	<0.001	<0.001	<0.001
Zinc	0.022	0.022	0.022	0.002

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 the use of Waterwise practices including water-efficient fixtures and fittings (taps, showerheads, toilets, rainwater tanks, Waterwise landscaping).
- Buildings to be built to 6-star building standards.
- Water-efficient POS design including the use of native plants.
- Use of groundwater bores for irrigation of POS.
- Maximising on-site retention and infiltration of stormwater at source.

More specific details on measures and approaches to be adopted to achieve water use efficiency objectives will be appropriately presented in the UWMP.

5.2 Water Supply

The Water Corporation's Integrated Water Supply System (IWSS) will supply potable water to the future homes on the site.

With respect to POS requirements, landscape planning undertaken by PlanE Landscape Architects is included as Appendix G.

Advice from project PlanE Landscape Architects indicate than based on the current plan approximately 12,000 kL/yr will be required to support temporary and permanent irrigation with only 8,000 kL/yr require for long term irrigation of approximately 1.1 ha.

The site is located within the Rockingham groundwater area. The Superficial Aquifer is in the Karnup West groundwater subarea and is currently fully allocated. The deeper Leederville Aquifer is in the Rockingham Confined Subarea which is also fully allocated.

This small requirement of POS water is proposed to be obtained via purchase and transfer of existing licencing via a commercial transaction to facilitate development. Should a groundwater transfer be unable to be secured, the following viable contingencies will be pursued:

- A negotiated outcome with a private landowner with an existing allocation.
- A negotiated outcome with the City of Rockingham. This City of Rockingham are the largest superficial licence holder in the Karnup West groundwater subarea with an existing licence of 478,383 kL/yr (GWL 65114). They also hold a further two licences (GWL's 169175 and 158268) totalling 467,355 kL/yr in the deeper Leederville Aquifer (Rockingham Confined Subarea). The estimated POS requirement of 8,000 kL/yr would represent only ~0.8% of the City of Rockingham's current licenced amount. Opportunities for including this POS irrigation requirement within the existing allocation will be negotiated with irrigation efficiency opportunities reviewed and considered.
- Review POS planning and design as an area with no long-term irrigation requirement.



Hyd2o understand the developer is currently in negotiations on licencing matters consistent with the above approach.

5.3 Wastewater Management

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

6. Stormwater Management Strategy

Stormwater management will be undertaken consistent with DWER water sensitive design practices outlined in Better Urban Water Management (WAPC, 2008) and the Stormwater Management Manual for Western Australia (DWER, 2022). The system will consist of lot soakwells, piped road drainage system, biofiltration areas, and stormwater storage detention and infiltration areas.

Key elements of the system which are reflected in the local structure plan include:

- Maintenance of existing conservation category wetlands within the site with all stormwater infrastructure located outside of the wetland buffers.
- Lots to have soakwells/on-site systems to provide 15mm infiltration of stormwater at source.
- Treatment of road runoff within each catchment via specified biofiltration areas for water quality,
- POS areas designed to be occasionally inundated for flood management in major events (1% AEP) with all water to be infiltrated on site.

The site has been designed to be self-contained in terms of stormwater management. Given its sandy soils and depth to groundwater it is not considered to require any regional stormwater infrastructure to facilitate its development.

6.1 Stormwater Modelling

Stormwater modelling for the site was performed using XP-Storm to determine flood storage requirements and provide an assessment of local structure plan areas required for drainage purposes.

The design rainfall storms modelled in XP-Storm were based on methodology in Australian Rainfall and Runoff (AR&R) (Ball et al, Australia, 2016). All design rainfall and temporal patterns were imported into the model using the ARR Data Hub. Rainfall was assumed to be spatially uniform across the catchment. Storm durations modelled ranged from 30 minutes to 72 hours and all ensembles were run for each storm to determine critical design events.

Post development catchments for the site are shown in Figure 8, based on the LSP and Cossill & Webley earthworks plans. A total of 5 main catchments were identified.

Key stormwater modelling runoff parameters for individual land use types are shown in Table 9. These rates have been based on Hyd2o's CURRV Runoff Calculator (Appendix H) with consideration of post development site characteristics. 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.

Figure 8 detail the location, areas and storage volumes for individual stormwater management areas based on the XP-Storm modelling. Modelling outcomes are presented in Table 9 and Appendix I.



Note that storage shapes shown in Figure 8 are based on current earthworks plans and indicative only for showing a representation of storage areas required in relation to POS areas allocated in the LSP. The final flood attenuation area configuration, location, and elevations will be documented in future UWMPs and will be dependent on final earthworks, drainage, and road design levels for the development.

Refinements to catchment areas in this report are likely to occur as detailed design proceeds, and modelling will be updated accordingly during the UWMP process.

Further opportunities for additional distributed storage and treatment throughout the site will also be reviewed at later stages of planning.

6.2 Major Event Flood Protection (1% AEP)

Modelled storage volumes, areas, flood rise, and inverts are detailed in Table 9 and Figure 8 for the 1% AEP flood events.

Stormwater management is proposed as follows:

- Catchments 1, 2 & 5 will receive and infiltrate all events on site within POS.
- Catchment 3 will treat (15mm) and infiltrate the 20% AEP event. Major events (1% AEP) will overflow towards the infiltration basin of Catchment 2.
- Catchment 4 will treat and infiltrate the 15mm event along a swale. 20% and 1% AEP events will overflow towards the Catchment 2 infiltration basin adjacent to the swale.

The minimum habitable building floor levels will comply with requirements for a 0.5 m clearance above estimated 1% AEP flood levels as shown in Table 9.

Conceptual stormwater basin cross sections are provided in Appendix J.

The total area within the site required for flood storage up to the 1% AEP event is approximately 0.32 ha or 1.9% of the total site area, with a total detention storage volume of approximately 1,162 m³ (via Table 9).

6.3 Minor Event Serviceability (20% AEP)

Modelled storage volumes, areas, flood rise and inverts are detailed in Table 9 and Figure 8 for the 20% AEP flood event, showing the extent of inundation of POS area.

The total area required for the 20% AEP event is approximately 0.23 ha or 1.4% of the total site area with a total detention storage volume of approximately 351 m³.



Table 9: Stormwater Management

Catchments	1	2	3	4	5
Resdential Lots (ha)	1.51	0.22	0.87	0.22	2.06
Road Reserve (ha)	0.68	0.11	0.31	0.18	0.90
POS (ha)	013	0.06	0.03	0.19	0.40
Equiv Imp Area (ha) (15mm)	0.44	0.07	0.20	0.12	0.58
Equiv Imp Area (ha) (20% AEP)	0.80	0.13	0.40	0.19	1.08
Equiv Imp Area (ha) (1% AEP)	1.15	0.18	0.59	0.26	1.58
Storage Parameters					
Туре	Storage	Linear Storage	Storage	Roadside Swale	Storage
MGL			2.25		
AAMGL			1.75		
Indicative Invert (mAHD)	12.00	12.60	13.70	13.90	10.90
Side slopes (v:h)	1:6	1:6	1:6	1:6	1:6
Biofilter K (m/day)	2.5	2.5	2.5	2.5	2.5
Flood Storage K (m/day)	5.0	5.0	5.0	5.0	5.0
Base Area (m²)	300	30	91	56	165
Flood Rise from Biofiltration Invert (m)	0.09	0.10	0.15	0.09	0.28
TWL (mAHD)	12.09	12.70	13.85	13.99	11.18
Volume (m³)	30	4	17	8	61
TWL Area (m²)	341	47	130	134	265
Flood Management: 20% AEP (inclusive of	15mm Event St	orage)			
Flood Rise from Biofiltration Invert (m)	0.35	0.10	0.30	0.18	0.13
TWL (mAHD)	12.35	12.70	14.00	14.08	11.03
Volume (m³)	133	22	40	23	133
TWL Area (m²)	465	873	176	214	594
Critical Storm (hrs)	3	1	3	1	3
Flood Management: 1% AEP (inclusive of 1	15mm Event Sto	rage)			
Flood Rise from Biofiltration Basin (m)	0.96	0.19	0.30	0.20	0.90
nood Nise nom bioliitiation basin (III)			14.00	4440	
TWL (mAHD)	12.96	12.79	14.00	14.10	11.80
	12.96 521	12.79 92	40	28	11.80 481
TWL (mAHD)					

6.4 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 and Bushland Retention, WSUD integration Maintenance: Storage areas, street sweeping manhole eduction Monitoring: Post development program and performance review

Structural Controls

Catchment Scale Infrastructure: Bioretention areas

Lot 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).

Storm volumes for ecological protection based on the 63% AEP (15mm) event are provided in Table 9 and Figure 8 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 0.09 ha (volume 120 m³).

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).

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 in relation to Design Criteria

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

^{1.} Typical Performance Efficiencies via DWER (2022)

7. Groundwater Management Strategy

7.1 Fill and Subsoil Drainage

Current engineering earthworks drawings are included as Appendix K. Considering the undulating nature of the site, earthworks will be required to achieve levels for lots and roads. Groundwater separation does not pose any risk as existing site levels have significant clearance from groundwater.

Based on the preliminary earthworks plan prepared by Cossill & Webley for the site, post development levels are proposed to range from approximately 13.20 mAHD to 21.83 mAHD, providing a clearance of approximately 11 m to 20 m above the calculated AAMGL for the site and 10.5 to 19.5m above MGL. No subsoil drainage will therefore be required.

Final finished lot levels and fill requirements are a detailed design issue to be addressed during the preparation of detailed engineering design drawings and preparation of the UWMP and will be ultimately submitted for council approval at that stage.

7.2 Acid Sulphate Soils

Acid sulphate soil mapping has been previously discussed in Section 4.2 with the southern portion of the property classified as having high to moderate risk with mapping shown on Figure 4. The affected areas are classified under 'Parks and Recreation Reserve' under the MRS rezoning, and no development is proposed in this area.

The area of the site proposed for development is classified as having no mapped risk.

Management of acid sulphate soils (ASS) will be addressed by a separate study to this LWMS if required. Details regarding the outcomes of any ASS studies required will be included as part of the UWMP. All assessment and management of ASS will be conducted in accordance with the Acid Sulphate Soil Guideline Series Identification and Investigation of Acid Sulphate Soils (DoE, 2004).

8. Urban Water Management Plans

Consistent with processes defined in WAPC (2008), an Urban Water Management Plan (UWMP) will be developed and submitted to support subdivision applications for various stages of development within the site. UWMP's will address:

- Demonstrated compliance with LWMS criteria and objectives to the satisfaction of City of Rockingham and DWER.
- Agreed/approved measures to achieve water conservation and efficiencies of water use
- Detailed stormwater management design including refining stormwater modelling detailed in the LWMS.
- Management of groundwater levels including proposed fill levels.
- 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 subdivisional works.
- Implementation plan including roles, responsibilities, funding and maintenance arrangements.
- Specific monitoring and reporting to be undertaken consistent with the monitoring program defined in the LWMS.
- Contingency plans (where necessary).

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

Preparation of the UWMP will be the responsibility of the developer.

9. Monitoring

9.1 Pre Development

A predevelopment groundwater monitoring program for the site has previously been conducted by Strategen over a 13-month period from October 2016 to October 2017, inclusive of 2 winter peaks. This program included the installation of 4 site bores and has been used to characterise the site groundwater quality, levels and flow. A further monitoring occasion was also undertaken by Hyd2o in April 2024.

It is important to note that for the proposed urban area of the MRS rezoning, based on preliminary earthworks prepared by Cossill & Webley (Appendix K), the clearance to groundwater ranges from in excess of 11 m to 20 m. DoW (2012) recommends groundwater monitoring should be undertaken where groundwater has close interaction with the surface, and 4 m has been previously applied by DWER as a depth for monitoring being required.

Based on the above, the previous program is considered sufficient to inform the development of an LWMS for the site. Additional predevelopment monitoring is not anticipated for the purpose of informing the UWMP and subdivision process. I

f any further monitoring is required, this will serve to inform engineering design rather than to satisfy government agency requirements.

9.2 Post Development

Post development groundwater monitoring locations and parameters are detailed in Figure 9 and Table 11.

Department of Water (2012) indicates a minimum of 3 years post development monitoring is required. The program is therefore designed to operate over a three-year post development period, with the timing for commencement of the program to be negotiated at UWMP stage with DWER and the City of Rockingham.

A standardised proforma will be used to assess the stormwater system performance against design intent. The proforma will consider processes such as vegetation health, scour, erosion, deposition, water levels, and retention periods in bioretention and flood storage areas.

Water level and quality monitoring of groundwater is proposed to be undertaken quarterly at the site, with all water quality testing to be conducted by a NATA approved laboratory. Post-development monitoring locations, trigger values and targets will be identified in the LWMS based on pre-development monitoring outcomes and ANZECC (2000) guidelines.

Assessment of monitoring outcomes will be undertaken as part of an annual review and reporting process. Should the system not be functioning in accordance with design a contingency action plan will be implemented, including:

- Assessing if an isolated, development area or regional occurrence.
- Determining if due to the development or other external factors.
 - a) Identify and remove any point sources causing problems.
 - b) Review operational and maintenance practices.
 - c) Consider alterations to POS areas and the stormwater system.



- d) Consider initiation of community-based projects.
- If necessary, inform residents of any required works and their purpose.

The timing for commencement of the program is to be negotiated at later stages of planning with the City of Rockingham. 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. Any modification to the program would be identified through review of the collected data and would require the agreement of all parties (DWER, City of Rockingham, and the developer).

Table 11: Post Development Monitoring Program

Monitoring	Parameter	Location	Method	Frequency/Timing
Local Stormwater	Performance assessment via proforma	Stormwater storages, inlets, and outlets	Visual assessment	Monthly during winter (4 times per year) for 3 years
Groundwater	Water Levels and Quality	Site bores	Pumped Sample & Water Level Meter	Quarterly for 3 years

10. Implementation

Table 12 details the roles, responsibilities and funding to implement the LWMS for this site.

Any modification required to the LWMS would be identified through the UWMP process and would require the agreement of all parties (DWER, City of Rockingham, and developer).

Given the size of the site and likely staged development, monitoring outcomes will be used in a continual improvement capacity to review the implemented WSUD within the site with outcomes used to inform future planning and design approaches for subsequent developments in the area.

