Riverlea

Workshop

Amendment to the Environmental Impact Statement and Response Document

28 August 2024

walker

What we heard from State Agencies

DEW

- **Assessing the impacts of the SWL over time.**
- **The analytical model (versus numerical modelling) is not currently considered sufficient to ascertain impacts outside of the site**

EPA

- **Modelling should be considered to determine the following.**
  - **If pumping regime is sufficient to maintain water quality across all seasons.**
  - **Summer evaporation rates (may require increased pumping).**
  - **Will evaporation rates lead to salt and nutrient accumulation within the SWL system.**
  - **What rain event levels may cause freshening of the SWL system to cause harm to established flora and fauna within the system.**
  - **Will 12hr pumping period be sufficient to maintain SWL system.**
  - **Can the SWL system be maintained under the worst environmental conditions?**
- **Clarification concerning the treatment plant and it is location**
  - **Clarification of the volumes and how wastewater would be managed and disposed of**
  - **Clarification concerning the chemical and/or biological treatment processes involved**

What we heard from State Agencies

- **Slower water movement means longer resident times within the lake system. While chlorophyll counts are low at Chapman Creek, this does not account for nutrient inputs from other sources such as:**

  - **Artificial roosting locations within the SWL system (as birds increase nutrient inputs directly / indirectly into the system)**
  - **Hydrocarbons and pollutants from stormwater inputs due to increased impervious surfaces.**
  - **Pigging of SWL system pipework**
  - **salt accumulation due to evaporation**

Secondary Licencing

- **Discharge to marine or inland waters containing chemical water treatments and of a total volume exceeding 50kL per day must be licensed under the *Environment Protection Act 1993*. Discharges to Thompson Creek may increase the temperature by more than 2 degrees at some point throughout the year; requiring licencing by the EPA regardless of the presence or absence of chemicals and discharge volume.**

- **Notwithstanding the SWLs will achieve secondary contact recreation standards, this water quality must also satisfy the *Environment Protection (Water Quality) Policy 2015, given it's* proposed discharge SWLs water to Thompson Creek outfall channel and ultimately the marine environment for 12 hours each day.**

The City of Playford accepts the responsibility of the ongoing monitoring and maintenance of the SWL and stormwater systems and infrastructure.

What we heard from the Council

- **Clarification of the preferred geomembrane liner system and why (longevity and leakage minimisation)**
  - ➢ **Clarification of the initial lake filling**
- **Clarification of the impact that stormwater entering the SWLs will have on the water quality**
  - ➢ **Clarification of pre-treatment and the need to restore/maintain salinity levels following a significant storm or flood event**
- **Cumulative impact of seawater extraction from Chapman Creek**
- **Clarification of highly saline intake water on lake and infrastructure**
- **Clarification concerning the clay lined outflow channel**
- **Clarification for a reduced flow rates turnover, rather than treatment in addition to high volumetric turnover rate**
- **Clarification (pros and cons) of treatment options:**
  - ➢ Chemical Dosing
  - ➢ Ultrasonic Algae Control
  - ➢ UV Irradiation
  - ➢ **Clarification how these different technologies affect aquatic fauna**
- **Clarification on Traffic Generation, Intersection Analysis and Modelling**
- **Clarification on the *Crown Lands Management Act 2009* process**
- **Consistency updates or deletion of figures, diagrams and models that been revised or made superfluous**

Riverlea - Saltwater Lakes System

Recreation and amenity

Water Quality to secondary water quality standards

Improved urban amenities

Assist with stormwater management

Focal point for the Riverlea development

Natural cooling effect of lakes

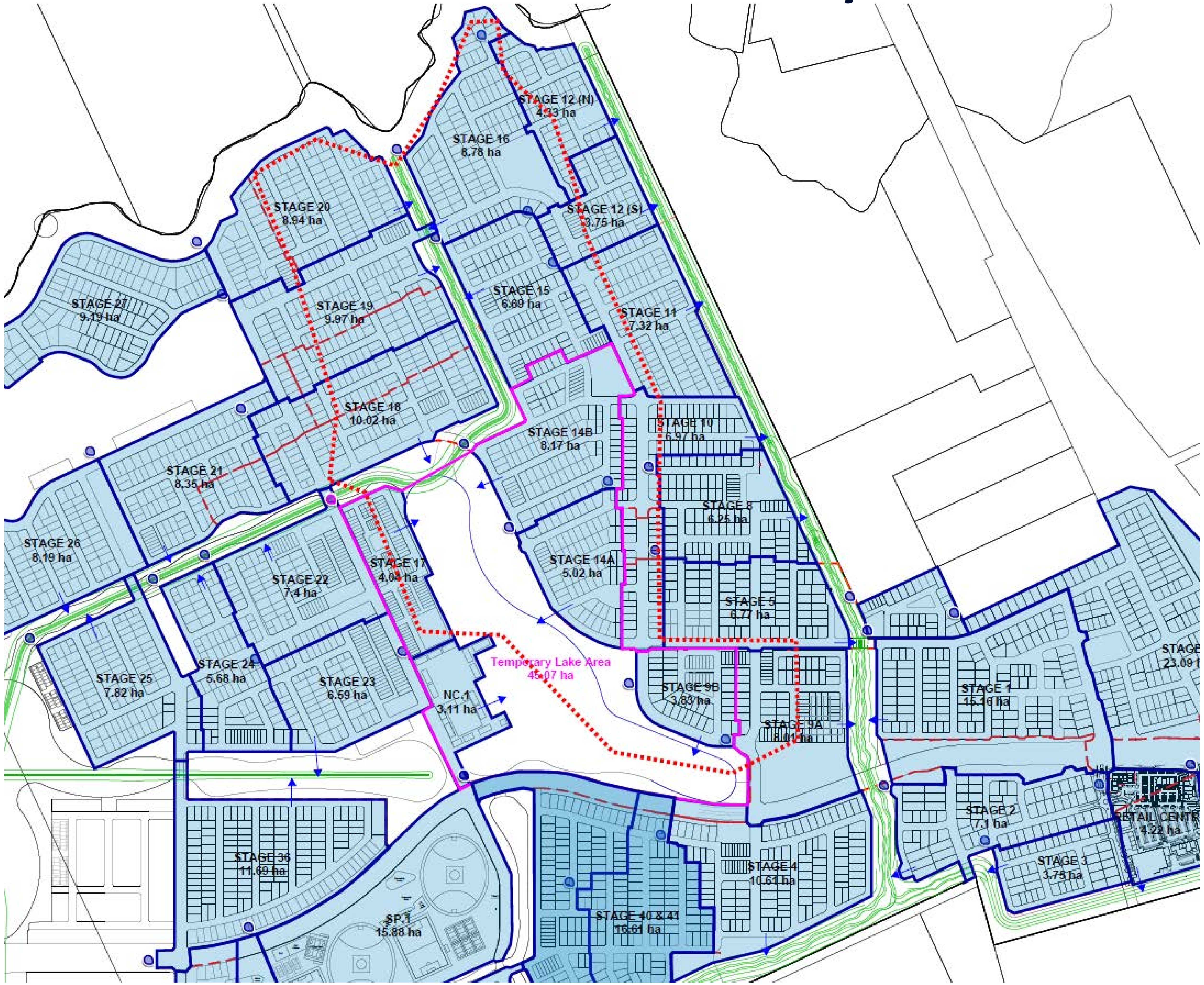
Riverlea

Riverlea - Saltwater Lakes System

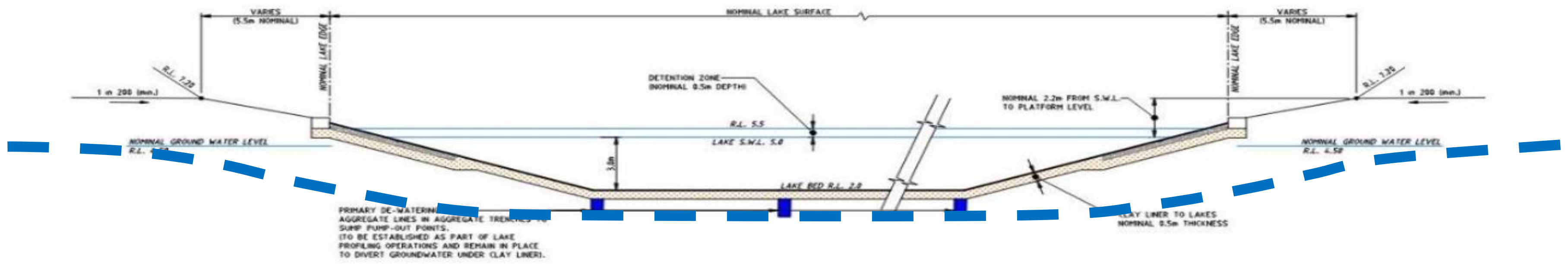
Stormwater and Flood Management

Primarily accommodates Stormwater flows as shown by the hatched red line

Accommodates very infrequent flooding break-outs from the Gawler River

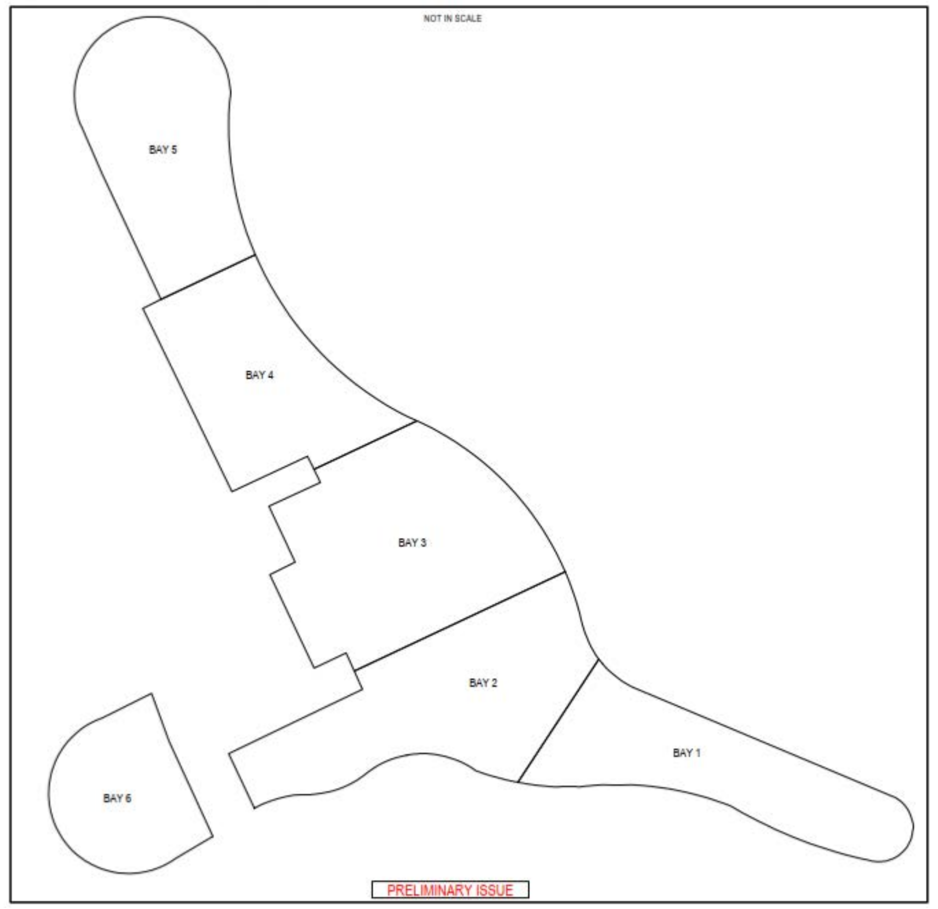


Design & Construction - Dewatering and Groundwater



Dewatering Investigation

- Hydrogeological characterisation of the groundwater system that will be affected by the lake construction works.
- Soil bores and investigation/monitoring wells
- Groundwater level monitoring
- Groundwater sampling and testing
- Slug tests and pump testing
- Hydrogeological modelling



Estimating Take of Groundwater

- Set target elevation for groundwater control
- Assess pumping rate to control groundwater to target elevation
- Construction methodology
- Construction Time

Impacts of Taking Groundwater

- Identify surrounding users of shallow groundwater
- Assess whether drawdown of groundwater adversely impacts existing users
- Dewatering wastewater storage/management/reuse/disposal

Riverlea

Design & Construction - Dewatering and Groundwater

Groundwater Modelling

Anaqsim model

- Analytic element model for simulating groundwater flow
- Can simulate multi-level aquifer systems
- Steady-state and transient flow conditions
- Uses subdomains, line elements, spatially-variable area sinks, and finite-difference time steps
- Riverlea model has over 4,000 equations, solved iteratively

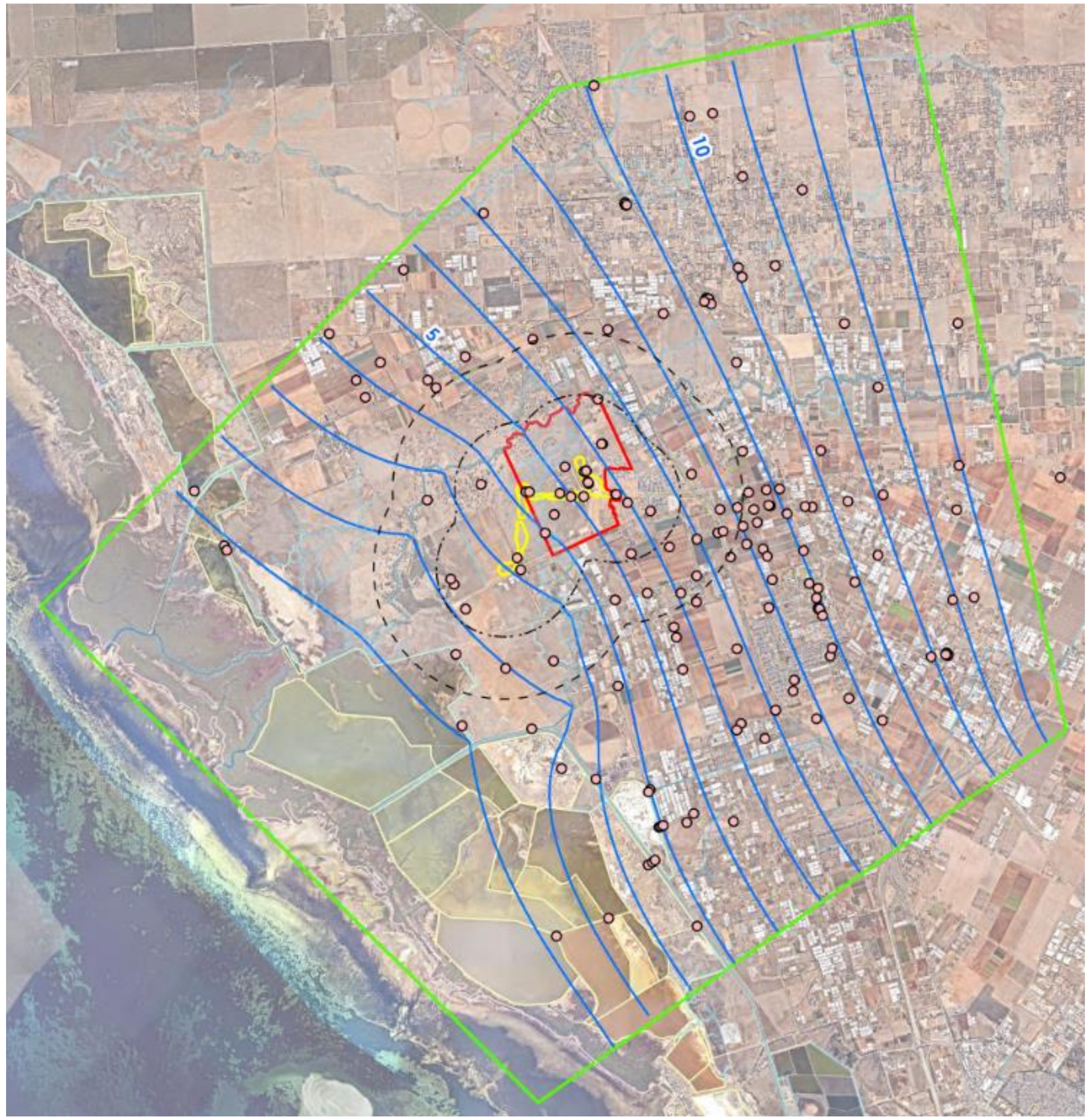
Modelling Strategy

- Collate groundwater level data since 2004 and develop contour plan
- Update model boundaries based on GW contours
- Update baseline model for acceptable match against GW contours
- Use updated model for transient dewatering simulations to assess:
  - Potential pumping rates
  - Simulated drawdown generally
  - Drawdown at locations of specific existing GW users
- Check sensitivity of model results to input parameters and assumptions

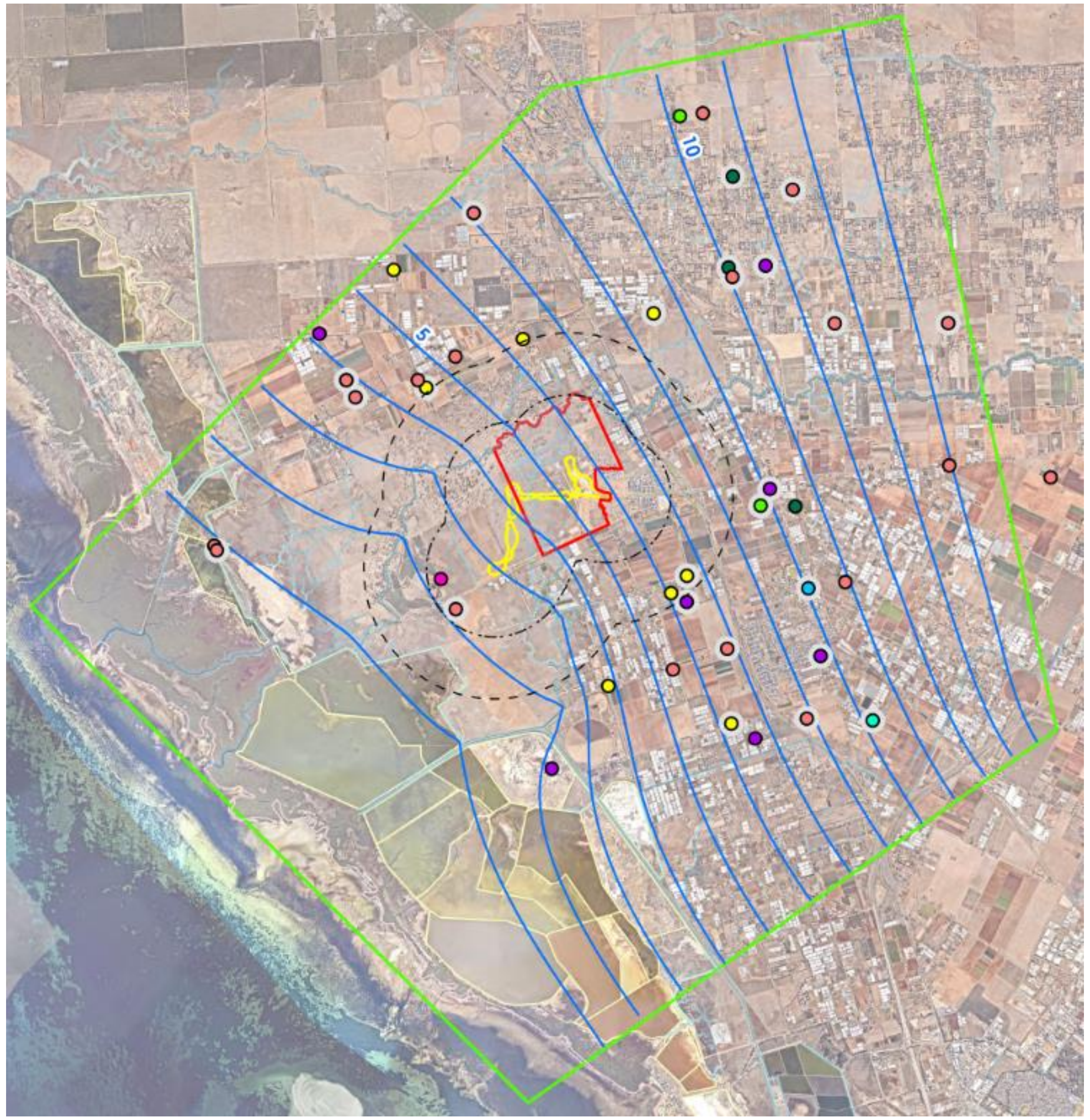
Trusted by Governments and Industry globally:

Design & Construction - Dewatering and Groundwater

All registered wells ≤15 m depth



Registered wells ≤15 m depth, excluding investigation/monitoring wells



Design & Construction - Dewatering and Groundwater

Dewatering Investigation Report Update

- **Respond to feedback from EPA and DEW**
- **Update presentation of groundwater modelling**
- **Update dewatering flow and volume calculations**
- **Provide assessment of simulated drawdown effects on surrounding users of shallow groundwater**
- **Update calculations of dewatering wastewater storage, reuse and disposal**

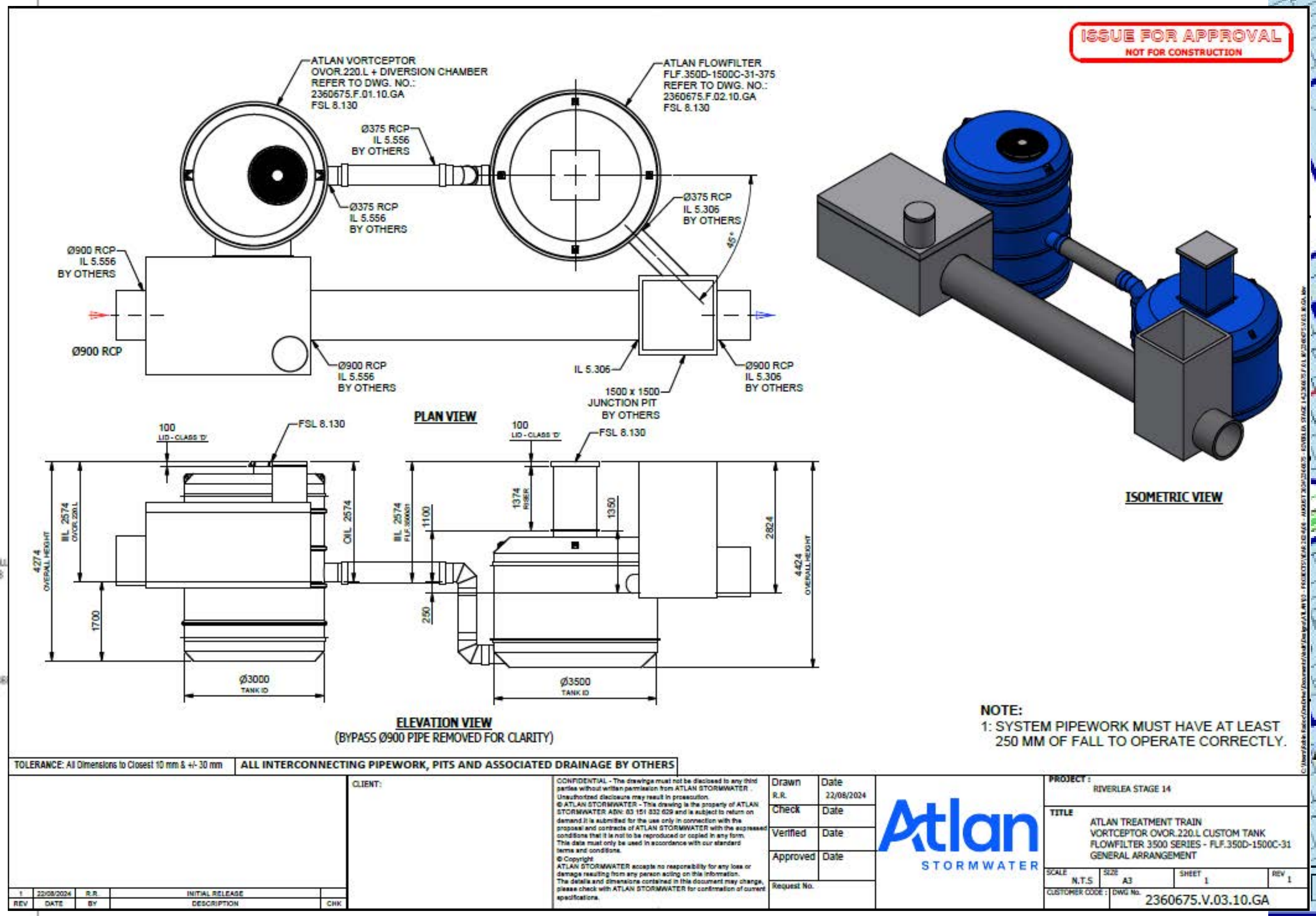
Dewatering Management Plan

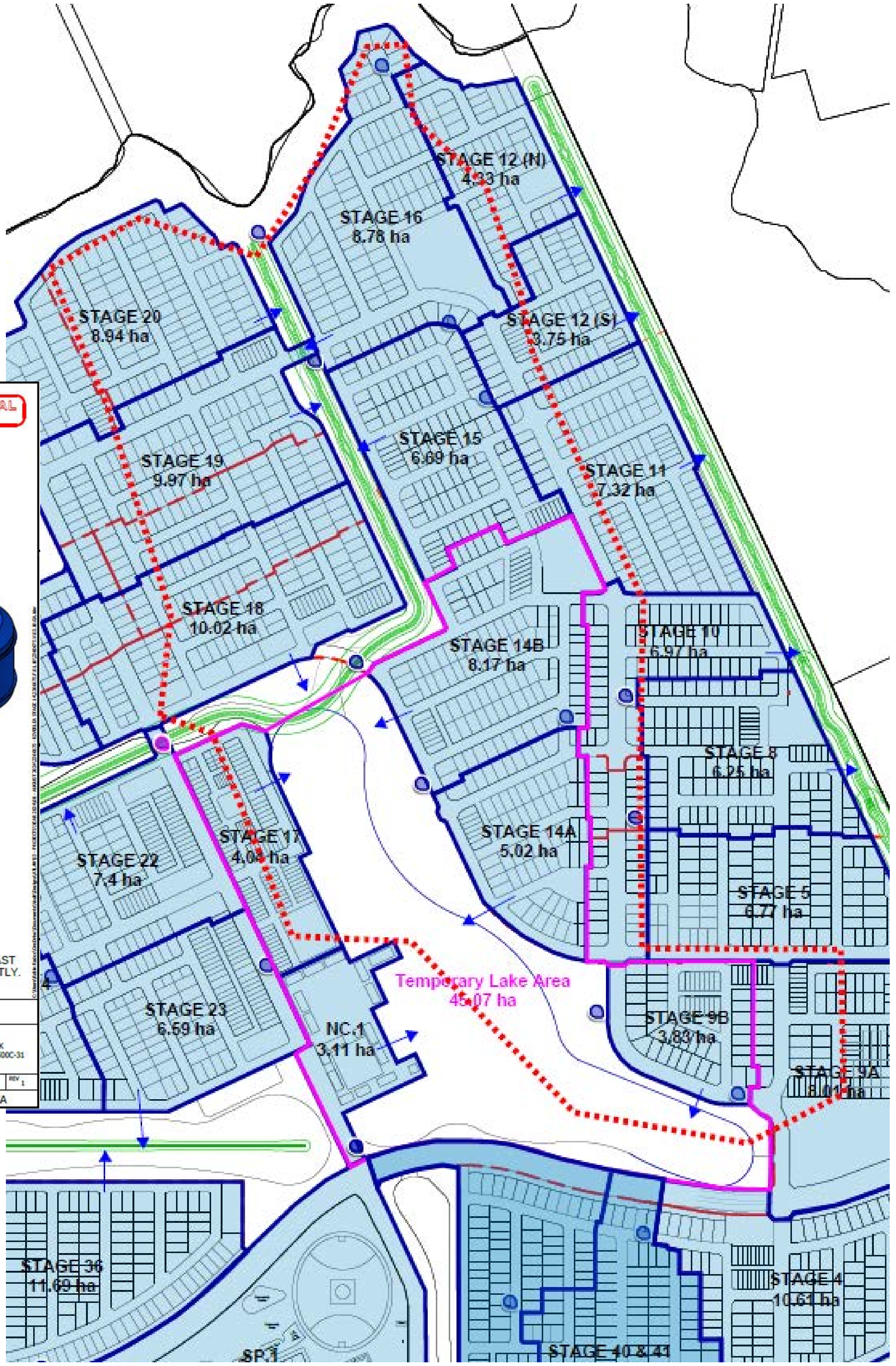
- **To be informed by detailed design and construction methodology**

Riverlea

Design & Construction - Atlan Stormwater Treatment System

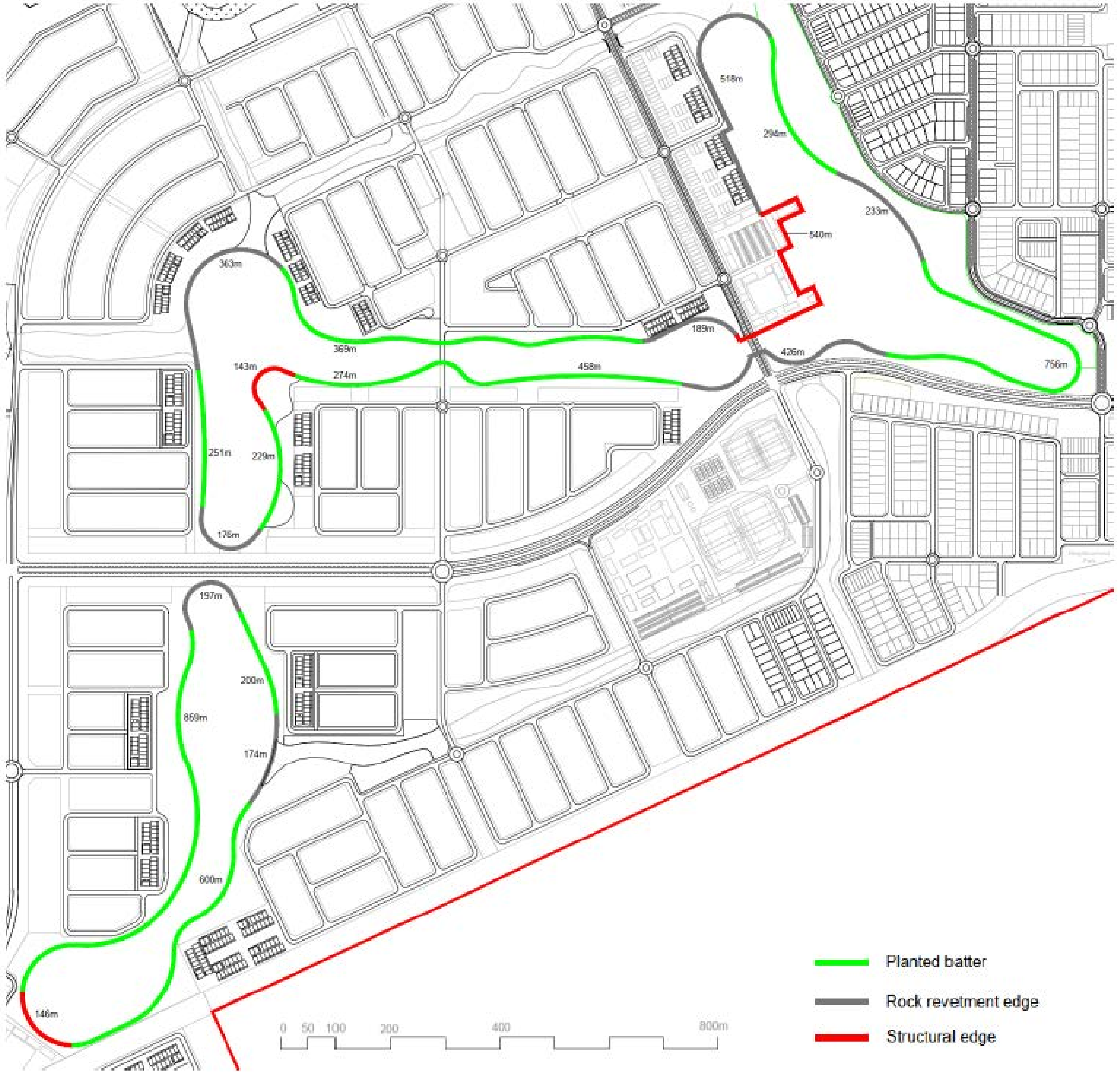
Atlan Stormwater Treatment Train
(Various stages & Neighbourhood Centre)

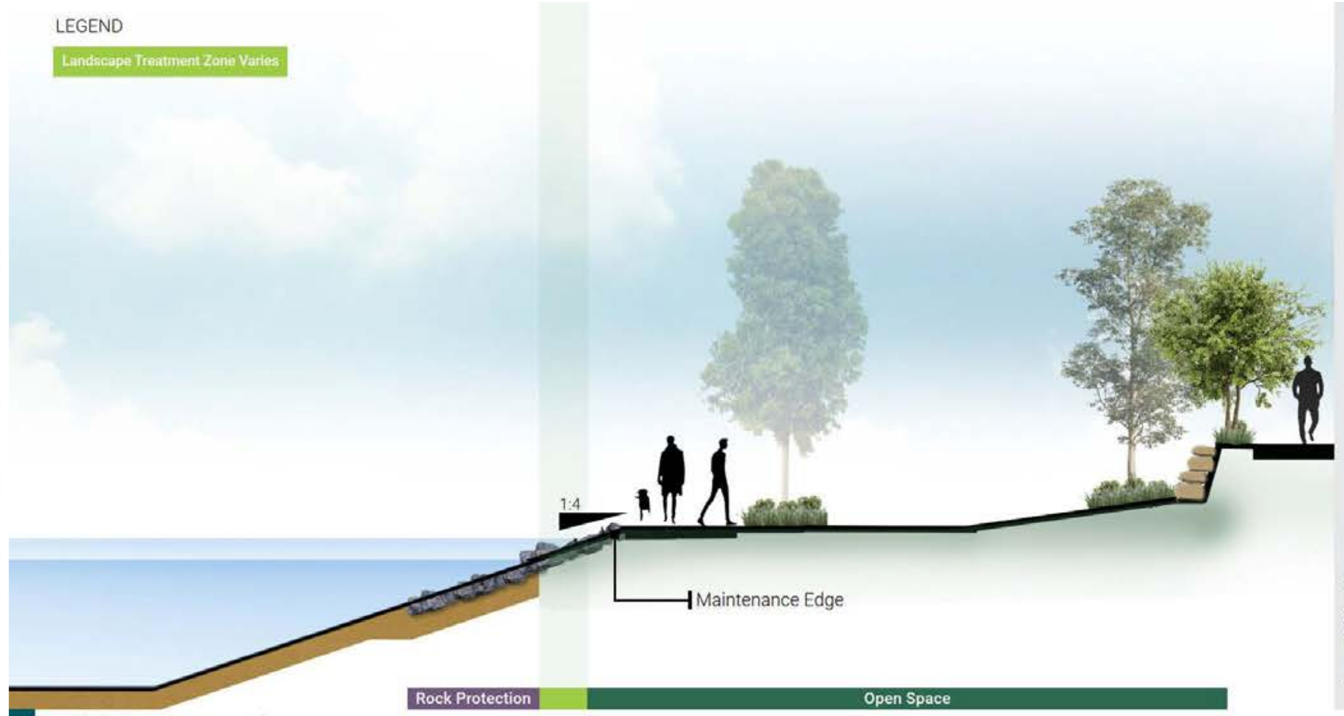




Riverlea

Design & Construction - Saltwater Lakes Edge Treatments





1 Rock Revetmenet Edge

Blue stone rock bedded within concrete to 200mm deep - 4m wide

Total= $200 per L/m

Planting preparation, 8 x 75mm tube stock, 300mm ameliorated site soil, 75mm mulch = $32 per m2
Tidal section is 4m wide

Total= $128 per L/m

Riverlea

Design & Construction - Saltwater Lakes Edge Treatments

5 Planted edge 'Salt Tolerant'

3 Structural Edge

6 Lake Rock Edge Protection to Engineer's Detail

.69 in dstone Revetment Edge

Riverlea

Design & Construction - HDPE Liner Details

<u>Liner Performance Considerations</u>

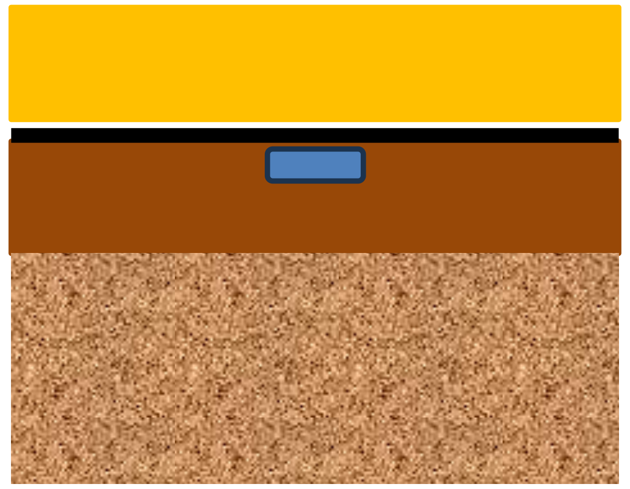
- Effective containment (acceptable leakage rate)
- Change over time (concern with clay in saline water)
- Life

<u>Liner System - </u>High density polyethylene (HDPE)

- Very good barrier (virtually impermeable and salt diffusion barrier)
- Durable (especially covered > no UV and lowers temperature)

- Long Life (more than 100 years to nominal failure)
  - Nominal Failure = loss of strength properties
  - Unstressed liner remains intact
  - Service life longer

- Available, understood and accepted in containment applications
  - Ponds and Dams
  - Landfills
  - Mining and CSG brine ponds



- Physical protection (soil)
- Liner (HDPE)
- Water & soil gas controls
- Clay (Reworked clay or GCL)

- Subgrade soils

Design & Construction - HDPE Liner Details

Leakage Rate (l/Ha/day)

- Only through holes (orders of magnitude lower than clay alone)
- Limited by composite action with clay and soil layers
- Function of
  - Frequency of defects
  - Hole size and composite action
  - Water level
- Field defect frequency and leakage rates available from US data

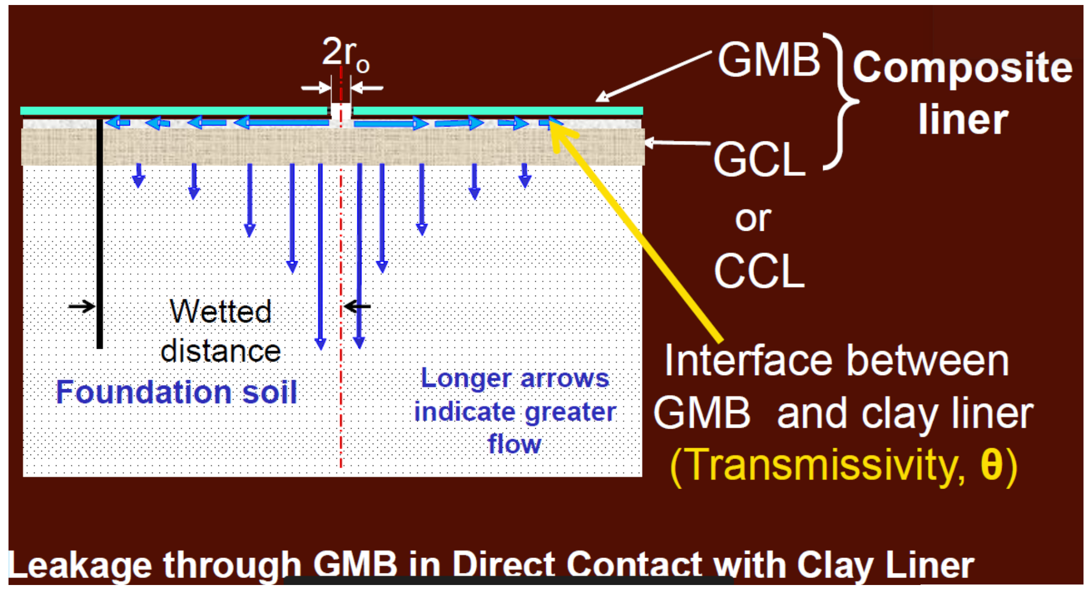
- Design leakage rate to achieve
  - Acceptable impact
  - Determine from modelling

Leakage Minimisation (holes and defects)

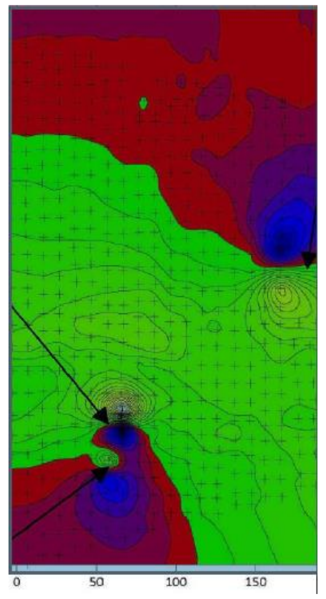
- Good design
  - Appropriate HDPE specification
  - Clay permeability and surface quality
  - Low stress
  - Physical protection
  - Uplift risk management

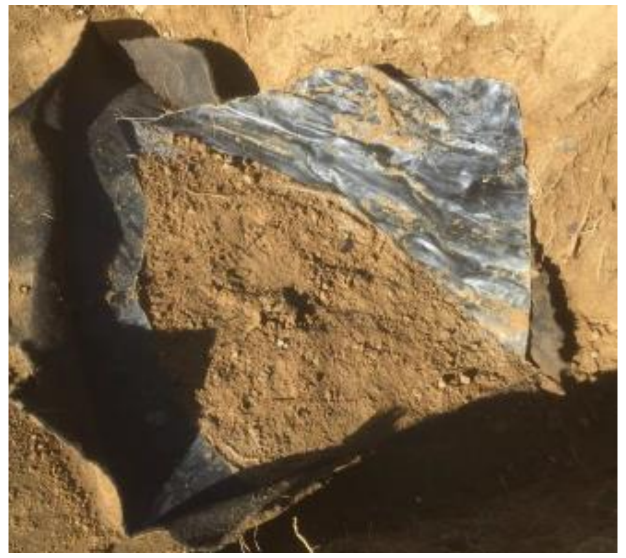
- Construction Quality Assurance

- Electrical Leak Location Surveys



Rowe (2019)

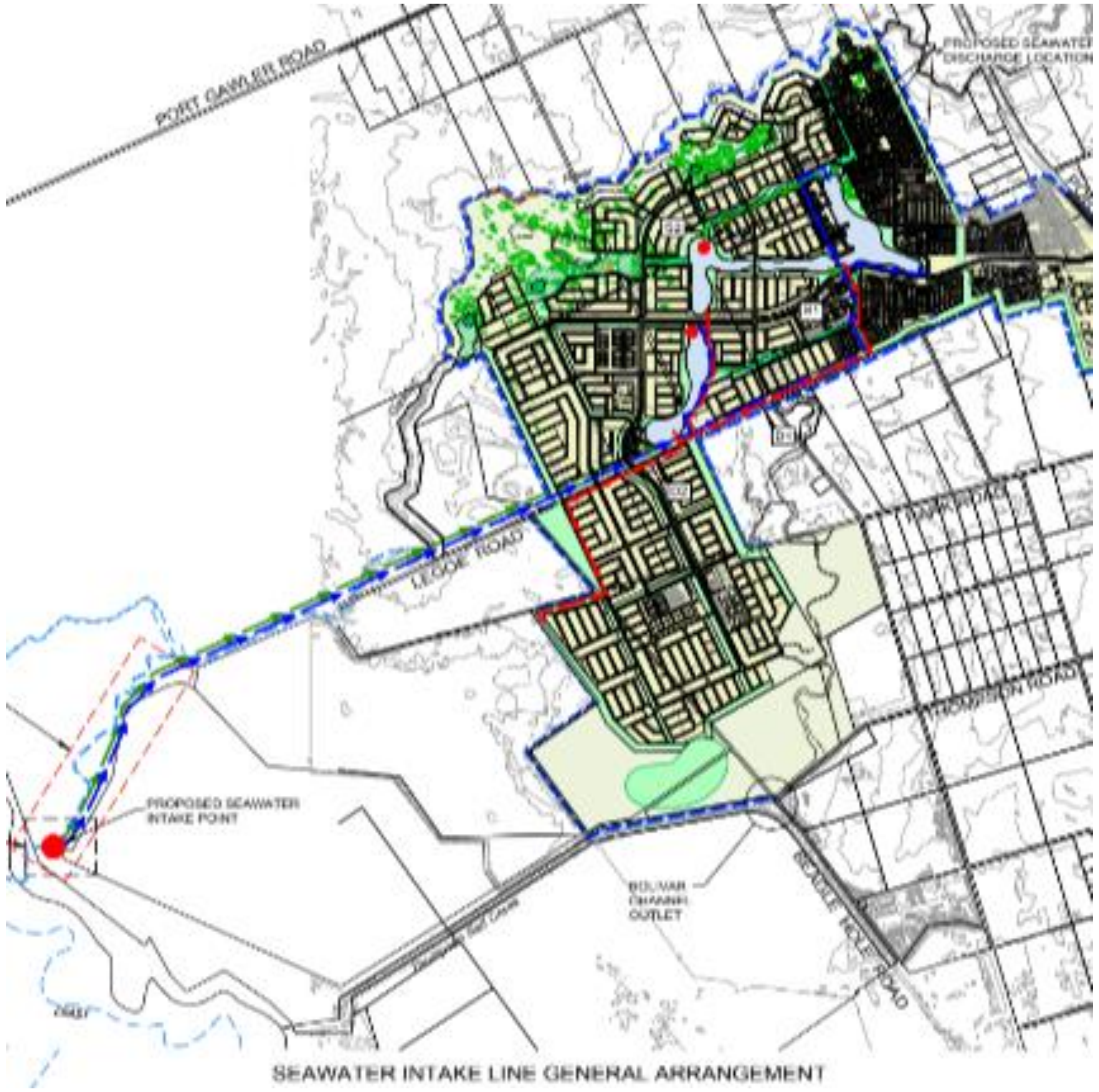


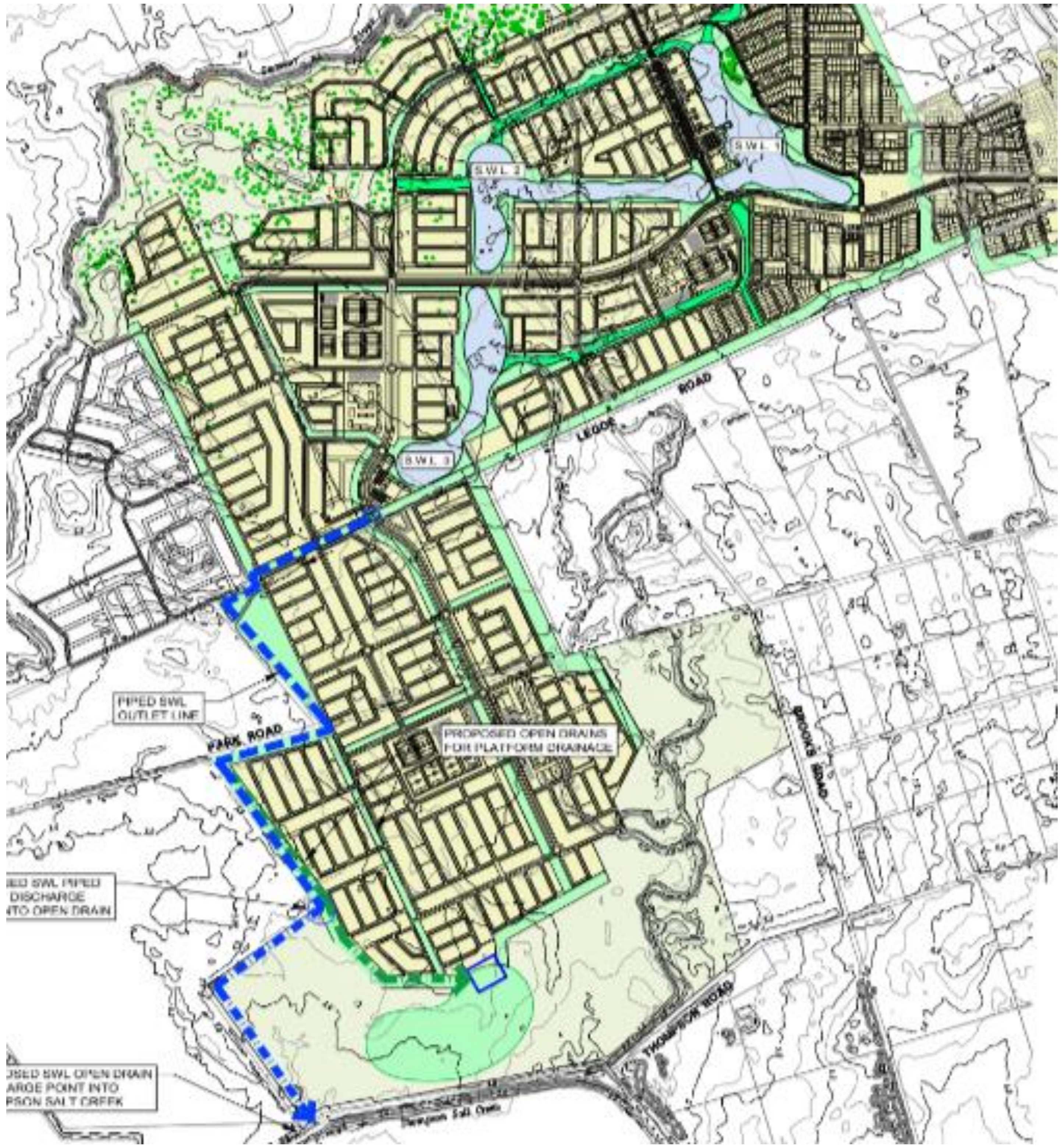


Riverlea

Operational - Saltwater Lakes System

Continuous Circulation





Riverlea

Operational - Lake Water Quality Modelling

1.0 Lake Water Quality Assessments

A two stage approach is proposed to demonstrate that the proposed Lake Concept Design is capable of delivering an appropriate water quality outcome for the lakes and receiving waters downstream of the lakes. Stage 1 proposes to utilise a deterministic Concept (black box) model and stage 2 proposes detailed hydrodynamic and water quality modelling. Stage 1 work is proposed to commence immediately to verify that the proposed lake circulation system and in lake treatment measures are robust and able to deal with all contingencies. This Stage 1work will inform the responses to The South Australian Government's and Council's request for further information.

Stage 1 – Concept (Black Box) Modelling
This modelling assumes a completely mixed water body. As the design intent is to have well mixed lakes, through circulation, diffuse inflows and, as a contingency, with the use of mechanical mixers and aerators, this assumption is reasonable, and will be validated by subsequent stage 2 detailed modelling work. Stage 2 modelling will require several months to complete and will follow on from the Stage 1 work.

Key inputs to the black box model are :

- Lake stage volume
- Inflow turnover supply rate including suspended solids concentrations
- Evaporation
- Developed site freshwater runoff
- Salinity level in the lake after initial filling
- Total nitrogen and total phosphorus levels in the lake after filling
- Chlorophyl 'a' initial lake concentrations

Modelling will assess lake salinity, nutrient levels and chlorophyl 'a' under a range of scenarios, including high salinity levels in supply water, under a large local runoff event, and during the hot dry summer period. The potential for hyper-salinity, eutrophication, low salinity after flooding and for sediment and algal deposition in the lake will be assessed.

This modelling will inform the refined lake management and Lake 1 Optimisation / Progressive Adaptive Strategy, as well as demonstrating that the proposed system is capable of delivering the desired water quality outcomes.

Operational - Lake Water Quality Modelling

Stage 2 - Detailed Hydrodynamic and Water Quality Modelling

Hydrodynamic and water quality modelling of the lakes is proposed utilising the Tuflow modelling system. Modelling will consider the range of pumping rates and times over a full tidal cycle and for the proposed hours of pumping each day. Both winter and summer months will be assessed. Model scenarios will include extended dry periods as well as significant rainfall runoff events, with a MUSIC model developed for the local site catchment runoff.

Water quality modelling will consider a range of supply water qualities, based on monitoring results to date. Parameters to be tested include nutrients, suspended solids, salinity, temperature and chlorophyl 'a'.

The hydrodynamic model will be a fine scale model of Lake 1 initially, and will be expanded to model all three lakes after additional monitoring of the Lake 1 Optimisation / Progressive Adaptive Management Strategy. The model will be designed to enable lake mixing and circulation to be assessed, including the effect of the proposed circulation measures. Wind mixing will also be considered as part of this stage of work.

This modelling will inform the detailed design for the lakes and management system, and will available as an on-going tool for use in managing the system, with refined calibration as more long term monitoring data becomes available.

2.0 Lake Aquatic Fauna Consideration

A healthy lake system will promote aquatic fauna. Based on our experience with other saline lake systems, benthic fauna, prawns, fish, crabs and other marine creatures are likely to establish in the lakes. To ensure their survival, it is important to avoid low oxygen levels, high sediment loads, algal blooms, total freshwater turnover and hyper-salinity. Screening on intake and pumping will limit the size of fauna entering, however larvae will still enter the lake system.

Based on research by Fisheries Research Consultants for Emerald Lakes on the Gold Coast, provided these factors are managed to appropriate levels, suitable environments for aquatic fauna can be achieved. With a shallow lake system as proposed, an option incorporated at Emerald Lakes was to construct localised deeper pools within the lakes, where, even in an extreme local freshwater runoff event, the lower sections remain saline as a refuge for fish and other aquatic fauna that is sensitive to salinity change. Fish will also move progressively downstream following the saline plume during a freshwater runoff event.

Monitoring of Lake 1 during the lake Optimisation / Progressive Adaptive Strategy should include surveys by an aquatic ecologist and their associated advice on management strategies for aquatic fauna will form part of the Strategy.

Operational - Water Quality & Treatment Options

Water Quality Treatment Options

Algaecide

Algaecide treatment is included at very low rates as a contingency treatment. Lake dredging is unlikely to be required over the project's life, given low sediment concentrations in the seawater supply and the pre-treatment from site runoff. The algaecide Earthtec proposed is dosed at very low dose rates at between 60-240ugCu/L, and its formulation allows the copper to disperse in the water column quickly and not precipitate quickly. This delivers significant reduction in dosage and frequency of treatment significantly compared to traditional use of copper sulphate at 2000-5000ugCu/L which principates within 1-3 days. Whilst the copper will ultimately precipitate into sediments, mass loads are not likely to result in significant copper concentrations in sediments.

Mixing and ultrasonic systems

The system proposed to be trialled for SWL1 uses solar power. Contingency backup arrangements of additional horizontal and vertical mixing systems are proposed and can be fine-tuned if needed in the Phase 1 (SWL1) stage of development.

Sediment removal

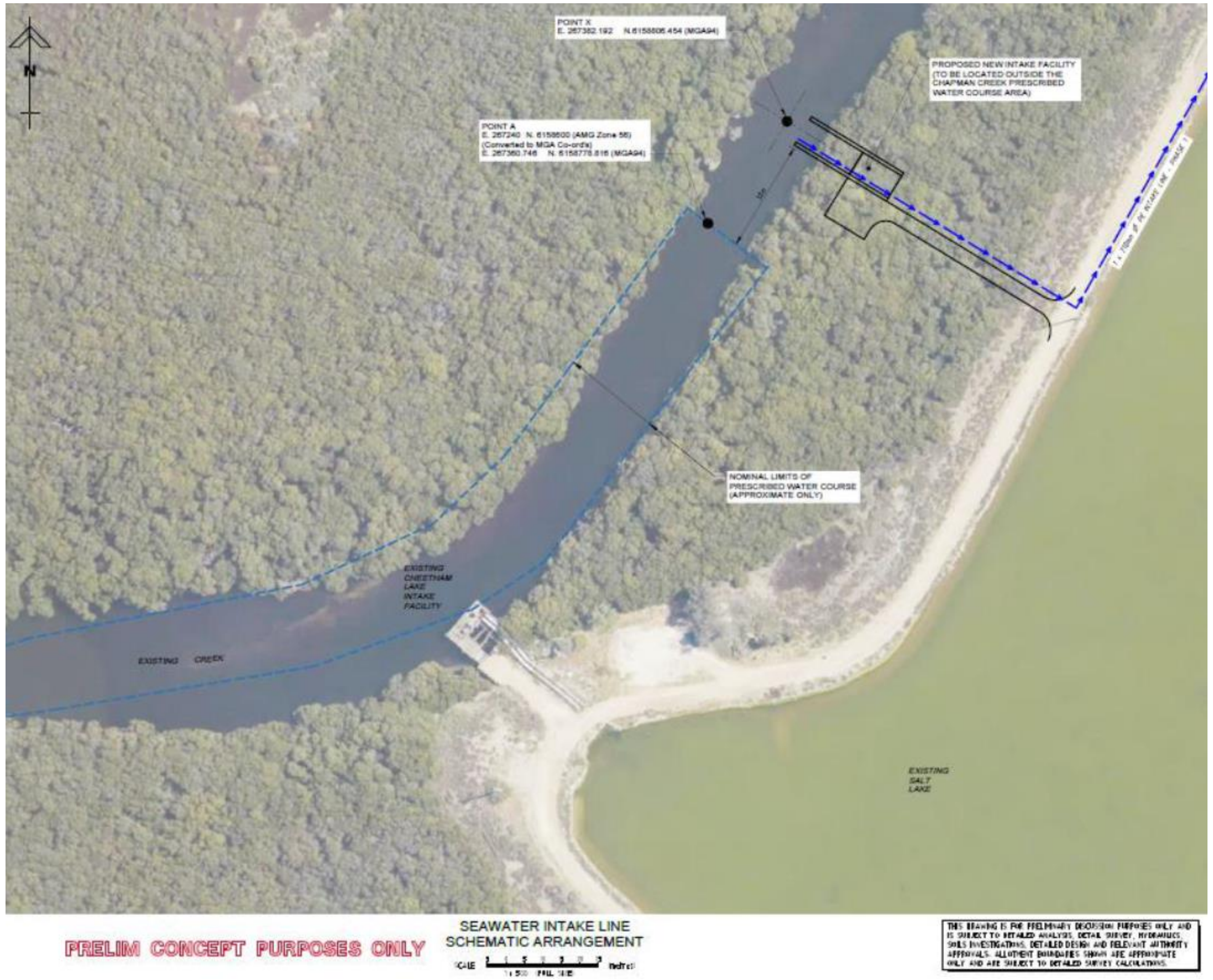
Sediment removal is a preferred option in terms of lake aesthetics and quality and to ensure lake dredging in the future is not required. The proposed nutrient and algal management measures are extensive, with multiple contingencies. The filtration of the water will remove algae and organic (non-soluble) nutrients and insoluble inert solids that would otherwise cycle in the lake water, adding to soluble nutrients as they break down under reductive decomposition in otherwise deposited sediments.

Injecting a high salt dose

There is cheap raw salt available in the adjacent area. Initial assessments indicate a one-off dose for an emergency is feasible.

Operational - Chapman Creek Intake

Subject to a Crown Application to be considered concurrently with AEIS



- **The Ponds adjacent Chapman Creek are presently in a holding pattern.**
- **The BRC pumping facility maintains adjacent ponds levels for environmental purposes rather than for its mining operations.**
- **It is forecast that the Chapman Creek pumps only pump approximately 2.2GL of the allocated 65GL of their current water allocation under their licence. And therefore the modest pumping proposed will not impact adversely on the environment or the BDC salt mining operations.**
- **Location is in an area that has the least impact (and approved under the Native vegetation Regulations).**
- **The Chapman Creek intake pumping station and associated pipework must maintain sufficient bunding capacity to prevent fuel and lubricants from entering the marine environment.**

Riverlea

Operational - Pond Lakes Holding Pattern

Dry Creek Salt Field PEPR Revision 4 v.1 Part 3 - Sept 2020 — 9 September 2020

BDC - Chapman Creek Intake (Environmental)

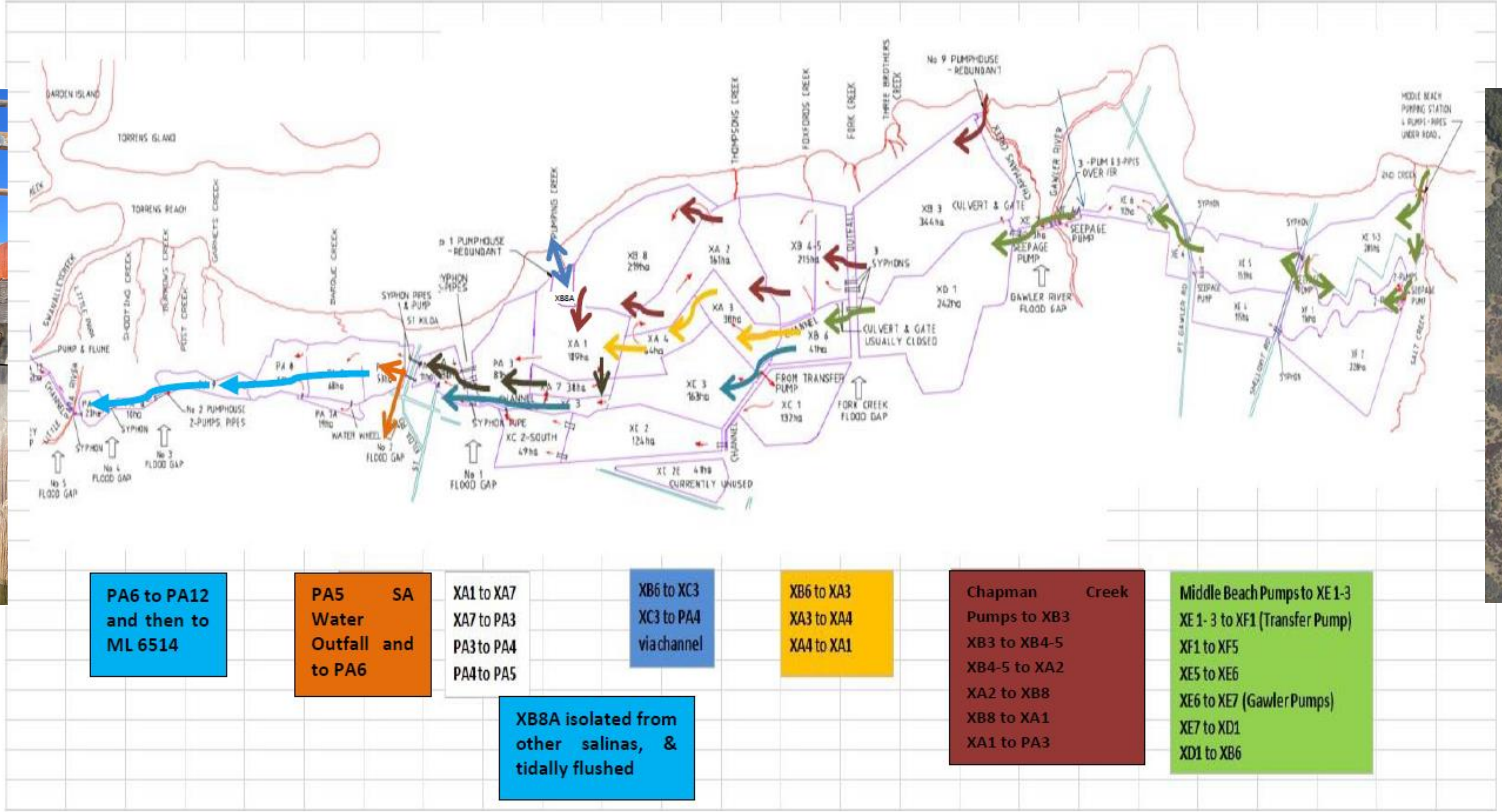


Figure 15-10: Pond layout and Holding Pattern water flow paths

BDC- Middle Beach Int (Operational)

Riverlea

Other Issues - Costs (Capex and Opex)

RIVERLEA MASTERPLANNED RESIDENTIAL DEVELOPMENT - Propose Saltwater Lakes Circulation and Treatment Management

PRELIMINARY COST ESTIMATES FOR BOTH THE CAPITAL AND OPERATIONAL EXPENDITURE (based on average costs)

				Cumulative Costs						
		SWL Costs		SWL 1 Costs (Phase 1)		SWL 1 + 2 (Phase 2)		SWL 1 + 2 + 3 (Phase 3)		Comment
		Capex Costs	Opex Costs	Capex Costs	Opex Costs	Capex Costs	Opex Costs	Capex Costs	Opex Costs	
SWL 1	**Primary Circulation**	$ 9,797,680	$ 136,763	$ 9,797,680	$ 136,763					
	WTP	$ 7,390,000	$ 220,000	$ 7,390,000	$ 220,000					
		$ 17,187,680	$ 356,763	$ 17,187,680	$ 356,763					
SWL 2	**Primary Circulation**	$ 545,060	$ 53,525			$ 10,342,740	$ 190,288			
	WTP	$ 160,000	$ 221,000			$ 7,550,000	$ 441,000			
		$ 705,060	$ 274,525			$ 17,892,740	$ 631,288			
SWL 3	**Primary Circulation**	$ 346,500	$ 27,562					$ 10,689,240	$ 217,850	
	WTP	$ 160,000	$ 210,000					$ 7,710,000	$ 651,000	Possible Savings Dependent upon WTP 1 delivering spare circulation water for SWL 3 Circulation, with limited treatment.
		$ 506,500	$ 237,562					$ 18,399,240	$ 868,850	
								-$ 160,000	-$ 210,000	
		$ 18,399,240	$ 868,850							

Riverlea

Other Issues - Flooding

Flood Modelling

Legend

Depth, m

- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2.5
- 2.5 - 5
- Greater than 5

Riverlea

Other Issues - Future Traffic Generation

- **Due to there being only one entry/exit to and from Riverlea, the traffic volumes generated by Precinct 3 affect the intersection designs and the capacity of Riverlea Boulevard. Critically, without a broader understanding of total traffic volumes, regardless of timing, it is critical to ensure that all proposed "ultimate" intersection designs can be implemented at the appropriate time, and that there is land available, and that there are no unforeseen costs on Council assuming that the "initial" intersection layouts have been vested to Council, prior to the "ultimate" designs being required.**

Walker

- **Consistent with PB's 2009 findings (refer to Section 8.1 - Site access strategy), traffic capacity calculations for the main access intersection at Port Wakefield Highway suggest that the proposed at-grade intersection will perform adequately for 10 years into the construction program.**

- **Walker can monitor traffic performance over this time. When performance falls short of acceptable service levels, Walker must consider options to provide safe and efficient access and egress to the area.**

- **Options include possible connections to, and construction of, a second at-grade intersection (not likely expected until almost 10 years into the construction program).**

- **Walker is investigating a structure planning exercise looking at options for a secondary access point from the Riverlea Park/Buckland Park areas the pending early release of:**

➢ **the Greater Adelaide Regional Plan (GARP) findings presently proposed to be brought forward in early 2025; and**

➢ **undertaking a peer review of all works undertaken to date on this issue.**

Riverlea

walker

Government
of South Australia

AUTHORISATIONS UNDER SECTIONS 21, 23 AND 29(1)(B) OF THE *ABORIGINAL HERITAGE ACT 1988* (SA)

On 13 March 2023, Walker Buckland Park Developments Pty Ltd (**Applicant**) sought authorisations under sections 21, 23 and 29(1)(b) of the *Aboriginal Heritage Act 1988* (SA) (**Act**) to facilitate the construction of a master-planned residential housing development with retail and commercial areas, schools, sports fields, lakes, reserves, stormwater management, and related services (**Project**). All terms used in this instrument are as defined in the Act (as amended from time to time), unless stated otherwise.

Authorisation Area

The authorisations are sought over multiple land parcels comprising approximately 566 hectares of land west of Port Wakefield Road and south of the Gawler River, in the suburb of Riverlea Park (**Authorisation Area**).

The Authorisation Area is shown bounded in yellow at Attachment 1. A list of coordinates for the Authorisation Area is at Attachment 2. To the extent of any inconsistency, Attachment 2 prevails.

Aboriginal Heritage

Known Aboriginal heritage

The Authorisation Area is known to contain and intersect extensive Aboriginal sites, objects and remains (together, **Aboriginal heritage**), as summarised in the table below:

Site Number	Name	Type/Description	Site Status
6628-7788	Buckland Park Archaeological Site 2	Archaeological	Listed
6628-7792	Buckland Park Artefact Scatter 1	Archaeological	Listed
6628-7791	WAL01-003	Culturally Modified Tree (**CMT**)	Listed
6628-7793	WAL01-006	CMT	Listed
N/A	CMT-01	CMT	Reported
N/A	CMT-02	CMT	Reported
N/A	CMT-03	CMT	Reported
N/A	CMT-04	CMT	Reported
N/A	CMT-05	CMT	Reported
N/A	CMT-06	CMT	Reported
N/A	CMT-07	CMT	Reported
N/A	Kadlitparri (Wild Dog River)	Cultural/anthropological	Reported

N/A	Burial Location 1	Burial	Reported
N/A	Burial Location 2	Burial	Reported
N/A	AAR ID# 174 (formerly HIMA#1)	Area of high archaeological potential	Reported
N/A	AAR ID# 175 (formerly HIMA#2)	Area of high archaeological potential	Reported
N/A	AAR ID# 176 (formerly HIMA#3)	Area of high archaeological potential	Reported

Authorised Activities

Authorisations under sections 21 and 23 of the Act were sought to facilitate the Project within the Authorisation Area, which proposes the following:

1. activities associated with the construction and ongoing maintenance of, or improvements to, houses, residential, retail, sporting and commercial precincts, schools, lakes, reserves, drainage channels and various other services, infrastructure and elements required to support the master-planned development
2. earthworks to facilitate the above, including:
    - stripping of topsoil
    - excavation
    - trenching
    - placement of excavated fill material
3. ancillary works that may be reasonably required to complete the Project
4. excavating, trenching, uncovering, exposing, removing, salvaging, collecting, storing, relocating, reburying and otherwise handling and managing Aboriginal heritage, where reasonably required to complete the Project.

(1 to 4 together being **Project Activities**).

In addition to the Project Activities, authorisations under sections 21, 23 and 29(1)(b) of the Act have been sought to allow archaeological and other scientific research analyses of Aboriginal sites, object, or Aboriginal remains (or parts of them) within the Authorisation Area (**Archaeological Samples**), to remove Archaeological Samples from South Australia, and to conduct destructive and non-destructive analyses on them (together, **Research Activities**).

Having considered the application and the outcomes of a consultation process undertaken on my behalf in accordance with section 13 of the Act, I, the Hon Kyam Maher MLC, being the Minister for Aboriginal Affairs and responsible for the Act, make the following authorisations:

Section 21, 23 and 29(1)(b) Authorisations

Pursuant to sections 21, 23 and 29(1)(b) of the Act, and subject to the conditions set out below, I hereby authorise the Applicant and the other parties described below to:

1. excavate land for the purpose of uncovering any Aboriginal site, object or remains
2. damage, disturb or interfere with any Aboriginal site
3. damage any Aboriginal object
4. where any Aboriginal object or remains are found:
    (i) disturb or interfere with the object or remains
    (ii) remove the object or remains

5. remove any Aboriginal object from South Australia,

in each case where reasonably necessary to undertake either Project Activities or Research Activities (together, the **Authorisations**).

These Authorisations extend to the following people and entities to the extent that any of them reasonably carry out any Project Activities within the Authorisation Area, or any Research Activities (together, the **Authorised Parties**):

1. the Applicant
2. subsidiaries and related corporate entities of the Applicant and its legal successors
3. private contractors and any other persons employed by or on behalf of the Applicant, its subsidiaries and related corporate entities
4. any corporate entities and their employees, agents, students, and volunteers engaged to undertake Research Activities
5. South Australian Water Corporation and its employees, agents, advisors, contractors, and subcontractors
6. employees, agents, contractors, and subcontractors of Crown instrumentalities and statutory authorities, and any administrative units associated with them
7. the City of Playford and its employees, agents, contractors, and subcontractors
8. current owners, lessees or occupiers, or future owners, lessees, or occupiers of houses, land, retail and commercial premises, schools, or sports facilities in the Authorisation Area
9. employees, agents, advisors, contractors, subcontractors, representatives, and volunteers of the people or entities listed in 1-8 above.

Duration of Authorisations

The Authorisations commence from the date of this instrument and expire **twenty-five (25) years** after that date.

Conditions of Authorisation

In accordance with my powers under section 14 of the Act, I impose the following conditions upon the Authorisations granted in this instrument:

General

1. Authorised Parties remain subject to any obligations that they may have under the Act (as amended from time to time) and any other applicable legislation not otherwise addressed in the Authorisations.
2. Where any Aboriginal heritage is discovered anywhere within the Authorisation Area, an Authorised Party must comply with the *Riverlea Park Development – Aboriginal Heritage Discovery Protocols* (Attachment 3).
3. An Authorised Party must engage an archaeologist to oversee the excavation and recording of any Aboriginal sites or remains discovered within the Authorisation Area.

Kaurna Cultural Heritage Management Plan (KCHMP)

4. An Authorised Party must ensure that the KCHMP for the Project is updated if required to make it consistent with the Authorisations, and thereafter provide copies of the amended KCHMP to the Kaurna Yerta Aboriginal Corporation RNTBC (**KYAC**) and Aboriginal Affairs and Reconciliation (**AAR**).
5. Where the KCHMP is inconsistent with the Authorisations, the terms of the Authorisations prevail to the extent of any inconsistency.

Management of Burial Location 1

6. An Authorised Party must:
   a) ensure that all known or discovered in-situ Aboriginal remains within Burial Location 1 (that area shown in blue at Attachment 4) are retained in their current locations, and are not subject to further excavation or any destructive scientific analyses
   b) as far as reasonably possible, in cooperation with, and in a manner that is culturally acceptable to, KYAC, return to and rebury within Burial Location 1 all Aboriginal remains previously removed from it, in locations as close to their discovery locations as possible
   c) after using best endeavours to seek to co-design it with KYAC, create a memorial Resting Place for Aboriginal remains (and if agreed by KYAC, other heritage) at Burial Location 1
   d) not conduct any Project Activities or Research Activities within Burial Location 1, other than in compliance with the Authorisations.

Note: Subject to Condition 6(a), prior to burial or reburial occurring, and subject to KYAC's agreement, no condition in the Authorisations requiring burial or reburial within Burial Location 1 prevents:

- *the collection of samples from remains for the purpose of **Research Activities**, including for their removal from the state for destructive analyses*
- *non-destructive Research Activities on remains undertaken either inside or outside of the Riverlea Park Development Master Plan Area.*

*Note: Any references to **contacting KYAC** in the Authorisations mean contacting KYAC's nominated contact person(s) (or the person(s) acting in that position/s) from time to time. Any references to **KYAC's agreement** in the Authorisations mean the written agreement of the KYAC Board given in accordance with the corporation's rules and procedures for decision making.*

Ongoing management and maintenance of Burial Location 1 (Resting Place)

7. The Applicant must, after consulting with KYAC as reasonably required from time to time, ensure the Resting Place is maintained in good order and kept free from damage, defacement, rubbish, or vermin for the duration of the Authorisations.

Management of Burial Location 2

8. An Authorised Party must:

   a) determine the extent of the Aboriginal remains at Burial Location 2 in accordance with the process set out in the *Method for Delineation Works* (Attachment 5)

   b) follow the *Method for Managing Aboriginal Remains* (Attachment 6) for all Aboriginal remains identified at Burial Location 2.

*Note: The area depicted in teal at Attachment 7 is the initial **'Discovery Zone'** for the purposes of Step 2 of the Method for Delineation Works. Additional Discovery Zones may be created in accordance with Step 5 of the Method for Delineation of Works.*

Management of specified known heritage areas

9. Prior to carrying out any Project Activities in any parts of the areas identified as AAR ID# 174 (formerly HIMA #1), AAR ID# 175 (formerly HIMA #2) and sites 6628-7788 and 6628-7792 (shown on the map at Attachment 1), an Authorised Party must:

   <u>Surface heritage inspection and collection</u>

   a) engage an archaeologist, and make an offer in good faith to KYAC to engage an adequate number of Aboriginal heritage monitors, being at least one, to:

      - conduct a pedestrian survey to seek to identify all visible surface Aboriginal objects (including stone artefacts, organic material and heat retaining stones)
      - for each Aboriginal object, where practical:
        - attribute a unique identifier number
        - record its location using a global positioning unit (GPS) unit (or equivalent technology) with an accuracy of no less than 20 cm
        - record raw material, object type, manufacture technique (where relevant, and where these attributes can be readily identified)
        - record any relevant information about the context in which the object is located, and any other archaeological observations relevant to the object
        - and where considered necessary by an archaeologist to demonstrate the range of objects within a given area, take a scale photograph
      - remove each Aboriginal object from its location, and place each in an appropriately labelled bag/container for secure storage within the Riverlea Park Development Master Plan Area (as shown in Attachment 1), unless storage or return elsewhere is agreed by KYAC.

*Note: For the purposes of the Authorisations, to **make an offer in good faith** means an offer in writing to KYAC's nominated contact person(s) (or the person(s) acting in that position/s from time to time) at least two business days prior to any work commencing or resuming (as applicable).*

Heritage monitoring of earthworks (including topsoil stripping)

b) make an offer in good faith to KYAC to engage an adequate number of Aboriginal heritage monitors, being at least one for each piece of earth moving equipment engaged in excavation works, for the purpose of observing all ground excavations

c) where the offer is accepted, heritage monitors must be retained until excavations are complete, or until they reach a level that is, in the view of an archaeologist, culturally sterile or bedrock

*Note: For the purposes of the Authorisations, where there is any disagreement between KYAC and an Authorised Party about what the **adequate number of heritage monitors** may be, AAR may definitively decide the matter.*

Archaeological sampling and excavations

d) where after consulting with KYAC, an archaeologist reasonably considers it necessary, engage an archaeologist to undertake archaeological excavations (including trenching) to capture further information about the nature or extent of the heritage. An Authorised Party must comply with the *Riverlea Park Development - Heritage Impact Procedure* (Attachment 8) in carrying out any such excavations

e) notwithstanding the above, AAR may instruct an Authorised Party about the extent of archaeological excavations that must occur in AAR ID# 174 (formerly HIMA #1), AAR ID# 175 (formerly HIMA #2) and sites 6628-7788 and 6628-7792

*Note: In the Authorisations and attachments, a reference to an **archaeologist** means a professional archaeologist with an honours or postgraduate degree in archaeology recognised in Australia who is engaged by an Authorised Party to undertake Project or Research Activities.*

Register of discovered Aboriginal objects

f) create a register of all Aboriginal objects identified within these areas, including at minimum the information collected at Condition 9(a).

10. Prior to carrying out any Project Activities within AAR ID# 176 (formerly HIMA #3), shown in pink on the map at Attachment 1, an Authorised Party must:

Heritage monitoring of earthworks (including topsoil stripping)

a) make an offer in good faith to KYAC to engage an adequate number of Aboriginal heritage monitors, being at least one for each piece of earth moving equipment engaged in excavation works, for the purpose of observing all ground excavations

b) where the offer is accepted, Aboriginal heritage monitors must be retained until excavations are complete, or until they reach a level that is, in the view of an archaeologist, culturally sterile or bedrock

Archaeological sampling and excavations

c) where after consulting with KYAC, an archaeologist reasonably considers it necessary, engage an archaeologist to undertake excavations (including trenching) to capture further information about the nature or extent of the heritage. An Authorised Party must have regard to the *Riverlea Park Development - Heritage Impact Procedure* (Attachment 8) in carrying out any excavations

d) notwithstanding the above, AAR may instruct an Authorised Party regarding the extent of archaeological excavations that must occur

Register of discovered Aboriginal objects

e) create a register of all Aboriginal objects identified within AAR ID# 176 (formerly HIMA #3), including at minimum the information required to be recorded under Condition 9(a).

Culturally Modified Trees

An Authorised Party must not:

11. deliberately damage, fell, or remove any culturally modified trees within the Authorisation Area, except with the agreement of KYAC

12. prune or otherwise maintain any culturally modified trees in the Authorisation Area unless it is necessary for public safety, in which case this work must only be performed by a qualified arborist following an Authorised Party giving KYAC five business days' written notice of the proposed maintenance, and offering in good faith to engage at least one Aboriginal heritage monitor to observe, and provide cultural input into, the works.

Aboriginal remains from outside Burial Location 1

An Authorised Party must:

13. ensure any Aboriginal remains discovered in the Authorisation Area outside Burial Location 1 prior to the date of the Authorisations are reburied within it in a manner that is, as far as reasonably possible, culturally acceptable to KYAC, and in a way that seeks not to disturb other known burials within Burial Location 1

14. ensure that any Aboriginal remains discovered in the Authorisation Area outside Burial Location 1 after the date of the Authorisations, which in the view of an Authorised Party, having followed the *Riverlea Park Development – Aboriginal Remains Discovery Protocol* (Attachment 3), cannot reasonably be retained in their original locations, are reburied within Burial Location 1 in a manner that is, as far as reasonably possible, culturally acceptable to KYAC, and in a way that seeks not to disturb other known burials within Burial Location 1

15. where, after consulting with and considering the views of KYAC and AAR, an archaeologist reasonably considers it necessary, engage an archaeologist to sieve excavated soils associated with discovered Aboriginal remains outside Burial Location 1. AAR must be notified if an Authorised Party or an archaeologist decides that sieving will not occur where Aboriginal remains are discovered

16. notwithstanding the above, despite the archaeologist's or an Authorised Party's decision to the contrary, AAR may still require an Authorised Party to sieve or rebury excavated soils that are reasonably likely to be associated with heritage discoveries.

Testing and management of Aboriginal objects

17. Subject to the Authorisations and the requirements of the *Riverlea Park Development – Aboriginal Heritage Discovery Protocols*, an Authorised Party must arrange for the secure storage, management, return and/or reburial of any Aboriginal objects collected from within the Authorisation Area, as reasonably required by KYAC.
18. An Authorised Party may only undertake destructive and non-destructive analyses of Aboriginal object/s from the Authorisation Area, and/or remove them from the state, with the agreement of KYAC.

Aerial / satellite imagery analysis and investigation

19. An Authorised Party must:
    a) prior to conducting Project Activities in any part of the Authorisation Area, first prepare an historic and contemporary aerial / satellite imagery analysis report (**Aerial Imagery Report**) for that part, which seeks to identify potential earthen mounds and/or burial sites within the Authorisation Area. The Aerial Imagery Report must:
        - provide an analysis of aerial and satellite imagery available for that part of the Authorisation Area (including both historic and contemporary imagery) and highlight any landscape features that may, in the opinion of an archaeologist, indicate the presence of Aboriginal earthen mounds and/or Aboriginal burial sites
        - include all aerial imagery used to make any conclusions in the report
        - be prepared in such a way that it can be distributed by AAR to Traditional Owners and interested Aboriginal people and organisations upon request
        - use best endeavours to ensure that this data includes imagery from each decade, beginning in the 1940s
        - be provided to KYAC and AAR for review, prior to finalisation.
20. Where potential burials and/or earth mounds are identified in the Aerial Imagery Report (or AAR's review of it), and where Project Activities are proposed within such areas, ensure that the following works occur there:
    a) the extent of the potential burials and/or earth mounds is physically demarcated using non-invasive bunting (**Investigation Area**)
    b) an Authorised Party must make an offer in good faith to KYAC to engage an adequate number of Aboriginal heritage monitors, being at least one for each piece of earth moving equipment engaged in excavation works, for the purpose of observing all ground excavations until excavations are complete, or until they reach a level that is, in the view of an archaeologist, culturally sterile or bedrock
    c) where Aboriginal heritage is discovered, the *Riverlea Park Development – Aboriginal Heritage Discovery Protocols* are followed

d) at the conclusion of steps (a) through (c), provide a report to KYAC and AAR outlining the results of the excavation works.

Note: For the avoidance of doubt, Project Activities must not occur within Investigation Areas until steps (a) through (d) are completed.

Heritage monitoring of soil stripping across the Authorisation Area

21. The Applicant must make an offer in good faith to KYAC to engage an adequate number of Aboriginal heritage monitors, being at least one for each piece of earth moving equipment engaged in excavation works, to observe all stripping of vegetation and topsoil, to a depth reasonably determined by an archaeologist, across the entire Authorisation Area.

Legislative Awareness Training

22. An Authorised Party involved in or directly managing ground-disturbing Project Activities must undergo a legislative awareness and a heritage identification session, approved by AAR, that covers the relevant provisions of the Act, the *Coroners Act 2003* (SA) and the Authorisations, prior to taking part in those Project Activities.

Aboriginal heritage reporting and site card requirements

23. An Authorised Party must comply with the Aboriginal heritage reporting and site card lodgement requirements as set out in Attachment 9.

General reporting requirements

24. An Authorised Party must, for the first five (5) years after the date of the Authorisations, provide six-monthly reports to KYAC and AAR documenting progress of the Project and all its intersections with Aboriginal heritage. With respect to both the period being reported upon, and in total, the report must, at minimum, include a summary of:

    a) the timing, nature and location of current and near-future Project Activities

    b) a plain English summary of the Aboriginal heritage information recorded in compliance with Condition 23, including photographs where appropriate

    c) the status and condition of the Burial Location 1 Resting Place, including the date and number of any Aboriginal remains reinterred there

    d) the nature, extent and location of all Aboriginal heritage being held in storage by an Authorised Party

    e) the nature and extent of any Aboriginal heritage reburied, relocated, or returned to KYAC

    f) the nature and outcomes of any Research Activities

    g) the management and maintenance of culturally modified trees within the Authorisation Area, including photographs

    h) the number of Aboriginal heritage monitors engaged

    i) a summary of approvals sought and/or received from KYAC

    j) a summary of any disputes with KYAC or any other Traditional Owners about Aboriginal heritage, Project Activities or Research Activities

k) a statement of compliance with each of the conditions of the Authorisations.

25. For the five (5) years after the first five (5) years of the Authorisations, an Authorised Party must provide reports containing the information required by Condition 24 to KYAC and AAR annually.

Note: The reporting requirements in Conditions 24 and 25 are addition to the requirements imposed by the Riverlea Park Development – Aboriginal Heritage Discovery Protocols and Condition 23 of the Authorisations.

Under section 14 of the Act, an Authorised Party, who without reasonable excuse, contravenes or fails to comply with a condition of the Authorisations, is guilty of a criminal offence.

Kyam Maher

HON KYAM MAHER MLC
MINISTER FOR ABORIGINAL AFFAIRS

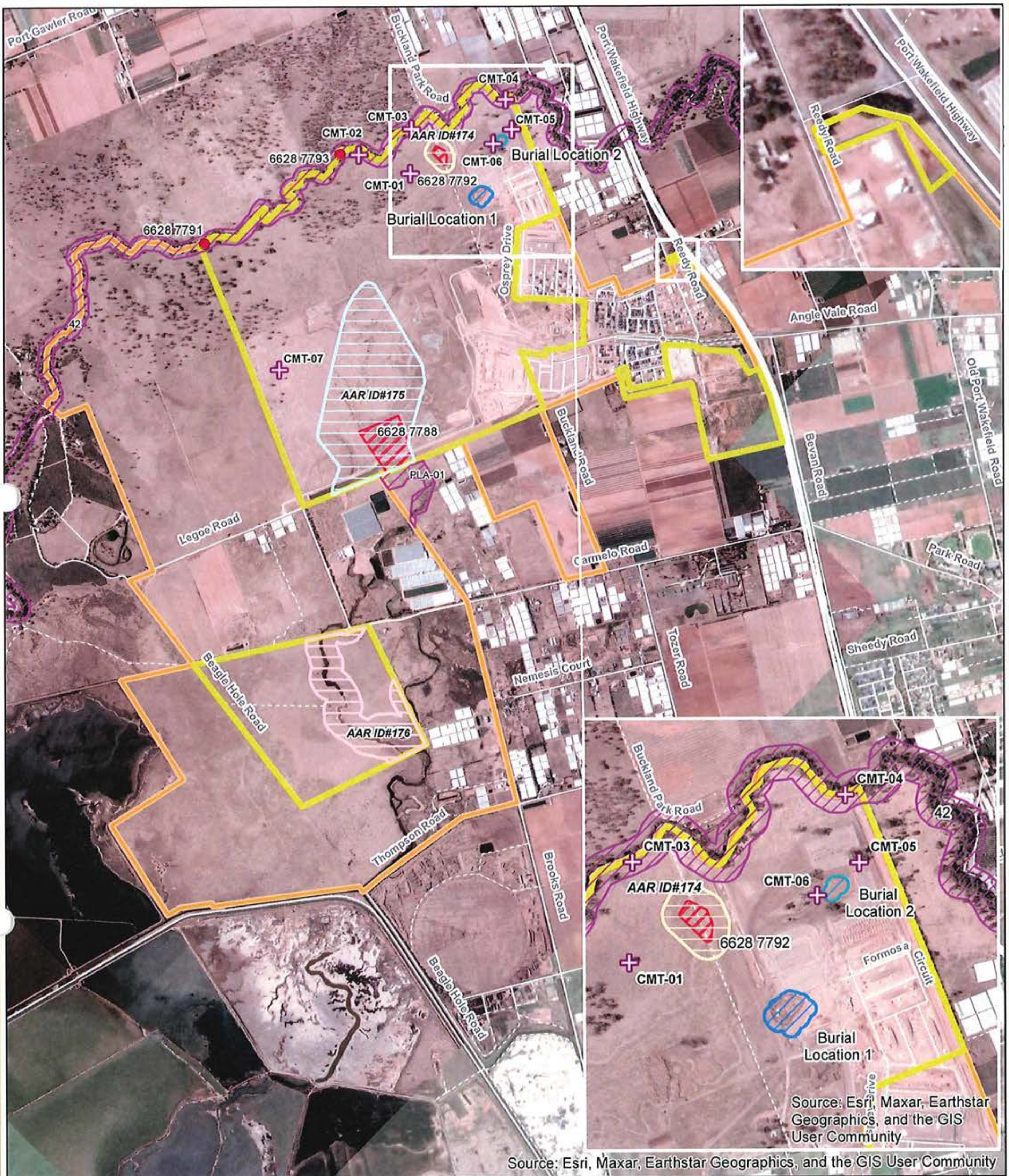
9 / 10 / 2024

Attachments:

1. Map of the Authorisation Area showing known Aboriginal heritage
2. List of coordinates for the Authorisation Area
3. Riverlea Park Development – Aboriginal Heritage Discovery Protocols
4. Map of Burial Location 1 boundary and list of coordinates
5. Method for Delineation Works
6. Method for Managing Aboriginal Remains
7. Map of Burial Location 2 'Discovery Zone' for the purposes of the Method of Delineation Works, and list of coordinates
8. Riverlea Park Development - Heritage Impact Procedure
9. Reporting and site card lodgement requirements

Attachment 1 - Authorisation Area and known Aboriginal heritage

Government of South Australia
Attorney-General's Department



AAR Heritage Sites

- Listed
- Listed
- Reported
- Reported (Culturally Modified Tree)

Burial Locations

- Burial Location 1 boundary
- Burial Location 2 'Discovery Zone'

Heritage Impact Mitigation Areas

- AAR ID #174 (HIMA #1)
- AAR ID #175 (HIMA #2)
- AAR ID #176 (HIMA #3)

Authorisation Area

- Authorisation Area

Riverlea Park Development

- Master Plan Area

Roads

- Highway
- Secondary Road
- Minor Road

N

1:35,000

0 250 500 750

Meters

Produced by:	Aboriginal Affairs and Reconciliation (AAR)
Data sources:	Aboriginal heritage - AAR Topographic / cadastral - Location SA Aerial imagery - BlackSky
Projection | Datum:	Lambert Conformal Conic | GDA2020
Job No:	2024236-001
Compiled:	20/09/2024

Information derived from AAR's central archives is confidential under section 10 of the Aboriginal Heritage Act 1988 (SA). AAR's central archives are not a comprehensive record of all Aboriginal heritage and other sources of heritage information may exist. The positional accuracy of this data is variable and dependent on the accuracy of information provided to AAR at the time of recording. The full geographic extent of Aboriginal heritage sites may not be depicted and sites may be larger than they appear on the map.