Specific maintenance responsibilities will be detailed at the UWMP stage. It is envisaged that the schedule for maintenance works will be consistent with typical requirements of the City of Rockingham.

Table 12: Implementation Responsibility

	Responsibility & Funding	
Implementation Action	Developer	City of Rockingham
Preparation of UWMP	☑	
Review & Approval of UWMP		☑
Construction of Stormwater System	Ø	
Post Development Monitoring Program	Ø	
Operation & Maintenance		
a) Prior to Handover	M	
b) Following Handover		☑

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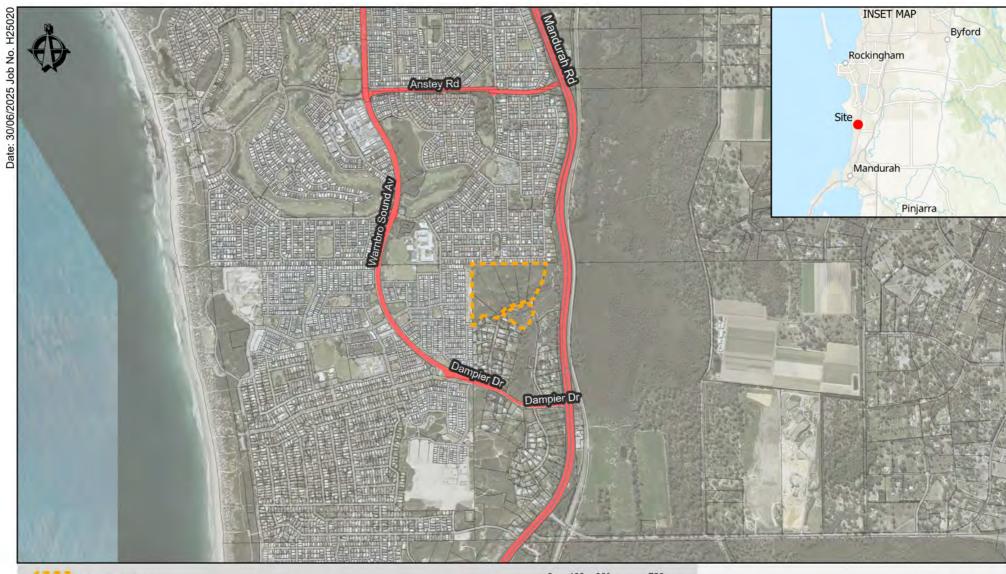
Western Australian Planning Commission (2008). Better Urban Water Management, October 2008.



Western Australian Planning Commission (2021a). Draft State Planning Policy 2.9 Planning for Water.

Western Australian Planning Commission (2021b). Draft State Planning Policy 2.9: Planning for Water, Guidelines for the implementation of State Planning Policy 2.9 Planning for Water.

FIGURES



Site Boundary

0 180 360 720
Meters
Source of data: SLIP DataWA

Source of data: SLIP DataWA Locate Mosaic - LGATE-322 Cadastre - LGATE-001 Roads - LGATE-195 hyd₂O Various Lots Sawley Close Golden Bay LWMS Location Plan

Figure 1

hyd₂O

Various Lots Sawley Close Golden Bay LWMS

Local Structure Plan

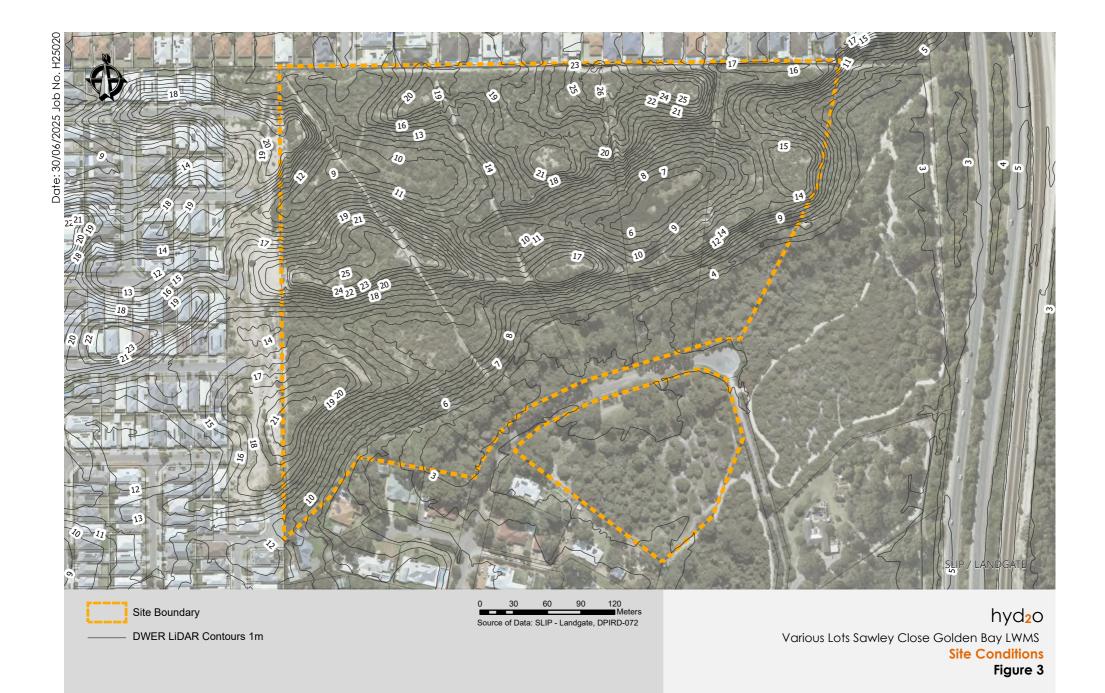
Figure 2a

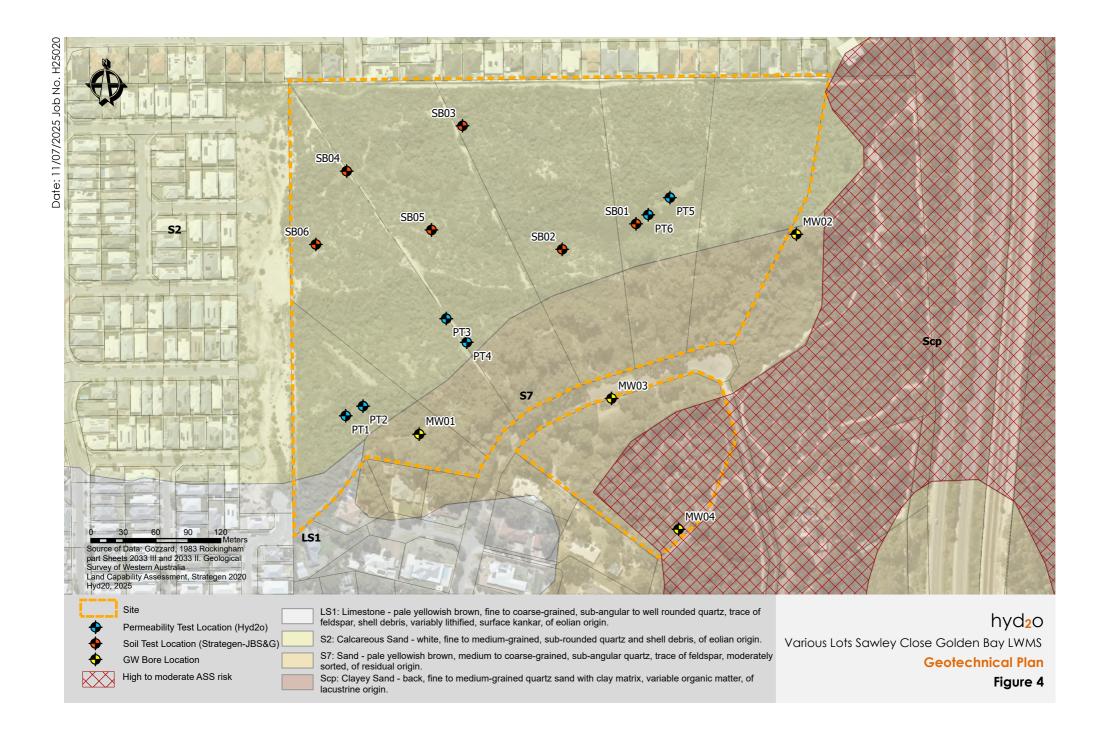
hyd₂O

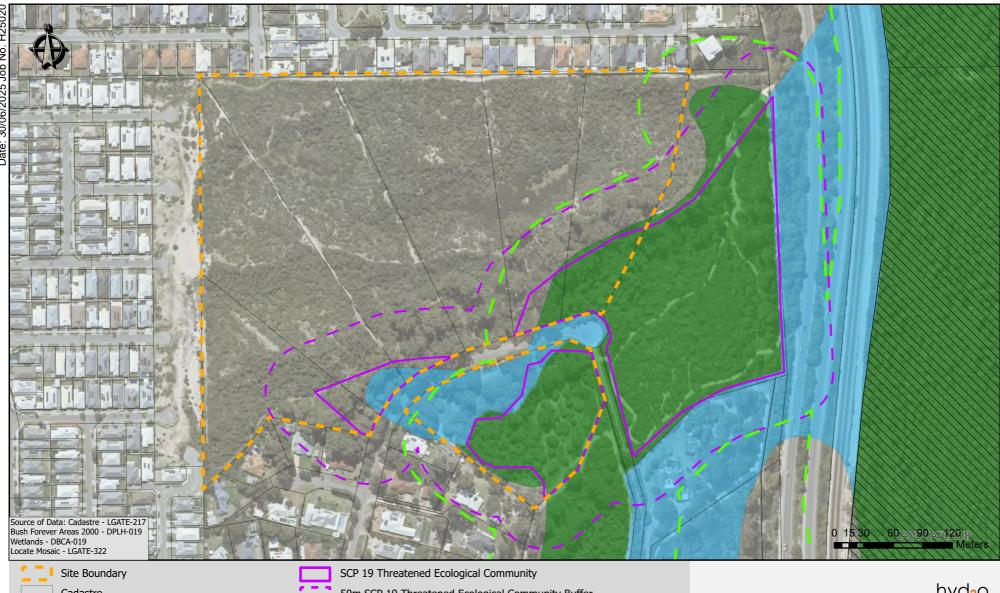
Various Lots Sawley Close Golden Bay LWMS

Development Concept Plan

Figure 2b









Multiple Use Category Wetland

SCP 19 Threatened Ecological Community

50m SCP 19 Threatened Ecological Community Buffer

Anstey Swamp, Karnup - Bush Forever Site No 379

hyd₂O Various Lots Sawley Close Golden Bay LWMS Environmental Plan Figure 5

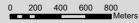


Site

Serpentine River

Punrak Drain

1 in 100 (1%) AEP floodplain



Source of Data: Hydrography Linear, DWER-031 FPM Floodplain Area, DWER-020

hyd20

Various Lots Sawley Close Golden Bay LWMS

Surface Water Plan

Figure 6





AAMGL

Site Bores (Strategen, 2018)

DWER Bores

Golden Bay Bores (JDA, 2024)