This map has been produced using information supplied by third parties. Whilst all reasonable care has been taken in the preparation of this information, AAR is not able to warrant its accuracy and accepts no responsibility for the loss, injury or any other liability incurred by any person that arises as a result of the use of this information by any person or organisation.

Attachment 2 – List of coordinates for the Authorisation Area

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
1	272767.500	6164427.499
2	272767.505	6164427.499
3	272767.512	6164427.500
4	272781.011	6164425.240
5	272794.254	6164420.181
6	272806.622	6164411.343
7	272810.025	6164408.083
8	272813.541	6164404.714
9	272813.785	6164404.413
10	272821.560	6164394.820
11	272821.572	6164394.806
12	272827.872	6164386.768
13	272831.310	6164382.405
14	272835.137	6164377.550
15	272842.410	6164367.921
16	272851.694	6164358.044
17	272857.596	6164353.542
18	272859.453	6164352.125
19	272865.701	6164348.451
20	272871.080	6164345.286
21	272876.840	6164343.060
22	272883.317	6164340.557
23	272897.005	6164338.898
24	272907.890	6164339.748
25	272919.005	6164341.948
26	272919.010	6164341.949
27	272932.281	6164346.046
28	272943.874	6164349.496
29	272952.352	6164353.582
30	272955.427	6164355.065
31	272961.202	6164358.932
32	272966.699	6164362.613
33	273320.157	6163609.616
34	273058.945	6163486.261
35	273055.191	6163484.488
36	273055.191	6163364.278
37	273042.691	6163364.357
38	273042.431	6163323.278
39	273055.690	6163323.278
40	273055.690	6163250.065
41	273063.840	6163234.065
42	273063.840	6163164.065

ID	Easting	Northing
43	273057.909	6163148.065
44	273057.609	6163029.646
45	273081.849	6163028.572
46	273086.082	6163020.299
47	273111.696	6163020.716
48	273120.943	6163034.546
49	273313.528	6163035.216
50	273323.673	6163023.537
51	273342.526	6163023.520
52	273351.983	6163034.516
53	273531.585	6163032.846
54	273531.587	6162836.164
55	273542.660	6162762.531
56	273420.546	6162717.957
57	273387.610	6162711.310
58	273354.674	6162704.664
59	273322.359	6162702.292
60	273290.050	6162699.507
61	273290.610	6162663.108
62	273249.387	6162664.640
63	273159.316	6162674.027
64	273122.491	6162680.014
65	273295.312	6162311.570
66	273277.163	6162303.422
67	272760.248	6162060.662
68	272242.681	6161817.171
69	271952.107	6161681.026
70	271725.625	6161574.910
71	271692.797	6161646.957
72	271251.341	6162615.798
73	271242.955	6162634.275
74	271181.325	6162762.449
75	270938.122	6163275.884
76	270942.826	6163276.786
77	270945.164	6163277.234
78	270953.039	6163278.094
79	270959.306	6163278.884
80	270965.667	6163281.094
81	270967.580	6163281.759
82	270967.593	6163281.763
83	270974.519	6163285.682
84	270982.530	6163290.050

Attachment 2 – List of coordinates for the Authorisation Area

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
85	270982.534	6163290.051
86	270987.622	6163294.890
87	270993.642	6163300.309
88	271002.217	6163307.268
89	271016.169	6163318.576
90	271025.932	6163322.249
91	271028.736	6163323.305
92	271040.923	6163324.274
93	271052.904	6163325.294
94	271066.939	6163326.294
95	271072.045	6163327.187
96	271080.652	6163328.693
97	271093.499	6163328.923
98	271107.484	6163330.423
99	271116.955	6163329.970
100	271121.897	6163329.733
101	271125.664	6163328.511
102	271130.646	6163326.894
103	271136.129	6163325.577
104	271141.300	6163324.334
105	271146.145	6163323.861
106	271148.944	6163323.587
107	271151.220	6163323.365
108	271160.785	6163322.635
109	271169.765	6163321.145
110	271179.256	6163322.115
111	271187.633	6163326.174
112	271196.390	6163331.333
113	271199.380	6163333.590
114	271200.390	6163334.352
115	271200.945	6163335.310
116	271204.612	6163341.631
117	271208.281	6163351.399
118	271212.181	6163359.977
119	271217.459	6163367.016
120	271224.341	6163373.831
121	271226.051	6163375.524
122	271227.673	6163377.672
123	271232.408	6163383.942
124	271239.599	6163392.570
125	271239.829	6163392.794
126	271246.385	6163399.149

ID	Easting	Northing
127	271252.736	6163404.842
128	271253.279	6163405.328
129	271259.463	6163411.887
130	271264.072	6163419.475
131	271269.389	6163426.821
132	271269.391	6163426.823
133	271270.026	6163427.626
134	271276.342	6163435.602
135	271281.463	6163442.600
136	271287.919	6163450.819
137	271288.013	6163450.950
138	271292.553	6163457.297
139	271298.005	6163463.513
140	271298.086	6163463.606
141	271298.182	6163463.738
142	271304.823	6163472.874
143	271307.951	6163476.170
144	271307.960	6163476.180
145	271307.965	6163476.183
146	271315.320	6163489.720
147	271320.565	6163498.869
148	271326.675	6163509.437
149	271335.531	6163517.495
150	271342.696	6163522.274
151	271352.542	6163525.653
152	271357.577	6163524.616
153	271362.783	6163523.544
154	271367.013	6163518.815
155	271369.170	6163510.210
156	271369.174	6163510.197
157	271367.330	6163501.470
158	271367.326	6163501.458
159	271365.476	6163495.969
160	271364.053	6163491.750
161	271361.760	6163482.711
162	271359.567	6163474.164
163	271358.471	6163465.500
164	271358.471	6163465.496
165	271358.488	6163465.378
166	271359.609	6163457.757
167	271361.042	6163455.066
168	271362.932	6163451.518

Attachment 2 – List of coordinates for the Authorisation Area

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
169	271367.274	6163448.801
170	271367.277	6163448.799
171	271374.542	6163450.629
172	271381.765	6163452.209
173	271381.770	6163452.210
174	271388.923	6163454.788
175	271393.878	6163460.327
176	271398.760	6163466.715
177	271405.052	6163472.934
178	271410.098	6163478.833
179	271414.856	6163484.112
180	271417.527	6163488.561
181	271421.848	6163493.359
182	271422.738	6163494.348
183	271423.119	6163494.770
184	271427.612	6163500.299
185	271432.378	6163505.138
186	271438.005	6163509.914
187	271438.043	6163509.947
188	271444.937	6163516.065
189	271452.647	6163521.154
190	271462.335	6163527.883
191	271472.511	6163534.421
192	271481.969	6163539.840
193	271493.175	6163545.499
194	271503.853	6163546.639
195	271516.931	6163548.329
196	271527.370	6163548.919
197	271538.222	6163551.558
198	271549.543	6163556.567
199	271555.645	6163561.776
200	271558.721	6163568.934
201	271562.473	6163580.052
202	271563.289	6163590.220
203	271559.620	6163596.809
204	271551.572	6163607.367
205	271551.560	6163607.379
206	271545.091	6163614.505
207	271537.538	6163620.314
208	271537.530	6163620.319
209	271526.975	6163626.633
210	271523.907	6163627.268

ID	Easting	Northing
211	271517.228	6163628.652
212	271511.953	6163628.789
213	271510.277	6163628.832
214	271507.296	6163630.490
215	271504.364	6163632.122
216	271504.361	6163632.130
217	271501.074	6163639.870
218	271502.130	6163647.888
219	271507.828	6163656.347
220	271514.655	6163660.516
221	271522.515	6163664.998
222	271524.262	6163665.995
223	271527.380	6163668.533
224	271532.491	6163672.693
225	271538.947	6163678.262
226	271549.708	6163685.811
227	271559.166	6163688.330
228	271568.010	6163688.690
229	271568.014	6163688.690
230	271577.703	6163692.359
231	271585.248	6163698.208
232	271590.558	6163708.806
233	271591.292	6163718.224
234	271590.690	6163729.012
235	271590.690	6163729.020
236	271589.775	6163741.050
237	271590.707	6163750.618
238	271595.737	6163757.466
239	271595.795	6163757.501
240	271604.090	6163762.565
241	271608.742	6163763.787
242	271608.773	6163763.795
243	271616.434	6163765.834
244	271627.706	6163768.044
245	271636.364	6163770.044
246	271639.934	6163770.785
247	271641.948	6163771.204
248	271650.764	6163773.928
249	271652.580	6163774.489
250	271652.592	6163774.493
251	271663.593	6163779.281
252	271665.891	6163780.281

Attachment 2 – List of coordinates for the Authorisation Area

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
253	271678.813	6163781.961
254	271692.110	6163782.161
255	271692.114	6163782.160
256	271693.450	6163782.076
257	271701.328	6163781.572
258	271701.333	6163781.571
259	271708.119	6163774.243
260	271717.099	6163766.954
261	271719.139	6163765.413
262	271723.440	6163762.165
263	271733.063	6163758.286
264	271743.807	6163756.126
265	271752.334	6163760.036
266	271759.124	6163765.001
267	271760.332	6163765.884
268	271767.420	6163772.010
269	271767.423	6163772.013
270	271772.635	6163779.912
271	271778.555	6163789.970
272	271781.614	6163800.277
273	271782.554	6163809.346
274	271785.210	6163817.344
275	271787.956	6163826.052
276	271790.792	6163835.400
277	271795.748	6163843.399
278	271804.035	6163852.747
279	271810.343	6163860.565
280	271815.940	6163868.610
281	271815.942	6163868.614
282	271820.725	6163878.202
283	271824.320	6163886.720
284	271827.783	6163897.288
285	271829.927	6163906.126
286	271830.488	6163913.844
287	271833.951	6163920.182
288	271835.427	6163922.883
289	271841.150	6163929.941
290	271847.260	6163934.950
291	271854.310	6163940.579
292	271865.697	6163944.238
293	271874.281	6163945.138
294	271883.253	6163947.207

ID	Easting	Northing
295	271895.209	6163949.567
296	271905.269	6163951.906
297	271915.263	6163955.286
298	271925.653	6163958.625
299	271939.242	6163962.514
300	271953.631	6163963.424
301	271962.629	6163964.352
302	271967.204	6163964.824
303	271978.641	6163963.224
304	271986.076	6163960.020
305	271988.874	6163958.815
306	271996.245	6163952.087
307	272001.407	6163945.938
308	272007.394	6163938.589
309	272010.844	6163935.688
310	272014.609	6163932.521
311	272021.750	6163927.241
312	272031.711	6163921.473
313	272031.852	6163921.401
314	272040.592	6163916.984
315	272046.980	6163914.549
316	272046.991	6163914.545
317	272055.162	6163910.795
318	272060.174	6163909.371
319	272066.772	6163907.496
320	272077.846	6163903.496
321	272091.716	6163899.947
322	272104.604	6163898.328
323	272118.630	6163899.437
324	272130.941	6163902.007
325	272141.199	6163909.995
326	272148.348	6163915.874
327	272157.353	6163924.042
328	272162.185	6163936.180
329	272165.055	6163946.488
330	272169.598	6163957.825
331	272170.878	6163962.297
332	272171.652	6163965.003
333	272172.748	6163968.833
334	272173.738	6163971.253
335	272175.387	6163975.282
336	272179.320	6163984.550

Attachment 2 – List of coordinates for the Authorisation Area

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
337	272186.716	6163998.637
338	272195.350	6164013.804
339	272195.560	6164015.732
340	272196.761	6164026.727
341	272196.974	6164028.681
342	272199.341	6164044.578
343	272200.998	6164049.688
344	272202.427	6164054.097
345	272204.692	6164061.084
346	272212.452	6164069.173
347	272224.738	6164076.001
348	272237.741	6164084.090
349	272247.109	6164088.809
350	272261.011	6164094.758
351	272274.436	6164098.907
352	272274.440	6164098.910
353	272285.073	6164105.195
354	272298.420	6164116.640
355	272298.423	6164116.642
356	272308.870	6164122.632
357	272322.880	6164129.313
358	272323.251	6164129.490
359	272337.203	6164135.199
360	272350.380	6164142.088
361	272363.713	6164154.375
362	272373.551	6164163.713
363	272382.250	6164174.771
364	272388.253	6164185.979
365	272390.397	6164194.477
366	272401.336	6164217.479
367	272401.355	6164217.470
368	272412.372	6164215.973
369	272424.518	6164213.293
370	272435.940	6164206.450
371	272435.947	6164206.445
372	272445.768	6164200.026
373	272451.169	6164196.344
374	272453.057	6164195.057
375	272456.241	6164192.854
376	272462.581	6164188.468
377	272470.648	6164183.836
378	272475.065	6164181.300

ID	Easting	Northing
379	272475.258	6164181.146
380	272484.853	6164173.471
381	272494.591	6164166.093
382	272497.677	6164163.312
383	272502.425	6164159.034
384	272510.510	6164150.840
385	272510.522	6164150.826
386	272517.705	6164142.863
387	272518.026	6164142.508
388	272526.041	6164133.500
389	272533.685	6164125.591
390	272537.337	6164122.473
391	272542.525	6164118.043
392	272551.257	6164113.594
393	272555.421	6164112.999
394	272562.743	6164111.954
395	272574.040	6164117.663
396	272580.662	6164127.481
397	272587.538	6164137.359
398	272594.111	6164150.236
399	272601.227	6164166.263
400	272607.065	6164180.480
401	272614.445	6164195.617
402	272620.761	6164205.985
403	272625.010	6164213.315
404	272627.646	6164217.862
405	272632.378	6164225.585
406	272636.008	6164231.510
407	272645.391	6164243.437
408	272651.370	6164256.005
409	272656.614	6164267.642
410	272657.884	6164277.320
411	272656.412	6164281.617
412	272655.949	6164282.970
413	272653.984	6164288.708
414	272649.045	6164295.545
415	272645.672	6164300.216
416	272645.670	6164300.220
417	272644.288	6164301.936
418	272637.900	6164309.870
419	272637.896	6164309.874
420	272634.193	6164320.861

Attachment 2 – List of coordinates for the Authorisation Area

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
421	272635.768	6164330.939
422	272635.851	6164331.055
423	272641.425	6164338.948
424	272649.132	6164346.536
425	272649.234	6164346.636
426	272655.756	6164348.206
427	272666.138	6164352.295
428	272672.652	6164360.063
429	272674.961	6164370.611
430	272676.594	6164382.939
431	272681.385	6164394.636
432	272688.583	6164403.165
433	272696.004	6164407.511
434	272697.830	6164408.580
435	272697.835	6164408.583
436	272707.689	6164413.863
437	272719.810	6164418.179
438	272719.818	6164418.182
439	272728.237	6164420.181
440	272740.128	6164423.551
441	272752.180	6164426.219
442	272752.183	6164426.220
443	274170.783	6163358.348
444	274217.965	6163308.475
445	274196.186	6163287.641
446	274158.846	6163353.402
447	274088.569	6163320.280
448	274084.912	6163321.594
449	274073.893	6163344.383
450	274121.227	6163367.751
451	274545.139	6162752.951
452	274647.415	6162615.200
453	274710.891	6162646.181
454	274798.205	6162467.288
455	274899.985	6162168.675
456	274407.378	6162030.419
457	274270.262	6162526.039
458	273836.598	6162405.510
459	273802.008	6162529.181
460	273797.787	6162549.190
461	273790.092	6162545.754
462	273775.903	6162585.655

ID	Easting	Northing
463	273830.491	6162608.279
464	273834.821	6162604.156
465	273841.185	6162581.256
466	273842.214	6162558.932
467	273864.504	6162478.684
468	273879.499	6162470.397
469	274125.685	6162538.334
470	274083.289	6162690.865
471	274076.217	6162775.608
472	274258.377	6162775.739
473	274299.525	6162772.309
474	274298.150	6162752.984
475	272203.200	6160802.308
476	272572.086	6160147.721
477	272632.445	6160040.613
478	272574.609	6160007.799
479	271825.252	6159582.816
480	271050.942	6160484.002
481	272022.492	6160752.558
482	272056.250	6160745.879
483	272098.972	6160773.514

Riverlea Park Development –
Aboriginal Remains Discovery Protocol

Consider avoiding impacts to heritage wherever possible.
Where impacts are unavoidable, they should be mitigated to the extent possible.
Any reference to Aboriginal Affairs and Reconciliation (AAR) is also a reference to the relevant Minister or their delegate.

Responsible parties

- You - Authorised party
- SA Police

1. Discovery of suspected skeletal remains

2. Immediately stop all works within the Discovery Zone

- This is a 10m radius from the visible extent of the discovery.
- Isolate all spoil/material associated with the discovery.
- Project works may continue in other areas.

3. Report discovery to SA Police – call 131 444

- This is required under the *Coroners Act 2003* (SA)

4. SA Police investigation

- The immediate area will be under the control of SA Police until further notice.
- SA Police and Forensic Science SA will determine if the remains are human.

5.1 Animal remains found

- If remains are **not** associated with Aboriginal heritage*, the area reverts to the authorised party's responsibility.
- Works may resume.

5.2 Ancestral remains found

- **No project works permitted** within the Discovery Zone.
- Take the following steps to contact AAR.

5.3 Further investigation required

- Area continues under SA Police control

6. Notification of discovery

- Notify AAR and KYAC, giving details of the nature, location and circumstances of the discovery.

7.1 Authorised Activities *will not* occur within the Discovery Zone

8.1 Consult with KYAC on management of the remains

- Advise AAR and KYAC in writing of:
  - how you intend to avoid impacts to the remains
  - the measures you will take to ensure their ongoing protection.

9.1 Recommence Project works

- Project works may proceed, but must not impact any discovered remains

7.2 Authorised Activities *will* occur within the Discovery Zone

- If Authorised Activities are proposed within the Discovery Zone, follow the ***Method for Delineation Works*** and Step 1 of the ***Method for Managing Aboriginal Remains***

8.2 Where **all** remains will be avoided

8.3 Where remains **will not** be avoided

9.2 Follow steps 4–7 of the *Method for Managing Aboriginal Remains*

- Consult with KYAC
- Notify AAR and KYAC in writing
- Offer to engage a heritage monitor to observe the excavation/removal
- Excavate and/or remove the remains after no fewer than two business days, provided this is overseen by an archaeologist

10. Recommence Project works

- Subject to the conditions of the Authorisation

*Animal remains, particularly those of native animals, found in association with Aboriginal objects (e.g. stone tools) and/or other cultural materials (e.g. charcoal, shell material, burnt stones) may indicate the presence of an Aboriginal site. If such a discovery is made, use the **Aboriginal Sites and Objects Discovery Protocol**.

Riverlea Park Development –
Aboriginal Sites and Objects Discovery Protocol

Consider avoiding impacts to heritage wherever possible.
Where impacts are unavoidable, they should be mitigated to the extent possible.
Any reference to Aboriginal Affairs and Reconciliation (AAR) is also a reference to the relevant Minister or their delegate.

1. Discovery of suspected Aboriginal site or object

2. Immediately stop all works within the Discovery Zone

- This is a 3m radius from the visible extent of the discovery.
- Isolate all spoil/material associated with the discovery.
- Project works may continue in other areas.

If the discovery includes skeletal remains, follow the ***Aboriginal Remains Discovery Protocol***

3. Notify AAR and KYAC

- Authorised Parties must give details of the nature, location and circumstances of the discovery

+

4. Establish if the discovery is an Aboriginal site or object

- Authorised Parties **must** seek the views of an archaeologist on whether the discovery is an Aboriginal site or object

→ **Not Aboriginal site or object**

- Notify AAR
- Recommence Project works subject to the conditions of the Authorisation

5.1 If you *cannot* avoid the discovery

5.2 If you *can* avoid the discovery

→
- Project works may proceed but **must** be kept outside the Discovery Zone

6.1 Where a KYAC representative is present

- For Aboriginal object(s), having regard for AAR's ***Riverlea Park Development -Heritage Impact Procedure***, record and collect them
- For Aboriginal site(s), having regard for AAR's ***Riverlea Park Development -Heritage Impact Procedure***, an archaeologist must oversee the excavation and recording of the site(s).

6.2 Where a KYAC representative is *not* present

- Provide AAR and KYAC with a proposed method prepared by an archaeologist for recording, collecting and/or excavating the discovered site/object, having regard for AAR's ***Heritag[illegible] Impact Procedure.***

Authorised Parties must make an offer in good faith to KYAC to engage a KYAC representative for the purpose of making recommendations about, participating in and/or observing these activities.

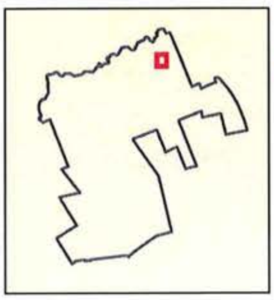
Following the above, and subject to advice from AAR, record, collect and/or excavate the discovered site/object

7. Recommence Project works

- Once the heritage has been removed, Project works may proceed in the Discovery Zone
- Subject to the conditions of the Authorisation

Attachment 4 - Burial Location 1 boundary and list of coordinates

Government of South Australia
Attorney-General's Department



Legend

Burial Location 1 boundary

N

1:1,250

0 6.5 13 19.5 26

Meters

Produced by:	Aboriginal Affairs and Reconciliation (AAR)
Data sources:	Aboriginal heritage - AAR Topographic / cadastral - Location SA Aerial imagery - BlackSky
Projection | Datum:	Lambert Conformal Conic | GDA2020
Job No:	2024236-002
Compiled:	14/08/2024

Information derived from AAR's central archives is confidential under section 10 of the Aboriginal Heritage Act 1988 (SA). AAR's central archives are not a comprehensive record of all Aboriginal heritage and other sources of heritage information may exist. The positional accuracy of this data is variable and dependent on the accuracy of information provided to AAR at the time of recording. The full geographic extent of Aboriginal heritage sites may not be depicted and sites may be larger than they appear on the map.

This map has been produced using information supplied by third parties. Whilst all reasonable care has been taken in the preparation of this information, AAR is not able to warrant its accuracy and accepts no responsibility for the loss, injury or any other liability incurred by any person that arises as a result of the use of this information by any person or organisation.

Attachment 4 – List of coordinates for Burial Location 1

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
1	272824.630	6163750.868
2	272829.044	6163749.112
3	272831.339	6163749.370
4	272835.690	6163749.097
5	272839.926	6163748.073
6	272843.921	6163746.328
7	272847.552	6163743.917
8	272850.709	6163740.911
9	272853.296	6163737.403
10	272855.235	6163733.499
11	272855.410	6163732.905
12	272856.968	6163732.648
13	272857.310	6163732.577
14	272857.397	6163732.559
15	272858.648	6163732.258
16	272860.214	6163731.783
17	272861.563	6163731.281
18	272861.646	6163731.248
19	272861.827	6163731.174
20	272863.317	6163730.498
21	272864.760	6163729.727
22	272865.527	6163729.266
23	272865.602	6163729.219
24	272866.224	6163728.816
25	272867.554	6163727.863
26	272868.819	6163726.825
27	272869.080	6163726.593
28	272869.146	6163726.534
29	272870.079	6163725.648
30	272871.197	6163724.454
31	272872.115	6163723.344
32	272872.169	6163723.274
33	272872.289	6163723.119
34	272873.242	6163721.789
35	272874.106	6163720.400
36	272874.540	6163719.617
37	272874.581	6163719.539
38	272874.919	6163718.879
39	272875.594	6163717.389
40	272876.170	6163715.858
41	272876.280	6163715.526
42	272876.308	6163715.442

ID	Easting	Northing
43	272876.673	6163714.208
44	272877.044	6163712.615
45	272877.284	6163711.195
46	272877.296	6163711.107
47	272877.323	6163710.913
48	272877.483	6163709.285
49	272877.537	6163707.650
50	272877.521	6163706.755
51	272877.517	6163706.666
52	272877.480	6163705.926
53	272877.320	6163704.298
54	272877.053	6163702.684
55	272876.983	6163702.341
56	272876.964	6163702.255
57	272876.663	6163701.004
58	272876.188	6163699.438
59	272875.686	6163698.088
60	272875.653	6163698.006
61	272875.579	6163697.825
62	272874.903	6163696.335
63	272874.132	6163694.892
64	272873.671	6163694.125
65	272873.624	6163694.050
66	272873.221	6163693.427
67	272872.268	6163692.098
68	272871.231	6163690.833
69	272870.998	6163690.572
70	272870.939	6163690.506
71	272870.053	6163689.573
72	272868.859	6163688.455
73	272867.749	6163687.537
74	272867.679	6163687.482
75	272867.524	6163687.362
76	272866.194	6163686.410
77	272864.805	6163685.546
78	272864.022	6163685.112
79	272863.944	6163685.071
80	272863.284	6163684.733
81	272862.504	6163684.379
82	272862.283	6163683.041
83	272862.212	6163682.698
84	272862.194	6163682.612

Attachment 4 – List of coordinates for Burial Location 1

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
85	272861.893	6163681.361
86	272861.418	6163679.795
87	272860.916	6163678.446
88	272860.883	6163678.363
89	272860.808	6163678.182
90	272860.133	6163676.692
91	272859.362	6163675.249
92	272858.901	6163674.482
93	272858.854	6163674.407
94	272858.451	6163673.785
95	272857.875	6163672.980
96	272857.805	6163672.690
97	272857.330	6163671.124
98	272856.828	6163669.775
99	272856.795	6163669.692
100	272856.721	6163669.511
101	272856.045	6163668.021
102	272855.274	6163666.578
103	272854.813	6163665.811
104	272854.766	6163665.736
105	272854.363	6163665.114
106	272853.410	6163663.784
107	272852.372	6163662.519
108	272852.140	6163662.258
109	272852.081	6163662.192
110	272851.939	6163662.043
111	272851.672	6163661.545
112	272851.211	6163660.778
113	272851.164	6163660.703
114	272850.762	6163660.080
115	272849.809	6163658.750
116	272848.771	6163657.486
117	272848.539	6163657.225
118	272848.479	6163657.159
119	272847.593	6163656.226
120	272846.399	6163655.108
121	272845.289	6163654.190
122	272845.219	6163654.135
123	272845.064	6163654.015
124	272843.735	6163653.062
125	272842.345	6163652.198
126	272841.563	6163651.765

ID	Easting	Northing
127	272841.484	6163651.723
128	272840.824	6163651.386
129	272839.334	6163650.710
130	272837.803	6163650.134
131	272837.471	6163650.024
132	272837.387	6163649.997
133	272836.153	6163649.632
134	272834.884	6163649.336
135	272834.752	6163648.785
136	272834.277	6163647.220
137	272833.775	6163645.870
138	272833.742	6163645.788
139	272833.667	6163645.607
140	272832.992	6163644.116
141	272832.976	6163644.086
142	272832.903	6163643.352
143	272832.637	6163641.738
144	272832.566	6163641.396
145	272832.548	6163641.309
146	272832.247	6163640.058
147	272831.772	6163638.492
148	272831.270	6163637.143
149	272831.237	6163637.060
150	272831.163	6163636.879
151	272830.487	6163635.389
152	272829.716	6163633.946
153	272829.255	6163633.179
154	272829.208	6163633.104
155	272828.805	6163632.482
156	272827.852	6163631.152
157	272826.814	6163629.887
158	272826.582	6163629.626
159	272826.523	6163629.560
160	272825.637	6163628.627
161	272824.443	6163627.509
162	272823.333	6163626.591
163	272823.263	6163626.537
164	272823.108	6163626.417
165	272821.778	6163625.464
166	272820.389	6163624.600
167	272819.606	6163624.166
168	272819.528	6163624.125

Attachment 4 – List of coordinates for Burial Location 1

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
169	272818.868	6163623.787
170	272817.378	6163623.112
171	272815.847	6163622.536
172	272815.515	6163622.426
173	272815.431	6163622.398
174	272814.197	6163622.033
175	272812.604	6163621.662
176	272811.184	6163621.422
177	272811.096	6163621.410
178	272810.902	6163621.383
179	272809.274	6163621.223
180	272807.639	6163621.169
181	272806.744	6163621.185
182	272806.655	6163621.189
183	272805.915	6163621.226
184	272804.287	6163621.386
185	272802.673	6163621.653
186	272802.330	6163621.723
187	272802.244	6163621.742
188	272800.993	6163622.043
189	272799.427	6163622.518
190	272798.694	6163622.790
191	272798.679	6163622.794
192	272798.592	6163622.812
193	272797.341	6163623.113
194	272795.776	6163623.588
195	272794.426	6163624.090
196	272794.344	6163624.123
197	272794.162	6163624.197
198	272792.672	6163624.873
199	272791.229	6163625.644
200	272790.463	6163626.105
201	272790.387	6163626.152
202	272789.765	6163626.555
203	272788.435	6163627.508
204	272787.171	6163628.545
205	272786.909	6163628.778
206	272786.844	6163628.837
207	272785.911	6163629.723
208	272784.792	6163630.917
209	272783.874	6163632.027
210	272783.820	6163632.097

ID	Easting	Northing
211	272783.700	6163632.252
212	272782.747	6163633.582
213	272781.883	6163634.971
214	272781.450	6163635.754
215	272781.408	6163635.832
216	272781.070	6163636.492
217	272780.395	6163637.982
218	272780.131	6163638.684
219	272780.041	6163638.675
220	272779.498	6163638.374
221	272779.420	6163638.333
222	272778.760	6163637.995
223	272777.270	6163637.320
224	272775.739	6163636.744
225	272775.407	6163636.634
226	272775.323	6163636.606
227	272774.089	6163636.241
228	272772.496	6163635.870
229	272771.076	6163635.630
230	272770.988	6163635.618
231	272770.794	6163635.591
232	272769.165	6163635.431
233	272767.530	6163635.377
234	272766.636	6163635.393
235	272766.547	6163635.397
236	272765.807	6163635.434
237	272764.179	6163635.594
238	272762.564	6163635.861
239	272762.222	6163635.931
240	272762.136	6163635.950
241	272760.885	6163636.251
242	272759.319	6163636.726
243	272757.969	6163637.228
244	272757.887	6163637.261
245	272757.706	6163637.335
246	272756.216	6163638.010
247	272755.172	6163638.568
248	272754.813	6163638.677
249	272753.463	6163639.179
250	272753.381	6163639.213
251	272753.200	6163639.287
252	272751.709	6163639.962

Attachment 4 – List of coordinates for Burial Location 1

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
253	272750.267	6163640.733
254	272749.500	6163641.194
255	272749.425	6163641.241
256	272748.802	6163641.644
257	272747.472	6163642.597
258	272746.418	6163643.462
259	272745.661	6163643.867
260	272744.894	6163644.328
261	272744.819	6163644.375
262	272744.197	6163644.778
263	272742.867	6163645.731
264	272741.602	6163646.769
265	272741.341	6163647.001
266	272741.275	6163647.060
267	272740.342	6163647.946
268	272739.224	6163649.140
269	272738.306	6163650.250
270	272738.252	6163650.320
271	272738.132	6163650.475
272	272737.179	6163651.805
273	272736.315	6163653.194
274	272735.882	6163653.977
275	272735.840	6163654.055
276	272735.502	6163654.715
277	272734.827	6163656.205
278	272734.251	6163657.736
279	272734.141	6163658.068
280	272734.113	6163658.152
281	272733.843	6163659.066
282	272733.043	6163659.723
283	272732.781	6163659.955
284	272732.716	6163660.015
285	272731.783	6163660.901
286	272730.664	6163662.095
287	272729.746	6163663.205
288	272729.692	6163663.274
289	272729.572	6163663.430
290	272728.619	6163664.759
291	272727.755	6163666.149
292	272727.322	6163666.931
293	272727.280	6163667.010
294	272726.942	6163667.670

ID	Easting	Northing
295	272726.267	6163669.160
296	272725.691	6163670.691
297	272725.581	6163671.023
298	272725.554	6163671.107
299	272725.189	6163672.341
300	272724.817	6163673.934
301	272724.577	6163675.354
302	272724.565	6163675.442
303	272724.538	6163675.636
304	272724.378	6163677.264
305	272724.325	6163678.899
306	272724.341	6163679.794
307	272724.344	6163679.882
308	272724.381	6163680.623
309	272724.542	6163682.251
310	272724.808	6163683.865
311	272724.879	6163684.207
312	272724.897	6163684.294
313	272725.198	6163685.545
314	272725.431	6163686.314
315	272725.570	6163687.717
316	272725.836	6163689.331
317	272725.907	6163689.673
318	272725.925	6163689.760
319	272726.226	6163691.011
320	272726.701	6163692.577
321	272727.203	6163693.926
322	272727.236	6163694.009
323	272727.311	6163694.190
324	272727.986	6163695.680
325	272728.757	6163697.123
326	272729.218	6163697.890
327	272729.265	6163697.965
328	272729.668	6163698.587
329	272730.621	6163699.917
330	272731.659	6163701.182
331	272731.891	6163701.443
332	272731.950	6163701.509
333	272732.836	6163702.442
334	272734.030	6163703.560
335	272735.140	6163704.478
336	272735.210	6163704.532

Attachment 4 – List of coordinates for Burial Location 1

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
337	272735.365	6163704.652
338	272736.695	6163705.605
339	272737.707	6163706.235
340	272737.714	6163706.471
341	272737.875	6163708.099
342	272738.141	6163709.713
343	272738.513	6163711.306
344	272738.988	6163712.872
345	272739.564	6163714.403
346	272740.239	6163715.893
347	272741.010	6163717.336
348	272741.874	6163718.725
349	272742.827	6163720.055
350	272743.865	6163721.319
351	272744.983	6163722.513
352	272746.177	6163723.632
353	272747.442	6163724.670
354	272748.772	6163725.623
355	272750.161	6163726.486
356	272751.604	6163727.258
357	272753.094	6163727.933
358	272754.076	6163728.302
359	272754.532	6163728.730
360	272755.797	6163729.768
361	272757.127	6163730.721
362	272758.516	6163731.585
363	272759.959	6163732.356
364	272761.449	6163733.031
365	272762.980	6163733.607
366	272764.546	6163734.082
367	272764.845	6163734.161
368	272765.871	6163734.422
369	272765.923	6163734.592
370	272766.499	6163736.123
371	272767.174	6163737.613
372	272767.946	6163739.056
373	272768.809	6163740.445
374	272769.762	6163741.775
375	272770.800	6163743.040
376	272771.919	6163744.234
377	272773.113	6163745.352
378	272774.377	6163746.390

ID	Easting	Northing
379	272775.707	6163747.343
380	272776.612	6163747.920
381	272784.838	6163752.919
382	272785.322	6163753.206
383	272786.764	6163753.977
384	272788.255	6163754.652
385	272789.786	6163755.229
386	272791.351	6163755.703
387	272792.944	6163756.075
388	272794.559	6163756.341
389	272796.187	6163756.502
390	272797.822	6163756.555
391	272799.457	6163756.502
392	272801.085	6163756.341
393	272801.215	6163756.324
394	272812.984	6163754.712
395	272814.468	6163754.463
396	272816.061	6163754.091
397	272817.627	6163753.616
398	272818.824	6163753.176
399	272824.620	6163750.872

Attachment 5 - Method for Delineation Works

Where Authorised Activities are proposed within 10 m of any Aboriginal remains located outside Burial Location 1, including those that may be discovered during the course of Project Activities, an Authorised Party must first ascertain whether the burial forms part of a larger Aboriginal burial site (**Delineation Works**). In carrying out the Delineation Works, an Authorised Party must ensure that:

1. AAR and KYAC are notified in writing of the discovery of the Aboriginal remains, and the Authorised Parties' intention to carry out Delineation Works
2. an area measuring 10 m in radius from the visible extent of the Aboriginal remains is measured and physically demarcated using non-invasive bunting (**Discovery Zone**)
3. the Discovery Zone is subject to careful excavation and removal of soil in layers of no more than approximately 10 cm deep using a hand trowel, shovel or small excavator, This excavation must occur until - in the view of an archaeologist - culturally sterile layers or bedrock is reached
4. all excavations are visually observed by an archaeologist, and that an offer is made in good faith to KYAC to engage an adequate number of Aboriginal heritage monitors to observe the works
5. where additional Aboriginal remains not associated with the original Aboriginal remains (i.e. any new set of remains or part thereof) are encountered within any Discovery Zone, Steps 1 through 4 must be followed. This includes the notification requirements at Step 1, and the creation of an additional Discovery Zone at Step 2
6. the above steps must be followed until no further remains are identified
7. write to AAR and KYAC detailing the outcomes of the Delineation Works, giving particulars of the total number, nature, location, and distribution of Aboriginal remains encountered, including through the provision of spatial data and a detailed map
8. following completion of the Delineation Works, an Authorised Party will be required to follow the *Method for Managing Aboriginal Remains* (Attachment 6) where the remains will not be avoided.

Notes: For the avoidance of doubt:

- *where **Aboriginal remains are discovered** in the process of carrying out Delineation Works, Authorised Parties are required to comply with any directions issued by the Minister under the Act in relation to the protection and preservation of the discovered Aboriginal remains.*
- *no excavation of remains is permitted until after the Method for Managing Aboriginal Remains has also been followed (Attachment 6)*
- *despite the foregoing, where Delineation Works would extend beyond the footprint required for Project Activities, or beyond the Authorisation Area, the Delineation Works should cease to avoid unnecessary disturbance of Aboriginal remains.*

Attachment 6 - Method for Managing Aboriginal Remains

Following completion of Delineation Works (see Attachment 5 – Method for Delineation Works), an Authorised Party must:

1. consult with KYAC in line with its obligations under the Kaurna Cultural Heritage Management Plan (KCHMP), to establish whether in the Authorised Party's view the Project can reasonably be modified to avoid disturbance of the discovered remains within the Discovery Zone.

Where an Authorised Party agrees that all remains within the Discovery Zone can be avoided, an Authorised Party must ensure that:

2. KYAC is consulted regarding the proposed management of the discovered remains
3. AAR and KYAC are notified in writing the outcomes of its consultation with KYAC in arriving at its decision in managing of the discovered Aboriginal remains, as required under steps 1 and 2.

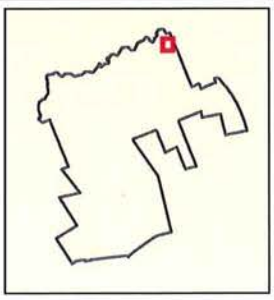
Where an Authorised Party decides that remains within the Discovery Zone cannot reasonably be avoided, or where some impacts to remains will likely occur, an Authorised Party must ensure that:

4. KYAC is consulted regarding the proposed management of the discovered Aboriginal remains that may be impacted
5. AAR and KYAC are notified in writing to be advised:
    - that it has decided that avoidance of remains within the Discovery Area is not reasonably possible
    - of the justification for this decision
    - the outcomes of its consultation with KYAC in arriving at the decision in managing the discovered Aboriginal remains, as required under Steps 1 and 4
    - of the proposed method for excavating/collecting/removing the remains from their location, having regard to the *Riverlea Park Development - Heritage Impact Procedure*
6. an offer is made to KYAC in good faith, seeking to engage at least one Aboriginal heritage monitor for the purpose of making recommendations about, participating in, and/or observing activities that will impact the remains
7. having completed the steps above, and after no fewer than two full business days from Step 6, the excavation and/or removal of the discovered remains may occur provided it is overseen by an archaeologist, having regard to the *Riverlea Park Development - Heritage Impact Procedure.*

    *Note: references to **contacting KYAC** in this Attachment mean contacting its nominated contact person(s) (or the person(s) acting in that position) from time to time. Any **agreement of KYAC** referred to in this Attachment means the written agreement of the KYAC Board given in accordance with the corporation's rules and procedures for decision making.*

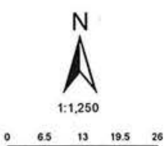
Attachment 7 - Burial Location 2 'Discovery Zone' and list of coordinates

Government of South Australia
Attorney-General's Department



Legend

Burial Location 2 'Discovery Zone'



Produced by:	Aboriginal Affairs and Reconciliation (AAR)
Data sources:	Aboriginal heritage - AAR Topographic / cadastral - Location SA Aerial imagery - BlackSky
Projection | Datum:	Lambert Conformal Conic | GDA2020
Job No:	2024236-003
Compiled:	19/09/2024

Information derived from AAR's central archives is confidential under section 10 of the Aboriginal Heritage Act 1988 (SA). AAR's central archives are not a comprehensive record of all Aboriginal heritage and other sources of heritage information may exist. The positional accuracy of this data is variable and dependent on the accuracy of information provided to AAR at the time of recording. The full geographic extent of Aboriginal heritage sites may not be depicted and sites may be larger than they appear on the map.

This map has been produced using information supplied by third parties. Whilst all reasonable care has been taken in the preparation of this information, AAR is not able to warrant its accuracy and accepts no responsibility for the loss, injury or any other liability incurred by any person that arises as a result of the use of this information by any person or organisation.

Attachment 7 – List of coordinates for Burial Location 2 'Discovery Zone'

Coordinate System: GDA2020 MGA Zone 54

ID	Easting	Northing
1	272927.983	6164099.842
2	272932.333	6164099.569
3	272936.570	6164098.545
4	272940.564	6164096.800
5	272944.195	6164094.389
6	272947.352	6164091.383
7	272949.939	6164087.875
8	272951.878	6164083.971
9	272953.109	6164079.790
10	272953.596	6164075.459
11	272953.323	6164071.108
12	272952.299	6164066.872
13	272950.554	6164062.877
14	272948.143	6164059.246
15	272945.137	6164056.089
16	272945.027	6164056.008
17	272942.200	6164053.038
18	272938.692	6164050.451
19	272936.189	6164049.208
20	272935.955	6164048.963
21	272932.447	6164046.376
22	272929.767	6164045.045
23	272929.181	6164042.624
24	272927.437	6164038.630
25	272925.025	6164034.999
26	272922.020	6164031.842
27	272918.512	6164029.255
28	272914.608	6164027.316
29	272910.427	6164026.085
30	272906.095	6164025.598
31	272901.745	6164025.871
32	272897.508	6164026.895
33	272893.514	6164028.640
34	272889.883	6164031.051
35	272886.726	6164034.057
36	272884.139	6164037.565
37	272882.200	6164041.469
38	272880.969	6164045.650
39	272880.482	6164049.982
40	272880.755	6164054.332
41	272881.779	6164058.569
42	272883.524	6164062.563
43	272885.935	6164066.194
44	272888.941	6164069.351
45	272889.610	6164069.844
46	272889.356	6164072.103
47	272889.629	6164076.453
48	272890.653	6164080.690
49	272892.398	6164084.684
50	272894.809	6164088.315
51	272897.815	6164091.472
52	272901.323	6164094.059
53	272905.227	6164095.998
54	272909.408	6164097.229
55	272912.634	6164097.592
56	272912.739	6164097.644
57	272916.920	6164098.875
58	272921.252	6164099.362
59	272923.248	6164099.237
60	272923.651	6164099.356

Attachment 8 – Riverlea Park Development – Heritage Impact Procedure

Government of South Australia
Attorney-General's Department

Riverlea Park Development - Heritage Impact Procedure

for use by Authorised Parties holding authorisations under the Aboriginal Heritage Act 1988 (SA) in relation to the Riverlea Park Development

This Riverlea Park Development - Heritage Impact Procedure (**Procedure**) is only for use by parties holding a ministerial authorisation (**Authorised Parties**) under sections 21, 23 and 29(1)(b) of the *Aboriginal Heritage Act 1988* (SA) in relation to the Riverlea Park Development (**Ministerial Authorisation**).

Authorised Parties should refer to the Procedure, following notification to Aboriginal Affairs and Reconciliation (**AAR**) of a discovery of suspected Aboriginal heritage, and where damage, disturbance or interference with the Aboriginal heritage will not be avoided by the authorised activities/works.

This Procedure covers potential methods to be considered in the recording and excavation of discovered Aboriginal heritage, where it will not be avoided by the Authorised Parties (**Heritage Impact Works**). AAR has developed the Procedure to assist Authorised Parties to prepare their own approach for undertaking Heritage Impact Works. The Authorised Parties' methods for Heritage Impact Works should be developed in accordance with this Procedure (where relevant) and any other applicable conditions of the Ministerial Authorisation.

The Procedure is a guide for the management of Aboriginal heritage discoveries. In circumstances where the Authorised Parties and the Kaurna Yerta Aboriginal Corporation RNTBC (**KYAC**) (in consultation with an archaeologist, where one has been engaged) consider that particular circumstances do not warrant the implementation of a process or processes set out below, the Authorised Parties may seek to develop an alternative strategy for managing the discovery.

However, Authorised Parties are advised that any Heritage Impact Works are subject to any direction that the Minister may consider necessary for the protection or preservation of Aboriginal heritage.

Authorised Parties are advised that elements of this Procedure form specific conditions of the Ministerial Authorisation.

For the avoidance of doubt, where an element of the Procedure is included as a specific condition of the Ministerial Authorisation, it will be mandatory and must be complied with. Authorised Parties are reminded that they are subject to the requirements of applicable State legislation whether or not referred to in the Ministerial Authorisation or its attachments.

Attachment 8 – Riverlea Park Development – Heritage Impact Procedure

When preparing a methodology for undertaking any Heritage Impact Works, the Authorised Parties should:

- where possible, incorporate recommendations for the management of heritage from KYAC and an archaeologist agreed to by KYAC
- aim to make the methodology fit for purpose. This means that the scope and scale of the Authorised Parties' methodology should be based on the nature and extent of the heritage discovery. It should be sufficiently flexible to allow for any changes that may be recommended (e.g. from KYAC, an archaeologist and/or AAR)
- have regard for the Kaurna Cultural Heritage Management Plan (KCHMP).

In the case of all Heritage Impact Works:

All Heritage Impact Works should be overseen by an archaeologist, ideally one who is approved by KYAC. Representatives of KYAC should always be notified of, and offered the opportunity to oversee, Heritage Impact Works.

It is recommended that, where appropriate, the following be undertaken:

- any heritage that would otherwise be damaged or destroyed by project works should instead be subject to archaeological excavation, prior to project works occuring
- any archaeological excavation should be conducted based on stratigraphic layers or arbitrary levels (spits) of no more than approximately 10 cm in depth, unless specified otherwise in this document, until base sterile soil or bedrock is reached, and that these excavations:
    a) should be conducted by hand, where practicable
    b) where hand excavation is not practicable, should be conducted using a shovel
    c) where hand or shovel excavation is not practicable, should be conducted using a small mechanical excavator
    d) should be documented using scale photographs showing, at minimum, each layer that is removed either by hand, shovel or via a small excavator.
- where the nature of the heritage discovered warrants it, all soil material excavated during any Heritage Impact Works (either manually by hand, shovel or machinery) should be sieved using a mesh of no greater than 10 mm so that smaller remains and cultural material can be identified
- all heritage removed during any Heritage Impact Works should be stored in a secure temporary storage location recommended by KYAC and/or an archaeologist, until such time as it is relocated and/or reburied
- the nature, condition and extent of the Aboriginal heritage should be recorded throughout the Heritage Impact Works (where relevant), including scale photographs that show or demonstrate:
    a) the heritage prior to any Heritage Impact Works, in order to illustrate its location, context and condition at the time of discovery

b) the progress of any Heritage Impact Works, including cross-section photography of the side walls of any excavation trenches and, where possible, drawings of stratigraphic profiles

c) the physical removal of the heritage from its original location (where applicable)

d) following completion of the excavation, that the heritage has been completely removed.

- adequate fieldnotes should be made for future reporting purposes
- the precise location of all heritage subject to Heritage Impact Works should be recorded, using a GPS unit (or equivalent) with sub-20 cm accuracy prior to any Heritage Impact Works.

In the case of isolated Aboriginal objects:

- For each object, record:

a) the nature of the object, its precise location, depth from ground surface or real level (where recorded and relevant), raw material type, manufacture technique and possible function (where possible)

b) any other information or archaeological observations relating to the object

c) scale photographs showing the object in its original location prior to removal and at minimum two aspects (sides) of each object.

- Remove the isolated Aboriginal object, and place it in an appropriately labelled bag/container
- Create an inventory (register) of all removed Aboriginal objects.

In the case of Aboriginal surface sites comprising Aboriginal objects (and other archaeological material):

- An archaeologist should be engaged to:

a) first conduct a comprehensive pedestrian survey of the entirety of the area that will be subject to Heritage Impact Works, in collaboration with the representatives of KYAC, where possible. This pedestrian survey should be undertaken at a narrow scale, ideally no wider than one person per 4 m-wide transect

b) use pin flags (or equivalent) to flag the location of all objects and other archaeological material, where considered appropriate

c) photographically record the distribution of the objects, using the pin flags for reference

d) record the location of each object using a GPS unit (or equivalent) with an accuracy of no less than 20 cm

e) record the highest, lowest and mean density of visible surface objects that will be subject to Heritage Impact Works.

- For each Aboriginal object subject to Heritage Impact Works, record:
    a) raw material, object type, manufacture technique (where known)
    b) scale photographs showing at minimum two aspects (sides) of the object
    c) any relevant information about the object, the context in which it is located, and its relationship to the site more broadly
- Remove each Aboriginal object, and place each in appropriately labelled bags/containers
- Create an inventory (register) of all removed Aboriginal objects.

In the case of archaeological features (including hearths and hearth material):

- An archaeologist should be engaged to record:
    a) the nature, extent, depth from ground surface or real level (where recorded and relevant), location and composition of the discovered heritage
    b) any other information or archaeological observations relating to the discovered heritage, including observations on the nature and distribution of the discovered heritage
    c) photographically, the distribution/extent of the discovered heritage, using a suitable scale
- An archaeologist should be engaged to excavate and remove the heritage, using hand tools or shovels where practicable, or using a small backhoe in any other case, until the feature has been removed and a culturally sterile layer is reached. Where an archaeological feature extends beyond the extent of the excavated area, broaden the excavation horizontally to capture the entirety of the feature.
- Make a photographic record of the excavation, including scale photographs of each excavated layer and any Aboriginal objects or other cultural materials exposed during the excavation
- Sieve all excavated and associated soils using a sieve with mesh of no greater than 10 mm
- Collect all Aboriginal objects and any other archaeological materials identified during the sieving process, and place them in appropriately labelled bags/containers
- Create an inventory (register) of the materials recovered during the excavation and sieving processes, which at minimum should include an identification of the feature's primary components, and details of any cultural material or other objects identified
- Make a photographic record of the excavation, including scale photographs of each excavated layer and any Aboriginal objects or other cultural material exposed and subsequently removed during the excavation.

In the case of archaeological sites containing stratigraphic deposits (including middens):

Attachment 8 – Riverlea Park Development – Heritage Impact Procedure

- Prior to excavations occurring, an archaeologist should be engaged to record:
    a) the nature, extent, depth from ground surface or real level (where recorded and relevant), location and composition of the site
    b) any other information or archaeological observations relating to the site. In the case of middens, include observations on the range of shell material (to species level where possible) and any other visible cultural material
    c) multiple scale photographs taken from the edge of the site facing in, and from the centre of the site facing out
    d) where possible, drawings of the site's profile showing any changes in stratigraphy and the location of any hearths, pits, or other features present
- An archaeologist should conduct a pedestrian survey of the visible heritage area to identify locations suitable for potential archaeological excavations, taking into consideration the advice of KYAC representatives present
- An archaeologist should excavate no less than one trench – measuring 50 cm by 50 cm – for every 4 square metres of observed heritage, with the trenches excavated in spits (layers) preferably no greater than approximately 10 cm at a time, until a culturally sterile layer (i.e. layer containing no cultural materials) is reached. Trenches should be excavated by hand or shovel or, where these are not practicable, via a small machine excavator
- For sites measuring less than 4 square metres in total area, an archaeologist should excavate one trench – measuring 50 cm by 50 cm – in spits (layers) preferably no greater than approximately 10 cm at a time, until a culturally sterile layer (i.e. layer containing no cultural materials) is reached. The trench should be excavated by hand or shovel or, where these are not practicable, via a small machine excavator
- Make a photographic record of the entire excavation process, including at least one scale photograph at the conclusion of each 10 cm spit excavation and any Aboriginal objects exposed and subsequently removed during the excavation
- Record the precise location of each excavation trench using a GPS unit (or equivalent) with sub-20 cm accuracy
- Sieve all excavated site contents using a sieve with mesh of no greater than approximately 10 mm
- Collect all objects and any other cultural materials identified during the sieving process and place them in appropriately labelled bags/containers
- Create an inventory of the materials recovered during the sieving process for each excavation trench that may include a brief identification of material types (i.e. shell, other faunal remains, heat retainers and charcoal), frequency/number/density of any objects, as well as their nature and dimensions
- Record scale photographs showing each of the main material types recovered during the sieving process.

Attachment 8 – Riverlea Park Development – Heritage Impact Procedure

Note that the remainder of the site that is not subject to the archaeological excavations recommended above should ideally be removed and relocated under the supervision of an archaeologist, and in consultation with KYAC and an Authorised Party. Note, if suspected human skeletal remains are observed at any time, stop works and comply with the Riverlea Park Development Aboriginal Remains Discovery Protocol.

In the case of Aboriginal remains:

- An archaeologist should be engaged to record:
    a) the orientation, articulation, position and direction of the remains
    b) the depth from ground surface, or real level (where recorded and relevant)
    c) the extent of the remains present
    d) the level of preservation
    e) the size and extent of the original burial cut, where possible
    f) any cultural materials identified during the excavation, uncovering and removal works, including but not limited to stone artefacts, ochre, faunal remains, charcoal or other organic materials
    g) any other information or archaeological observations relating to the remains, or the circumstances of their original interment.
- Excavate the entirety of the remains, the surrounding burial cut/feature, as well as all associated cultural materials until a culturally sterile layer is reached
- Remove the remains as carefully as possible, along with any associated Aboriginal objects or other cultural materials, and place them in appropriately labelled environmentally appropriate storage containers
- Make a photographic record of all stages of the excavation, including scale photographs of each excavated layer and any Aboriginal remains/objects exposed and subsequently removed during the excavation.

In the case of any other Aboriginal site types:

- In the case of any other Aboriginal site types, the Authorised Party should develop a bespoke methodology in consultation with KYAC and an archaeologist, based on the principals in this Procedure. Authorised Parties are reminded that the Minister may issue directions for the protection of Aboriginal heritage where he/she considers it necessary or appropriate.

Attachment 9 –
Reporting and site card requirements for Aboriginal heritage discoveries

Archaeological reporting

1. Where Aboriginal sites and remains cannot be retained in-situ, and are removed from their original locations, an Authorised Party must provide AAR and KYAC with a plain English report within six months of this removal, which, at minimum, includes:
    a) an executive summary
    b) introduction and background
    c) the nature and extent of the discovered site or remains
    d) the location of the discovered site or remains, depicted on a colour map
    e) details of the methods used for the excavation, uncovering, removal, relocation and/or reburial of the site or remains
    f) the results and outcomes of excavation, uncovering, removal, relocation and/or reburial of the site or remains
    g) the dates upon which any excavation, uncovering, removal, relocation and/or reburial works took place, including a comprehensive list of individuals present during these works
    h) the results of any sieving of soil associated with these works
    i) the results of any non-destructive analysis of excavated site or remains, including:
        - an inventory and basic archaeological analysis of any heritage excavated, uncovered, removed, relocated and/or reburied, such as objects, hearth contents, or faunal remains
        - in the case of Aboriginal remains, the sorting of the remains into specific individuals
        - in the case of Aboriginal remains, an inventory of the remains excavated, uncovered, removed, relocated and/or reburied, and an assessment of same, which may include the individual's stature during life, sex, age at death and any other relevant observations such as tooth wear, bone condition and pathologies.
        - the results of any destructive scientific analyses undertaken, such as radiocarbon dating, where authorised under the *Aboriginal Heritage Act 1988* (SA).
    j) details concerning the temporary storage of any heritage, prior to its relocation and/or reburial
    k) details about the relocation and/or reburial of any heritage, including spatial data and scale photographs of this process where appropriate
    l) any heritage recommendations stemming from these works.

*Note: In this document, a reference to **Aboriginal sites and remains** includes previously known Aboriginal sites and remains, as well as discovered Aboriginal sites and remains.*

2. In the case of Aboriginal objects discovered, or collected from, within the Authorisation Area, an Authorised Party must provide AAR and KYAC with an inventory within six months of the discovery or collection of the object (whichever is first) that, at minimum, includes:
   a) a unique identifier number for each object
   b) a physical description of each object
   c) geospatial information about the discovery location of each object, where recorded
   d) where practical, and where considered necessary by an archaeologist to demonstrate the range of objects within the Authorisation Area, scale photographs of the object(s).

   *Note: In this document, a reference to **Aboriginal objects** includes previously known Aboriginal objects, as well as discovered Aboriginal objects.*

Site card lodgement

3. An Authorised Party must lodge with AAR and KYAC:
   a) in the case of Burial Location 1, a site card completed to AAR's satisfaction within 12 months of the date of this Authorisation, which includes the measures that will be employed to ensure the protection of Burial Location 1 for the duration of the Authorisation. Where additional Aboriginal remains are re-interred within Burial Location 1, provide an updated site card to AAR within six months of this occurring
   b) in the case of any other Aboriginal sites or remains that are discovered within the Authorisation Area that the Applicant agrees may be retained in-situ, a site card completed to AAR's satisfaction within six months of the date of discovery, which includes the measures that will be employed to ensure the protection of the site or remains for the life of the Project.

WGA

Walker Corporation

Riverlea Park

STORMWATER MANAGEMENT - WATER, WASTEWATER AND RECYCLED WATER

WGA080163

WGA080163-RP-CV-0004_H

December 2023

Revision History

REV	DATE	ISSUE	ORIGINATOR	CHECKER	APPROVER
A	Nov 08	For Client Review	JME	DB	DB
B	Dec 08	For Client Review	JME	DB	DB
C	Dec 08	For Client Review	JME	DB	DB
D	Mar 09	Issued to Client	JME	DB	DB
E	Nov 22	Issued to Client	FL	DB	DB
F	Dec 22	Final Issue	FL	DB	DB
G	April 23	Addressed EPA/DEW comments	GL	DB	DB
H	Dec 23	EPA/DEW Comments	GL	DB	DB

CONTENTS

Figures

Tables

Appendices

1 INTRODUCTION

1.1 Introduction

This is an updated version of the Technical Paper prepared in 2009 to take into account the following changes to the development proposal:

- Introduction of a Salt Water Lake scheme within the development to provide amenity but to also provide stormwater detention for a significant component of the site.
- Changes to the Gawler River Flood Model, and updating the 100 year ARI floodplain mapping based on the updated model and introduction of the salt water lakes.
- Updates by SA Water in regards to the Potable Water Supply to the development.
- Updates by SA Water in regards to the provision of irrigation (recycled water) to the site, as a result of the recent construction of the Northern Adelaide Irrigation Scheme (NAIS).

1.2 Background

The Riverlea development by Walker Corporation, which is now currently under construction with Precinct 1 and sections of Precinct 2 under construction. It will comprise approximately 12,000 residential allotments, a number of commercial and industrial precincts, three permanent neighbourhood centres, one district centre, one retail centre and both primary and high schools, local shopping areas and employment opportunities. Figure 1.1 below shows the Masterplan layout of the proposal.

Figure 1.1: Riverlea Park Proposal Masterplan

Construction of the proposal will be staged over a 25 year period. The provision of infrastructure (such as the stormwater, potable water and waste-water) will also be staged, and constructed as demand requires it. Therefore, capital costs associated with implementation of infrastructure will be progressive over the 25 year construction period.

Figure 1.2 shows the current Riverlea Park proposal staging plan developed so far. The intention is for development to progressively move from the east to the west as that is the logical path to bring infrastructure to the site.

Figure 1.2: Riverlea Park Proposal Staging Plan

1.3 Planning and Design Code

The Riverlea site is within the City of Playford and is zoned Masterplanned Neighbourhood.

As a result of the area's horticultural character, the Riverlea Park area currently has no major water or sewer trunk services available, however recycled water is currently supplied to the residents for irrigation and horticultural purposes via the WRSV (Western Reticulation Systems Virginia) pipeline and more recently through the extension of the Northern Adelaide Irrigation System (NAIS), which has a pipeline in Port Wakefield Highway.

1.4 Site Description

The Riverlea Park site covers an approximate area of 1,308 hectares. The site is situated approximately 32km north of the Adelaide CBD, bounded by Gawler River to the north, Buckland Dry Creek salt fields to the south, Port Wakefield Highway to the east (see Figure 1.3 for the locality plan). The Riverlea Park site is approximately 2.7 kilometres inland of the Gulf St Vincent coastline and it is for this reason it is not considered to be a coastal site.

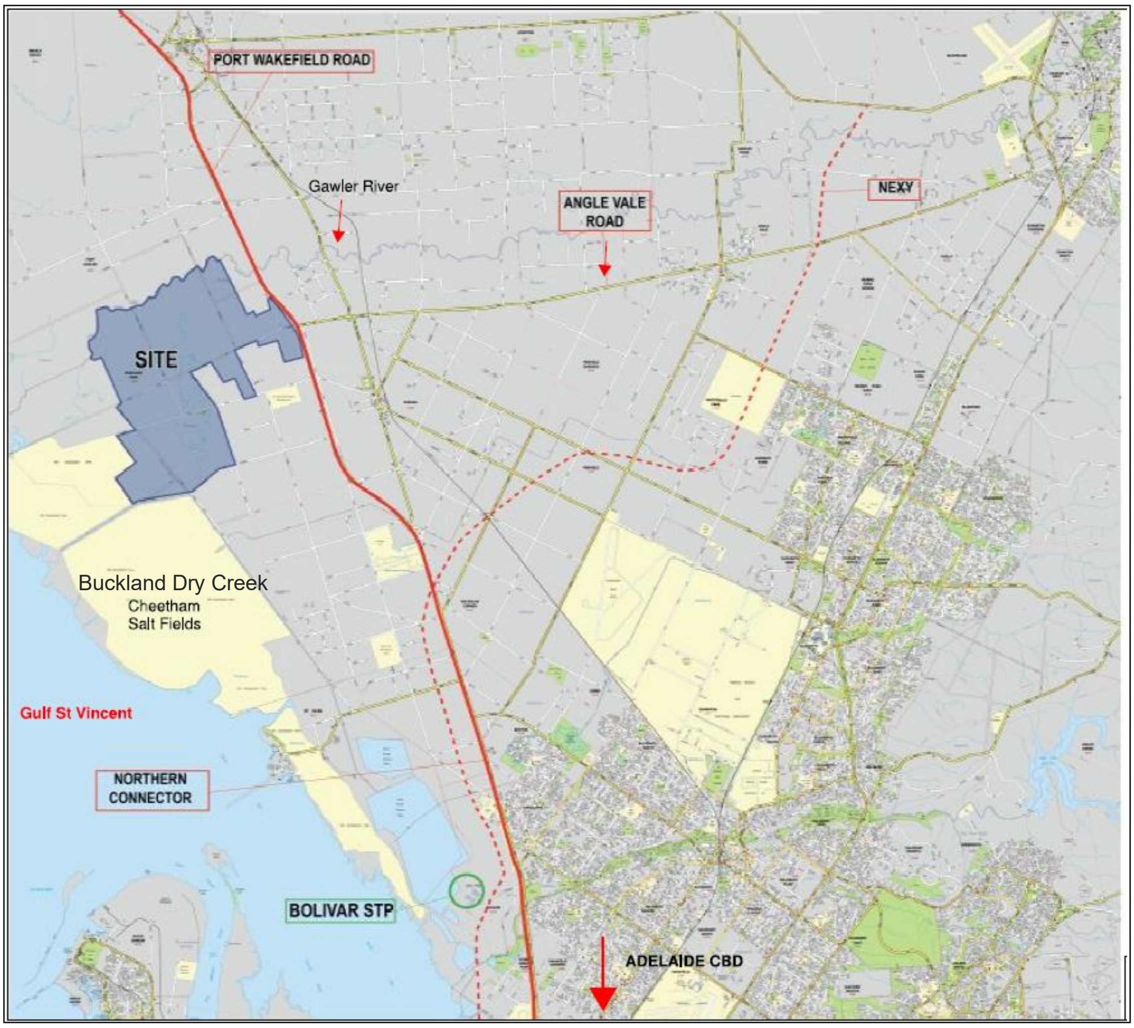


Figure 1.3: Locality Plan

The topography of the site is relatively flat with an approximately fall of 0.2% across the site from east to west. The site also lies within the Gawler River flood plain. Figure 1.4 shows the site location in relation to the surrounding community.

Figure 1.4: Site Boundary in Context of Surroundings

As a part of the initial site investigations ground water mapping was undertaken by Resource and Environmental Management (REM) (Reference 7). This mapping indicated that the depth to ground water within the site ranges from 0.2 metres to 7 metres below the natural surface level. It can be seen in Figure 1.5 that approximately 75% of the site has a depth to ground water of approximately 3 metres below the surface level.

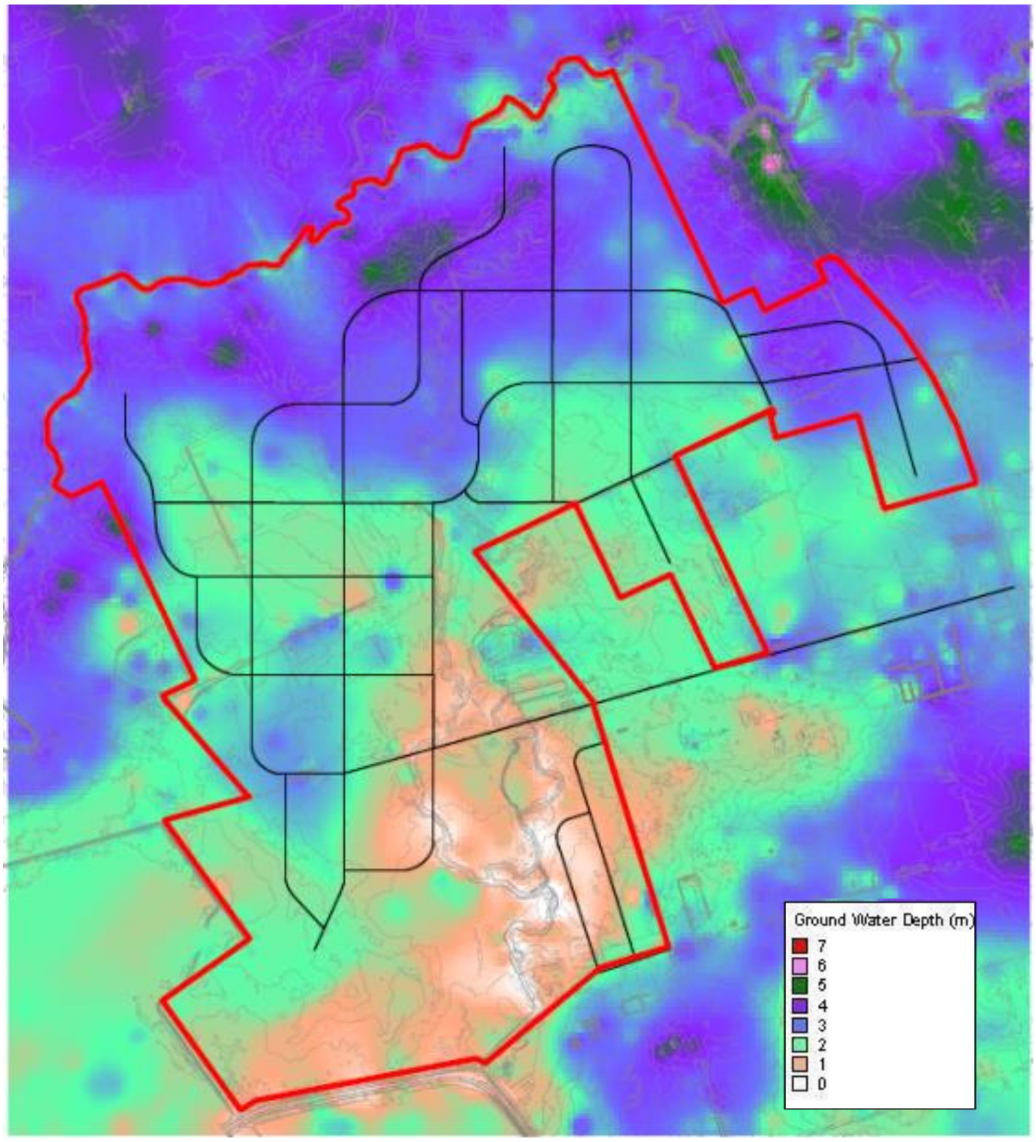


Figure 1.5: Depth to Groundwater

Site investigations by both Golder Associates (Reference 5) and REM (Resource and Environmental Management, reference 7) revealed the ground water in the Riverlea Park area is highly saline, with the salinity ranging from 1000ppm to 5000ppm Total Dissolved Solids (TDS). These investigations also indicated that some portions of the site are affected by Acid Sulphate Soils (ASS).

1.5 Water Management Aims

This technical paper outlines the formulation of the following concepts as they relate to the Riverlea Park proposal:

- Stormwater capture, treatment and reuse (minor flow management)
- Stormwater Management (major flow management)
- Sewerage reticulation systems
- Potable water supply
- Flood protection from Gawler River
- Provision of Recycled Water (NAIS) to the site

These concepts will be discussed in relation to site conditions and how they influence the recommendations for water infrastructure and the layout of the proposal's Masterplan – particularly the location and configuration of stormwater management facilities.

The EIS Guidelines that will be addressed in this report are outlined in Appendix A.

2 STORMWATER

2.1 Introduction

The current method of stormwater management within the Riverlea Park site relies on a system of natural open creek lines and roadside open drains and culverts to move the stormwater runoff through the catchment and discharge it to the ocean via the Thompson Outfall Channel.

The Riverlea Park site generally drains away from the Gawler River in a south westerly direction towards the Thompson Outfall Channel. The Gawler River is situated within the northern section of the Riverlea Park site and is a perched river system. As the banks of the Gawler River are higher than the adjacent floodplain, stormwater runoff from the Riverlea Park site will not drain to the Gawler River nor to the Buckland Lake System as they are both effectively located upstream of the Riverlea Park proposal site.

Figure 2.1 shows the site levels in metres to Australian Height Datum (AHD) and shows that the site falls away from the Gawler River towards the Thompson Outfall Channel.

Section 2 of this report will focus primarily on minor and major internal stormwater flow management whilst water quality and the management of external flood water flows will be addressed in Sections 3 and 4 respectively.

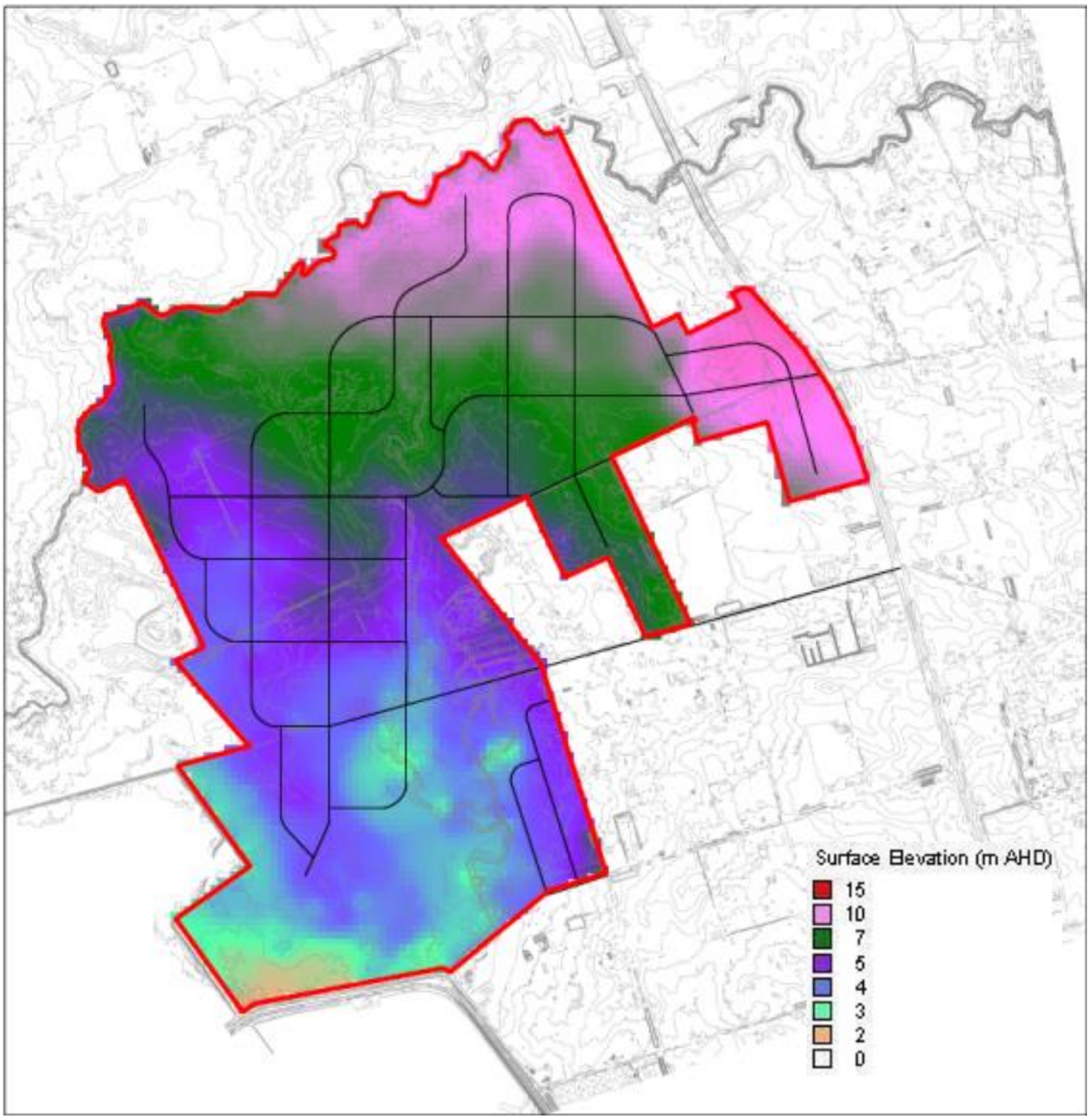


Figure 2.1: Existing Site levels

2.2 Pre-Development Site Conditions

Currently stormwater infrastructure in the Riverlea Park area is limited. The majority of the stormwater flows are carried by a system of natural creek lines, culverts and open drains that run along the road side and discharge to the Thompson Outfall Channel (see Figure 2.2 for stormwater infrastructure layout).

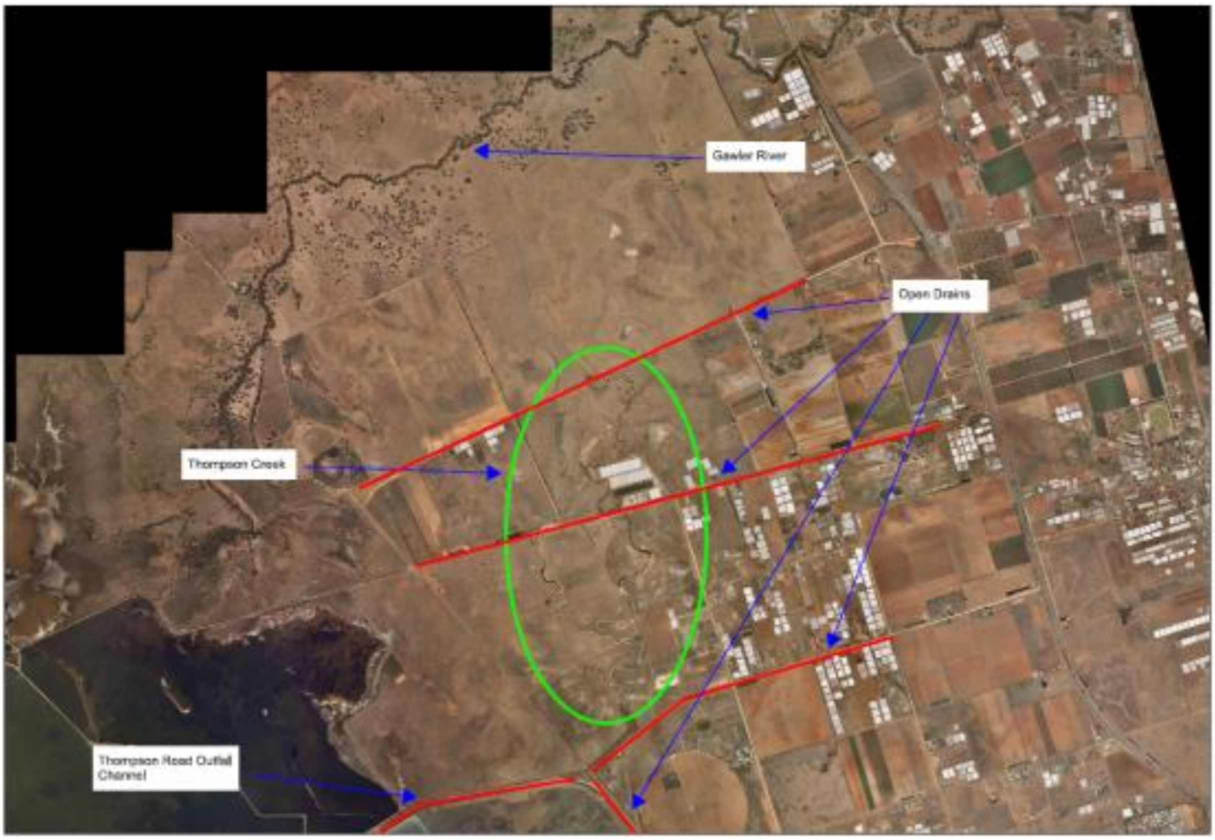


Figure 2.2: Existing Stormwater Infrastructure

The Thompson Outfall Channel is a large earth channel that extends from the western most end of Thompson Road and discharges into Gulf St Vincent.

Thompson Creek is a natural creek which runs through the centre of the Riverlea Park site (see Figure 2.2). The catchment that contributes to Thompson Creek extends west from Port Wakefield Highway, between Thompson Road and the Gawler River.

2.2.1 Thompson Outfall Channel

Thompson Outfall Channel extends from the western most end of Thompson Road in Riverlea Park and runs parallel with the SA Water Bolivar effluent discharge channel (see Figure 2.2 for location). The drain is earth lined with a varying trapezoidal cross section.

Thompson Outfall Channel receives stormwater runoff from a large catchment of approximately 85km^2 known as the Western Virginia Catchment. This catchment lies within the bounds of Gawler River to the north, Andrews Road, Munno Para Downs in the east, St Kilda Road to the south and the Salt crystallization pans to the west. The outfall channel discharges directly to Gulf St Vincent and the capacity of the channel will be affected by tide levels.

It is a requirement of the Planning and Design Code that all new projects make an allowance for rises in sea level when designing stormwater outlets that discharge to the sea. The Port Adelaide Seawater Stormwater Flooding study (Reference 11) undertook a detailed assessment of tidal and rainfall records to determine if there was a relationship between tides and storms. The study determined there was no direct correlation and formulated a series of criteria for combined storm and tide events based on likely probability.

Port Adelaide Enfield Council adopts the following when assessing the drainage strategies for projects:

- 1 in 100 year ARI (1% AEP) storm with a corresponding long term Mean High Water Springs (MHWS) tide
- 1 in 1 year ARI storm (100% AEP), with a long term 1 in 100 year tide event (1%AEP)

Taking into account predicted long term sea level rise at the downstream end of the Thompson Outfall Channel, an outlet tailwater level of 1.95m AHD has been adopted. This level was determined as follows:

- Mean High Water Springs (MHWS) level = 0.95m AHD
- Expected sea level rise (2100) = 1.0m

Mean High Water Springs is a level that is the average of all the twice daily high tides in spring.

In order to determine the capacity of the Thompson Outfall Channel a HEC-RAS computer model was setup. HEC-RAS is a software package that uses one dimensional hydraulic calculations to analyse flows in natural or constructed channels. The parameters used in the analysis include the following:

- Mannings n = 0.04
- Downstream water level = 1.95m AHD (as indicated previously)
- Length 2.6km

From the analysis it was determined that the maximum capacity of the outfall channel is approximately 28 to 30m^3/s assuming the existing degraded levee on the northern banks is reinstated to a level similar to the dividing levee to the Bolivar Outfall channel which is set at approximately RL 3m AHD.

2.2.2 Thompson Creek

Thompson Creek is a naturally occurring creek that runs directly through the centre of the site (see Figure 2.2 for location).

The creek currently meanders through the site with a number of branching tributaries and terminates at Thompson Road where it connects into the Thompson Outfall Channel.

2.2.3 Stormwater Drainage Infrastructure

Pre-development, the stormwater infrastructure within the site was limited, with the stormwater runoff from the undeveloped site being carried through the catchment area via a system of road side open drains and culverts (see Figure 2.2 for details) that terminate at the Thompson Road outfall channel.

The exact capacity of the current stormwater drainage system is not known, but is expected to be limited.

2.2.4 Gawler River

The Gawler River is a perched waterway that runs along the northern most boundary of the site.

The river is situated upstream of the site and the banks of the river are raised so they are higher than the surrounding floodplain as shown in Figure 2.1. As such the Gawler River receives no contribution of stormwater runoff from the Riverlea Park site.

The site will however experience flood events from water breaking the banks of the Gawler River. This is discussed in detail in Section 5 of this report.

2.3 Post-Development Stormwater Management

Once the proposal is complete, the Riverlea Park catchment will produce a significantly larger volume of stormwater runoff than it would currently give its undeveloped state. Therefore, to capture and discharge the runoff to Gulf St Vincent, whilst considering and managing the environmental impacts of the increased flows, a more structured stormwater management system will be required.

In order to meet the Council's criteria that peak stormwater flows discharged from the Riverlea Park proposal must not exceed the pre-developed discharge rate and considering the relatively limited capacity of the Thompson Outfall Channel, onsite detention will be required within the proposal's Masterplan.

Stormwater detention will be provided by two means, the salt water lakes will provide stormwater detention above lake water level for those catchments draining to the lakes. For the southern most catchments and parts of Precinct 1, a detention basin/wetland will be constructed at the southern most portion of the site prior to discharge to Thompson's Outfall Channel.

In order to model the estimated peak flows from the developed site a TUFLOW model was created to model the 20% AEP and 1%AEP events. A more detailed Flood Modelling Report is included in Appendix E.

DRAINS was used to estimate the pre-development flows and TUFLOW has been used to model the post development flows and model the impacts of stormwater detention.

TUFLOW is a software package used for designing and analysing urban stormwater drainage systems. TUFLOW uses hydraulic and hydrologic calculations to simulate rainfall events on catchment areas. From this it then calculates the resultant flows, velocities, and hydraulic grade lines that are produced by the rainfall events.

A 1D/2D TUFLOW model has been developed in accordance with AR&R 2019 guidelines. The latest design surface for the development site has been used. The modelling has been undertaken for 1% AEP event.

In order to effectively convey and capture the stormwater runoff created by the proposal a number of different techniques will be used. These techniques include the following:

- A network of concrete pipes to collect local drainage from rooves and roadways
- A network of linear drainage reserves to convey larger flows that will provide a dual use for water quality treatment
- Detention basins and lakes to reduce the peak outflow from the proposal

Detention above the Salt Water Lakes combined with a single large detention basin in the south western corner of the site was considered appropriate. The southern basin was chosen as the low lying nature of the land in this area makes it unsuitable for residential purposes also zoned as 'open space'.

2.3.1 Stormwater Modelling

The analysis required the setup of a DRAINS model for pre-development runoff, and a TUFLOW model for post development runoff.

A number of hydrologic parameters need to be established in order to undertake the DRAINS analysis, particularly in regards to estimating runoff from pervious areas. These assumptions were constant for both the undeveloped and developed site and include the following:

- Soil Type = 2 (Moderate infiltration rates and Moderately well drained)
- Antecedent Moisture Content (AMC) = 3
- Grassed initial loss = 30mm
- Paved initial loss = 2mm
- Supplementary paved initial loss = 2mm

Rainfall data is also required to be entered into the model. In this situation rainfall intensities for the Light Region situated slightly north of Riverlea Park was considered to be the closest and most accurate representation of rainfall at Riverlea Park. Recent reports prepared by the CSIRO suggest that in the future Climate Change could increase the intensities of storms experienced in South Australia by up to 4 to 5 % higher by 2050 (Reference 4). In order to take some account for climate change the rainfall intensity from Australian Rainfall and Runoff were increased by a factor of 15% to allow for some further potential increases in predictions through to 2100. This was achieved in the model by specifying a rainfall multiplier factor of 1.15.

Table 2-1 shows a comparison between the undeveloped and developed stormwater peak runoff volumes for both the 100 year ARI and 1 year ARI storm events and also the increased flows attributed to accounting for climate change.

Table 2-1 - Peak Flow Rates for the Developed and Undeveloped Site Conditions

	UNDEVELOPED (M^3/s)	DEVELOPED (M^3/s)	DEVELOPED WITH CLIMATE CHANGE ALLOWANCE (M^3/s)
100% AEP	4	22	25
1%AEP	10	82	92

The runoff from the developed catchment in a 1%AEP storm is approximately 82m^3/s greater than the undeveloped peak flow rate. In accordance with Council's requirements this flow will be detained within the site to curtail the peak so that it does not exceed the undeveloped flow rate of 10m^3/s.

2.3.2 Pipe Network

A network of concrete pipes will be used to collect the stormwater runoff from the developed catchment area including the commercial and residential areas as well as from the roadways and other impervious surfaces. Following collection, the pipe network will discharge at intermittent locations into a network of Salt Water Lakes and major linear drainage reserves as shown in Figure 2.3.

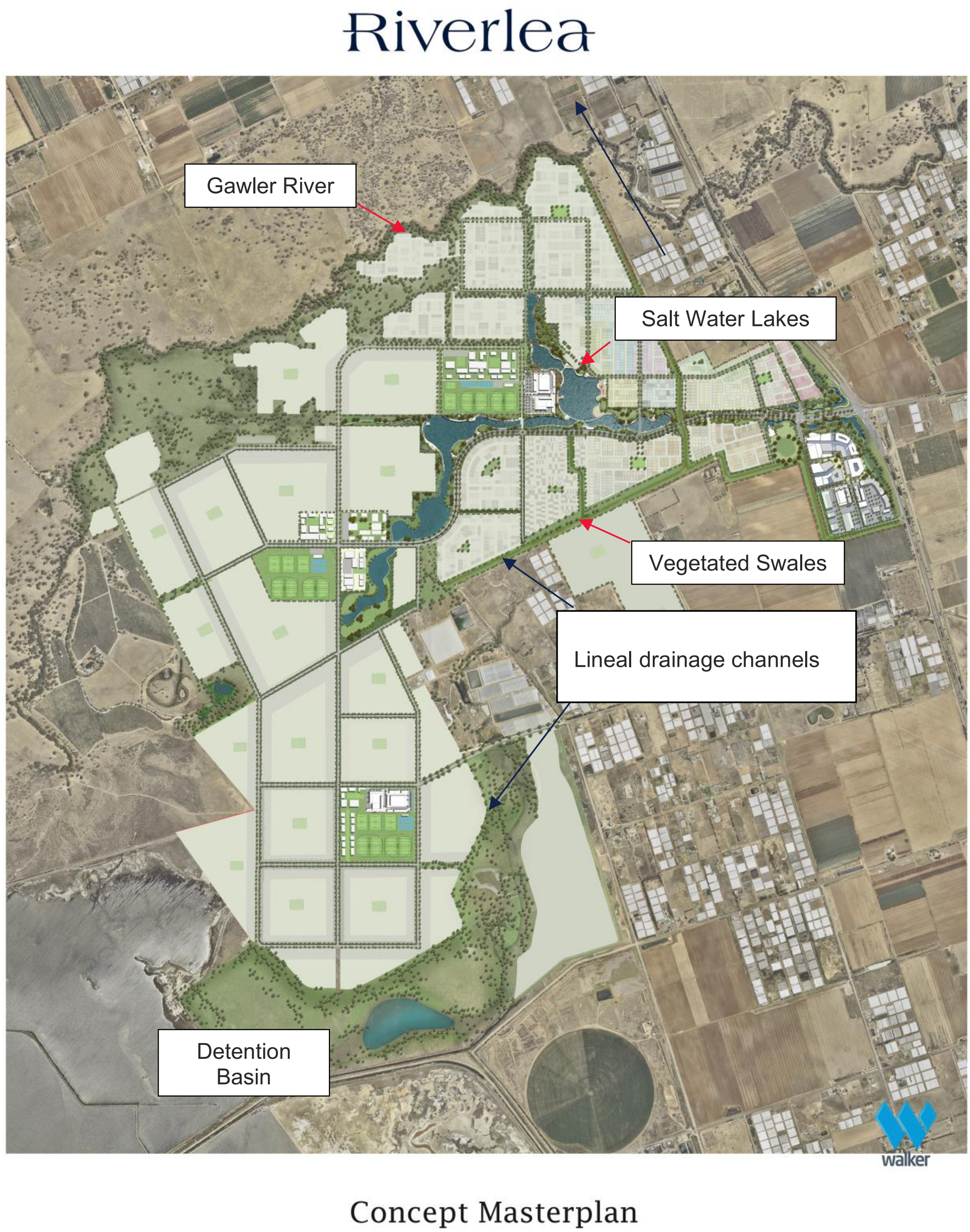


Figure 2.3: Proposed Lake and Lineal Open Drainage System

2.3.3 Linear Drainage Reserves

Linear drainage reserves will be placed within the Masterplan to convey the peak stormwater flows through the site to the Salt Water Lake system to provide stormwater quality treatment and parts of the site will drain through the southern detention basin to the Thompson Outfall Channel. These drains are positioned within the site to take advantage of the natural slope of the land.