Source of Data: Water Information Reporting, DWER Strategen, 2018; JDA, 2024

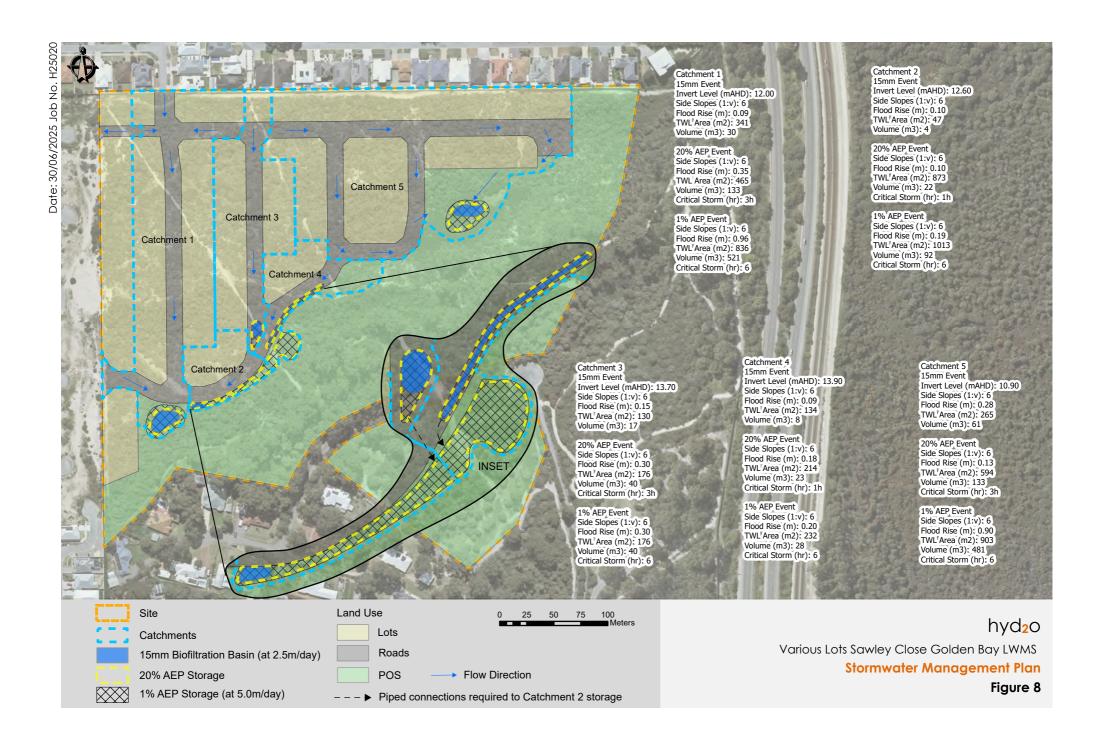
Note: MGL = AAMGL + 0.52m

hyd20

Various Lots Sawley Close Golden Bay @WMS

Groundwater Plan

Figure 7





APPENDIX A LWMS Checklist

Better Urban Water Management LWMS Checklist

Land Market Market 1 Company	Delia III	✓	6
Local Water Management Strategy Item	Deliverable		Comments
Executive summary			
Summary of the development design strategy, outlining how the	Design elements		Executive Summary & Section 3
design objectives are proposed to be met	and requirements for BMP's	$\overline{\mathbf{A}}$	
	and critical control points		
Introduction			!
Total water cycle management - principles and objectives	1		Introduction, Sections 1.1 & 1.2
Planning background		$\overline{\mathbf{A}}$	introduction, Sections 1.1 & 1.2
Previous studies		V	
Proposed development			
Structure plan, zoning and land use	Site context plan		Section 1, 2, & 4. Figure 1, Figure 2, Figure 3
Key landscape features	Structure plan	\overline{V}	
Previous land use		Ľ	
Landscape - proposed POS areas, POS credits, water source,	Landscape plan		
bore(s), lake details (if applicable), irrigation areas	Landscape plan		Stormwater Areas and Volumes to inform POS credits
bore(s), take details (if applicable), irrigation areas		\checkmark	in Section 6 & Figure 8. Water supply identified
			in Section 5.2. Landscape Plan in Appendix G
Design criteria			
Agreed design objective and source of objective		$\overline{\mathbf{Q}}$	Section 3
Due development environment			
Pre-development environment Existing information and more detailed assessments			Courts A 0 Etc. 11 2 7
(monitoring). How do the site characteristics affect the design?		$\overline{\mathbf{A}}$	Section 4 & Figures 3-7
(monitoring). How do the site characteristics affect the design:		V	
Site conditions- existing topography/ contours, aerial photo	Site condition plan	$\overline{\mathbf{A}}$	Section 4.1, Figure 3
underlay, major physical features			
Geotechnical - topography, soils including acid sulfate soils and	Geotechnical plan	$\overline{\mathbf{A}}$	Section 4.2, Figure 4
infiltration capacity, test pit locations			
Environmental- areas of significant flora and fauna, wetlands	Environmental plan plus	$\overline{\mathbf{Q}}$	Sections 4.4 & 4.5, Figure 5
and buffers, waterways and buffers, contaminated sites	supporting data where appropriate	V	
Surface water- topography, 100 year floodways and flood fringe	Surface water plan		Section 4.6, Figure 6
areas, water quality of flows entering and leaving (if applicable)		\checkmark	
Groundwater - topography, pre development groundwater	Groundwater plan plus	_	Section 4.7, Figure 7
levels and water quality, test bore locations	details of groundwater	\checkmark	
	monitoring and testing		
Water use sustainability initiatives	T T		T
Water efficiency measures- private and public open spaces including method of enforcement		$\overline{\checkmark}$	Section 5.1
Water supply (fit- for-purpose strategy), agreed actions and			
implementation. If non-potable supply, support with water			Section 5.2
balance			
Wastewater management		$\overline{\square}$	Section 5.3
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels	100yr event plan	_	Section 6 - 6.1 & 6.2, Figures 8, Appendices H to J
at control points, 100 year flow paths and 100 year detentions	Long section of critical	$\overline{\checkmark}$, , , , , , , , , , , , , , , , , , , ,
storage areas	points		
Manage serviceability - storage and retention required for the	5yr event plan	[.7i	Section 6 - 6.1 & 6.3, Figures 8, Appendices H to J
critical 5 year ARI storm events		$\overline{\checkmark}$	
Minor roads should be passable in the 5 year ARI event	1 ur quant plac		
Protect ecology - detention areas for the 1 yr 1 hr ARI event,	1 yr event plan		Section 6 - 6.1 & 6.4 Figures 8, Appendices H to J
areas for water quality treatment and types of (including	Typical cross sections		, , , , , , , , , , , , , , , , , , , ,
indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of		\checkmark	
waterways, wetlands (and their buffers), remnant vegetation			
and ecological linkages			
מווע ככטוטבונמו ווווגמצבי	1		

Local Water Management Strategy Item	Deliverable	✓	Comments
Groundwater management strategy			
Post development groundwater levels, fill requirements	Groundwater/subsoil plan		Section 7
(including existing and likely final surface levels), outlet controls,		$\overline{\checkmark}$	
and subsoil areas/exclusion zones			
Actions to address acid sulphate soils or contamination		$\overline{\checkmark}$	Section 7
The next stage - subdivision and urban water management plan	S		
Content and coverage of future urban water management plans		_	Section 8
to be completed at subdivision. Include areas where further			
investigations are required prior to detailed design			
Monitoring			
Recommended future monitoring plan including timing,			Section 9
frequency, locations and parameters, together with		$\overline{\checkmark}$	
arrangements for ongoing actions			
Implementation			
Developer commitments		\checkmark	Section 10
Roles, responsibilities, funding for implementation		$\overline{\mathbf{V}}$	Section 10
Review		$\overline{\mathbf{V}}$	Section 10

APPENDIX B

Geotechnical Extracts (Strategen – JBS&G, 2020)



5. Results

5.1 Soil profile

Hand auguring in the locations identified within Figure 5.1 identified only one soil type which can be described as:

• SAND – light brown, very loose, poorly sorted and poorly graded, dry

Each bore excavated provided the same soil type and characteristics (Table 5.1). Due to the dry nature of the sand, small amounts of water were required to be added to boreholes SB1, SB2 and SB4 to assist in providing stability to the soil during excavation. SB3, SB5 and SB6 required the bottom of the bore to be excavated by hand shovel as the sand was too dry to be removed with the auger. The hand removal resulted in some collapse of the bore however, ensured the minimum depth of 1.5 mbgl was achieved. None of the bores excavated hit refusal or provided any indication of an impermeable layer (rocky material). No limestone outcrops were observed in close proximity to the Development Envelopes within the Project Area and all bores were considered to have the required minimum separation to an impermeable layer

Topographically, SB05 and SB06 are located on proposed future Lots that have the steepest grade across the Project Area. Each Development Envelop is expected to be required to be earth worked and contoured to achieve a stable slope; therefore, current slopes within the Project Area are not reported here as they will be irrelevant to the effluent disposal practices following construction. While the final earthwork design for each Development Envelope has not yet been finalised, the slope gradient for each Development Envelope, or at least the effluent disposal area, has been assumed to be consistent with the requirements of Table K1 of AS/NZS 1547:2012 in accordance with the proposed disposal method.

Table 5.1: Soil testing descriptions and locations within the Project Area

Total disc	Ameliada	Denth (m)	Call and this are and a constant	GPS (GDA94)			
Test site	Analysis	Depth (m)	Soil conditions and comments	Latitude	Longitude		
SB01	PRI and soil logging	1.7	SAND – fine to medium grained	-32.418163	115.77064		
			loose and poorly graded, Dry				
	Permeability	0.5	SAND – very loose poorly				
			structured, Dry				
SB02	PRI and soil logging	1.5	SAND – fine to medium grained	-32.418369	115.769932		
			loose and poorly graded, Dry				
	Permeability	0.5	SAND – very loose poorly				
			structured, Dry				
SB03	PRI and soil logging	1.5	SAND – fine to medium grained	-32.417328	115.768965		
			loose and poorly graded, Dry				
	Permeability	0.5	SAND – very loose poorly				
			structured, Dry				
SB04	PRI and soil logging	2.0	SAND – fine to medium grained	-32.417695	115.76782		
			loose and poorly graded, Dry				
	Permeability	0.5	SAND – very loose poorly				
			structured, Dry				
SB05	PRI and soil logging	1.7	SAND – fine to medium grained	-32.418195	115.768648		
			loose and poorly graded, Dry,				
			some shovel excavation required				
			as sand would not remain in				
			auger during excavation				
	Permeability	0.5	SAND – very loose poorly				
			structured, Dry				
SB06	PRI and soil logging	1.6	SAND – fine to medium grained	-32.418305	115.767508		
			loose and poorly graded, Dry				
	Permeability	0.5	SAND – very loose poorly				
			structured, Dry, Water drained				
			very quickly				



5.2 Phosphorous Buffer Index

Results of the PBI testing are shown below in Table 5.2. SB01 demonstrates a high PBI result indicating this location has the capacity to bind large amounts of phosphorous. Results for SB02, SB03, SB04 & SB06 all demonstrate a very low PBI while the result for SB05 indicates a low PBI capacity.

Table 5.2: Phosphorous Buffering Index Results across the Project Area

Soil Site	PBI Result	Equivalent PRI result range	Phosphorous sorption rating
SB01	801.6	275–1680	High
SB02	56.3	9–28	Very low
SB03	58.2	9–28	Very low
SB04	39.5	9–28	Very low
SB05	96.4	28–87	Low
SB06	68.8	9–28	Very low

5.3 Soil permeability test

The indicative soil permeability results are provided below in Table 5.3. All testing locations identified the soils as category 1-2 as per Table L1 and M1 of AS/NZS 1547:2012. Bores SB01, SB02 and SB04 demonstrated similar results with 3.2 m/d, 3.6 m/d and 3.8 m/d respectively. Bores SB03 and SB05 both demonstrate high indicative permeability rates with 7.1 m/d and 9.7 m/d respectively. Bore SB06 demonstrated a very high permeability result with 17.3 m/d.

Table 5.3: Indicative permeability results

Soil site	Indicative permeability result (Ksat) (m/d)	Soil category as per Table L1 of AS/NZS 1547:2012
SB01	3.2	Category 1 / 2
SB02	3.6	Category 1 / 2
SB03	7.1	Category 1 / 2
SB04	3.8	Category 1 / 2
SB05	9.7	Category 1 / 2
SB06	17.3	Category 1 / 2

5.4 Groundwater

Groundwater was not encountered during the bore excavations. Based on the results of the groundwater investigation undertaken by Strategen-JBS&G in 2016/2017, the separation to groundwater across all Development Envelopes identified in Figure 1.2, is anticipated to be between 2.05 m and 22.95 m. A review of historical areal imagery identified that the Project Area has never been inundated, the wetland directly to the south was last inundated in the early 1983; however, there is a lack of images at the suitable time of year (July to September) through the 1980s, 1990s and 2000s (Landgate n.d.).

Long term ground water data was reviewed as part of the baseline groundwater investigation, recent observation has identified the local groundwater aquifer has not exceed 2.3 mAHD since 1994 (Strategen 2018). Groundwater levels have been on a declining trend for the last 20 years (Strategen 2018).



PROJECT NUMBER 58143
PROJECT NAME Golden Bay Effluent Report
CLIENT Cape Bouvard

ADDRESS Sawley Close, Golden Bay

DRILLING DATE 8/01/2020 DRILLING COMPANY N/A
DRILLER NA
DRILLING METHOD Hand Auger
TOTAL DEPTH 1.7

COORDINATES 384403, 6412512
COORD SYS GDA94_MGA_zone_50
SURFACE ELEVATION LOGGED BY PM
CHECKED BY CL

(m) Hopeth (m) Pepth (m) P	Is Analysed? Graphic Log	SOSN	Material Description SP: SAND, poorly graded, fine to medium grained, very loose,light brown, homogeneous, dry	Additional Observations
-			SP: SAND, poorly graded, fine to medium grained, very loose,light brown, homogeneous, dry	
- SB01-1.5			SP: SAND, poorly graded, fine to medium grained, very loose, light orangey brown, homogeneous, dry	
- 1.5 -	_			
- - -2	1 138000		Termination Depth at:1.7 m - Refusal at 1.7 m bgl due to collapsing hole	



PROJECT NUMBER 58143
PROJECT NAME Golden Bay Effluent Report
CLIENT Cape Bouvard

ADDRESS Sawley Close, Golden Bay

DRILLING DATE 8/01/2020 DRILLING COMPANY N/A
DRILLER NA
DRILLING METHOD Hand Auger
TOTAL DEPTH 1.5

COORDINATES 384357, 6412523
COORD SYS GDA94_MGA_zone_50
SURFACE ELEVATION LOGGED BY PM
CHECKED BY CL

	1	I	ı				
Depth (m)	PID	Samples	Is Analysed?	Graphic Log	nscs	Material Description	Additional Observations
- - - 0.5 - - - 1		SB02-1.5				SP: SAND, poorly graded, fine to medium grained, very loose, light brown, homogeneous, dry Termination Depth at:1.5 m - Refusal at 1.5 m bgl due to	
-						Termination Depth at:1.5 m - Refusal at 1.5 m bgl due to collapsing hole	
						gestechnical numeros	Page 1 of 1



PROJECT NUMBER 58143 PROJECT NAME Golden Bay Effluent Report

CLIENT Cape Bouvard

ADDRESS Sawley Close, Golden Bay

DRILLING DATE 8/01/2020 -**DRILLING COMPANY N/A** DRILLER NA

DRILLING METHOD Hand Auger and Shovel **TOTAL DEPTH** 1.5

COORDINATES ,

COORD SYS GDA94_MGA_zone_50

SURFACE ELEVATION -LOGGED BY PM

CHECKED BY

Depth (m)	PID	Samples	Is Analysed?	Graphic Log	nscs	Material Description	Additional Observations
- - - - - - - - - - -		SB03-1.5				SP: SAND, poorly graded, fine to medium grained, very loose, light brown, homogeneous, dry Termination Depth at:1.5 m - Refusal at 1.5 mbgl due to	Shovel needed to excavate soil to 1.0 mbgl due to loose soil
- - - -2						collapsing hole	



PROJECT NUMBER 58143
PROJECT NAME Golden Bay Effluent Report
CLIENT Cape Bouvard

ADDRESS Sawley Close, Golden Bay

DRILLING DATE 8/01/2020 DRILLING COMPANY N/A
DRILLER NA
DRILLING METHOD Hand Auger
TOTAL DEPTH 2

COORDINATES ,
COORD SYS GDA94_MGA_zone_50
SURFACE ELEVATION LOGGED BY PM
CHECKED BY CL

Depth (m)	PID	Samples	Is Analysed?	Graphic Log	nscs	Material Description	Additional Observations
		<u> </u>			<u> </u>	SP: SAND, poorly graded, fine to medium grained, very loose,light grey/brown, homogeneous, dry	
_							
-							
_							
_							
- 0.5							
_							
-							
-							
– 1							
-							
_							
-							
– 1.5							
_		SB04-1.7	$\mid \mid$				
_						CD. CAND people graded fire to readilize and a second	
						SP: SAND, poorly graded, fine to medium grained, very loose,orangy brown, homogeneous, dry	
_							
_2			Н			Termination Depth at:2 m	



PROJECT NUMBER 58143
PROJECT NAME Golden Bay Effluent Report
CLIENT Cape Bouvard

ADDRESS Sawley Close, Golden Bay

DRILLING DATE 8/01/2020 DRILLING COMPANY N/A
DRILLER NA
DRILLING METHOD Hand Auger and
TOTAL DEPTH 1.7

COORDINATES 384318, 6412531
COORD SYS GDA94_MGA_zone_50
SURFACE ELEVATION LOGGED BY PM
CHECKED BY CL

	MENIS		_				
Depth (m)	PID	Samples	Is Analysed?	Graphic Log	nscs	Material Description	Additional Observations
0.55 1.5	Old	Samp	Is An	Graph	SSSN NSC	SP: SAND, poorly graded, fine to medium grained, very loose, light grey/brown becoming more light brown with depth, homogeneous, dry	Shovel needed to excavate to 1.4 mbgl due to loose soil
- - - 2						Termination Depth at:1.7 m - Refusal at 1.7mbgl due to collapsing hole	
							Page 1 of



PROJECT NUMBER 58143
PROJECT NAME Golden Bay Effluent Report

CLIENT Cape Bouvard **ADDRESS** Sawley Close, Golden Bay

DRILLING DATE 9/01/2020 DRILLING COMPANY N/A
DRILLER NA
DRILLING METHOD Hand Auger and Shovel

TOTAL DEPTH 1.6

COORDINATES 384108, 6412528
COORD SYS GDA94_MGA_zone_50
SURFACE ELEVATION LOGGED BY PM
CHECKED BY CL

Depth (m)	PID	Samples	Is Analysed?	Graphic Log	nscs	Material Description	Additional Observations
-						SP: SAND, poorly graded, fine to medium grained, very loose,light grey/brown, homogeneous, dry	Shovel needed to excavate to 1.4 mbgl due to loose soil
-							
- 0.5 -							
-							
- - 1							
-							
-							
- 1.5		SB06-1.6				Termination Donth at 1.6 m. Polysol at 1.6 m/gl due to	
_						Termination Depth at:1.6 m - Refusal at 1.6mbgl due to collapsing hole	
-							
- 2							

APPENDIX C

Lithological Bore Logs (Strategen, 2016)

Project Number: CBI16341.01

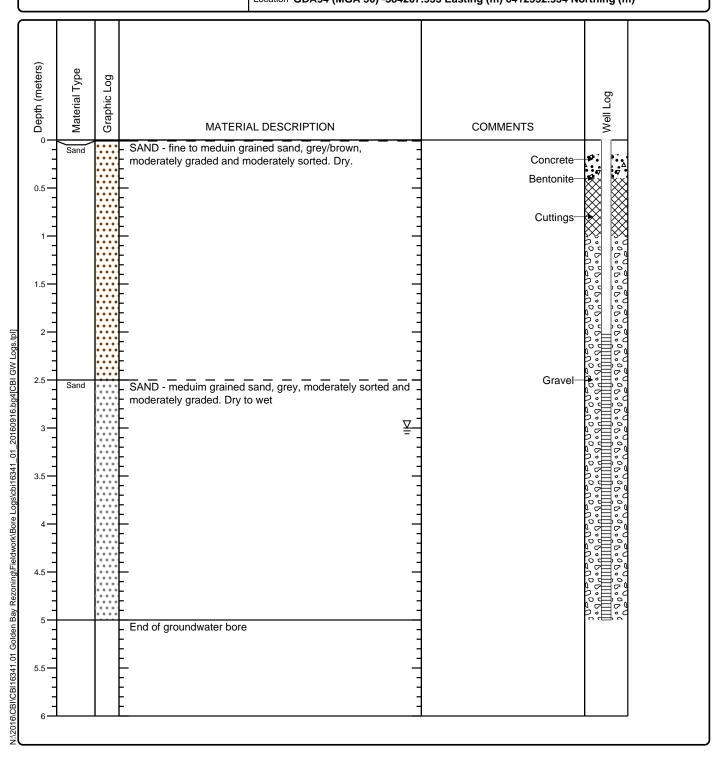
Project: installation
Project Location: Golden Bay, Western
Australia

Strategen Environmental Consultants

Lvl 1, 50 Subiaco Square Road Subiaco, WA 6008

MW 01 Sheet 1 of 1

Date(s) 16/09/2016	Logged By CL	Checked By MD			
Drilling Method Hollow Auger	Drill Bit Size/Type 150 mm	Total Depth of Borehole 5 meters bgs			
Drill Rig Type Truck	Drilling Contractor eDrill	Approximate Surface Elevation 4.008 m			
Groundwater Level and Date Measured 3.0 mbgl					
	Location GDA94 (MGA 50) -384207 933 Fasting (m) 6412352 954 Northing (m)				



Project Number: CBI16341.01

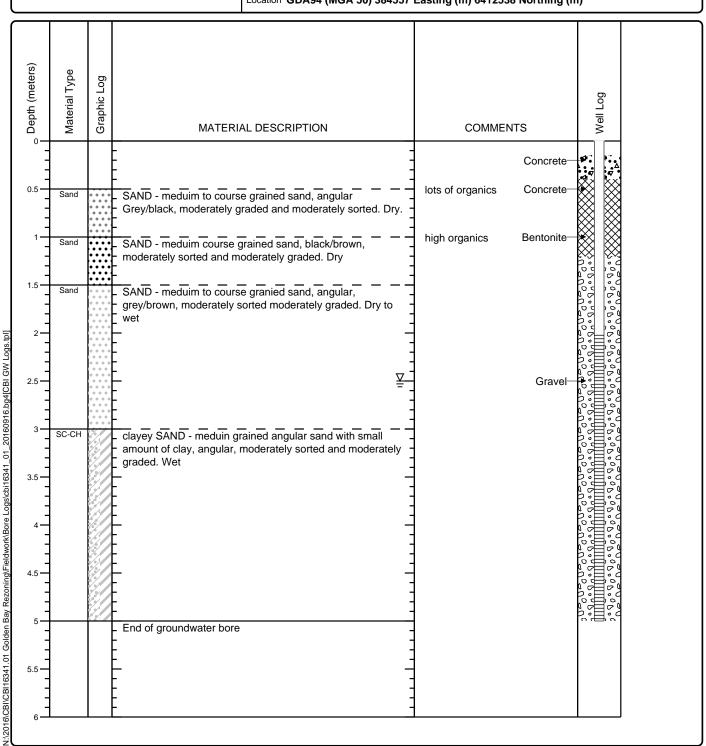
Project: installation Project Location: Australia Project Location: Australia

Strategen Environmental Consultants Lvl 1, 50 Subiaco Square Road Subiaco, WA 6008

MW 02 Sheet 1 of 1

Date(s) 16/09/2016	Logged By CL	Checked By MD
Drilling Method Hollow Auger	Drill Bit Size/Type 150 mm	Total Depth of Borehole 5 meters bgs
Drill Rig Type Truck		Approximate Surface Elevation 3.759 m
Groundwater Level and Date Measured 2.5 mbgl		

Location GDA94 (MGA 50) 384557 Easting (m) 6412538 Northing (m)



Project Number: CBI16341.01

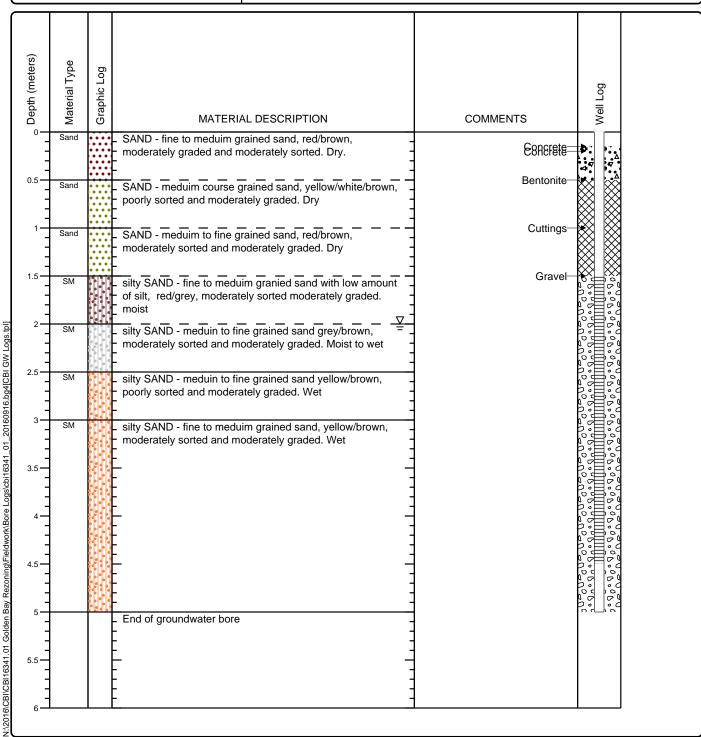
Project: installation Project Location: Australia Project Location: Australia

Strategen Environmental Consultants

Lvl 1, 50 Subiaco Square Road Subiaco, WA 6008

MW 03 Sheet 1 of 1

Date(s) Drilled 16/09/2016	Logged By CL	Checked By MD
Drilling Method Hollow Auger	Drill Bit Size/Type 150 mm	Total Depth of Borehole 5 meters bgs
Drill Rig Type Truck	L 5 30°	Approximate Surface Elevation 3.234 m
Groundwater Level and Date Measured 2.0 mbgl		
	Location GDA94 (MGA 50) 384386.06 Easting (m) 6412386.086 Northing (m)	



Project Number: CBI16341.01

Project: installation
Project Location: Australia

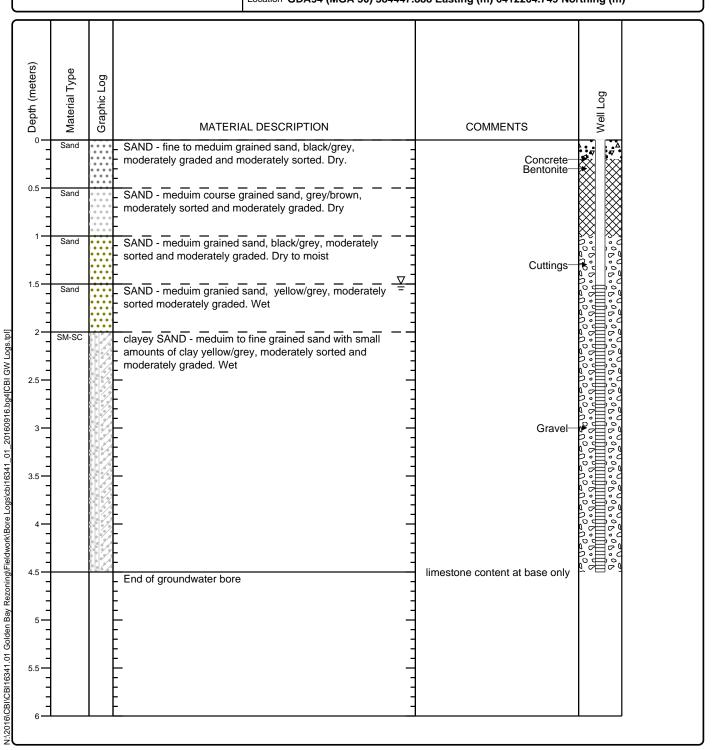
Project Location: Australia

Strategen Environmental Consultants

Lvl 1, 50 Subiaco Square Road Subiaco, WA 6008

MW 04 Sheet 1 of 1

Date(s) Drilled 16/09/2016	Logged By CL	Checked By MD
Drilling Method Hollow Auger	Drill Bit Size/Type 150 mm	Total Depth of Borehole 4.608 meters bgs
Drill Rig Type Truck	Drilling Contractor eDrill	Approximate Surface Elevation 2.957 m
Groundwater Level and Date Measured 1.5 mbgl		
	Location, GDA94 (MGA 50) 384447 888 Fasting (m) 6412264 749 Northing (m)	



installation Golden Bay, Western

Project Location: Golden B Project Number: CBI16341.01

Strategen Environmental Consultants

Lvl 1, 50 Subiaco Square Road Subiaco, WA 6008

Key to Log of Boring Sheet 1 of 1

Depth (meters)	Material Type	raphic Log	MATERIAL RECORDINA	OOMMENTO.	rell Log	
Оер	Mat	Gra	MATERIAL DESCRIPTION	COMMENTS	Well	
1	2	3	4	5	6	,

COLUMN DESCRIPTIONS

- 1 Depth (meters): Depth in meters below the ground surface.
- Material Type: Type of material encountered.
- Graphic Log: Graphic depiction of the subsurface material encountered.
- 4 MATERIAL DESCRIPTION: Description of material encountered. May include consistency, moisture, color, and other descriptive
- COMMENTS: Comments and observations regarding drilling or sampling made by driller or field personnel.
- Well Log: Graphical representation of well installed upon completion of drilling and sampling.