The preliminary sizing of these drainage reserves was on the basis that it becomes more practical and cost effective to capture and pass 1%AEP flows within open channels, when these flows begin to exceed the capacity of the combined street and drainage system. This is considered to be when flows reach levels of the order of approximately 5m^3/s. From calculations it has been estimated that a catchment area of approximately 50 hectares would be required to produce this magnitude of peak flow in a 100 year storm event. Figure 2.3 shows the proposed locations of the drainage reserves and Salt Water Lakes.

The concept design for the linear channels includes a low flow channel that will accommodate up to a 100% AEP flow and an upper portion that will accommodate a 1% AEP peak flow. The low flow channel aims to collect minor flows and minimise scour across the base of the channel, and will confine the low flows to provide for better water quality treatment.

The assumptions that were made in the design process include the following:

LAND USE	MANNING'S N VALUE
Salt Water Lakes	0.03
Park reserve	0.04
Open space/channel	0.03
Water surface/wetland	0.05
Lots	0.30
Roads	0.02

The channel sizes presented are indicative sizes only. The channels will need to be individually designed during the detailed design process when the catchment area contributing to each drain can be more confidently determined, however it is considered that the extent of the network as shown will be required due to the size of the proposal. The network of drainage channels also provide for flood protection from the Gawler River, which will be discussed further in Section 5.

Due to the length and depth of the proposed drainage channels a significant amount of excavation will need to be undertaken and therefore a significant amount of excavated material will be produced. This excavated material will be used within the site to fill lower areas of the site, to provide shape for road drainage on the flatter areas of the site and also to provide flood protection.

2.3.4 Detention Basins

The pre-development peak flow rate was calculated to be approximately 10m^3/s, whereas the post-development peak 1%AEP flow rate was found to be 92m^3/s based on the allowance for Climate Change. The proposed detention basin will be located in the south western corner of the site and will reduce the peak flows from the site to a maximum of 6.4m^3/s which is significantly lower than the pre-development flows of 10m^3/s. This is primarily due to the significant size of the proposed saltwater lake system which provides for significant stormwater attenuation. Refer to the flood report in Appendix E.

This location for the southern detention basin was chosen for the following reasons:

- Lowest point on the site
- Low possibility of encountering acid sulphate soils (see ASS report)
- Limited development potential of this area as the site elevations are low

Figure 2.4 and Figure 2.5 summarise the Peak Flood Depths and Peak Flood Levels (AHD) for the 1% AEP event.

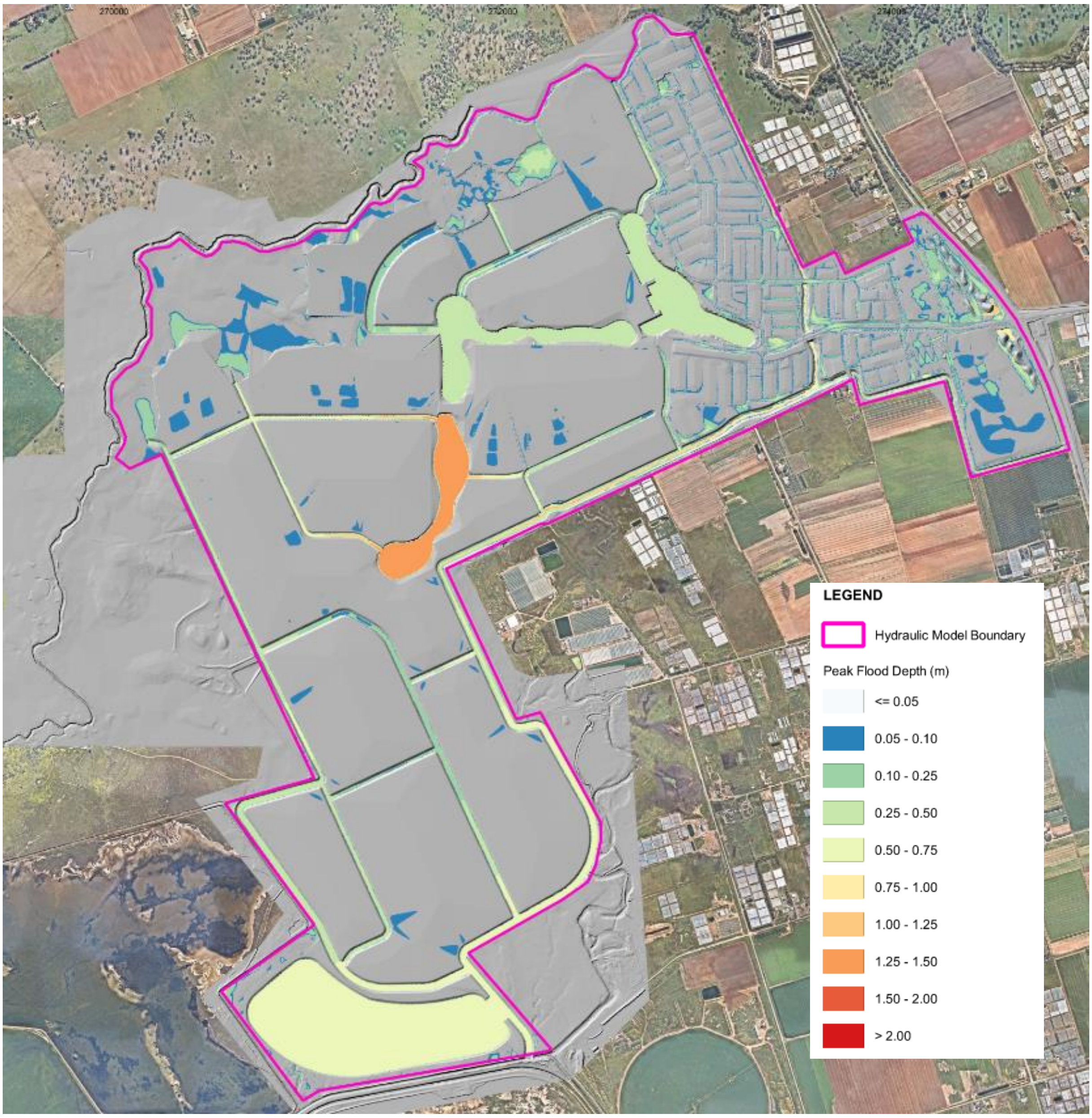


Figure 2.4: Peak 1%AEP Flood Depths

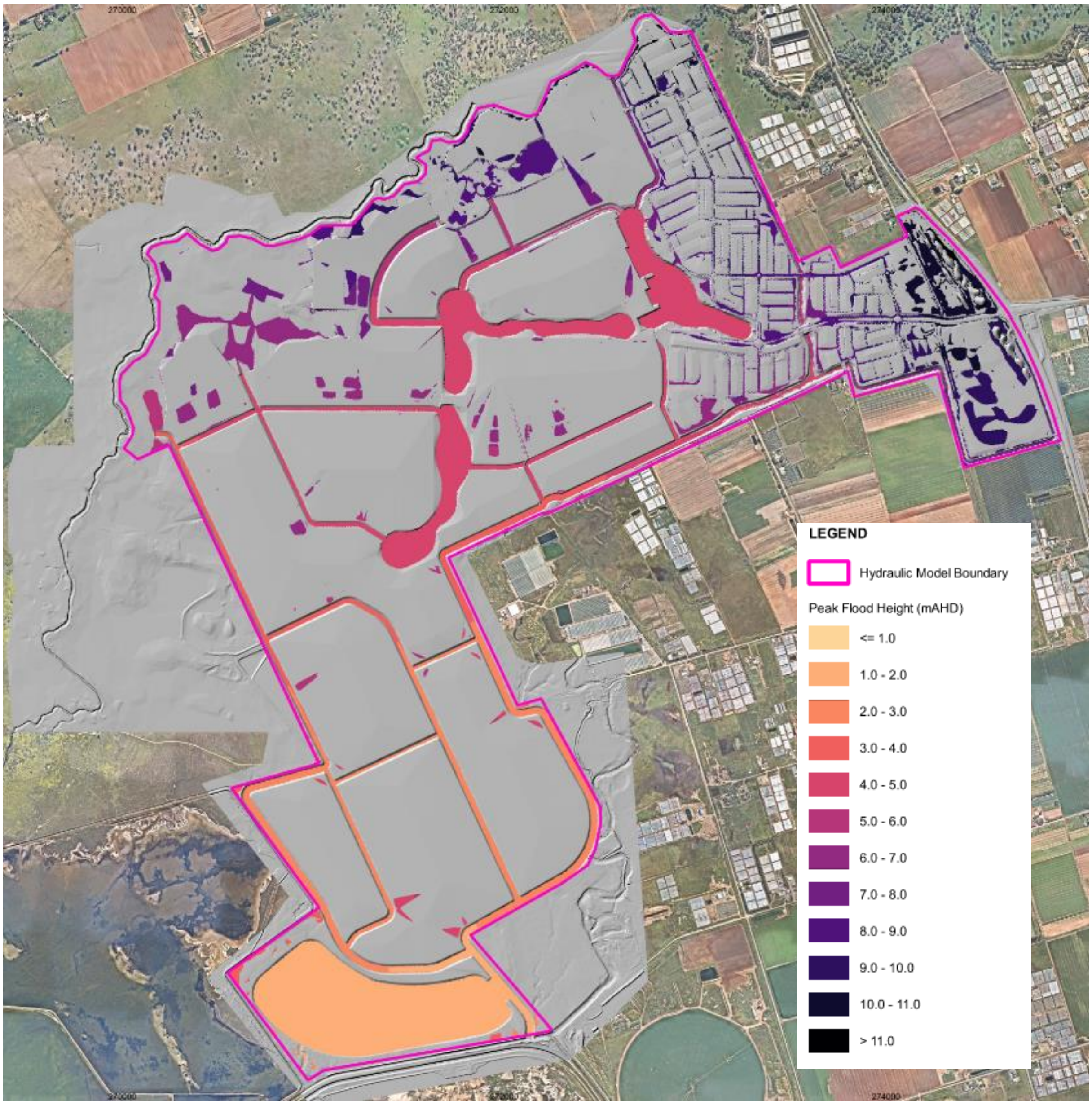


Figure 2.5: Peak 1%AEP Flood Levels in AHD

A copy of the detailed Flood Modelling Report is provided in Appendix E.

3 WATER QUALITY

3.1 Introduction

A Water Sensitive Urban Design (WSUD) approach will be adopted at both a Masterplan and a detailed design level. The basis of the WSUD for the proposal as a whole has been set in the stormwater management system designed for the Masterplan. In terms of stormwater management, this places an emphasis on stormwater treatment, peak flow mitigation, harvesting and reuse, while also ensuring that such practices adopt the multi-objective approach to stormwater management.

The multi-objective approach includes features such as:

- Detain and slow the conveyance of stormwater through the site
- Use vegetation and landscaping to filter and treat stormwater (primarily in the extensive open channel network)
- Integrate the stormwater management into the landscaping
- Water efficient landscaping and the use of local indigenous vegetation species
- Protection of the water related environments and their associated values
- Protection and enhancement of recreational, social, and cultural values
- Improved biodiversity, ecological and habitat outcomes
- Community education and demonstration

Overall, the proposal will incorporate the following stormwater management features:

- Capture and treatment of stormwater runoff at the allotment level, and at the site level
- Treatment of stormwater via wetlands, and vegetated swales in open lineal channels
- Management of the major storm events up to the 1%AEP as discussed in Section 2

This report will focus on the areas of WSUD required at the macro Masterplan level, noting the intention is also to include WSUD features throughout the proposal at the detailed precinct level.

Some examples of typical WSUD features that might be incorporated throughout the proposal are shown in the following images.

Rain Garden/Bio-Filtration Bed

Biofiltration Systems

Infiltration/Wetland Pond **Vegetated Swale**

Pre-development stormwater runoff from the site was not treated prior to discharging via the Thompson Outfall Channel.

The stormwater runoff from Riverlea Park will need to be treated to achieve the South Australian Environmental Protection Authority (SAEPA) – Environment Protection (Water Quality) Policy 2015, guidelines, on the basis the water will either be discharged to the marine environment or to the aquifer for storage.

It is recognised by the Institute of Engineers Australia (refer Reference 6) that treatment of up to a 1 in 3 month storm event, is equivalent to treatment of 93% of the annual runoff. It is not considered practical to capture and treat water for events greater than a 100%AEP. For water quality treatment, a design treatment event between a 333%AEP and a 100%AEP event is normally adopted.

A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was established to assist in developing the proposed water quality treatment strategy to achieve the SA EPA Water Quality Policy Guidelines.

3.2 Objectives and Water Quality Criteria

The objective of this stormwater quality assessment is to evaluate the treatment performance of the proposed/revised systems within Riverlea estate against the required standards at a master plan level.

The proposed stormwater treatment system was designed to treat the runoff in accordance with the standards as defined by:

- The South Australian EPA water quality policy WSUD targets.
- WSUD pollutant reduction targets as defined in the WSUD Guidelines for the Greater Adelaide Region (2013).

The pollutant treatment performance targets as specified in the above guidelines are:

- 80% retention of typical annual urban load of suspended solids (TSS)
- 60% retention of typical annual urban load of total phosphorus (TP)
- 45% retention of typical annual urban load of total nitrogen (TN)
- 90% reduction of gross pollutants of typical urban load (GP)

In addition to the above targets for the site as a whole, it was also aimed to achieve the treatment performance targets before discharging into the Salt Water Lakes (SWL). The basis of this is that the SWLs can be negatively impacted by the poor quality stormwater inflows from local catchments as described by BMT (2021) in Riverlea Concept Stormwater Quality Management Plan.

Figure 3.1: Proposed Riverlea Master Plan (November 2023) Showing Extensive Open Channel Network

3.3 Stormwater Treatment Strategy

In order to determine the level of water treatment required to meet the SA EPA guidelines a preliminary treatment strategy was prepared. The strategy employs the use of large lineal treatment swales and wetlands to promote natural water treatment processes to occur as the flows move through the catchment area.

A MUSIC model was setup to evaluate the effectiveness of these treatment strategies.

It can be seen in the stormwater layout that gross pollutant traps, swales with lineal wetlands are proposed to treat the stormwater prior to its reuse, or discharge.

3.3.1 Water Quality Criteria

There are a number of guidelines and standards that can be used to assess the outcomes of a water quality strategy.

The proposed stormwater treatment system is assessed to treat the runoff in accordance with the standards as defined by:

- The South Australian EPA water quality policy WSUD targets
- WSUD pollutant reduction targets as defined in the WSUD Guidelines for the Greater Adelaide Region (2013)

The pollutant treatment performance targets as specified in the above guidelines are:

- 80% retention of typical annual urban load of suspended solids (TSS)
- 60% retention of typical annual urban load of total phosphorus (TP)
- 45% retention of typical annual urban load of total nitrogen (TN)
- 90% reduction of gross pollutants of typical urban load (GP)

The stormwater treatment strategy also adopts the principles of the Australian and New Zealand Environment and Conservation Council (ANZECC) water quality guidelines as a framework. This relates to providing a sound approach that facilitates an environmental duty to prevent or minimise harm to the downstream environment though a treatment train approach.

3.3.2 MUSIC Modelling

A MUSIC model was prepared for the strategy in accordance with the South Australian MUSIC Guidelines (2021) This includes all modelling parameters, model setup and approach top modelling comply with the Guidelines (2021). This is consistent with the Stormwater Quality Modelling Technical note (2022) provided in Appendix F. The model is available for Auditing by Authorise upon request.

MUSIC is a software model which predicts the performance of stormwater quality improvement systems by simulating the quantity and quality of runoff produced by catchments and assessing the effectiveness of downstream treatment points to reduce pollutant loads. The treatment systems adopted in this strategy include:

- Gross Pollutant Traps (GPT's)/Trash racks
- Swales
- Wetlands
- Ponds

There are a number of pollutants which can be present in stormwater runoff. Within the MUSIC model only the following are analysed:

- Total Nitrogen
- Total Phosphorus
- Total Suspended Solids
- Gross pollutants

Other pollutants are expected to be present in the runoff prior to treatment, it is known however that fine particulate pollutants attach themselves to other particulate pollutants such as Total Phosphorus (TP) and Suspended Solids (SS). MUSIC therefore assumes that by targeting pollutants such as TP and SS it will also be treating other pollutants.

Figure 3.3 shows how the stormwater strategy has been arranged within the MUSIC model. It can be seen that each sub-catchment is connected to a GPT/Trash rack and a swale prior to entering either a wetland or a capture basin.

This layout is not a true representation of how the system will operate, but was an altered version constructed to suit the capacity of the modelling program and also shows the Treatment Catchments for the development. Figure 3.2 shows the Treatment Catchments for the development.

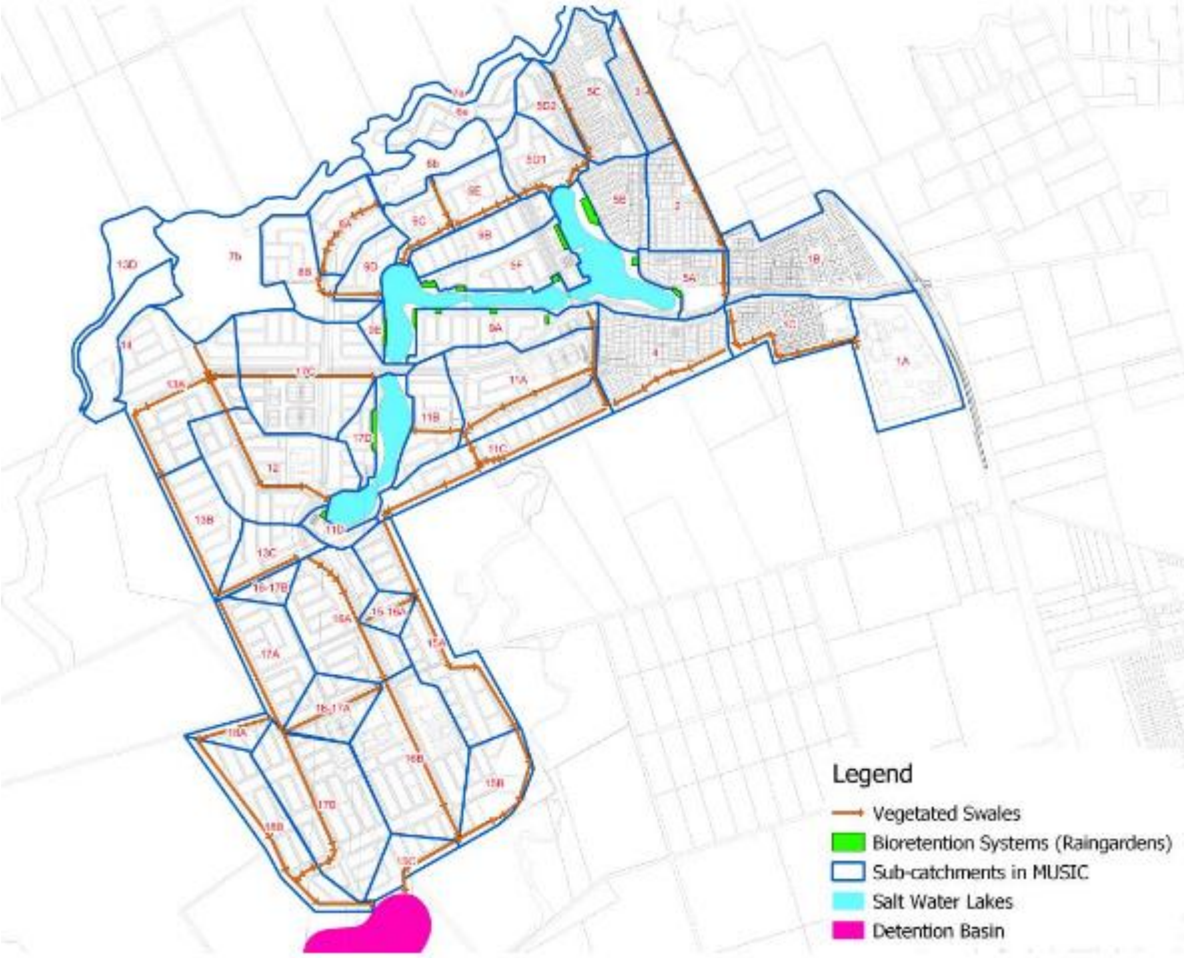


Figure 3.2: MUSIC Model Catchment Plan and WSUD Assets Locations

Figure 3.3 shows the MUSIC Model Schematic and Table 3-1 shows the Water Quality Results. These results are reported prior to discharge into the Saltwater Lakes. Therefore, the strategy has adopted the Saltwater Lakes as being the receiving environment.

Table 3-1: Water Quality Results Compared to Best Practice Standards

POLLUTANT TYPE	TSS	TP	TN	GROSS POLLUTANTS/LITTER
Target percentage reduction (%)	80	60	45	>50 mm and retention in 3-month ARI
Reduction achieved at SWL1 (%)	94.8	70.2	49.6	100% trapped (averaged over the simulated period)
Reduction achieved at SWL2 (%)	96.5	79.8	61.0	100% trapped (averaged over the simulated period)
Reduction achieved at SWL3 (%)	95.2	70.1	45.4	100% trapped (averaged over the simulated period)
Reduction achieved at Site Overall (%)	96.6	82.0	63.1	100% trapped (averaged over the simulated period)

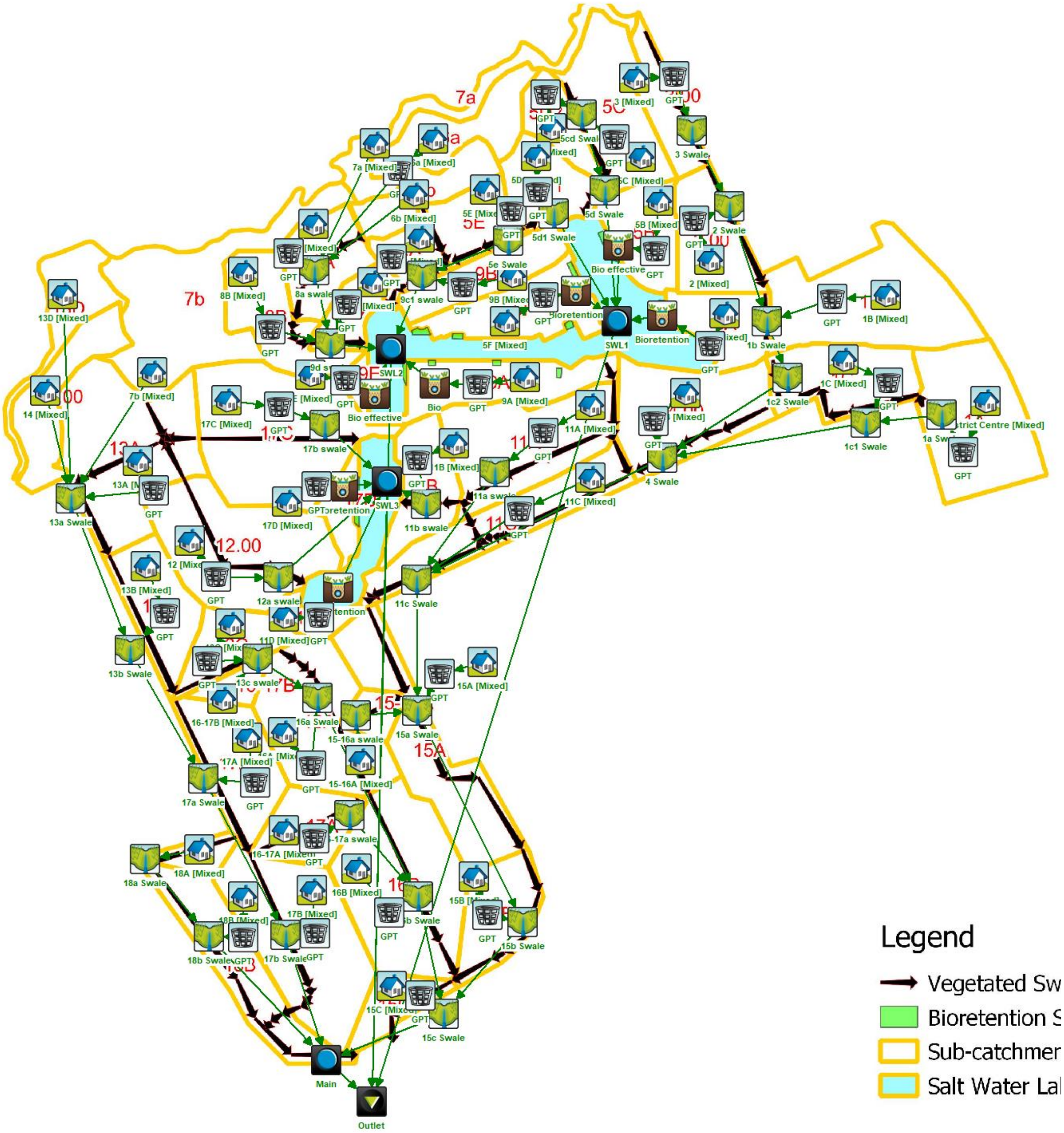


Figure 3.3: MUSIC Model Schematic

3.4 Water Quality Summary

This Master Plan level assessment of the stormwater treatment strategy for Riverlea Park indicates that stormwater quality discharging from the estate (to the Salt Water Lakes) will meet the treatment performance targets as defined in EPA WSUD treatment targets and the Greater Adelaide Region's WSUD pollutant reduction targets. The Strategy has adopted the ANZEC framework with regards to the adoption of a treatment train approach that minimise risk or harm to the receiving waters. Furthermore, the reported treatment targets a based on the point of discharge into the Salt Water Lakes and therefore ensure that stormwater do not impact the water quality within the lakes.

A more detailed Stormwater Quality Modelling Report is provided in Appendix F

3.5 Aquifer Storage and Recovery Potential

The Aquifer Storage and Recovery Potential at Riverlea Park has been assessed by REM in their report Aquifer Storage and Recovery Potential for Riverlea Park, (Reference 7). REM has advised the T2 aquifer has the potential to accept up to 50ML/a of water without pressurising the aquifer. Pressuring the aquifer would potentially result in increased storage potential, however, it would significantly impact on all existing bores connected to the T2 aquifer, requiring the bore heads to be sealed, and pumps changed to suit the new aquifer pressure.

There are a currently 287 recorded local bores that could be affected by pressurising the aquifer and it is therefore concluded planning should exclude this option.

For the purposes of assessing the ASR potential of the site, it has been assumed a maximum of 50ML/a of treated water can be discharged to the local T2 aquifer, compared to the potential to capture up to 2000ML/a of annual runoff.

The ASR potential is therefore very limited in terms of its ability to be a reliable source of secondary water supply, unless above ground storages with floating covers are considered which have proven to be very costly and would add significantly to the cost of water. SA Water advised that sufficient recycled water will be made available from Bolivar for the recycled water supply for the entire proposal. On this basis it is likely that the 50ML/a of ASR potential will be used to provide recycled water for irrigation of some parks, and to top up wetland water bodies.

For the provision of irrigation water to the development, SA Water have advised that connection to the NAIS scheme can be provided which will allow for a relatively cheap source of irrigation water. ASR is no longer being considered for the development.

4 FLOOD PROTECTION FROM GAWLER RIVER

4.1 Introduction

The Riverlea Park site is currently subject to flooding during a 5%AEP event via a breakout from the Gawler River. Refer to the Floodplain Mapping for the Gawler River – Technical Report 2008, prepared by Water Technology and Australian Water Environments (Reference 1). Appendix B contains the Gawler River Flood Plain Maps.

The lower reaches of the Gawler River through Virginia and Riverlea Park is an example of a 'perched' river, as its banks are higher than the surrounding floodplain. When water breaks the banks of the Gawler River in these areas, water flows away from the Gawler River as opposed to being contained in a low lying floodplain. There are a number of breakouts that enter the site as shown in Figure 4.1.

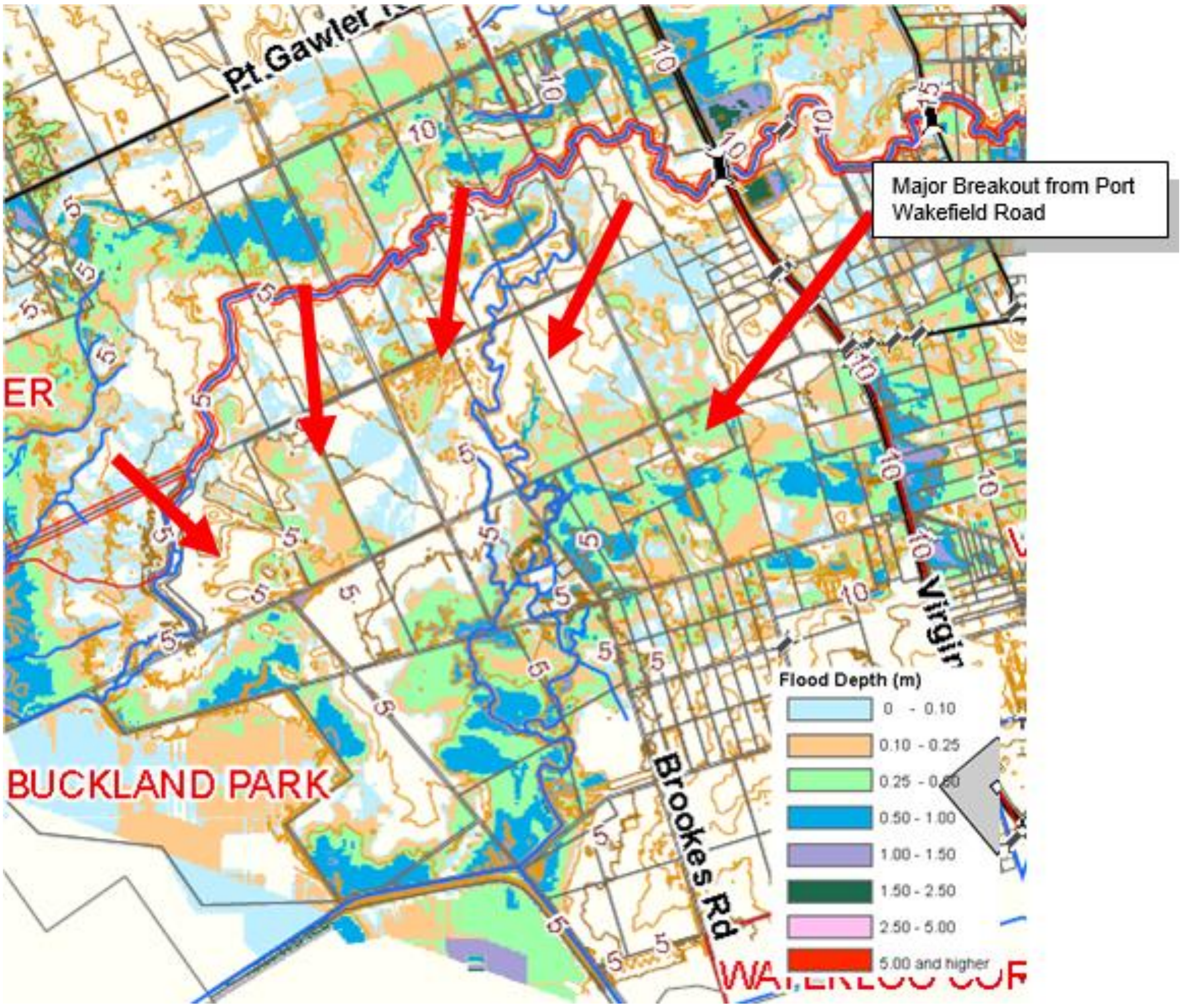


Figure 4.1: Extract from 1%AEP Floodplain Map from AWE/Water Technologies Floodplain Report

The flows are relatively shallow in nature and in terms of Flood Hazard as defined by the Australian Government SCARM 2000, Floodplain Management in Australia, Best Management Practices and Principles, the flood hazards are primarily in the low to medium category as they are relatively shallow and the flow velocities are low.

The largest breakout from the Gawler River approaches the site from the east via Port Wakefield Highway and in the 100 year ARI event, is in excess of 100m3/s. The other breakouts are relatively minor, however, they do pose some risk to the site and need to be managed. Figure 4.2 shows in greater detail the predicted extent of flooding within the site in the 100 year ARI event.

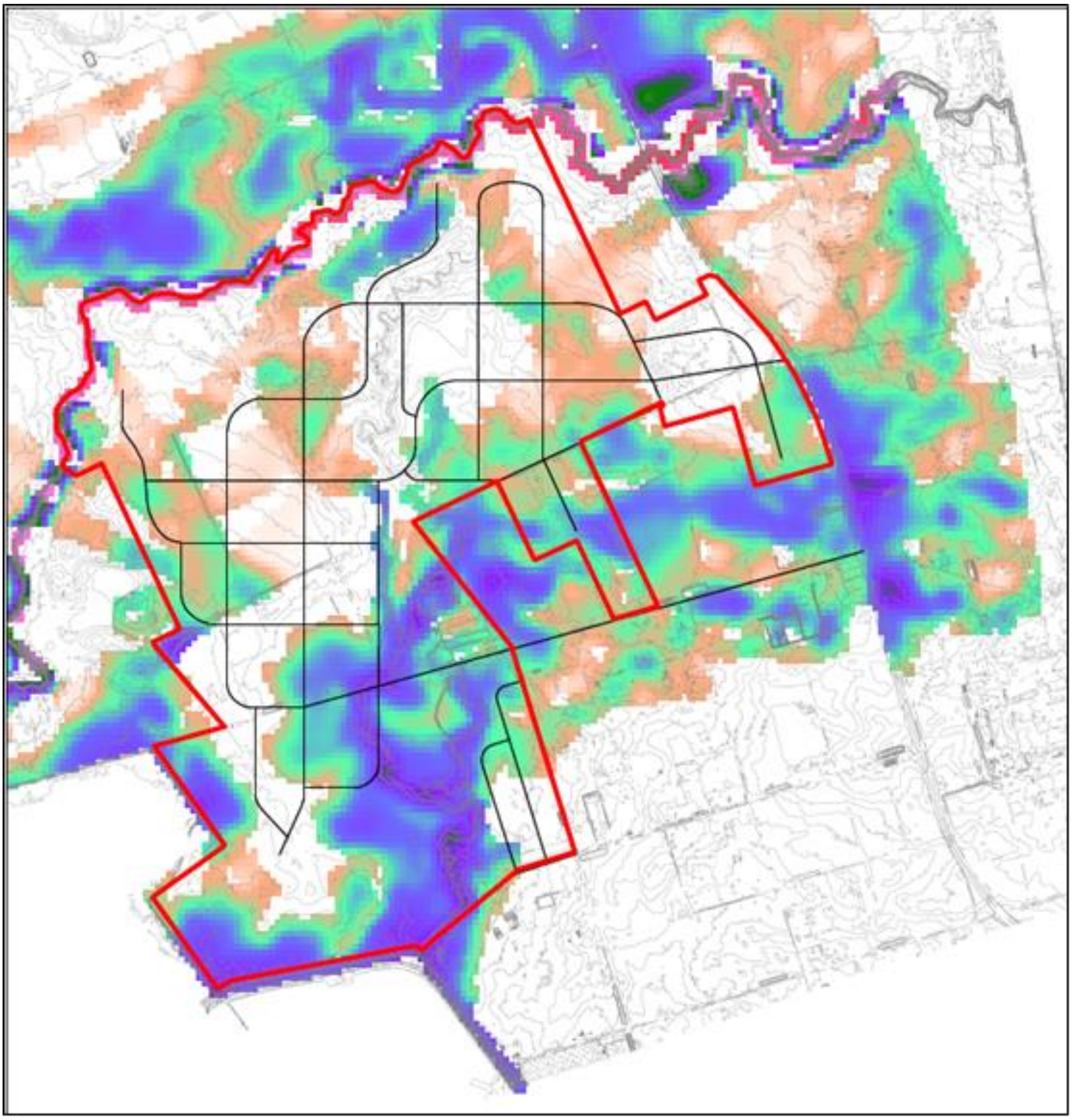


Figure 4.2: 1%AEP Gawler River Floodplain as it Relates to the Riverlea Park Site

4.2 Flood Management Strategy

The flood management strategy proposed for the site involves of a series of flood channels.

The use of levees was initially trialled, particularly against the banks of the Gawler River, however, it was found that introducing levees to control breakouts often forced breakouts in other areas. Similarly, the introduction of a levee system often diverts flood flows to other areas, potentially adversely impacting adjoining properties.

It should be noted that pre-development when the 1%AEP breakout flows leave the southwestern boundary of the site, they overtop the Thompson Outfall Channel into the Cheetham salt crystallisation pans, and into the Bolivar Outfall channel.

As this would occur in a 1%AEP flood event, and to alter this situation would require significant works outside of the site boundaries, the flood mitigation strategy allows this to continue to occur in the future as it would do now, and provides protective works within the site.

The proposed major drainage channel system proposed for Riverlea Park is shown in Figure 4.3. The system consists of a number of major drains through the site to capture the breakout flows from the Gawler River. It should be noted that a flood event that would produce a breakout in the Gawler River is a long duration storm event, peaking after some 20 to 30 hours. Refer Hydrological Study of the Gawler River Catchment (Reference 2).

The critical storm durations for the internal drainage system are of the order of 30 to 60 minutes. Therefore, the drainage system within Riverlea Park would not need to accommodate a coincident peak flood event from the Gawler River and from within the site, hence, significant sections of the proposed major drainage system have been designed to provide a dual purpose.

The drains are relatively flat, particularly the main capture drain which is as flat as 0.05% in some areas. The drains have been kept relatively shallow, up to a maximum of 2.0m, to keep the invert as high as possible to keep the risk of groundwater intrusion to a minimum.

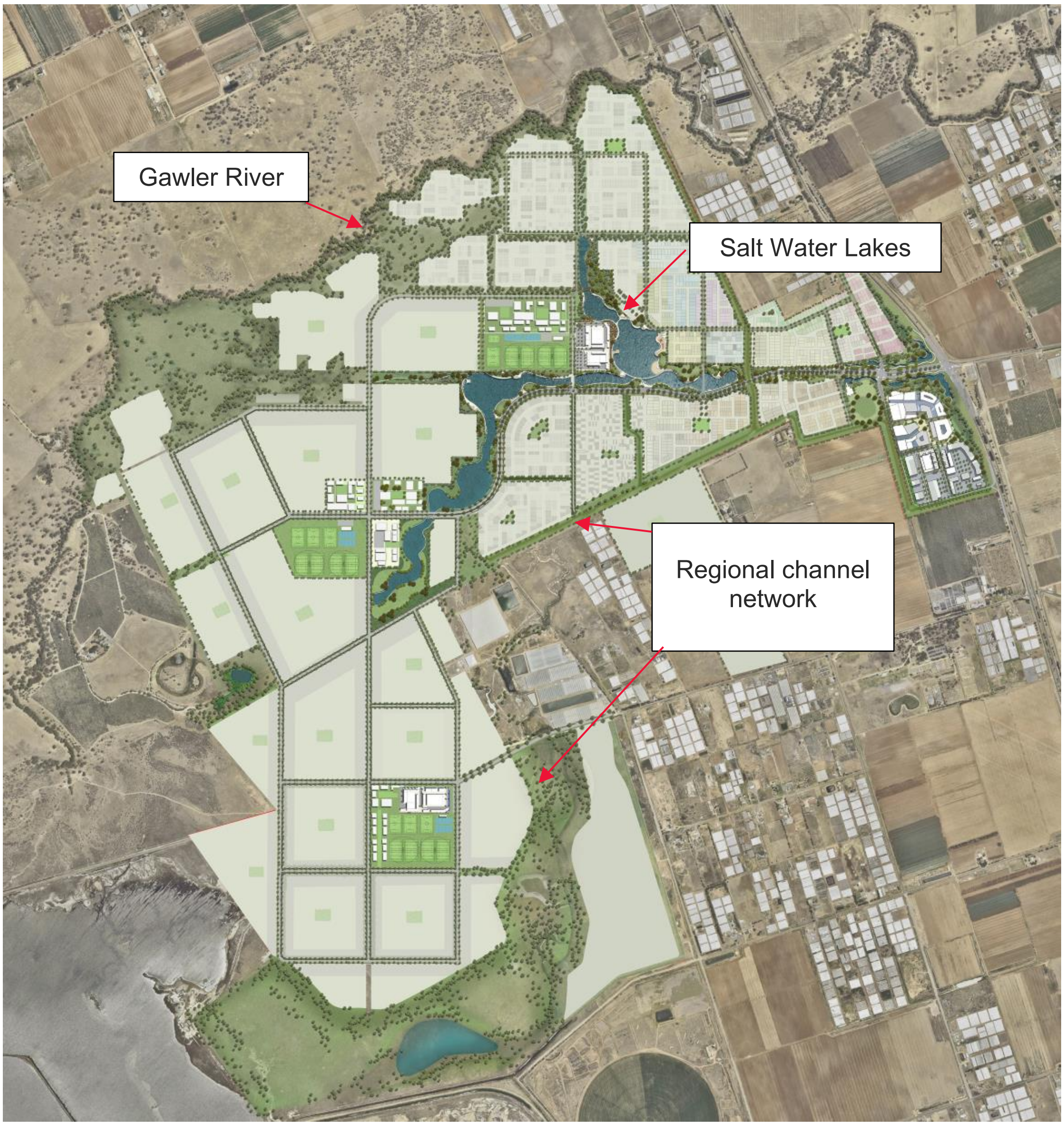


Figure 4.3: Proposed Riverlea Park Major Regional Drainage Channel Network

The major drainage system is the large open channel networked depicted in Figure 4.3.

4.3 Modelling

The modelling of the flood performance from breakouts from the Gawler River has been undertaken by Water Technologies as the consultants for the Gawler River Floodplain Mapping Project.

The modelling has been undertaken using the two dimensional floodplain model MIKE 21, using the modelling assumptions adopted and agreed for that study.

A series of trials have been carried out which have led to the preferred solution for the proposal.

4.4 Results

Figure 4.4 presents the results of a 1%AEP event on the Gawler River.

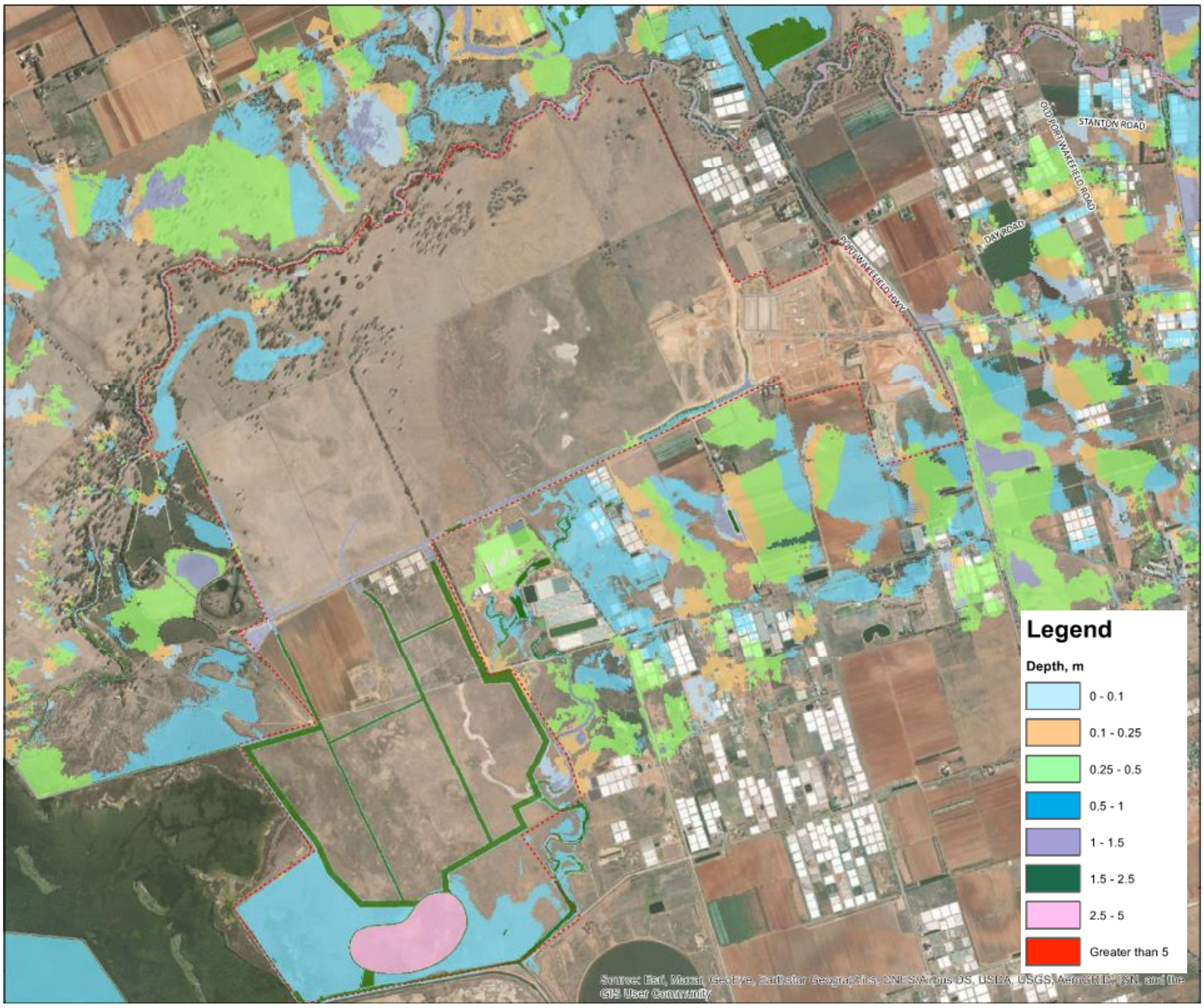


Figure 4.4: 100 Year ARI Event in Gawler River with Proposed Flood Protection Channels

The modelling shows that the proposed open channel system has the capacity to capture and pass the 1%AEP event Gawler River breakouts through the site, the exception is the proposed District Centre and Mixed Use precinct adjacent Port Wakefield Highway which has been highlighted in Figure 4.4.

4.5 Impacts of blockage in the Gawler River

The potential for a blockage to occur on the Gawler River, and the resulting impacts this would have on flooding in Riverlea Park has been considered.

In the 2005 flood event in the Gawler River, a fallen tree contributed significantly to the flooding, primarily by causing a break in a levee on the banks of the River (Personal Communication with AWE, November 2008).

Consideration included the potential flood impacts of an obstruction in the Gawler River, between Port Wakefield Highway and the site's western boundary. A channel blockage factor of 25% was considered a reasonable upper limit. A 25% blockage was trialed at a number of locations, however, no additional breakouts were predicted, as the section of Gawler River downstream of Port Wakefield Highway has greater capacity than sections upstream, and water will break the banks of the Gawler River at locations indicated in AWE mapping, resulting in flows less than the capacity of the Gawler River in the channel downstream of Port Wakefield Highway.

Figure 4.7 and 4.8 show the predicted 100 year ARI floodplain in Riverlea Park created by placing 25% blockages at two locations on the Gawler River, downstream of Port Wakefield Highway.

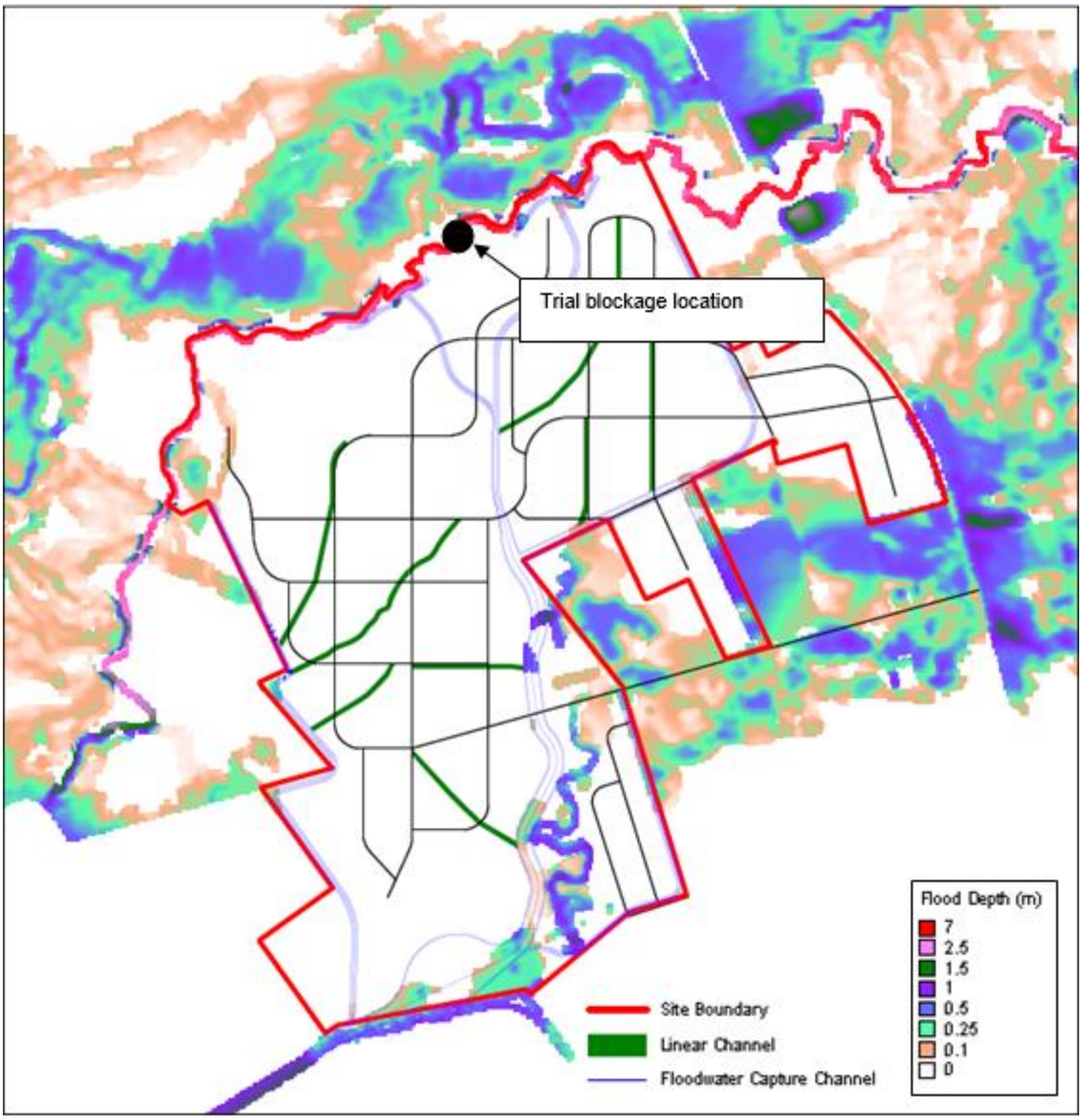


Figure 4.5: 100 Year ARI Floodplain with a 25 Percent Blockage of Gawler River at Location 1

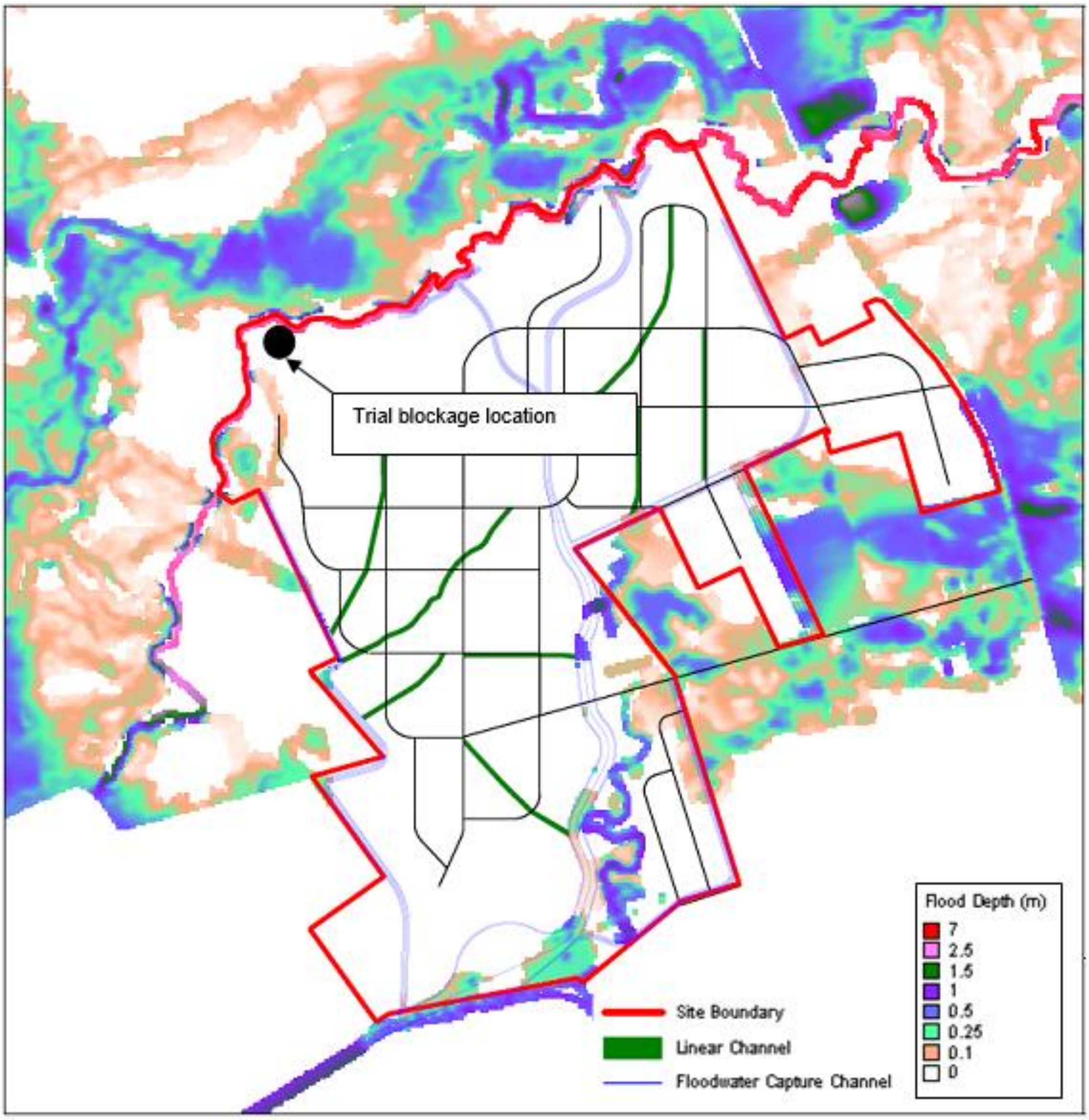


Figure 4.6: 100 Year ARI Floodplain with a 25 Percent Blockage of Gawler River at Location 2

The modelling indicates that the risk of a blockage occurring in the Gawler River downstream of Port Wakefield Highway has little to no impact on an increase in flood risk in the 100 year ARI event.

A more detailed flood assessment report by Water Technologies is included in Appendix B.

5 WASTE WATER

5.1 Introduction

Pre-development within the Riverlea Park area there was no formal system for the collection and disposal of waste water.

New waste water infrastructure will therefore be required to serve the proposal.

SA Water have advised (Reference 9) that a new rising main will be required from the site to deliver sewage directly to the Bolivar Wastewater Treatment Plant, located approximately 14km south of the site.

In order to determine the most efficient method of waste water collection system for this proposal the following network types were considered:

- Vacuum
- Pressure
- Gravity
- Septic Tank Effluent Disposal System (STEDS)
- Full Sewer

These four sewerage schemes were assessed based on their cost effectiveness, and the suitability of their design characteristics for the environmental conditions on site.

The environmental conditions within the Riverlea Park site that could significantly impact on the suitability of the use of a particular sewerage system include the following:

- High ground water level
- Highly saline ground water
- Acid sulphate soils

Based on the preliminary costing and the expected site environmental conditions a vacuum system was recommended for the Riverlea Park proposal see the Network Options Report (W&G, August 2008) in Appendix C.

5.2 Environmental Conditions

Site specific environmental conditions are instrumental in determining the suitability of a sewer system. The selection of an environmentally suitable sewer system could significantly reduce the risk of cost escalations during construction, reduce ongoing running costs and increase constructability.

5.2.1 High Ground Water

The majority of the site has a depth to water table of less than 3 metres. To minimise the length of drain constructed below the groundwater table the maximum drain depth was set to 3 metres. In order to keep the pipes as shallow as possible pump stations would need to be installed at regular intervals.

From analysis it was determined for a gravity system approximately 35 pump stations would be required to keep the pipe invert level within 3 metres of the surface level. Even with this large number of pump stations, as much as 75% of the gravity drains would still be installed within the ground water zone, this is prior to considering the impacts of long term sea level rise on groundwater levels. Figure 5.1 shows a depth to water table plan for the site highlighting all areas where the groundwater is less than 3m below the surface. This map is based on recent site mapping undertaken by REM.

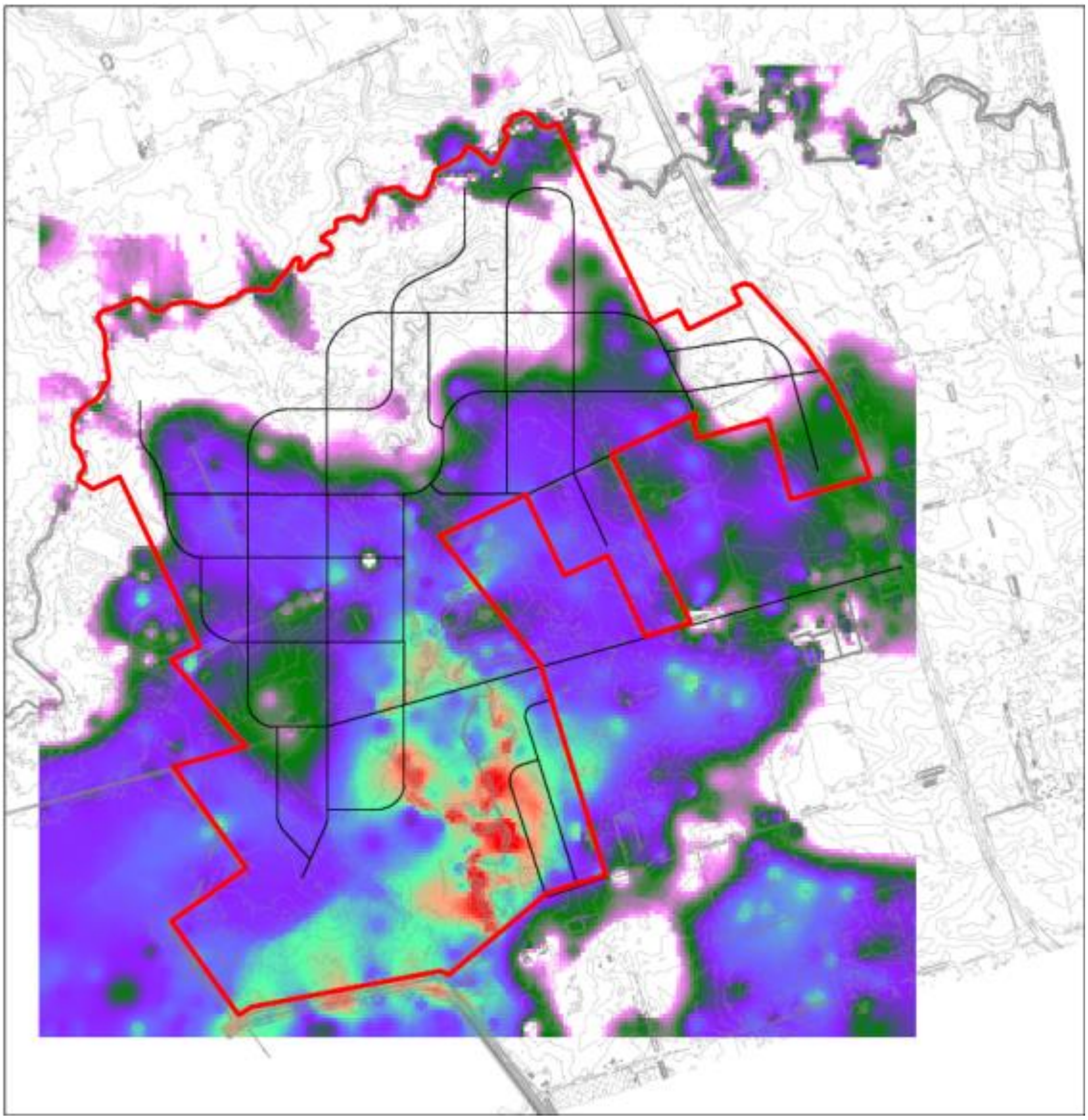


Figure 5.1: Depth to Groundwater within 3m of Existing Surface Level

It should be noted that seasonal fluctuations of up to 1 metre could be experienced based on the advice from the REM report (Reference 10). This could see as much as 95% of the gravity drain being below the standing groundwater level.

Constructing a gravity system within the ground water table could potentially result in water infiltration at manholes, pump stations and any breaks or cracks in the pipe work. STED systems also have potential for ground water ingress at septic tanks.

The drains for a vacuum system are generally installed between a depth of 1.2m and 1.5m. It is estimated that for a vacuum system only 10% of vacuum drains would be installed within the water table.

Figure 5.2 indicates the area of the site that the depth to ground water is less than 1.5m

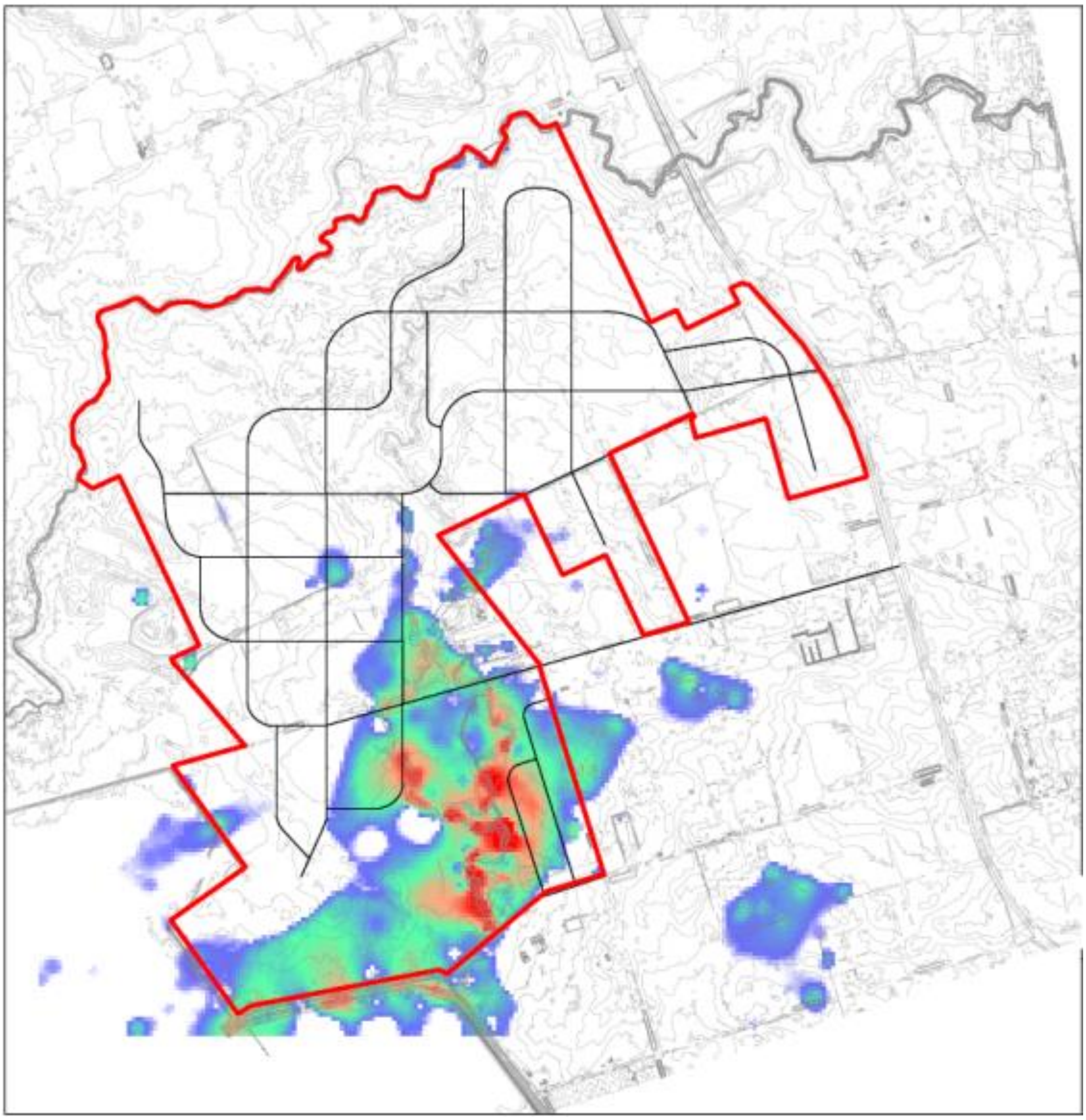


Figure 5.2: Depth to Groundwater within 1.5m of Existing Surface Level

It should be noted some of the areas within the proposed urban areas shown here as being within 1.5 of groundwater, will be filled to provide for adequate protection from long term sea level rise.

5.2.2 Salinity

Ingress of saline ground water into the waste water pipe network could cause the salinity of the waste water to increase and highly saline waste water can impact on the effectiveness of the operation of the WWTP at Bolivar. Increased salinity could also impact on the potential number of reuse applications for the treated effluent.

The ground water within the Riverlea Park site is expected to have salinity in the order of 1000ppm to 5000ppm (TDS).

The salinity of typical treated waste water schemes in South Australia is between 800ppm and 1000ppm (TDS). This would mean relatively small volumes of ingress could significantly impact on producing treated waste water of an acceptable salinity level.

The Riverlea Park proposal places a high priority on the potential to reuse the treated waste water, therefore the potential for ingress of saline groundwater into the waste water management system was a significant factor in selecting the most appropriate method of waste water management.

5.2.3 Acid Sulphate Soils

It has been confirmed by Golders Associates (Reference 5) that sections of the Riverlea Park site have the potential to encounter acid sulphate soils below the ground water level (see Figure 5.3 for potential acid sulphate soil locations)

If Acid Sulphate Soils (ASS) are encountered within trenches, the soil will need to be treated prior to the installation of any infrastructure, therefore causing construction costs to increase.

Precautions will need to be taken to prevent ingress of leachate from ASS getting into the trenches and being transported around the site. Both vacuum and pressure systems will minimise leachate ingress due to the relatively shallow depth of drains. Gravity drains also drain for long distances at a constant downward grade which facilitates the transport of leachate (if encountered). Both the vacuum and pressure sewerage drains are not required to constantly grade downward, this in itself would minimise the spread of ASS leachate should it be encountered.

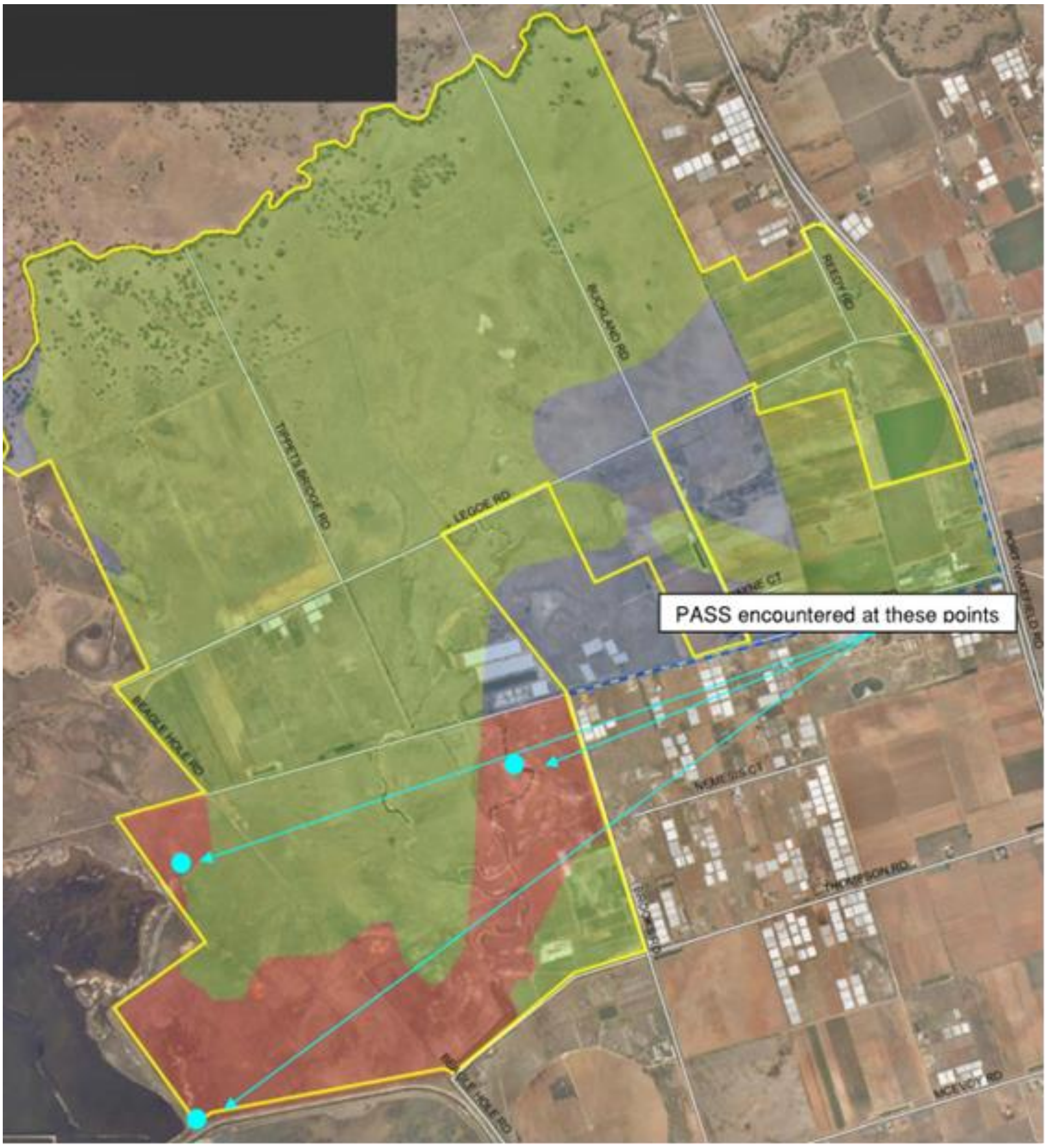


Figure 5.3: Potential Acid Sulphate Soil Locations

5.3 Recommended Waste Water Management System

From WGA's analysis in Appendix C it was determined that the most suitable form of communal waste management system for Riverlea Park is a vacuum system.

The reasons for recommending this option include:

- Lower estimated capital cost and all of life costs
- Reduced potential impacts of salinity on the reuse applications
- Lesser impact of peak wet weather flows on the WWTP and pump stations
- Lesser potential for long term ground water ingress
- Reduced risk of system failure due to groundwater ingress
- Lower pumping costs associated with limited groundwater ingress
- Approximately 75% of drains in a gravity system would be installed below the current ground water levels, even with the installation of 35 pumping stations

5.4 Methods for Disposal of Waste Water

In order to determine the most feasible method for treating and disposing of Riverlea Park's waste water a number of scenarios were considered.

The main scenarios that were considered are shown in the table below:

SCENARIO	INTERIM	ULTIMATE
1	Onsite WWTP with 5000 Person capacity	450mm pipe to pump waste water to Bolivar WWTP
2	225mm pipe to pump waste water to Bolivar WWTP	450mm pipe to pump waste water to Bolivar WWTP
3	150mm pipe to pump waste water to Bolivar WWTP	450mm pipe to pump waste water to Bolivar WWTP
4	33,000 person capacity onsite WWTP	

The above scenarios include opportunities for the disposal method to be staged in order to cater for:

- Initial capital cost reduction
- Waste water flow production

The treatment of effluent in an onsite WWTP has been considered and discounted for the following reasons:

- Buffer areas around the Plant will require a large area within the site, which may be more efficiently used for urban purposes.
- There are environmental constraints associated with areas that do not have urban potential, which preclude a WWTP. For example, significant flora, high ground water and potential acid sulphate soils.
- A new facility may be more costly to construct than augmentation at an existing WWTP facility.

The preferred method for disposal of the effluent generated by the completed Riverlea Park proposal is pumping the effluent via a rising main to the Bolivar WWTP.

The Bolivar WWTP is located approximately 14 kilometres south of the Riverlea Park site. This represents a considerable pumping distance and will result in large friction losses and potentially long travel times.

Refer to Appendix D, for a summary of the proposed pumping and rising main staging options for the development. There are 5 Vacuum Pump Stations proposed and a series of Booster Pump Stations and Rising Mains to take wastewater to the Bolivar WWTP.

6 WATER SUPPLY

6.1 Introduction

There is a limited amount of SA Water infrastructure in the area.

Upon completion, the Riverlea Park proposal will comprise approximately 12,000 allotments. A proposal of this scale will create a large demand for potable water in a previously undeveloped area.

In order to provide a reliable source of potable water, major infrastructure works will be required. SA Water outlined a number of potential potable water supply options can be considered for the proposal (see Appendix D). These options include potential for short term water supply from existing infrastructure during the initial stages of construction and occupation. This will reduce initial capital costs and will also potentially provide the site with a long term backup potable water source.

Water restrictions, and the ever increasing need to conserve water resources, have made recycled water use for applications that do not require drinking quality water a necessity. Recycled water is sourced from waste water treatment systems and stormwater runoff, and is increasingly being used for non potable applications within industry and also in new residential communities. With SA Water having recently completed the NAIS scheme, which now passes by the development in Port Wakefield Highway, Walker Corporation are negotiating with SA Water to bring the NAIS water into the site for the purposes of irrigation water only.

Appendix D contains SA Water's assessment of the water supply options, available to the Riverlea Park proposal, which involve a number of significant pipe upgrades outside of the site, that will need to be funded and constructed over a number of budget periods.

6.2 Recycled Water Supply

To ensure potable water supply sustainability, the use of recycled water for all applications which do not require drinking water quality water is becoming more and more common in residential, industrial and commercial projects.

Typically, the incentive for consumers to use recycled water is its cost. Recycled water is cheaper than potable water as it commonly does not require the same high level of treatment that potable water does.

Recycled water can be used for most applications where humans do not have direct contact with the water, such as:

- Toilet flushing
- Garden watering
- Car washing
- Irrigation

Using recycled water for the above applications would significantly reduce the use of potable water.

6.2.1 Recycled Water Sources

Sources of recycled water available to the Riverlea Park proposal include:

- Treated waste water delivered from the Bolivar Waste Water Treatment Plant via the Western Reticulation Systems Virginia (WRSV) pipeline or a new pipeline direct from the Bolivar WWTP.
- Treated waste water delivered from the Bolivar Waste Water Treatment Plant via the Northern Adelaide Irrigation (NAIS) pipeline.
- Stormwater runoff

Walker Corporation are negotiating with SA Water to provide irrigation water to the site via the NAIS scheme.

7 SEA LEVEL RISE AND MINIMUM SITE LEVELS

7.1 Coastal Protection Board

The current figures advised the required minimum Site Level (SL) and Finished Floor Level (FFL) to prevent coastal flooding for design to 2050 and 2100, as outlined in Table 7-1.

Table 7-1: Minimum Site Levels (Coastal Protection Board SA, 2008)

	2050	2100
Minimum SL (m AHD)	3.30m AHD	3.30m AHD+0.7m = 4.0m AHD
Minimum FFL m AHD)	3.55m AHD	3.55m AHD+0.7m = 4.25m AHD

Figure 7.1 shows the extent of existing land within the site that is less than the recommended Coastal Protection Board 2100 site level of 4.0m AHD.

Areas within the proposed residential and commercial zones identified on the Masterplan that have a ground level below 4.0m AHD will be filled to achieve this minimum requirement. Further fill above this level will be required on site in order to create fall on the land and to achieve drainage and minimum road grades.

Although the proposal is located several kilometres from the Gulf St Vincent, the site is linked to the Gulf via the Thompson Outfall Channel and would therefore be subject to tidal surge.

7.2 Recommendation

The recommended minimum site level is therefore 4.0m AHD with minimum floor levels of 4.25m AHD. It should be noted however, that due to the need to create falls across the site to drain the road system that the majority of properties will have site levels well in excess of the recommended minimum level.

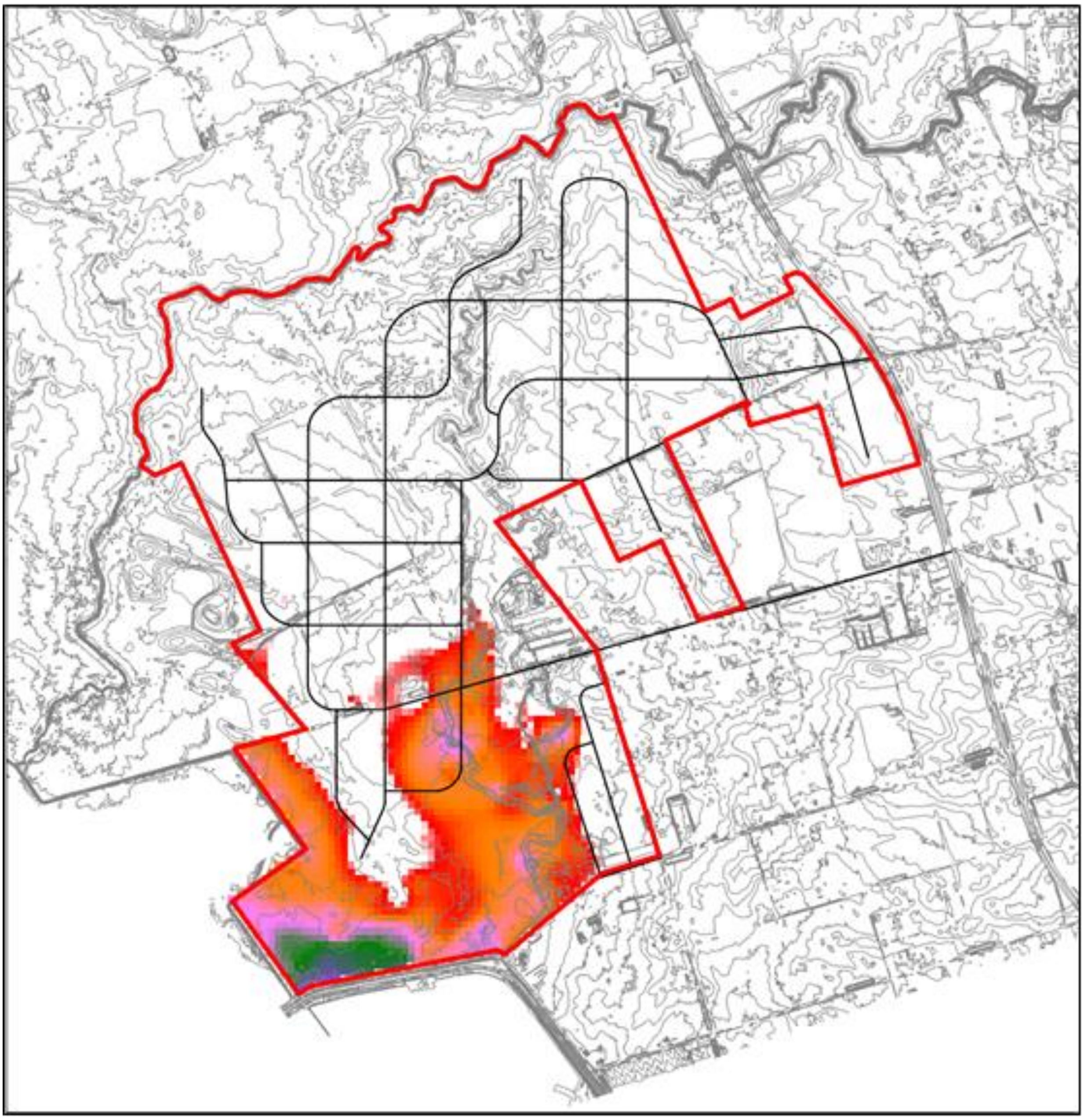


Figure 7.1: Extent of Existing Site Less Than 4.0m AHD

.

8 SUMMARY

The following is a brief summary of the outcomes of this study.

8.1 Stormwater Management

- A Water Sensitive Urban Design approach will be applied across the entire site and is incorporated in the Masterplan.
- A series of lineal stormwater management corridors will be constructed to manage minor stormwater flow water quality treatment and for the passage of major flows from the site prior to the proposed Salt Water Lake systems or the open channel drainage network. These are incorporated in the Masterplan.
- A series of major channels will also act as capture channels to intercept flood water ‘breakouts’ from the Gawler River and provide protection for the 1%AEP flood. These are incorporated in the Masterplan.
- Site level collection of stormwater for reuse will be adopted where practical.
- On site detention above the Salt Water Lakes, and a large detention basin in the southern most portion of the site are proposed to control post development flows to less than predevelopment levels.
- ASR potential on the site is limited to 50ML/a which is significantly less than the estimated annual runoff. ASR is no longer being consider for the site.

8.2 Wastewater

- A vacuum sewer scheme is proposed to accommodate the shallow groundwater levels across the site which will include approximately 5 vacuum pump stations.
- All wastewater will be pumped to the Bolivar Wastewater Treatment Plant.
- An interim series of rising mains and pump stations with boosters will be developed to deliver wastewater to Bolivar in a staged manner
- The ultimate rising main to Bolivar is likely to 2 x 300mm rising mains.

8.3 Potable Water

- Potable water supply to the site will come from the Little Para Water Treatment Plant.
- Short term options have been proposed by SA Water that can supply up to 1100 services.
- The ultimate scheme will require a new supply main from the Little Para system that is based on a number of pipeline upgrades and extensions.
- Walker is working with SA Water to ensure short, medium and long-term portable water solutions are in place as each stage is progressed.

8.4 Recycled Water

- A third pipe system will be provided throughout the site for irrigation purposes only through the NAIS scheme developed by SA Water.

9 GLOSSARY OF TERMS

AHD = Above height datum

AMC = Antecedent moisture content

ARI = Average recurrence interval

ASS = Acid sulphate soil

EL = Elevation level

FFL= Finished floor level

GL = Giga litres

GPT = Gross pollutant trap

GRC = Glass reinforced concrete

HEC-RAS = Hydrologic Engineering Centre river analysis system

LGA = Local government association

MHWS = Mean high water springs

ML = Mega litre

ML/a = Megalitres per annum

MUSIC = Model for urban stormwater improvement conceptualisation

PASS = Potential acid sulphate soil

ppm = Parts per million

PRV = Pressure release valve

RO = Reverse osmosis

SCADA = Supervisory control and data acquisition

SL = Surface level

STED = Septic tank effluent disposal

TDS = Total dissolved solids

TP = Total phosphorus

TSS = Total suspended solids

WRSV = Western reticulation scheme Virginia

WTP = Water treatment plant

WWTP = Waste water treatment plant

10 REFERENCES

1. Australian Water Environments, Floodplain Mapping for the Gawler River-Technical Report, prepared for the Gawler River Floodplain Management Authority, February 2008
2. DTEI Hydrologic Study of the Gawler River Catchment 2007
3. Connell Wagner, Coastal influences and climate change considerations for Riverlea Park proposal, prepared for Walker Corporation Pty Ltd, November 2008
4. CSIRO, Climate Change in Australia, prepared for the Department of the Environment and Water Resources, October 2007
5. Golder Associates, Preliminary ASS Investigation, Riverlea Park, South Australia, prepared for the Walker Corporation Pty Ltd, November 2008
6. IE Aust, T, Wong, Australian Rainfall and Runoff Quality- A guide to water sensitive urban design, 2006
7. Resource and Environmental Management, Aquifer Storage and Recovery Potential for Riverlea Park, prepared for the Walker Corporation Pty Ltd, February 2008
8. SA Environment Protection (Water Quality) Policy 2003 – Schedule 2
9. SA Water, Memorandum: Ultimate water supply for the Riverlea Park/Waterloo Corner Area, prepared by Paul Feronas for Wallbridge & Gilbert, September 2008
10. Sinclair Knight Merz, Groundwater investigation – Riverlea Park proposal, prepared for Walker Corporation, November 2008
11. Tonkin Consulting, Port Adelaide Seawater Stormwater Flooding Study, prepared for the City of Playford Council, October 2005
12. Tonkin Consulting, Western Catchment - Stormwater Master Plan, prepared for the City of Playford Council, April 2008

APPENDIX A
EIS GUIDELINES

3.1.1 Determine the flood potential for the area, including flood plain mapping for a 1 in 100year ARI storm, as a result of the restriction of the floodplain in the vicinity of the proposed development and taking into account the construction of a dam on the North Para River.

Section 4

3.1.2 Outline the requirements for the likely location of water, sewerage, stormwater management infrastructure.

Section 2, 4, 5, 6

3.1.3 Describe the approach to water sustainability, including ways in which mains water supply use can be minimised or supplemented and opportunities for reducing and recycling water, particularly stormwater and waste water from the Virginia Pipeline through Water Sensitive Urban Design (WSUD).

Section 6

3.1.4 Identify opportunities for the reuse of grey water.

Section 6

3.1.5 Detail measures to minimise impacts and to protect the Gawler River and coastal environments during both the construction phase and on an ongoing basis.

Section 2

3.1.6 Identify the impact of possible erosion, subsidence or inundation as a result of flooding arising from construction on this low lying part of the coast.

Section 1.2

3.1.7 Describe the connection to water supply for the proposed development, the required upgrading or provision of pipelines and the implications for water sources, include information on the quantity of potable water required.

Section 6

3.1.8 Describe the proposed method of dealing with wastewaters.

Section 5 and 6

3.1.9 Describe measures to protect, maintain and monitor suitable water quality in waterways.

Section 3

4.2.11 Outline measures to prevent soil, fertilizers, herbicides and pesticides derived from residential allotments and open space reserves from entering the waterways.

Section 3

4.2.12 Identify the potential effects as a result of stormwater runoff on the St Kilda-Chapman Creek and Barker Inlet-St Kilda Aquatic Reserves (nursery areas) ecosystem and fish breeding grounds.

Section 1.2 and Section 3

4.2.13 Identify the potential effects of the proposal on the adjacent salt operations (intake water quality issues) such as storm water discharge, nutrients management, sewage management, waste management, water pollution from littering and illegal dumping, oil and fuel spill management, wash down and toxic seepage.

Section 3

4.2.19 Describe the proposal of excavated materials for the proposed waterways.

Section 2 and 7

4.2.20 Describe how the proposal will comply with the coastal flooding policy outlined in the Development Plan.

Section 7

4.2.24 Describe any special engineering requirements for infrastructure due to the expected high water table in this area including the costs of developing and maintaining infrastructure for saline and acid sulphate soils, seasonal variations in height and groundwater rise due to sea level rise.

Section 5 and 7

4.3.5 Describe the requirements of the sea level rise policies in the Development Plan and how these would be achieved in undertaking this proposed development.

Section 7

4.3.7 Describe any impacts on the neighbouring Port Gawler Conservation Park, adjacent Crown land and the Riverlea Park Lake System.

Section 3

4.3.8 Outline the potential effects of climate change from a risk management perspective, including adaptive management strategies.

Section 2 and 7

4.3.31 Describe the likely effects on marine organisms and seagrasses, in the context of runoff from the proposed development into the river and out to sea potentially reducing the salinity and increasing nutrients, suspended sediments and pollutants, particularly heavy metals.

4.7.1 Describe the condition and capacity of existing trunk infrastructure and the likely impacts of the development on that capacity.

Section 6

4.11.6 Describe how the proposal would comply with the requirements under the Environment Protection Act, 1993 and the Adelaide Dolphin Sanctuary Act, 2005 and the duty of care under these Acts.

Section 3

APPENDIX B
GAWLER RIVER FLOOD MAPS

MEMORANDUM

To	Brent Eddy
From	Alison Miller
Date	31 October 2022
Subject	Modelling of Riverlea development in the broader Gawler River floodplain model

Riverlea is a proposed housing development at Buckland Park, currently under development by Walker Corporation. Water Technology have been engaged at various stages of the project to provide advice on riverine flood impacts at the development site and adjacent properties.

This memo documents the hydraulic modelling undertaken to assess the performance of the proposed division of floodwaters from the Gawler River along the western side of the development. Modelling was undertaken in the broader Gawler River floodplain model, versions of which are currently being used in the development of the Gawler Stormwater Management Plan and for the Enhanced Flood Hazard Mapping project.