FIELD AND LABORATORY TEST ABBREVIATIONS

CHEM: Chemical tests to assess corrosivity

COMP: Compaction test

CONS: One-dimensional consolidation test

LL: Liquid Limit, percent





Bentonite powder

Portland Cement Concrete

Cuttings

PI: Plasticity Index, percent

SA: Sieve analysis (percent passing No. 200 Sieve) UC: Unconfined compressive strength test, Qu, in ksf WA: Wash sieve (percent passing No. 200 Sieve)



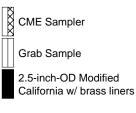
Clayey SAND to Sandy CLAY (SC-CH)

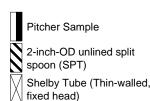
Silty SAND (SM)

Silty to Clayey SAND (SM-SC)

TYPICAL SAMPLER GRAPHIC SYMBOLS







OTHER GRAPHIC SYMBOLS

- Water level (at time of drilling, ATD)
- Water level (after waiting)
- Minor change in material properties within a stratum
- Inferred/gradational contact between strata
- -?- Queried contact between strata

GENERAL NOTES

- 1: Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive, and actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.
- 2: Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

APPENDIX D

Permeability Tests (Hyd2o, 2025)

HYDROLOGY

Project/Site Location

Golden Bay PT1 384140 mE 6412370 mN

0 - 40 cm: SAND, Fine to Medium grained, Dark Brown, Low Organics 40 - 60 cm: SAND, Fine to Medium grained, Light Brown, None Organics

-311		
r	4.5	cm
Н	20.0	cm
time step	5	secs
H/r	4.44	
С	1.45	

Н	20.0 cm	
time step	5 secs	
H/r	4.44 1.45	
С	1.45	
Time (sec)	Level (cm)	Diff (cm)
0	1.9	0.0
5	18.5	16.6
10	28.0	9.5
15	37.5	9.5
20	46.0	8.5
		11.0
	q (cm³/s)	11.0
	q (Cm /s)	20.6

TE	ST	2

E31 Z		
r	4.5	
Н	10.0	cm
time step	5	secs
· ·		
H/r	2.22	
\subset	0.91	

H/r	2.22	
С	2.22 0.91	
Time (sec)	Level (cm)	Diff (cm)
0	1.7	0.0
5	7.0	5.3
10	10.7	3.7
15	12.5	1.8
20	16.5	4.0
25	20.5	4.0
30	22.5	2.0
35	24.5	2.0
40	28.2	3.7
45	30.5	2.3
50	32.2	1.7
55	36.4	4.2
60	38.2	1.8
65	41.5	3.3
70	44.2	2.7
75	46.0	1.8

TEST 3

r	4.5	cm
Н	20.0	cm
time step	5	secs
H/r C	4.44	
С	1.45	

H/r C	4.44 1.45	
	1.45	
Time (sec)	Level (cm)	Diff (cm)
0	2.4	0.0
5	16.0	13.6
10	23.5	7.5 7.5
15	31.0	7.5
20	39.0	8.0
25	EOT	
Av	g Diff (cm)	9.2
	q (cm³/s)	17.1

METHOD 1: Elrick and Reynolds (1992)

Ks (cm/s) Ks (m/day)

Sum

0.0115 9.90

Ks (cm/s) Ks (m/day)

Avg Diff (cm)

q (cm³/s)

0.0073 6.34

3.0

5.5

Ks (cm/s) Ks (m/day) 0.0095 8.22

Average (m/day)

8.15

METHOD 2: Talsma and Hallam Method (recommended for low Ks only <2.9)

q (cm3/min)	1235.7
r (cm)	4.5
H (cm)	20.0
0.5sinh ⁻¹ (H/2r)	0.77
-sqrt((r/H)^2+0.25)	-0.55
r/H	0.23

Sum*4.4*q 2425.53 2*pi*H² 2513.27

Ksat (cm/min) 1.0 13.90 Ksat (m/day)

331.0	cm3/min
4.5	cm
10.0	cm

0.48 -0.67 0.45 0.26

373.17 628.32

0.6 8.55 1025.5 cm3/min 4.5 cm 20.0 cm

0.77 -0.55 0.23 0.45

2013.03 2513.27

8.0 11.53

Average (m/day)

11.33

hyd20

Project/Site	Golden Bay PT2	HYDROLOGY	
Location	384156 mE	0 - 40 cm: SAND, Fine to Medium grained, Dark	Brown Low Organics
	6412379 mN	40 - 60 cm: SAND, Fine to Medium grained, Light	, 0

TEST 1				TEST 2				TEST 3		
IESI I			1	IESI Z			1	1531 3		
r	4.5			r	4.5			r	4.5	cm
Н	10.0			Н	20.0			Н	20.0	
time step	5	secs		time step	5	secs		time step	5	secs
H/r	2.22]		H/r	4.44	1		H/r	4.44	l
C	0.91			C	1.45			C C	1.45	
	0171	l				l				l
Time (sec)	Level (cm)	Diff (cm)		Time (sec)	Level (cm)	Diff (cm)		Time (sec)	Level (cm)	Diff (cm)
0	3.0	0.0		0	3.3	0.0		0	2.3	0.0
5	14.0	11.0		5	22.0	18.7		5	16.5	14.2
10	22.3	8.3		10	32.0	10.0		10	23.2	6.7
15	26.5	4.2		15	41.0	9.0		15	33.0	9.8
20	30.0	3.5		20	46.0	5.0		20	39.0	6.0
25	37.0	7.0						25	EOT	
30	42.5	5.5					_			
35	EOT		ļ				1			
			ļ				1			
			ļ				-			
			ł				ł			
							1			
			-				1			
			ł				1			
			ł				1			
			1				1			
			ł				1			
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			1				1			
			1							
							1			
							1			
			1				1			
							1			
	, 3,,	6.6		Av	g Diff (cm)	10.7	1	Av	g Diff (cm)	9.2
	q (cm³/s)	12.3]		q (cm³/s)	19.9]		q (cm³/s)	17.1

METHOD 1 : Elrick and Reynolds (1992)

Ks (cm/s)	0.0163	Ks (cm/s)	0.0111	Ks (cm/s)	0.0095
Ks (m/day)	14.13	Ks (m/day)	9.59	Ks (m/day)	8.24

Average (m/day) 10.65

Average (m/day)

METHOD 2 : Talsma and Hallam Method (recommended for low Ks only <2.9)

q (cm3/min)	737.9	1196.5 cm3/min	1028.3 cm3/min
r (cm)	4.5	4.5 cm	4.5 cm
H (cm)	10.0	20.0 cm	20.0 cm
0.5sinh ⁻¹ (H/2r)	0.48	0.77	0.77
-sqrt((r/H)^2+0.25)	-0.67	-0.55	-0.55
r/H	0.45	0.23	0.23
Sum	0.26	0.45	0.45
Sum*4.4*q	831.84	2348.53	2018.53
2*pi*H ²	628.32	2513.27	2513.27
Ksat (cm/min) Ksat (m/day)	1.3	0.9	0.8

Project/Site Golden Bay PT3 Location

384233 mE 6412460 mN 0 - 40 cm: SAND, Fine to Medium grained, Dark Brown, Low Organics 40 - 60 cm: SAND, Fine to Medium grained, Brown, None Organics

TEST 1		
r H time step	4.5 10.0 5	cm
H/r C	2.22 0.91	
Time (sec)	Level (cm)	Diff (cm)
0	4.1	0.0
5	8.1	4.0
10	10.2	2.1
15	12.1	1.9
20	14.2	2.1
25	17.8	3.6
30	19.7	1.9
35	21.6	1.9
40	25.4	3.8
45	27.1	1.7
50	28.1	1.0
55	30.8	2.7
60	33.6	2.8
65	36.4	2.8
70	38.1	1.7
75	40.1	2.0
80	42.0	1.9
85	43.7	1.7
90	EOT	

TEST 2			
r	4.5		
Н	10.0		
time step	5	secs	
H/r	2.22		
С	0.91		
Time (sec)	Level (cm)	Diff (cm)	
0	3.6	0.0	
5	6.3	2.7	
10	8.6	2.3	
15	11.0	2.4	
20	13.1	2.1	
25	15.5	2.4	
30	15.5	0.0	
35	17.6	2.1	
40	19.7	2.1	
45	22.0	2.3	
50	22.0	0.0	
55	24.1	2.1	
60	26.2	2.1	
65	28.6	2.4	
70	30.9	2.3	
75	30.9	0.0	
80	33.3	2.4	
85	35.8	2.5	
90	35.8	0.0	
95	38.2	2.4	
100	40.3	2.1	
105	42.5	2.2	
110	44.3	1.8	
115	44.3	0.0	
120	EOT		
			[
			[
	- 444		ļ [
Av	g Diff (cm)	1.8	
	q (cm³/s)	3.3	

r H time step H/r		cm cm secs
C		
Time (sec)	Level (cm)	Diff (cm)
Av	g Diff (cm) q (cm³/s)	

METHOD 1: Elrick and Reynolds (1992)

q (cm³/s)

2.3

Ks (cm/s) 0.0058 Ks (cm/s) 0.0044 Ks (cm/s) 0.00 Ks (m/day) 5.00 Ks (m/day) 3.80 Ks (m/day)

Average (m/day) 2.93

METHOD 2: Talsma and Hallam Method (recommended for low Ks only <2.9)

q (cm3/min)	261.1	198.3 cm3/min	0.0 cm3/min
r (cm)	4.5	4.5 cm	0.0 cm
H (cm)	10.0	10.0 cm	0.0 cm
0.5sinh ⁻¹ (H/2r)	0.48	0.48	0.00
-sqrt((r/H)^2+0.25)	-0.67	-0.67	
r/H	0.45	0.45	
Sum	0.26	0.26	
Sum*4.4*q	294.33	223.59	0.00
2*pi*H ²	628.32	628.32	
Ksat (cm/min)	0.5	0.4	0.00
Ksat (m/day)	6.75	5.12	

Average (m/day) 3.96

Project/Site Location

Golden Bay PT4 384252 mE

0 - 40 cm: SAND, Fine to Medium grained, Dark Brown, Medium Organics 6412438 mN 40 - 70 cm: SAND, Fine to Medium grained, Brown, Low Organics

TEST 1		
r	4.5	cm
Н	10.0	cm
time step	5	secs
		·
H/r	2.22	
С	0.91	
Time (sec)	Level (cm)	Diff (cm)
0	2.3	0.0
5	6.5	4.2
10	10.6	4.1
15	12.1	1.5
20	15.3	3.2
25	17.2	1.9
30	20.9	3.7
35	22.5	1.6
40	26.0	3.5
45	27.0	1.0
50	31.2	4.2
55	33.0	1.8
60	36.5	3.5
65	38.2	1.7
70	41.2	3.0
75	44.0	2.8
80	EOT	

TEST 2		
r	4.5	
Н	10.0	cm
time step	5	secs
H/r C	2.22	
С	0.91	

time step	5	secs
	0.00	ı
H/r	2.22	
С	0.91	
Time (sec)	Level (cm)	Diff (cm)
0	6.0	0.0
5	10.0	4.0
10	13.5	3.5
15	15.0	1.5
20	17.2	2.2
25	20.0	2.8
30	22.0	2.0
35	24.1	2.1
40	25.5	1.4
45	26.8	1.3
50	29.0	2.2
55	30.5	1.5
60	34.5	4.0
65	37.5	3.0
70	39.6	2.1
75	41.5	1.9
80	44.0	2.5
85	EOT	
A	g Diff (cm)	2.4
AV	g Diff (cm) q (cm ³ /s)	2.4
	q (CIII /S)	4.4

EST	3	

r	4.5	
Н	10.0	cm
time step	5	secs
H/r	2.22 0.91	
С	0.91	
Time (sec)	Level (cm)	Diff (cm)
0	3.7	0.0
5	6.2	2.5
10	8.5	2.3
15	11.0	2.5
20	13.5	2.5
25	16.1	2.6
30	18.1	2.0
35	20.5	2.4
40	20.5	0.0
45	23.0	2.5
50	25.5	2.5
55	27.8	2.3
60	30.0	2.2
65	30.0	0.0
70	32.2	2.2
75	35.1	2.9
80	37.1	2.0
85	40.0	2.9
90	40.0	0.0
95	41.8	1.8
100	44.0	2.2
105	EOT	

q (cm³/s) METHOD 1: Elrick and Reynolds (1992)

0.0069 Ks (cm/s) Ks (m/day) 5.96

Ks (cm/s) Ks (m/day) 0.0059 5.10 Ks (cm/s) Ks (m/day)

Avg Diff (cm)

q (cm³/s)

0.0050 4.32

2.0

3.8

Average (m/day)

5.13

2.8

METHOD 2: Talsma and Hallam Method (recommended for low Ks only <2.9)

q (cm3/min) 311.6 r (cm) 4.5 10.0 H (cm) 0.5sinh⁻¹ (H/2r) 0.48 -sqrt((r/H)^2+0.25) -0.67 r/H 0.45 Sum 0.26 Sum*4.4*q

351.27 2*pi*H² 628.32

Ksat (cm/min) 0.6 8.05 Ksat (m/day)

266.2 cm3/min 4.5 cm 10.0 cm

0.48 -0.67 0.45 0.26

300.09 628.32

0.5 6.88 225.8 cm3/min 4.5 cm 10.0 cm

0.48 -0.67 0.45 0.26

254.61 628.32

0.4 5.84

Average (m/day)

Project/Site Location

Golden Ba	y PT5
384440	mE
6412572	mN

0 - 20 cm: SAND, Fine to Medium grained, Black, High Organics 20 - 40 cm: SAND, Fine to Medium grained, Dark Brown, Medium Organics 40 - 70 cm: SAND, Fine to Medium grained, Brown, Low Organics

TEST	1
------	---

TEST 1		
r	4.5	cm
Н	15.0	cm
time step	5	secs
H/r	3.33 1.20	
С	1.20	
, ,	I, .	D.111 /
Time (sec)	Level (cm)	Diff (cm)
0	4.5	0.0
5	9.0	4.5
10	13.3	4.3
15	17.6	4.3
20	19.5	1.9 4.1
25	23.6	
30	25.6	2.0
35	29.7	4.1
40	31.5	1.8
45	35.9	4.4
50	38.1	2.2
55	40.2	2.1
60	44.0	3.8
65	EOT	

TEST 2		
_	1.5	l
' _H	4.5 15.0	
time step	5	secs
H/r	3.33	

H/r	3.33	1
C	3.33 1.20	
	1,20	ı
Time (sec)	Level (cm)	Diff (cm)
0	4.6	0.0
5	9.2	4.6
10	11.5	2.3
15	15.1	3.6
20	17.1	2.0
25	21.0	3.9
30	22.6	1.6
35	26.3	3.7
40	28.0	1.7
45	29.6	1.6
50	33.2	3.6
55	35.6	2.4
60	37.7	2.1
65	42.0	4.3
70	44.1	2.1
75	EOT	
Av	g Diff (cm)	2.8
	q (cm³/s)	5.3
	-	,

TEST 3

ESIS		
r	4.5	cm
Н	15.0	cm
time step	5	secs
H/r C	3.33 1.20	
С	1.20	
Time (sec)	Level (cm)	Diff (cm)
Λ	E E	0.0

11/=	2 22	ı
H/r C	3.33 1.20	
C	1.20	
Time (sec)	Level (cm)	Diff (cm)
0	5.5	0.0
5	10.6	5.1
10	12.2	1.6
15	14.5	2.3
20	16.6	2.1
25	19.0	2.4
30	21.1	2.1
35	23.3	2.2
40	25.5	2.2
45	30.0	4.5
50	31.5	1.5
55	34.0	2.5
60	36.0	2.0
65	38.1	2.1
70	40.0	1.9
75	42.1	2.1
80	44.3	2.2
85	EOT	
Av	g Diff (cm)	2.4
	q (cm³/s)	4.5

q (cm³/s) METHOD 1: Elrick and Reynolds (1992)