MODEL DETAILS

The existing conditions model, currently being developed for the Enhanced Flood Hazard Mapping project, was adopted as the base case for assessment of the Riverlea development. The model is a coupled MikeFlood model, with the river and floodplain represented in 2D (Mike21), linked to 1D representation of culverts (Mike11).

Topography

The model adopts a flexible mesh representation, which allows higher resolution detail to be incorporated in the model where required (e.g. along the river) without dramatically increasing run times. The model adopts elevations from the two recently captured LiDAR datasets:

- Middle Beach 50cm LiDAR, captured 26 November 2021
- Adelaide Metro LiDAR, captured 21-31 January 2022.

The two datasets overlap along the alignment of the Gawler River. Where this has occurred, the 2022 data has been used in preference.

Note that the only difference between the model adopted for this assessment, and that in development for the Gawler SMP, is the underlying topography. The Gawler SMP model adopts the 2021 LiDAR, but the topography on the south-eastern side of the river alignment is based on a series of earlier topographic datasets.

The model incorporates 344 dike structures, which have been used to control the level at which water can move across various areas. Typically, these are representative of levees, however dikes have also been used to incorporate other key features such as road crests, where the element vertex sampling may have missed this detail. Crest elevations for each dike have been sampled from the 2021 or 2022 LiDAR.

Inflow/outflow boundaries

Inflow boundaries to the model were retained, and include:

- A hydrograph input for the South Para River at South East of Gawler
- A hydrograph input for the North Para River downstream of Turretfield.

Note that the hydrology inputs were derived from the XP-RAFTS hydrology model which incorporates the Bruce Eastick Dam and the upgraded South Para Dam. Hydrographs to the model were extracted at the spatial location of the hydraulic model. This is downstream of the South Para Dam (hence the flood mitigation is incorporated in the hydrology) and upstream of the Bruce Eastick Dam (flood mitigation here is incorporated in the hydraulic model).

A sea level of 1.5 mAHD (equivalent to the Highest Astronomical Tide) was applied as a downstream boundary along the western and (partial) southern model edges. This has been retained form the original study in 2008 which assessed tidal data for Port Adelaide and Outer Harbour.

A second 'free outflow' boundary has been incorporated on the southern edge of the model further upstream, on the western side of the Northern Expressway. This was to prevent breakouts from the Gawler River from artificially ponding at the model edge. In reality, this water is anticipated to flow initially south-west and then further west to meet other breakout flows from the Gawler River near Port Wakefield Road.

Infrastructure

All major bridges and culverts, of which there are 89, have been incorporated in the 1D domain. These were adopted from the previous Light River and Smith Creek models. Where these relate to drainage infrastructure for the Northern Expressway, these have been validated against details in the DRAINS model provided by City of Playford.

Where the mesh resolution was coarser than the width of the culvert/bridge outlet, the elevation of the linking cell has generally required altering to represent the invert.

Updates for the current assessment

The underlying mesh was refined across the area of the Riverlea site, to ensure sufficient resolution to capture the proposed development layout of swales. As a result of changes to the mesh, existing conditions have also been updated to ensure the same representation of detail.

The proposed development conditions have been represented by sampling a digital elevation model of the proposed conditions, created from the design drawing provided by Walker Corporation 'Riverlea_Existing+Sitewide EW_05092022.dwg'.

Further details of the model schematisation will be made available through the Enhanced Flood Hazard Mapping project report for the Gawler River.

Note that the model is currently undergoing validation, and further refinements will be made. This will include re-enforcement of the bank levels on the eastern side of the Gawler River near Windermere. The model version adopted here, is appropriate for comparing like-for-like but may not necessarily be representative of actual flood levels, depending on the outcome of the validation process.

SCENARIOS

Scenarios analysed for this assessment include:

- Current conditions (referred to as 'existing').
- Future development conditions.

The digital elevation model for the proposed developed conditions can be seen in Figure 1. The proposed design includes a concept for diverting breakouts from the Gawler River into a zone along the northern edge of the development, conveying floodwaters along the north and western borders to a discharge point at the south-western corner.

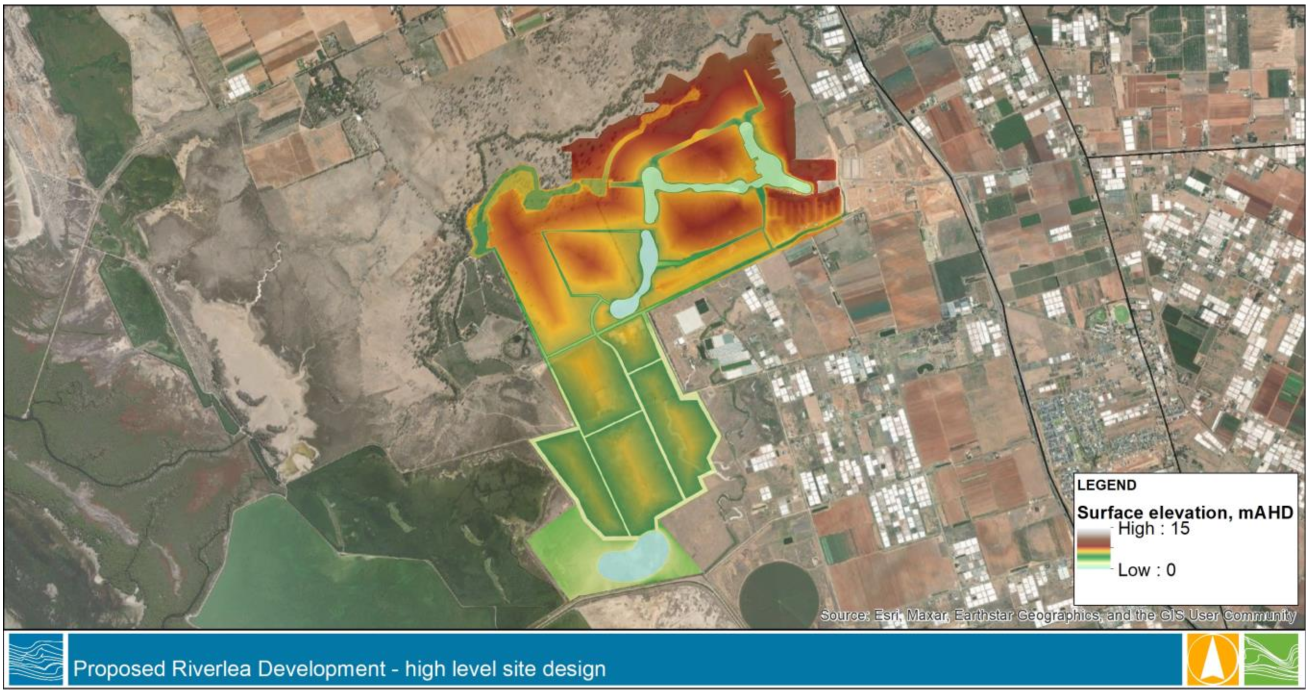


Figure 1 Proposed development surface elevations

RESULTS

The resulting flood depth for the 1% AEP flood event in the Gawler River for the current and future development scenarios is provided in Attachment 1 and 2. The scheme to divert breakouts to the south-western corner works as intended, however it demonstrates that the floodwaters are diverted from the location further west than intended.

The developed conditions (Attachment 2) show an extensive area of flooding surrounding the most southern basin, near the existing salt pans. While the majority of this area is inundated in existing conditions, refinement to the outflow path may need to be considered.

Differences in 1% AEP flood levels between the two scenarios is shown in Figure 2 (and Attachment 3). The results indicate reduced flooding along the western portion of the development (i.e. 'was wet now dry'), and reduced flood levels further west and south of the site.

Note that the existing conditions 1% AEP flood extent differs slightly to that provided previously. Output from the previously adopted TUFLOW site specific model indicated floodwaters breakout out near the intersection with Port Wakefield Road to south of the Gawler River, inundating the existing greenhouses and extending south-west across the Riverlea site. This breakout flow is not observed in the updated modelling adopted here as the bank heights have been more accurately represented through the adoption of recently captured 2022 LiDAR.

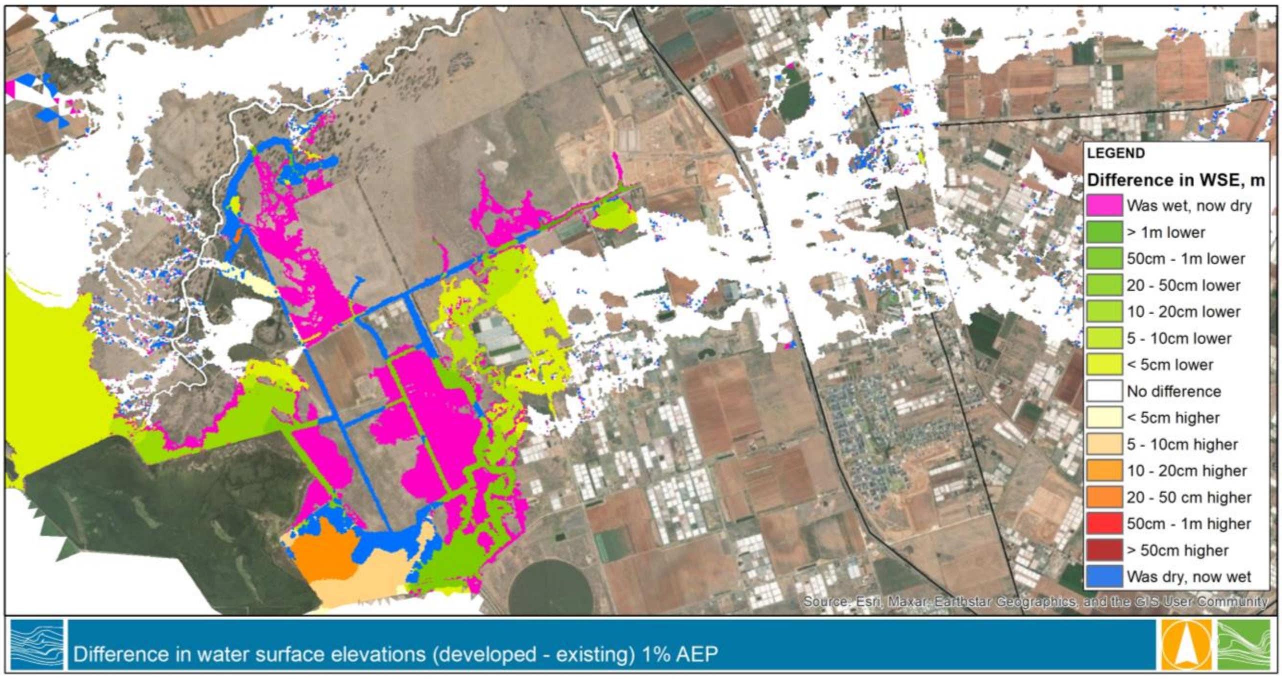


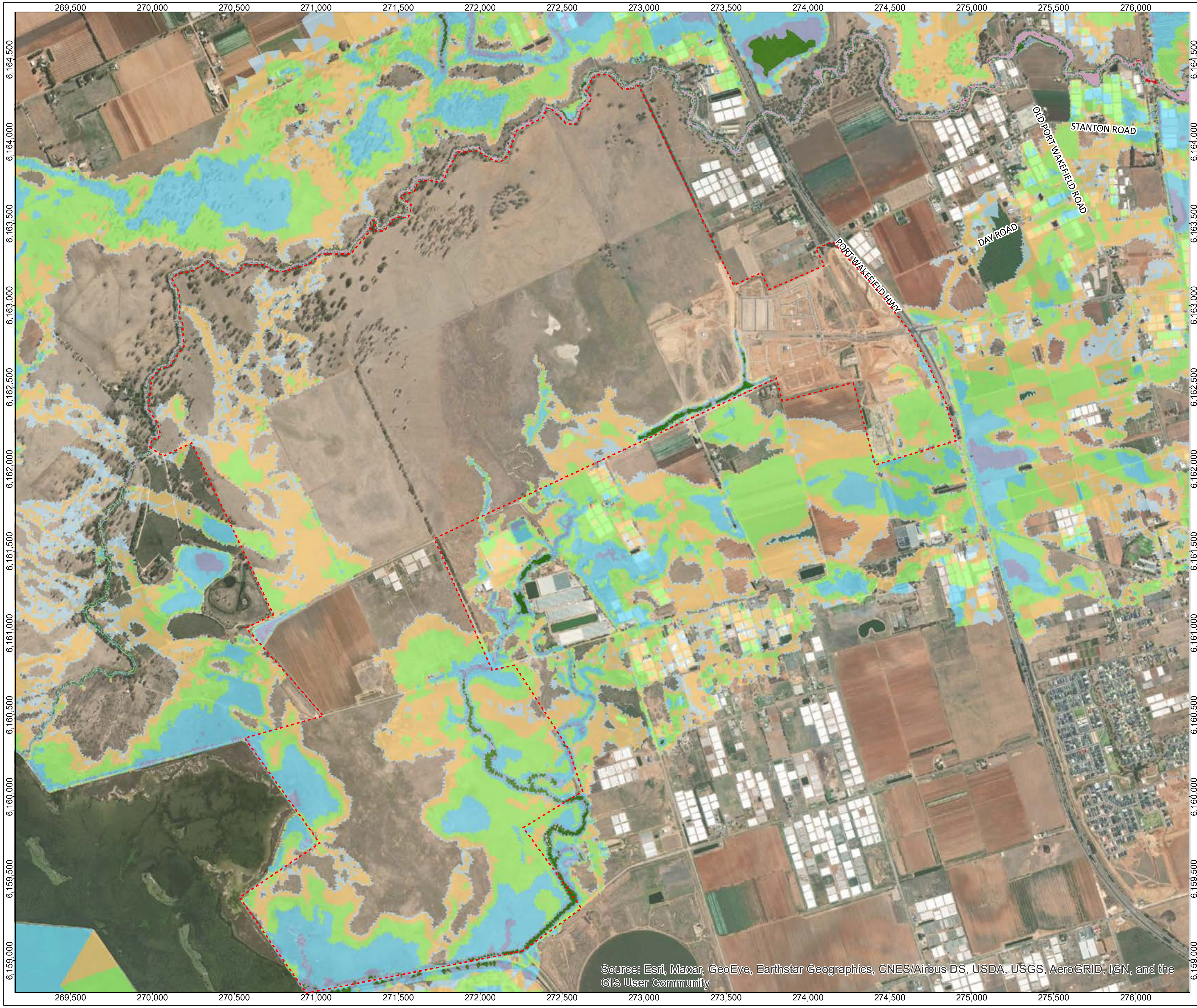
Figure 2 **1% AEP flood depth for current development conditions across site**

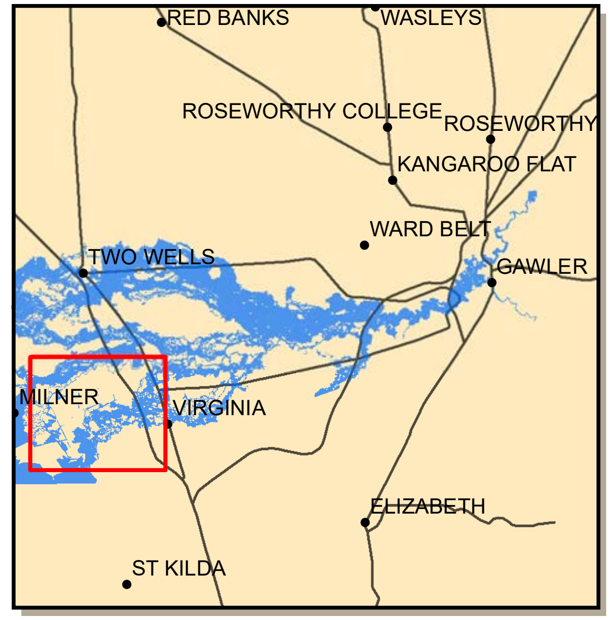
Enclosed:

Attachment 1 – 1% AEP flood depth, existing conditions

Attachment 2 – 1% AEP flood depth, proposed development conditions

Attachment 3 – 1% AEP difference in water surface elevation (developed minus existing)





Legend

Depth, m

- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2.5
- 2.5 - 5
- Greater than 5

NOTE
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Walker Corp for their specific use.

DISCLAIMER
Walker Corp and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains PLB Images, https://maps.sa.gov.au/SAPPA/

0 250 500 1,000 Meters

Coordinate System: GDA 1994 MGA Zone 54

1:25,000 at A3

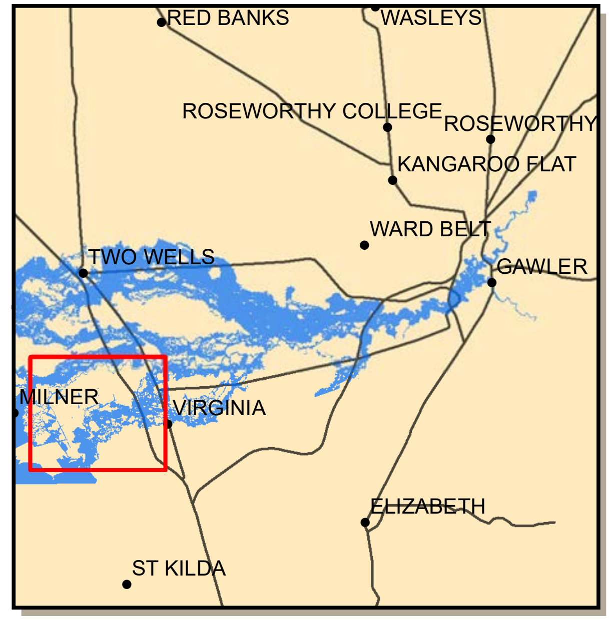
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Existing Conditions 1% AEP Depth

Riverlea Development Site

REFERENCE: A3L_wInset_Riverlea_Ex_1AEP_DEPTH

DATE: 28/10/2022 SHEET: 1 of 1 DRAWING NUMBER: 1



Legend

Depth, m

- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2.5
- 2.5 - 5
- Greater than 5

NOTE
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Walker Corp for their specific use.

DISCLAIMER
Walker Corp and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains PLB Images, https://maps.sa.gov.au/SAPPA/

0 250 500 1,000 Meters

Coordinate System: GDA 1994 MGA Zone 54

1:25,000 at A3

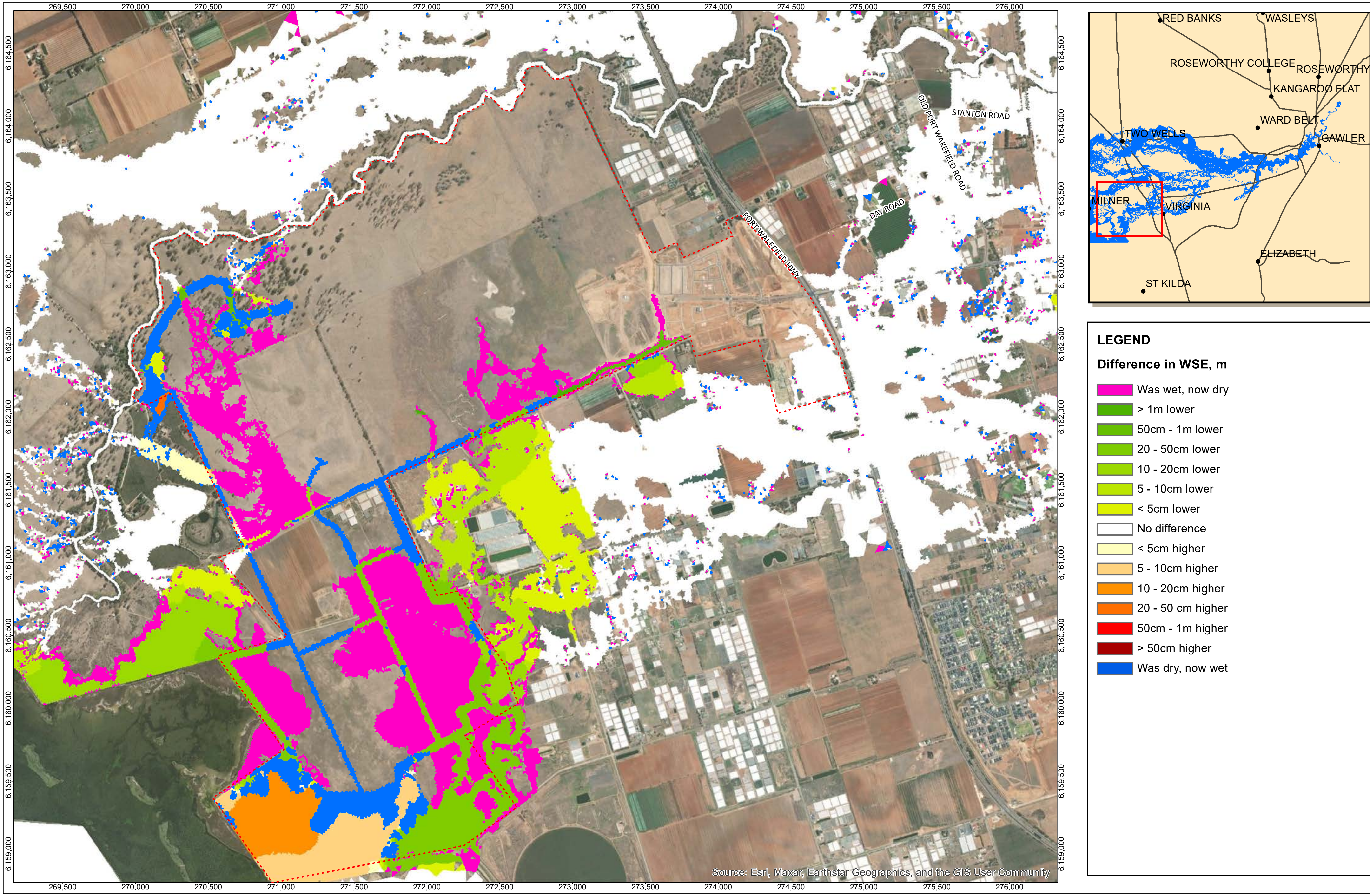
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Developed Conditions 1% AEP Depth

Riverlea Development Site

REFERENCE: A3L_wInset_Riverlea_Dev_1AEP_DEPTH_v3

DATE: 28/10/2022 | SHEET: 1 of 1 | DRAWING NUMBER: 1



NOTE
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Walker Corp for their specific use.

DISCLAIMER
Walker Corp and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains PLB Images, https://maps.sa.gov.au/SAPPA/

0 250 500 1,000 Meters

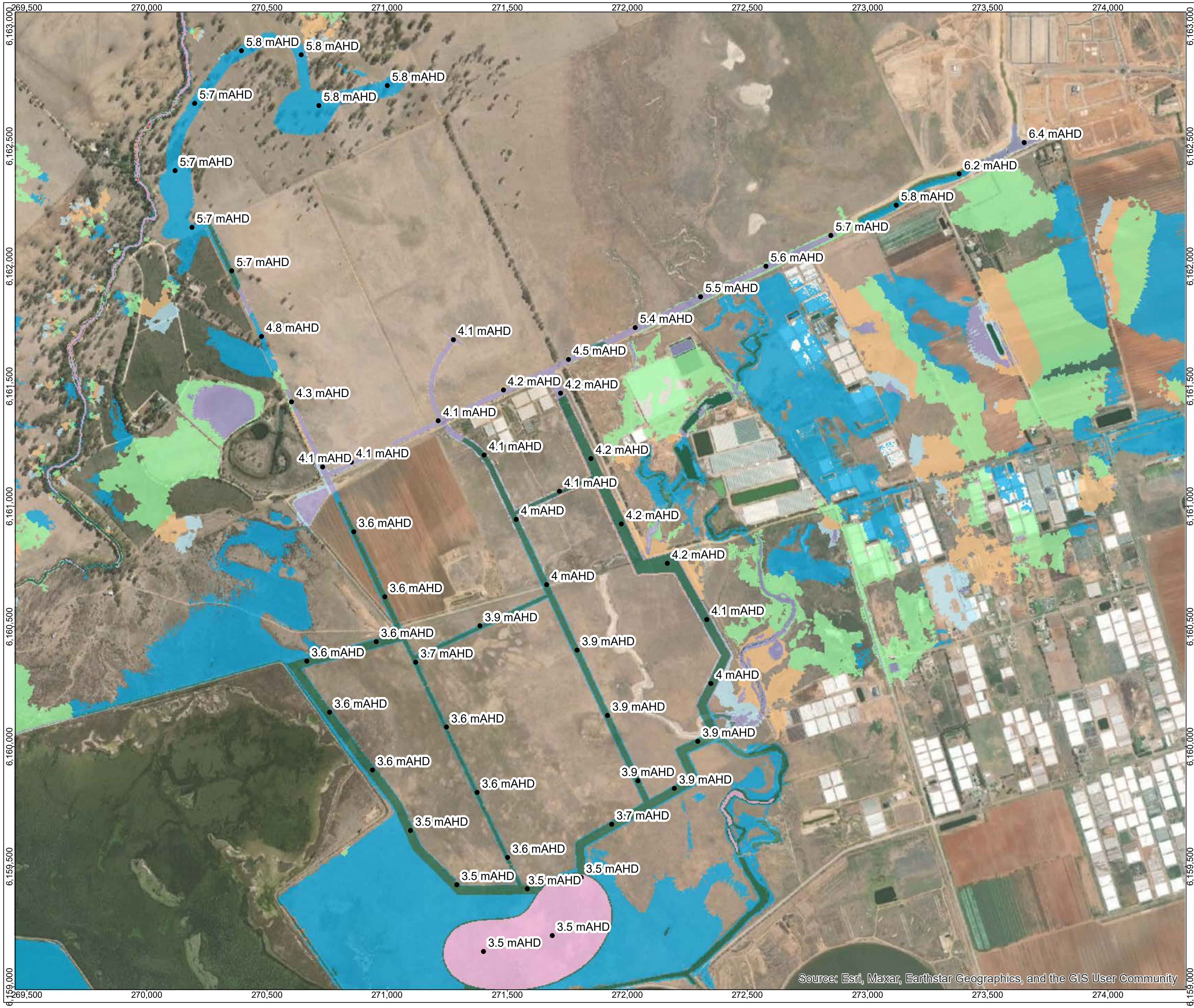
Coordinate System: GDA 1994 MGA Zone 54

1:25,000 at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Difference in flood levels (Dev-Ex) 1% AEP Depth
Riverlea Development Site

REFERENCE: A3L_wInset_Riverlea_Dev-Ex_1AEP_DIFF_v2
DATE: 31/10/2022 | SHEET: 1 of 1 | DRAWING NUMBER: 1



Legend

• Water surface elevation at point

Depth, m

- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2.5
- 2.5 - 5
- Greater than 5

NOTE
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Walker Corp for their specific use.

DISCLAIMER
Walker Corp and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains PLB Images, https://maps.sa.gov.au/SAPPA/

N W E S

0 250 500 1,000 Meters

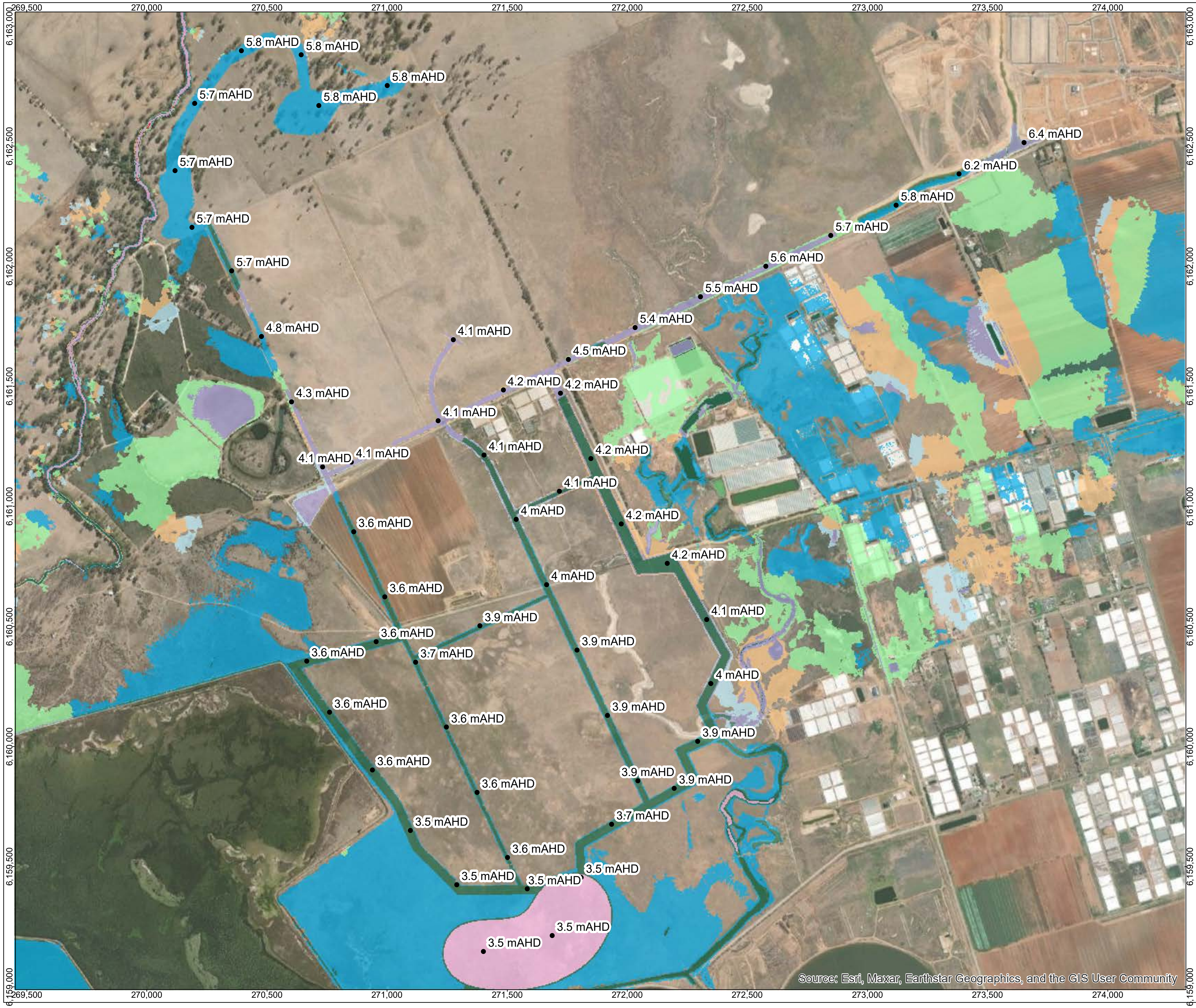
Coordinate System: GDA 1994 MGA Zone 54

1:17,000at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Developed Conditions 1% AEP Depth
Riverlea Development Site

REFERENCE: A3L_wInset_Riverlea_Dev_1AEP_DEPTH_v3_w_WSEpts
DATE: 2/11/2022
SHEET: 1 of 1
DRAWING NUMBER: 1



Legend

- • Water surface elevation at point

Depth, m

- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2.5
- 2.5 - 5
- Greater than 5

NOTE
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Walker Corp for their specific use.

DISCLAIMER
Walker Corp and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains PLB Images, https://maps.sa.gov.au/SAPPA/

0 250 500 1,000 Meters

Coordinate System: GDA 1994 MGA Zone 54

1:17,000at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Developed Conditions 1% AEP Depth

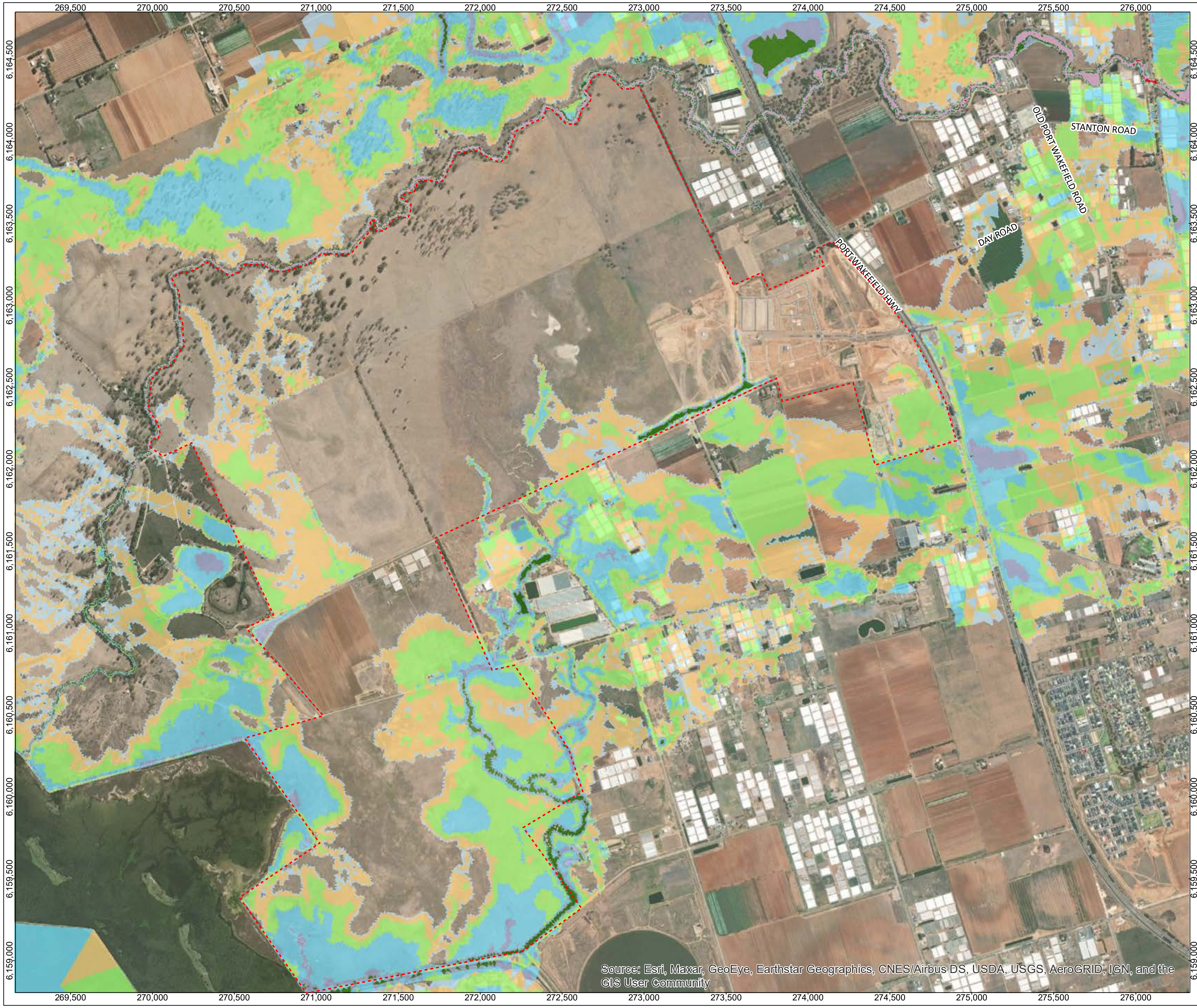
Riverlea Development Site

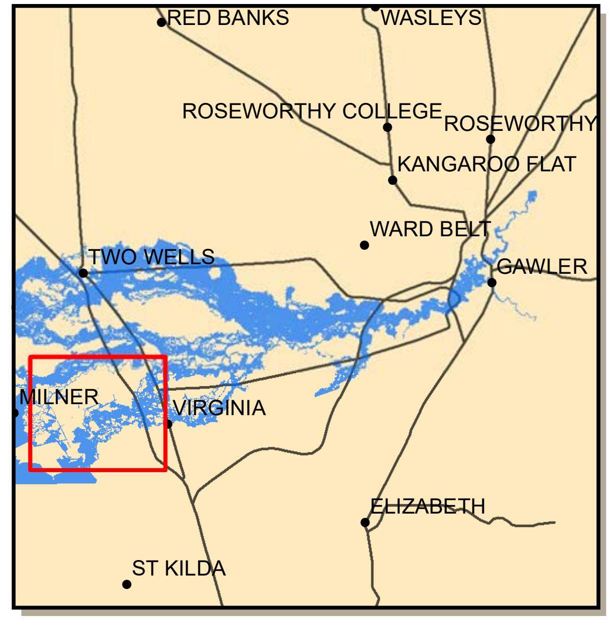
REFERENCE: A3L_wInset_Riverlea_Dev_1AEP_DEPTH_v3_w_WSEpts

DATE: 2/11/2022

SHEET: 1 of 1

DRAWING NUMBER: 1





Legend

Depth, m

- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2.5
- 2.5 - 5
- Greater than 5

0 250 500 1,000 Meters

Coordinate System: GDA 1994 MGA Zone 54

1:25,000 at A3

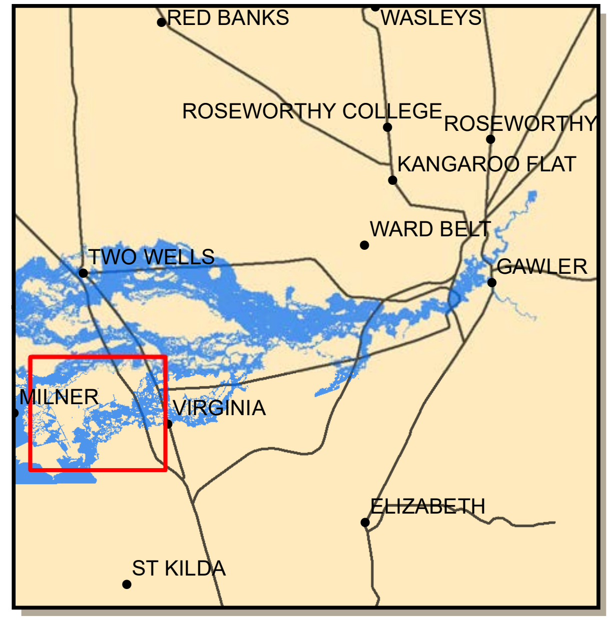
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Existing Conditions 1% AEP Depth

Riverlea Development Site

REFERENCE: A3L_wInset_Riverlea_Ex_1AEP_DEPTH

DATE: 28/10/2022 | SHEET: 1 of 1 | DRAWING NUMBER: 1



Legend

Depth, m

- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2.5
- 2.5 - 5
- Greater than 5

NOTE
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Walker Corp for their specific use.

DISCLAIMER
Walker Corp and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains PLB Images, https://maps.sa.gov.au/SAPPA/

0 250 500 1,000 Meters

Coordinate System: GDA 1994 MGA Zone 54

1:25,000 at A3

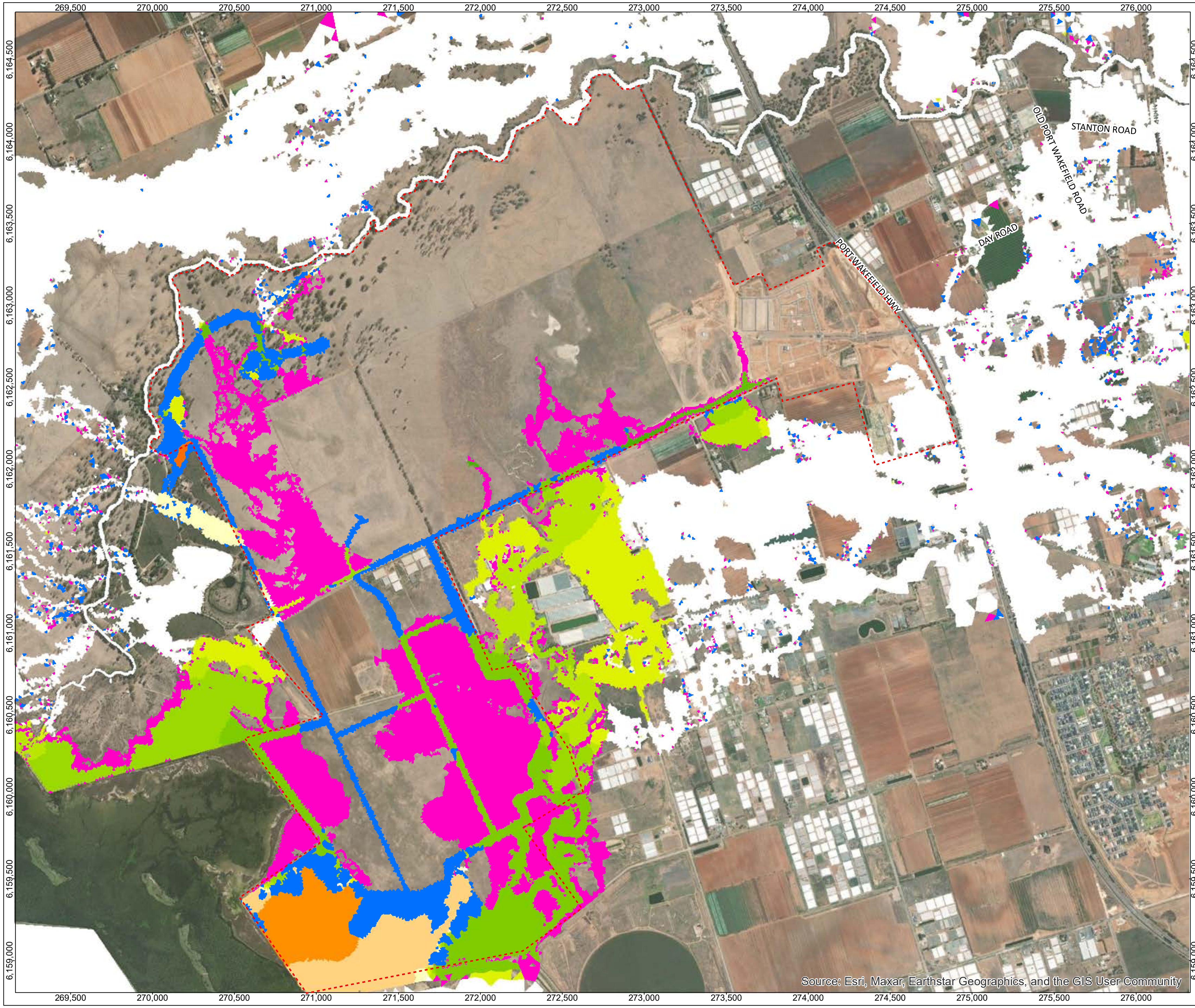
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

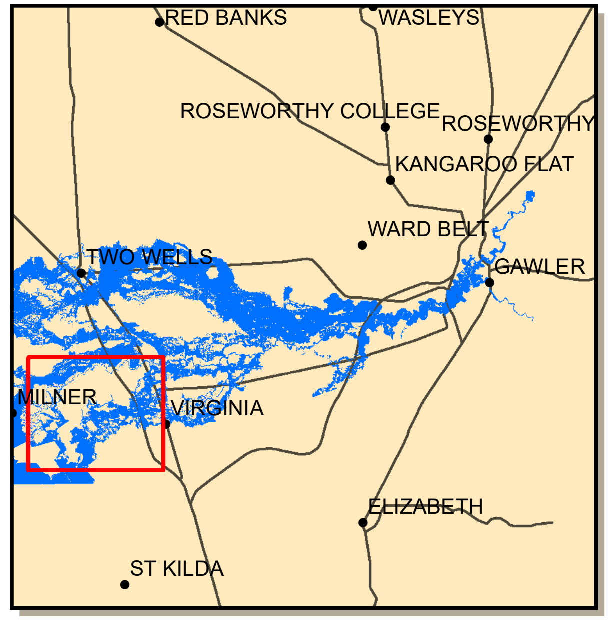
Developed Conditions 1% AEP Depth

Riverlea Development Site

REFERENCE: A3L_wInset_Riverlea_Dev_1AEP_DEPTH_v3

DATE: 28/10/2022 | SHEET: 1 of 1 | DRAWING NUMBER: 1





LEGEND

Difference in WSE, m

- Was wet, now dry
- > 1m lower
- 50cm - 1m lower
- 20 - 50cm lower
- 10 - 20cm lower
- 5 - 10cm lower
- < 5cm lower
- No difference
- < 5cm higher
- 5 - 10cm higher
- 10 - 20cm higher
- 20 - 50 cm higher
- 50cm - 1m higher
- > 50cm higher
- Was dry, now wet

NOTE
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Walker Corp for their specific use.

N
W E
S

0 250 500 1,000 Meters

Coordinate System: GDA 1994 MGA Zone 54

1:25,000 at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Difference in flood levels (Dev-Ex) 1% AEP Depth

Riverlea Development Site

REFERENCE: A3L_wInset_Riverlea_Dev-Ex_1AEP_DIFF_v2

DATE: 31/10/2022 | SHEET: 1 of 1 | DRAWING NUMBER: 1

APPENDIX C
WGA ASSESSMENT OF WASTE WATER TREATMENT METHODS

BUCKLAND PARK
WASTEWATER COLLECTION SYSTEMS

NETWORK OPTIONS ASSESSMENT

prepared for

WALKER CORPORATION

by

WALLBRIDGE & GILBERT
Consulting Engineers

NOVEMBER 2008

REV E

Job No: C080163

CONTENTS

EXECUTIVE SUMMARY

Wallbridge & Gilbert (W&G) were engaged by the Walker Corporation to undertake a first order assessment of the most economically and technologically suitable form of communal collection system for domestic wastewater within the Buckland Park proposal.

Gravity drainage systems are commonly thought to be the most economically viable wastewater management systems. However, issues such as a high water table, acid sulphate soils and high salinity levels within the groundwater at Buckland Park mean that the cost to build a gravity system could escalate, and there would be an increased potential for groundwater ingress into the system. These factors prompted the need to investigate the viability of vacuum and pressure systems.

This report assesses the applicability of the following four collection systems:

- Gravity
  - Septic Tank Effluent Disposal System (STEDS)
  - Full Sewer
- Pressure
- Vacuum

A general technical description of the characteristics of each scheme as well as a summary of the advantages and disadvantages is enclosed within this report.

First order cost estimates for each of the systems have been presented with the all of life costs derived using the LGA's CWMS (Community Waste Management System) all of life cost model.

The latest groundwater mapping indicates that the depth to ground water across the site varies from 0.2m to 7m below the current surface level. In the order of 60% of the proposal site has a ground water depth of less than 2m from the surface level. Seasonal water level fluctuations in the order of 0.5m to 1m could be expected.

The key impacts that the high ground water table, acid sulphate soils and saline ground water conditions have on the suitability of a waste management system include:

- Increased construction costs for deeper drains, manholes and pump stations
- Increased risk of cost escalation during the construction phase especially if construction is undertaken in years when the seasonal variation in groundwater is higher than current measurements
- Increased OHS&W risks associated with construction of the drains (this adds to the cost for mitigation but also to the potential of an accident)
- Increased risk of system failure from overflow due to ground water intrusion into the wastewater management network.

- Increased running costs associated with pumping and treatment systems
- Increase in capital costs to cater for emergency storage or increased pump sizes to cater for peak wet weather flows
- Greater potential for a higher salinity within treated effluent, therefore limiting potential reuse applications
- Increases the risk of future settlement of reinstated trenches due to difficulties in achieving compaction.
- Potential to create a greater trench footprint due to collapsing trenches during construction.
- Risk of creating acidic soil conditions due to construction in acid sulphate soils, also creating the potential to transport leachate along the trench spreading the extent of the potential impacts.

Table E1 (on page 3) summarises the capital and all of life cost estimates for the various collection options assessed. These costs are for comparative purposes only and have been based on indicative layouts. Cost estimates of the preferred option would be produced after a preliminary design has been completed.

The following assumptions need to be considered when reading the table:

1) The gravity sewer concept is based on a maximum drain depth of 3m. This results in the order of 35 pump stations being required to service the proposal.
2) Vacuum sewer is based on 3 vacuum stations and an average of 5 connections per valve pit.
3) It has been assumed that the capital costs for scheme installation are expended in year 1. In practice this will not be the case but the costings are for comparative purposes only and are not intended as an absolute measure of the all of life costs.
4) The costs do not include treatment or disposal, they relate to the collection network only.
5) The all of life costs shown in the summary table do not include an allowance for increased operational costs due to ground water ingress, as the impact is difficult to estimate.
6) The costs of installation and maintenance of property pumps has been included in the pressure system. This cost is often excluded from cost estimates for schemes in South Australia as traditionally these costs have been met by the individual land owner, however W&G believe that if a true cost comparison is to be made between the schemes then these costs should be included.

Table E1 – Summary of Comparative costs

Effluent		
Discount Rate	Capital Cost	All of Life Cost
4%	$78,100,000	$100,900,000
Sewer		
Discount Rate	Capital Cost	All of Life Cost
4%	$41,800,000	$58,400,000
Pressure		
Discount Rate	Capital Cost	All of Life Cost
4%	$132,700,000	$248,000,000
Vacuum		
Discount Rate	Capital Cost	All of Life Cost
4%	$37,900,000	$55,300,000

Recommended Collection System for Buckland Park

W&G recommend that design development be based on a vacuum sewerage system.

The reasons for recommending this option include:

- The lower estimated capital cost and all of life costs
- The reduced potential impacts of salinity on the reuse applications
- Lesser impact of peak wet weather flows on the WWTP and pump stations
- Lesser potential for long term ground water ingress
- Reduced potential for system overflow at the pump stations during peak wet weather events or power outages
- Reduced risk of system failure due to groundwater ingress
- Lower pumping costs associated with limited groundwater ingress (which is not captured in Table 5.1.1)
- Reduced operational requirements in a major power failure scenario
- Approximately 75% of drains in a gravity system would be installed below the current ground water levels, even with the installation of 35 pumping stations
- Aeration of the sewage through the collection network will have a positive impact on the WWTP operation.

1. INTRODUCTION

Wallbridge & Gilbert (W&G) were engaged by the Walker Corporation to undertake an assessment to determine the most appropriate wastewater collection system for the Buckland Park proposal.

It is currently envisaged that the Buckland Park proposal will ultimately consist of 12,000 properties with a likely ultimate population of up to 33,000 persons.

This report summarises the general characteristics of the following four collection systems:

- Gravity
  - Septic Tank Effluent Disposal System (STEDS)
  - Full Sewer
- Pressure
- Vacuum

It outlines the suitability of each of the systems as applicable to Buckland Park, as well as comparing estimates of the capital and all of life costs that could be expected for each of the systems.

Section 3 and 4 of this report have been included as background knowledge for those who are not familiar with collection technologies and provide a general description of each of the systems and generic advantages and disadvantages of each.

2. PURPOSE

The purpose of this report is to:

- To enable comparison of the various collection system options available
- Inform the utility owner of the operational implications of each individual system inclusive of the impacts on future reuse applications
- Outline comparative all of life costs for operation of the schemes
- Recommend the most suitable option to adopt for design development.

3. GENERAL DESCRIPTION OF SCHEMES

Gravity

Gravity sewer systems are the oldest and most commonly used form of collection system utilised in South Australia.

There are two basic forms of gravity systems employed in South Australia. Generically these are full sewer (also known as conventional sewerage) and Septic Tank Effluent Disposal Schemes (STEDS).

A gravity system collects wastewater from all properties via gravity and as such the connection point has to be deep enough to drain the site. In steep terrain where land slopes away from the main drains, this can result in deep excavations for individual property owners.

Gravity systems grade downhill from the top of the catchment to the lowest point. A pump station is generally located at this point to pump the wastewater to a treatment facility, either directly or indirectly via other catchments.

The system consists of a network of main drains and individual property connections. An Inspection Point (IP) is located at all property boundaries, with the property owner being responsible for plumbing within the property and the authority for all drains downstream of the connection IP. The main drains may be in public land such as road reserves or within easements through private property.

At all significant changes of direction and regular spacings along straight runs, flushing points are installed. Flushing points take the form of maintenance holes or access chambers for full sewer systems but can be IP's (also known as risers) for STEDS.

Pump stations are used at low points in the catchment to lift the effluent to the treatment plant or to ensure the depth of the gravity drains is minimised. Placement of pumping stations is at the discretion of the designer and is dependent on the local conditions, which may limit the viability of installing deep gravity drains.

The major difference between the two gravity systems is that a full sewerage system transfers all wastewater from the property including solids, whereas the STED schemes utilise a septic tank at each individual residence to capture the solids and only transfer the effluent to the collection system.

This difference has resulted in STED schemes having smaller pipes laid at lesser grades. While the prior removal of solids significantly reduces the number of maintenance holes or access shafts required. This generally results in the collection network for a STED scheme being shallower and having a lower capital cost to install especially in existing communities where all properties have septic tanks operating. STED schemes require a septic tank pump out program to desludge each tank on a four yearly cycle.

Pressure

Pressure sewerage schemes are becoming more widely adopted in South Australia, particularly over the past 8 years. Each property is fitted with a storage tank. In South Australia, this tank is required to provide 600 L of emergency storage for a residential domestic dwelling. The pump chamber is placed directly inline with the house's plumbing and hence receives all wastewater from the dwelling (inclusive of solids). A typical pressure system layout for a residential property is shown in Figure 3.1

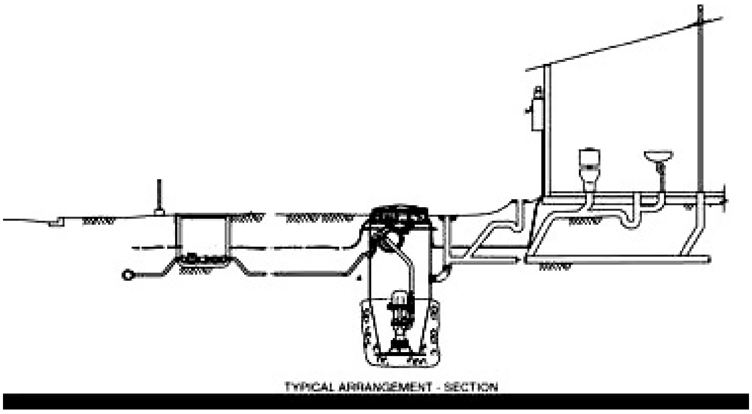


Figure 3.1 Pressure system layout

Diagram obtained from Environmental Systems Limited

For the pressure sewerage systems, a single grinder or cutter pump is installed in the pump sump to pump the wastewater from the property to the network. The network of drains may either deliver directly to a treatment facility or may pump to a main pumping station, which then transfers the wastewater to the treatment facility. Generally, where the treatment site is either elevated or a long distance from the network (i.e. high pumping heads) a transfer pumping station will be required. Over the past few years there have been significant developments in domestic pump units and several are now capable of duties approaching 50m head. A package system has recently been released to the market which is capable of pumping against a 60m head.

Each property connection consists of a 32mm connection line from the pump chamber to the main drain. A valve pit is to be located at each property boundary containing isolation valves and a non return valve.

Pressure systems have traditionally utilised centrifugal submersible pumps, but the introduction of more sophisticated control systems have resulted in positive displacement pumps also now being suitable for this application.

Pressure systems allow for the use of smaller bore drains than gravity systems and can be laid at shallower depths, as they do not require a minimum downhill grade and can be laid to the contour of the land.

Most of the pump supply companies in South Australia now market a package system suitable for installation in domestic situations. The quality and capability of each of the systems varies and needs to be assessed for the particular application.

Pump selection is a critical component of the design of a pressure network. Utilising pumps with performance curves that differ from that of the design can adversely impact on the system performance. Ensuring that the pumps specified in the design are actually installed requires vigilant monitoring and control. Most land owners will substitute the specified pump for cheaper alternatives if the installation is not monitored and strict controls placed on pump installation.

The reticulation network in a pressure system generally remains full of wastewater. Each time an individual property pumps into the system it forces wastewater in at the top end of the catchment and consequently out of the system at the outlet end. In large networks significant volumes of wastewater can be retained within the pipe network for long periods of time.

The period of time the wastewater remains in the network depends on the volume of the pipes within it and the volume of wastewater being pumped into it. The biochemical reaction occurring in the sewage/effluent quickly uses all available oxygen in the process. Once this occurs, anoxic or even anaerobic conditions are established, which causes septicity to occur, a by product of this process is hydrogen sulphide which is highly corrosive, toxic and at low concentrations has an unpleasant odour.

The potential for hydrogen sulphide generation within the systems will impact on the system design. The location of air valves need to be considered carefully so as not to position them in areas likely to be sensitive to odours. Head works at the treatment plant need to be designed to cater for the higher

Hydrogen sulphide load as it is highly corrosive. The gas can also be highly toxic, so safety of operators needs to be considered in the design. In addition to this the treatment process itself needs to account for the septic conditions particularly when calculating oxygen demands.

Vacuum

In a vacuum system, houses gravity feed to a chamber, usually located in the road reserve. Inside this chamber there is a level sensor, which activates the opening of the valve. The pressure in the pipeline is lower than that in the pit and the contents of the pit are effectively “sucked out”. The valve then closes to allow the network to maintain its vacuum. A significant volume of air is “sucked” into the line along with the wastewater. The wastewater slug that results from the valve opening and emptying the chamber soon disintegrates and flows via gravity to a low point in the system, where it reforms. Subsequent flows of air push the wastewater through the system to the vacuum/pump station.

Figure 3.2 shows the generic layout of a vacuum scheme

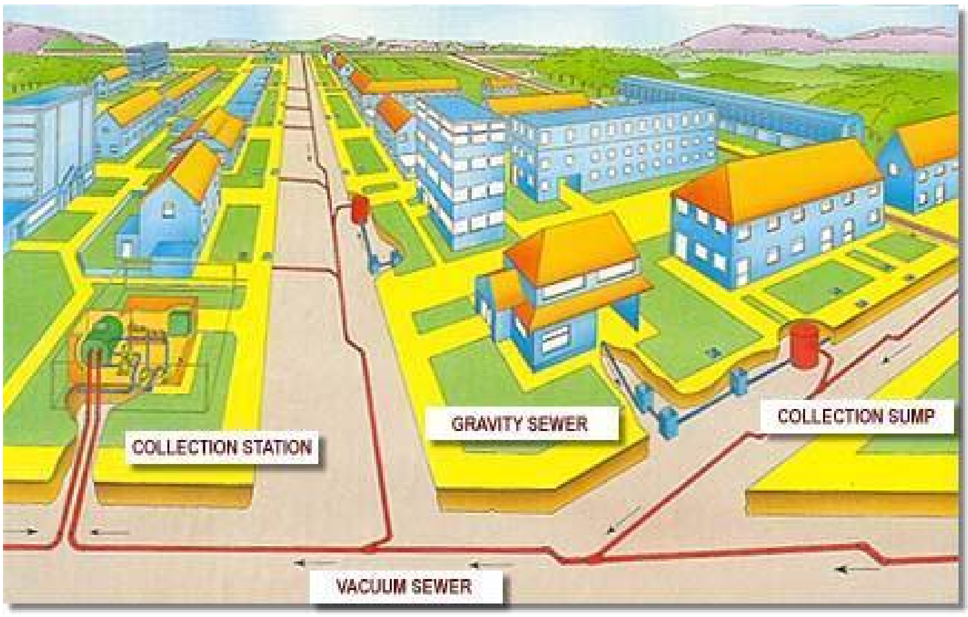


Fig 3.2 Typical Scheme Layout

Diagram provided by Flovac Pty Ltd

At the main pump station there are two types of pumps. One is used to create and maintain the vacuum in the pipe network, and the other is a conventional pump, which transfers the wastewater from the pump station to the treatment facility.

The chambers located outside the residential properties are generally service between 1 and 10 connections. The chambers vent via an 80-100mm vent located within each property. Unlike pressure or STEDS, vacuum systems do not require infrastructure other than the vent and drains on each individual property.

Care needs to be taken when situating the vents if the site is in a flood prone area. They will allow infiltration into the system if inundated.

The vacuum network is designed with a saw-tooth system, which allows a shallow depth to be maintained. Figure 3.3 outlines a typical detail for a property connection. It also outlines the saw-tooth arrangement for the main drains.

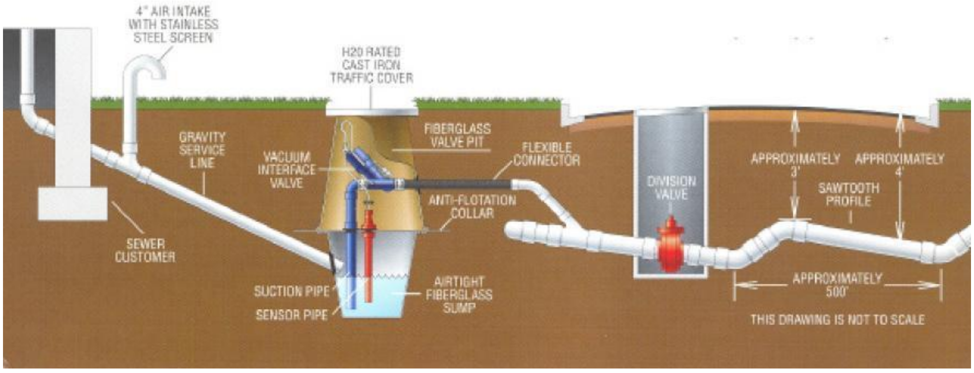


Figure 3.3 Saw-tooth Design

Diagram from Eurobodalla Shire Council Community fact sheet

The introduction of air each time the valve opens and the velocity of the wastewater within the network, acts to aerate the sewage and reduce the potential for odour generation otherwise resulting from the creation of septic conditions.

Vacuum pumps generally operate continuously to maintain the required pressure differential in the system. In times of low flow the pumps turn off and a vacuum vessel maintains the pressure differential in the system.

The vacuum pump stations have a high capital cost, which tends to result in the vacuum systems having a high unit connection cost, where the number of connections is low.

4. GENERAL COMPARISON OF AVAILABLE COLLECTION NETWORKS

4.1 SUITABILITY OF THE COMMUNITY WASTEWATER MANAGEMENT SYSTEMS

The decision to select a pressure or gravity system is dependent on a number of factors but the key issues include:

- The terrain and ground conditions
- Number of connections within the system
- The level of skills within authority's operations personnel and/or contract administrators.

No individual system is generally "better" than the others, as the functionality of each system will vary from site to site. The following guidelines can be used to select the most appropriate and economical option.

Gravity

Suited to;

- Gently sloping terrain towards one side of the site
- Areas with good excavation conditions
- Reasonably dense housing (i.e. not sparsely spaced blocks)
- Remote areas where system response times are likely to be long
- Areas with a high probability of prolonged power failure.

Pressure

Suited to:

- Areas where excavation conditions are difficult
- Areas with high ground water
- Sites that are elongated such as those that follow coastlines or rivers
- Areas with sparsely located houses
- Areas with significantly undulating terrain
- Areas that require large lifts from individual properties
- Hilly areas (vacuum lift is restricted to about 6m)
- Areas where construction impact needs to be minimised
- Where significant land acquisition would be required to install gravity drains

Vacuum

Suited to:

- Areas where excavation is difficult
- Areas of high ground water
- Proposals with over 100 connections
- Gently undulating sites
- Sites that are elongated such as those that follow coastlines or rivers

4.2 GENERIC ADVANTAGES AND DISADVANTAGES

There are a number of advantages and disadvantages of each of the waste collection alternatives. These are outlined below:

Gravity

Advantages

- There are limited maintenance issues for property owners (STEDS do require maintenance of the septic tank)
- Access to individual properties is not necessarily required by the authority (STEDS may require access depending on the pump out arrangements in place for septic tanks)
- The system is simple with very few mechanical parts or valves that may result in choke points.
- Power failure does not result in total system shutdown. Emergency response in such circumstances requires response to only a few key locations such as pump stations. This can be achieved by a trailer mounted diesel pump or a generator.
- Systems have minimal electrical requirements.
- Most civil contractors are able to install a gravity sewerage scheme.

Disadvantages

- Tracking infiltration or illegal stormwater discharges is difficult.
- Network isolation for maintenance purposes is more difficult.
- Drains tend to be deeper, making access for maintenance or replacement difficult. It also increases the construction costs, particularly when adverse ground conditions exist.
- Internal plumbing for individual properties may require deep excavation.
- Ground water ingress potential is higher than for either pressure or vacuum.
- Wastewater egress from the system is almost untraceable.

- System may not be appropriate to accept effluent and full sewer. Full sewer would accept effluent connections but STEDS drains may not accept full sewer.
- Stormwater ingress can significantly increase peak flows, which may cause system capacities to be exceeded (particularly at the pump stations or treatment plants).
- Deep excavation can cause considerable damage to nearby structures, as can the removal of rock by percussion.
- Pump stations have 9m or 12m vent stacks and may also have pump sheds that can have an adverse visual impact.
- Odour may be generated at pump stations in low flow situations as the wastewater may sit in the pump station for some time, which may result in septicity.
- System upgrades can be costly as gravity flow through a system is limited by the capacity of the pipe. Pressure and vacuum systems are a little more flexible as the system pressures can be increased to increase flow capacity.
- A larger working corridor is required for construction of the drains. Where access is required through sensitive areas or private property then gravity systems will require the largest construction corridor and hence cause the greatest damage during construction.
- Construction tolerances on the main drain are relatively small especially in schemes constructed on flat ground (due to being at flat grades 0.15% to 0.4% minimum grade)
- Septic tanks are located on the property for a STEDS which impacts on the space available for building on the allotment. Therefore larger minimum allotment sizes are required, reducing the efficiency of land use.

Pressure

Advantages

- Pipelines are shallower than for gravity and can follow the terrain.
- Pipelines are a smaller bore than for gravity.
- Drainage network is cheaper to install.
- Greater tolerance in levels and alignment can be accepted than for the other two systems.
- Being a pressure system, groundwater ingress into the system is highly unlikely (due to the pressure in the pipe being higher than the external water pressure) other than at main pump stations or on the individuals' property.
- Tracking of illegal connections can be facilitated by requiring hour run meters or flow meters and checking volumes.
- System is easily adaptable from effluent to full sewer, as long as the treatment facility has the sludge handling facilities.

- Most pump manufacturers in South Australia produce a pressure pump unit, so there is a good choice of supply.
- Avoiding services during construction is straight forward.
- Due to using a smaller bore pipe and being at a minimal depth the construction corridor is smaller than for other systems and the damage caused by installation is minimised.

Disadvantages

- Pumps are required for each individual property.
- The question of who owns and maintains the pumps needs to be addressed. If the owner maintains the pump then the likelihood of malfunction due to poor maintenance is increased. If the authority maintains the pump then the issue of access to infrastructure arises.
- If pump unit installation is not controlled (types of pumps) can impact negatively on the operation of the system.
- The system can not operate in the event of a power failure. The scheme then relies on individual on-site storage. Hence extended power failure is difficult to mitigate, since every allotment would need to be pumped out by portable pumps and disposal units.
- Leakage of effluent from the system can be difficult to trace or detect.
- The area for buildings on each allotment is restricted by mandatory setback distances.
- Design is significantly more complex than for gravity.
- Air valves are required throughout the scheme. This can result in odour within residential areas. Air valves also tend to be prone to leakage which results in small releases of effluent to the environment.
- The onus is on the land owner to detect faults and either fix or report the fault depending on what ownership model is adopted.
- Pump sumps are located on each allotment which limits the area available for buildings. Therefore larger allotments are required, reducing the efficiency of land use.
- There are more mechanical and electrical components within the system which will result in a more rigorous maintenance regime being required.
- Each individual property owner is paying the power bill for the pumps. This is a hidden community cost which artificially deflates the comparable cost of this system.

Vacuum

Advantages

- Pipeline construction can be kept at a minimum depth, saving excavation costs. Generally these mains will be deeper and larger than for pressure systems but shallower than for gravity. This helps reduce water ingress.
- Generally there will be fewer pump stations than for a gravity system.
- Eliminates the need for maintenance holes, reducing costs compared to conventional sewerage and reducing ground water ingress.
- The system is easily adaptable from effluent to full sewer as long as the treatment facility has the sludge handling facilities.
- Property owners do not need to maintain infrastructure, as is the case with conventional sewerage. With pressure schemes they have a pump and sump, STEDS they have a septic tank.
- The risk of egress of effluent to the environment is less than any other scheme due to the low pressures in the mains.
- The potential for ingress of stormwater is reduced. Suppliers have indicated that the system can tell due to the loss of vacuum if water is getting into the system. The system has the potential to track illegal stormwater discharges depending on the level of monitoring equipment installed.
- The mixture of air and wastewater in the system maintains wastewater in an aerobic state, reducing the potential for odour and providing a small level of pre-treatment before it is delivered to the WWTP. This reduction in septicity also reduces the potential for corrosion.

Disadvantages

- Stormwater ingress can occur upstream of the vacuum chambers.
- A vent is required on the individual property so there is a potential for odour in the event that effluent remains in the chamber for some time.
- Should the vacuum pumps fail then the whole system will become inactive. There is some limited storage at the vacuum chambers.
- Suppliers have indicated that it is possible to track leaks in the system. However, this is done via an elimination process and could be time consuming.
- Because individual connections are via gravity then deep connections within each property may be required. This is the same as for gravity. Pressure systems do not present this difficulty.
- Design costs are significant as design is significantly more complex than for a gravity system.
- Adherence to tolerances is very important, making construction standards and supervision very important.

- There are limited suppliers of vacuum systems.
- There are more mechanical components within the system (compared to gravity) which will result in a more rigorous maintenance regime being required.
- System requires more vigorous monitoring than a gravity system, to ensure vacuum pressures are maintained. This is likely to require a SCADA system for this monitoring to be effective.

5. SITE SPECIFIC CONDITIONS AND ISSUES AT BUCKLAND PARK

The following conditions and issues at the Buckland Park site will influence the selection of an appropriate collection network.

High Ground Water Levels

The majority of the site has a depth to water table of less than 3 metres. To minimise the length of drain constructed below the groundwater table level the maximum drain depth was set to 3m by installing pump stations. To achieve this, approximately 35 pump stations would be required to service the proposal. Even with this number of pump stations up to 75% of the gravity drains would be installed within the water table. Appendix A shows a depth to water table plan for the site highlighting all areas where the groundwater is less than 3m below the surface. This map is based on recent site mapping undertaken by Golder and Associates. It should be noted that seasonal fluctuations of up to 1m could be experienced. This would result in the majority of gravity drain being below the standing groundwater level.

Constructing a gravity system within the ground water table could potentially result in water infiltration at manholes, pump stations and any breaks or cracks in the pipe work. STED systems also have potential for ground water ingress at septic tanks.

Sewer systems generally have more manholes in the system than STEDS and the drain depths are greater due to the larger minimum grade required for sewer systems so the risk of infiltration is increased.

The drains for vacuum systems are generally installed between a depth of 1.2m and 1.5m. Appendix B indicates the area of the site that the depth to ground water is less than 1.5m. It is estimated that for a vacuum system only 10% of vacuum drains would be installed within the water table.

The maximum number of houses connected to each valve pit should be set to minimise the depth of the vacuum pits. The cost estimate in this report has assumed an average of 5 connections per pit, however, when detailed design is undertaken up to 8 houses may be able to connect and still keep the pits above the standing water table level. It is likely that some of these pits will need to be installed below the current groundwater levels.

With a pressure system almost all the drains will be above the ground water level which will minimise construction costs. Since the drains are pressurised it is unlikely that ingress would occur in any case as the pressure in the pipe network is likely to prevent infiltration.

It is likely however that a fair percentage of the domestic pumping units will be installed within the ground water table, which does introduce the potential for ground water ingress. If GRC pumping units are used then precautions will be required to prevent flotation of the pump chambers.

Salinity

Ingress of saline ground water into the waste management network causes the salinity of the waste water to increase and highly saline waste water can impact on the effectiveness of the WWTP operation. It will also impact on the potential number of reuse applications that the treated effluent may be used for.

The ground water within the Buckland Park site has salinity in the order of 3000ppm to 5000ppm (TDS).

This would mean that relatively small volumes of ingress could have a significant impact on the salinity of the waste water.

The salinity of typical treated waste water schemes in South Australia is between 800ppm and 1000ppm (TDS). Anecdotal information from the Virginia region indicates that soil salinity in the area is of concern to the local growers. As such if salinity of the treated water increases much above the typical values then the applications for reuse may be limited.

Within the Buckland Park proposal a high priority is placed on the potential to reuse the treated waste water, therefore the potential for ingress of saline groundwater into the waste water management system is likely to be a significant factor in selecting the most appropriate method of waste water management.

Salinity can be managed in a number of ways:

- Reduce the potential for it entering the system (by implementing a vacuum or pressure system)
- Shandy the treated water with mains or harvested stormwater.
- Install a desalinisation (RO) plant. This is likely to increase capital cost by $300,000 to $400,000 and running costs by $40,000 to $50,000 per annum.
- Do not reuse the water and dispose via evaporation (not a desirable option).

Acid Sulphate Soils

It has been confirmed within a report prepared by Golders Associates (November 2008) that sections of the Buckland Park site have the potential to encounter acid sulphate soils below the ground water level.

Construction within these zones is likely to occur if installation of a gravity waste management system is to be implemented.

If Acid Sulphate Soils (ASS) are encountered the soil will need to be treated prior to the installation of any infrastructure, therefore causing the construction cost to increase.

Precautions will need to be taken to prevent ingress of leachate from ASS getting into the trenches and being transported around the site. Both vacuum and pressure systems will minimise this due to the relatively shallow depth of drains. Gravity drains also drain for long distances at a constant downward grade which facilitates the transport of leachate (if encountered). Both the vacuum and pressure sewerage drains are not required to constantly grade downward, this in itself would minimise the spread of ASS leachate should it be encountered.

Resource Availability

When selecting a scheme the resource availability and skill levels within the region need to be considered.

The gravity options will have the lowest site maintenance requirements and also require the lowest level of system familiarisation.

This needs to be carefully considered when selecting the most appropriate system for the Buckland Park proposal.

Technology

The gravity options are the oldest form of collection system and their operation is generally understood.

Pressure technology uses conventional pumps and as such there is a wide variety of suppliers and a considerable availability of skilled labour to service the pumps, however with the increased number of mechanical and electrical components the potential for faults is increased.

Vacuum is not a commonly utilised technology in SA with only 3 schemes currently known to W&G being:

- Hindmarsh Island Marina
- Waterfall Gully
- A marina project within the Murray Bridge Council area.

The Alexandrina Council are about to install a significant scheme to expand the area serviced by its STEDS network at Goolwa. There is also a vacuum system currently being constructed at Port Wakefield.

This technology however is widely used in Western Australia particularly and also in some of the eastern states.

From all reports and the research undertaken by W&G these systems are proving to be reliable if designed and operated appropriately.

6. COST COMPARISON

Table 5.1.1 provides a summary of the capital and all of life costs that are associated with each of the different wastewater management systems. These costs have been calculated taking into account a discount rate of 4 percent. The cost comparison has been based on estimates completed on capital and running costs produced by W&G through experience and industry knowledge using rates based on similar recently completed projects. These estimates have then been entered into the LGA's all of life cost model to obtain the all of life cost per connection, for each of the options.

These cost comparisons have been based on servicing the projected total population of 33,000 as outlined previously.

Table 6.1.1 Summary of costs from LGA cost evaluation spreadsheet

Effluent		
Discount Rate	Capital Cost	All of Life Cost
4%	$78,100,000	$100,900,000*
Sewer		
Discount Rate	Capital Cost	All of Life Cost
4%	$41,800,000	$58,700,000*
Pressure		
Discount Rate	Capital Cost	All of Life Cost
4%	$132,700,000	$248,000,000
Vacuum		
Discount Rate	Capital Cost	All of Life Cost
4%	$37,900,000	$55,300,000

- *This does note take into account additional pumping costs to cater for groundwater ingress*
- *It also does not account for additional costs to manage salinity for any reuse applications*
- *The impact of staging the proposal has not been taken into account in the all of life cost comparison.*

The gravity sewer concept has been based on a maximum drain depth of 3m, resulting in the need for 35 pumping stations and 75% of the drains laid in the water table.

The vacuum sewer cost has been based on an average of 5 houses being serviced by each vacuum pit and the scheme requiring 3 vacuum pumping stations.

From the above summary it can be seen that a vacuum system will require the lowest all of life cost and capital cost out of all four of the options considered.

It should be noted that the two gravity options will have the greatest risk/potential for cost escalations during construction due to unfavourable ground conditions.

Given these cost estimates have been produced at the proposal's concept design stage a number of assumptions have been made.

The accuracy limits of the cost model would suggest that the all of life costs for the options outlined above with less than a 10% differential could be considered to be of comparable value and should not totally influence the decision for the selection of the most appropriate scheme. In this instance for the purpose of comparison it can be assumed that the gravity sewer and the vacuum systems are of the same order of cost and as such other factors should determine which system is adopted.

7. RECOMMENDATION

W&G recommend that design development be based on a vacuum sewerage system.

The reasons for recommending this option include:

- The lower estimated capital cost and all of life costs
- The reduced potential impacts of salinity on the reuse applications
- Lesser impact of peak wet weather flows on the WWTP and pump stations
- Lesser potential for long term ground water ingress
- Reduced potential for system overflow from the pump stations during peak wet weather events or power outages
- Reduced risk of system failure due to groundwater ingress
- Lower pumping costs associated with groundwater ingress (which is not captured in Table 5.1.1)
- Reduced operational requirements in a major power failure scenario
- It is estimated that approximately 75% of drains in a gravity system would be installed below the current ground water levels, even with the installation of 35 pumping stations
- Aeration of sewage through the collection network will have a positive impact on the WWTP operation.

We recognise vacuum sewer systems are a new technology in South Australia, and they are likely to require additional resources for maintenance, than a gravity scheme. We also recognise that specialist skills are required to operate the system.

We believe that these issues can be mitigated by:

- Ensuring the construction contract allows for significant training and support after the scheme is installed.
- The economies of scale offered by a proposal of this scale justify creation of a maintenance team with specialist training.
- Ensuring spare parts are provided as part of the supply contract, and keeping the valves on hand so they can simply be swapped in the field, and the valves later repaired in the workshop.

Salinity is critical for future reuse applications within the proposal and therefore all practical measures should be taken to prevent, or at least minimise, the potential for groundwater ingress.

8. REFERENCES

Golder and Associates Geotechnical Investigations Report (2008)

Interview with Michael Frost, Mid Murray Council, 21/2/06

Interview with Peter Adams, SA Water 27/2/06

Shoalhaven Water – Alternative Sewerage Systems Compared, Sewerage collection systems compared - http://www.shoalwater.nsw.gov.au/6hotnews/SewerageSystems.html

South East Water – Pressure v Gravity Comparison, no source reference

Yara Valley Water – Pressure v Gravity Comparison – Community fact sheet

Eurobodalla Shire Council – Conventional Gravity Sewerage System Comparison – Community Fact Sheet

Eurobodalla Shire Council – Vacuum Sewerage System – Community Fact Sheet

Eurobodalla Shire Council – Low Pressure Sewerage System – Community Fact Sheet
www.eurocoast.nsw.gov.au

Wagga Wagga Protocol Draft Pressure Sewerage Guidelines – March 202

EPA# 625477011 Alternatives for Small Wastewater Treatment Systems: Volume 1 - On-Site Disposal/Septage Treatment and Disposal

EPA# 625477011 Alternatives for Small Wastewater Treatment Systems: Volume 2 - Pressure Sewers/Vacuum Sewers

EPA# 625477011 Alternatives for Small Wastewater Treatment Systems: Volume 3 - Cost/Effectiveness Analysis

EPA# 600275072 Economical Residential Pressure Sewer System with No Effluent

EPA# 625191024 Manual: Alternative Wastewater Collection Systems

EPA# 600979010 National Conference on Less Costly Wastewater Treatment Systems for Small Communities

EPA# 600278166 Pressure and Vacuum Sewer Demonstration Project: Bend, Oregon

EPA# 832F02006 Wastewater Technology Fact Sheet: Sewers, Pressure

FloVac – product Catalogue

Auqutec Fluid Systems – Product Catalogue

Australian Standards and Codes

SA Water Sewer construction manual and technical standards

SA Water Technical Standard TS130 – Pressure Sewer Systems, 8/12/05

SA Water Pressure Sewerage Design Manual – available on SA Water Website

WSAA – Pressure Sewerage Code of Australia – Interim Edition 2005

WSAA – Sewerage Code of Australia 2002 version 2.3

WSA – Vacuum Sewerage Code of Australia 2004 Version 1.1

Local Government Association – STEDS Design Guildelines, 1997

Draft Standard – Connection to a Communal Waste Control System, Department of Health South Australia

APPENDIX D
SA WATER CONSIDERATION OF WATER SUPPLY OPTIONS

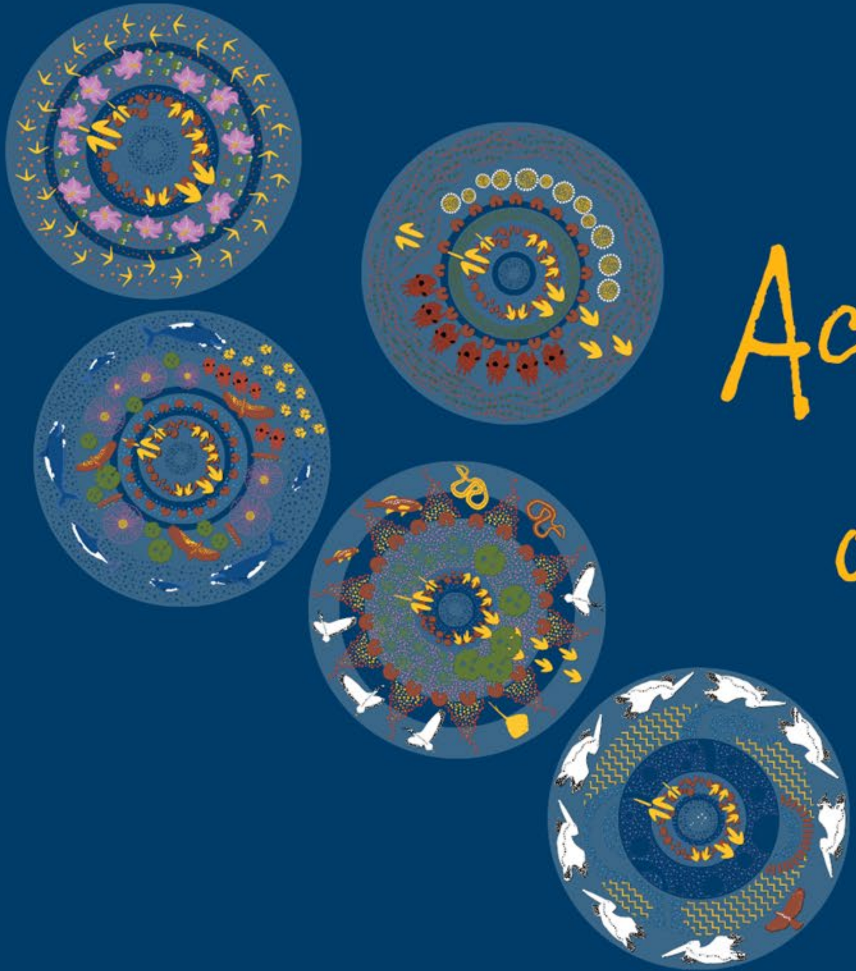
SA Water

Riverlea Masterplan presentation

27th October 2022

SA Water House

Government of South Australia



Acknowledgement of Country

Agenda

- Master planning – process and context
- Water Servicing
- Wastewater Servicing
- Open Space Irrigation Servicing
- Next steps

Master planning Process

- Whole of system review with the purpose of meeting Riverlea requirements
- Completed to show the ultimate servicing solution for the Riverlea (based on information to hand)
- Reliant on assumptions
  - Growth numbers
  - Timing of the growth
- High level and may change over time (20+yrs life of the development)
  - Responding to:
    - Actual growth levels
    - Actual development delivery (more/less, commercial, golf course?)
    - Changes in technology.... The list goes on

Water servicing

master plan 2022 supply main and additional demands (compared to FY20/21)

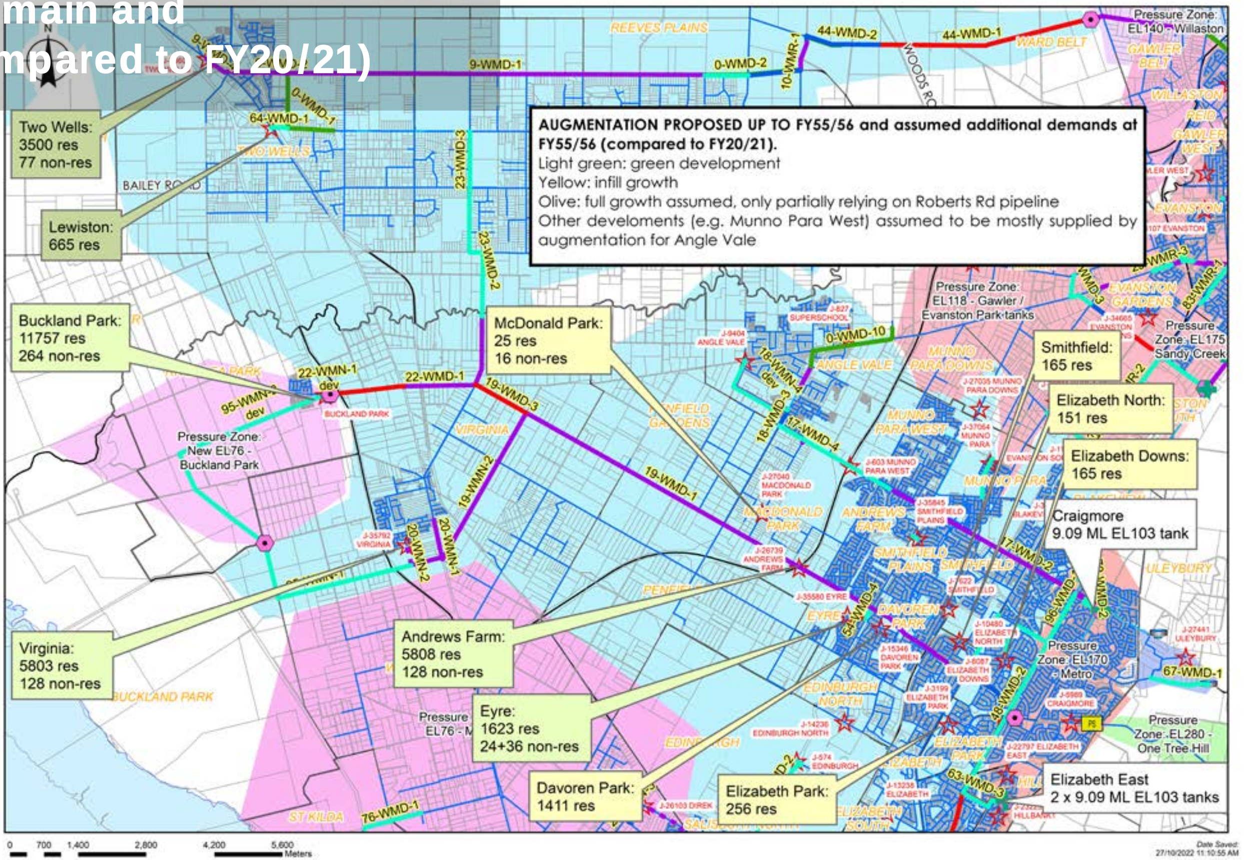
Legend

- MasterPlan-OperChanges
- MasterPlan-Pumps
- MasterPlan-Valves
- MasterPlan-Tanks

MasterPlan_Mains

AUG_PERIOD

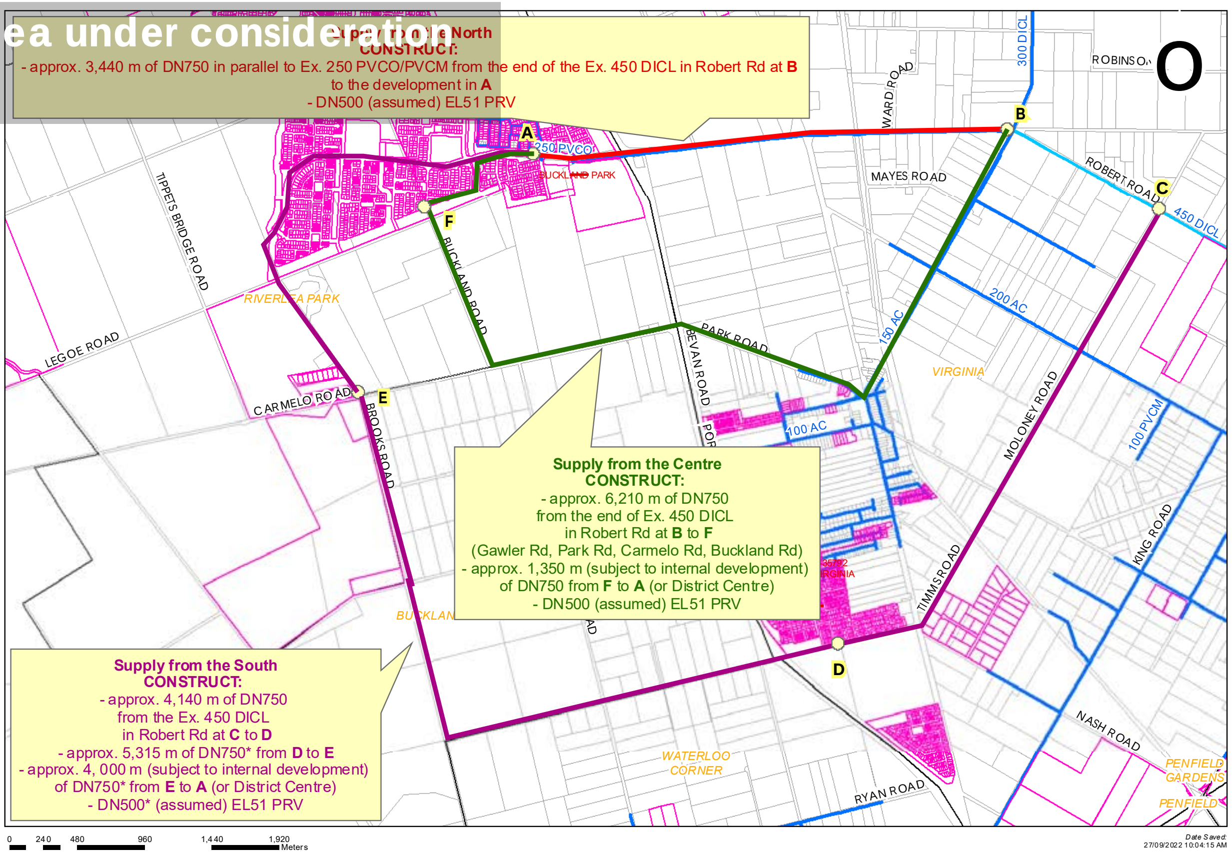
- 20-24
- 24-28
- 24-28 dev
- 28-32
- 28-32 dev
- 32-36
- 32-36 dev
- 52-56
- 52-56 dev
- AdditionalDemandNodes



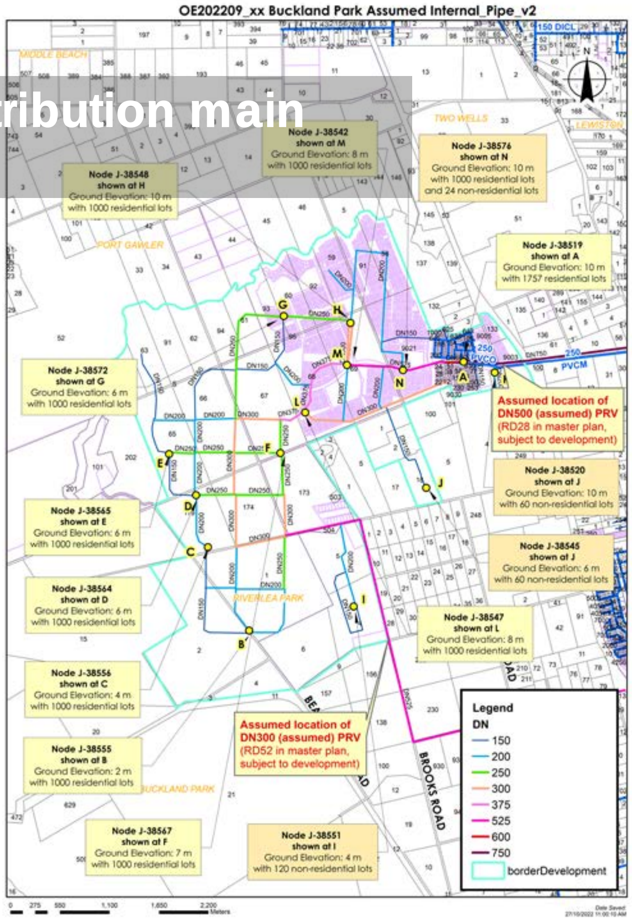
Summary of the augmentation ‘directly’ used by Riverlea development (downstream of storage tanks)

AUG ODE	AUG DN	AUG PERIOD	AUG REASON	LENGTH (m)
19-WMD-1	1000	24-28	DN1000 duplication along Robert Rd (from FP 7617680 to Moloney Rd) to improve supply to Virginia and Buckland Park	6459
22-WMD-1	750	24-28	DN750 main duplication in Angle Vale Rd (from Old Pt Wakefield Rd to crossing with Baker Rd, Virginia) to improve supply to Buckland Park	1477
19-WMD-4	1200	24-28	DN1200 duplication main along Petherton Rd (from FP7617680 to Main North Rd) to supply Virginia and Buckland Park	4119
38-WMD-1	750	28-32	Duplicate 250 PVCM with DN750 along Angle Vale Rd from Old Pt Wakefield Rd in Virginia to supply Buckland Park	1651
19-WMD-3	1000	28-32	DN1000 duplication in Robert Rd from 19-WMN-1 in Moloney Rd (Virginia) to Gawler Rd to supply Buckland Park	1198
95-WMN-1	525	52-56	New DN525 main in McEvoy Rd (Buckland Park) from end of 21-WMN-1 supplying Virginia, along Brooks Rd until new (southern) EL76 PRV for the development	3979
95-WMN-2 dev	525	52-56	New DN525 pipe modelled to simplify the pipes internal to the Buckland Park development (i.e. between the northern and southern new EL76 PRVs)	5824

Supply options into Riverlea under consideration

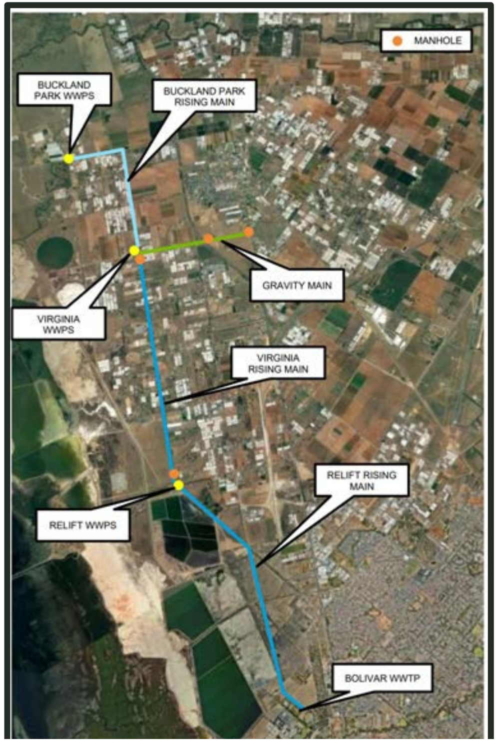


Assumed layout and distribution main



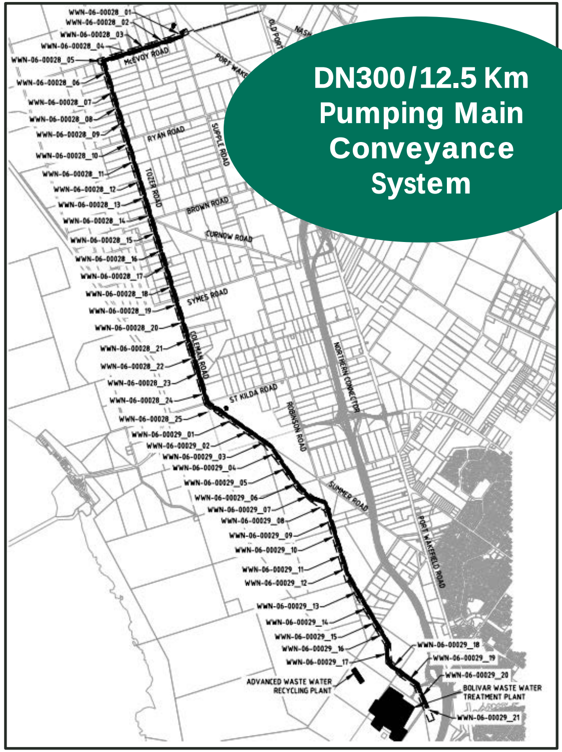
Sewer servicing

SA Water Network Growth Program – BP-V Augmentation Project



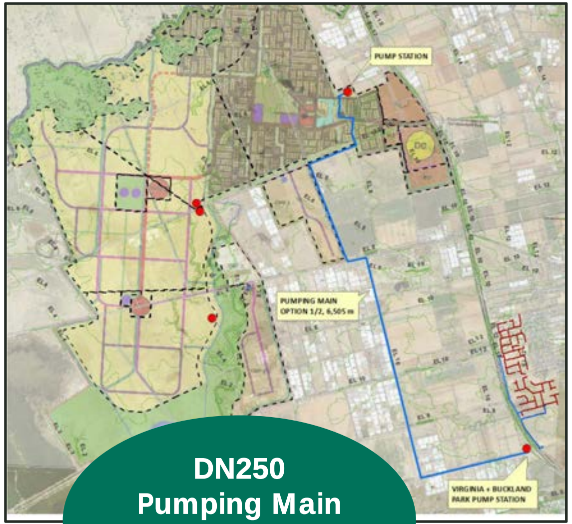
CONCEPT ONLY – FINAL ALIGNMENTS HAVE BEEN SUBJECT TO DETAILED DESIGN PHASE

12 km transfer pumping system from Virginia to Bolivar WWTP (in delivery)



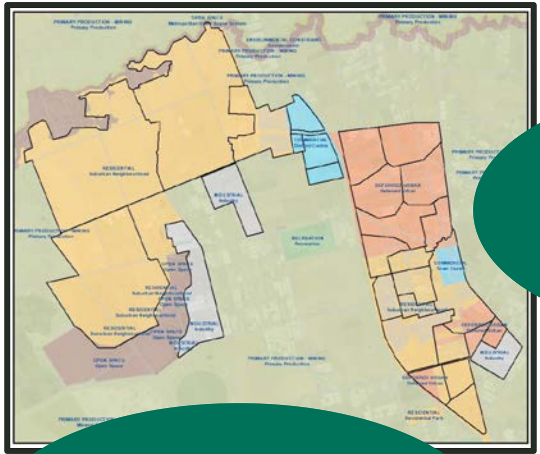
DN300/12.5 Km Pumping Main Conveyance System

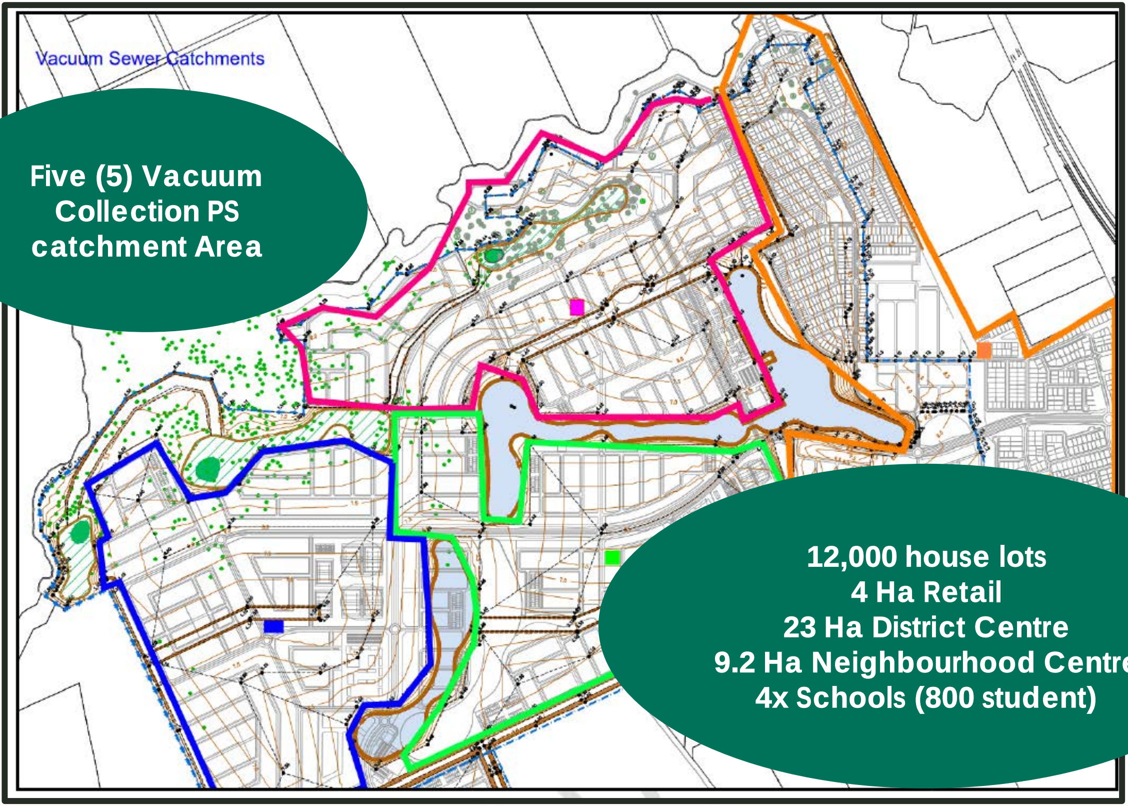
6 km transfer pumping system from Buckland Park to Virginia (in design)



DN250 Pumping Main Conveyance System

Vacuum catchment areas



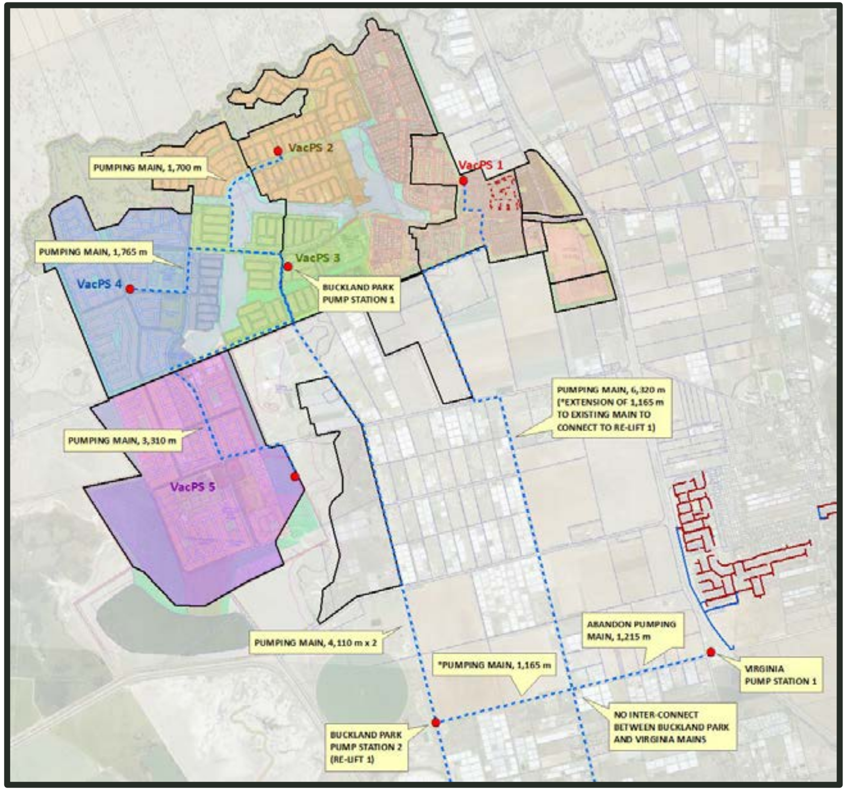


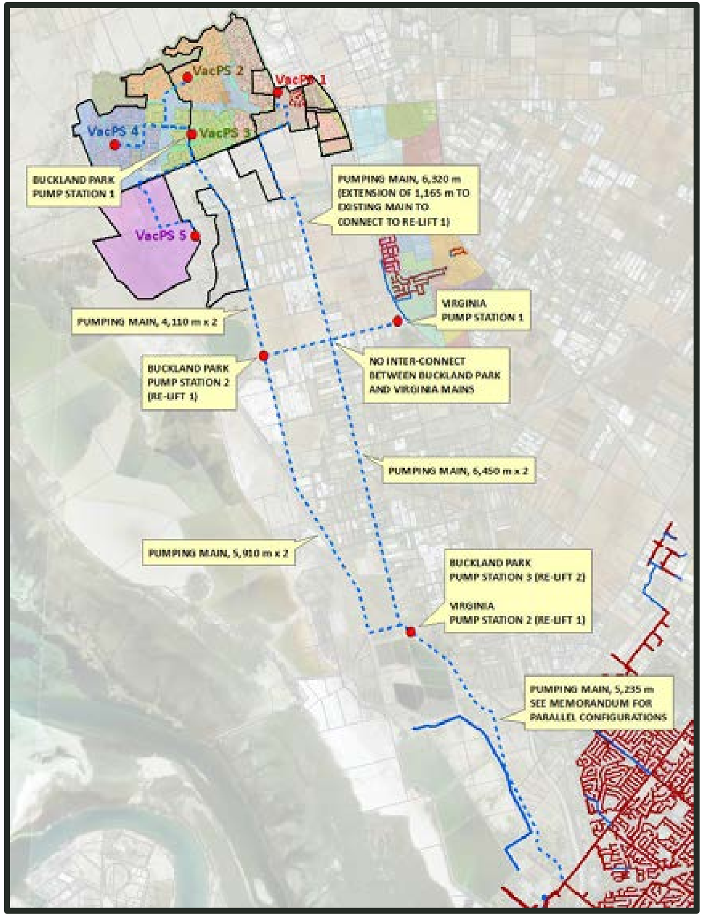
Five (5) Vacuum Collection PS catchment Area

EXCLUDED:
2x Employment Lands
(Total 115 Ha)

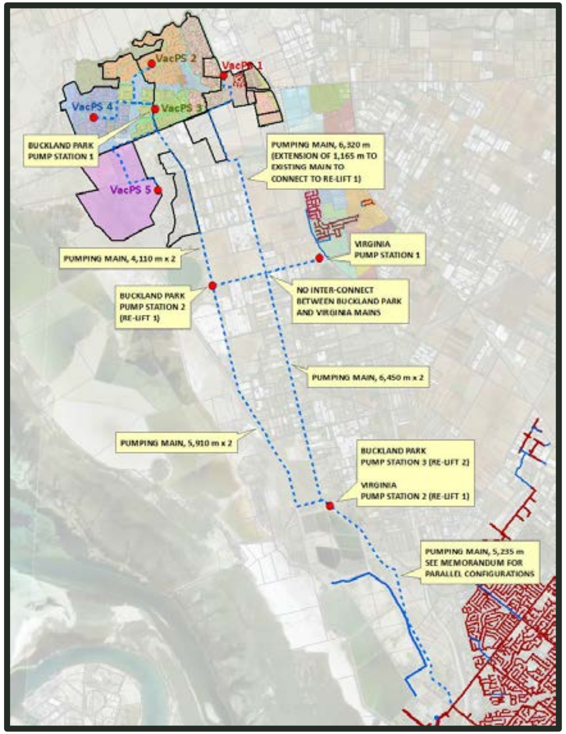
12,000 house lots
4 Ha Retail
23 Ha District Centre
9.2 Ha Neighbourhood Centre
4x Schools (800 student)

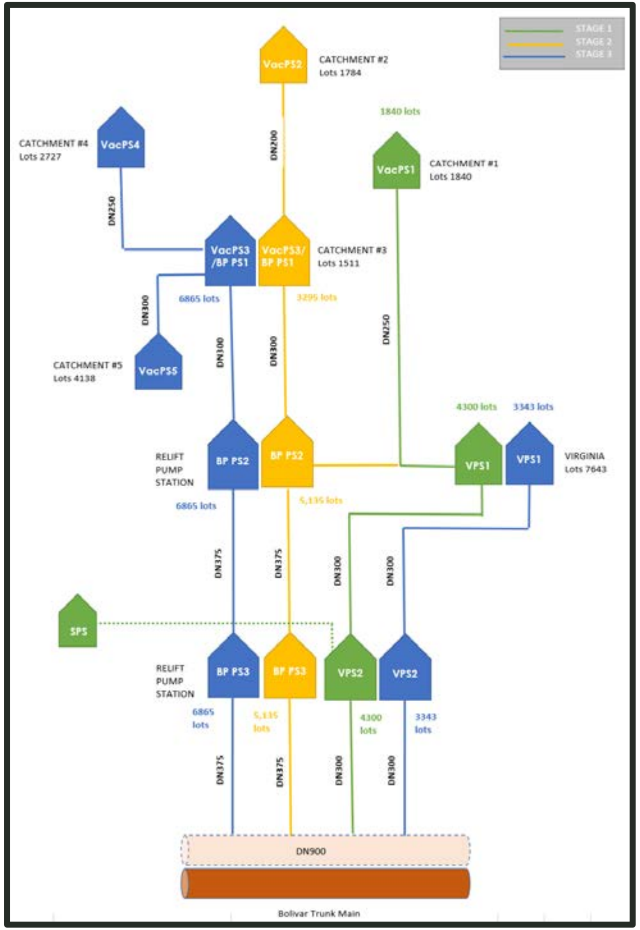
2022 Scheme Layout





Infrastructure stages





STAGES	BUCKLAND PARK	VIRGINIA
1	1,840	1,700
2	5,135 (+3,295)	4,300 (+2,600)
3	12,000 (+6,865)	7,643 (+3,343)

Infrastructure requirements

STAGES	BUCKLAND PARK	VIRGINIA
1	1,840	1,700
2	5,135 (+3,295)	4,300 (+2,600)
3	12,000 (+6,865)	7,643 (+3,343)

CONVEYANCE INFRASTRUCTURE - STAGE 1

FROM	TO	DISTANCE (m)	PUMP DETAILS		PUMPING MAIN DIAMETER	COMMENTS
			FLOW (L/s)	HEAD (mH2O)		
VacPS1	VPS1	6505	55*	36*	DN250	*Under design
VPS1	VPS2	6450	92	38	DN300	In construction
VPS2	Ex. Bolivar TM	5235	94	29	DN300	In construction, includes allowance from Defence at St Kilda

CONVEYANCE INFRASTRUCTURE - STAGE 2

FROM	TO	DISTANCE (m)	PUMP DETAILS		PUMPING MAIN DIAMETER	COMMENTS
			FLOW (L/s)	HEAD (mH2O)		
VacPS1	~~VPS1~~ BP PS1	extend by 1165m (from Cnr. McEvoy Rd/Tozer Rd)	55	37	DN250	Virginia PS is now dedicated for Virginia (Buckland Park de-coupled)
VacPS2	BP PS1	1700	45	25	DN200	New
BP PS1	BP PS2	4110	99	33	DN300	New, includes VacPS2 & VacPS3 catchment
BP PS2	BP PS3	5910	154	36	DN375	New
BP PS3	Ex. Bolivar TM	5235	154	35	DN375	New

CONVEYANCE INFRASTRUCTURE - STAGE 3

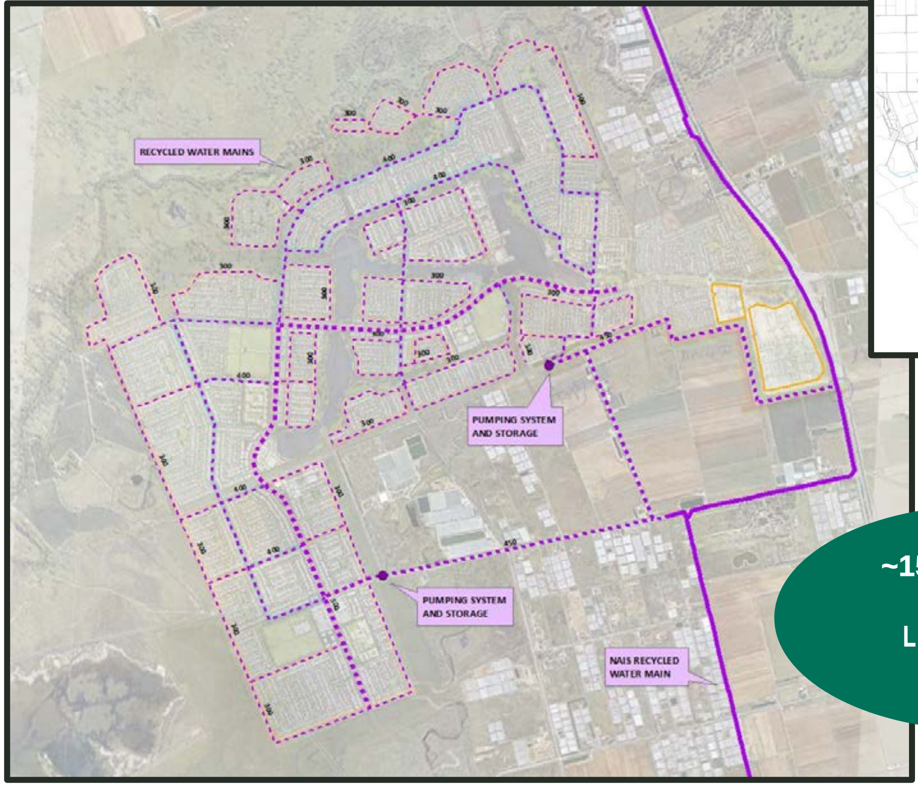
FROM	TO	DISTANCE (m)	PUMP DETAILS		PUMPING MAIN DIAMETER	COMMENTS
			FLOW (L/s)	HEAD (mH2O)		
VPS1	VPS2	6450	92	38	DN300	New, duplicated pumping system
VPS2	Ex. Bolivar TM	5235	94	29	DN300	New, duplicated pumping system
VacPS4	BP PS1	1765	68	22	DN250	New
VacPS5	BP PS1	3310	103	32	DN300	New
BP PS1	BP PS2	existing	127 (upgrade)	50 (upgrade)	DN300	Upgraded pumping capacity
BP PS1	BP PS2	4110	127	50	DN300	New, duplicated pumping system
BP PS2	BP PS3	5910	154	36	DN375	New, duplicated pumping system
BP PS3	Ex. Bolivar TM	5235	154	35	DN375	New, duplicated pumping system

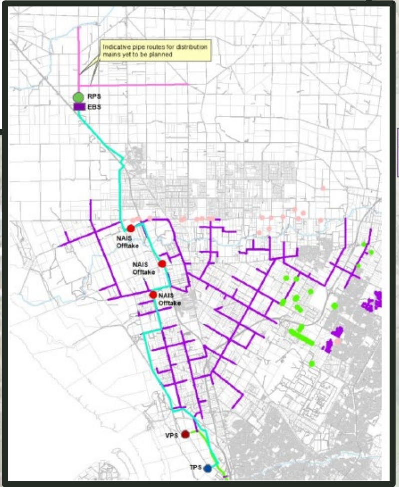
GRAVITY MAINS (FULL BUILD OUT)

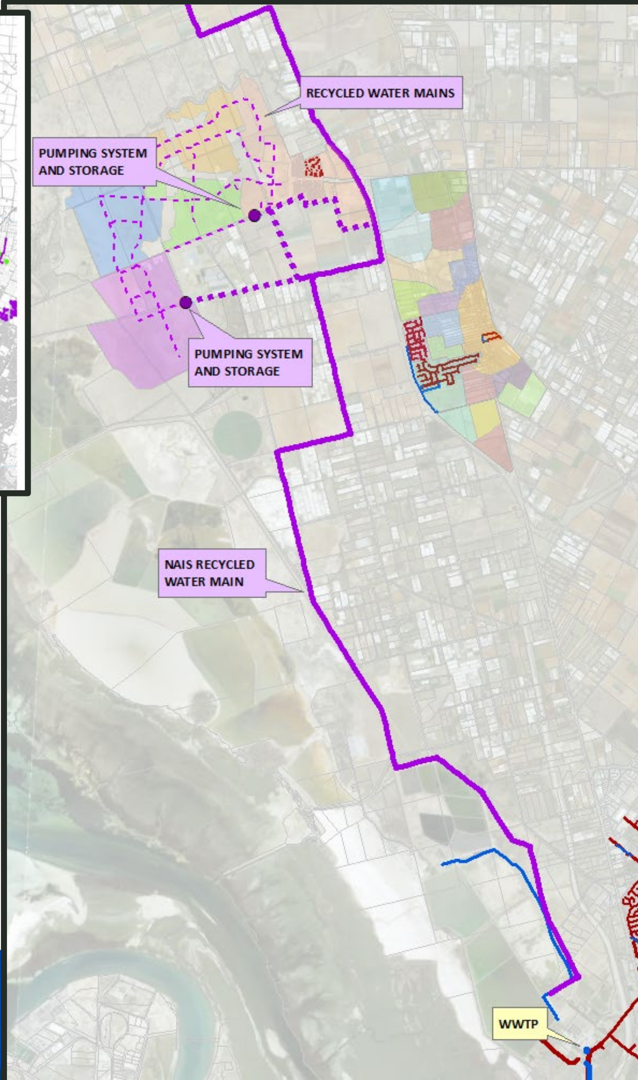
FROM	TO	DISTANCE (m)	DIAMETER	GRADE	COMMENTS
New BP-V Connection	Bolivar WWTP	425	DN900	0.13%	High level, PWWF

Open space landscape irrigation servicing

2022 Scheme Layout







~150 Ha Open Space Landscape Irrigation

Next steps

Information Request from Walker Corp

Current and forecasted

- Timing
- Staging
- Dwelling & commercial tenancy construction commencement
- Dwelling & commercial tenancy completion dates
- Commercial/School forecasting (nature of development, timing meter size and connection size)
- Reserves and meter sizing
- Finished survey information

making life flow

Government of South Australia

SA Water

APPENDIX E
FLOOD MODELLING REPORT

Walker Corporation

Riverlea Park

2009 TECHNICAL PAPER UPDATE – FLOOD ASSESSMENT

WGA080163

WGA080163-RP-CV-0013_B

Rev B

30 November 2023

Revision History

REV	DATE	ISSUE	ORIGINATOR	CHECKER	APPROVER
A	17/11/022	Update to 2009 technical paper	FL	MM	DB
B	30/11/2023	Update to Design	DJB	FL	DB

CONTENTS

Figures

Tables

Attachments

1 BACKGROUND

WGA has been engaged Walker Corporation to assess the ability of the proposed integrated saltwater lake and stormwater channels system for the Riverlea Park - Riverlea development to manage a 1% AEP flood event. This includes undertaking a flood modelling assessment for the proposed development and checking the freeboard for saltwater lakes, detention basin, and channels/drains.

The Riverlea development is located approximately 32km north of the Adelaide CBD, in the City of Playford, bounded by Gawler River to the north. Figure 1 shows the project site locality. The surrounding catchment area is relatively flat and has a gentle slope from east to west.

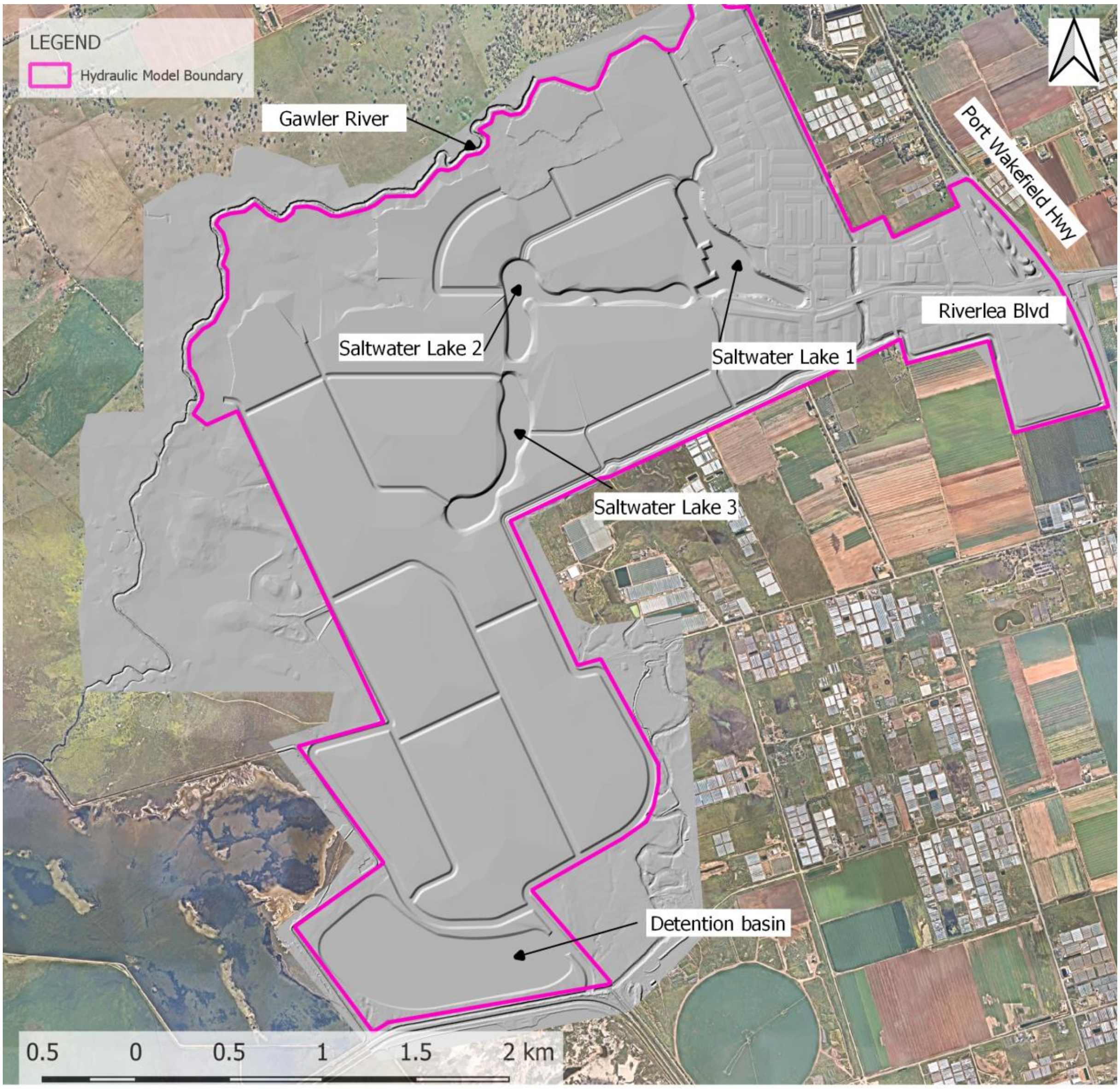


Figure 1: Project Site Locality

The development is proposed to contain three saltwater lakes, several channel networks and a detention basin located at the southern side of the development site. Saltwater lakes 2 and 3 are connected by an overflow weir and excess water from lake 3 is proposed to be released through a 750mm diameter gravity pipe to the open channel system. Salt water will be pumped into the lake system from the sea. Flood water from the development site is collected through the channel system and transferred to the detention basin, before discharging flows when required out through a button pipe outlet to Thompson's Outfall Channel.

In 2009 a technical paper was prepared based on an older design for the development site that included a flood modelling assessment. This current flood modelling assessment for the site is based on the most recent development design which includes three saltwater lakes, channels, and a detention basin.

The saltwater lakes contain saline water and any spills from the channel system may cause potential risk to the environment. The operational functional design capacity of the saltwater lakes, detention basin and channel system to not spill during a 1% AEP event has been assessed in this report.

The following information was used in this flood modelling assessment:

- Riverlea Park proposal, Stormwater management water, wastewater and recycled water, technical paper 2009
- Riverlea Saltwater Lakes, Second Phase of Preliminary Investigations January 2022
- Riverlea Development Flood Assessment Addendum 2022
- Design development area drawings

For this updated site flood risk assessment Rain on Grid (RoG) 1D/2D TUFLOW modelling has been undertaken to simulate the inflow from the catchments and the flood levels in the channels, salt lakes and the detention basin. The modelling has been performed for a 1% AEP event. This report explains the modelling process and summarises the findings.

2 SCOPE

The key activities undertaken for this report include:

- Reviewing the design information for the development
- Developing a flood model based on:
  - Undertaking 1D/2D TUFLOW modelling
  - Using the Rain on Grid (RoG) approach
  - Modelling 1% AEP as the major storm event
  - Simulating a range of rainfall durations and ten temporal patterns per duration
  - Using AR&R 2019 guidelines for the modelling
  - Modelling the proposed development site design surface
  - Using HPC solver for modelling
- Running the TUFLOW model for the proposed development site
- Processing the results and extracting median results for temporal patterns and peak results for the durations
- Checking the freeboard for the saltwater lakes, channels/drains, and detention basin
- Preparing the flood maps and summarising the findings

The next sections of the report explain the details and assumptions for the flood modelling and the results.

3 FLOOD MODELLING

3.1 Methodology

A 1D/2D TUFLOW model has been developed in accordance with AR&R 2019 guidelines. The latest design surface for the development site has been used. The modelling has been undertaken for 1% AEP event.

The model boundary is shown in Figure 1 and covers about 10.2km^2. The flooding from Gawler River was assessed in “Riverlea Development Flood Assessment Addendum - 2002” report prepared by Water Technology. In this assessment only the flooding from the development site area was modelled. The flooding from Gawler River has not been assessed, therefore its catchment has not been included in the model.

A range of storm durations was selected and for each duration 10 temporal patterns were modelled. The median of all 10 temporal patterns for each duration was processed and the maximum of the medians were then extracted to form the critical results. This approach ensures only the critical results are presented for each modelling cell. The results have been checked for all the modelled durations to ensure the peak results have been captured.

Hydrological data including rainfall and losses has been entered directly into the model using the Rain on Grid (RoG) approach, which directly applies rainfall to the modelling area. By using this approach, both hydrologic and hydraulic modelling can be simulated together in TUFLOW rather than separately.

3.2 Digital Elevation Model (DEM)

The latest development site design DEM has been used. Minor modifications have been undertaken to correct identified DEM generated anomalies.

3.3 Durations and Temporal Patterns

A wide range of short and long rainfall durations were modelled to ensure peak flood elevations for the development site were captured. Durations modelled included 15 min, 30 min, 60 min, 120 min, 180 min, 360 min, 540 min, 720 min, 1,080 min, 1,440 min, 1,800 min, 2,160 min and 2,880 min. For each duration 10 temporal patterns were modelled.

3.4 Rainfall Data

Rainfall depths and temporal patterns have been sourced from the AR&R 2019 data hub and the Bureau of Meteorology (BOM). The design rainfall inputs adopted, used the coordinates below, which is the centroid of the modelling area:

- Latitude : -34.663200
- Longitude : 138.507350

3.5 Surface Materials and Manning’s n Value

The development site has several different surfaces and terrains to account for with the flood modelling. The surfaces have different loss and roughness coefficients (manning’s n value). To model this, the modelling area was classified based on the different land use that will be present with completion of the development site. The surface material classification assigned for the site are shown in Figure 2. The following surface material categories were used in the model:

- Saltwater lakes (standing water)
- Open channel, straight banks, and well-maintained channel
- Roads

- Park reserves, containing light shrub and tree planting and grass lands
- Lots, block of lands containing high density of impervious area such as roofs, concretes and it was assumed 70% of the area was impervious
- Water surface, which covers tall shrubs and average depth of flow

The Manning's n value used for the modelled land uses are presented in Table 1.

Table 1: Manning's n Value

LAND USE	MANNING'S N VALUE
Saltwater lakes	0.03
Park reserve	0.04
Open space/channel	0.03
Water surface	0.05
Lots	0.30
Roads	0.02

3.6 Water Loss Estimation

The initial and continuing loss method has been used for the modelling. The losses have been sourced from the AR&R 2019 data hub. The initial and continuing loss adopted was 29 mm and 4 mm/hr respectively. The initial loss has been adjusted to model the pre-burst rainfall. The pre-burst rainfall depths have been deducted from the initial losses.

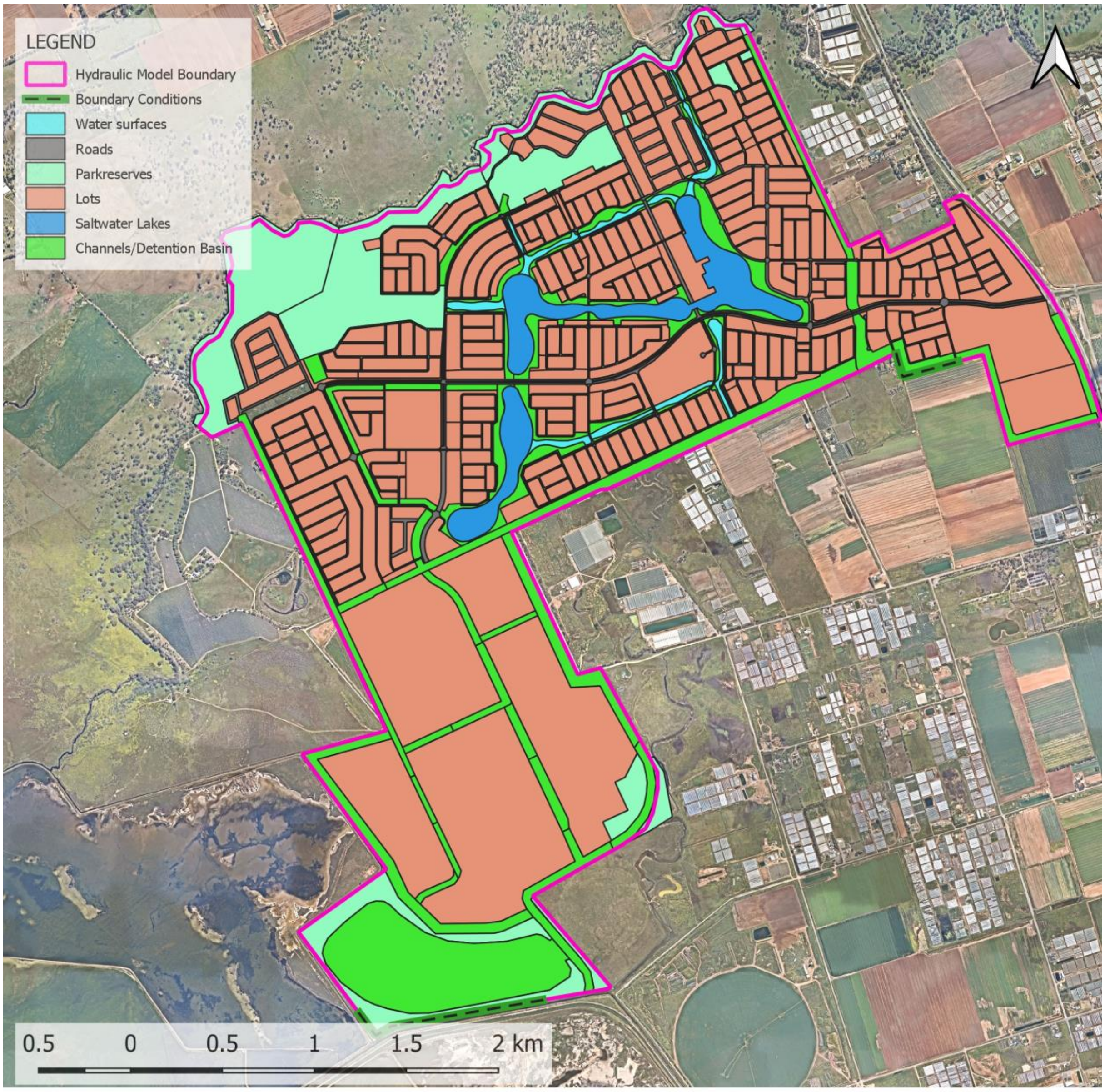


Figure 2: Materials/Land Use Classifications for Losses and Manning's n Value Assignment

3.7 Boundary Condition

The flow boundary conditions have been used for the locations where water flows out from the modelling area. HQ (head-discharge curve) type boundaries were modelled with 0.004, 0.003, and 0.38 slopes for three locations. The hydraulic boundary and flow boundary conditions are shown in Figure 3.

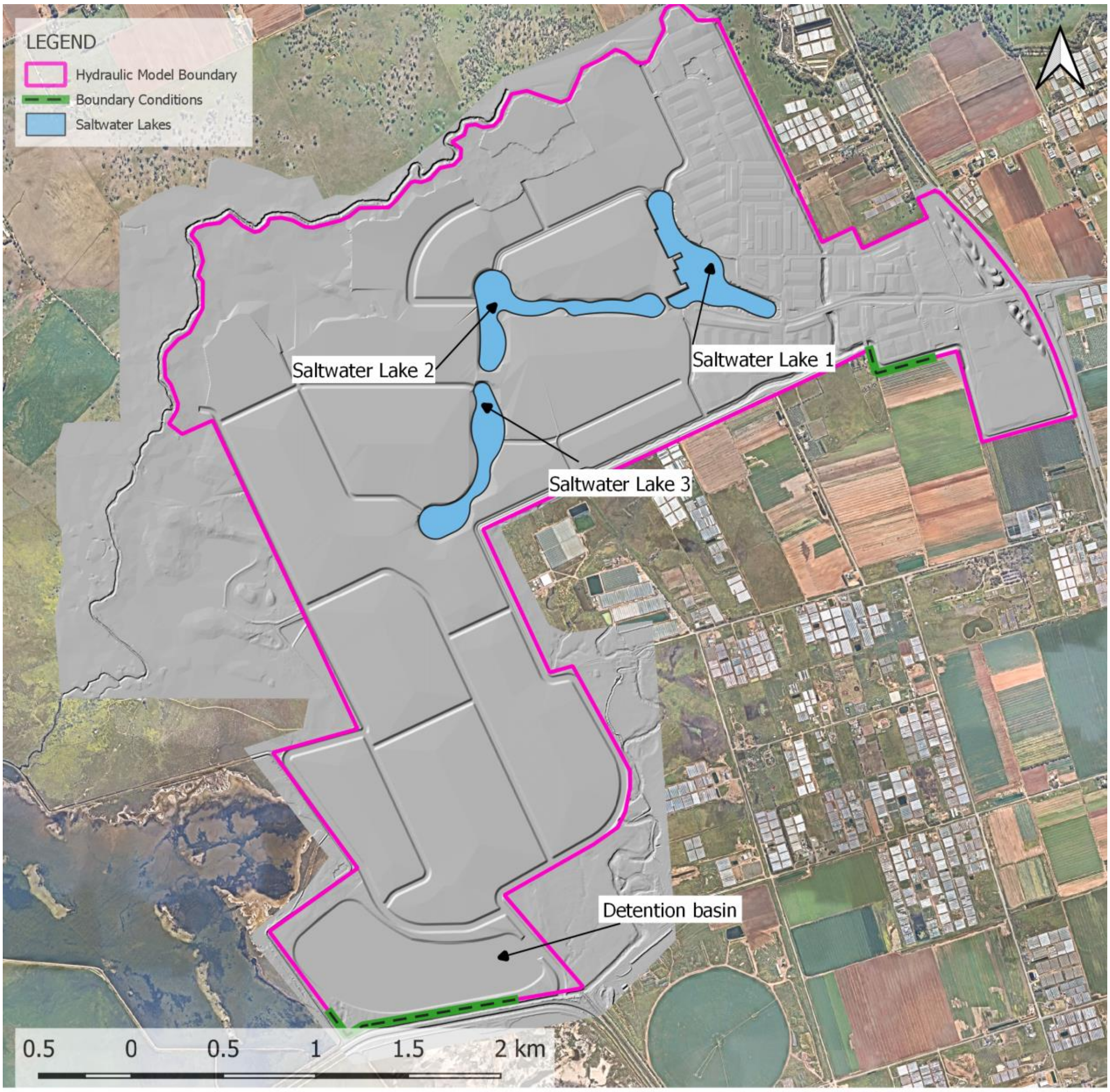


Figure 3: Model Boundary Conditions and Saltwater Lakes

3.8 Initial Water Level

For modelling the initial water level of the saltwater lakes and detention basin have been set to that which they will be normally maintained. The initial conditions applied were 4.0 m AHD for Lakes 1 and 2, 3.0 m AHD for Lake 3, and no water/empty for detention basin. The locations of the saltwater lakes and detention basin where the initial condition has been applied are shown in Figure 3.

3.9 1D System

The 1D system modelled for the site included the following water control and transfer elements:

- Saltwater lakes 1, 2, and 3 outlet pipes
- Detention basin outlet pipe
- Culverts in the Kapinka Parade, Riverlea BLVD and District Centre-Legoe Road

The location of the 1D system in the model is shown in Figure 4.

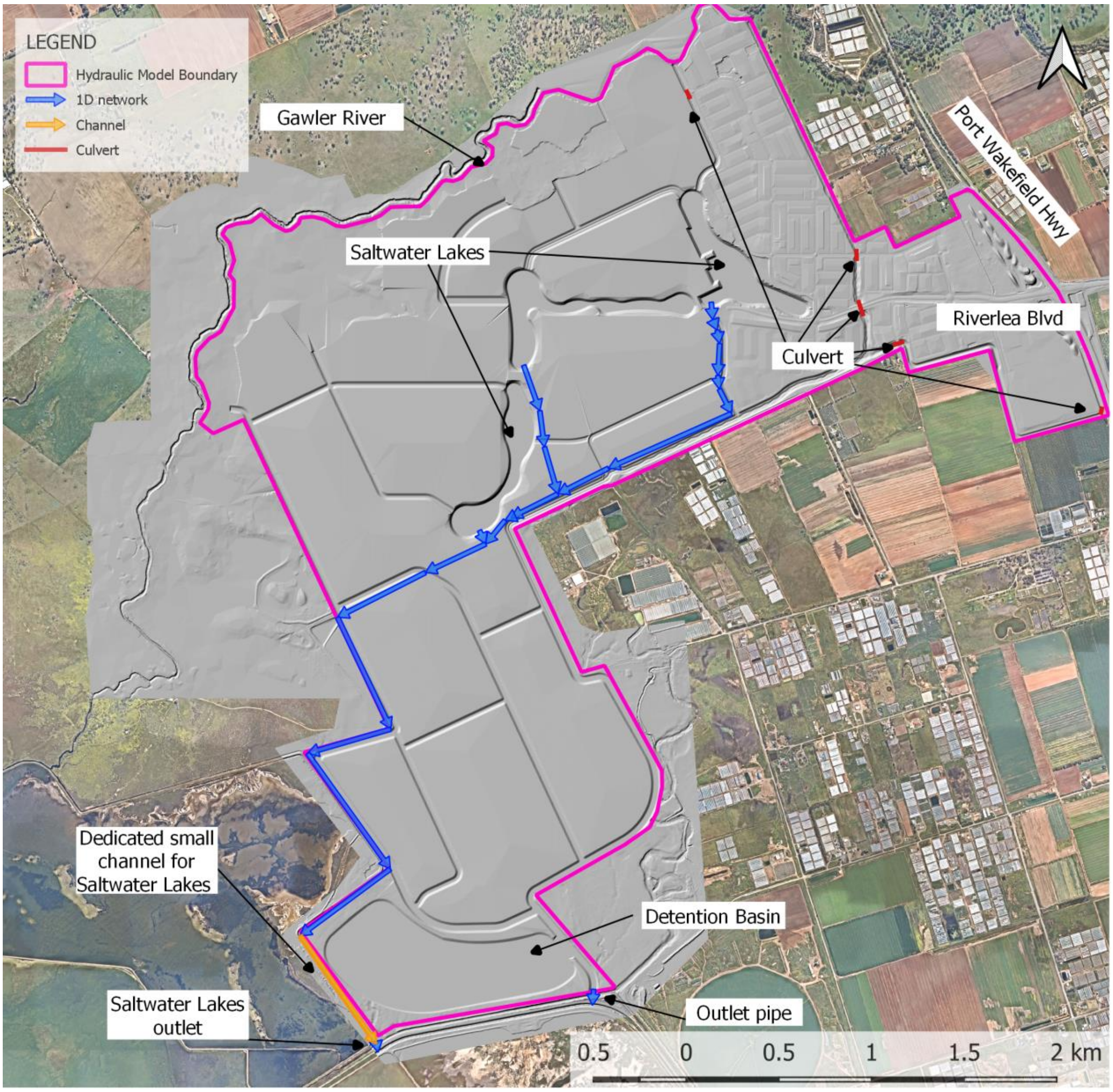


Figure 4: 1D System

3.10 Modelling Results

The modelling results were processed to extract median results from the temporal patterns and the maximum from durations. The flood depth and level maps for these median results were prepared, and are presented in Attachment A. Several cross-sections were prepared to show the peak water levels at key locations including the lakes, basin, and channels. The locations of the cross sections are shown in the Figure 5. The cross sections are provided in Attachment B.

The critical duration was identified for the key locations. Table 1 shows the critical duration for the lakes, channel, and basins.

Table 2: Critical Durations

CATCHMENTS	CRITICAL DURATION
Saltwater lake 1	24 hr
Saltwater lake 2	24 hr
Saltwater lake 3	24 hr
Detention basin	12 hr
Channels	Varies from 1 to 24 hr

The details of the results are discussed in the next sections:

3.10.1 Saltwater lake

The saltwater lakes 1 and 2 had a 4.0m AHD water elevation set as their normal condition (beginning of the modelling time) and reached a maximum 4.32m AHD with the flooding scenarios modelled. The freeboard for lakes 1 and 2 were 2.8m and 3.3m respectively.

The saltwater lake 3 had a 3.0m AHD water elevation set as the normal condition, and it reached maximum 4.32m AHD with the flooding scenarios modelled. It provided 1.3m freeboard to its crest elevation.

3.10.2 Basin

Several outlet pipe diameter sizes were checked for the basin to ensure the outlet was not exceeding the recommended maximum peak outflow of 10 m^3/s – resulting in eight 1.2 m diameter pipes being adopted. The maximum water elevation in the detention basin with this outlet size with the flooding scenarios modelled was 1.71m AHD with a water depth of 0.55m. This provides 780mm freeboard to its crest elevation. The water elevation peaks after 24 hours and is then expected be fully emptied after several hours.

The peak outflow from the basin to Thompson's Outfall Channel was 6.4m^3/s which is a result of the significant amount of stormwater attenuation provided by the lake and wetland system. This is less than the pre-development flow from the catchment which is estimated to be 10m^3/s and is primarily due to the storage available provided through the extensive open channel network.

3.10.3 Channel

The flood levels for the channels located at the northern side of the development site (upstream side) reached their peak with the shortest events. The channels at the southern side (downstream) reached their peak levels with the longer modelled storm duration events. The events vary from 1 to 24 hours. Freeboard for each of the channel cross sections are shown in Table 3. The freeboard varies from 1.1 m to 3.0m. No spill has been modelled to occur from any channel.

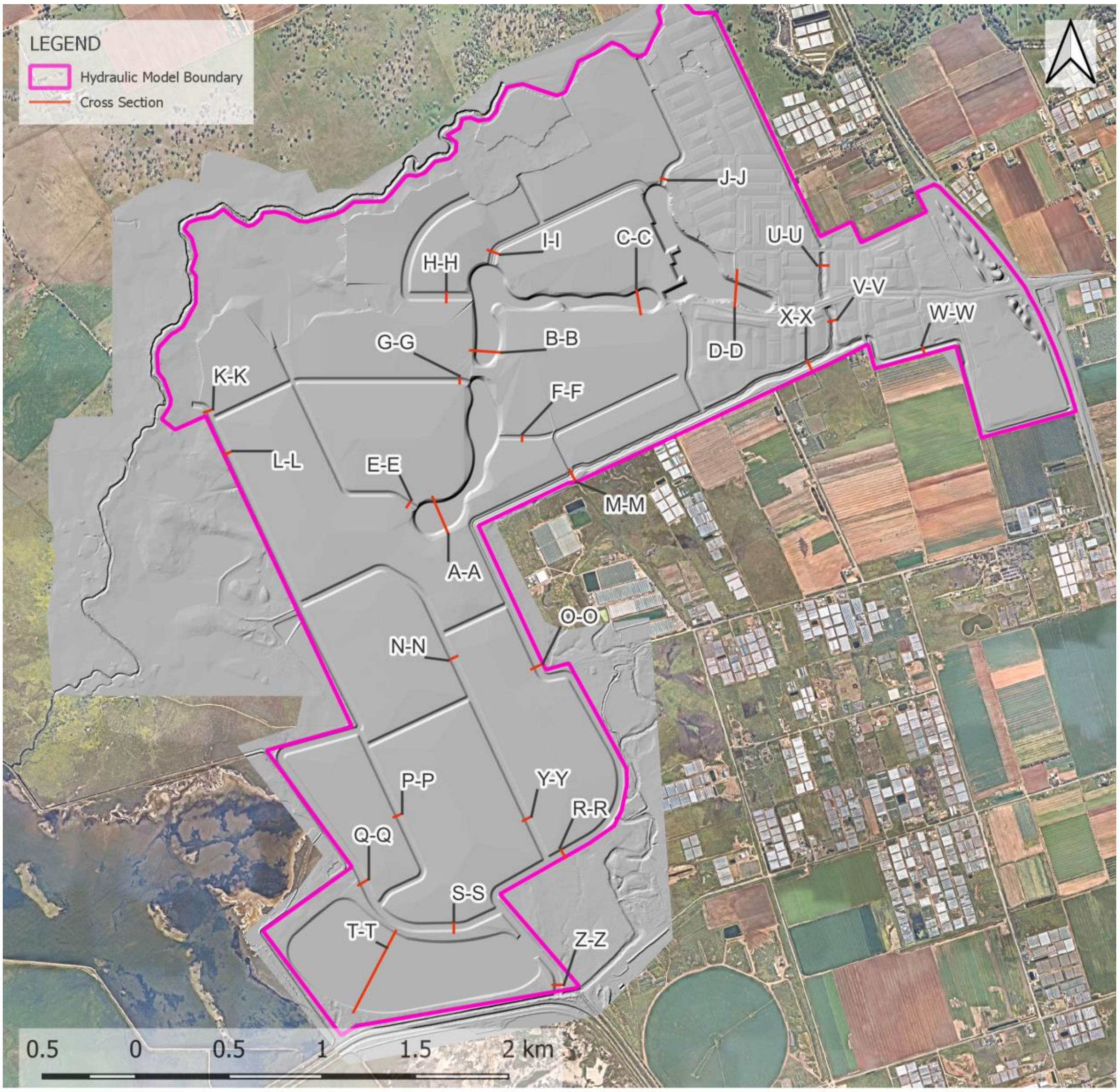


Figure 5: Cross Section Locations

Table 3: Freeboard for Each Cross Section

CROSS SECTION	FREE BOARD (m)	PEAK WATER LEVEL (mAHD)
A-A	1.32	4.32
B-B	1.37	4.32
C-C	1.25	4.32
D-D	3.40	4.32
E-E	1.35	4.32
F-F	1.13	4.32
G-G	1.40	4.32
H-H	2.34	4.40
I-I	2.03	4.82
J-J	2.99	5.49
K-K	2.22	3.46
L-L	2.25	3.39
M-M	1.74	3.83
N-N	2.14	2.75
O-O	1.06	2.56
P-P	2.15	2.33
Q-Q	2.05	2.09
R-R	1.77	2.11
S-S	1.42	1.97
T-T	0.78	1.75
U-U	2.33	5.76
V-V	2.29	5.18
W-W	2.86	6.69
X-X	2.40	4.51
Y-Y	2.01	2.11
Z-Z	1.09	1.71

4 CONCLUSIONS

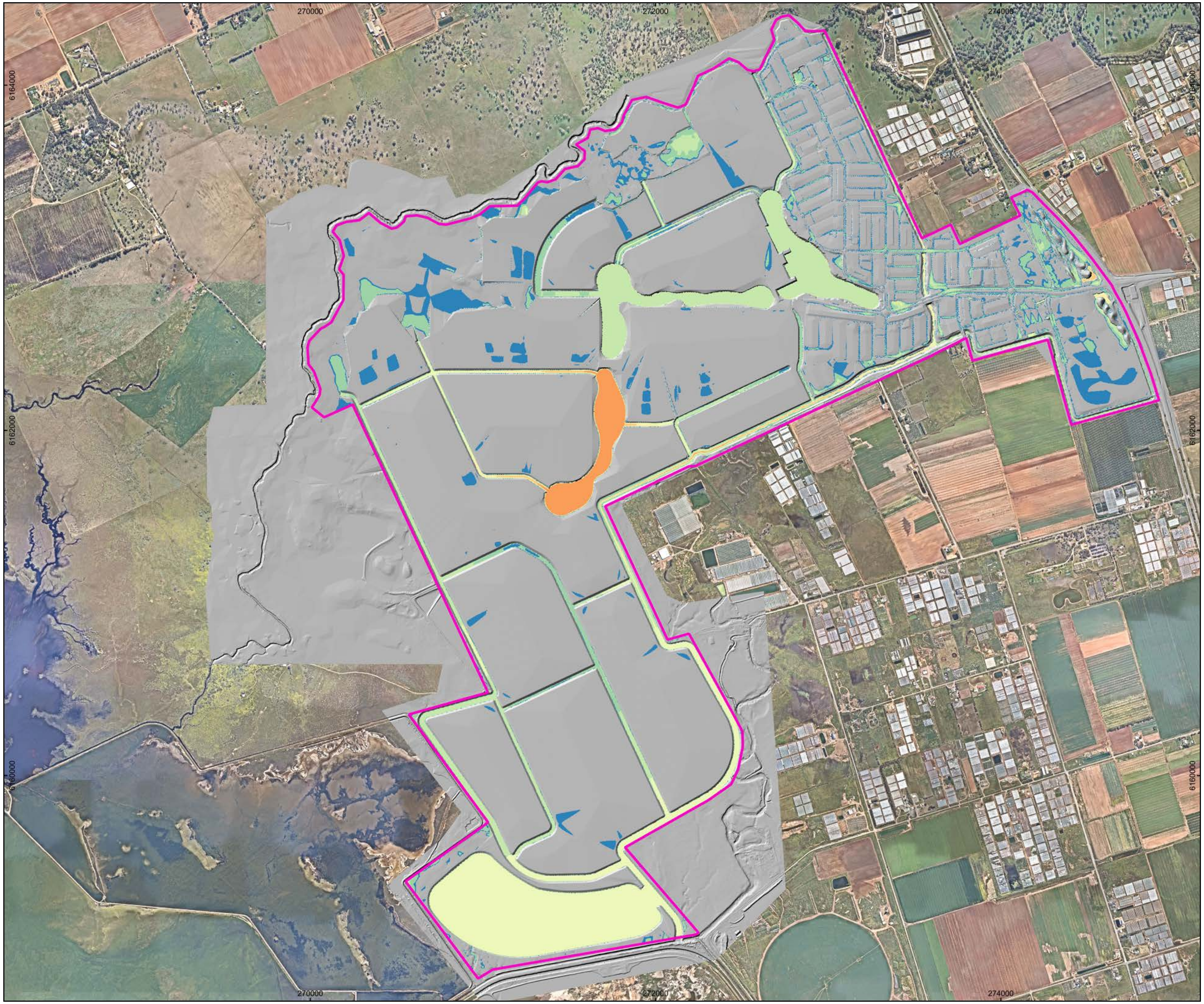
As part of the Riverlea development, a revised flood modelling assessment has been undertaken to account for modifications to the original development site configuration assessed in 2009. The current plans for the development site now include three saltwater lakes, channels, and a detention basin. The saltwater lakes contain saline water and any spills from the lakes may cause potential risks to the environment and adjacent infrastructure. The capacity of the saltwater lakes, detention basin and channel system were assessed in this report to ensure the system can contain 1% AEP storm event.

A 1D/2D TUFLOW model was developed in accordance with AR&R 2019 guideline for undertaking the flood assessment. The latest development site design surface has been used. A range of short to long rainfall durations have been modelled to ensure the peak flood levels were captured in the results.

The flood modelling results demonstrated:

- For the saltwater lakes, the 24-hour storm duration was the critical event. The freeboard for lakes 1, 2 and 3 were 2.8m, 3.3m and 1.3m AHD respectively. Therefore, they have sufficient capacity to contain the 1% AEP storm event.
- The detention basin reaches its peak elevation in a 12-hour event. If eight 1.2m diameter outlet pipe are used, the detention basins maximum water elevation is 1.71m AHD. For these conditions the basin will have 780mm of freeboard to its spillway elevation.
- For the channels, the critical storm event durations vary from 1 to 24 hours depending on the location of the channel. The channel freeboards vary from 0.8m to 3.4m. No spill event has been modelled to occur from any channel.
- The peak outflow to Thompson's Outfall Channel is approximately 6.4m^3/s compared to an estimated pre-development flow rate of 10m^3/s.

ATTACHMENT A
FLOOD MAPS



LEGEND

Hydraulic Model Boundary

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- 1.50 - 2.00
- > 2.00

200 0 200 400 600 800 m

Scale 1:21,000 on A3

Coordinate System: GDA 1994 MGA Zone 54

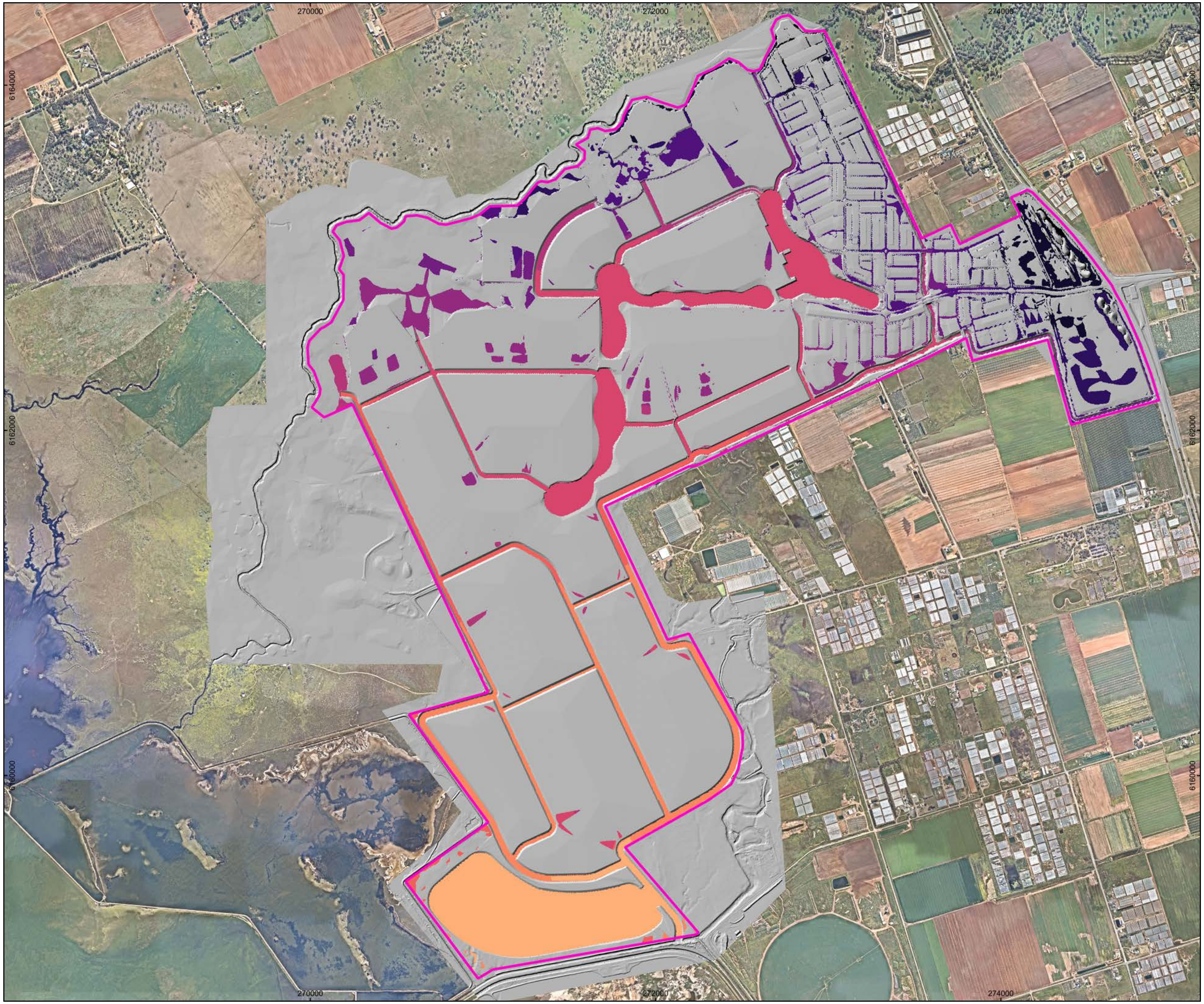
WGA

Map 01

Riverlea Development

Peak Flood Depth
1% AEP

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.



LEGEND

Hydraulic Model Boundary

Peak Flood Height (mAHD)

- <= 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 11.0
- > 11.0

200 0 200 400 600 800 m

Scale 1:21,000 on A3

Coordinate System: GDA 1994 MGA Zone 54

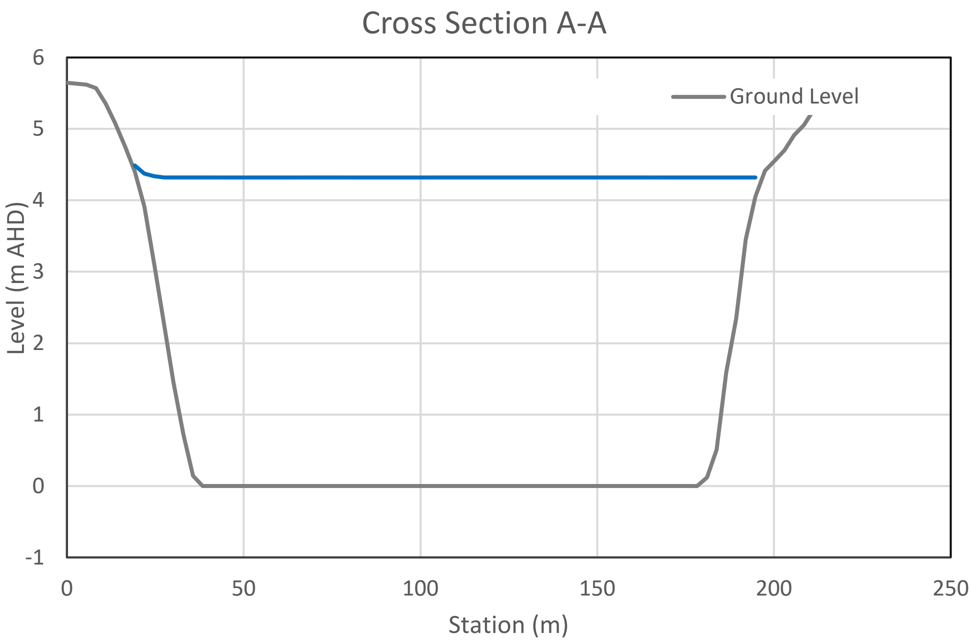
WGA

Map 02

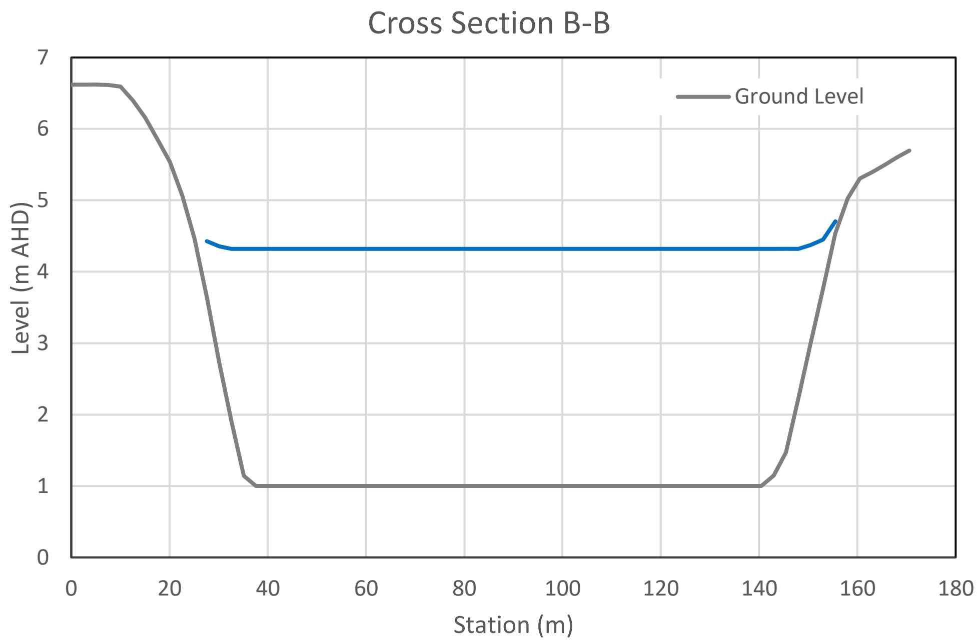
Riverlea Development

Peak Flood Height
1% AEP

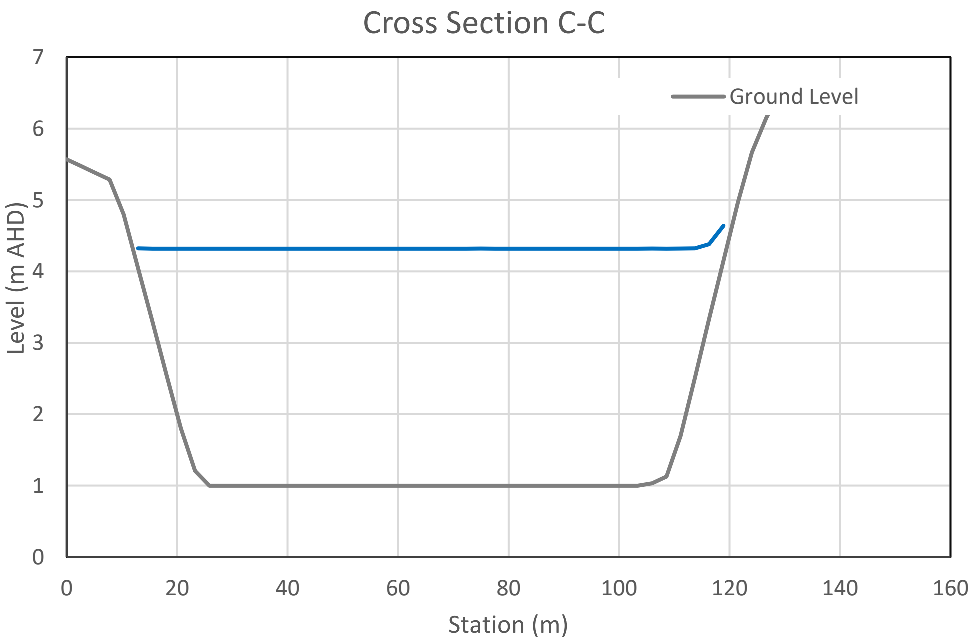
ATTACHMENT B
CROSS SECTIONS FOR PEAK FLOOD WATER LEVELS



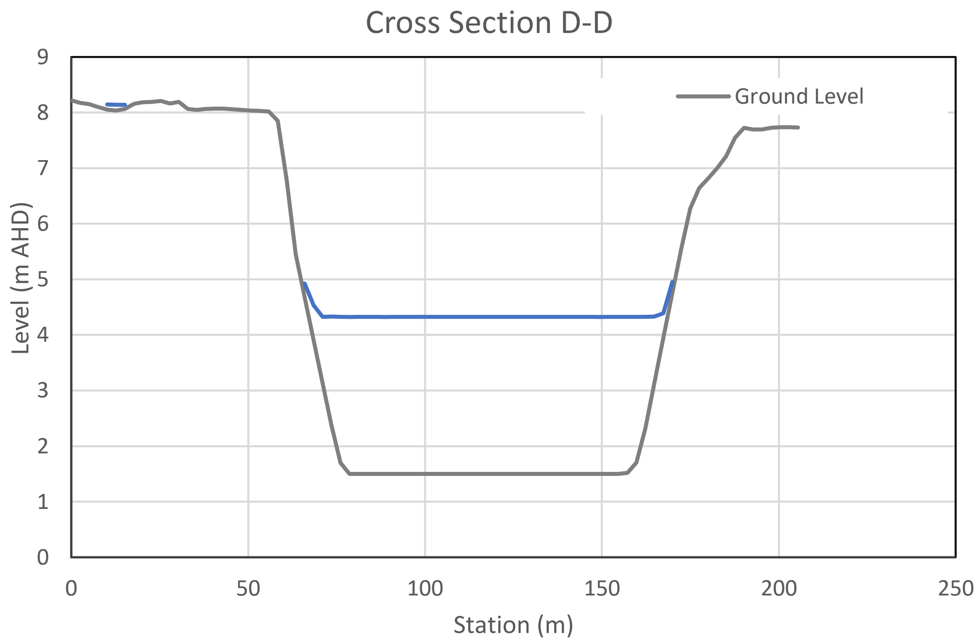
Cross Section A-A
Ground Level
Level (m AHD)
Station (m)
-1
0
1
2
3
4
5
6
0
50
100
150
200
250



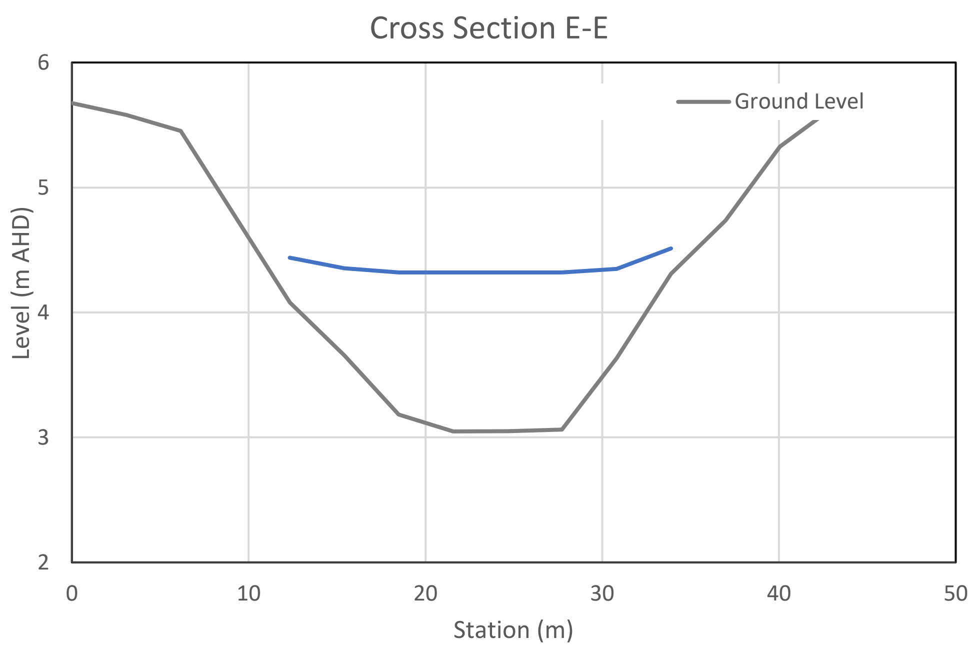
Cross Section B-B
Ground Level
Level (m AHD)
Station (m)
0
1
2
3
4
5
6
7
0
20
40
60
80
100
120
140
160
180

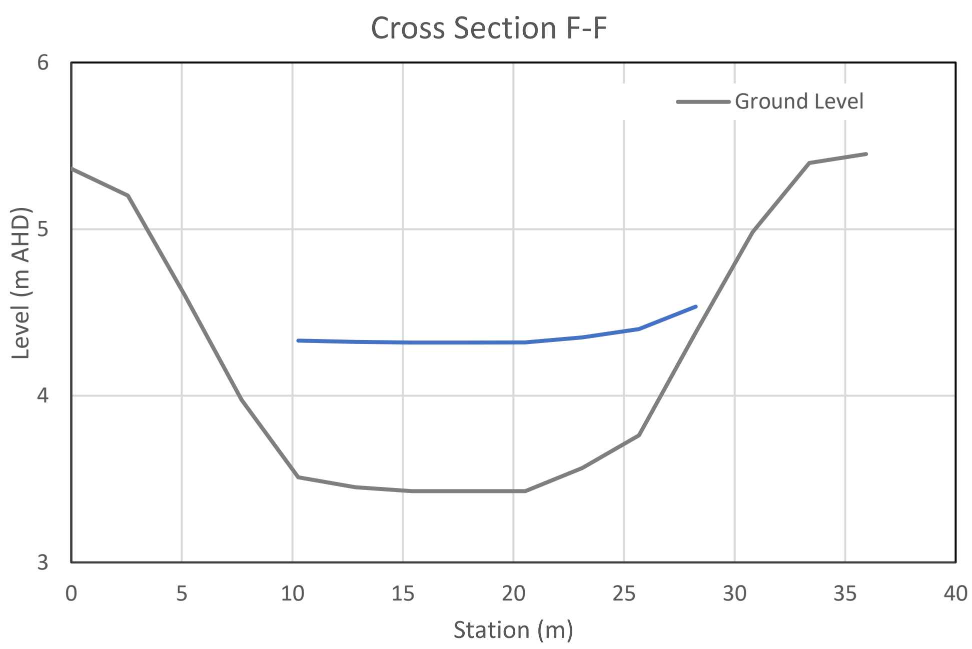


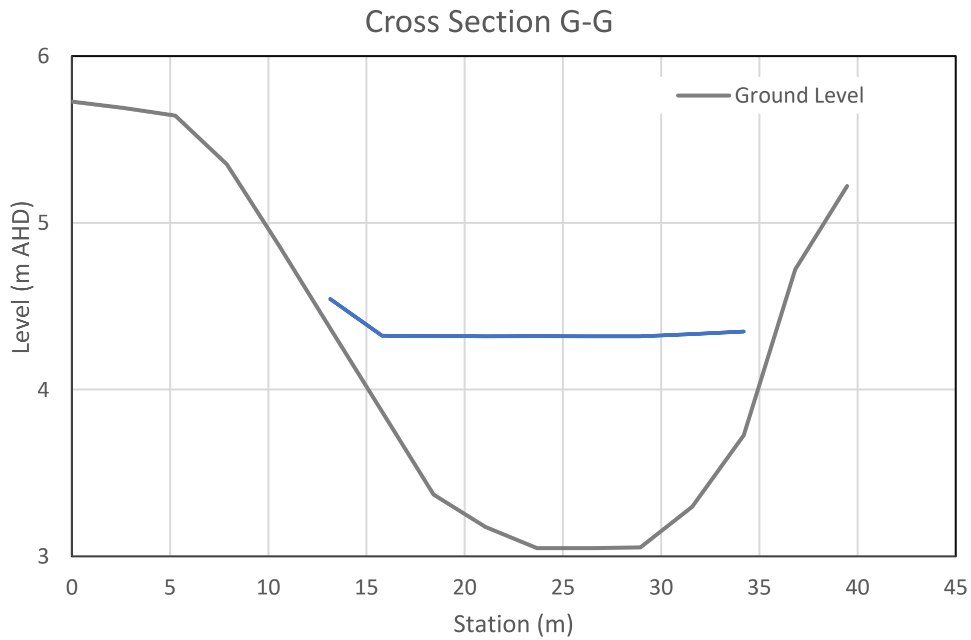
Cross Section C-C
Ground Level
Level (m AHD)
Station (m)
0
1
2
3
4
5
6
7
0
20
40
60
80
100
120
140
160

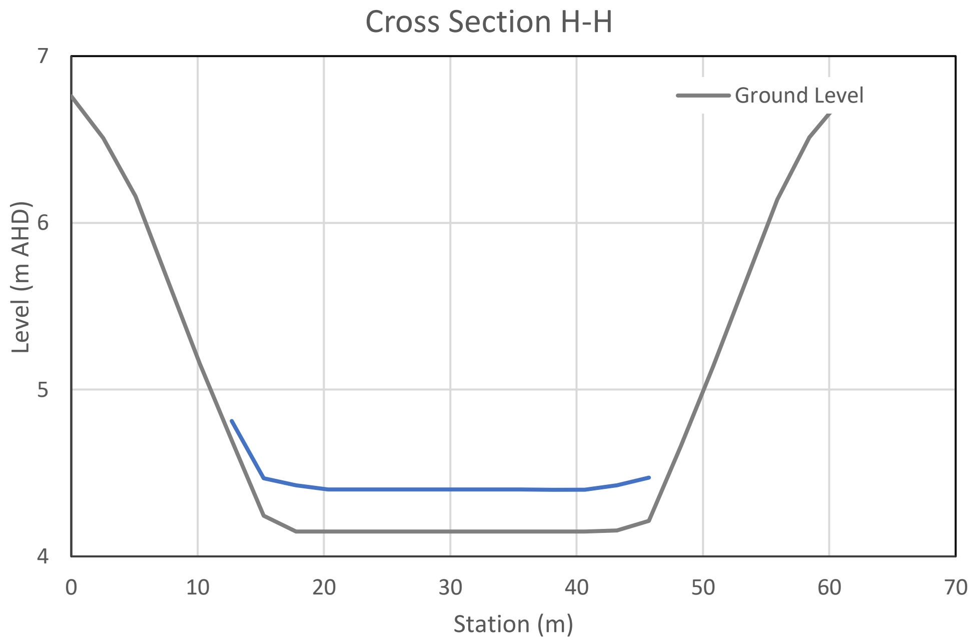


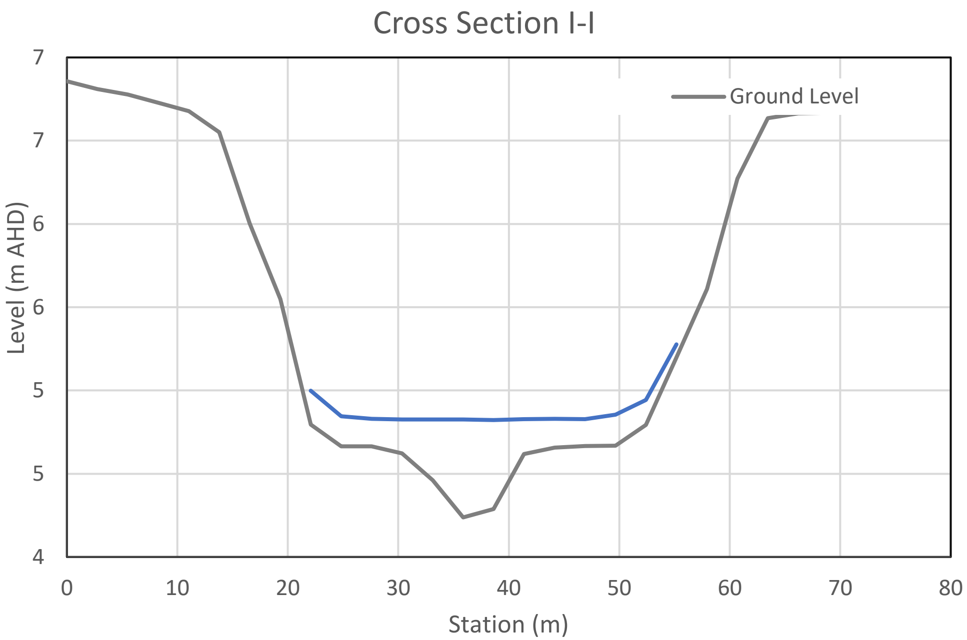
Cross Section D-D
Ground Level
Level (m AHD)
Station (m)
0
1
2
3
4
5
6
7
8
9
0
50
100
150
200
250

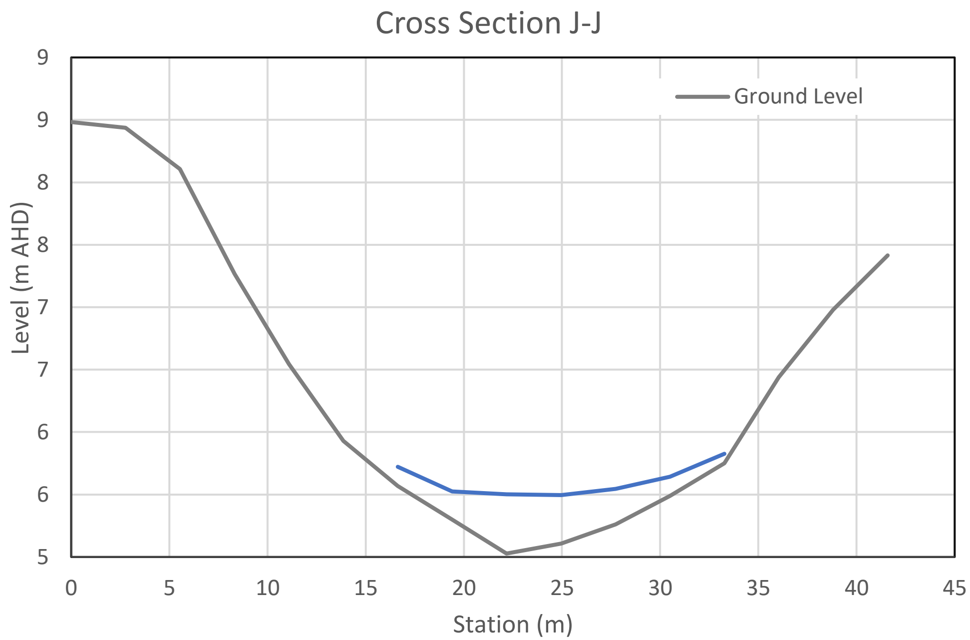

Cross Section E-E
Ground Level
Level (m AHD)
Station (m)
6
5
4
3
2
0
10
20
30
40
50

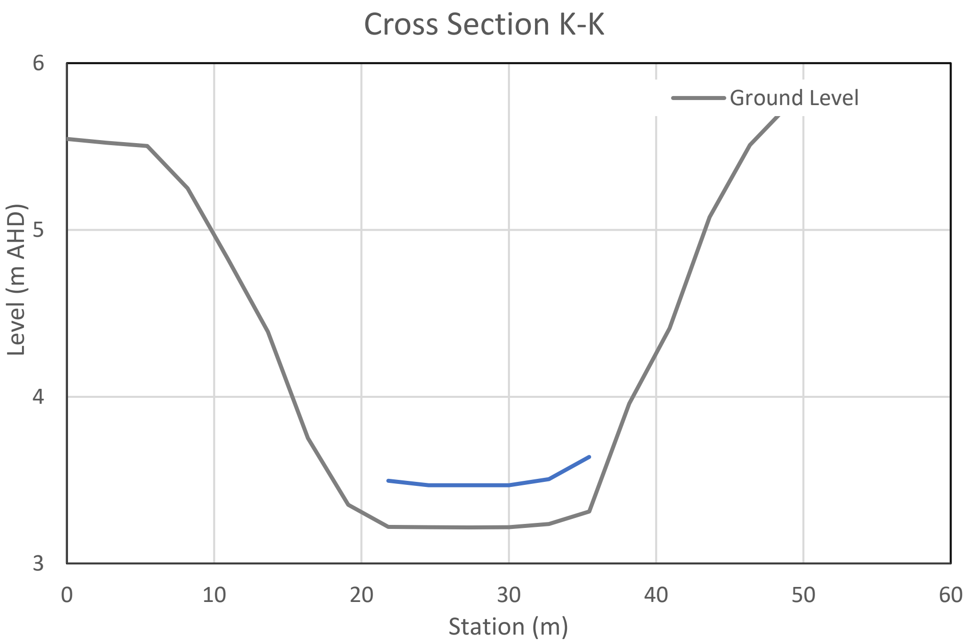

Cross Section F-F
Ground Level
Level (m AHD)
Station (m)
6
5
4
3
0
5
10
15
20
25
30
35
40