Ks (cm/s) Ks (m/day) 0.0050 4.28

3.3

Ks (cm/s) Ks (m/day) 0.0043 3.67 Ks (cm/s) Ks (m/day) 0.0037 3.16

Average (m/day)

3.70

METHOD 2: Talsma and Hallam Method (recommended for low Ks only <2.9)

q (cm3/min)	368.9
r (cm)	4.5
H (cm)	15.0
0.5sinh ⁻¹ (H/2r) -sqrt((r/H)^2+0.25) r/H Sum	0.64 -0.58 0.30

Sum*4.4*q 582.44 2*pi*H² 1413.72

Ksat (cm/min) 0.4 Ksat (m/day) 5.93

316.2	cm3/min
4.5	cm
15.0	cm

0.64
-0.58
0.30
0.36

499.24 1413.72

0.4 5.09

271.8	cm3/mir
4.5	cm
15.0	cm

0.64 -0.58 0.30 0.36

429.09 1413.72

0.3 4.37

Average (m/day)

Project/Site Location

Golden Bay PT6		
384420	mE	
6412556	mN	

0 - 30 cm: SAND, Fine to Medium grained, Brown, No Organics

30 - 50 cm: SAND, Fine to Medium grained, Dark Brown, Low Organics

50 - 60 cm: SAND, Fine to Medium grained, Dark Brown, High Organics

TEST 1

TEST 1		
r H time step	4.5 20.0 5	cm cm secs
H/r C	4.44 1.45	
Time (sec)	Level (cm)	Diff (cm)
0	5.1	0.0
5	9.6	4.5
10	14.0	4.4
15	18.0	4.0
20	21.5	3.5
25	25.1	3.6
30	29.0	3.9
35	31.0	2.0
40	34.6	3.6 3.5
45	38.1	
50	42.0	3.9
55	EOT	

TEST 2			
ı	4.5	l	
r	4.5		
Н	20.0	cm	
time step	5	secs	
11/-	1 1 1 1		

H/r	4 44	
C	4.44 1.45	
	1.10	
Time (sec)	Level (cm)	Diff (cm)
0	5.0	0.0
5	10.1	5.1
10	13.4	3.3
15	17.5	4.1
20	21.0	3.5
25	24.5	3.5
30	27.6	3.1
35	32.1	4.5
40	34.9	2.8
45	39.0	4.1
50	41.9	2.9
55	EOT	
Av	g Diff (cm)	3.7
7.,	q (cm ³ /s)	6.9
	9 (0111 /3)	0.7

TEST 3	3
--------	---

r	4.5	cm
Н	20.0	cm
time step		secs
H/r	4.44 1.45	
С	1.45	
Time (sec)	Level (cm)	Diff (cm)
0	4.7	0.0
5	9.3	4.6
10	13.2	3.9
15 20	17.0	3.8
20	20.4	3.4
25	22.1	1.7
30	26.2	4.1
35	30.4	4.2
40	33.6	3.2
45	35.6	2.0
50	39.2	3.6
55	42.6	3.4
60	EOT	

METHOD 1: Elrick and Reynolds (1992)

q (cm³/s)

Ks	(cm/s)
Ks	(m/day)

q (cm3/min)

0.0038
3.31

3.7

Ks (cm/s) Ks (m/day)

0.0038 3.31 Ks (cm/s) Ks (m/day)

Avg Diff (cm)

q (cm³/s)

0.0036 3.09

3.4

6.4

Average (m/day)

3.24

413.6

METHOD 2: Talsma and Hallam Method (recommended for low Ks only <2.9)

r (cm)	4.5
H (cm)	20.0
0.5sinh ⁻¹ (H/2r)	0.77
$-sqrt((r/H)^2+0.25)$	-0.55
r/H	0.23
Sum	0.45

Sum*4.4*q 811.81 2*pi*H² 2513.27

Ksat (cm/min) 0.3 Ksat (m/day) 4.65

cm3/min
cm
cm

0.77
-0.55
0.23
0.45

811.81 2513.27

0.3	
4.65	

386.2 cm3/min 4.5 cm 20.0 cm

0.77
-0.55
0.23
0.45

758.01 2513.27

0.3 4.34

Average (m/day)

APPENDIX E

Pre-Development Site Groundwater Monitoring Data

Groundwater levels (mAHD)

Bore	Top of casing						Da	ate					
bore	(mAHD)	6/10/2016	3/11/2016	9/12/2016	5/01/2017	7/03/2017	6/04/2017	3/05/2017	2/06/2017	7/07/2017	8/08/2017	5/09/2017	5/10/2017
MW01	4.608	1.508	1.450	1.307	1.192	1.133	1.069	0.985	1.115	1.326	1.540	1.877	1.905
MW02	4.359	1.555	1.485	1.322	1.215	1.150	1.075	1.011	1.153	1.413	1.598	1.915	1.956
MW03	3.834	1.533	1.471	1.316	1.200	1.143	1.069	1.001	1.127	1.394	1.585	1.896	1.935
MW04	3.557	1.482	1.416	1.260	1.144	1.091	1.016	0.955	1.079	1.358	1.542	1.839	1.880
T480	8.45	-	1.501	1.357	-	1.176	1.069	1.022	1.170	1.367	1.612	1.973	1.994

	[Lab Parameters					
		Ηď	Electrical Conductivity	TDS			
	FWG	7-8.5	NE	NE			
	MWG	8-8.4	NE	NE			
	LIWG	NE		1,500			
	NPUG	NE	NE	NE			
Limits o	f Reporting (LOR)	-	-				
Sample ID	Date Sampled	-	μs/cm	mg/L			
MW01	6/10/2016	7.2	900	500			
MW02	6/10/2016	7.1	1700	1000			
MW03	6/10/2016	7.3	1900	1100			
MW04	6/10/2016	7.3	2000	1200			
MW01	5/01/2017	7.2	1100	720			
MW02	5/01/2017	7.2	2000	1300			
MW03	5/01/2017	7.3	1900	1100			
MW04	5/01/2017	7.4	2100	1300			
MW01	6/04/2017	7.2	930	560			
MW02	6/04/2017	7.1	1900	1300			
MW03	6/04/2017	7.2	2000	1200			
MW04	6/04/2017	7.2	2200	1200			
MW01	8/08/2017	6.9	2200	1,200			
MW02	8/08/2017	7.4	1800	940			
MW03	8/08/2017	7.4	2100	1,100			
MW04	8/08/2017	7.7	1500	850			

Notes:

NE = Regulatory guideline value not established

- ¹ value derived from ANZECC (2000) wetland ecosystems in South-west Australia
- ² value derived from ANZECC (2000) lakes, reservoirs & wetland ecosystems in South-west Australia
- ³ value derived from ANZECC (2000) for moderately tolerant crops
- value derived from ANZECC (2000) for micelately tole
 value derived from ANZECC (2000) for sensitive crops
 indicates ADWG (2011) aesthetic value
- < Indicates sample results below the laboratory limit of reporting (LOR)
- Not Analysed

Regulatory Guidelines:
Guidelines are derived from DER (2014) Assessment and management of contaminated sites - Contaminated sites guidelines,
NEPC (2013) National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1),
NHMRC & NRMMC (2011) Australian Drinking Water Guidelines and ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

shading indicates concentration exceeds the FWG (Fresh Water Guidelines for slightly - moderately disturbed systems - Wetlands).

shading indicates concentration exceeds the MWG (Marine Water Guidelines for slightly - moderately disturbed systems - marine waters inshore). shading indicates concentration exceeds the LIWG (Long-term Irrigation Water Guidelines). shading indicates concentration exceeds the NPUG (Non-Potable Groundwater Use - Department of Health, 2014).

		Nutrients							
		Total Nitrogen (mg/l)	TKN	NOx (as N) (mg/l)	Total Phosphorus	Phosphate (as P)	Nitrate-N	Nitrite-N	Ammonia (as NH ₃ - N)
	FWG	1.5	NE	0.1	0.06	0.03	NE	NE	0.04
	MWG LIWG	0.23 5	NE	0.005	0.02	0.005	NE NE	NE	0.005
	NPUG	NE NE	NE NE	NE NE	0.05 NE	NE	113	NE 9	NE NE
Limite of B	eporting (LOR)	0.2	0.1	0.01	0.01	0.01	0.01	0.01	0.02
Sample ID	Date Sampled	0.2	0.1	0.01		ng/L	0.01	0.01	0.02
MW01	6/10/2016	0.2	0.2	< 0.01	0.07	<0.01	< 0.01	< 0.01	0.14
MW02	6/10/2016	0.3	0.3	< 0.01	0.06	< 0.01	< 0.01	< 0.01	0.1
MW03	6/10/2016	0.3	0.3	< 0.01	0.05	< 0.01	< 0.01	< 0.01	0.2
MW04			0.9	< 0.01	0.14	0.02	< 0.01	< 0.01	0.42
MW01	5/01/2017	0.5	0.5	< 0.01	0.06	0.01	< 0.01	< 0.01	0.21
MW02	5/01/2017	0.5	0.5	0.01	0.05	< 0.01	0.01	< 0.01	0.15
MW03	5/01/2017	0.6	0.6	< 0.01	0.05	< 0.01	< 0.01	< 0.01	0.22
MW04	5/01/2017	1	1	< 0.01	0.14	0.05	< 0.01	< 0.01	0.49
MW01	6/04/2017	0.3	0.3	< 0.01	0.08	< 0.01	< 0.01	< 0.01	0.12
MW02	6/04/2017	0.5	0.5	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.16
MW03	6/04/2017	0.8	0.8	< 0.01	0.03	< 0.01	< 0.01	< 0.01	0.32
MW04	6/04/2017	0.9	0.9	< 0.01	0.16	0.05	< 0.01	<0.01	0.49
MW01	8/08/2017	1.2	1.2	0.05	0.14	0.01	0.04	0.01	0.13
MW02	8/08/2017	0.3	0.3	< 0.01	0.08	0.01	< 0.01	< 0.01	0.1
MW03	8/08/2017	1.2	1.2	< 0.01	0.11	0.01	<0.01	< 0.01	0.08
MW04	8/08/2017	1.2	0.9	0.34	0.1	0.02	0.29	0.05	<0.02

- NG = Regulatory guideline value not established

 1 value derived from SRT (2008) Healthy Rivers Action Plan

 2 value derived from ANZECC (2000) trigger values for slightly moderately disturbed wetland ecosystems

 < Indicates sample results below the laboratory limit of reporting (LOR)

Regulatory Guidelines:
Guidelines are derived from DER (2014) Assessment and management of contaminated sites - Contaminated sites guidelines,
NEPC (2013) National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1),
NHMRC & NRMMC (2011) Australian Drinking Water Guidelines and ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

shading indicates concentration exceeds the FWG (Fresh Water Guidelines for slightly - moderately disturbed systems - Wetlands).

shading indicates concentration exceeds the MWG (Marine Water Guidelines).

shading indicates concentration exceeds the NPUG (Non-Potable Groundwater Use - Department of Health, 2014).

	Metals									
		Arsenic	Cadmium	Chromium*	Copper	Lead	Mercury (Total)	Nickel	Zinc	
	FWG	NE	0.0002	0.001*	0.0014	0.0034	0.00006	0.011	0.008	
	MWG	NE	0.0007	0.027	0.0013	0.0044	0.0001	0.007	0.015	
	LIWG	0.1	0.01	NE	0.2	2	0.002	0.2	2	
	NPUG	0.1	0.02	0.5	20	0.1	0.01	0.2	3	
Limits of F	Reporting (LOR)	0.001	0.0001		0.001	0.001	0.05	0.001	0.001	
Sample ID	Date Sampled				mg/	/L				
MW01	6/10/2016	0.016	< 0.0001	< 0.001	< 0.001	< 0.001	< 0.05	< 0.001	0.022	
MW02	6/10/2016	0.014	< 0.0001	< 0.001	< 0.001	< 0.001	< 0.05	< 0.001	0.022	
MW03	6/10/2016	0.002	< 0.0001	< 0.001	< 0.001	< 0.001	< 0.05	< 0.001	0.022	
MW04	6/10/2016	0.002	< 0.0001	0.003	< 0.001	< 0.001	< 0.05	< 0.001	0.002	

Notes

NG = Regulatory guideline value not established

- * indicates ADWG (2011) aesthetic value
- ^ indicates total value
- $^{\it \#}$ Indicates duplicate or triplicate sample analysis used instead of primary sample concentration
- < Indicates sample results below the laboratory limit of reporting (LOR)
- Not Analysed

Regulatory Guidelines:

Guidelines are derived from DER (2014) Assessment and management of contaminated sites - Contaminated sites guidelines,

NEPC (2013) National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1),

NHMRC & NRMMC (2011) Australian Drinking Water Guidelines and ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

shading indicates concentration exceeds the FWG (Fresh Water Guidelines for slightly - moderately disturbed systems).

shading indicates concentration exceeds the MWG (Marine Water Guidelines for slightly - moderately disturbed systems).

shading indicates concentration exceeds the LIWG (Long-term Irrigation Water Guidelines).

shading indicates concentration exceeds the NPUG (Non-Potable Groundwater Use - Department of Health, 2014).