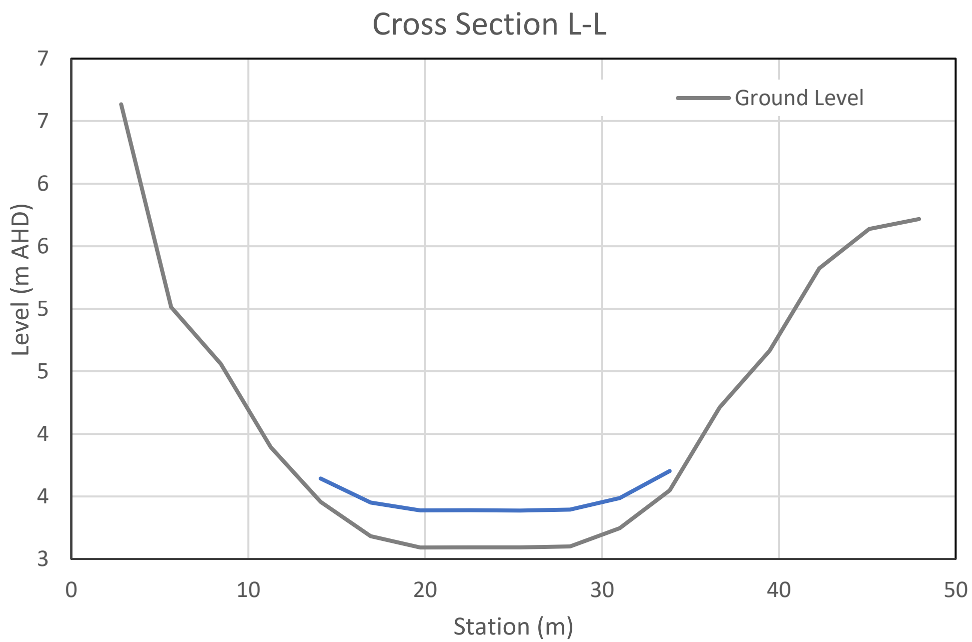

Cross Section G-G
Ground Level
Level (m AHD)
Station (m)
6
5
4
3
0
5
10
15
20
25
30
35
40
45

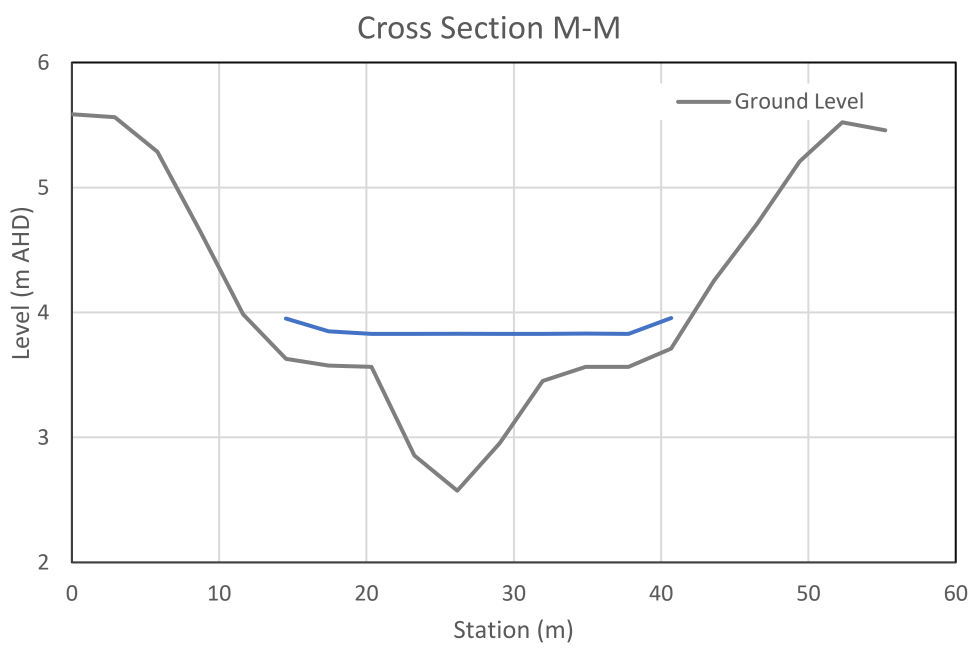

Cross Section H-H
Ground Level
Level (m AHD)
Station (m)
7
6
5
4
0
10
20
30
40
50
60
70

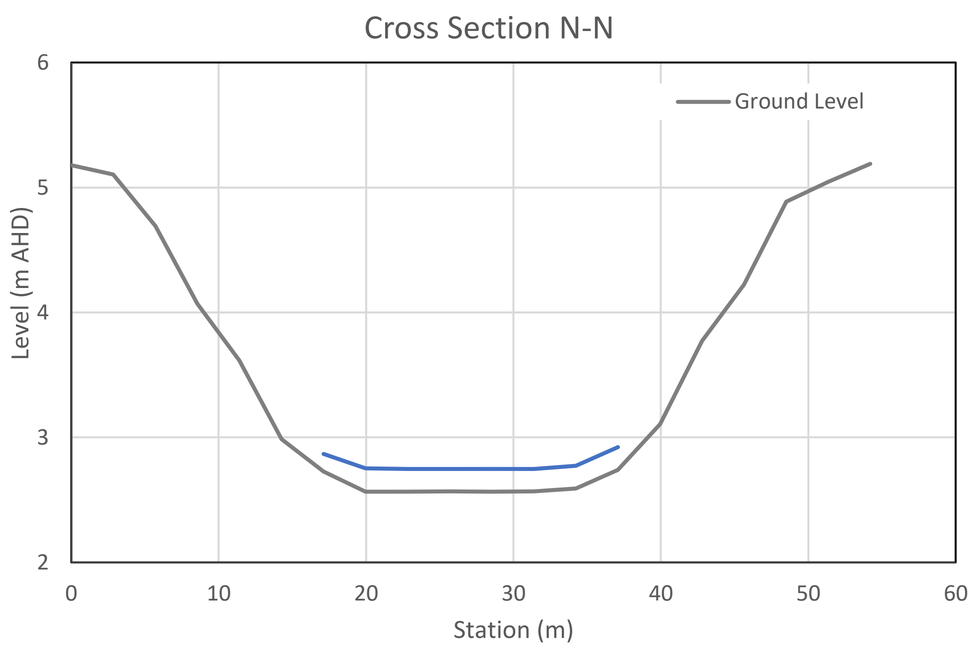

Cross Section I-I
Ground Level
Level (m AHD)
Station (m)
7
7
6
6
5
5
4
0
10
20
30
40
50
60
70
80

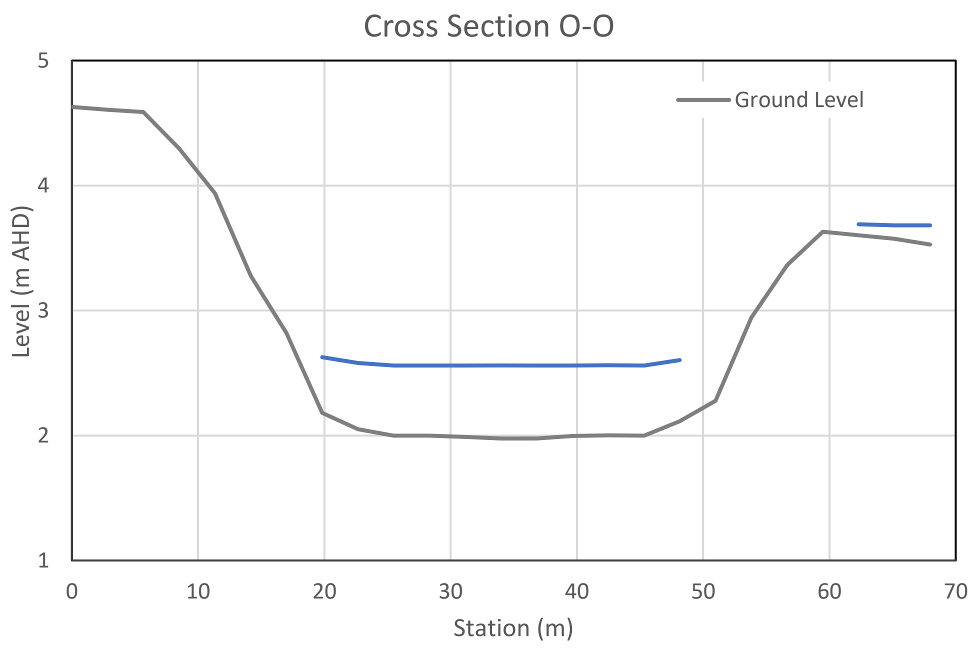

Cross Section J-J
Ground Level
Level (m AHD)
Station (m)
9
9
8
8
7
7
6
6
5
0
5
10
15
20
25
30
35
40
45

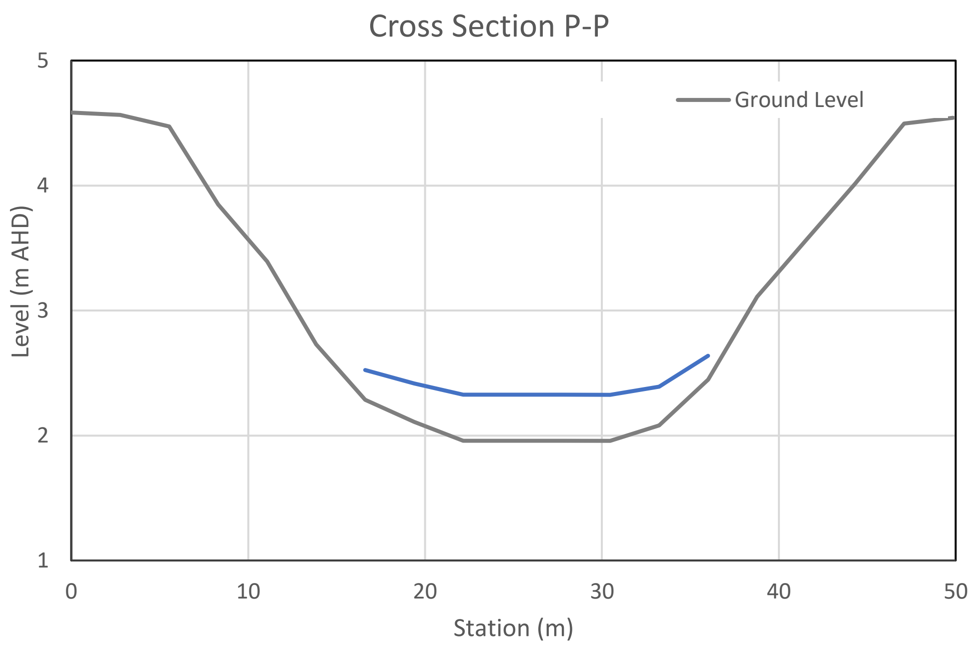

Cross Section K-K
Ground Level
Level (m AHD)
Station (m)
6
5
4
3
0
10
20
30
40
50
60

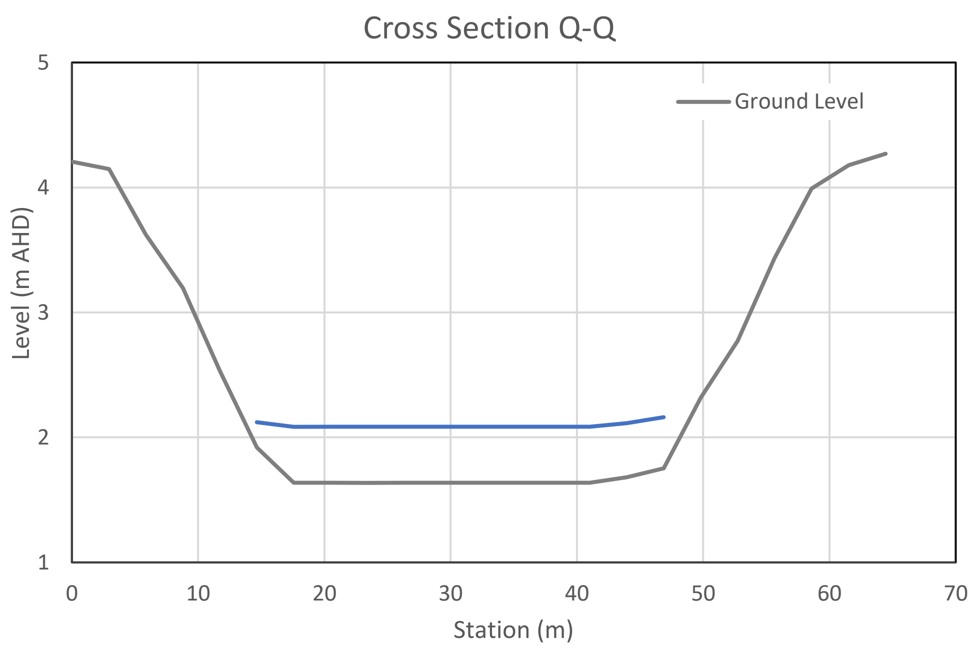

Cross Section L-L
Ground Level
Level (m AHD)
Station (m)
7
7
6
6
5
5
4
4
3
0
10
20
30
40
50

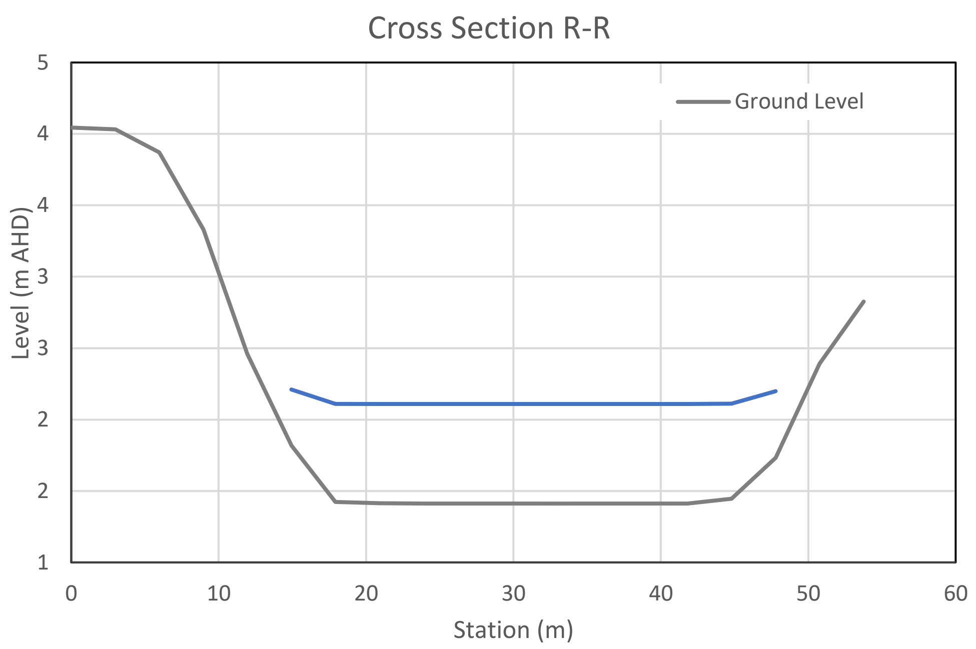

Cross Section M-M
Ground Level
Level (m AHD)
Station (m)
6
5
4
3
2
0
10
20
30
40
50
60

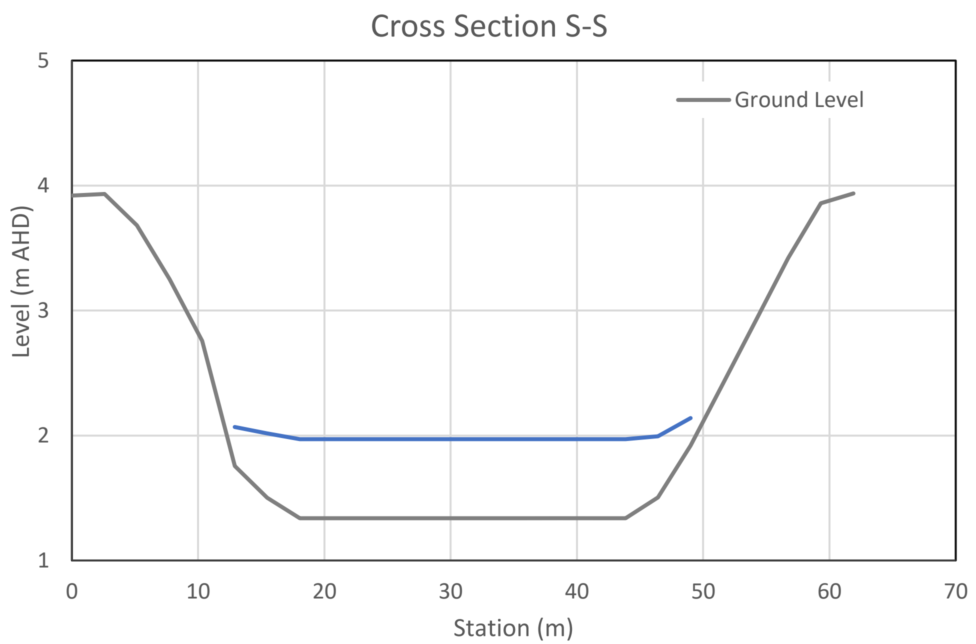

Cross Section N-N
Ground Level
Level (m AHD)
Station (m)
6
5
4
3
2
0
10
20
30
40
50
60

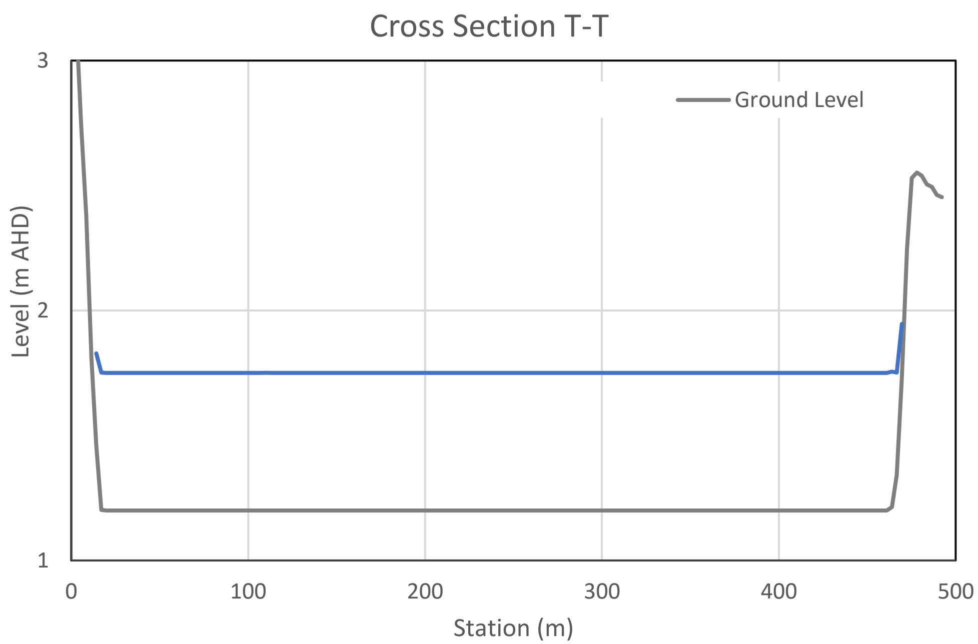

Cross Section O-O
Ground Level
Level (m AHD)
Station (m)
5
4
3
2
1
0
10
20
30
40
50
60
70

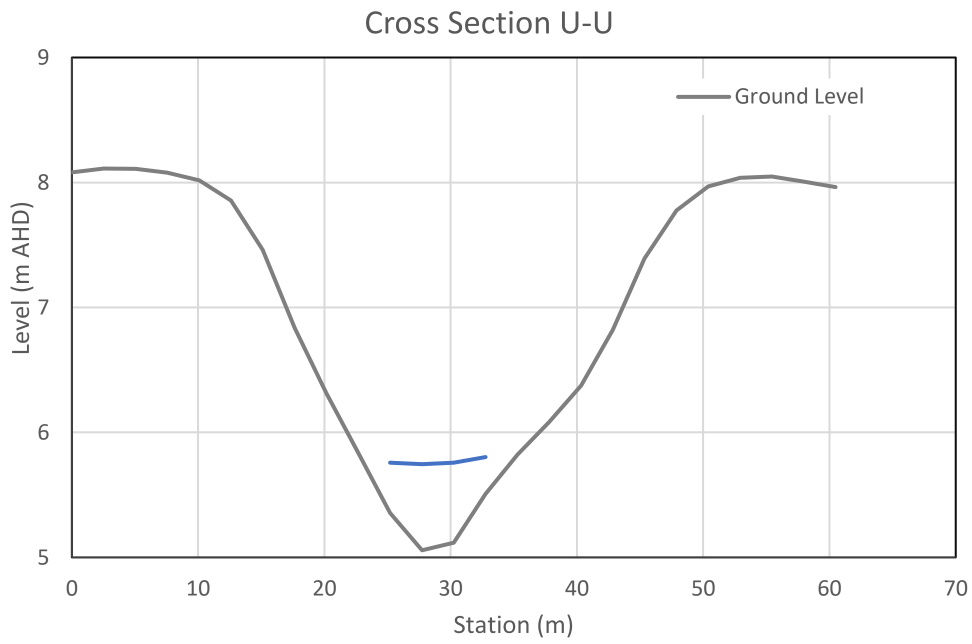

Cross Section P-P
Ground Level
Level (m AHD)
Station (m)
5
4
3
2
1
0
10
20
30
40
50

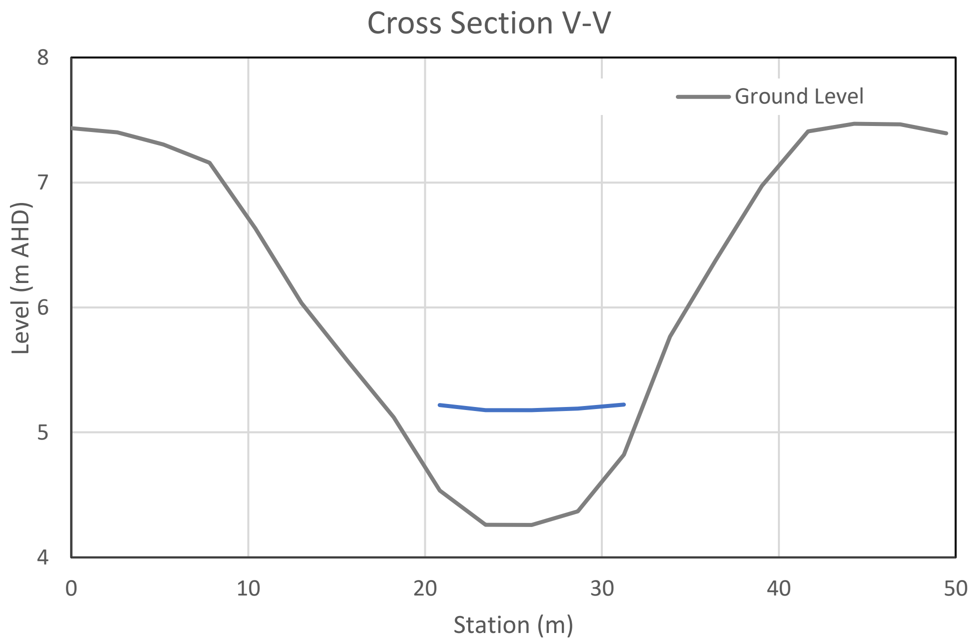

Cross Section Q-Q
Ground Level
Level (m AHD)
Station (m)
5
4
3
2
1
0
10
20
30
40
50
60
70

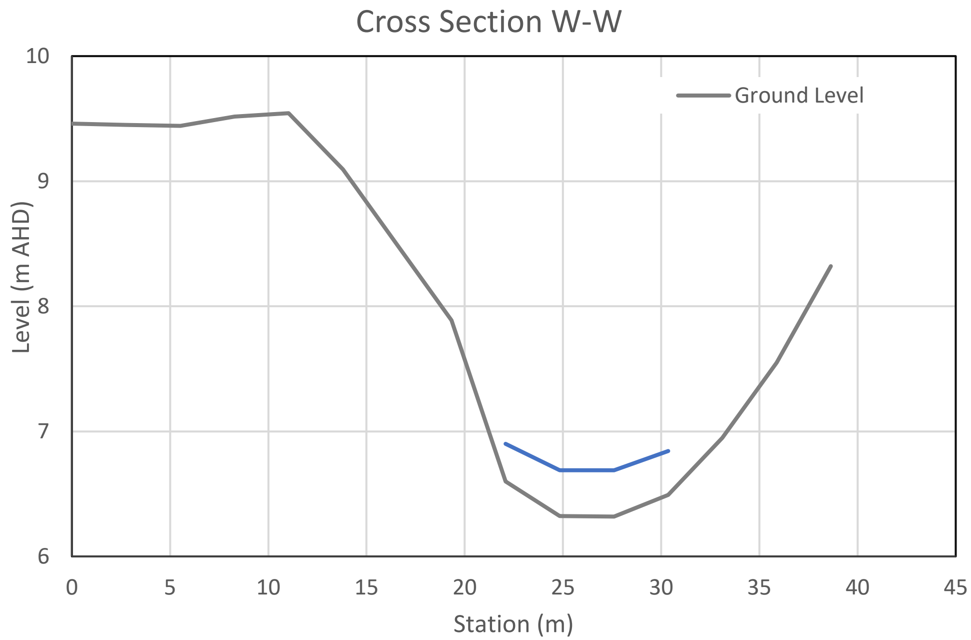

Cross Section R-R
Ground Level
Level (m AHD)
Station (m)
5
4
4
3
3
2
2
1
0
10
20
30
40
50
60

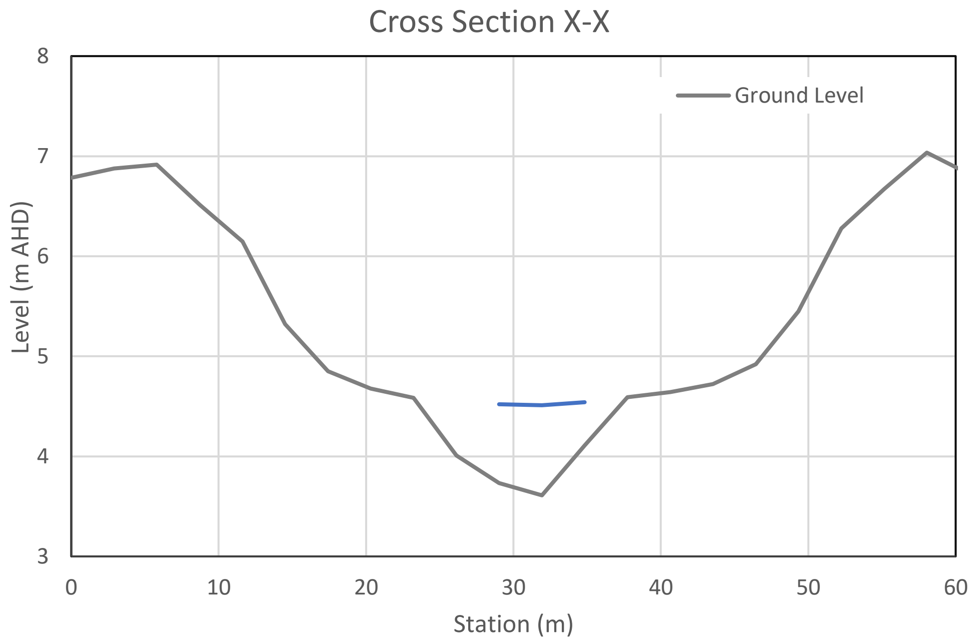

Cross Section S-S
Ground Level
Level (m AHD)
Station (m)
5
4
3
2
1
0
10
20
30
40
50
60
70

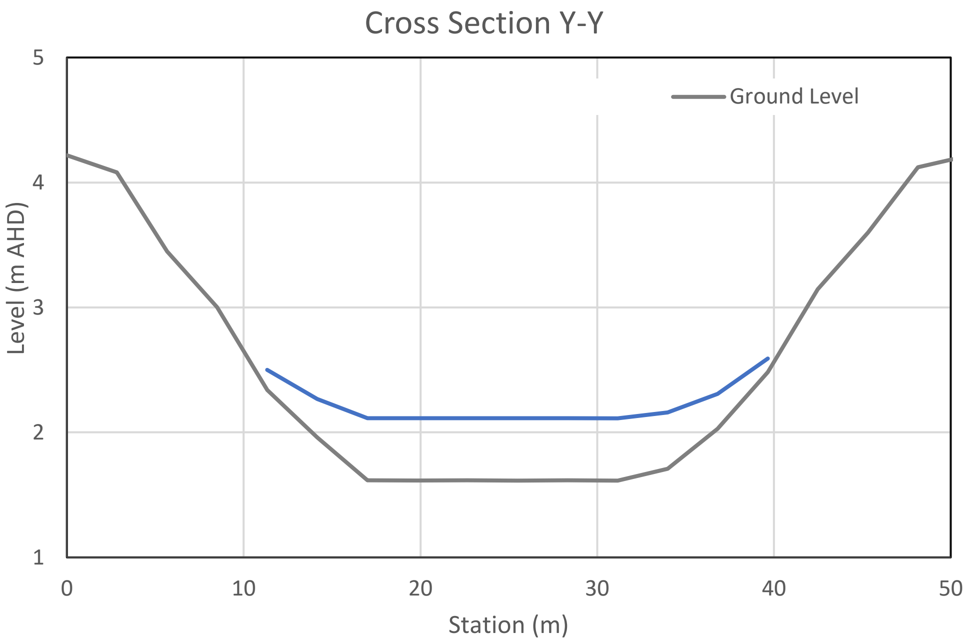

Cross Section T-T
Ground Level
Level (m AHD)
Station (m)
3
2
1
0
100
200
300
400
500


Cross Section U-U
Ground Level
Level (m AHD)
Station (m)
9
8
7
6
5
0
10
20
30
40
50
60
70

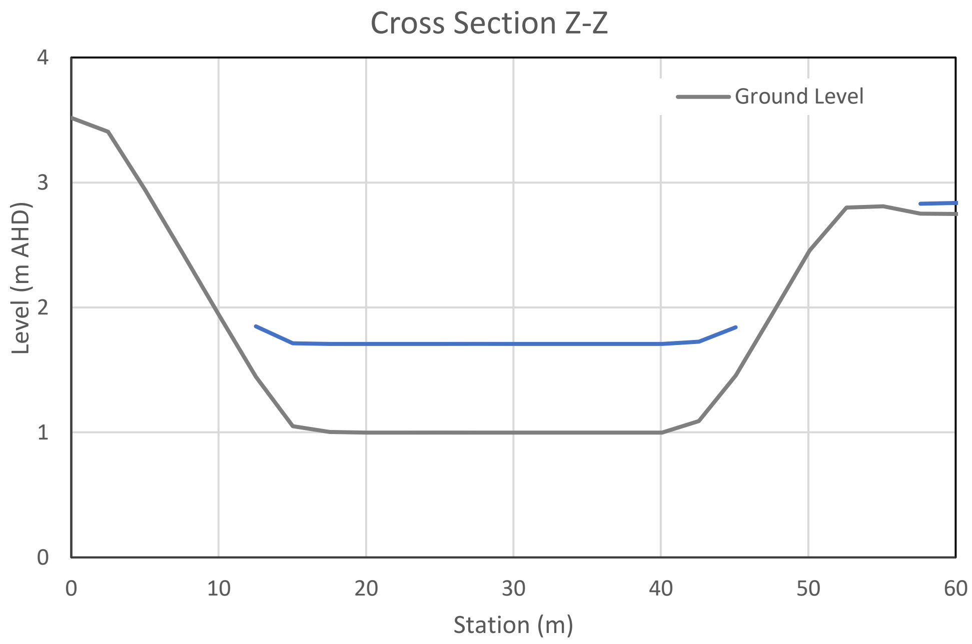

Cross Section V-V
Ground Level
Level (m AHD)
Station (m)
8
7
6
5
4
0
10
20
30
40
50


Cross Section W-W
Ground Level
Level (m AHD)
Station (m)
10
9
8
7
6
0
5
10
15
20
25
30
35
40
45


Cross Section X-X
Ground Level
Level (m AHD)
Station (m)
8
7
6
5
4
3
0
10
20
30
40
50
60



Cross Section Y-Y
Ground Level
Level (m AHD)
5
4
3
2
1
0
10
20
30
40
50
Station (m)



Cross Section Z-Z
Ground Level
Level (m AHD)
4
3
2
1
0
0
10
20
30
40
50
60
Station (m)

APPENDIX F
STORMWATER QUALITY MODELLING

Walker Corporation

Riverlea Park

2009 TECHNICAL PAPER UPDATE - STORMWATER QUALITY MODELLING

WGA080163

WGA080163-RP-CV-0012_C

30 November 2023

Revision History

REV	DATE	ISSUE	ORIGINATOR	CHECKER	APPROVER
A	17.11.2022	Update to 2009 technical paper	SA	JL	DB
B	14.04.2023	Amendments based on EPA and DEW feedback	JL	JL	DB
C	30.11.2023	Amendments based on latest Master Plan (11.2023)	SA	JL	DB

CONTENTS

Figures

Tables

1 INTRODUCTION AND BACKGROUND

This stormwater treatment quality assessment has been undertaken to update the master plan level stormwater quality treatment analysis performed in the technical paper titled Stormwater Management Water, Wastewater and Recycled Water prepared by WGA (2009) (then W&G).

Since the 2009 Technical Paper, the Proposed Revised Riverlea Master plan (December 2021) now includes internal salt water lakes system (SWL) which integrate with the local trunk stormwater drainage channels in place of the original open drain system. The revised landform proposal now includes 40.4 ha of linked saline lakes centrally located within the development. This proposed salt water lakes (SWL) also provide an alternative to manage the breakout of the regional Gawler River floodwaters through the site. The concept plan is shown in Figure 1.

Figure 1 : Proposed Riverlea Master Plan (October 2023)

1.1 Objectives and Water Quality Criteria

The objective of this stormwater quality assessment is to evaluate the treatment performance of the proposed/revised systems within Riverlea Estate against the required standards at a master plan level.

The proposed stormwater treatment system was designed to treat the runoff in accordance with the standards as defined by:

- The South Australian EPA water quality policy WSUD targets.
- WSUD pollutant reduction targets as defined in the WSUD Guidelines for the Greater Adelaide Region (2013).
- Adopts to the framework principles of the ANZEC guidelines (2000) with regards to adopting a treatment train approach to minimise harm to downstream waters.

The pollutant treatment performance targets as specified in the above guidelines are:

- 80% retention of typical annual urban load of suspended solids (TSS)
- 60% retention of typical annual urban load of total phosphorus (TP)
- 45% retention of typical annual urban load of total nitrogen (TN)
- 90% reduction of gross pollutants of typical urban load (GP)

In addition to the above targets for the site as a whole, it was also aimed to achieve the treatment performance targets prior to the discharge point into the Salt Water Lakes (SWL). The basis of this is that the SWLs can be negatively impacted by poor quality stormwater inflows from the local urban catchments as described by BMT (2021) in Riverlea Concept Stormwater Quality Management Plan.

1.2 Treatment Catchment Plan

The treatment catchment plan described below was developed for a master plan level assessment. Therefore, the sizes and placement of proposed Water Sensitive Urban Design (WSUD) assets are not at a detailed design accuracy, and the details of these assets are to be further assessed in the detailed precinct level as part of the detailed design documentation. It is therefore important to note that this report presents this at a strategic functional level.

The internal catchments and flow directions used in the catchment plan were based on the concept earthwork model for the Master Plan (October 2023). The locations and treatment catchments of the WSUD assets were also based on the proposed master plan and the concept earthwork model. The catchments and the WSUD assets as used in the MUSIC model are shown in Figure 2.

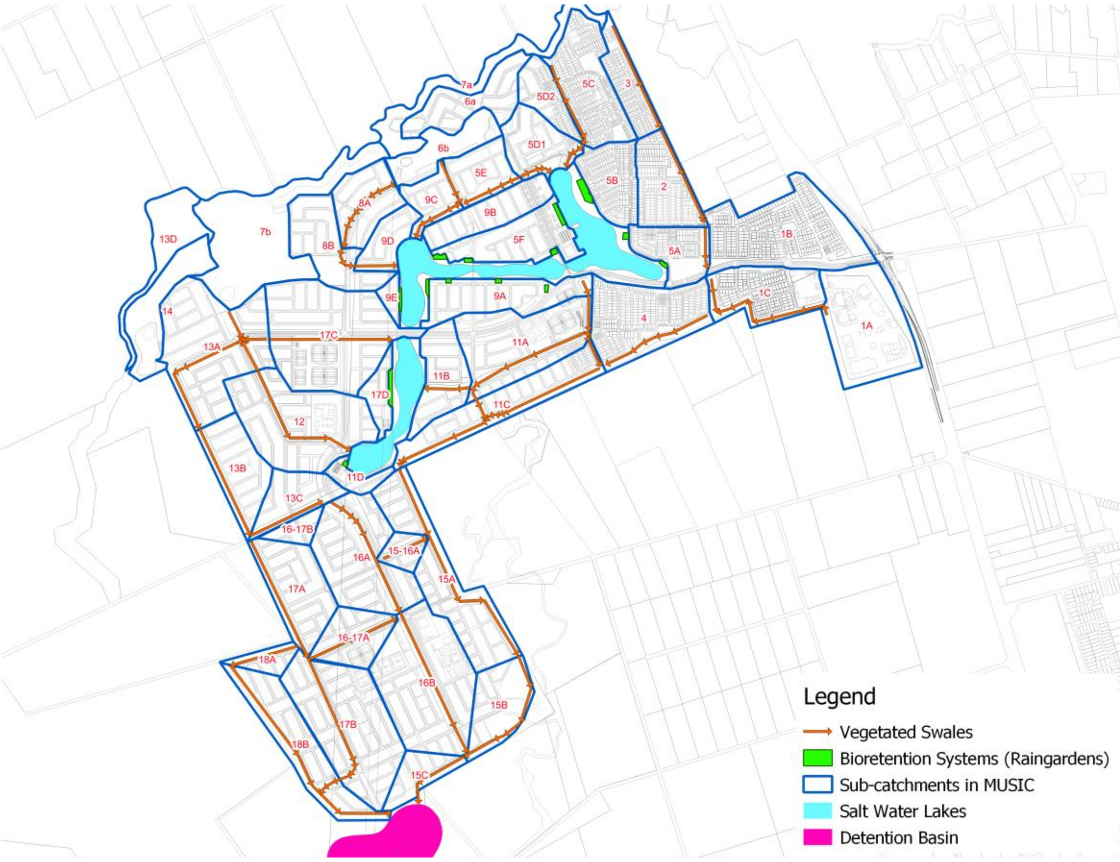


Figure 2 : MUSIC Model Catchment Plan and WSUD Assets Locations With Indicative Proposed Layouts

1.2.1 Treatment Assets

The following stormwater treatment assets are considered in the revised master plan based on the site layout, constraints, and opportunities.

Gross Pollutant Traps (GPTs)

It is proposed to incorporate a Gross Pollutant Trap (GPTs) at each major outlet into the vegetated swale or the regional channels These GPTs are to provide an effective means of removing debris and coarse sediments before discharging into the downstream system. GPT's form the first line of defence to intercept primary gross pollutants. A high performing GPT using CDS technology has been adopted throughout the development that achieves a high level of pollutant trapping performance. This type of GPT has been universally accepted by Council through other correspondence outside of this report.

Vegetated Swales/Regional Channels

A system of regional channels has been proposed throughout the Riverlea Park Development in order to manage and convey breakout flows from Gawler River for long duration flooding events in addition to managing stormwater outflows from the development during short duration events. The regional channel network will protect the development from flooding both regional and localised flood events. The basis on which the channels were designed and are based on the flood modelling undertaken by Water Technology (formerly Australian Water Environments).

The basis of this strategy follows those that have been approved and implemented in the Precinct 1's Stormwater Management Plan by WGA (2022). Therefore, this has been adopted as the base design for the entire regional channels across the development. The proposed regional drainage channels include a series of online ephemeral wetland pools integrated into the low flow channels. These pools are densely vegetated shallow water bodies with 200 to 300 mm depth that provide treatment of urban stormwater from the development. Their treatment function provides enhanced sedimentation, fine filtration, adhesion and biological uptake, and chemical processes to remove pollutants from urban stormwater. Given that the channel network is quite long in length, therefore with suitable residence times, and this provides extensive opportunity for stormwater to be treated. The details of these ephemeral wetland treatment pools are described in "Riverlea Development – Stages 1 to 12: Stormwater Management Plan (WGA, 2022)".

Bioretention Basins

Bioretention systems are proposed for the local catchments which drains directly into the SWL where these are not released via the linear vegetated swale / channel systems. The densely planted bioretention systems at the downstream discharge point of the urban catchments will treat the stormwater runoffs before discharging into the SWLs.

In this Master Plan level assessment, the filter areas of the bioretention systems are sized for 2% of their contributing catchments. These bioretention systems are typically full depth with entire system perimeter fully lined with an impermeable material, and will include a saturation zone to improve plant health and sustaibility of the system during drier periods.

For the vegetation types in the bioretention, it was tested to model with both "Vegetated with effective nutrient removal plants" and "Vegetated with ineffective nutrient removal plants". It was found that some catchments will require effective nutrient removal plants to meet the required treatment criteria. If this cannot be met, larger areas of bioretention will be required to treat the stormwater to the treatment criteria. Therefore, the planting pallet will be based on selecting Nitrogen effective plant species that will be suitable for the local climatic characteristics.

An alternative to using the bioretention system is to adopt ephemeral wetland pond systems. This option can be explored with Council at a more detailed conceptual level. For the purposes of this strategy report, the bioretention systems have been considered.

The ephemeral wetland pond system would adopt the following approaches and benefits, and will also ensure stormwater treatment targets are met accordingly:

- Surface area based on 5 to 6% of catchment impervious area.
- Capacity to detain a runoff volume of runoff from the urban catchment of up to 20mm rainfall event, with 72hour residence time to provide treatment.
- The ponds will drain completely to the SWL via a controlled low flow discharge and therefore will not incorporate permanent pools.
- Exhibit strong envirnemtnal values with biodiversity plantings.
- Robust and sustainable system adaptable to climate change.

It is also noted that the bioretention systems will equally incorporate the above inherent performance characteristics, however the ephemeral wetlands will provide a lower ongoing maintenance regime over the asset life.

MUSIC Model Setup

The assessment of the water quality uses performed using the industry accepted modelling software MUSIC (Version 6.3) to demonstrate compliance with pollutant reduction targets in accordance with South Australian MUSIC Guidelines (2021).

The parameters entered into MUSIC model for the source and treatment nodes are summarised in Table 1. The table provides a general overview of the typical parameters used for the source and treatment nodes. In this case, it is noted that some parameters are stated as being "varied", this is due to the variable dimensional characteristics associated with the different WSUD assets within the development. The MUSIC model therefore adopts the actual dimension. The source nodes are represented by "urban nodes", and the treatment nodes are represented by GPTs, vegetated swales and bioretention. Figure 3 shows the MUSIC model schematic developed based on the treatment catchment plan and the parameters.

Table 1: MUSIC Parameters

MUSIC INPUT PARAMETER	UNITS	VALUE	NOTES	REFERENCE
Rainfall Time Step	Minutes	6	–	South Australian MUSIC Guidelines 2021
Rainfall Template	31 Year Period	Edinburgh RAAF		
Catchment Characteristics (Source Nodes)				
Source Node Type - Urban (Mixed)	%	–	Fraction impervious values vary from nodes to nodes	
Soil Parameters (Residential areas)				
Soil Storage Capacity	mm	40		South Australian MUSIC Guidelines 2021
Initial Storage (% of capacity)	%	25	–	MUSIC Default value
Field Store Capacity	mm	30		South Australian MUSIC Guidelines 2021
Pollutant Concentration Data (Residential areas)				
TSS Mean Storm Flow Concentration	log mg/L	1	Lumped Catchments	South Australian MUSIC Guidelines 2021, Table 4.10
TSS SD Storm Flow Concentration	log mg/L	0.34	Lumped Catchments	South Australian MUSIC Guidelines 2021, Table 4.10
TP Mean Storm Flow Concentration	log mg/L	-0.97	Lumped Catchments	South Australian MUSIC Guidelines 2021, Table 4.10
TP SD Storm Flow Concentration	log mg/L	0.31	Lumped Catchments	South Australian MUSIC Guidelines 2021, Table 4.10
Pollutant Concentration Data				
TN Mean Storm Flow Concentration	log mg/L	0.2	–	South Australian MUSIC Guidelines 2021, Table 4.10
TN SD Storm Flow Concentration	log mg/L	0.2	–	South Australian MUSIC Guidelines 2021, Table 4.10
Serial Correlation For TSS, TP, TN	R Squared	0	–	South Australian MUSIC Guidelines 2021, Table 4.10
Estimation Method	–	Stochastically Generated	–	South Australian MUSIC Guidelines 2021, Table 4.10
Bioretention Design Inputs				
High Flow By-pass	m^3/s	100	–	
Extended Detention Depth	m	0.2	–	
Surface Area	m^2	Varied	–	
Filter Area	m^2	Varied	(Sized up to 2% of catchment)	
Unlined Filter media Perimeter	m	0	–	
Saturated Hydraulic Conductivity	mm/hr	100	100-200 mm is preferred	MUSIC v6 Documentation and Help
Filter Depth	m	0.4	–	

MUSIC INPUT PARAMETER	UNITS	VALUE	NOTES	REFERENCE
TN Content of Filter Media	mg/kg	800	–	
Exfiltration Rate	mm/hr	0	–	
Vegetated Swale Design Inputs				
Length	m	Varied	–	
Bed Slope	%	Varied	–	
Base Width	m	Varied	–	
Top Width	m	Varied	–	
Depth	%	Varied		
Vegetation Height	m	0.25		
Exfiltration Rate	mm/hr	0.7		
Gross Pollutant Traps				
High Flow By-pass	m^3/s	Varied	Sized for treatment up to 3-month ARI	
Gross Pollutants Inputs & Outputs Concentration	%	90		
Total Suspended Solids Inputs & Outputs Concentration	%	70		
Total Phosphorus Inputs & Outputs Concentration	%	0		
Total Nitrogen Inputs & Outputs Concentration	%	0		

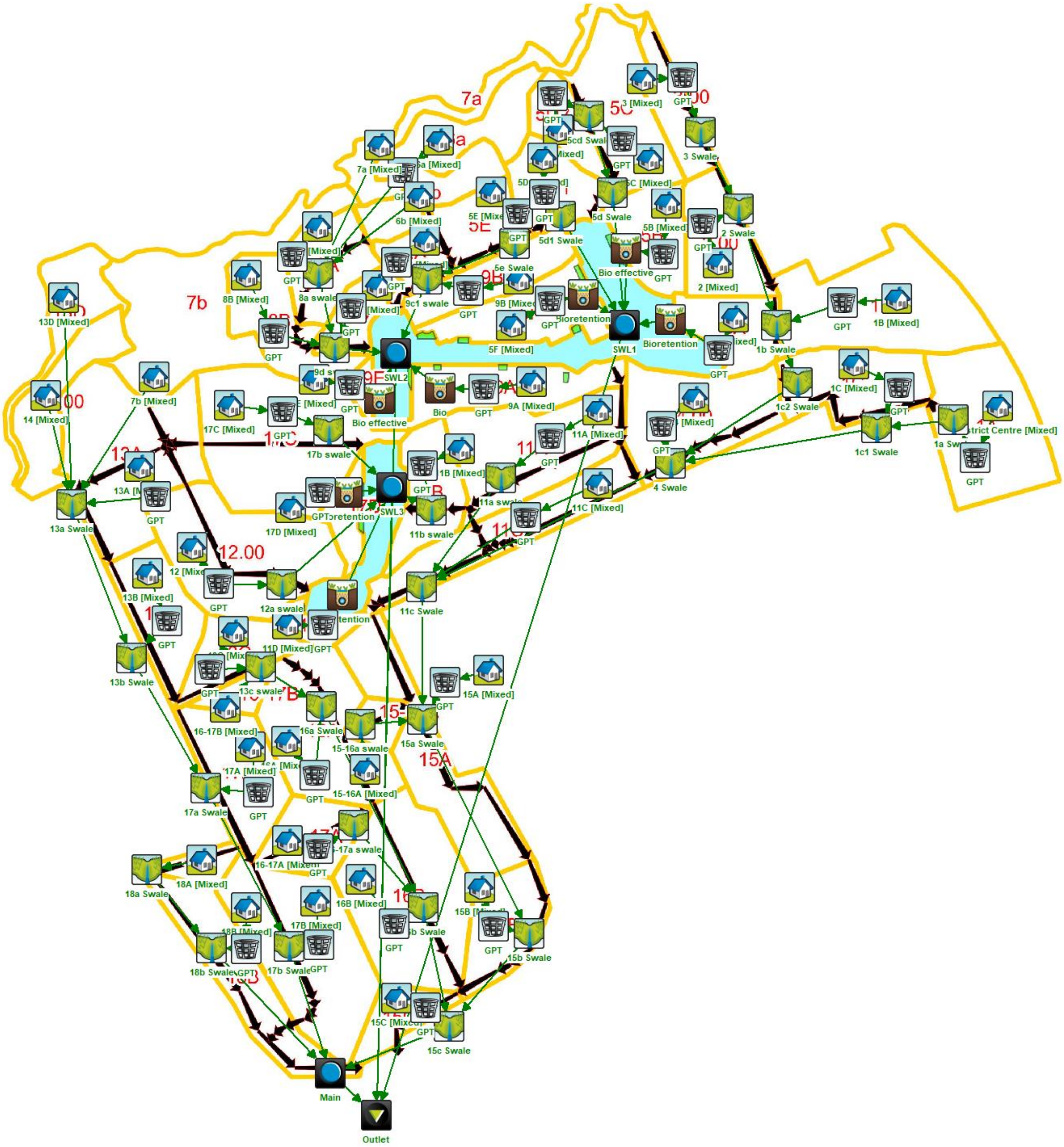


Figure 3 : MUSIC Model Schematic

1.3 Stormwater Treatment Performance Results

The stormwater treatment performance results at the three SWLs and at the main outlet at the southern end are summarised and compared with the required performance criteria in Table 2.

The results indicate that the overall stormwater treatment systems across the site will comply with the treatment criteria, in addition to meeting all the treatment criteria at each individual outlet.

Table 2: Water Quality Results Compared to Best Practice Standards

POLLUTANT TYPE	TSS	TP	TN	GROSS POLLUTANTS/LITTER
Target percentage reduction (%)	80	60	45	>50 mm and retention in 3-month ARI
Reduction achieved at SWL1 (%)	94.8	70.2	49.6	100% trapped (averaged over the simulated period)
Reduction achieved at SWL2 (%)	96.5	79.8	61.0	100% trapped (averaged over the simulated period)
Reduction achieved at SWL3 (%)	95.2	70.1	45.4	100% trapped (averaged over the simulated period)
Reduction achieved at Site Overall (%)	96.6	82.0	63.1	100% trapped (averaged over the simulated period)

1.4 Summary

This Master Plan level assessment of the stormwater treatment strategy for Riverlea Estate indicated that stormwater quality discharging from the estate will meet the treatment performance targets as defined in EPA water quality policy and Greater Adelaide Region's WSUD pollutant reduction targets. In addition, it was shown that the proposed treatment strategy also achieves the stormwater treatment targets suitable for discharging into the proposed SWL to not impact the water quality within the lakes.

2 REFERENCES

BMT, 2021. Riverlea Concept Stormwater Quality Management Plan.

WGA, 2022. Riverlea Development – Stages 1 to 12: Stormwater management Plan.

Wallbridge & Gilbert (W&G), March 2009. Riverlea Park Proposal: Stormwater Management: Water, Wastewater and Recycled Water – Technical Paper.

Water Sensitive South Australia, 2021. South Australian MUSIC Guidelines, Adelaide, South Australia.

FOR FURTHER INFORMATION CONTACT:

Damien Byrne
Director

T 08 8223 7433
M 0417 841 948
E dbyrne@wga.com.au

WGA.COM.AU
WGANZ.CO.NZ

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Riverlea Development Flood Assessment Addendum

Walker Corporation

31 January 2020

Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
V1	Final Draft	GF	GF	31/1/2020

Project Details

Project Name	Riverlea Development Flood Assessment Addendum
Client	Walker Corporation
Client Project Manager	Ben Moore
Water Technology Project Manager	Melinda Lutton
Water Technology Project Director	Geoff Fisher
Authors	Geoff Fisher, Sebastien Barriere, Melinda Lutton
Document Number	20030058 Riverlea Development Stage 1a Report Flood Assessment Addendum V1_3 201231

1/198 Greenhill Road
Eastwood SA 5063

Telephone	(08) 8378 8000
Fax	(08) 8357 8988
ACN	093 377 283
ABN	60 093 377 283

EXECUTIVE SUMMARY

Walker Corporation is planning Riverlea, a 1,340 hectare master planned community in Buckland Park that will deliver new infrastructure, diversity of housing, a supermarket, speciality shops, schools and parks. Over a proposed 25 year period, Riverlea will comprise 12,000 lots and will feature 200 hectares of conservation and recreational land, and a large lake with the capacity for water sports and other recreational activities.

This addendum to the Stage 1a Report summarises further work undertaken to address regional flood management issues in order to facilitate improved outcomes for the development and also for the broader community.

The primary objectives from the Stage 1 report that are further progressed in this Addendum Report are:

- The assessment of offsite floodwater entering the site to determine how this could be best managed, particularly in light of the Gawler River Floodplain Management Authorities' (GRFMA) proposed Northern Floodway mitigation scheme; and
- To identify Port Wakefield Road flooding and access issues and how these could be addressed.

Flood Risk

The flooding from upstream in the catchment was reviewed to assess the risk to the site, and some additional modelling undertaken as part of this study.

The present configuration provides flood immunity for the Riverlea Development, but access issues are likely to be prevalent for floods at the 10% AEP and larger. Whilst overtopping of the Port Wakefield Road is anticipated for flow at the 5% AEP it is likely that emergency services will close Port Wakefield Road before then, consequently emergency access will be possible but normal access will be prevented.

The Northern Floodway mitigation scheme, as presently proposed by the GRFMA, will avoid over topping of the Port Wakefield Road and should avoid road closure as well for those events. However, overtopping and road closure is still expected for larger events including the 2% and 1 % AEP flood events.

A minor extension to the levees upstream of Pederick Road (by approximately 450m) would prevent overtopping in that area for events up to the 1 %AEP and should avoid closure of the Port Wakefield Road. Modelling conducted as part of this Addendum work has demonstrated this to be the case. It is noted that the levee extension is consistent with the GRFMA's Northern Floodway concept (being highlighted as a possible optimisation option in their 2018 prospectus report).

Assessment of the expected behaviour of the Northern Floodway in a 1% AEP flood event, with the proposed levee extension in place, indicated that some further refinements to the floodway configuration would be desirable to avoid overtopping to the Port Wakefield Highway immediately to the north of the Gawler River. Those refinements include streamlining the floodway flow path immediately downstream of the highway to optimise the performance of the existing culverts. With those works in place, over topping of the highway immediately north and south of the Gawler River would be avoided for flood events up to (and including) a 1% AEP event.

The reduced flooding south of the Gawler River that would be achieved by the Northern Floodway would however push significantly more water through the Riverlea development from the north. The initial concept for conveying these increased flows was to simply increase the size of the originally proposed flood swales. These flood swales were intended to transfer water through the site created by natural breakouts from the Gawler River downstream of Port Wakefield Highway. However, under the proposed Northern Floodway configuration these flows become much larger and the swale system would need to be doubled in size with channel widths varying between 60 and 90 metres. Whilst effective, a series of swales of this size would have a significant impact on the amenity and connectivity within the development.

The additional flood waters would also be redirected towards Thompson Creek and away from Buckland Park Lake. It is understood that Buckland Park Lake would benefit from additional freshwater inflows and an increase in the duration of inundation of the lake when inflows had occurred. The Northern floodway option could help to achieve an increase in floodwaters towards the Buckland Park Lake and the duration of inundation, if the floodwaters continued westwards through the Riverlea site towards the lake rather than to the south. Such a configuration would also avoid the large north-south flows swales that bisect the Riverlea site and provide greater opportunities for innovative landscape design within the development.

A westerly flowing flood path has therefore been evaluated which still passes floodwaters from the Northern Floodway through the Riverlea development but keeps most of the floodwaters along the northern boundary of the site. Provision for a small overflow section can also be provided to ensure water can also be directed towards Thompson Creek.

This westerly flowing floodwater configuration has been modelled and developed sufficiently to demonstrate that it is technically feasible, effectively manages floodwater, and increases the volume and duration of water in the Buckland Park lake during a flood.

Minor earthworks are required to assist with flooding on the neighbouring Windamere site, which is presently at risk of flooding (ie without the Northern Floodway).

CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY AND ABBREVIATIONS

Term	Definition	Abbreviation
Annual Exceedance Probability	The probability that a given rainfall total accumulated over a given duration will be exceeded in any one year. This is expressed as a ratio, for example 1:100 or 1%. There is a 1% chance that the 1:100 AEP flood will be equalled or exceed in any one year.	AEP
Average Recurrence Interval	The ARI of a flood event is the number of years on average within which a given flood will be equalled or exceeded. For example, a 100-year ARI event may occur on average once in 100 years. Floods may also be expressed in terms of 'Annual Exceedance Probability' (AEP), which describes the probability of occurrence in any given year. A 100-year ARI event, has an AEP of 1%.	ARI
Australian Height Datum	The datum that sets mean sea level as zero elevation.	AHD
Average Recurrence Interval	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration.	ARI
Design Flood	A significant event to be considered in the design process; various works within the floodplain may have different design event requirements. E.g. some roads may be designed to be overtopped in the 1 in 10 year or 10% AEP flood event.	-
Digital Elevation Mode	A bare-earth elevation model of the earth's surface, with features such as vegetation, bridges and roads filtered out	DEM
Digital Terrain Model	A DTM is a mathematical representation of the ground surface. A DTM augments a DEM by including linear features of the bare-earth terrain	DTM
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.	-
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.	-
Flood Frequency Analysis	A technique to predict flow values corresponding to specific return periods or probabilities along a watercourse or flow path	FFA
Gawler River Floodplain Management Authority	Authority to coordinate the construction, operation and maintenance of flood mitigation infrastructure for the Gawler River`	GRFMA
HEC RAS	Hydrologic Engineering Centre River Analysis System	HEC RAS

Term	Definition	Abbreviation
Model for Urban Stormwater Improvement Conceptualisation	MUSIC provides the ability to simulate both quantity and quality of runoff from catchments ranging from a single house block and urban areas up to many square kilometres, and the effect of a wide range of treatment facilities on the quantity and quality of runoff downstream. MUSIC predicts the performance of the stormwater quality management systems.	MUSIC
Primary Industries and Regions South Australia	Key economic development agency in the Government of South Australia, with responsibility for the prosperity of the state's primary industries and regions. One of their tasks is to manage adverse events effectively and help primary industries and communities improve preparedness, resilience and recovery	PIRSA
Probable Maximum Flood	The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions.	PMF
Storm Duration	The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms, produce the greatest flows from undeveloped hills areas	

1 INTRODUCTION

Riverlea Development is a proposed housing development at Buckland Park, 40km north of Adelaide. The proposed development is for 12,000 new homes, to be developed over 25-30 years.

The site is bounded by the Gawler River to the north of the site, and the Port Wakefield Road to the east. Thompson Creek runs to the south of the site and runs parallel to the outflow treated effluent channel from Bolivar Wastewater Treatment Plant. The Bolivar outfall channel discharge to the sea remains separated from Thompson Creek.

State Approval has been gained for the proposed development.

The development area and surrounding areas are presently subject to flooding from the Gawler River. The Gawler River Floodplain Management Authority (GRFMA) have proposed a flood mitigation scheme that would alleviate flooding in the surrounding areas but increase the flow of flood waters through Riverlea. The proposed mitigation measures are however of significant benefit to Riverlea because they reduce flooding from the south and help to alleviate access issues to Riverlea Development in time of flood.

Walker Corporation are now seeking ways accommodate an increase in flood flows entering the site from the north that does not adversely affect the development concept.

This addendum report documents the results of investigations to more effectively manage the floodwaters through the site assuming that the GRFMA's Northern Floodway flood mitigation option is implemented as planned.

2 BACKGROUND

2.1 Topography

The Buckland Park site generally drains away from the Gawler River in a south westerly direction towards the Thompson Outfall Channel. The Gawler River is situated within the Northern section of the Buckland Park site and is a perched river system. As the banks of the Gawler River are higher than the adjacent floodplain, stormwater runoff from the Buckland Park site will not drain to the Gawler River nor to the Buckland Park Lake System as they are both effectively located upstream of the Buckland Park proposal site.

Thompson outfall channel extends from the westernmost end of Thompson Road in Buckland Parkland runs parallel to the SA Water Bolivar treated wastewater channel.

2.2 Floodplain Mapping for the Gawler River

Australian Water Environments prepared a report Floodplain Mapping for the Gawler River in 2008 for the Gawler River Floodplain Management Authority. This review of modelling and mapping provides an understanding of flood behaviour and risk at the site. The 2008 modelling of the Gawler included a range of AEPs: 1%, 2%, 5% and 0.2% for review. The existing conditions flood extent is shown in Figure 2-1 below.

Key information includes:

- The development site could be subject to flood depths up to 1m in depth
- The development site falls predominantly in the Low Hazard Category
- "The capacity of the Gawler River channel falls from east to west Near Gawler the capacity of the river is around 400m^3/s…and down to 10m^3/s immediately upstream of Buckland Park Lake" (Water Technology 2017)
- Behaviour of flood flows (inundation and duration) across Port Wakefield Road, and the hazard ratings

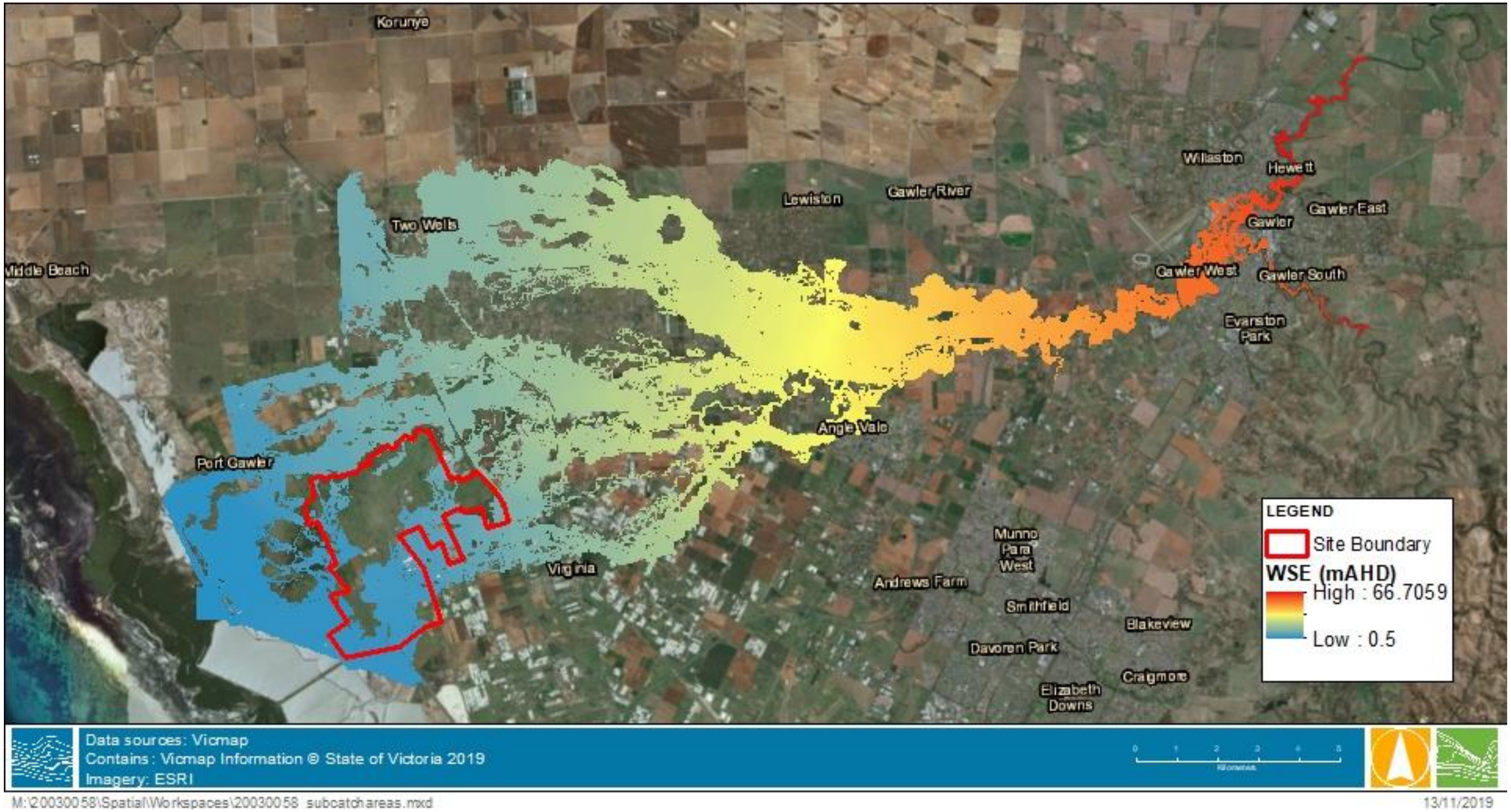


FIGURE 2-1 MODEL EXTENT AND SITE LOCATION (1% AEP FLOOD EVENT FROM 2008 REPORT SHOWN)

M:\20030058\Spatial\Workspaces\20030058_subcatch1.mxd 12/11/2019

FIGURE 2-2 EXISTING CONDITIONS INUNDATION EXTENT – 1 %AEP (2008)

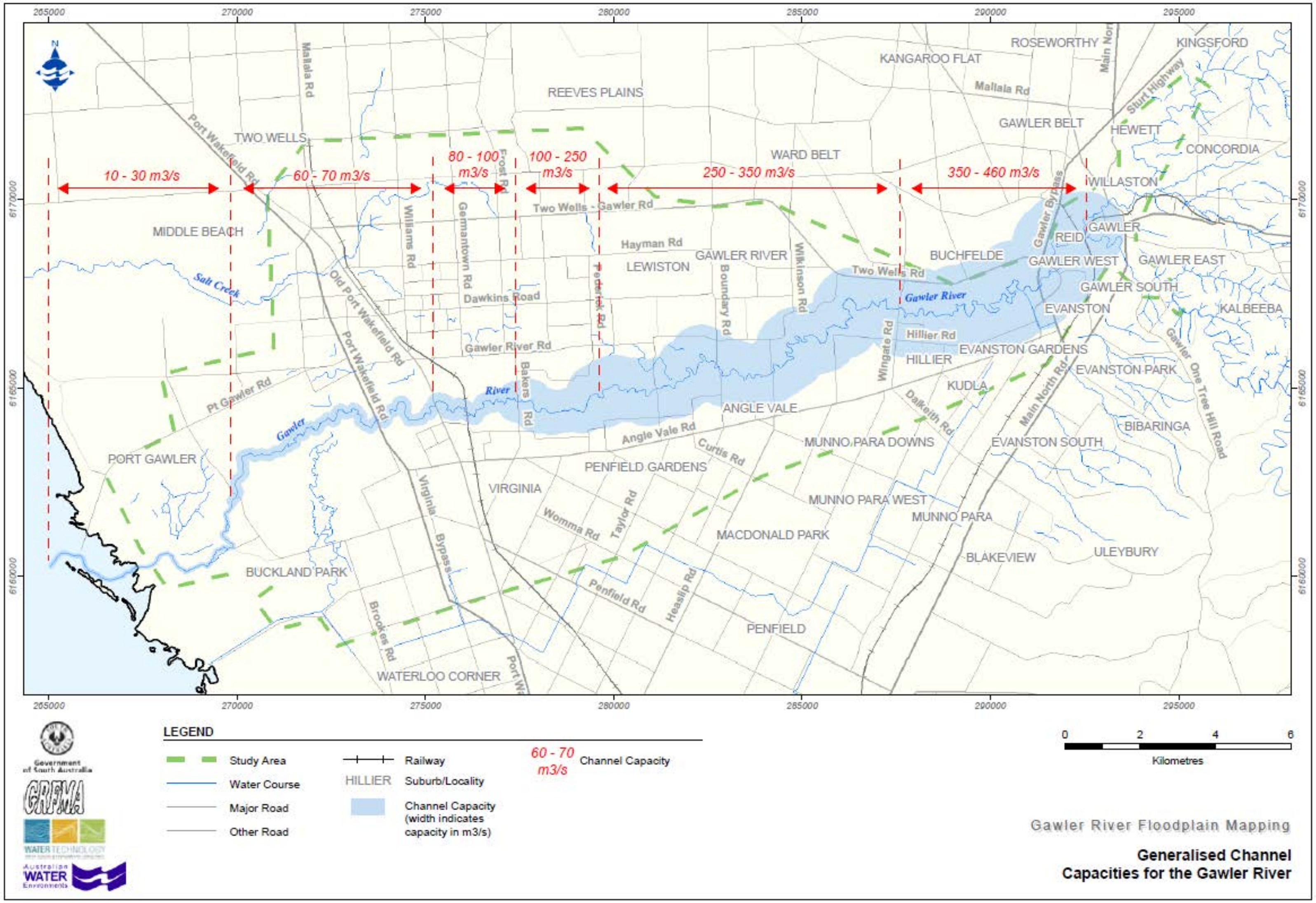


FIGURE 2-3 GENERAL CHANNEL CAPACITIES FOR GAWLER RIVER

This mapping work was the first time 2D hydrodynamic modelling had been applied to the Gawler River.

- Numerous hydrologic and hydraulic investigation have been undertaken over the years due to the significant economic losses, including property damage in 2005.
- Hydrologic data was provided by Department for Water Land and Biodiversity Conservation, with hydrographs for 20,50,100, 200 and 500 ARI floods were used as inputs into the hydrodynamic model.
- Peak flow at Gawler Junction for a 1% AEP was estimated to be 642 m^3/s with a critical storm duration of 72 hours.
- MIKE FLOOD was used to determine Gawler River channel capacity and breakouts from the river resulting in overland flow.
- Design flood simulations based on updated hydrologic inputs were modelled. Detailed flood extents, flood hazard maps and design flood hydrographs and flow paths have been produced
- Flood depths were mapped for the study area and Hazard Categories were allocated to the extent of the modelling area
- The model may be improved/updated in the future as new survey information becomes available
- General channel capacities for the Gawler River are shown in Figure 2-3, which shows a current capacity of 60-70 m^3/s at Buckland Park.
- Adjacent to Gawler River, the Port Wakefield Road is overtopped in a 5% and larger AEP event. It was estimated that the road would not be over topped for events of 10% AEP and less.
- Port Wakefield Road is closed before it is over topped to avoid structural damage to the road and to ensure public safety is maintained.
- Information on road accessibility, hazard ratings, risks etc.

2.3 Existing Flood Management Works

The Bruce Eastick North Para Flood Mitigation Dam on the North Para and modifications to the South Para Reservoir have reduced the extent of flooding in the Gawler River catchment for events up to the 2% AEP whilst eliminating major flooding in the upper portions of the Gawler River for the 5% AEP and smaller events. However, flooding from the 5% AEP still occurs in the lower reaches of the Gawler River (west of Virginia) due to limited capacity in the river in this area (e.g. in 2016 this area was extensively flooded and the Port Wakefield Road overtopped, following an event estimated to be 5%AEP).

Historically there have been incidences of Port Wakefield Road flooding, which creates an access hazard, and is also a route for flooding onto the proposed development site. During the September 2016 rainfall event, Port Wakefield Road was closed due to flooding for 3 days.

3 MODELLING SCENARIOS

3.1.1 1% AEP Flood Performance of Northern Floodway

During our review of existing modelling data, some additional modelling was carried out to investigate the Northern Floodway option for the lower Gawler River, which had not yet been tested under a 1 % AEP flood of the Gawler River.

3.1.2 Levee Extension and Western Diversion of Floodwaters

Following the additional Northern Floodway modelling, further modelling was undertaken to investigate further improvements to the flood management arrangements for the Riverlea Development. Two scenarios were investigated:

Scenario 1: Extend the Gawler River Levees a short distance upstream of Pederick Road

This scenario modelled the existing levee upgrade arrangement proposed by the GRFMA near Pederick Road, and extended the levees by up to 450 metres further upstream, to prevent the modelled breakout occurring in the 1 % AEP flood. The aim was to demonstrate that this would then avoid overtopping of the main Port Wakefield Road during a 1% AEP event.

Scenario 2: Create a western flow path along the northern boundary of the Riverlea Development

Floodwaters for the Gawler River immediately north of the Riverlea Development are presently directed southwards through the development via a series of major flood conveyance channels, following natural flow paths to Thompson Creek and the Thompson Creek outlet. With the creation of the Northern Floodway the flows through the channel would be much larger and hence the channels also need to be made bigger, as the flood water volumes from the north would be increased further. An alternative flow path was modelled to keep flood waters towards the northern boundary of the Riverlea Development and direct them westward so that discharge to sea is via Buckland Park Lake and the main Gawler River outlet (rather than via Thompson Creek).

4 HYDRAULIC MODEL DEVELOPMENT

4.1 Overview

In 2014, the original model was updated to include additional one-dimensional floodplain features such as culverts. The river and floodplain flow was represented in the 2D model grid and culverts were represented as 1D model elements, linked to the 2D model at their upstream and downstream end. Therefore, a coupled 1D/2D MIKE FLOOD model was developed.

The revised model from 2014 was used for the present assessment and the inflow boundaries updated.

4.2 Summary of the 2014 Model Update

The resolution for the updated hydraulic model was maintained at 15m as was used for the original Gawler River modelling and modelling of the adjacent Light River floodplain and Smith Creek rural areas modelling.

The model grid was extended to the west to incorporate breakout flow paths through Two Wells and toward Middle Beach.

The model DEM, used to describe the topography, was built upon numerous layers and sources of data. For completeness the datasets are summarised in Table 4-1. A map of the final topography and breaklines is provided in Figure 4-1.

TABLE 4-1 TOPOGRAPHY LAYERS

Layer	Dataset	Details
1 (Bottom)	Gawler River LiDAR (1m)	Grid shift issues in the original Gawler model and an inconsistency in grid origins between the Gawler and Light River models were addressed by reverting back to the 1m LiDAR DEM and resampling a 15 m DEM on the same grid as the Light River model. The Bruce Eastick Flood Control Dam was removed from the topography as it was close to the upstream boundary. The effect of this dam will be captured in the hydrological assessment. The Northern Expressway and basins were stamped back in north of river. Details from the old Gawler model were adopted. It was flagged that these details appear different to the as constructed details as shown in Google Earth, however the as constructed details were not available.
2	Light River model DEM (15m)	Used as is except at boundaries – boundaries clipped out of grid.
3	Smith Creek DTM (1m)	Used as is.
4	Buckland Park Ultimate	The Buckland Park ultimate DEM had fill areas raised to a flood-free level and approximate channel details.
5	Buckland Park Stage 1	Actual fill levels and final channel designs for Stage 1 were superimposed on the ultimate design to give better detail in the stage 1 area.
6	SA Greyhound Club Redevelopment	Design levels for tracks and building floors, and existing site levels were combined to produce a DEM of developed conditions.
7	Eden Development Two Wells	Fill areas and channels/basins were included directly in the M21 grid. Fill areas were raised to 12.9 m which is the design fill level for the eastern edge of the development. This is well above the 200 year flood level for the site so further detail was not required.

Layer	Dataset	Details
8	Liberty Development Two Wells	Fill areas and channels/basins were included directly in the M21 grid. Fill areas were raised to 10.6 m which is the design fill level for the eastern edge of the development. This is well above the 200 year flood level for the site so further detail was not required.
9	Donaldson Road Development Two Wells	Areas to be filled and the basin were included in the M21 grid as per the Proposed Land Division plans. Roads were raised to 11.8-12.2 m AHD as per the plans.
10	Gullacci Development Two Wells	As constructed levels were converted to a grid and stamped into the model. However, level information was not available across the entire development. Manipulation of the Mike 21 grid was undertaken to ensure all fill areas were included.
11	Gawler River Road	Breaklines developed by Water Technology for previous assessments were resampled for the new grid. Levels were adjusted to as constructed levels which were available for a section of the road.
12	Gawler Skate Park	DEM generated from design contours and strings.
14	Hillier Development	Fill area raised in M21 grid above flood level. Reserve area lowered to 41.2 m AHD.
15	Gawler Par 3 Golf Course Levee	Levee alignment and heights were digitised from plans and added to the grid.
16	Gawler Footbridges	Proposed footbridges were incorporated over the Gawler River and its tributaries. These footbridges are part of the planned *Gawler Urban Rivers Shared Path*. Four of the key footbridges were incorporated into the model as 1D elements, with the deck height added to the 2D grid.
17	Northern Expressway Levee Survey	Survey of the Northern Expressway levee was incorporated into the model. This levee aims at stopping breakout flows to the south of Gawler River, and is located upstream of the recently constructed Northern Expressway. The levee crest was incorporated in the 2d model topography.
18	Northern Expressway Survey	Survey of the recently upgraded Northern Expressway crossing of the Gawler River was incorporated into the 2d model. This also includes surrounding detention basins and earthworks.
19 (Top)	Breaklines and Channel	Breaklines from existing models were collated and stamped onto the grid. Road/levee embankments were treated by sampling the maximum level within 15m of the breakline and applying that maximum level to the grid. Railway embankments were treated similarly, but the embankments were lowered in places to account for wash-out of ballast when overtopping occurs. The Salt Creek crossing in two Wells was lowered as per the original Light River modelling. The Gawler and South Para crossings in Gawler township were lowered by approximately 0.2m. The rail lines elsewhere were not lowered. The Gawler River channel definition from the original Gawler model was stamped into the model grid. The Smith Creek channel was also stamped onto the grid.

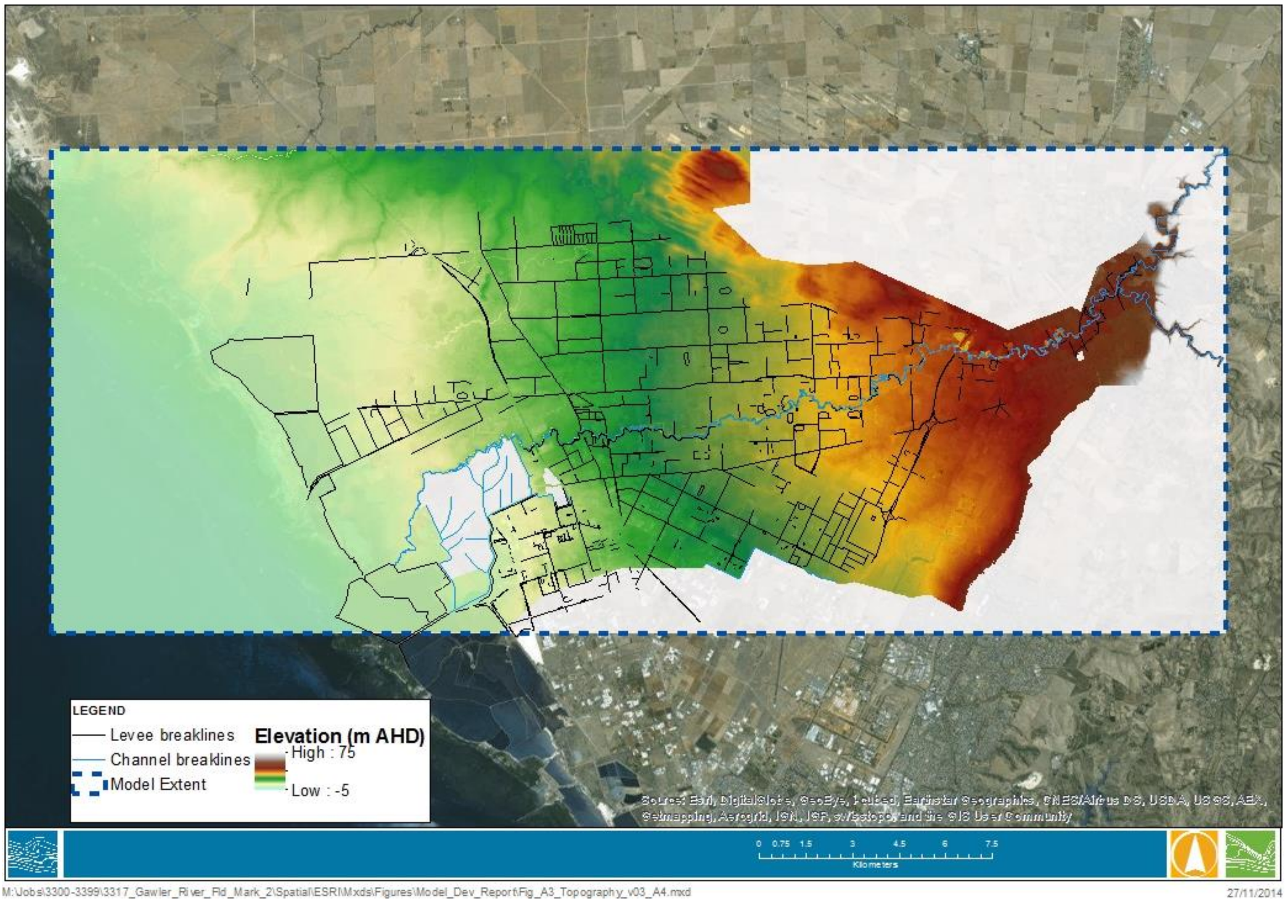
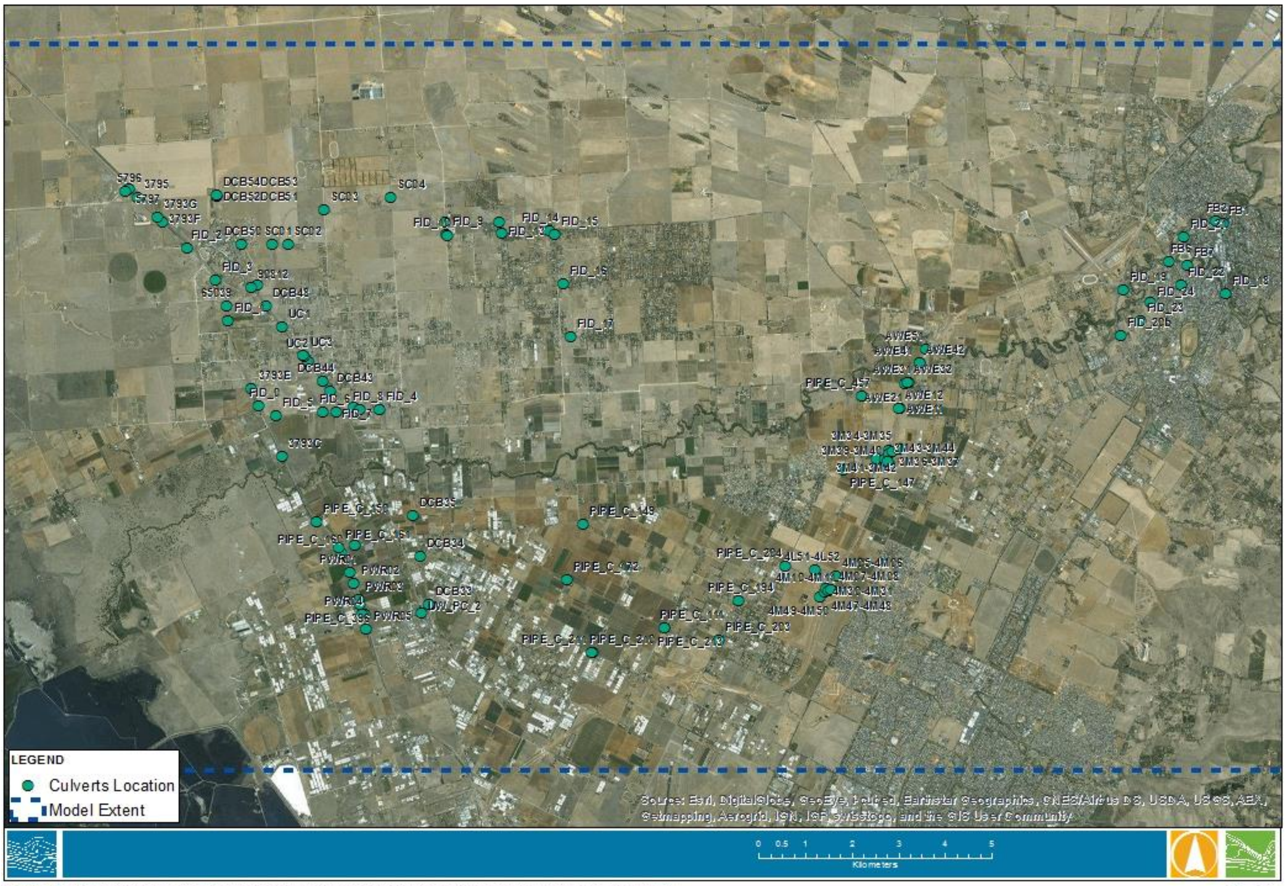


FIGURE 4-1 GRID EXTENT AND TOPOGRAPHY

Culverts were adopted from the previous Light River and Smith Creek models. All culverts were transferred for the Light River model, whereas culverts were selectively transferred from the Smith Creek model. The four proposed footbridges from the planned *Gawler Urban Rivers Shared Path* were also included as 1D elements.

A total of 111 bridge/culvert crossings were included in the model. A map of culverts included in the model is provided in Figure 4-2 Culvert LocationsFigure 4-2.



M:\Jobs\3300-3399\3317_Gawler_River_Fld_Mark_2\Spatial\ESRI\Mxds\Figures\Model_Dev_Report\Fig_A3_Culverts_v03_A4.mxd 27/11/2014

FIGURE 4-2 CULVERT LOCATIONS

Inflow boundaries were applied at the upstream end of the North Para and South Para Rivers. These hydrographs were extracted from the hydrologic model downstream of Turretfield and at the South Para River SE Gawler gauging station. These inflow boundaries have been updated for the present assessment.

An ocean level boundary was applied along the western and southern model edges. A level of 1.5 m AHD, equal to the Highest Astronomical Tide was applied. Model Boundary locations are displayed in Figure 4-3

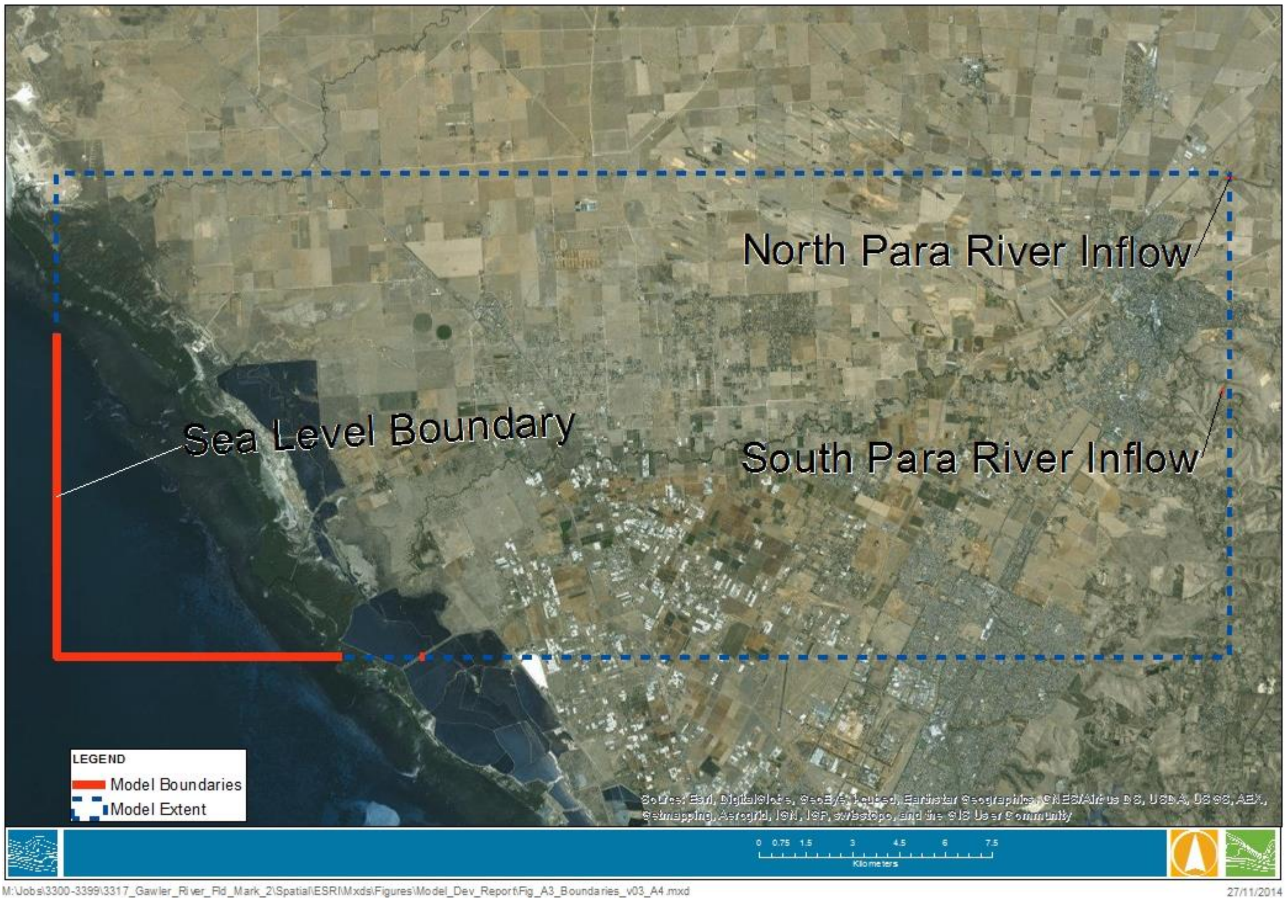


FIGURE 4-3 MODEL BOUNDARIES

4.3 Model Boundary Update

The North Para inflow boundary has been updated for these additional simulations. The hydrographs correspond to the boundary conditions applied in the Gawler River Flood study. The hydrographs applied for the 1% and 2% AEP events are presented in Figure 4-4.