APPENDIX F DWER Bore Long Term Hydrographs

APPENDIX G Plan/E Landscape Plan



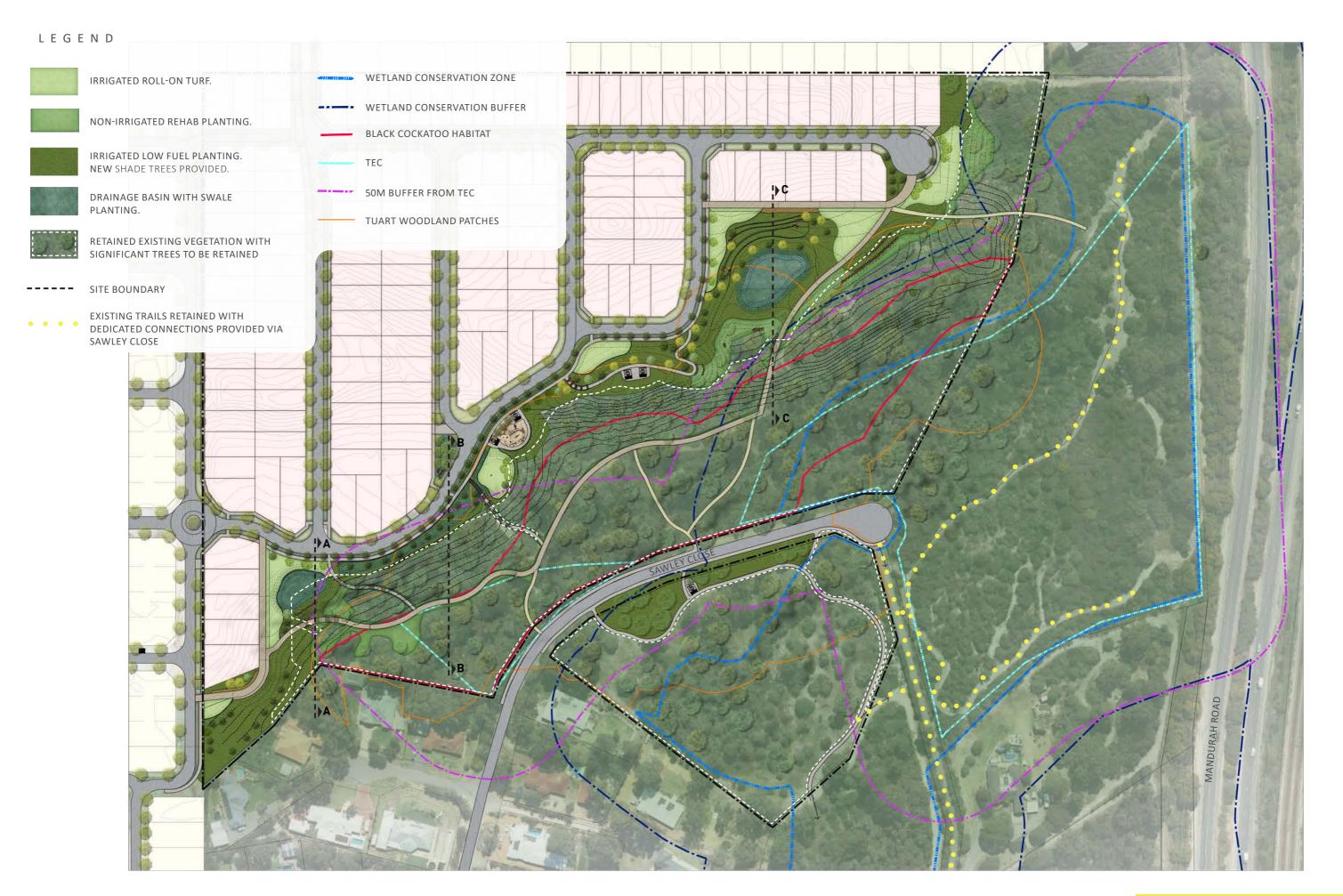
GOLDEN BAY LANDSCAPE MASTERPLAN

PREPARED FOR CAPE BOUVARD

JOB NO. 2306601 1:1000 @ A3







GOLDEN BAY LANDSCAPE MASTERPLAN

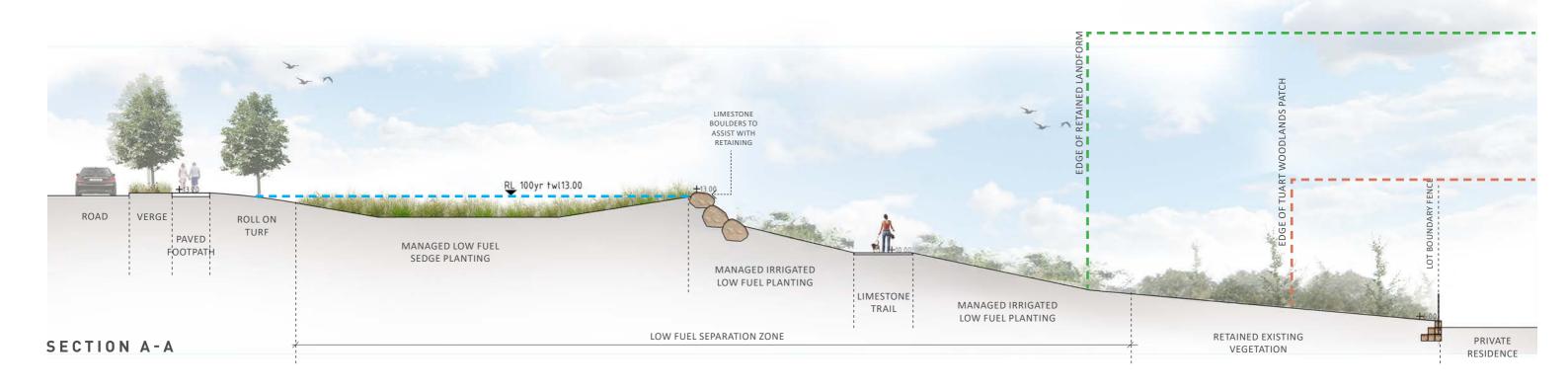
LANDSCAPE CONCEPT - OVERALL PLAN

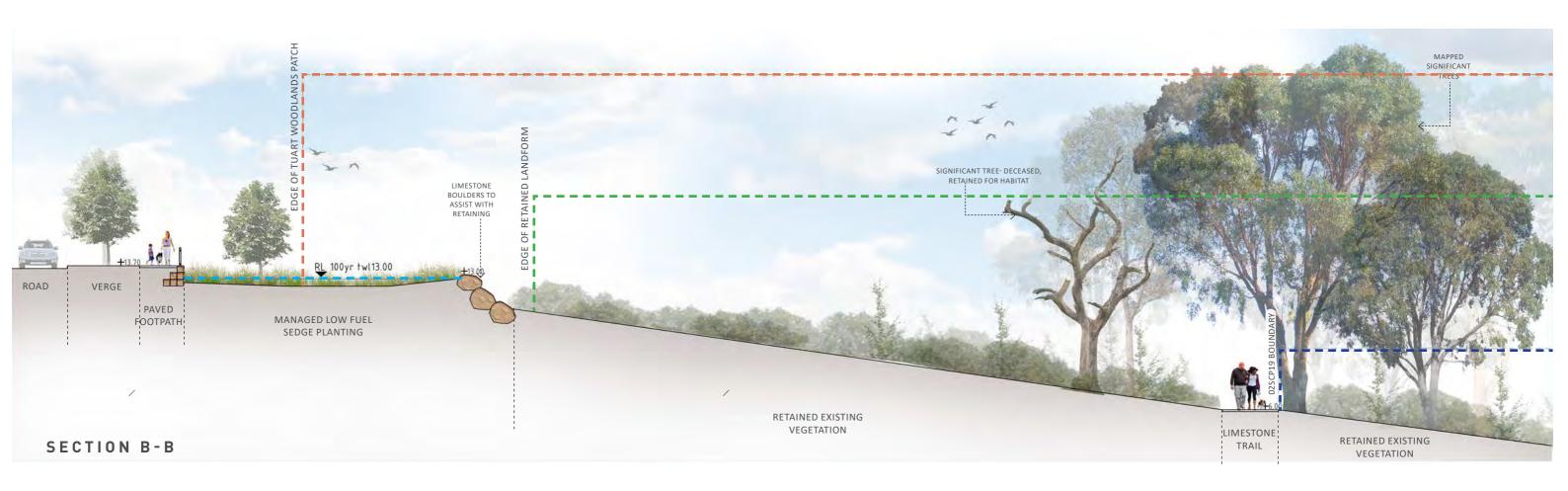
PREPARED FOR CAPE BOUVARD

AUGUST 2024

JOB NO. 2306601 1:1000 @ A3 C1.102 REV F



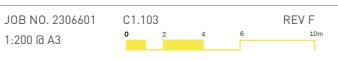




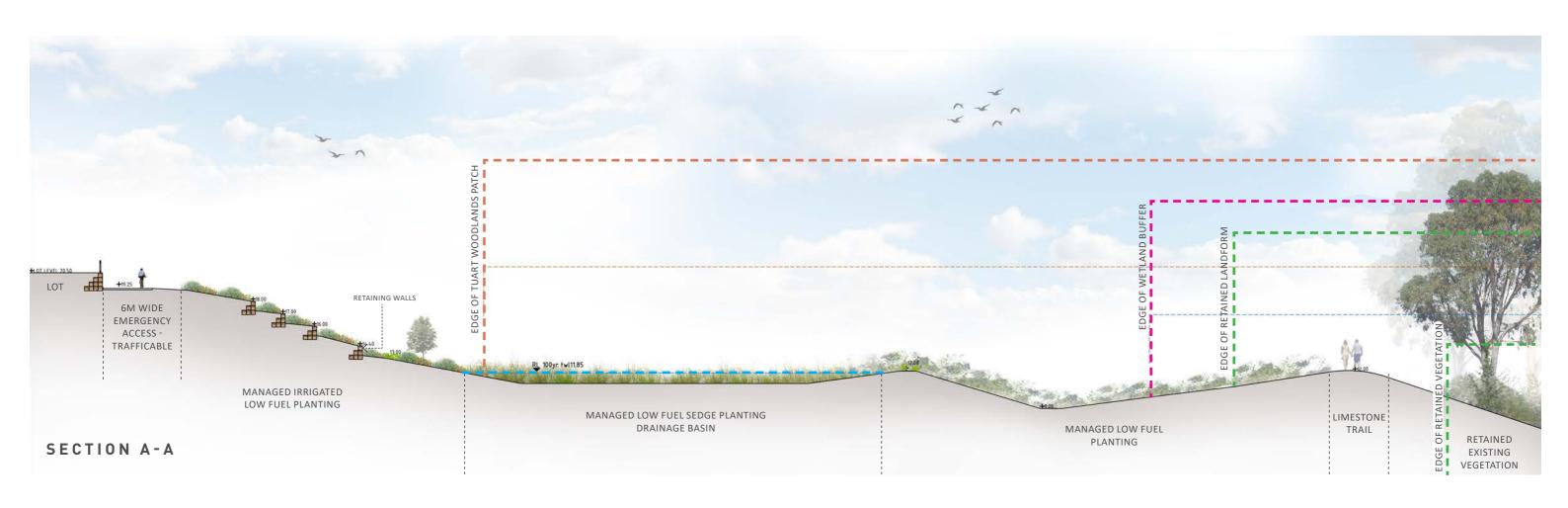
GOLDEN BAY LANDSCAPE MASTERPLAN

PREPARED FOR CAPE BOUVARD

LANDSCAPE CONCEPT - SECTIONS AUGUST 2024







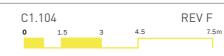
GOLDEN BAY LANDSCAPE MASTERPLAN

PREPARED FOR CAPE BOUVARD

AUGUST 2024

LANDSCAPE CONCEPT - SECTIONS

JOB NO. 2306601 C1.104 1:300 @ A3



HARD LANDSCAPE THEMING













GOLDEN BAY LANDSCAPE MASTERPLAN

PREPARED FOR CAPE BOUVARD

NTS

SOFT LANDFSCAPE THEMING



GOLDEN BAY LANDSCAPE MASTERPLAN

PREPARED FOR CAPE BOUVARD

NTS

URBAN CHARACTER THEMING (COLOURS & MATERIALS)















GOLDEN BAY LANDSCAPE MASTERPLAN

PREPARED FOR CAPE BOUVARD

APPENDIX H CURRV Runoff Rate Calculator

CURRV

AR&R

hyd ₂ c	
\sim	
HYDROLOG	Y

ł	nyd20
4	~~
Н	YDROLOGY

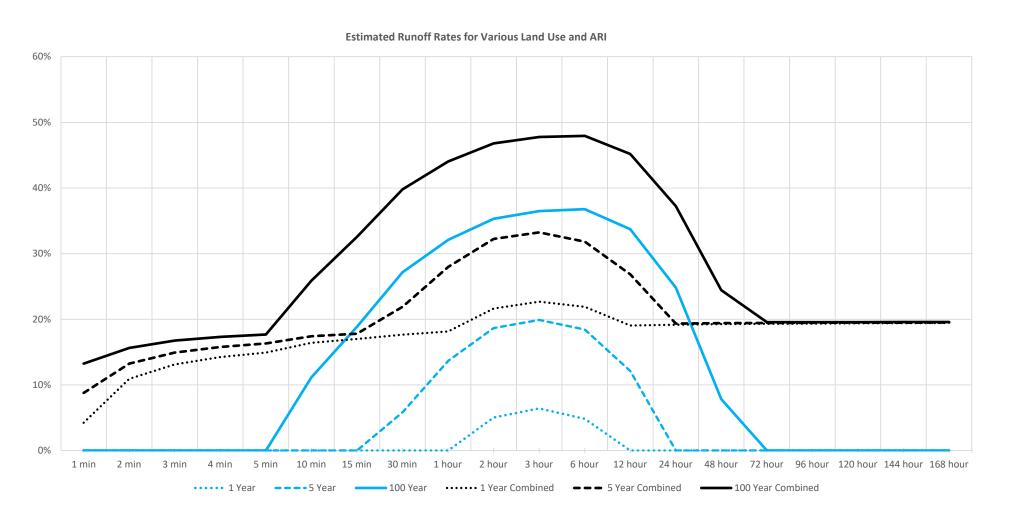
Calcula	tor for Urban Runoff Rates & Volumes			Imperv	Perv	Perv			EIA/TIA					Hyu20
8/08/20	024			Initial	Initial	Continue			System					~
		Area	Use in	Loss	Loss	Loss	On Site	Empty	Connect	Roof	Ext Imp	Ext Perv		HYDROLOGY
Land	Use Description	(ha)	Calc	mm	mm	mm/hr	Soak (mm)	(days)	Ratio	%	%	%	Comment	
1 Resid	ential 300-600m2	4.88	Yes	1.5	20.0	4.0	15.0	0.25	60%	60	20	20	soakwells	
2 Local	Roads	2.18	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	no soakwells assumed	
3 Active	POS	0.73	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	assume similar EIA/TIA to rural residential	
4				1.5	20.0	4.0		1.00						
5				1.5	20.0	4.0		1.00						
6				1.5	20.0	4.0		1.00						
7				1.5	20.0	4.0		1.00						
8				1.5	20.0	4.0		1.00						
9				1.5	20.0	4.0		1.00						
10				0.0	20.0	4.0		1.00						

EIA: Effective Impervious Area, TIA: Total Impervious Area

Land Use Graph Selector

(11 - combined total)

Residential 300-600m2



Various Lots Sawley Close DWMS

Rainfall IFD Data

Annual E	xceedenc	e Probal	oility			
63.2%	50%	20%	10%	5%	2%	1%

		63.2%	50%	20%	10%	5%	2%	1%
	Duration	1.00	1.44	4.48	10	20	50	100
1	1 min	1.91	2.1	2.7	3.12	3.54	4.11	4.55
2	2 min	3.36	3.65	4.57	5.2	5.82	6.61	7.22
3	3 min	4.48	4.89	6.16	7.04	7.91	9.05	9.92
4	4 min	5.4	5.91	7.52	8.63	9.73	11.2	12.3
5	5 min	6.18	6.78	8.68	9.99	11.3	13	14.4
6	10 min	8.93	9.84	12.8	14.8	16.8	19.5	21.7
7	15 min	10.8	11.9	15.4	17.8	20.3	23.6	26.1
8	30 min	14.3	15.7	20.2	23.4	26.5	30.7	34
9	1 hour	18.6	20.4	25.9	29.8	33.7	38.9	43
10	2 hour	24	26.1	33.1	38	43	49.9	55.4
11	3 hour	27.7	30.1	38.3	44.1	50.1	58.5	65.3
12	6 hour	35	38.3	49.1	57.1	65.5	77.7	87.8
13	12 hour	43.5	47.7	62.2	73.1	84.8	102	116
14	24 hour	52.9	58.2	76.4	90.3	105	126	144
15	48 hour	63.4	69.6	90.8	107	123	145	163
16	72 hour	71.1	77.8	100	117	133	155	172
17	96 hour	78.1	85.3	109	125	142	163	179
18	120 hour	85.2	92.8	117	134	150	172	188
19	144 hour	92.4	101	126	143	160	182	199
20	168 hour	100	109	136	154	171	194	212

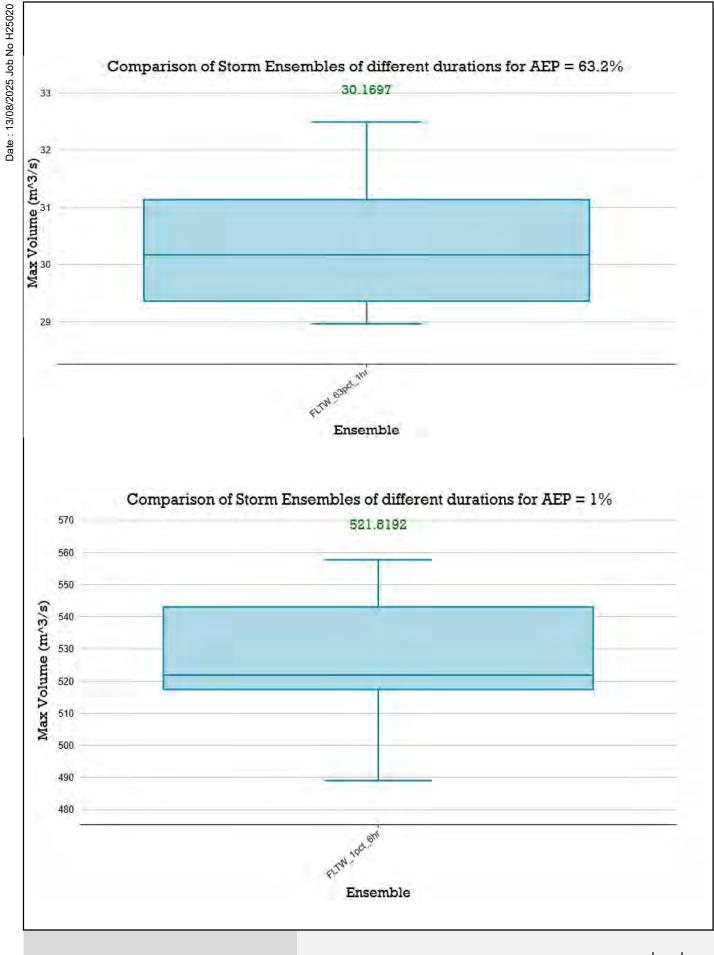
Estimated Runoff Rates

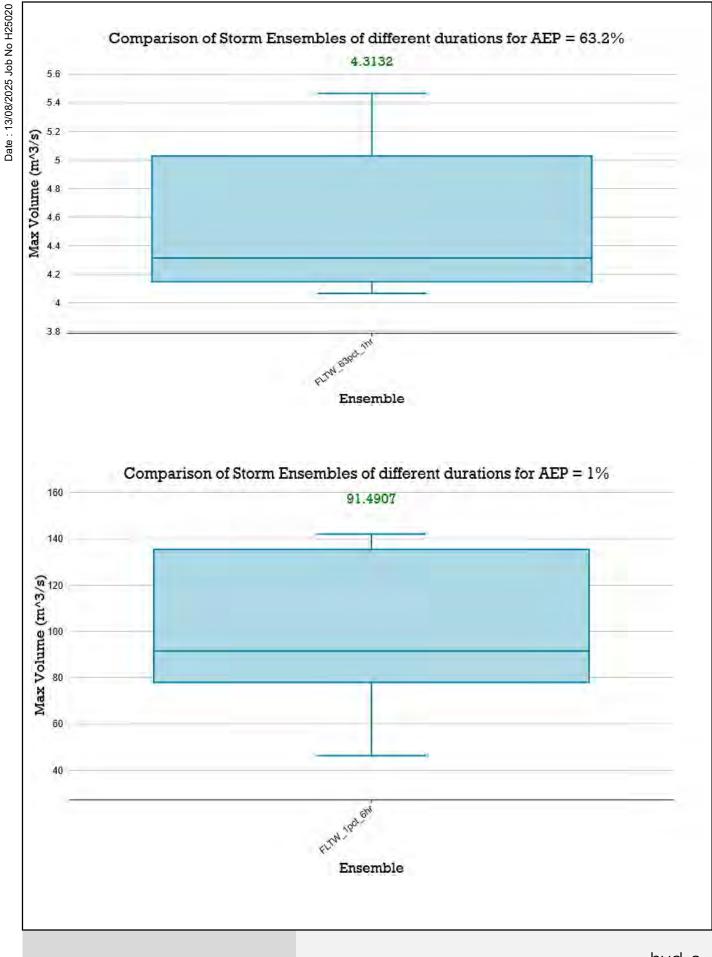
Annual Exceedence Probability

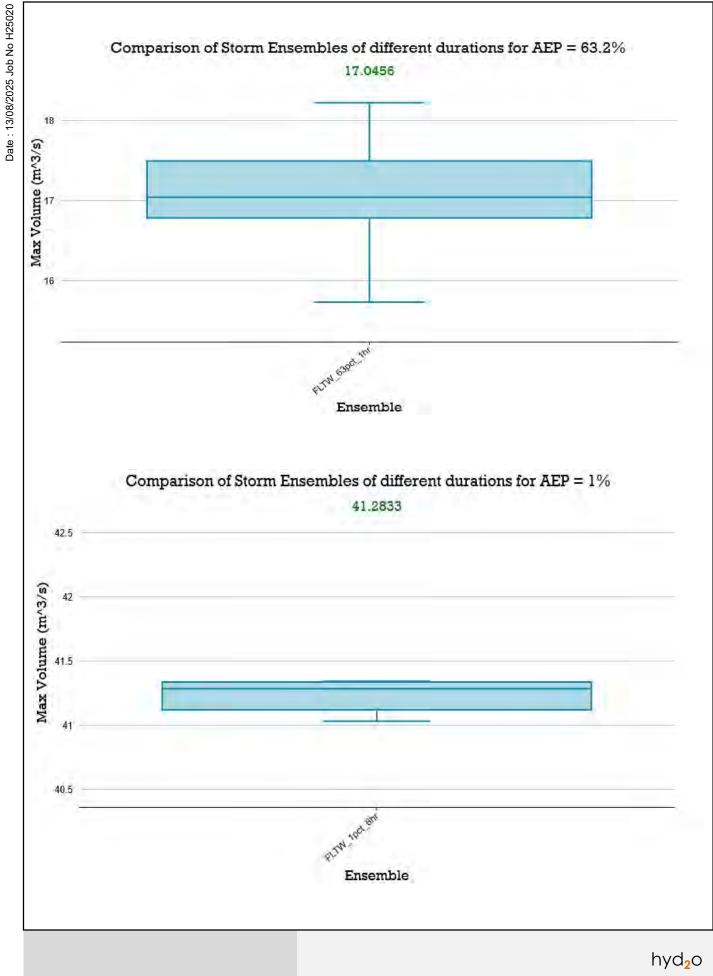
	63.2%	50%	20%	10%	5%	2%	1%
Maximum of All Events	1.00	1.44	4.48	10	20	50	100
Residential 300-600m2	6%	10%	20%	25%	29%	34%	37%
Local Roads	69%	69%	72%	76%	79%	82%	84%
Active POS	1%	1%	6%	9%	12%	14%	16%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	23%	25%	33%	38%	42%	45%	48%

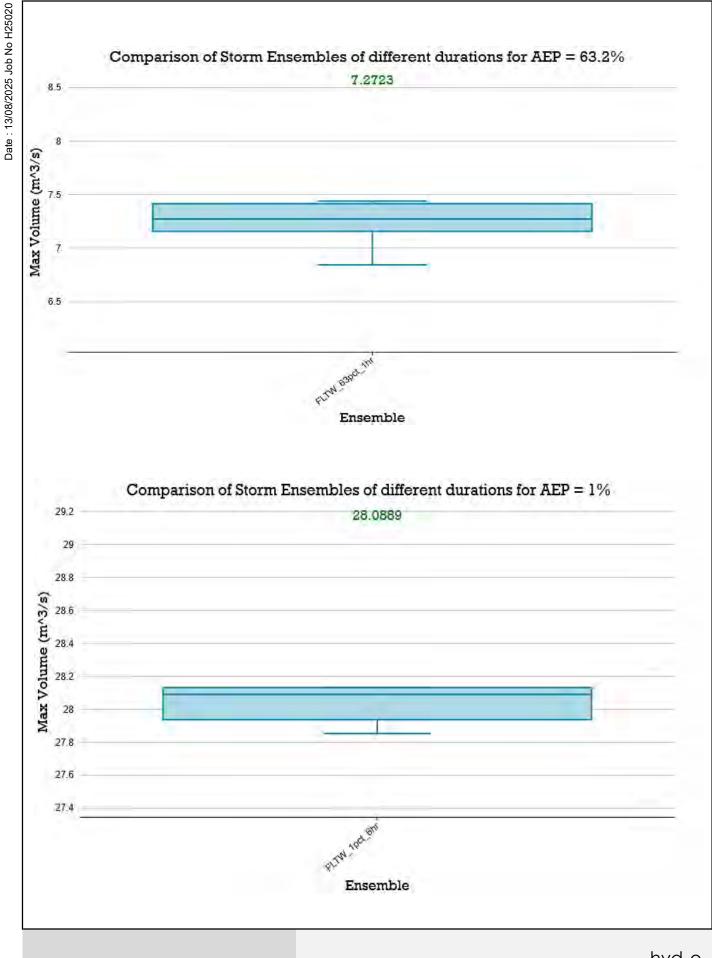
Event Selector	9	1 hour					
Residential 300-600m2	0%	3%	14%	20%	24%	29%	32%
Local Roads	64%	65%	68%	72 %	76%	79%	81%
Active POS	1%	1%	4%	7%	10%	12%	14%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	18%	20%	28%	33%	37%	41%	44%

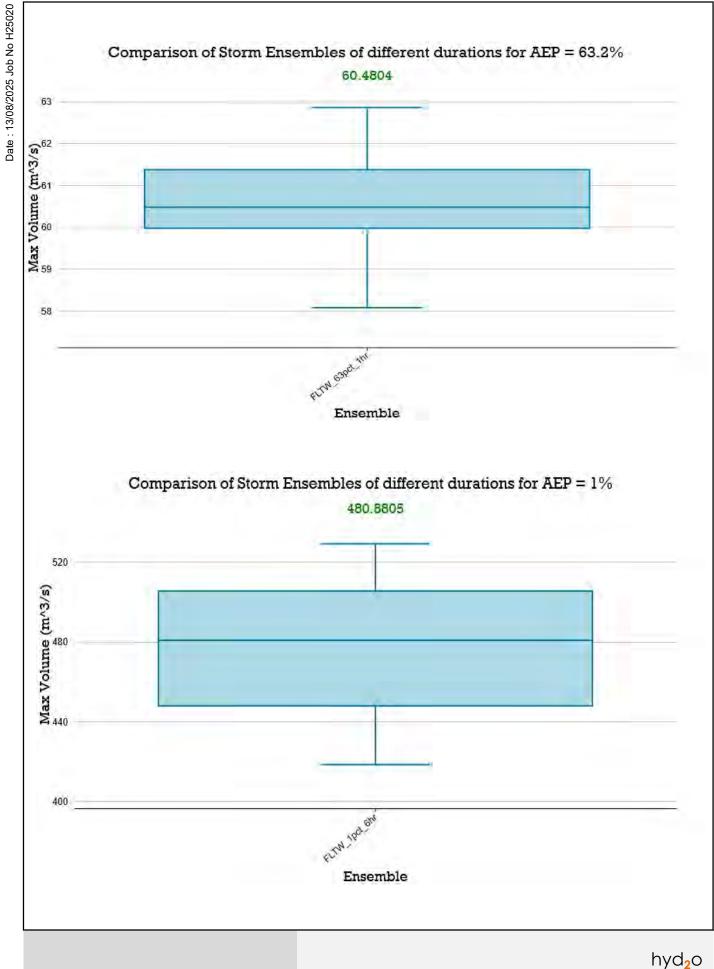
APPENDIX I XP-Storm Modelling Results











APPENDIX J

Conceptual Stormwater Basin Cross Sections

Note: Cross-sections are not to scale.

hyd₂o

Golden Bay LWMS

Stormwater Storage Cross Sections : Catchments 1 & 5

Appendix J

APPENDIX K

Earthworks Plan (Cossill & Webley Engineers)