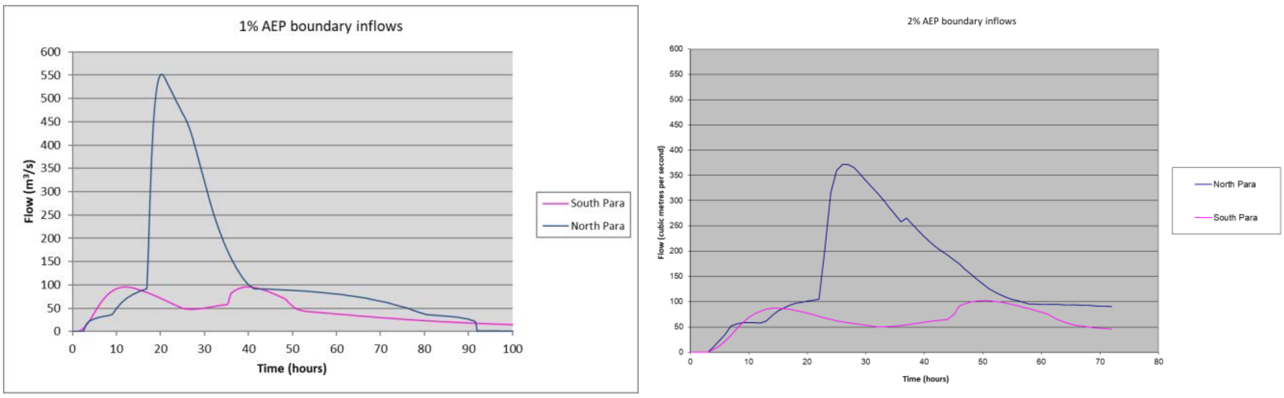


FIGURE 4-4 INFLOW BOUNDARIES – HYDROGRAPHS

4.4 Modelled mitigation options

The primary mitigation assessments evaluated in the model were the following:

- Northern floodway and levees – evaluation of 1% AEP performance
- Optimisation of Northern floodway to achieve 1%AEP performance by:
  - Short extension of the levees
  - Streamlining hydraulics downstream of Port Wakefield Highway
- Replacing large central swales within development with westerly flowing flood path.

The GRFMA proposed Northern Floodway configuration is presented below.

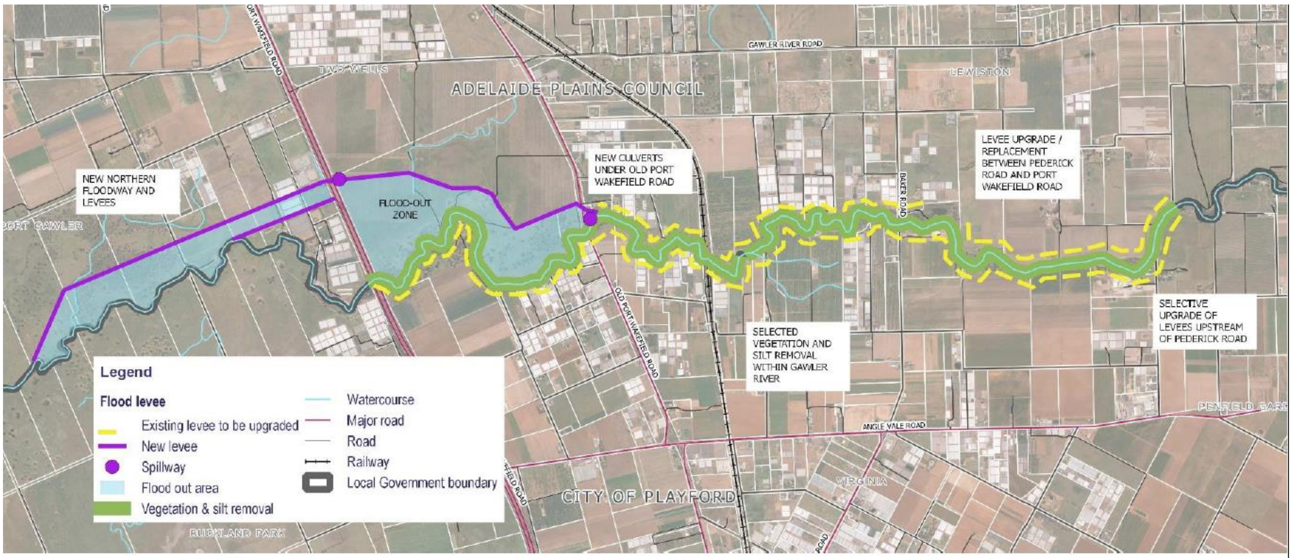


FIGURE 4-5 GRFMA NORTHERN FLOODWAY OPTION

4.5 1% AEP Flood Performance of Northern Floodway

Additional modelling was carried out to investigate the Northern Floodway option for the lower Gawler River under a 1 % AEP flood. Two scenarios were tested; one with the enlarged flood control dam on the North Para River and the second without the enlarged dam (i.e. maintaining the current dam configuration).

4.6 Levee Extension and Western Diversion of Floodwaters

Following the additional Northern Floodway modelling, further modelling was undertaken to investigate further improvements to the flood management arrangements for the Riverlea Development. Two scenarios were investigated:

4.6.1 Scenario 1

This scenario modelled the existing levee upgrade arrangement proposed by the GRFMA near Pederick Road, and extended the levees by approximately 450 metres further upstream, to prevent the modelled breakout occurring in the 1 % AEP flood. The aim was to demonstrate that this would then avoid overtopping of the main Port Wakefield Road during a 1% AEP event.

The extended levee was found to reduce the flow to the south breakout, and the Port Wakefield Road is no longer overtopped south of the Gawler River. Furthermore, the main entrance and southern access route to Riverlea would remain flood free for flood events up to the 1 %AEP event. However, with more water in the Gawler River, levels are increased within the Northern Floodway by 5cm upstream of the Highway and the Highway would be overtopped on the right bank (north) of the Gawler River. Further refinements to the Northern Floodway configuration where made downstream of the highway to streamline the floodway by removing a raised area of topography, thereby providing an consistent gradient to the west alleviated this overtopping issue, refer the 1% AEP inundation map shown in Figure 4-6.

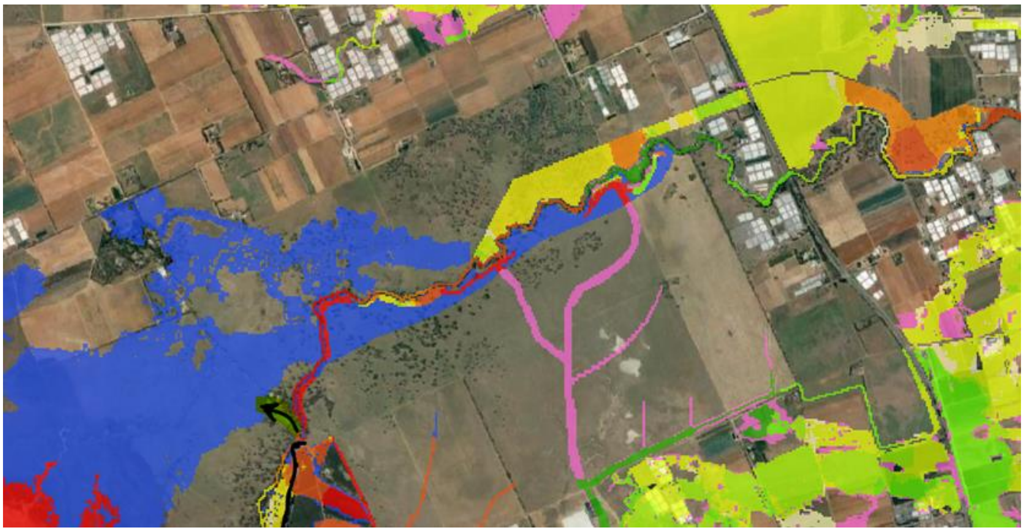


FIGURE 4-6 1 % AEP FLOOD WITH EXTENDED LEVEE AND NORTHERN FLOODWAY

The improved Northern Floodway configuration prevents overtopping of the Highway, both north and south of the Gawler River (within the area of interest).

4.6.2 Scenario 2

Floodwaters for the Gawler River immediately north of the Riverlea Development were previously proposed to be directed southwards through the development via a series of major flood conveyance channels, following natural flow paths to Thompson Creek and the Thompson Creek outlet. With the creation of the Northern Floodway, the flows through the channel would be much larger and hence the channels also need to be made bigger as the flood water volumes from the north would be increased further. An alternative flow path was modelled to keep flood waters towards the northern boundary of the Riverlea Development and direct them westward so that discharge to sea is via Buckland Park Lake and the main Gawler River outlet (rather than via Thompson Creek).

The second scenario for the levee extension and western diversion and changes to the model are summarised in Figure 4-7. The initial results presented below were encouraging and hence this configuration was further refined to be more in tune with the natural character of this area and the development objectives.

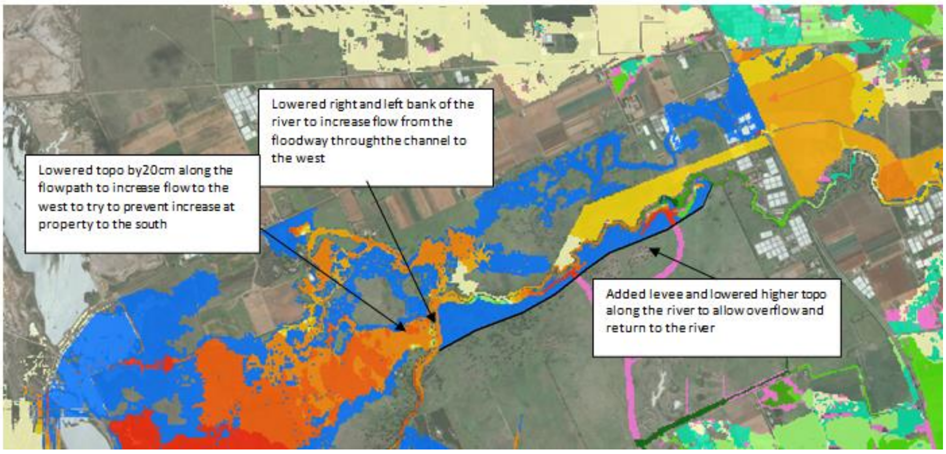


FIGURE 4-7 WESTERN DIVERSION – INITIAL TRIAL RESULTS

Following the initial results from the mitigation options listed above, the model setup was further refined to achieve the following :

- Prevent flooding locally within the western floodway to provide flood-free areas for development. Levees and the Gawler river banks along the western floodway will be modified to obtain the proposed flood-free areas as shown in Figure 4-7. In order to maintain the flow capacity in the western floodway, the topography in between the flood-free "islands" was smoothed. Additionally, the levee along the northern side of the floodway was extended to prevent flooding to the northwest.
- Reduce flooding on the Windamere property caused by the mitigation options implemented upstream. The riverbanks have been lowered where the river changes direction and flows to the south, to facilitate the overtopping to the west and reduce the flow towards the south. Levees have been added along the Gawler River banks to prevent overtopping of the riverbanks towards the property and concurrently direct floodwaters to the west.

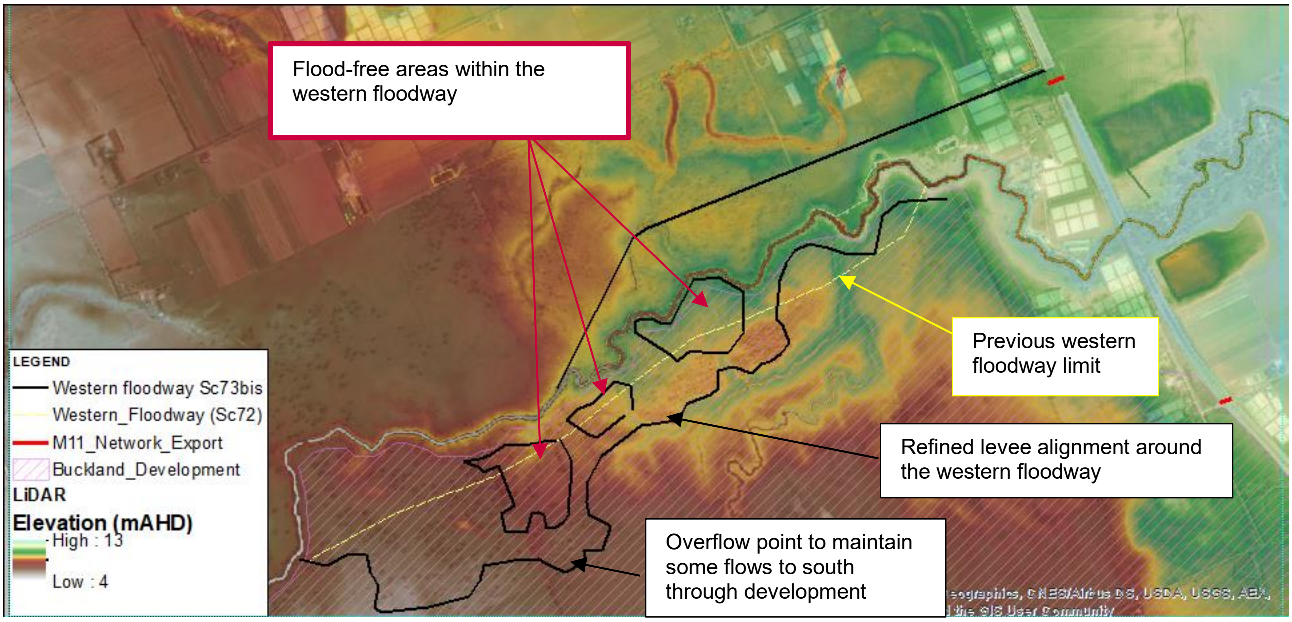


FIGURE 4-8 REFINED WESTERN FLOODWAY LEVEE ALIGNMENT

5 RESULTS

5.1 1% AEP Flood Event : Results from the Refined Setup

Model results for the mitigated set-up with the refined western floodway and the additional levees near the Windamere property were compared to the base case scenario. The difference plot below shows flooding north of the Western floodway no longer occurs and flood extents on the Windamere property are reduced when compared to the base case scenario. Floodwaters are contained within the western floodway and redirected to the west of Gawler River.

Under mitigated conditions, water depths within the floodway are mostly above 1m and can reach up to 2m in the low lying parts. Where the flow area is reduced, velocity peak at 1.6 m/s locally in the narrow flood paths is between the protected areas.

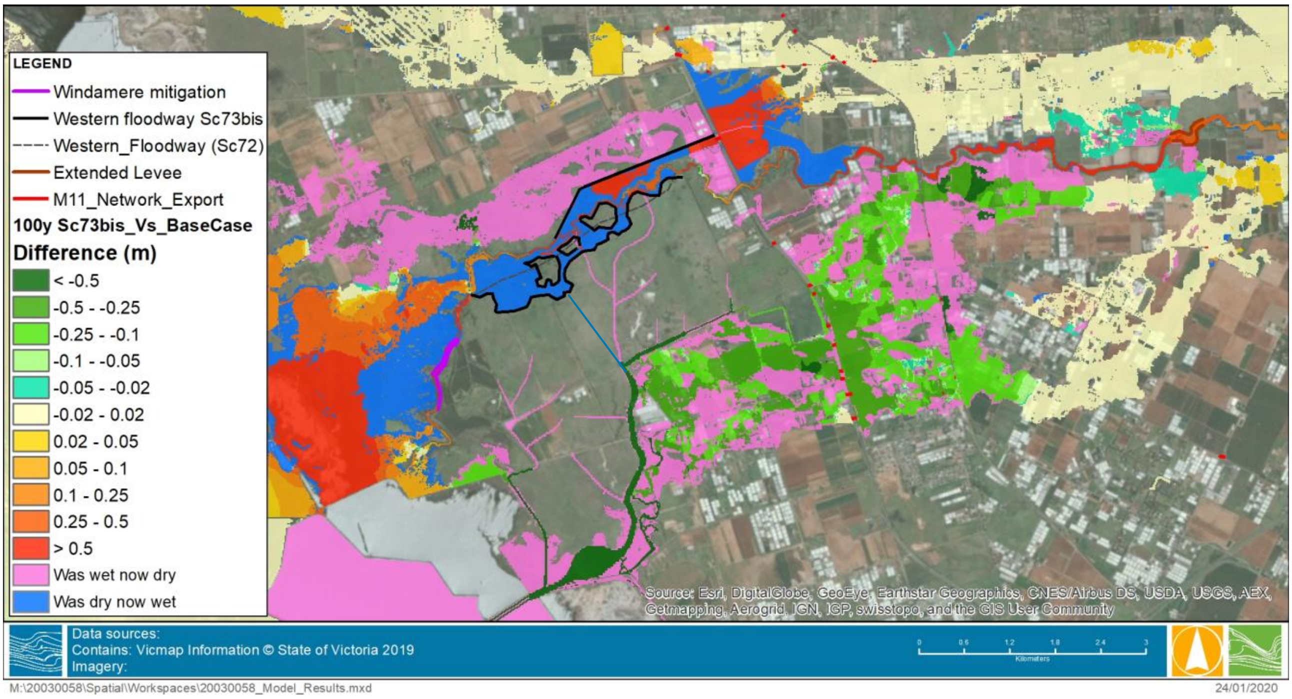


FIGURE 5-1 DIFFERENCE PLOT: 1% AEP FLOOD EVENT MITIGATED CONDITIONS VS. BASE CASE SCENARIO

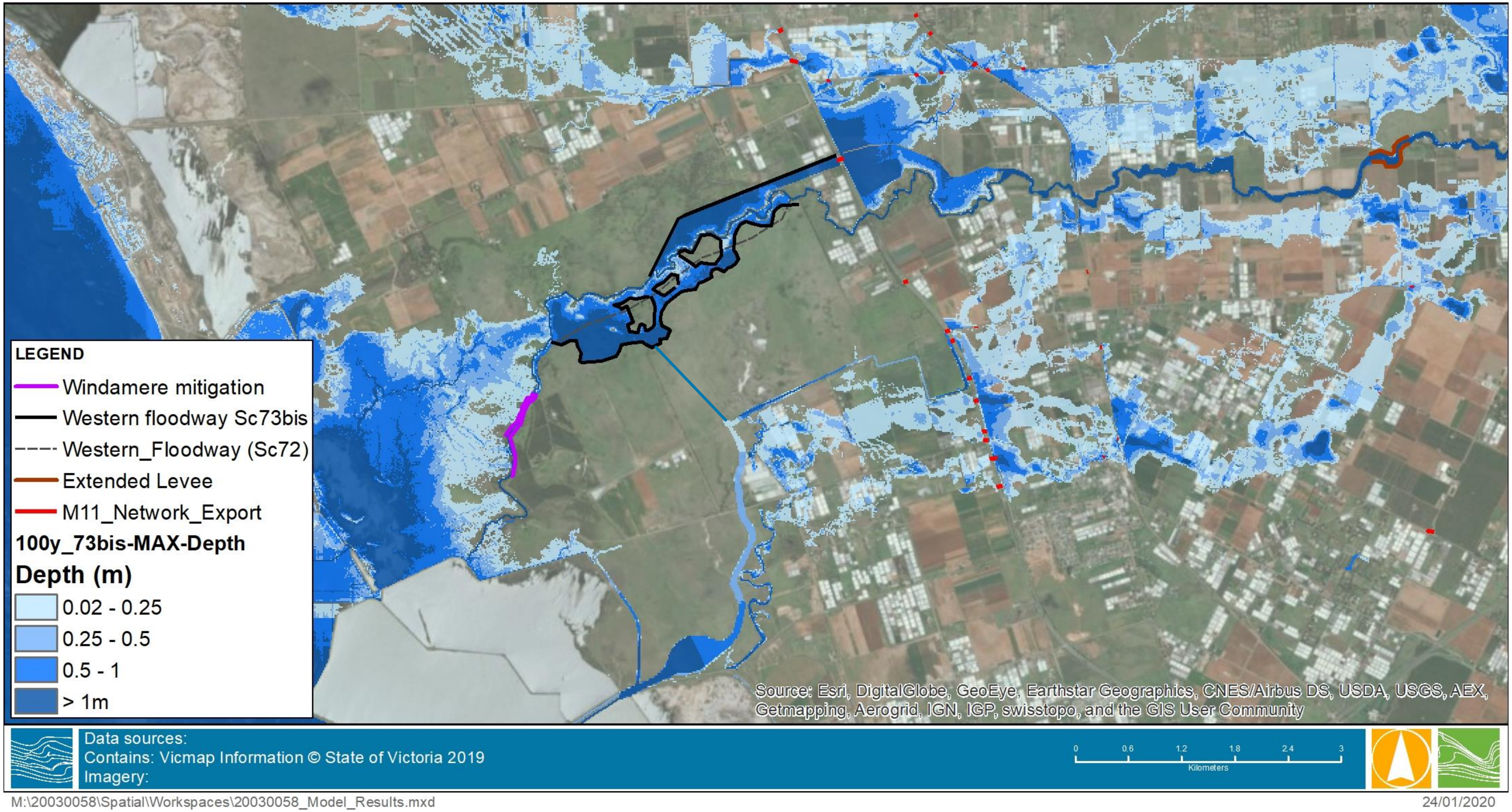


FIGURE 5-2 1% AEP FLOOD EVENT : WATER DEPTHS

REFERENCES

ANZECC & ARMCANZ (October 2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality Volume 1*. Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra

Australian Government (2012). *Technical Flood Risk Management Guideline: Flood Hazard.* Australian Institute for Disaster Resilience.

Australian Water Environments (March 2016). *Findings Report for the Gawler River Flood Mitigation Scheme*. Gawler River Floodplain Management Authority

Water Technology (2008) *Gawler River Floodplain Mapping Hydraulic Model Report*. Australian Water Environments

Australian Water Environments (February 2008). *Floodplain Mapping for the Gawler River*. Gawler River Floodplain Management Authority

Water Technology (2014) *Gawler River Model update*. Australian Water Environments

Australian Water Environments (September 2017). *Project Report - Gawler River Floodplain Management Authority*. Gawler River Floodplain Management Authority

Gawler River Floodplain Management Authority (June 2018). *Northern Floodway Project Prospectus*. Tonkin Consulting

Government of South Australia (October 2012). *South Australian Recycled Water Guidelines*. SA Health

SA Water (2013) *Regulatory Business Proposal - Wastewater Treatment Plants and Catchments*. SA Water

Wallbridge and Gilbert (December 2013). *Buckland Park Development Precinct 1 – Stormwater Management. Plan*. Wallbridge and Gilbert

Wallbridge and Gilbert (March 2009). *Buckland Park Proposal – Stormwater Management. Water, Wastewater and Recycled Water – Technical Paper*. Wallbridge and Gilbert

Tonkin Consulting (June 2018). *Northern Floodway Project Prospectus*. Tonkin Consulting

Melbourne

15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800
Fax (03) 9558 9365

Brisbane

Level 3, 43 Peel Street
South Brisbane QLD 4101
Telephone (07) 3105 1460
Fax (07) 3846 5144

Adelaide

1/198 Greenhill Road
Eastwood SA 5063
Telephone (08) 8378 8000
Fax (08) 8357 8988

Perth

Ground Floor
430 Roberts Road
Subiaco WA 6008
Telephone 08 6555 0105

Geelong

PO Box 436
Geelong VIC 3220
Telephone 0458 015 664

Gippsland

154 Macleod Street
Bairnsdale VIC 3875
Telephone (03) 5152 5833

Wangaratta

First Floor, 40 Rowan Street
Wangaratta VIC 3677
Telephone (03) 5721 2650

Wimmera

PO Box 584
Stawell VIC 3380
Telephone 0438 510 240

www.watertech.com.au

info@watertech.com.au

MEMORANDUM

To	Brent Eddy
From	Alison Miller
Date	31 October 2022
Subject	Modelling of Riverlea development in the broader Gawler River floodplain model

Riverlea is a proposed housing development at Buckland Park, currently under development by Walker Corporation. Water Technology have been engaged at various stages of the project to provide advice on riverine flood impacts at the development site and adjacent properties.

This memo documents the hydraulic modelling undertaken to assess the performance of the proposed division of floodwaters from the Gawler River along the western side of the development. Modelling was undertaken in the broader Gawler River floodplain model, versions of which are currently being used in the development of the Gawler Stormwater Management Plan and for the Enhanced Flood Hazard Mapping project.

MODEL DETAILS

The existing conditions model, currently being developed for the Enhanced Flood Hazard Mapping project, was adopted as the base case for assessment of the Riverlea development. The model is a coupled MikeFlood model, with the river and floodplain represented in 2D (Mike21), linked to 1D representation of culverts (Mike11).

Topography

The model adopts a flexible mesh representation, which allows higher resolution detail to be incorporated in the model where required (e.g. along the river) without dramatically increasing run times. The model adopts elevations from the two recently captured LiDAR datasets:

- Middle Beach 50cm LiDAR, captured 26 November 2021
- Adelaide Metro LiDAR, captured 21-31 January 2022.

The two datasets overlap along the alignment of the Gawler River. Where this has occurred, the 2022 data has been used in preference.

Note that the only difference between the model adopted for this assessment, and that in development for the Gawler SMP, is the underlying topography. The Gawler SMP model adopts the 2021 LiDAR, but the topography on the south-eastern side of the river alignment is based on a series of earlier topographic datasets.

The model incorporates 344 dike structures, which have been used to control the level at which water can move across various areas. Typically, these are representative of levees, however dikes have also been used to incorporate other key features such as road crests, where the element vertex sampling may have missed this detail. Crest elevations for each dike have been sampled from the 2021 or 2022 LiDAR.

Inflow/outflow boundaries

Inflow boundaries to the model were retained, and include:

- A hydrograph input for the South Para River at South East of Gawler
- A hydrograph input for the North Para River downstream of Turretfield.

Note that the hydrology inputs were derived from the XP-RAFTS hydrology model which incorporates the Bruce Eastick Dam and the upgraded South Para Dam. Hydrographs to the model were extracted at the spatial location of the hydraulic model. This is downstream of the South Para Dam (hence the flood mitigation is incorporated in the hydrology) and upstream of the Bruce Eastick Dam (flood mitigation here is incorporated in the hydraulic model).

A sea level of 1.5 mAHD (equivalent to the Highest Astronomical Tide) was applied as a downstream boundary along the western and (partial) southern model edges. This has been retained form the original study in 2008 which assessed tidal data for Port Adelaide and Outer Harbour.

A second 'free outflow' boundary has been incorporated on the southern edge of the model further upstream, on the western side of the Northern Expressway. This was to prevent breakouts from the Gawler River from artificially ponding at the model edge. In reality, this water is anticipated to flow initially south-west and then further west to meet other breakout flows from the Gawler River near Port Wakefield Road.

Infrastructure

All major bridges and culverts, of which there are 89, have been incorporated in the 1D domain. These were adopted from the previous Light River and Smith Creek models. Where these relate to drainage infrastructure for the Northern Expressway, these have been validated against details in the DRAINS model provided by City of Playford.

Where the mesh resolution was coarser than the width of the culvert/bridge outlet, the elevation of the linking cell has generally required altering to represent the invert.

Updates for the current assessment

The underlying mesh was refined across the area of the Riverlea site, to ensure sufficient resolution to capture the proposed development layout of swales. As a result of changes to the mesh, existing conditions have also been updated to ensure the same representation of detail.

The proposed development conditions have been represented by sampling a digital elevation model of the proposed conditions, created from the design drawing provided by Walker Corporation 'Riverlea_Existing+Sitewide EW_05092022.dwg'.

Further details of the model schematisation will be made available through the Enhanced Flood Hazard Mapping project report for the Gawler River.

Note that the model is currently undergoing validation, and further refinements will be made. This will include re-enforcement of the bank levels on the eastern side of the Gawler River near Windermere. The model version adopted here, is appropriate for comparing like-for-like but may not necessarily be representative of actual flood levels, depending on the outcome of the validation process.

SCENARIOS

Scenarios analysed for this assessment include:

- Current conditions (referred to as 'existing').
- Future development conditions.

The digital elevation model for the proposed developed conditions can be seen in Figure 1. The proposed design includes a concept for diverting breakouts from the Gawler River into a zone along the northern edge of the development, conveying floodwaters along the north and western borders to a discharge point at the south-western corner.

Figure 1 Proposed development surface elevations

RESULTS

The resulting flood depth for the 1% AEP flood event in the Gawler River for the current and future development scenarios is provided in Attachment 1 and 2. The scheme to divert breakouts to the south-western corner works as intended, however it demonstrates that the floodwaters are diverted from the location further west than intended.

The developed conditions (Attachment 2) show an extensive area of flooding surrounding the most southern basin, near the existing salt pans. While the majority of this area is inundated in existing conditions, refinement to the outflow path may need to be considered.

Differences in 1% AEP flood levels between the two scenarios is shown in Figure 2 (and Attachment 3). The results indicate reduced flooding along the western portion of the development (i.e. 'was wet now dry'), and reduced flood levels further west and south of the site.

Note that the existing conditions 1% AEP flood extent differs slightly to that provided previously. Output from the previously adopted TUFLOW site specific model indicated floodwaters breakout out near the intersection with Port Wakefield Road to south of the Gawler River, inundating the existing greenhouses and extending south-west across the Riverlea site. This breakout flow is not observed in the updated modelling adopted here as the bank heights have been more accurately represented through the adoption of recently captured 2022 LiDAR.

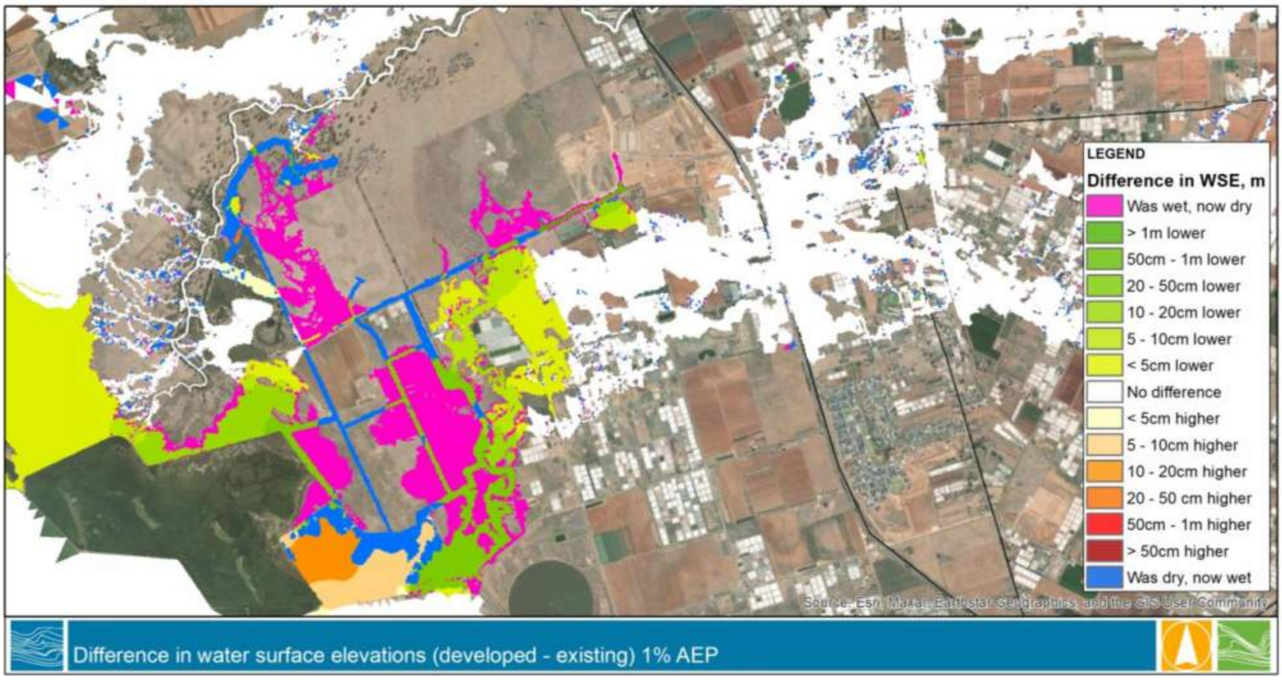


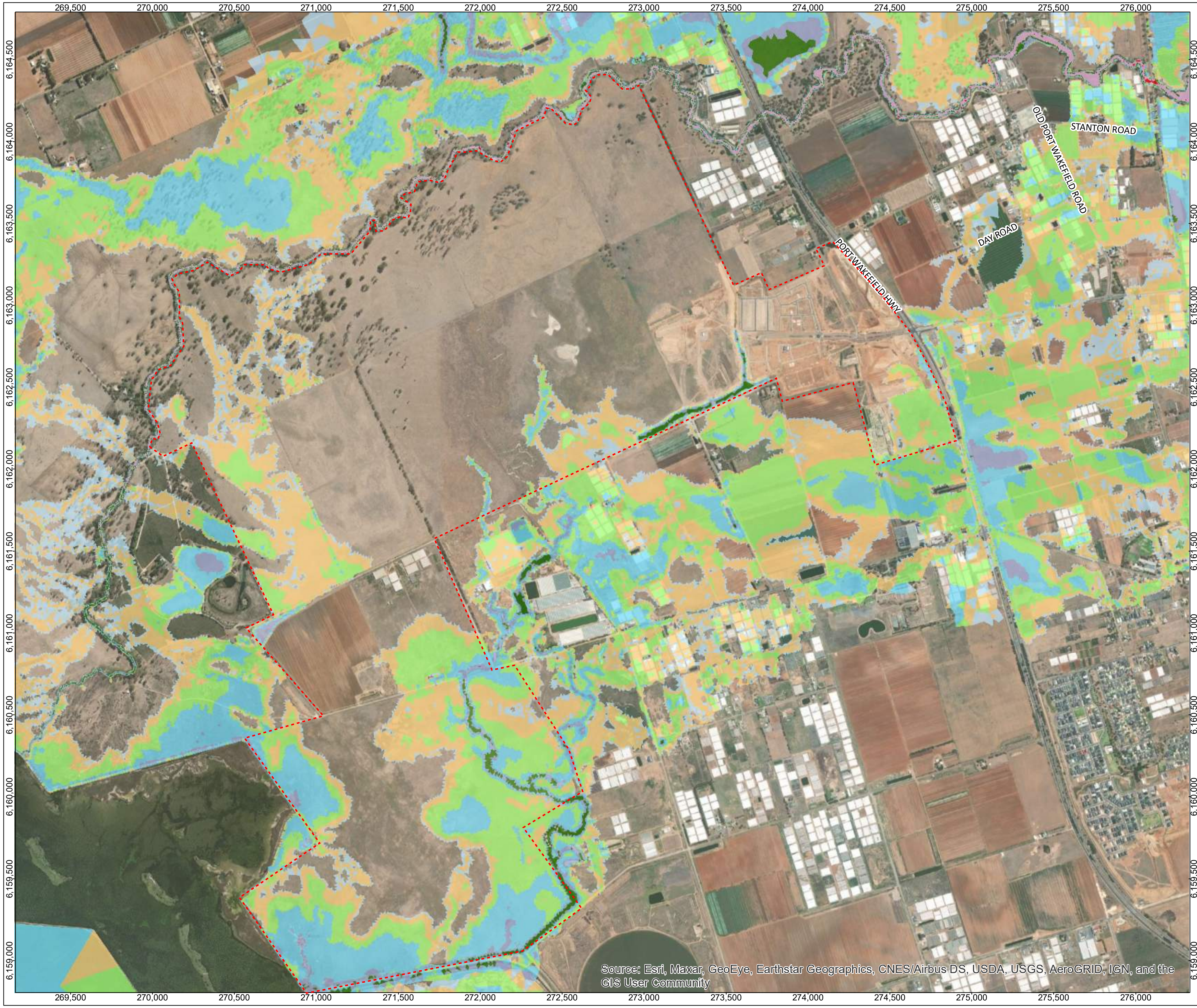
Figure 2 1% AEP flood depth for current development conditions across site

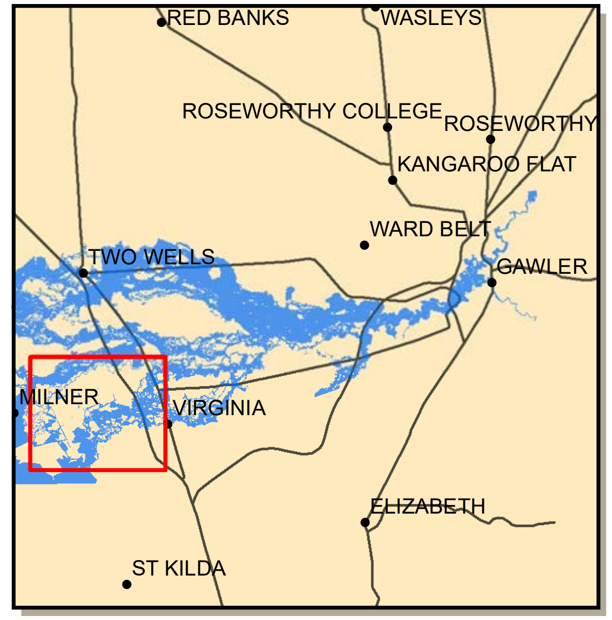
Enclosed:

Attachment 1 – 1% AEP flood depth, existing conditions

Attachment 2 – 1% AEP flood depth, proposed development conditions

Attachment 3 – 1% AEP difference in water surface elevation (developed minus existing)





Legend

Depth, m

- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2.5
- 2.5 - 5
- Greater than 5

NOTE
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Walker Corp for their specific use.

Contains PLB Images, https://maps.sa.gov.au/SAPPA/

N E S W

0 250 500 1,000 Meters

Coordinate System: GDA 1994 MGA Zone 54

1:25,000 at A3

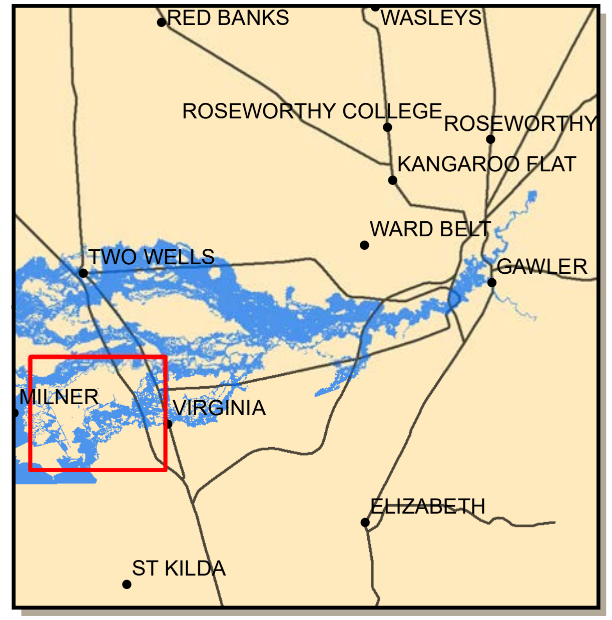
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Existing Conditions 1% AEP Depth

Riverlea Development Site

REFERENCE: A3L_wInset_Riverlea_Ex_1AEP_DEPTH

DATE: 28/10/2022 | SHEET: 1 of 1 | DRAWING NUMBER: 1



Legend

Depth, m

- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2.5
- 2.5 - 5
- Greater than 5

NOTE
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Walker Corp for their specific use.

DISCLAIMER
Walker Corp and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains PLB Images, https://maps.sa.gov.au/SAPPA/

N W E S

0 250 500 1,000 Meters

Coordinate System: GDA 1994 MGA Zone 54

1:25,000 at A3

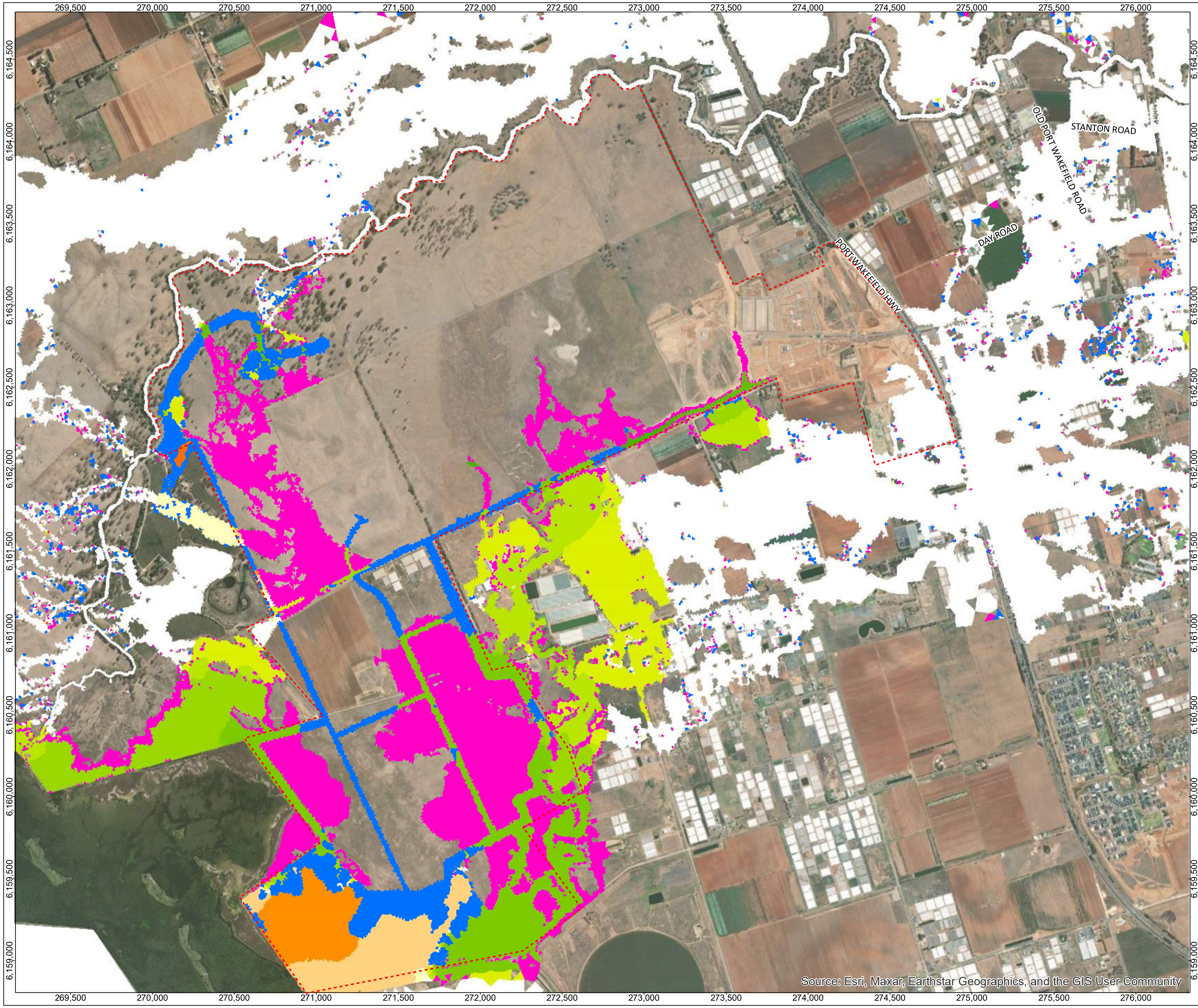
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

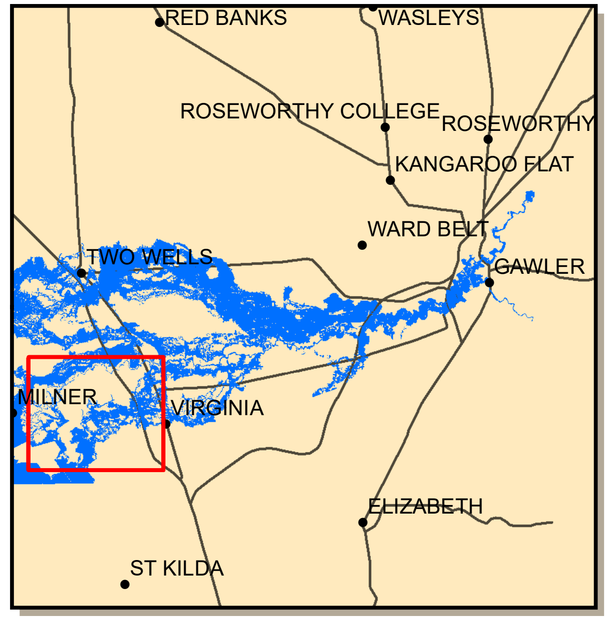
Developed Conditions 1% AEP Depth

Riverlea Development Site

REFERENCE: A3L_wInset_Riverlea_Dev_1AEP_DEPTH_v3

DATE: 28/10/2022 | SHEET: 1 of 1 | DRAWING NUMBER: 1





LEGEND

Difference in WSE, m

- Was wet, now dry
- \> 1m lower
- 50cm - 1m lower
- 20 - 50cm lower
- 10 - 20cm lower
- 5 - 10cm lower
- < 5cm lower
- No difference
- < 5cm higher
- 5 - 10cm higher
- 10 - 20cm higher
- 20 - 50 cm higher
- 50cm - 1m higher
- \> 50cm higher
- Was dry, now wet

NOTE
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Walker Corp for their specific use.

DISCLAIMER
Walker Corp and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains PLB Images, https://maps.sa.gov.au/SAPPA/

N W E S

0 250 500 1,000 Meters

Coordinate System: GDA 1994 MGA Zone 54

1:25,000 at A3

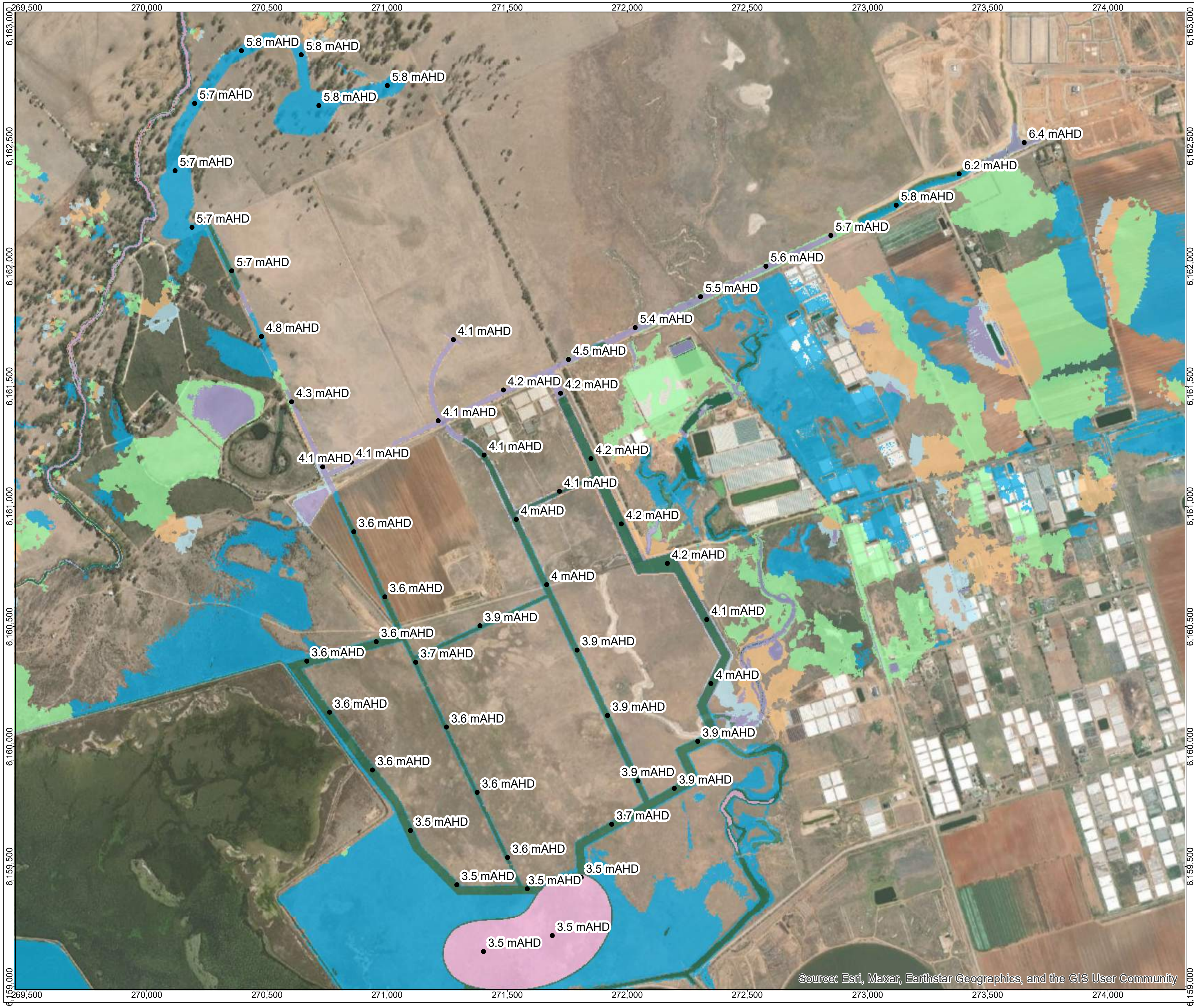
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Difference in flood levels (Dev-Ex) 1% AEP Depth

Riverlea Development Site

REFERENCE: A3L_wInset_Riverlea_Dev-Ex_1AEP_DIFF_v2

DATE: 31/10/2022 | SHEET: 1 of 1 | DRAWING NUMBER: 1



Legend

- • Water surface elevation at point

Depth, m

- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2.5
- 2.5 - 5
- Greater than 5

0 250 500 1,000 Meters

Coordinate System: GDA 1994 MGA Zone 54

1:17,000at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Developed Conditions 1% AEP Depth

Riverlea Development Site

REFERENCE: A3L_wInset_Riverlea_Dev_1AEP_DEPTH_v3_w_WSEpts

SHEET: 1 of 1

DRAWING NUMBER: 1

WALKER PTY LTD

RIVERLEA SALT WATER LAKES

ASSESSMENT OF THE IMPACT ON SALTWATER LAKES ECOLOGY

V1.1

COOE Pty Ltd   ABN 65 147 909 751

www.cooe.com.au | +61 8 8398 5090 | info@cooe.com.au

Document Information	
Client	Walker Pty Ltd
Project	Riverlea Salt Water Lakes
Document Title	Assessment of the Impact on Saltwater Lakes Ecology
Document Distribution Date	4/12/2023
Document Version	V1.1
File Name	WAL.RIV.002_SWL ecology_4Dec2023

Document Control

Version	Issue Date	Author/s	Reviewer/s	Date Reviewed	Amendment Type
V1.0	30/11/2023	Joe Mifsud	Patrick Mitchell	3/12/2023	Draft for client review
V1.1	4/12/2023	Joe Mifsud			

Distribution

Version	Issue Date	Copies, Format	Recipient/s
V1.0	30/11/2023	Soft copy via email	Patrick Mitchell
V1.1	4/12/2023	Soft copy via email	Patrick Mitchell

Document Owner

COOE Pty Ltd
ABN 65 147 909 751
PO Box 591
Littlehampton, South Australia, 5250
Tel: +61 8 8398 5090
Email: info@cooe.com.au | www.cooe.com.au

TABLE OF CONTENTS

FIGURES

TABLES

EXECUTIVE SUMMARY

This report provides a comprehensive analysis of the environmental implications of the Riverlea Saltwater Lakes (SWL) project, focusing on the effects on lakes ecosystem. The project involves constructing and operating strategically placed saltwater lakes to enhance urban amenity and mitigate flood risks, the Chapman Creek intake and Thompson Creek outflow. The report assesses various factors affecting water quality, including salinity, temperature, dissolved oxygen, pH, nutrient levels, turbidity, heavy metals, and toxicants.

The baseline assessment identifies potential ecological impacts, and the impact assessment explores stressors affecting plant and animal receptors in the SWL. The management of water quality is crucial for safeguarding the SWL ecology, considering both natural and anthropogenic factors. The proactive approach of Riverlea Development is highlighted through the implementation of a Lakes Management Plan, Lakes Operational Management Plan, and engagement of a Water Quality Specialist.

The establishment of sustainable saltwater lakes is outlined through initial monitoring, responsible construction protocols, gradual salinity adaptation, habitat enhancement, regular monitoring, and contingency plans for mass die-off events. The commitment to continuous improvement is evident in the long-term monitoring program and adaptive management strategies.

1. INTRODUCTION

Walker sought the expertise of COOE Pty Ltd (COOE) to assess the potential impacts of the proposed Riverlea Saltwater Lakes project on local ecosystems. This report is a response to concerns and specific requests regarding the environmental implications of the project, with a primary focus on its effects on the local flora and fauna. The project involves the construction and operation of the Chapman Creek intake and Thompson Creek outflow, both playing roles in the area's ecosystem, demanding careful consideration.

Our goal is to address the concerns and provide essential information related to the Saltwater Lakes (SWL) ecology. The Riverlea Saltwater Lakes project is designed to enhance urban amenity, utilising three Ornamental Saltwater Lakes strategically located within the floodplain. These lakes not only serve as a social gathering place but also contribute to visual amenity and recreational facilities.

The SWL project serves practical purposes such as receiving local stormwater and floodwater from to safeguard the property and infrastructure of the Riverlea development. Additionally, the use of fill material from the lakes aims to elevate surrounding blocks, mitigating sea level rise and flood risk. This approach reduces the environmental impact of importing fill and overall project costs.

The Chapman Creek and Thompson Creek are integral components of the local ecosystem. Our report aims to provide insights and practical solutions to ensure the project's sustainability while minimising adverse effects on the environment.

This report follows the impact assessment report of flora and fauna that may be impacted by the Riverlea development (COOE, 2023). This report is prepared as a standalone document.

1.1 Background

Riverlea Park, located approximately 30 kilometres north of the Adelaide CBD, has undergone significant development in recent years. The proposed modification to Precinct 2, introducing the saltwater lakes system, is drawing attention due to its potential impacts on the ecological balance within the locality.

Of specific concern are the Chapman Creek intake and Thompson Creek outflow, components of the local hydrological system. These water bodies play a vital role in managing stormwater and flooding from the Gawler River, while also sustaining the surrounding flora and fauna.

While the saltwater lakes project aims to enhance urban amenity and improve floodwater management, there's a growing awareness of its potential to disrupt the equilibrium of these waterways. This study is therefore dedicated to a comprehensive examination of how the project will influence the local environment, particularly focusing on Riverlea SWL ecology. The assessment aims to identify potential ecological disturbances and determine the necessary measures to safeguard the continued well-being of the SWL and the local ecosystem.

1.2 Relevant legislation and Guidelines

There relevant legislation within the scope for the SWL ecology and management are:

1.2.1 National Level

- Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act): Oversees matters of national environmental significance, including impacts on listed threatened species and ecological communities.
- Australian Fisheries Management Authority (AFMA) Regulations: The Riverlea project may have impacts on marine species.

1.2.2 State Level (South Australia)

- Planning, Development and Infrastructure Act 2016 : Governs planning and development approvals at the state level. The project has development approval under this act.
- Environment Protection Act 1993: Addresses pollution control, waste management, and environmental impact assessments.
- National Parks and Wildlife Act 1972 (NPW Act): aimed at the conservation of biodiversity, including the protection of native plants and animals. The saltwater lake ecosystem may impact areas with significant biodiversity and habitats for native species.
- Natural Resources Management Act 2004: Concerns the management and sustainable use of natural resources, including water.
- Native Vegetation Act 1998 (NV Act): Intended to protect native vegetation and vegetation clearance application.
- Fisheries Management Act 2007: Regulates fisheries in South Australia, which may be relevant depending on the impact on marine life.
- Water Industry Act 2012: Governs water supply and sewerage services because the project involves water extraction or discharge.

1.2.3 Local Council Level

- Local Environment Plans (LEPs): These plans may include specific environmental controls and requirements.
- Stormwater Management Regulations: because the SWL involves changes to stormwater runoff and relevant regulations must be followed.

1.2.4 Indigenous and Cultural Heritage Protection

- Aboriginal Heritage Act 1988: Relevant to the Riverlea project due to Aboriginal cultural heritage sites.
- Native Title Act 1993: Addresses native title issues, and engagement with Indigenous communities may be required.

1.2.5 Consultation and Approvals

- Public and Environmental Health Acts: to ensure compliance with health and safety standards, especially if the lake will be used for recreational purposes.
- Community Engagement and Consultation: projects require community consultation.

1.2.6 Outside scope of this study:

This study assumes that the Riverlea Development has engaged with the relevant authorities early in the planning stages to identify and address potential regulatory requirements and obtain the necessary approvals. This study was initiated by Walker to address concerns raised by some of these authorities and does not provide any legal opinion or claim the information provided fully complies with the legislation.

2. SITE DESCRIPTION

The Riverlea development spans an area of approximately 1,340 hectares, historically used for agriculture. The topography is characterised by a low-lying coastal plain, with the Gawler River to the north and Thompson Creek to the south. Geologically, it consists mainly of Quaternary sediments, with variations in soil composition and depth. Saline groundwater influences soil productivity in the southwest.

2.1 Climate

Adelaide experiences a Mediterranean climate characterised by hot, dry summers and mild winters. The city receives most of its annual rainfall between May and September, with an average of around 550 millimetres per year. Summers are marked by temperatures exceeding 30 degrees Celsius, occasionally leading to heatwaves, while winters are mild with temperatures ranging from 12 to 16 degrees Celsius. Evaporation rates are high during the warm summer months, and the region is susceptible to drought conditions. Adelaide's climate features a distinct wet season in winter and a dry season in summer, with the surrounding Gulf of St Vincent influencing temperature moderation.

2.2 Hydrology

Hydrologically, the Gawler River and Thompson Creek are the main drainage sources. The Gawler River, a perched system, controls surface water hydrology. Stormwater runoff is directed southwest towards the Thompson Outfall Channel. The proposed development includes three main catchment areas, with plans for stormwater quantity management, including the saltwater lakes for the central catchment.

The central catchment, covering 412 hectares, involves a 40.4 ha lake with a 250,000 m^3 storage volume. Discharge during extreme events may flow to Thompson Creek and then to the Thompson Outfall Channel. Other catchment areas include the southern catchment (302 hectares), where runoff will be diverted through parkland corridors, and the eastern external catchment (161 hectares), draining via approved channels to Thompson Creek. Overall, the development aims to manage stormwater effectively across the diverse landscape of the site.

Groundwater levels and drainage around the lakes contribute to the overall impact assessment of the salt lakes on the environment, considering the interplay between groundwater levels, drainage systems around the lakes, and the intended water levels of the lakes themselves.

2.2.1 Groundwater Levels

The site's topography influences groundwater levels, especially in the southwest portion where saline groundwater tables affect soil profiles. As the land descends below 10 m AHD toward the southwest, saline groundwater becomes a factor, impacting soil productivity potential. In areas where the land drops to low-lying coastal flats, associated with saline water courses, poorly drained soils and shallow saline water tables are observed. This leads to recognisable land salinisation, either as saline subsoils or surface seepage, with the presence of salt-tolerant vegetation.

2.2.2 Drainage Around the Lakes

The proposed development outlines a comprehensive stormwater management plan (BMT, February 2022). The lakes occupying around 40.4 ha within the Central Catchment, with a 250,000 m^3 storage capacity, will also provide detention storage for the southern and eastern areas. During extreme events, discharge can occur from the lakes to Thompson Creek and then to the Thompson Outfall Channel.

2.3 Salt Water Lakes

The proposed Riverlea Concept Plan includes a saltwater lakes system (SWL) comprising a total surface area of over 40 hectares once fully completed. Walker intends to stage the construction of the saltwater lakes system over approximately 15 years, with each phase delivered at about 5-year intervals. Each phase of the SWL is designed to operate independently of one another.

The Riverlea salt water lakes (SWL) will be excavated, and the spoil used to elevate the residential areas for protection from 1:100 year flood levels and the projected sea level rise. The excavation will be lined with a 500 mm compacted clay liner to separate the lakes from groundwater. The lakes water level will be 0.6 m below standing groundwater to reduce the risk of seawater entering the groundwater. Storm water from the central catchment of Precinct 2 will run into the SWL during rain events after passing through the stormwater treatment devise (BMT, February 2022).

The lakes will be built in three Phases over a period of 15 years and designed for a total water holding capacity of 1,110 ML.

- Phase 1 will hold 408 ML
- Phase 2 will hold 386 ML (combined volume to end of Phase 2- 794 ML)
- Phase 3 will hold 318 ML (combined volume of all lakes- 1,110 ML).

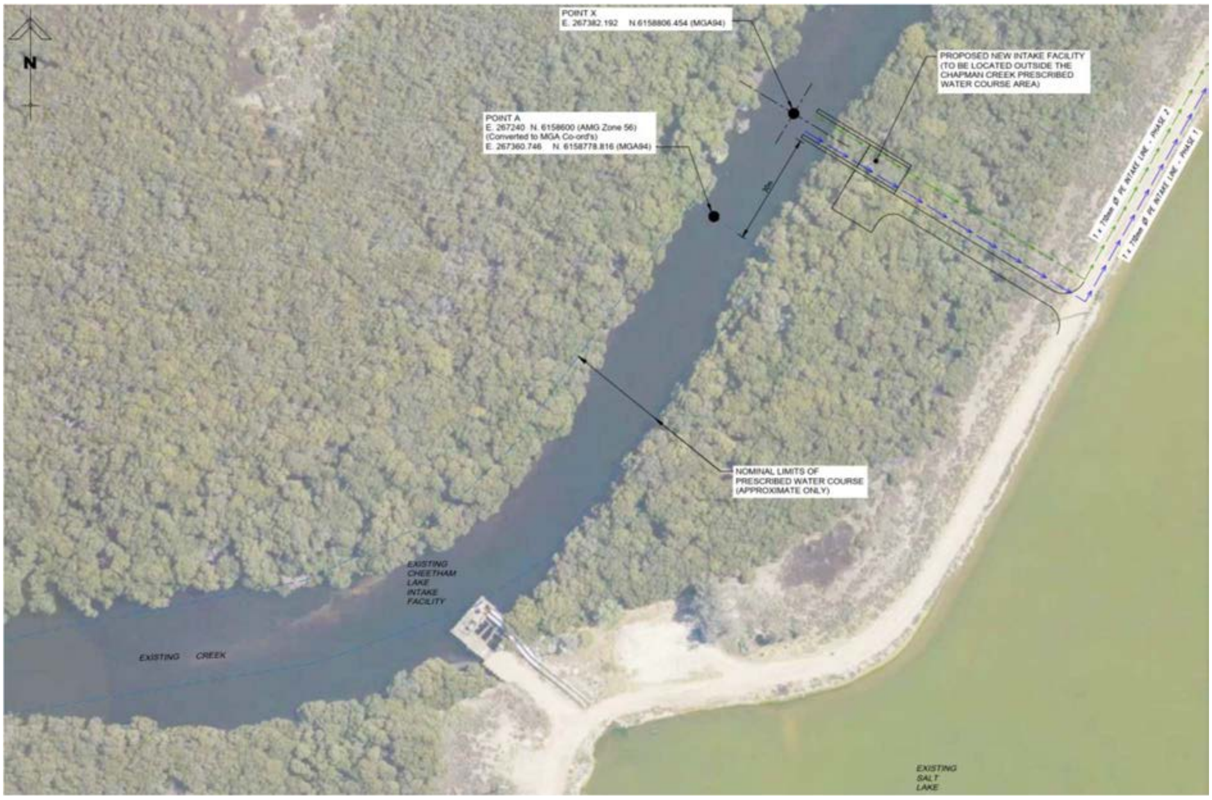
To achieve a 40 day lake turnover period the cumulative volume of water required per day will be 10.2 ML/day in Phase 1, 19.9 ML/day in Phase 2 and 27.8 ML/day thereafter.

A conceptual engineering design of the Riverlea SWL circulation system (WSP, Februry 2022) proposed submersible pumps, one pumping at 240 L/s for phase 1 and 640 L/s (using 2x 320 L/s pumps) for phase 2 and phase 3. These pumps will meet the required daily volumes in around 12 hours of pumping.

During the operational phase flowmeters will be used to monitor seawater abstraction volumes and reported to the EPA. Cleaning and maintenance of pipelines to remove significant marine growth in the first 100m or so of pipeline will be managed via a number of ways, including Pigging and Chemical dosing. Pump removal for inspection and maintenance will require a hard stand for a crane.

2.4 Seawater Intake structure

The proposed Riverlea seawater intake structure will be located upstream of the Cheetham Lake intake facility and outside the prescribed water course defined for the creek, Figure 1.



(BMT, February 2022)

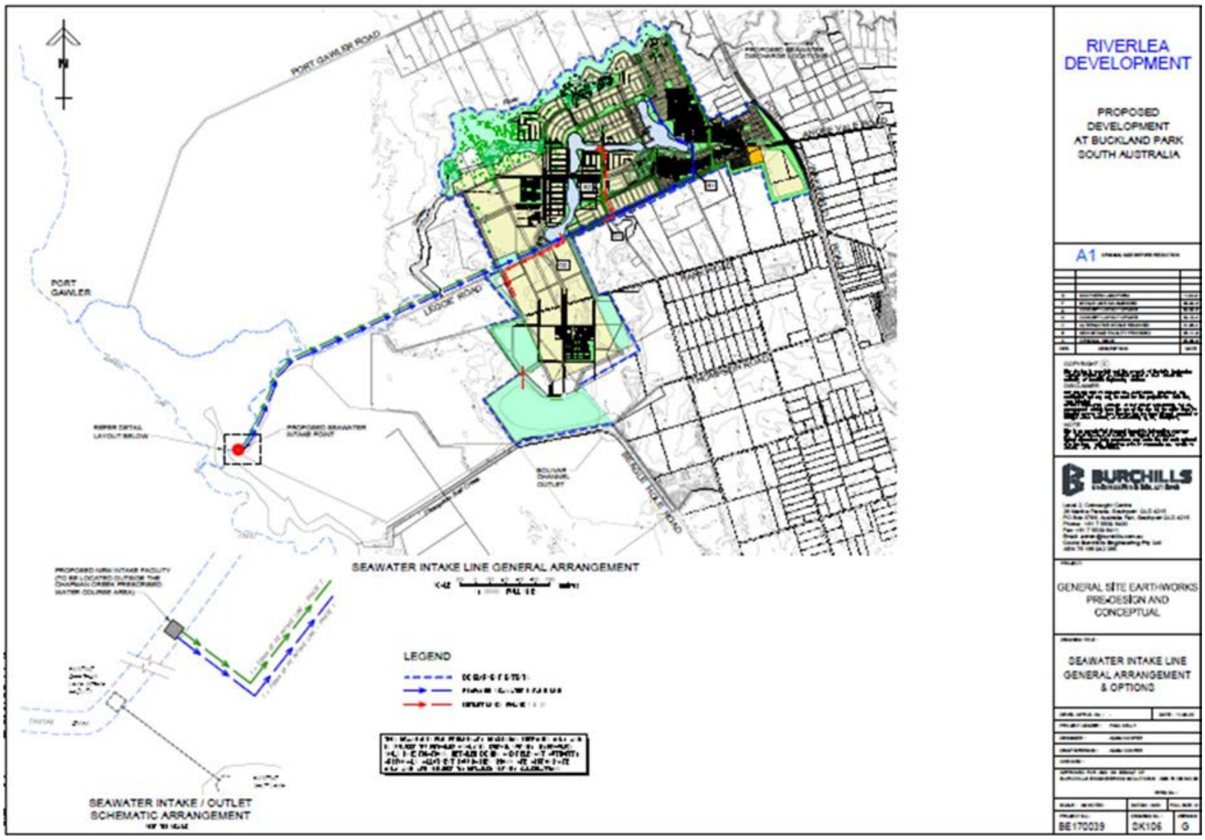
Figure 1. Seawater intake location upstream of Cheatham Lake intake for the Riverlea SWL

Based on the conceptual plan in Figure 1, the intake structure will require a permanent area to support the pump, power supply and a hard pad for ongoing maintenance. It is estimated that during construction a vegetation clearance area of around 600 m^2 will be required, the proposed site comprises of low dense mangal woodland habitat. Annual or more frequent pipe maintenance will be required to remove marine growth, the use of pigging and chemical dosing will require careful management to minimise periodic impacts on the receiving environment.

The seawater inflow pipelines will cross the access track to the edge of the Cheetham Salt Fields as shown in Figure 1 and travel along the infrastructure access corridors and via Legoe Road to the Riverlea SWL, Figure 2. Clearance of vegetation along these corridors will be required to lay the seawater pipeline, vegetation appears to be highly degraded in this corridor; a detailed survey of vegetation will be required to confirm this observation.

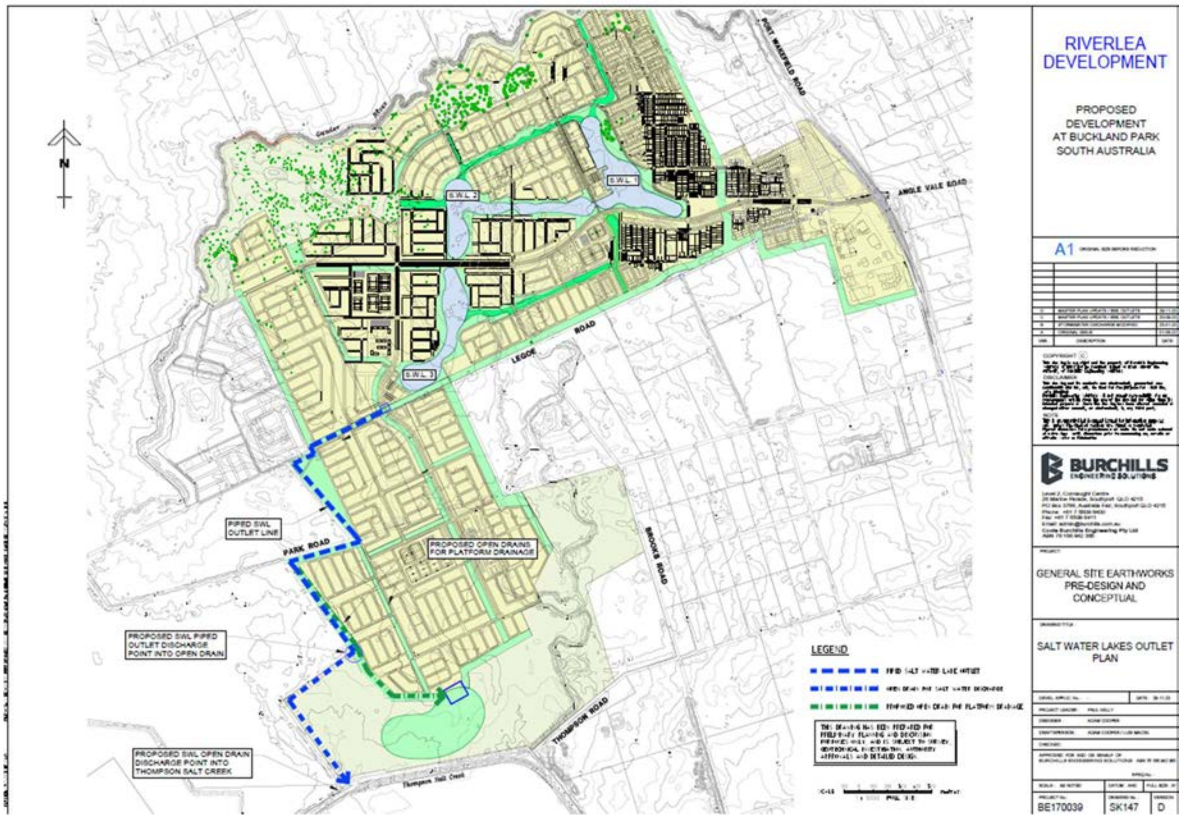
2.5 Discharge from the Saltwater Lakes

Overflow from the SWL will be discharged into the Thomson Creek Outfall Channel via a system of pipes and open drains Figure 3. The Thompson Creek outflow channel merges with the Bolivar Channel which contains treated effluent from the Bolivar Wastewater Treatment Plant.



(WSP, Februry 2022)

Figure 2. Seawater inflow access corridor to the Riverlea SWL



*Site plan provided by Riverlea Development 29 Nov 2023

Figure 3. Discharge from the Lakes

2.6 Baseline Assessment for Riverlea Project

The Baseline Assessment for the Riverlea Project involved comprehensive flora and fauna surveys in areas potentially affected by the project. EBS Ecology conducted additional assessments, leading to the preparation of a Flora and Fauna Management Plan (FFMP) for Precinct 2 (Walker, 2023). The survey identified Rohrlach's Bluebush as a potentially present rare species. Seventeen bird species were observed in Precinct 2 in 2022.

For the Buckland Park Intake Pipeline, EBS Ecology prepared a Native Vegetation Clearance Data Report, identifying and mapping four native vegetation associations. The Threatened Species Assessment revealed the presence of a Subtropical and Temperate Coastal Saltmarsh ecological community, with proposed removal of 0.42 ha of vegetation.

Habitat Description highlighted diverse ecosystems, including samphire, mangrove, and cyanobacterial mat in coastal areas, and unconsolidated substrate and seagrass in subtidal habitats.

Seawater inflow and outflow corridors were assessed, expanding the NatureMaps database search to include Thompson Creek. The proposed seawater intake pumping station and outflow channels were detailed (EBS, 2022).

The Threatened Species Assessment identified the Subtropical and Temperate Coastal Saltmarsh as a threatened ecological community. State and territory reserves were also identified, and a total of 44 listed threatened species and 62 migratory species were potentially occurring in the Pipeline corridors (COOE, 2023).

The South Australian Government NatureMap database was consulted to identify historic flora and fauna observations within the pipeline corridor. Of the recorded species, none were classified as threatened. Fauna recorded consisted of 163 species, including critically endangered and vulnerable species (COOE, 2023).

These assessments provided a comprehensive understanding of the ecological landscape, potential impacts on flora and fauna, and measures to mitigate adverse effects in the Riverlea Project area, especially around the Buckland Park Intake Pipeline and the seawater inflow and outflow corridors. The report emphasises the importance of preserving threatened species and maintaining ecological balance during project development.

2.7 Potential Ecology in the Riverlea Salt Water Lake

To evaluate the impact on the proposed SWL ecology a further literature review was undertaken to investigate potential marine flora and fauna that may establish in the Riverlea SWL.

In evaluating the potential of the SWL to disrupt the natural waterways and marine ecosystem, this study undertook a comprehensive literature review of marine flora and fauna in the local creek estuaries and the adjacent salt lakes that form a part of the Dry Creek salt mine.

2.7.1 Flora and fauna within the seawater inflow and outflow corridors

The proposed seawater intake pumping station will be located north of the mouth of Cheetham saltfields intake structure and via buried pipelines along Legoe road to the SWL, Figure 4 (in green). The outflow from the SWL will traverse along Legoe Road in a piped system following the western boundary of Riverlea until flowing into an open channel to Thompson Creek, Figure 4 (in orange).

Site plan provide by Riverlea Development, 23 November 2023, overlay on Google Maps Pro, not geo referenced.

Figure 4. SWL and reticulation system

2.8 Marine fauna that may establish in the Riverlea SWL

The salt evaporation ponds, forming a diverse range of low and moderate hypersaline ponds to the west of the Riverlea Development, sustain a thriving ecosystem. This environment supports various species of fish, molluscs, and plankton, including the larval stages of brine flies. Such ecological diversity makes these ponds a vital food source for shorebirds. Notably, the salt evaporation ponds stretching from St Kilda in the south to the Gawler River at Port Gawler in the north have been identified as hosting a significant concentration of shorebirds and waterbirds, with reported peaks exceeding 16,000 birds in the shallower and more saline ponds, as documented in the Program for Environment Protection and Rehabilitation (PEPR) for the Dry Creek Saltfields (BDC, 2020).

In 2004, the Mining and Rehabilitation Program conducted an extensive survey of fish in the Dry Creek Saltfields, revealing the presence of over 34 different species of fish (Coleman & Cook, April 2009). These species, detailed in Table 1, span the salt fields and their immediate surroundings.

Table 1. Dry Creek Saltfields Fish Diversity

Species name	Common name	Species name	Common name
Acanthopagrus butcheri	Black Bream	*Platycephalus laevigatus*	Rock Flathead
Pseudogobius sp. 9	Bluespot Goby	*Myxus elongatus*	Sand mullet
Arenogobius bifrenatus	Bridled Goby	*Callogobius mucosus*	Sculptured Goby
Gymnapistes marmoratus	Cobbler/Soldier	*Atherinosoma microstoma*	Smallmouth Hardyhead
Pseudaphritis urvillii	Congolli	*Chrysophrys auratus*	Snapper
Christiceps australis	Crested Weedfish	*Hyporhamphus melanochir*	Southern Garfish
Kaupus costatus	Deepbody Pipefish	*Favonigobius lateralis*	Southern Longfin Goby
Platycephalus fuscus	Dusky Flathead	*Scorpaena ergastulorum*	Southern Red Scorpionfish
Arripis truttaceus	Australian Salmon	*Platycephalus bassensis*	Southern Sand Flathead
Trygonorrhina fasciata	Eastern Fiddler Ray	*Sillago bassensis*	Southern School Whiting
Pelates sexlineatus	Eastern Striped Grunter	*Argyrosomus hololepidotus*	Mulloway
Mughil cephalus	Flathead/Sea mullet	*Stigmatopora argus*	Spotted Pipefish
Liza argentea	Goldspot Mullet	*Assorted*	Toadfish
Rhombosolea tapirina	Greenback Flounder	*Stigmatopora nigra*	Widebody Pipefish
Sillaginodes punctata	King George Whiting	*Aldrichetta forsteri*	Yelloweye Mullet
Gambusia affinis	Mosquitofish	*Sillago schomburgkii*	Yellowfin Whiting
Enoplosus armatus	Old Wife	*Girella zebra*	Zebrafish

(Coleman & Cook, April 2009)

The composition of fish in the northern salt lake ponds (north of Shellgrit Road) was surveyed using a fyke net, resulting in the capture of 141 fish, with an additional two individual fish caught by line, as detailed in Table 2 (BDC, 2020). The captured fish from the northern salt lake ponds include six identifiable species: smallmouth hardyheads, gobies, mullet (yellow-eye and gold spot), Australian salmon, and a solitary rock flathead.

It is anticipated that the composition of fish species in these northern salt lake ponds closely mirrors that of the Riverlea SWL marina due to the expected similarity in salinity levels between the two environments.

Of particular note, smallmouth hardyheads were the most commonly caught fish. These small fish are prevalent in saline lagoons in southeastern Australia, such as the Coorong, where they feed on small planktonic and benthic invertebrates. Remarkably, they exhibit breeding tolerance across a wide salinity range, from 9 g/L to 94 g/L in the Coorong. Recognised as one of the most salinity-tolerant species globally, smallmouth hardyheads serve as a crucial prey species for piscivorous birds (Molsher, Geddes, & Paton, 1994). Other fish also present in the Coorong at high salinities include yellow-eye mullet, congolli, and blue spot goby (Molsher, Geddes, & Paton, 1994).

Table 2 presents the details of the fish caught in September 2013 at the Dry Creek (northern) Saltfields, including scientific names, common names, the number caught, and size measurements.

Table 2. Fish caught September 2013 at the Dry Creek (northern) Saltfields

Scientific name	Common name	Number caught	Size, mm		
			Mean	Min	Max
Atherinosoma microstoma	Smallmouth hardyhead	130	4.3	2	6.9
Pseudogobius oolorum	Goby	5	5.6	4.5	7.0
Liza argentea	Goldspot mullet	4	25	3.5	36
Aldrichetta forsteri	Yelloweye mullet	2	44	41	46.5
Arripis truttaceus	Western Australian salmon	1	57	57	57
Platycephalus laevigatus	Rock flathead	1	61	61	61

(BDC, 2020)

2.8.1 Potential Ecosystem in the SWL

The current plan for the Riverlea Development includes utilising the lakes as a stormwater management system with aesthetic features aimed at enhancing the overall appeal of the planned urban development.

The proposed SWL are intended to draw seawater from Chapman Creek, a habitat for native fish and crustaceans. This creek is also part of the St Kilda-Chapman Creek Aquatic Reserve. As the lakes draw seawater, it is anticipated that various macrofauna and propagules from marine plants and animals will be introduced, including seeds from seagrass, spores from seaweed, larvae or juvenile crustaceans, and fish eggs, larvae, or fry.

The composition of specific macrofauna in the lakes is expected to vary seasonally, influenced by tides and the overall health of the estuarine ecosystem. Filamentous brown algae of the Genus *Giffordia* are likely to establish soon after filling of the Lakes. Filamentous green Enteromorpha, large green algae (*Codium* sp and *Ulva lactuca*) and a red algae (*Hypnea* sp) are likely to establish within the first twelve months based on observations of the Dry Creek Saltfields (Coleman & Cook, April 2009). The seagrass *Ruppia* spp may also establish in the lakes providing a food source for fish and crustacea.

The Chapman Creek estuary is likely to host a variety of species, including bivalve molluscs (mussels and cockles), crustaceans (crabs, shrimps, mud crabs, blue crabs, and amphipods), polychaete worms, fish (such as juvenile mullet, flathead, and various gobies, see Table 2), annelid worms (like lugworms and ragworms), amphibious insects (water beetles and water bugs), and echinoderms (sea stars and sea cucumbers).

Section 2.8 provided insights on the likely fish species migrating into the lakes based on surveys conducted in the northern Saltfields, where salinities are anticipated to be similar to those in the

Riverlea SWL. The establishment of marine life in the Riverlea Lakes will be primarily influenced by the physical and water quality conditions prevailing at the time these organisms enter the lake.

2.8.2 Establishment of a Steady State Ecosystem in the SWL

During the construction phase, the Lakes will be filled with seawater sourced from Chapman Creek. As the lakes lack physical features conducive to settlement, such as designed aggregation structures or marine substrates, the establishment of marine flora and fauna will be opportunistic and inherently unstable until some rudimentary habitat is developed or an equilibrium in the lake system is achieved. The primary determinants shaping the establishment of marine life in the lakes are the diurnal and seasonal patterns of water temperature, salinity, pH, and nutrient levels.

Marine organisms have the capability to colonise artificial structures submerged in seawater, such as concrete, steel, and plastic. These structures can serve as habitat, food sources, and shelters for a variety of species, including algae, corals, sponges, molluscs, crustaceans, fish, and birds. However, it is crucial to acknowledge that artificial structures can also pose challenges to marine ecosystems, potentially altering natural hydrodynamics, sedimentation, light, temperature, and salinity of the water. They may introduce invasive species, pollutants, and pathogens, and disrupt the connectivity and diversity of native species.

The man-made lakes, lined with clay liners and filled with seawater from a marine/estuarine ecosystem, can be considered a form of artificial marine habitat. The clay liners are employed to prevent seawater leakage into the surrounding soil and groundwater, ensuring the maintenance of water quality and salinity within the lake.

The colonisation of marine organisms in these lakes is contingent on several factors, including the source, quantity, and frequency of seawater input, the size, shape, depth, and substrate of the lake, the presence and type of vegetation, exposure to sunlight and wind, and the disturbance and management of the lake (Kingsford, 2023).

2.9 Water Quality in the SWL

Several natural and anthropogenic (human-caused) factors will drive the water quality of the proposed SWL. Water circulation patterns, influenced by wind and lake morphology, affect the distribution of temperature, oxygen, and nutrients. Ambient temperature, wind, precipitation and evaporative losses are seasonally dependent (Section 2.1). The Lakes are not connected tidally to the sea water levels and flow through the lake system is dependent on the pumping rate, direct rainfall interception and run-off from the Percent 1 and 2 catchments.

Walkers have implemented a baseline water quality monitoring program to track the variation in water quality around the intake and discharge points over several seasons. A good understanding of the seasonal and diurnal fluctuation on natural marine water quality will provide management tools for monitoring and maintain key environmental water quality parameters.

This assessment of the lakes' ecology is based on the water quality monitoring undertaken by ALS Hydrographics and the report summarising the data for eighteen months, between March 2022 and September 2023 (Water Engineering Plus, October 2023). The monitoring sites are shown in Figure 5.

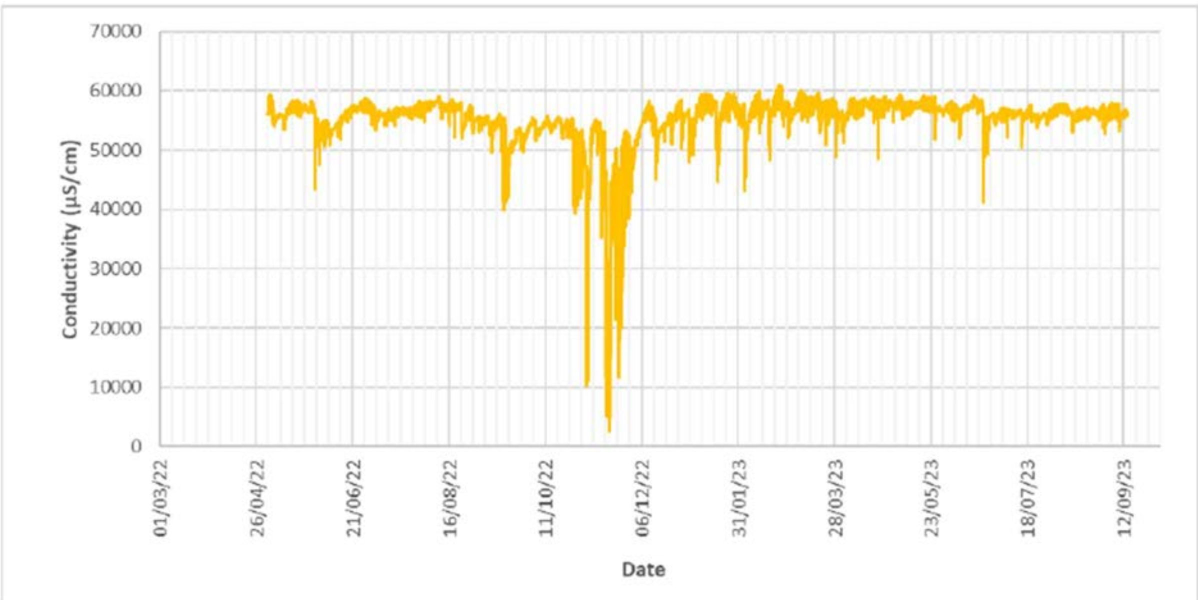
Figure 5. Water Quality Monitoring Stations for the Riverlea SWL intake and discharge system

The Australian Government has derived physical and chemical stressor default guideline values (DGVs) for marine water on a bioregion scale. In this discussion the DGV for slightly to moderately disturbed systems are based on either 80th or 20th percentiles of minimally impacted reference-site data will be used for the St Vincent Gulf bioregion, to provide high level guidance on the management of the proposed saltwater lakes (Australian Government Initiative, 2023)

2.9.1 Salinity:

Salinity levels are critical for assessing the compatibility of the water with saltwater-tolerant flora and fauna. It is essential to ensure that salinity remains within the acceptable range for the species that are likely establish within the SWL and the receiving environment.

The electrical conductivity data of potential seawater from the proposed Intake in Chapman Creek, shows that the intake location is strongly influenced by rain events, one such event occurred in November 2022, Figure 6 (Water Engineering Plus, October 2023). y.



* as reported by ALS Hydrographic it is assumed that the conductivity is normalised to 25 °C

Figure 6. Conductivity data at site 6 near the proposed Chapman Creek seawater intake structure

It is important to note that salinity levels can fluctuate naturally in estuarine environments due to tidal influences and other factors. Sudden or extreme changes in salinity can occur during flood events and this can stress or harm estuarine organisms, emphasising the importance of maintaining a stable and suitable salinity range for the well-being of the lake ecosystem.

2.9.2 Temperature:

Water temperature influences the metabolic rates and behaviours of aquatic organisms. The water temperature within the SWL is likely to increase during summer, increases by 2°C are generally considered as potentially detrimental to the lakes ecosystem. When pumping water into the lake it is important to regulate the pumping rate to ensure that the temperature variation stays within plus or minus 2°C of the Lake Water temperature.

Baseline seawater temperatures are currently being monitoring in Chapman Creek near the proposed pumping station, the data will inform pumping regimes to regulate lake water temperature.

2.9.3 Dissolved Oxygen (DO):

Sustaining optimal levels of dissolved oxygen is critical for the survival of aquatic organisms. Various factors, including temperature, salinity, and the presence of aquatic plants, can influence DO levels. Water bodies draw oxygen from the atmosphere, with moving water, mixing, or wave action enhancing oxygen dissolution compared to stagnant water. Aquatic plants further contribute to increased oxygen concentration.

DO concentration requirements vary among plants and animals in marine environments, as different species have adapted to thrive within specific ranges. Most marine and estuarine organisms require levels between 4 and 6 mg/L for survival.

Continuous remote monitoring at the Chapman Creek Intake (Site 6) reveals fluctuating dissolved oxygen levels from 0 to around 20 mg/L between January and March 2023. While concentrations may seem high, it is the lower levels of dissolved oxygen that pose greater concern for fish and crustaceans within the SWL.

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 trigger values suggest that DO saturation should be around 90% (EPA, June 2021). It's important to note that dissolved oxygen levels can fluctuate due to factors such temperature changes, and organic matter decomposition.

The DGV for DO is between 5.283 mL/L in autumn and 5.569 mL/L is winter (Australian Government Initiative, 2023). Contributing factors to low DO conditions include:

1. High nutrient inputs from urban runoff, which stimulate algal blooms and organic matter production. Decomposing organic materials sink, consuming oxygen from the Lake waters.

2. High water temperatures in summer, reduce oxygen solubility and increase metabolic rates of organisms. Warmer water stratifies the water column, preventing the mixing of oxygen-rich surface waters with oxygen-poor bottom waters.

3. Limited flushing and water exchange with the ocean, impeding oxygen replenishment in the Lakes. A proposed 40 day residence time will initially be implemented.

The repercussions of low DO conditions in the Lakes extend to the marine life and the ecosystem services they provide, such as fisheries, tourism, and biodiversity. Observed or potential effects of reduced DO include:

- Reduced growth, reproduction, and survival of fish and invertebrates, especially those that are sensitive to low oxygen or with limited mobility.
- Altered community structure and trophic interactions, favouring more tolerant or opportunistic species like jellyfish, worms, and bacteria.
- Changes in biogeochemical cycles and water quality, leading to increased production of greenhouse gases (carbon dioxide and methane), acidification, and eutrophication.

Monitoring and managing the DO levels in the SWL are crucial to ensure the sustainability and resilience of the marine life and the associated ecosystem services.

2.9.4 Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD):

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are water quality parameters that indicate the amount of oxygen required by microorganisms to break down organic matter in water. The impact of BOD and COD on aquatic flora and fauna is related to DO concentrations and can lead to both short-term and long-term consequences:

High BOD levels indicate the presence of organic pollutants that require oxygen for decomposition by bacteria. As microorganisms break down this organic matter, they consume dissolved oxygen in the water. The reduction in dissolved oxygen can be harmful to aquatic organisms that rely on oxygen for respiration.

Similarly, COD measures the overall oxygen demand resulting from both organic and inorganic pollutants. High COD levels suggest a greater demand for oxygen, which can lead to a reduction in dissolved oxygen concentrations.

Impact on Aquatic Organisms

Excessive BOD and COD levels can lead to the growth of oxygen-consuming bacteria, algae, and other microorganisms. Algal blooms, fuelled by nutrient-rich organic matter, can shade out submerged aquatic plants and disrupt the balance of the aquatic ecosystem.

Fish and other aquatic organisms may experience stress or mortality in low-oxygen conditions. Species with higher oxygen requirements or those unable to adapt to lower oxygen levels may be particularly vulnerable.

Alteration of Ecosystem Structure

Elevated BOD levels can alter the balance of the aquatic ecosystem by favouring the growth of certain bacteria over others. This can lead to changes in nutrient cycling, impacting the availability of resources for both flora and fauna.

The composition of pollutants contributing to COD can vary, and certain chemical compounds may have toxic effects on aquatic life, leading to changes in the abundance and diversity of species.

Long-term Consequences

Chronic exposure to high BOD and COD levels can result in the degradation of aquatic habitats over time. This degradation may lead to the decline or loss of sensitive species, impacting the overall biodiversity of the ecosystem.

Eutrophication

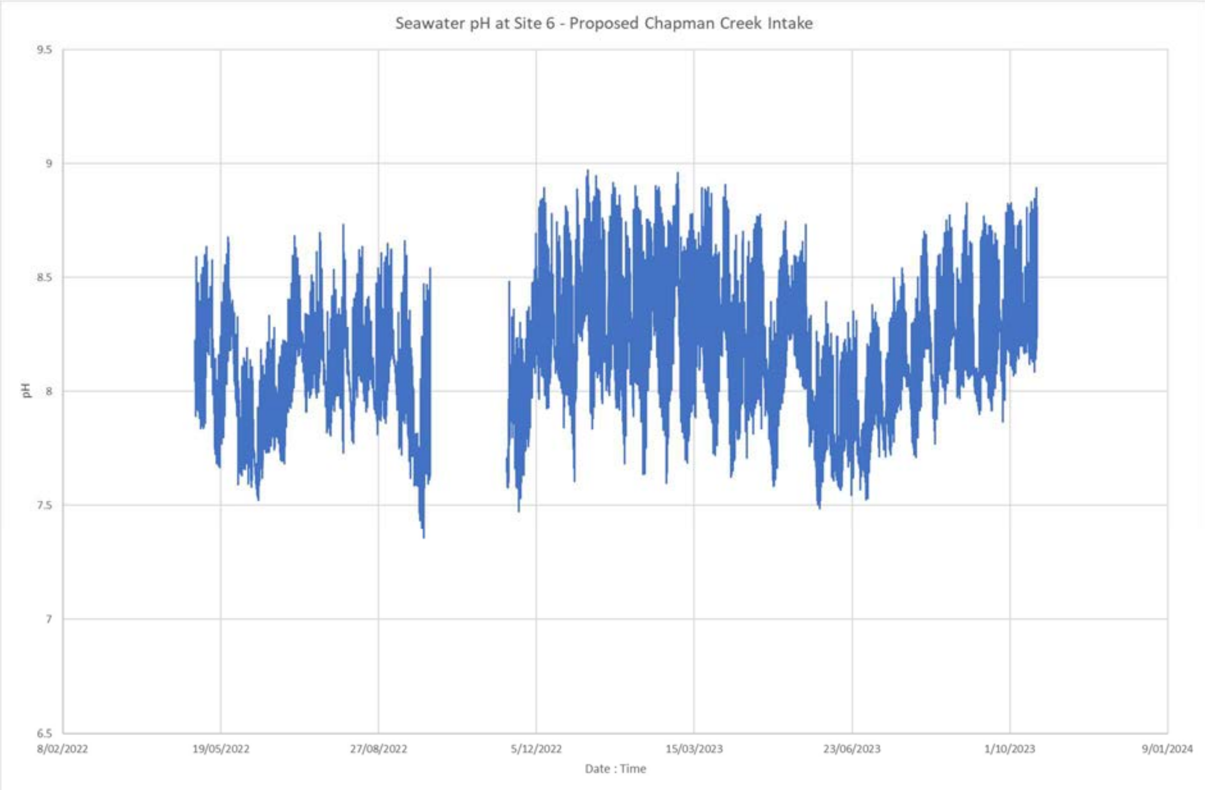
Elevated levels of organic matter from BOD and COD can contribute to eutrophication, a process where excessive nutrients lead to increased plant and algae growth. This, in turn, can lead to oxygen depletion as these plants and algae decay, further impacting aquatic organisms.

To mitigate the impact of BOD and COD on aquatic flora and fauna, it is crucial to implement effective wastewater treatment practices, manage nutrient inputs, and promote sustainable water management strategies. Monitoring and regulating BOD and COD levels are essential for maintaining the health and balance of aquatic ecosystems.

2.9.5 pH (Acidity/Alkalinity):

The pH of the water affects the solubility of nutrients and metals, influencing the overall health of aquatic ecosystems. Fluctuations outside the optimal pH range can impact the survival and reproduction of aquatic organisms. Seawater pH is usually highly buffered in the natural marine environment.

The pH and alkalinity of the lake water is mainly dependent on the water pumped in from Chapman Creek, although the geological characteristics of the lake basin, the clay liner, can influence the pH. Figure 7 shows that the pH range in Chapman Creek is between 7.8 and 8.6. It is recommended that pH be monitored to avoid pH stress on any organisms that establish in the SWL and the receiving environment in Thompson Creek. If monitoring indicates the need to control seawater pH a water treatment plant will be able to regulate the pH to the required range.



Data for this graph was provided by ALS Hydrographics

Figure 7. Seawater pH in Chapman Creek proposed intake location

2.9.6 Nutrient Levels (Nitrogen and Phosphorus):

Nitrogen (N) and phosphorus (P) are essential building blocks for plant and animal growth. Nitrogen is an integral component of organic compounds such as amino acids, proteins, DNA and RNA. Phosphorus is found in nucleic acids and phospholipids (OzCoasts, 2023). Monitoring nutrient levels is important to prevent eutrophication, which can lead to algal blooms and oxygen depletion. Excessive nutrients can negatively impact water quality and the balance of the ecosystem.

The seawater intake location in Chapman Creek exhibits low nutrient pollution. The median nitrogen concentrations stand at 0.6 mg/L at the creek's mouth (Site 1) and median phosphate concentrations at 0.1 mg/L. These median values hover around the ANZECC trigger values for SA of 1.0 mg/L for total nitrogen and 0.1 mg/L for total phosphates.

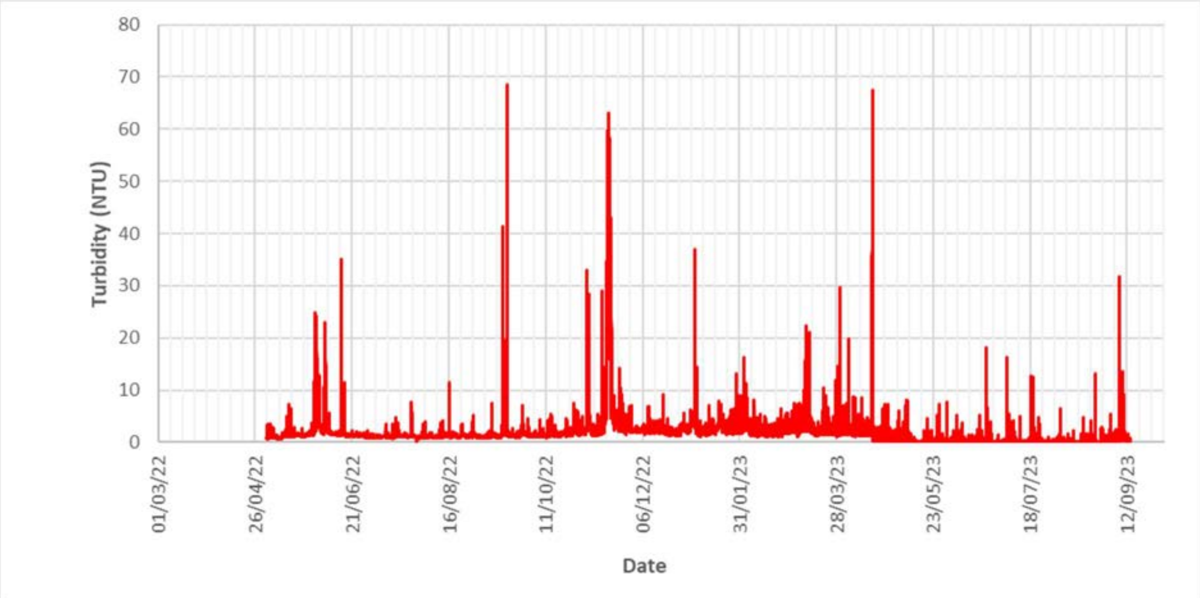
The nutrient levels at the intake point suggest a potential risk of nutrient build up in the SWL leading to algae blooms and eutrophication, which could lead to fish kills and unpleasant odours. Riverlea Project has noted the high levels of nutrients in Chapman Creek water and has engaged a water treatment expert company to develop a plan to treat seawater at the intake prior to release in the lakes (Mitchell, 2023).

It is recommended to closely monitor pumping times and conduct regular water quality testing for nutrients in the intake waters and Chlorophyll a, a surrogate or indicator of the nutrient status in the SWL.

2.9.7 Turbidity and Total Suspended Solids

Turbidity measures the cloudiness or clarity of the water and can affect light penetration. Changes in turbidity may impact the growth of aquatic plants and the visual hunting abilities of some fauna.

Turbidity monitoring at the proposed seawater intake location was between 0 and 68 NTU during the monitoring period between April 2022 and September 2023, with a median of 1.4 NTU (Water Engineering Plus, October 2023). The recorded values are consistent with the low suspended solids readings with the occasional spikes as would be expected after a storm event.



(Water Engineering Plus, October 2023)

Figure 8. Turbidity records at the proposed Riverlea seawater intake station

The monitored results for suspended solids and turbidity are relatively low and are not expected to pose an issue with respect to SWL water quality.

Total suspended solids (TSS) measurements can indicate the presence of sediment in the water, which may affect light penetration, habitat quality, and the feeding behaviour of aquatic organisms. Monitoring of TSS is being undertake at six locations (Figure 5). The data showed considerable fluctuations.

TSS concentrations in Chapman Creek, were generally at low levels with occasional spikes particularly in 2023. Water Engineering Plus suggested that there may be an association of the elevated TSS values with local runoff events, but advised caution in interpreting the data, especially in relation to recorded rainfall (Water Engineering Plus, October 2023).

Sediment resuspension and deposition are influenced by lake currents and human activities. Sediments can act as a sink for nutrients and pollutants, influencing water quality.

Elevated TSS in the SWL, particularly after a storm event, may be indicative of stormwater management issues within the catchment but natural resuspension of sediments can be indicative of sedimentation on the lake bed and the potential for the release of nutrients and other [pollutants entrained the sediments.

2.9.8 Heavy Metals:

Monitoring concentrations of heavy metals is crucial, as these pollutants can accumulate in organisms and pose a risk to both flora and fauna. Riverlea has been monitoring water quality since 10 March 2022. The water quality report, particularly focusing on heavy metals, suggests that the concentrations of various heavy metals in the sampled water are consistently below the guideline values for recreational use (Water Engineering Plus, October 2023).

The concentrations of heavy metals (Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Zinc, and Mercury) from March 10, 2022, to September 13, 2023, are compared to the ANZECC guideline values for recreational purposes.

The water quality monitoring indicates that the concentrations of heavy metals in the sampled water are consistently below guideline values for recreational use. This suggests that heavy metals are not expected to pose a significant threat to the flora and fauna in the Riverlea development area.

An environmental audit undertaken by ERM in 2012 indicated the presence of elevated concentrations of molybdenum, fluoride, nitrate and selenium identified in groundwater beneath the Stage 1 development area were considered to be related to regional groundwater quality (LBWco, October 2022).

The presence of fluoride, nitrate and selenium identified in groundwater under Precent 1 is not expected to contaminate the SWL as there is no clear connective pathway. However, it is recommended that regular monitoring for such heavy metals and pollutants in the SWL is essential to identify and mitigate potential sources of contamination. The presence of fluoride, selenium and molybdenum in the SWL may indicate a breech in the clay lining.

2.9.9 Toxicants and Pollutants:

Toxicants and pollutants, such as pesticides and industrial chemicals, can contaminate soil, water, and air, posing risks to the health of plants and animals. The introduction of pollutants can contribute to a decline in biodiversity by adversely affecting the survival and reproduction of different species, leading to imbalances in ecological communities.

Some of the interactions with toxicants and pollutants from urban developments that may impact flora and fauna include:

- Runoff from urban areas can carry pollutants into water bodies, causing water quality degradation, impacting aquatic ecosystems, and potentially harming aquatic plants and animals.
- Urban development activities may introduce contaminants into the soil, affecting soil quality and potentially harming plant life and soil-dwelling organisms.
- Urban development can facilitate the introduction and spread of invasive species, further threatening native flora and fauna by outcompeting or preying upon indigenous species.
- Pollution and toxicants can disrupt essential ecological processes such as nutrient cycling, leading to cascading effects on ecosystem health.

The management systems proposed by the Riverlea Project in the Development Application are intended to control the potential releases of toxicants and pollutants via a series of treatment additional measures such as public education in the form of signage or information boards in strategic locations around the lake will be investigated.

2.9.10 Microbial Quality

In a temperate climate, saltwater lakes can be influenced by various factors that may affect their microbial quality. Monitoring microbial parameters is crucial for protecting the flora within saltwater lakes. Sources of microbial vectors that may be introduced into the lakes include contaminants in the intake water from Chapman Creek, runoff from the urban catchments or windblown organisms.

Poor water circulation can lead to stratification, creating distinct layers with different microbial conditions. Stagnant areas may foster the growth of specific microbial groups. Other factors that affect microbial activity include temperature fluctuations, nutrient levels, changes in salinity and UV radiation.

Once the SWL are constructed monitoring of microbial parameters, including the presence of pathogens and faecal coliforms, is crucial for ensuring water safety and preventing potential risks to both aquatic organisms and human users.

Regular and systematic monitoring of these water quality parameters will enable a comprehensive evaluation of the impacts on flora and fauna in the man-made seawater lake, facilitating adaptive management strategies to maintain a healthy and sustainable aquatic ecosystem.

2.10 Impact Assessment

Building upon the comprehensive overview presented in Section 2.8 which highlighted potential flora and fauna based on Chapman Creek and Dry Creek Saltfields literature. Section 2.9, delves into the water quality stressors that may impact the plant and animal receptors, as well as the overall ecology of the SWL.

During rain events, the influx of freshwater into the sea via Chapman Creek, as depicted in Figure 6 during a November rain event, results in a temporary drop in salinity from 58,000 µS/cm to less than 10,000 µS/cm. Additionally, precipitation on the lakes and runoff from the Precinct 2 catchment introduce a flush of fresh water to the SWL, posing potential risks to flora and fauna. Prolonged exposure to low salinity, exceeding 48 hours, may have adverse effects on marine organisms. Furthermore, considering the lakes are 3 meters deep, stratification becomes a concern when lower density freshwater flows into the lakes.

Addressing flood events by simply pumping higher rates of water from Chapman Creek may not be a straightforward solution. Monitoring at the Chapmen Creek intake indicates considerable salinity drops during such events. To navigate this complexity, mathematical modelling is necessary to evaluate the duration of a 1 in 100 year flood event and its impact on the SWL. This modelling serves as a key component in risk assessment, guiding the design of strategies to prevent issues such as algal blooms, fish kills, eutrophication, and the accumulation of nutrients and odours.

Recognising these challenges, it is important to emphasise that effective management of the following factors is essential to safeguard the water quality in the SWL. Through strategic management interventions, Riverlea Development can ensure the protection of the SWL ecology, fostering a resilient and thriving environment for all stakeholders involved.

The following factors influence water quality in the SWL, it is through management of these factors that Riverlea Development can ensure that the SWL ecology is protected.

2.10.1 Natural Factors

- The geological composition of the lake basin, essentially the clay liner and rock armouring, affects the types and amounts of minerals present in the water.
- The movement of water into and out of the lake, affecting its overall water balance.
- Temperature influences the rate of biological and chemical processes in the water.
- Precipitation affects the input of water into the lake and can influence nutrient levels and turbidity.
- Riparian vegetation can act as a buffer, filtering pollutants and stabilising the shoreline.
- The shape of the lake basin affects water circulation patterns, stratification, and the distribution of nutrients and sediments.
- Runoff from surrounding land can introduce nutrients like nitrogen and phosphorus into the lake, influencing algal growth.
- Atmospheric deposition of nutrients can also contribute to water quality.
- Aquatic plants and algae play a crucial role in oxygen production and consumption.
- Microorganisms and bacteria are involved in nutrient cycling and decomposition.

2.10.2 Anthropogenic Factors

- Roads, parking lots, and rooftops prevent water from infiltrating the soil, leading to increased runoff. This runoff can carry pollutants such as oil, heavy metals, and debris into the lake.
- Inadequate stormwater management can result in increased runoff, erosion, and sedimentation in lakes. The proposed stormwater management systems will reduce the transport of pollutants.
- The use of fertilisers and pesticides in residential areas can contribute to nutrient loading and the introduction of harmful chemicals into the lake.
- Removal of natural vegetation for lawns and gardens reduces the ability of the land to filter pollutants and stabilise soil.
- Improper disposal of untreated or partially treated wastewater into the lake can introduce pathogens and pollutants.
- Accidental spills from boats and recreational watercraft can introduce hydrocarbons and other pollutants into the water.
- Wave action from boats and recreational activities along the shoreline can contribute to erosion.
- Construction activities can lead to soil erosion and sedimentation in lakes if proper erosion control measures are not implemented.
- Improper Disposal of Household Chemicals: Disposing of household chemicals, cleaning agents, or pharmaceuticals into the lake or storm drains can introduce harmful substances.
- Intentional or accidental introduction of non-native species can disrupt the natural balance of the lake ecosystem.
- Changes in precipitation patterns due to climate change and increased impervious surfaces can alter the hydrology of the lake.

The holistic vision of Riverlea Development is evident in the project's design, which thoughtfully incorporates management systems and engineering measures to safeguard the water quality of the SWL and preserve the vital environmental services it offers. This proactive approach reflects a commitment to responsible development practices.

The implemented management system is seen as an evolving entity, with ongoing enhancements planned as the planning details reach deeper levels. This commitment by Riverlea to continual improvement underscores the dedication to staying ahead of challenges and adopting the latest advancements in environmental management.

By addressing these factors within the project's overarching design, Riverlea Development not only prioritises the protection of the SWL ecology but also showcases a positive model for sustainable development. Through this proactive stance, the project aims to contribute positively to the broader community and environment, ensuring a lasting legacy of responsible and environmentally conscious development.

2.10.3 Management of Water Quality in the SWL

Artificially managed lakes, while facing challenges like restricted flushing and mixing, provide an opportunity for strategic intervention to enhance their ecological resilience. As discussed in the previous section, the potential for stratification and nutrient build-up exists, primarily due to their limited connectivity to natural tidal patterns in St. Vincent Gulf. This unique condition, however, offers a platform for targeted management strategies.

While the lakes lack the natural tidal influence for organism movement and recolonisation during unfavourable conditions, proactive measures can be implemented. By understanding the limitations and developing effective management plans, a more robust ecosystem within the Riverlea SWL can be developed.

The current water monitoring program (Section 2.9) highlights opportunities for improvement. Relying on Chapmans Creek as a seawater source poses challenges, such as periods of elevated nutrients and low salinity after flood events. Additionally, organic material from Chapman Creek intake and residential runoff may contribute to nutrient levels. Recognising these challenges presents an opportunity to refine the approach and mitigate potential impacts.

Increased nutrients and water temperature, if not managed effectively, can lead to undesirable consequences such as elevated algae concentrations and the presence of microorganisms on the lake surface. This, in turn, hinders light penetration and oxygen absorption crucial for marine life. During summer periods with high water temperature and low wind, the potential depletion of dissolved oxygen poses a risk to fish and invertebrate populations.

In response to these challenges, Walker has taken a proactive stance by developing a comprehensive Lakes Management Plan (LMP) and a Lakes Operational Management Plan (LOMP). These plans encompass all aspects of SSWL management, including robust monitoring of water quality and the overall lake biology. Engaging a recognised Water Quality Specialist further demonstrates a commitment to expert advice and solutions.

The LMP, LOMP, and the expertise of the Water Quality Specialist collectively address various concerns at key points in the flow cycle: (1) upon extraction from the receiving environment and before entering the lakes; (2) within the lake; and (3) before exiting the system and entering the Thompson Creek environment. Additionally, exploring treatment options for peripheral stormwater before entering the lake further underscores a holistic approach to environmental management.

In summary, while challenges exist, the proactive measures outlined by Walker demonstrate a positive commitment to sustainable water management, ensuring the well-being of the Riverlea SWL ecosystem for generations to come.

3. ESTABLISHING SUSTAINABLE SALTWATER LAKES

3.1 Initial Monitoring: A foundation for Informed Design

Prior to the commencement of construction, an extensive baseline survey of water quality at both intake and discharge points has been ongoing for over eighteen months. This continuous data collection forms a robust foundation, informing the design of Water Quality Management Systems.

Recognising the importance of understanding marine flora and fauna in Chapman Creek, it is recommended to conduct surveys aimed at bridging the knowledge gaps, particularly regarding potential invasive species. This ensures a thorough understanding, crucial for effective lake management.

3.2 Construction Phase: Responsible Protocols and Environmental Protection

Protocols safeguarding the environment will be finalised pre-construction, demonstrating a commitment to responsible practices. Implementation and monitoring during construction will ensure the effectiveness of protocols designed to minimise disturbance to existing ecosystems. The establishment of exclusion zones and the use of silt curtains, among other measures, underscore a proactive approach to prevent sedimentation and protect the surrounding environment.

3.3 Salinity Adaptation: Gradual Introduction for Ecosystem Balance

The gradual introduction of seawater into the lakes is a critical phase, aiming to establish a suitable habitat for potential aquatic flora and fauna recruitment. A phased approach to regulating salinity and nutrients will be implemented, allowing for adaptive responses from the ecosystem, ensuring a gradual transition in water quality conditions.

3.4 Habitat Enhancement: Thoughtful Planning for Marine Life

While no artificial reefs or structures are currently planned, the possibility of incorporating such features is under consideration during the planning stage. This forward-thinking approach allows for additional habitats for marine life, with the flexibility for retrofitting post-construction if developers seek to promote the growth of salt-tolerant plants in specific areas.

3.5 Regular Monitoring Adaptive Management for Ecosystem Health

A comprehensive, long-term monitoring program is in place to track changes in marine ecosystems. This program, designed to measure key indicators of ecosystem health and the effectiveness of proposed water treatment systems, serves as a proactive measure. The ongoing monitoring commitment ensures a dynamic approach to management, allowing for adjustments based on real-time results and a commitment to continuous improvement.

3.6 Management of Mass Die-Off Events Caused by Freshwater Incursion

In a flood event freshwater incursion into the SWL may trigger a rapid change in salinity and release of nutrients from lake bed sediments leading to algae blooms and potential mass die-offs of marine organisms.

3.7 Emergency Response Plan

A comprehensive plan for responding to mass die-off events will be developed in consultation with the Water Treatment Specialist engaged by the Riverlea Development to design and implement water treatment systems within the lakes.

The establishment of a trained rapid response team with the capability to remove deceased organisms and remove sludge promptly will be considered and if deemed necessary implemented.

3.8 Water Quality Monitoring

Sensors will be installed at the intake and or along the pipeline to continuously monitor salinity and temperature levels.

Monitoring stations at strategic locations around the lakes will provide an early warning systems to detect changes in water quality and send an alarm to notify the lake manager to implement remediation measure to avoid algae blooms, anoxic conditions or eutrophication.

The current monitoring sites will remain active to provide management with feedback on the performance of the water quality management systems in the Lakes.

3.9 Containment Measures

If a mass die-off event occurs containment booms or barriers will be deployed around affected areas during to prevent nutrient runoff. Nutrient rich materials will be rapidly cleaned up.

3.10 Water Treatment Systems

Walker Corporation’s commitment to environmental stewardship, the envisioned water treatment systems are designed to effectively eliminate excess nutrients before their discharge into the lakes. This comprehensive approach encompasses a stormwater treatment system featuring gross pollutant traps, a wetland and a 50m^2 bioretention pond (BMT, December 2021). To ensure the utmost effectiveness, water treatment interventions will be applied at various stages, including intake water, within the lake system, and prior to discharge.

Recognising the significance of this task, a Water Treatment Expert has been actively engaged in designing these systems. This reflects the commitment to implementing cutting-edge solutions, ensuring the sustainable and responsible management of water resources within the project (Mitchell, 2023).

The saltwater intake faces the potential challenge of fouling organism accumulation, leading to compromised water circulation and hindering the system's capacity to effectively flush out accumulated nutrients and pollutants. As a crucial aspect of the final design, it is strongly recommended to integrate antifouling copper/nickel screens with a 3 mm aperture. This choice aims to enhance longevity, particularly in an environment continually exposed to saline water. Additionally, the design allows for aeration, facilitating the cleaning of screens and ensuring optimal functionality over time.

4. CONCLUSION AND RECOMENDATIONS

In conclusion, the Riverlea SWL project stands as a testament to responsible and environmentally conscious development. The comprehensive analysis of water quality factors highlights potential challenges, but the proactive management approach underscores a commitment to mitigating ecological risks. As the project moves forward, several key recommendations emerge from the report:

1. **Ongoing Monitoring and Adaptive Management**: The commitment to continuous improvement is crucial. Ongoing monitoring, as outlined in the Lakes Management Plan and Lakes Operational Management Plan, allows for real-time adjustments based on evolving conditions.
2. **Mathematical Modelling for Flood Events**: Given the complexity of salinity fluctuations during flood events, the recommendation to employ mathematical modelling of the lake's water quality for a 1 in 100 year flood event is essential. This modelling serves as a key component in risk assessment and guides strategies to prevent issues such as algal blooms, fish kills, and eutrophication.
3. **Surveillance and Containment Measures for Mass Die-Off Events**: The development of a comprehensive Emergency Response Plan, including a trained rapid response team, containment booms, and nutrient runoff prevention, is crucial for addressing potential mass die-off events caused by freshwater incursion.
4. **Strategic Surveys for Native and Invasive Species**: Conducting surveys to bridge knowledge gaps regarding potential native and invasive species in Chapman Creek ensures a thorough understanding, crucial for effective lake management.
5. **Community Engagement and Education**: Establishing ongoing communication channels with the community to educate them about responsible practices, such as proper disposal of chemicals and the impact of stormwater runoff, can contribute to long-term water quality management.

By incorporating these recommendations into the project's overarching design and management systems, Riverlea Development not only prioritises the protection of the SWL ecology but also showcases a commitment to addressing challenges proactively. Through this holistic approach, the project aims to contribute positively to the broader community and environment, ensuring a lasting legacy of responsible and environmentally conscious development.

5. REFERENCES

Australian Government Initiative. (2023, November 29). *Guidelines for Fresh & Marine Water Qual;ity.* Retrieved from St Vincent Gulf: https://www.waterquality.gov.au/anz-guidelines/your-location/australia-marine-IMCRA/search-results?region=SVG

BDC. (2020). *Dry Creek Salt Field, Integrated Program for Environment Protection and Rehabilitation and Mine Operations Plan, Revision 4 v.1 Part 2.* Buckland Dry Creek Pty Ltd.

BMT. (December 2021). *Riverlea Concepts Stormwater Qaulity Management Plan.* Wlaker Corporation.

BMT. (February 2022). *Technical Memorandum- Use of Chapman Creek to Supply Saline Water to Riverlea Development.* Walker Corporation.

Brennan, C. E., Blanchard, H., & Fennel, K. (2016). Putting Temperature and Oxygen Thresholds of Marine Animals in Context of Environmental Change: A Regional Perspective for the Scotian Shelf and Gulf of St. Lawrence. *PLOS ONE*, 1-27.

Coleman, P. (2012). *Risk and opportunities: A briefing paper on coastal habitat and shorebird conservation in the light of potential closure of the Ridley Dry Creek salt fields.* AMLR NRM Board.

Coleman, P., & Cook, F. (April 2009). *Mining and Rehabilitation Program (MARP) Dry Creek .* Delta Environmental report to Cheetham Salt.

COOE. (2023). *Riverlea Salt Water Lakes, Assessment of the Impact on Flora and Fauna.* Walker.

DCCEEW. (2023, November 15). *Protected Matters Search Tool*. Retrieved from https://pmst.awe.gov.au/

DEW. (2023, July 25). Corrrespondence from Kerrie Burmeister. *DEW-D0022861*.

DEW. (2023, November 15). *NatureMaps*. Retrieved from coast and marine - estuary habitats: http://spatialwebapps.environment.sa.gov.au/naturemaps/?locale=en-us&viewer=naturemaps

DEW. (August 2021). *Dry Creek salt fields vegetation impact mapping. Summary report .* Department for Environment and Water.

EBS. (2022). *Native Vegetation Clearance Buckland Park Intake Pipeline Data Report.*

ECF. (2023, 11 22). *Barker Inlet and Port River Estuary*. Retrieved from Esturay Care Foundation: https://www.estuary.org.au/the-estuary/

EPA. (1999). *Stromwater pollution prevention code of practice for the building and construction industry .* Department for Environment,Heritage and Aboriginal Affair.

EPA. (2023, July 26). Correspondence from Phil Hazell. *EPA 775-446*. South Australia.

EPA. (June 2021). *Water Quality Guideline, environmental management of dewatering during construction activities.* EPA.

Kingsford, M. J. (2023, 11 24). *Patterns and processes influencing the structure of marine assemblages*. Retrieved from Biological Productivity: https://www.britannica.com/science/marine-ecosystem/Biological-productivity

LBWco. (October 2022). *Preliminary Site Investigation, Precinct 2, Riverlea Development, Riverlea Park, South Australia.* Report for Walker Buckland Park Developments Pty Ltd.

Millero, F. J. (1996). *Chemical Oceanogrpahy, 2nd Edition, .* CRC Press LLC.

Mitchell, P. (2023, November 29). eMail: Riverlea. Walkers Corporation .

Molsher, R., Geddes, M., & Paton, D. (1994). . Population and reproductive ecology of the small-mouthed hardyhead Atherinosoma microstoma (Gunther) (Pisces: Atherinidae) along a salinity gradient in the Coorong, South Australia. *Transactions of the Royal Society of South Australia 118:*, 207-216.

OzCoasts. (2023, November). *Water column nutrients*. Retrieved from Australian Online Coastal Information: https://ozcoasts.org.au/indicators/biophysical-indicators/water_column_nutrients/

PIRSA. (2023, November 15). *St Kilda - Chapmen Creek Aquatic Reserve*. Retrieved from https://www.pir.sa.gov.au/__data/assets/pdf_file/0014/411611/CHAPMAN_CREEK_.pdf

Ridley Corporation. (2013, 11 24). *Dry Creek Salt Fields, Fish Community Sampling and Health Assessment .* Retrieved from Dry Creek Salt Field PEPR Revision 4 v.1 Appendix 5.

USGS. (2023, November 29). *Dissolved Oxygen and Water.* Retrieved from USGS science for changing the world: https://www.usgs.gov/special-topics/water-science-school/science/dissolved-oxygen-and-water

Walker. (2023). *Riverlea Major Development, Development Application Amendment to the EIS. Principally - Alteration to the Precinct 2 Subdivision:.* Walker.

Water Engineering Plus. (October 2023). *Water Quality Monitoring Program Results to 13 September 2023.* Walker Corporation.

Wikipedia. (2023, November 15). *St Kilda – Chapman Creek Aquatic Reserve*. Retrieved from https://en.wikipedia.org/wiki/St_Kilda_%E2%80%93_Chapman_Creek_Aquatic_Reserve

WSP. (Februry 2022). *Salt Water Lakes Circulation System Concept Review.* Walker Corporation.

COOE Pty Ltd ABN 65 147 909 751

www.cooe.com.au | +61 8 8398 5090 | info@cooe.com.au

Water Engineering Partners Pty Ltd

Water Quality Monitoring Program Results to 2 July 2024

Prepared for: Walker Corporation

Date: 20 September 2024

File Reference: R.30073.003.02

DOCUMENT CONTROL

PROJECT / REPORT DETAILS

Document Title:	Report title
Principal Author:	Martin Giles
Client	Walker Corporation
Ref. no:	R.30073.003.01

DOCUMENT STATUS

Issue	Description	Date	Author	Reviewer
1	Monitoring Report	13 July 2024	M. Giles	A. Charlesworth
2	Updated Report	20 September 2024	M. Giles	D. Sturgeon Smith

DISTRIBUTION RECORD

Recipient	Distribution Method
Walker Corporation	Digital

Water Engineering Partners Pty Ltd
ABN: 47 664 596 105
Level 1, 21 Quay Street, Brisbane QLD 4000
PO Box 5106, West End, QLD 4101
P: 0455866107
E: info@wep.com.au

www.wep.com.au

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

1 Introduction

The 12,000 lot Riverlea Master Planned Community is located 25 kilometres north of Adelaide, immediately west of the Port Wakefield Highway and immediately to the south of the Gawler River.

To provide improved amenity, a 40.4 hectare saltwater lake (SWL) system is proposed for the development. To ensure the regular turnover of water and to maintain a high water quality standard in the lake system, the lakes will draw saline water from Chapman Creek. Water will discharge from the lakes to St Vincent Gulf via Thompson Creek.

In support of the design of the saltwater exchange system, a water quality monitoring program is underway to collect baseline water quality data. The intent of the program is to collect data over a sufficient period to allow the variation in water quality over time to be assessed.

Water quality sampling is being undertaken by ALS Hydrographics.

Sampling commenced in March 2022, with the BMT report *Water Quality Monitoring Program Results to 16 November 2022* (Version 1, 21 December 2022) (the first water quality monitoring report) summarising the first period of monitoring and the Water Engineering Plus report *Water Quality Monitoring Program Results to 13 September 2023* (Version 2, 13 November 2023) (the second water quality monitoring report) summarising the second period of monitoring.

In order to be a standalone document, this report summarises the results of monitoring over the full monitoring period (i.e., including the periods considered in the previous reports).

2 Details of Sampling Program

2.1 Discrete Sampling Program

Discrete sample collection was undertaken at five locations for the first year of monitoring on a fortnightly basis for the key water quality parameters and quarterly with respect to heavy metals. To allow ongoing assessment of water quality, additional monitoring was undertaken on a monthly basis, with the inclusion of a sixth sampling location.

1. Mouth of Chapman Creek (full period of monitoring)

   This location provides an indication of the quality of water entering the creek from St Vincent Gulf (incoming tides) and leaving the creek (outgoing tides and rainfall events).

2. Upper Chapman Creek (full period of monitoring)

   This location provides an indication of the water quality in the reach upstream of the likely intake point.

3. Offshore (full period of monitoring)

   The Offshore location provides an indication of the general water quality close to shore and enables the influence of discharges from the nearby sewage treatment plant to be assessed.

4. Channel (full period of monitoring)

   The channel location provides water quality data for the area downstream of the lakes and enables the existing quality of water to be assessed relative to the quality of water discharged from the lakes. In particular, it allows the influence of existing land uses within the catchment drained by the channel and any indirect influence (via tidal inflow) of the quality of water discharged from the nearby sewage treatment plant to be quantified.

5. Thompson Creek (full period of monitoring)

   This location provides water quality data for the area downstream of the lakes at a point closer to the lake discharge point and enables the quality of water discharged from the lakes to be compared to the quality of water in the creek.

7. Inshore Bolivar Outlet (From second year of monitoring)

   This location provides additional information relating to the variation of water quality between the outlet of Thompson Creek and the offshore monitoring location.

The location of each sampling point is shown on Figure 2.1, with the coordinates of each point listed in Table 2.1.

Table 2-1 Standard Sampling Locations

Location	Latitude	Longitude
Discrete Sampling Locations		
1. Mouth of Chapman Creek	-34.689478°	138.455836°
2. Upper Chapman Creek	-34.680268°	138.464233°
3. Offshore	-34.701344°	138.469317°
4. Channel	-34.686207°	138.514891°
5. Thompson Creek	-34.684494°	138.515039°
7. Inshore Bolivar Outlet	-34.700877°	138.474635°
Continuous Monitoring		
6. Intake (Chapman Creek)	-34.686290°	138.460800°

Figure 2-1 Standard Sampling Points

The following parameters were sampled fortnightly in the first year of monitoring and monthly in the second year of monitoring:

- pH;
- Electrical Conductivity;
- Suspended Solids;
- Ammonia as N;
- Nitrite as N;
- Nitrate as N;
- Nitrite and Nitrate as N;
- Total Kjeldahl Nitrogen;
- Total Nitrogen;
- Total Phosphorus;
- Reactive Phosphorus; and
- Chlorophyll 'a'.

At the time of sampling, field testing is also undertaken for the following parameters via a hand-held probe:

- pH;
- Temperature; and
- Field Dissolved Oxygen.

In addition to the above, the sampling program allows for the collection of samples during two wet weather periods annually.

Quarterly sampling is also completed with respect to heavy metals:

- Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Lead;
- Nickel;
- Zinc; and
- Mercury.

2.2 Continuous Sampling

To provide a long-term record in the vicinity of the lake water intake point in Chapman Creek, a continuous sampling gauge was installed in Chapman Creek. The location of the continuous gauge is shown on Figure 2.1, with the coordinates of the gauge listed in Table 2.1.

The gauge, together with a buoy, mooring system, solar charging and telemetry systems was installed on 2 May 2022. A photograph of the installed system is provided in Figure 2.2.

Figure 2-2 Continuous Sampling Device

The sampler is used to collect data for the following water quality parameters:

- Temperature;
- Electrical Conductivity/ Salinity;
- pH;
- Turbidity; and
- Dissolved Oxygen (mg/L and % saturation).

2.3 BDC Channel Sampling

To identify potential contributors to the quality of water in the vicinity of the Bolivar Outlet, additional water quality sampling was undertaken on 4 December 2023 with respect to the BDC channel.

The location of the points is listed in Table 2-2, and shown in blue on Figure 2-3.

Table 2-2 BDC Channel Sampling Locations

Location	Latitude	Longitude
8. BDC Channel Outlet	-34.687450°	138.499775°
9. BDC Channel 1	-34.687275°	138.499700°
10. BDC Channel 2	-34.681883°	138.495381°
11. BDC Channel 3	-34.679114°	138.500286°

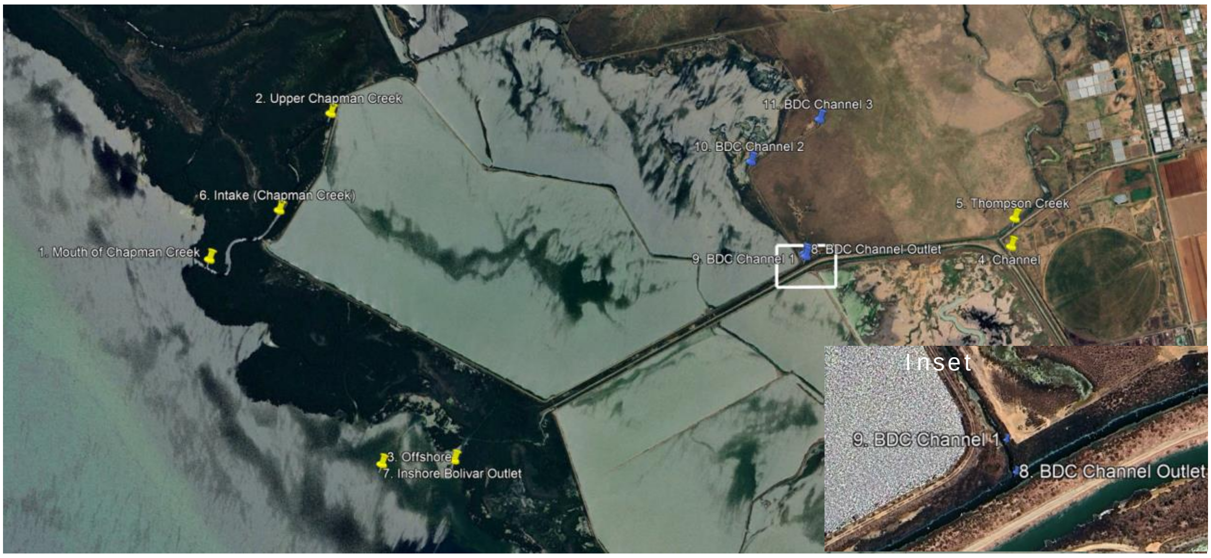


Figure 2-3 BDC Channel Sampling Points

3 Results of Water Quality Monitoring to Date

3.1 Discrete Sampling Program

3.1.1 Overview

The results of the discrete sampling program to the most recent sampling date (2 July 2024) at the time or preparation of this report are presented in Appendix A.

To assist in the interpretation of data, Table 3-1 lists the rainfall that occurred on the day of sampling, the day before sampling, and the total rainfall in the four days prior to sampling to provide an indication of the potential influence of local runoff on sampling results. The rainfall data was sourced from the Edinburgh RAAF Base gauge (023083), which is located about 10 km from the sampling area. The full daily rainfall record is provided in Appendix B.

With reference to the table, significant rainfall occurred in the periods prior to the sampling completed on 1 June 2022 and 16 November 2022.

It is relevant to note that access to Chapman Creek is constrained due to the sand bar at the mouth of the creek, with the tide needing to be higher than 1.8m to safely cross the bar (ALS email, 3 May 2022). ALS noted that the water quality varies depending on the condition of the tide at the time of sampling. The results therefore tend to reflect high tide conditions.

It is also noted that limited opportunities to collect specific wet weather samples have been available to date, and weather conditions in such situations have made the collection of samples difficult. However, the April 2023 samples were collected after reasonable rainfall and some of the discrete samples were collected following local rainfall and therefore provide guidance with respect to water quality following rainfall events.

An interpretation of the results of the samples collected and analysed to date is provided in the following sections. In cases where the exact concentration is not known, the highest possible value is conservatively plotted in the figures (for example, <1 mg/L is plotted as 1 mg/L).

Further, each of the graphs in this section includes the concentrations typically associated with acceptable water quality (noting that good or poor overall water quality may occur at concentrations less than or greater than the concentrations noted with respect to one parameter).

Table 3-1 Rainfall Prior to Sample Collection

Date	Total Rainfall (mm)		
	Day of Sampling	Day Prior to Sampling	Four Days Prior to Sampling
10-Mar-22	0	0	0
23-Mar-22	0	1.4	1.4
4-Apr-22	0	0	0
20-Apr-22	0.6	3.2	18.4
2-May-22	0	0.2	1
18-May-22	0	5.6	8.4
1-Jun-22	0.2	0.2	66
28-Jun-22	0	0.2	2.6
13-Jul-22	0.2	2.6	4.2
27-Jul-22	0	0	5.6
8-Aug-22	0	0	8.2
31-Aug-22	0	0	5.4
6-Sep-22	0	0	0
28-Sep-22	0	0.2	14.8
10-Oct-22	0	0	7
16-Nov-22	0	0.2	45
30-Nov-22	0	0	0.6
15-Dec-22	0	0.2	11.6
11-Jan-23	0	0	0
9-Feb-23	0	0	0
21-Feb-23	0	0	0
15-Mar-23	0	0	0
29-Mar-23	5.4	4.2	7.6
4-Apr-23	0	0	2.2
17-Apr-23	0.2	16.4	23.4
5-May-23	0	0	8
20-Jun-23	8	3.2	17
4-Jul-23	0.6	0	2.6
1-Aug-23	1	2	5.2
13-Sep-23	0	0	0.2

Date	Total Rainfall (mm)		
	Day of Sampling	Day Prior to Sampling	Four Days Prior to Sampling
18-Oct-23	0	0	0
20-Nov-23	0	0	0
4-Dec-23	0	0	0
29-Jan-24	0	0	0*
13-Feb-24	0	0	0
13-Mar-24	0	0	0.8
22-Apr-24	0	0	2.6
6-May-24	0	0	0
3-Jun-24	0	0.2	7.2
2-Jul-24	0	0	15.6

Note: * Rainfall data not available

3.1.2 pH and Electrical Conductivity (Salinity)

- *Chapman Creek (Points 1 and 2), Offshore (Point 3) and Inshore Bolivar Outlet (Point 7)*

  At these locations, apart from one anomalous outlier (offshore on 23 March 2022), the pH readings were generally consistent and within the anticipated range over the full period of monitoring, noting that salt water typically has a higher pH (slightly greater than 8) than fresh water.

  Electrical Conductivity (salinity) was high at all locations for all readings, indicating fully saline conditions. This indicates that a reliable supply of saline water will be available to supply the lakes (noting the short-term influence of local runoff as noted in Section 3.2.2).

- *Downstream of Future Lake (Points 4 and 5)*

  Apart from one anomalous outlier at both points (23 March 2022), the pH readings were generally consistent and within the anticipated range over the full period of monitoring.

  Electrical Conductivity (salinity) was found to be variable. In particular, the lower salinity values recorded on 1 June 2022, 16 November 2022 and 2 July 2024 indicate the influence of freshwater runoff due to rainfall over the preceding days. In general, the water would be described as brackish (i.e., not fully saline and containing fresh water). Discharge from the future lakes to Thompson Creek will be typically saline during low rainfall periods, and brackish following rainfall.

3.1.3 Suspended Solids

Figure 3.1 presents the variation in the concentration of suspended solids over time. It is noted that the presence of a limited number of high concentration readings limits the definition of the lower concentrations that occur over the majority of the sampling period. To provide greater clarity with respect to these lower concentrations, Figure 3-2 presents the variation in concentration between 0 and 70 mg/L.

With reference to Figure 3.1 and Figure 3-2, suspended solids concentrations in the vicinity of Chapman Creek (i.e., Point 1 (Mouth of Chapman Creek) and Point 2 (Upper Chapman Creek)) are generally low and can be managed via screening for the supply of water to the lake system.

For comparative purposes, values less than 10 mg/L (indicated on the figures) such as those typically recorded in this case are considered to be quite low, albeit expected in this case given the marine environment and proximity to St Vincent Gulf.

While suspended solids readings for 2023 were relatively low, there was a trend for higher concentrations in 2023 compared to 2022. In particular, slightly elevated suspended solids concentrations were obtained on 9 February 2023 (with some sites showing increased concentrations on 11 January 2023) and 4 July 2023. In both cases, readings returned to more standard values in the following months. The trend for higher concentrations continued into 2024 at Thompson Creek and the Channel sites, tending to fall towards the middle of 2024.

Elevated values are expected to be typically associated with local runoff events. Unless local rainfall occurred that was not recorded at the gauge (which is possible but unlikely given it is about 10 km from the area), in this case the elevated values do not appear to correspond to recorded rainfall.

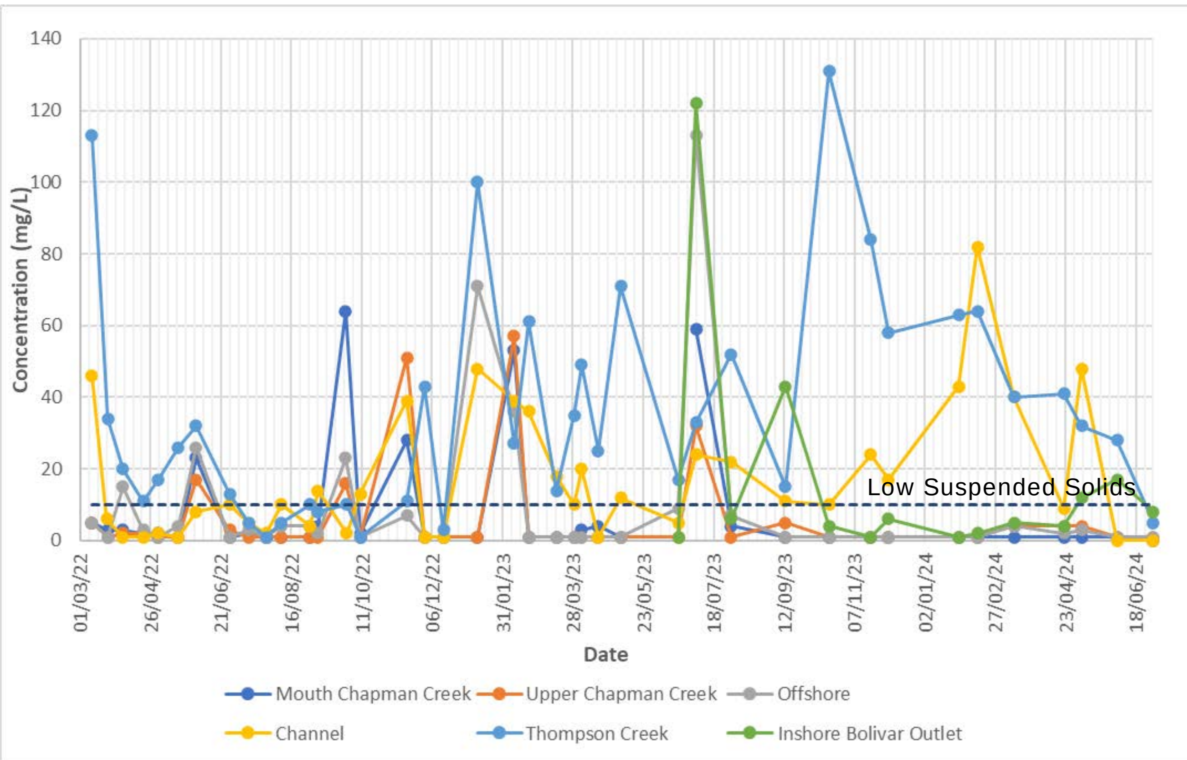


Figure 3-1 Suspended Solids Readings (Full Range)

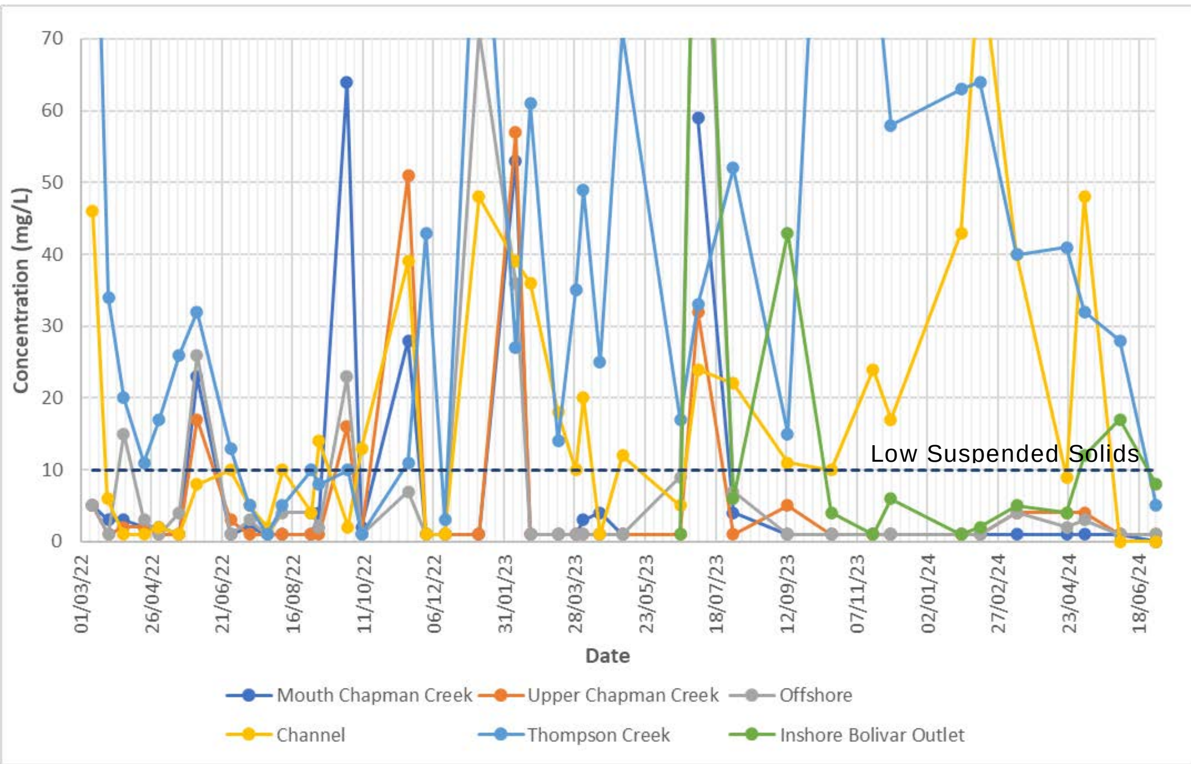


Figure 3-2 Suspended Solids Readings (up to 70 mg/L)

3.1.4 Nitrogen

Figure 3-3 presents the variation in Total Nitrogen over time. It is noted that the presence of a number of high concentration readings limits the definition of the lower concentrations that occur at a number of the sites. To provide greater clarity with regard to these lower concentrations, Figure 3-4 presents the variation in concentration between 0 and 10 mg/L.

The readings in Chapman Creek at Point 1 (Mouth) and Point 2 (Upper) are generally consistent with the concentration in the St Vincent Gulf (Point 3, Offshore). The concentrations are considered to be relatively high, noting that for an urban (freshwater) lake a typical target value is less than 1 mg/L (noting also that in this case a saltwater lake is proposed). This value is shown on Figure 3-3 and Figure 3-4.

In comparison, 9 of the 40 samples at Point 1 (Mouth) and 10 of the 40 samples at Point 2 (Upper) are in excess of 1 mg/L. It is noted that the concentrations are typically lower in 2023 and 2024 compared to 2022, with only 1 reading at both Point 1 (Mouth) and Point 2 (Upper) being above 1 mg/L. The reason for the reduction in concentrations is uncertain and may be attributable to natural variation in water quality or changes in discharges from land uses in the area or the Bolivar STP.

Within Chapman Creek and in the St Vincent Gulf, the Total Nitrogen is predominantly organic in nature (i.e., bound to organic substances), with the Kjeldahl Nitrogen concentration essentially matching the Total Nitrogen concentration in the majority of samples and the ammonia concentration being typically 10-15% of the total. As part of future design, it will be necessary to consider options to limit Total Nitrogen concentrations by focussing on organic substances.

The composition of Total Nitrogen at both Point 4 (Channel) and Point 5 (Thompson Creek) is more variable, with higher proportions of inorganic Nitrogen. The concentrations at these points could be influenced by land use practices and the water discharged from the Bolivar Sewage Treatment Plant, with subsequent mixing in St Vincent Gulf minimising the concentration of inorganic Nitrogen components and resulting in the organic dominated situation occurring in Chapman Creek.

Overall, it is anticipated that Total Nitrogen concentrations are governed by discharge from the Bolivar Sewage Treatment Plant and discharges from horticultural land uses within the catchments. This is evidenced by the extremely high Total Nitrogen concentrations recorded at Point 4 (Channel) and Point 5 (Thompson Creek) throughout the period of monitoring, reducing at Point 7 (Inshore Bolivar Outlet) and Point 3 (Offshore) due to mixing.

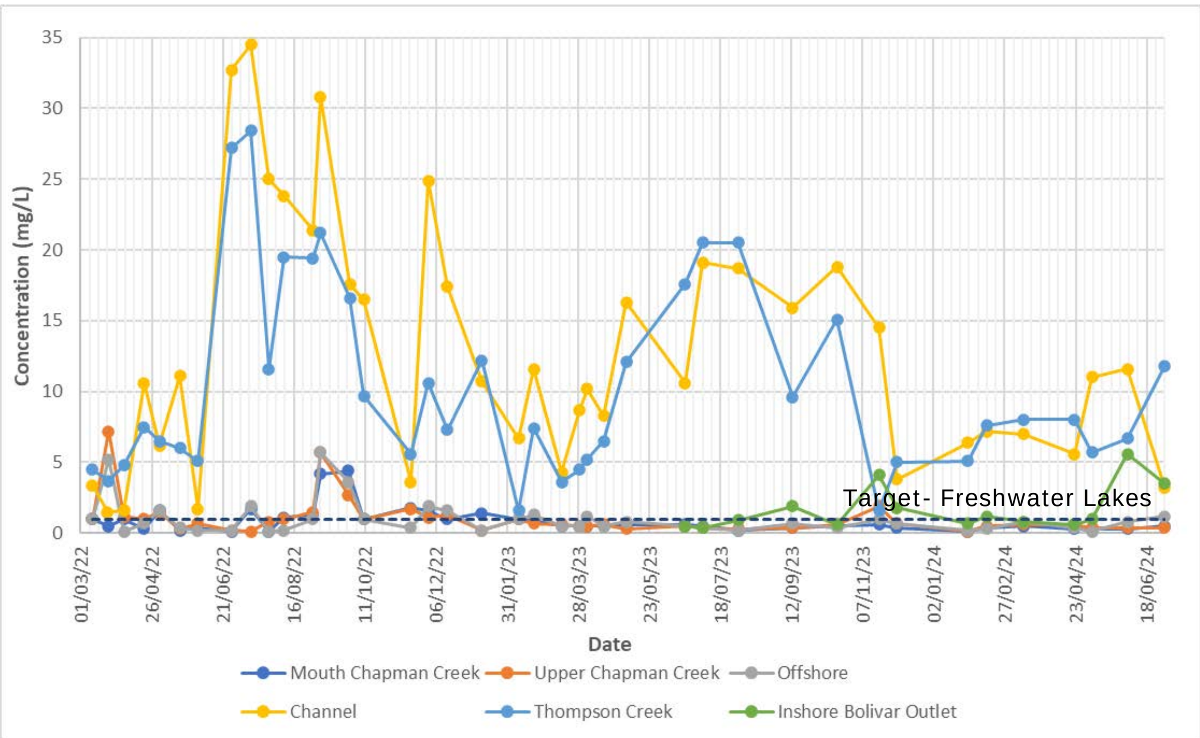


Figure 3-3 Total Nitrogen Readings (Full Range)

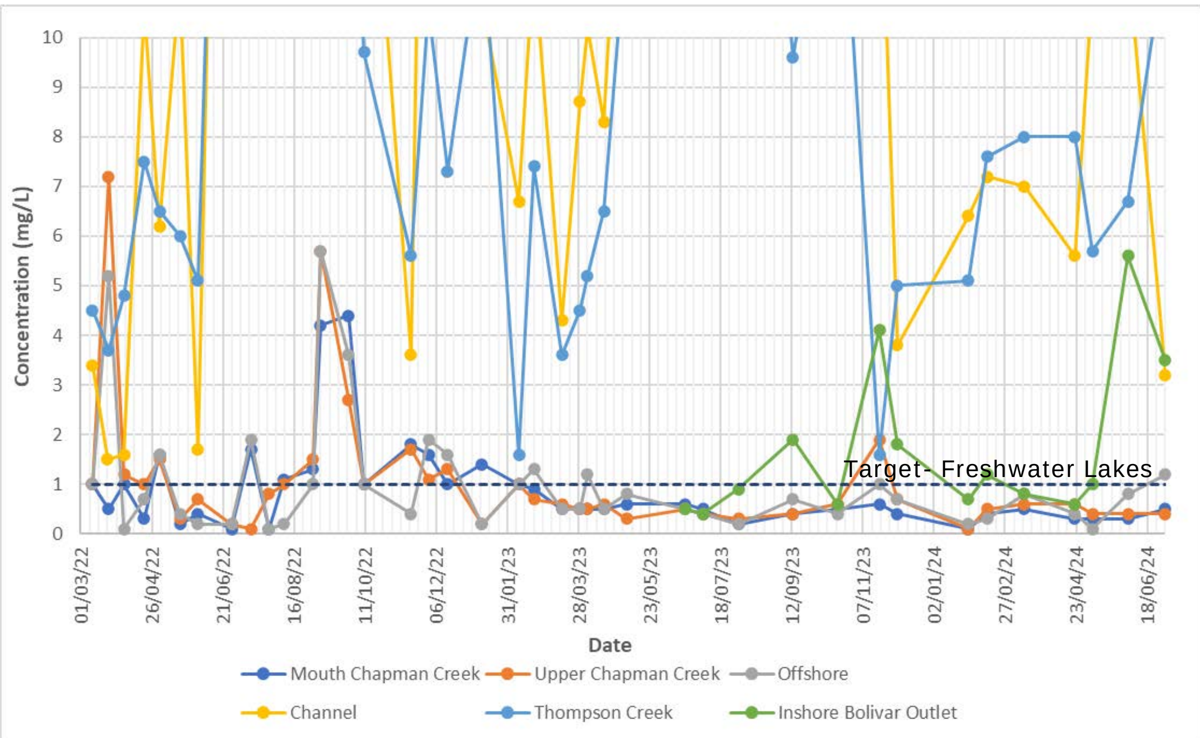


Figure 3-4 Total Nitrogen Readings (up to 10 mg/L)

3.1.5 Total Phosphorus

Figure 3-5 presents the variation in Total Phosphorus over time. It is noted that the presence of a number of high concentration readings limits the definition of the lower concentrations that occur at a number of the sites. To provide greater clarity with regard to these lower concentrations, Figure 3-6 presents the variation in concentration between 0 and 1 mg/L.

Similar to Total Nitrogen, the readings in Chapman Creek at Point 1 (Mouth) and Point 2 (Upper) are generally consistent with the concentration in the St Vincent Gulf (Point 3, Offshore). The concentrations are considered to be relatively high, noting that for an urban (freshwater) lake a typical target value is less than 0.1 mg/L (noting also that in this case a saltwater lake is proposed). This value is shown on Figure 3-5 and Figure 3-6.

It is also noted that Total Phosphorus concentrations are generally higher in the latter part of 2023 and 2024 than the prior period of sampling. The reason for the increase in concentration is uncertain and may be attributable to natural variation in water quality or changes in discharges from land uses in the area or the Bolivar STP.

It will therefore be necessary to consider the influence of Total Phosphorus as part of water quality modelling in support of detailed design of the lake.

The Total Phosphorus concentrations at both Point 4 (Channel) and particularly at Point 5 (Thompson Creek) are high, typically decreasing downstream at Point 7 (Inshore Bolivar Outfall) and Point 3 (Offshore) due to mixing. The cause of the high values recorded at Point 7 (Inshore Bolivar Outfall) in September 2023 and June 2023 is uncertain as the concentration upstream and downstream of Point 7 (Inshore Bolivar Outfall) is lower. A potential explanation for this is that the recording reflects a particular discharge from the Bolivar STP outlet channel.

Further, in 2024 for a number of samples the Total Phosphorus concentration at Point 4 (Channel) is higher than the concentration upstream at Point 5 (Thompson Creek). Prior to this, sampling consistently indicated concentrations at Point 4 (Channel) lower than the concentration upstream at Point 5 (Thompson Creek).

Further, Total Phosphorus concentrations at Point 4 (Channel) and Point 5 (Thompson Creek) appear to be generally higher in 2023 and 2024 than in 2022, particularly with respect to Point 4 (Channel).

It is expected that Total Phosphorus concentrations at Point 4 (Channel) and Point 5 (Thompson Creek) could be influenced by land use practices and the water discharged from the Bolivar Sewage Treatment Plant, with subsequent mixing in St Vincent Gulf minimising the concentration found in Chapman Creek.

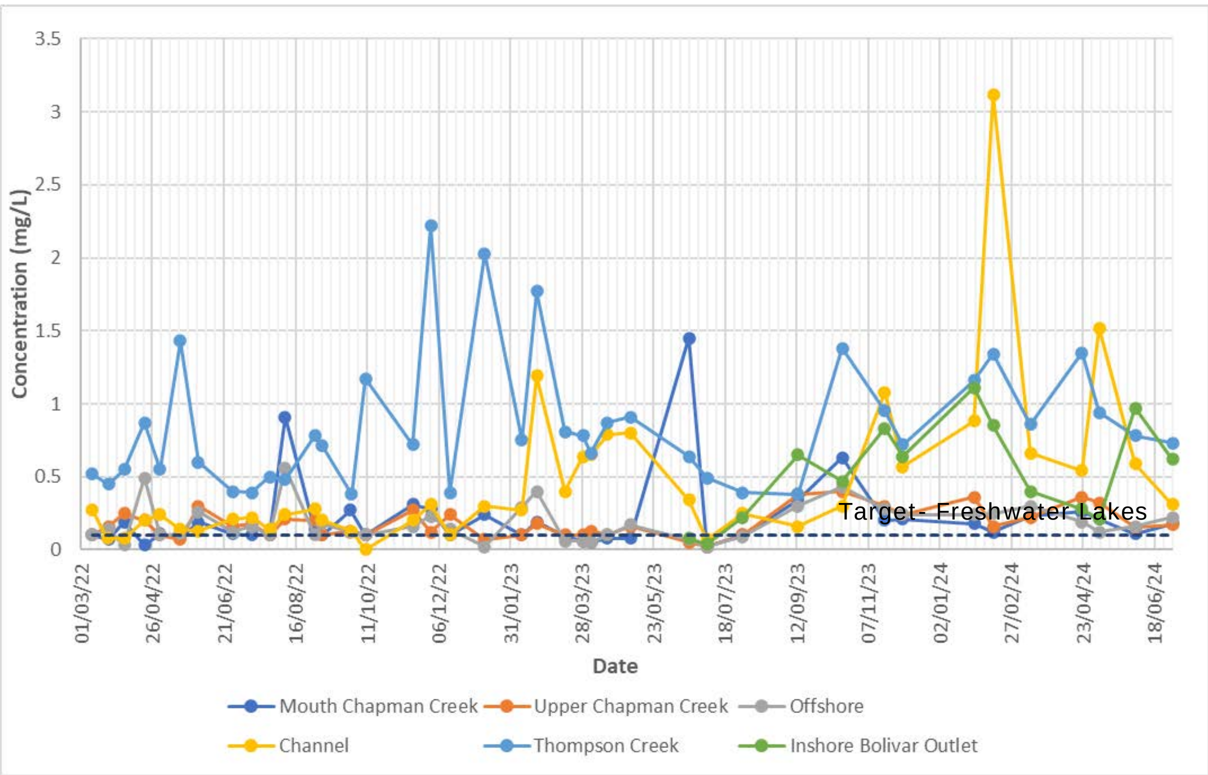


Figure 3-5 Total Phosphorus Readings (Full Range)

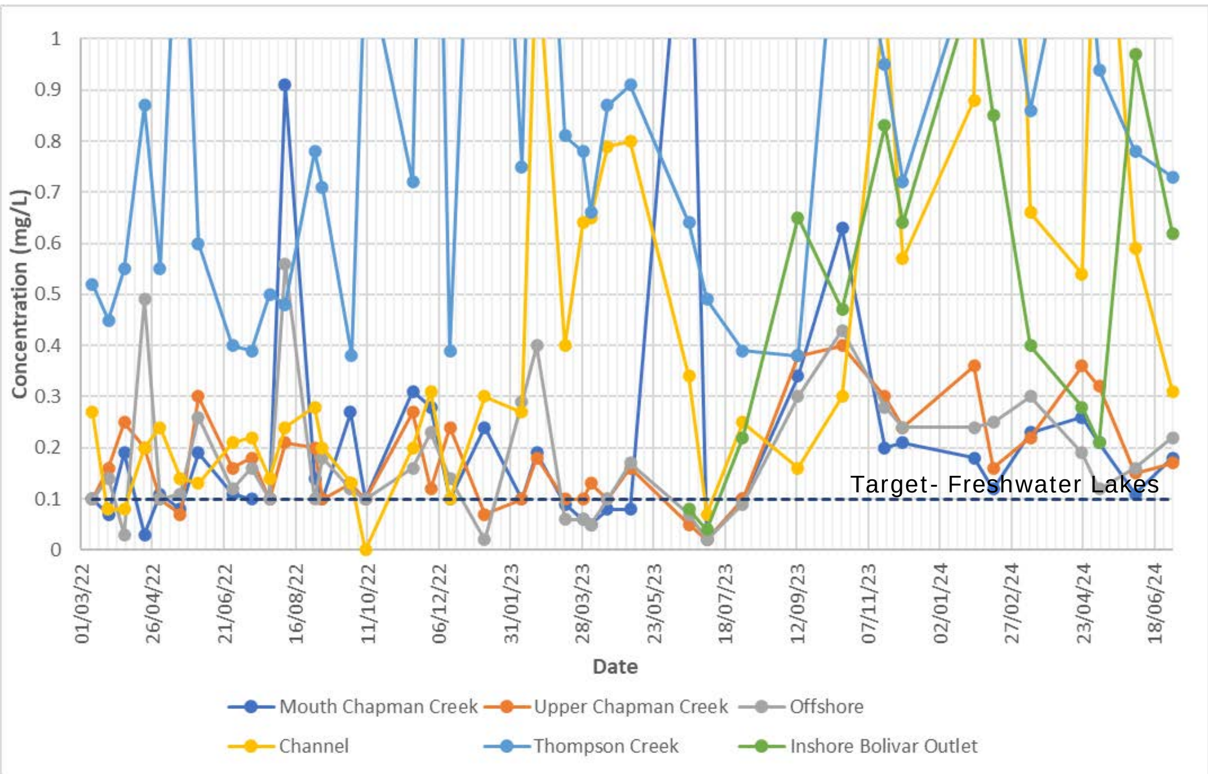


Figure 3-6 Total Phosphorus Readings (up to 1 mg/L)

3.1.6 Chlorophyll 'a'

Figure 3-7 presents the variation in Chlorophyll 'a' over time. It is noted that the presence of a number of high concentration readings limits the definition of the lower concentrations that occur at a number of the sites. To provide greater clarity with regard to these lower concentrations, Figure 3-8 presents the variation in concentration between 0 and 20 mg/m^3.

Chlorophyll 'a' is a measure of the amount of algae in a water sample. Typically, a high concentration reflects elevated nutrient levels and usually turbid water (limiting the penetration of light). However, despite relatively high Total Nitrogen and Total Phosphorus levels in Chapman Creek and in St Vincent Gulf (i.e., Points 1 (Mouth), 2 (Upper) and 3 (Offshore)), Chlorophyll 'a' concentrations remain consistently low (and also noting the low suspended solids levels).

For comparative purposes, algae outbreaks can typically occur when the Chlorophyll 'a' value exceeds 15 mg/m^3 and values less than 5 mg/m^3 are considered to be low. The algae outbreak limit is shown on Figure 3-7 and Figure 3-8, with the low level shown on Figure 3-8. In this case, in Chapman Creek the recorded values are typically 2 mg/m^3 or less and often less than 1 mg/m^3. While the readings for 15 December 2022 and 1 August 2023 at Point 2 (Upper) were higher than the typical readings, the values were still low (being 5-6 mg/m^3), and the value for Point 1 (Mouth) was not elevated.

This result is encouraging for the use of water in Chapman Creek to turn over the water in the Riverlea lake system.

In contrast, the Chlorophyll 'a' concentration is consistently extremely high at both Point 4 (Channel) and particularly at Point 5 (Thompson Creek), decreasing at Point 7 (Inshore Bolivar Outlet) and Point 3 (Outfall) due to mixing. It is noted that the concentrations at Point 4 (Channel) and Point 5 (Thompson Creek) are above 20 mg/m^3 in 2024 and are not visible at the limits of the graph in Figure 3-7. Figure 3-8 includes these higher values by using greater plot limits with respect to Chlorophyll 'a'.

Again, it is considered that the high values could be affected by land use practices and the Bolivar Sewage Treatment Plant, with mixing in St Vincent Gulf consistently reducing concentrations in the vicinity of Chapman Creek.

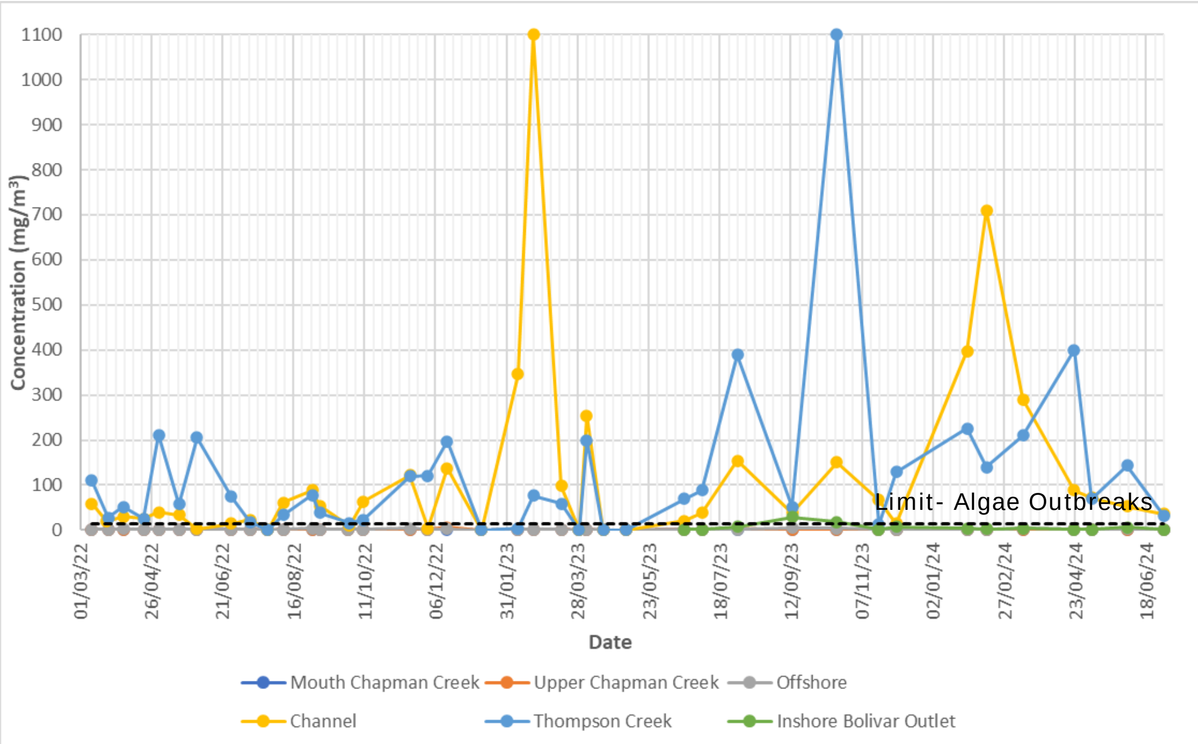


Figure 3-7 **Chlorophyll 'a' Readings** (Full Range)

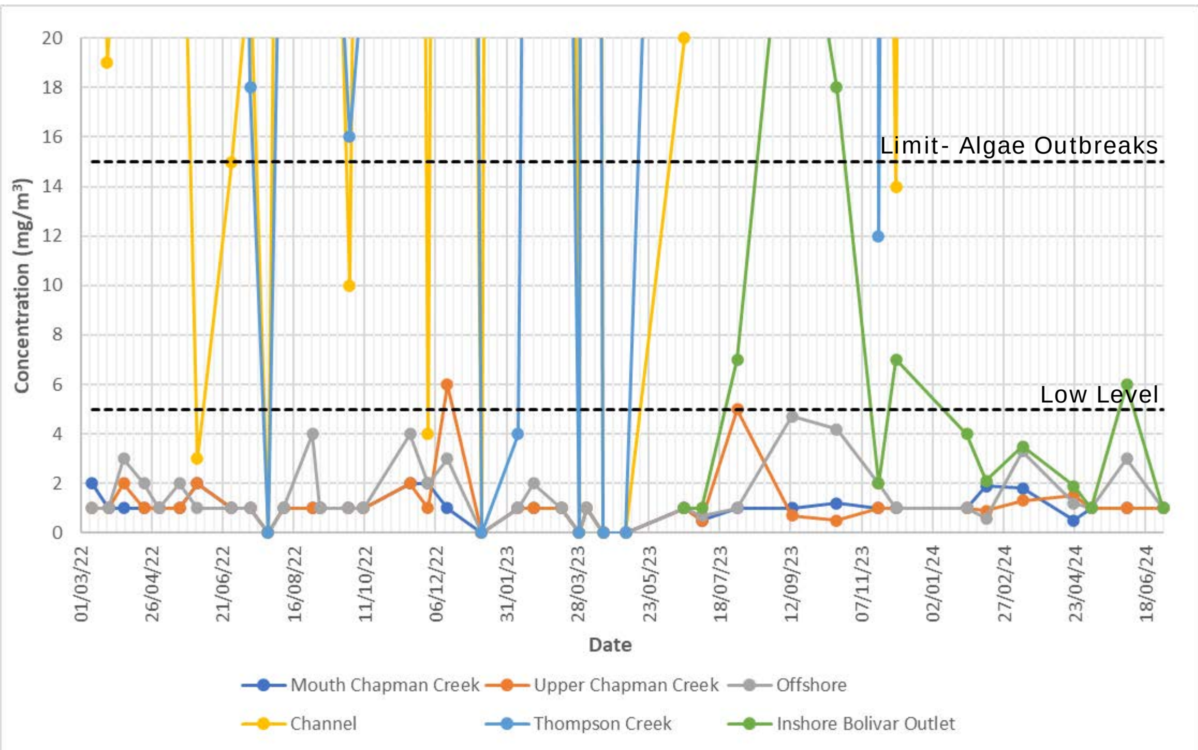


Figure 3-8 **Chlorophyll 'a' Readings** (up to 20 mg/m^3)

3.1.7 Heavy Metals

Table 3-2 and Table 3-3 present the results of the quarterly sampling of heavy metals (as also shown in Appendix A). For comparative purposes, the table also lists the guideline values nominated in Table 5.2.3 of the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1, The Guidelines* (Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand, October 2020) for recreational purposes.

The values nominated in the table represent the maximum value obtained at the seven sampling points.

Table 3-2 Heavy Metals Sampling Results

Heavy Metal	Concentration (mg/L)						
	Limit	10 Mar 2022	1 Jun 2022	6 Sep 2022	30 Nov 2022	20 Jun 2023	13 Sep 2023
Arsenic	0.05	<0.01	0.003	0.01	0.005	<0.005	<0.005
Cadmium	0.005	<0.001	<0.0002	0.0026	<0.0005	<0.0005	<0.0005
Chromium	0.05	<0.01	0.002	0.004	<0.005	<0.005	<0.005
Copper	1	<0.01	0.004	0.008	0.005	<0.005	0.009
Lead	0.05	<0.01	0.005	0.003	<0.005	<0.005	<0.005
Nickel	0.10	0.017	<0.002	0.012	0.013	0.008	0.006
Zinc	5	<0.052	<0.01	0.014	<0.026	<0.026	<0.026
Mercury	0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Table 3-3 Heavy Metals Sampling Results

Heavy Metal	Concentration (mg/L)			
	Limit	4 Dec 2023	13 Mar 2024	3 Jun 2024
Arsenic	0.05	0.004	0.007	0.008
Cadmium	0.005	<0.0005	<0.0005	<0.0005
Chromium	0.05	<0.005	0.002	<0.005
Copper	1	0.004	0.003	0.013
Lead	0.05	<0.005	<0.005	<0.005
Nickel	0.10	0.006	0.018	0.042
Zinc	5	<0.026	0.008	0.042
Mercury	0.001	<0.0001	<0.0001	<0.0001

With reference to the above tables, as expected for the area, the concentrations of heavy metals were found to be well below (and typically below the limit of reporting) the guideline values for recreational use throughout the monitoring period. Given this ongoing result, monitoring to date suggests that heavy metals will not be a significant concern for the Riverlea development.

3.2 Continuous Sampling Results

3.2.1 Overview

While Annex B of the previous *Water Quality Monitoring Program Results to 16 November 2022* (Version 1, 21 December 2022) contained the results from the continuous sampling probe in Chapman Creek, as over 75,000 samples have been collected to 2 July 2024 it is not practicable to list the results in this report.

Apart from the failure of the pH probe (resulting in no results between 25 October and 16 November 2022), the sensor has worked well.

The results obtained from the continuous sensor are discussed in the following sections.

3.2.2 pH and Electrical Conductivity (Salinity)

Figure 3-9 and Figure 3-10 present the pH and Electrical Conductivity (salinity) readings respectively.

With reference to the figures, the pH results are generally consistent with the discrete sampling program at Point 1 (Mouth of Chapman Creek) and Point 2 (Upper Chapman Creek).

While the electrical conductivity results are generally consistent with the discrete sampling in Chapman Creek, the continuous readings capture the drop in conductivity associated with local catchment runoff.

A review of rainfall recorded prior to the periods of lower conductivity indicates a strong correlation between rainfall and reduced conductivity (for example towards the end of May 2022, the middle of September 2022, early November and around 16 November 2022, April 2023 and June 2023).

However, the measurements indicate that conductivity levels (salinity) rise to more typical levels within a short period (less than a day) of the end of rainfall. It is considered that short periods of reduced conductivity levels (salinity) can be readily managed as part of lake operation and that the salinity level is typically high.

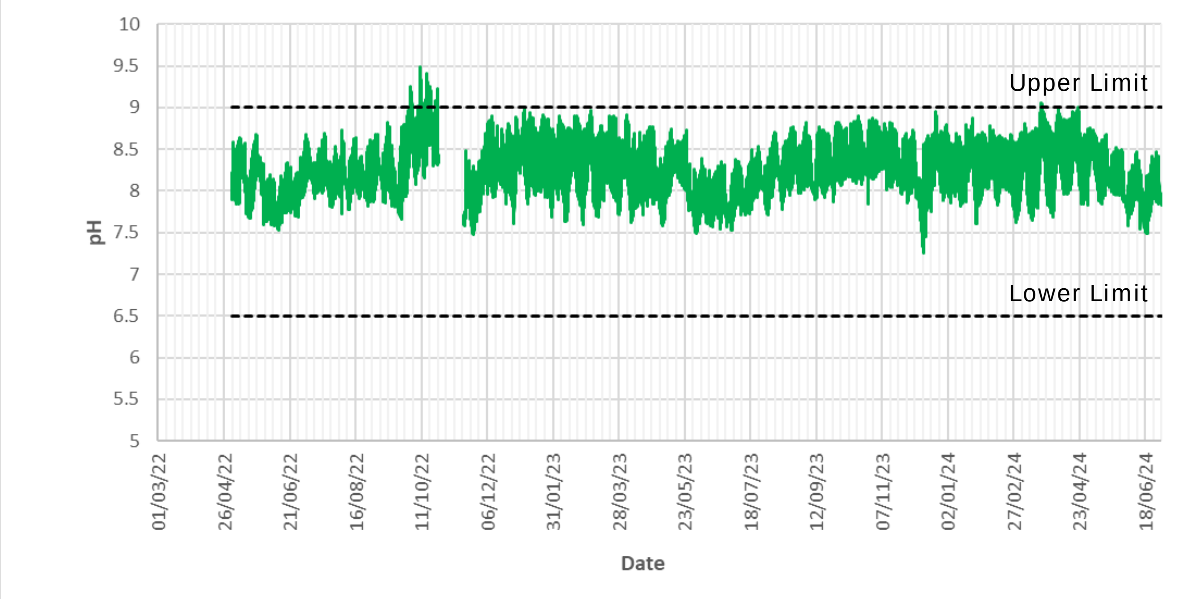


Figure 3-9 pH Readings

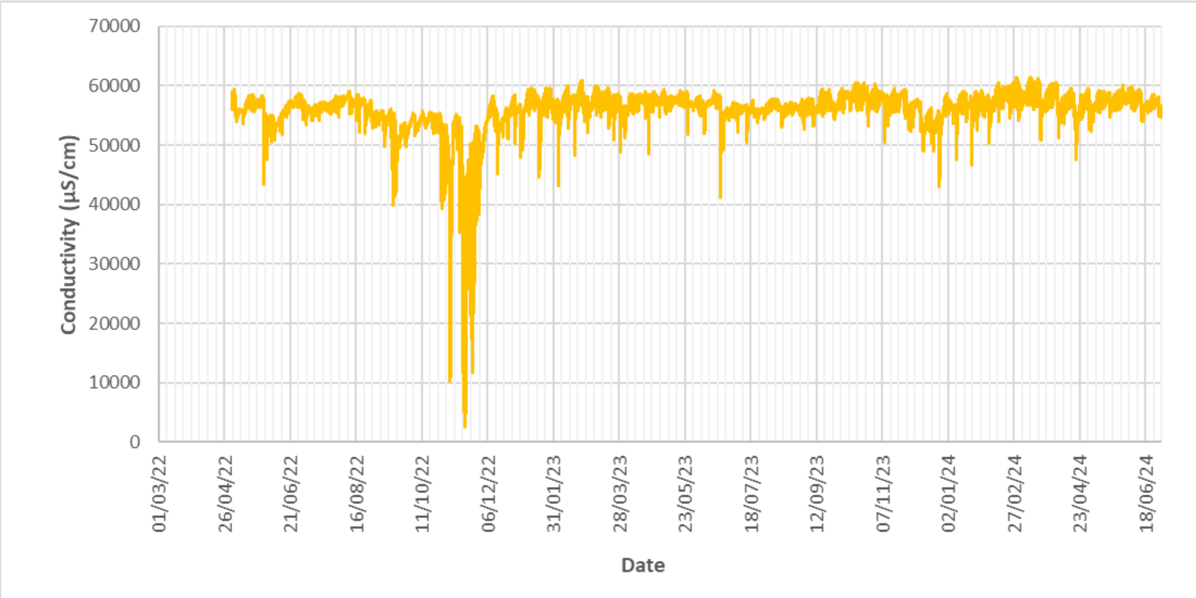


Figure 3-10 Electrical Conductivity Readings

3.2.3 Turbidity

Figure 3-11 presents the variation in turbidity over time.

Turbidity is an indirect measure of suspended solids and provides an indication of the ability for light to penetrate the water column.

For comparative purposes, a value of up to 20 NTU is typically acceptable, with values less than 8 NTU without associated rainfall considered to be associated with good water quality.

In this case, in periods without significant rainfall, turbidity values are very low throughout the monitoring period. Although low turbidity water is to be expected given the proximity to St Vincent Gulf, the ability to draw water with low turbidity will be of benefit in limiting turbidity in the lake system.

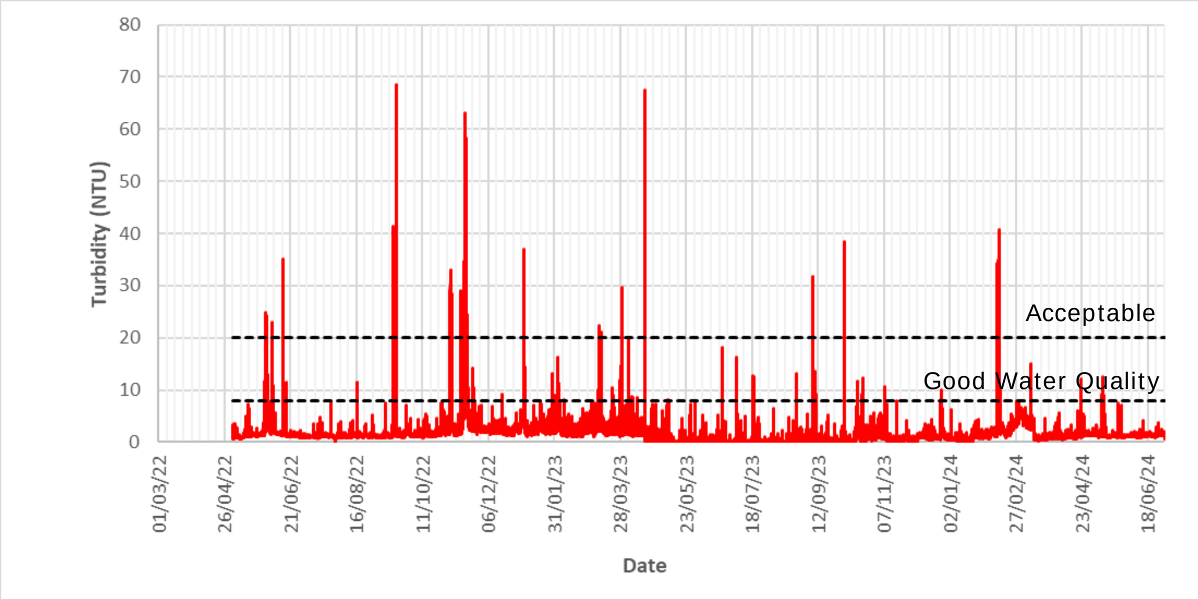


Figure 3-11 Turbidity Readings

3.2.4 Dissolved Oxygen

Figure 3-12 and Figure 3-13 present the variation in dissolved oxygen over time in terms of concentration and percentage dissolved oxygen respectively.

In general, dissolved oxygen concentrations of between 6.5 and 8.5-9.5 mg/L are consistent with healthy waters. Dissolved oxygen percentages exceeding about 120% can be harmful to aquatic life. About 19 percent of the readings are in this category to 13 September 2023.

A period of generally elevated dissolved oxygen levels is evident in the period from January to March 2023, the period from July to October 2023 and March to June 2024.

Low dissolved oxygen levels are typically of greater concern with respect to aquatic life. The results in the first part of 2023 and the first part of 2024 suggest a seasonal tendency to low dissolved oxygen levels in the wet season. It is recommended that sampling continue to determine if such seasonal conditions continue.

In any event, dissolved oxygen levels can be readily controlled via aeration as part of the pumping process.

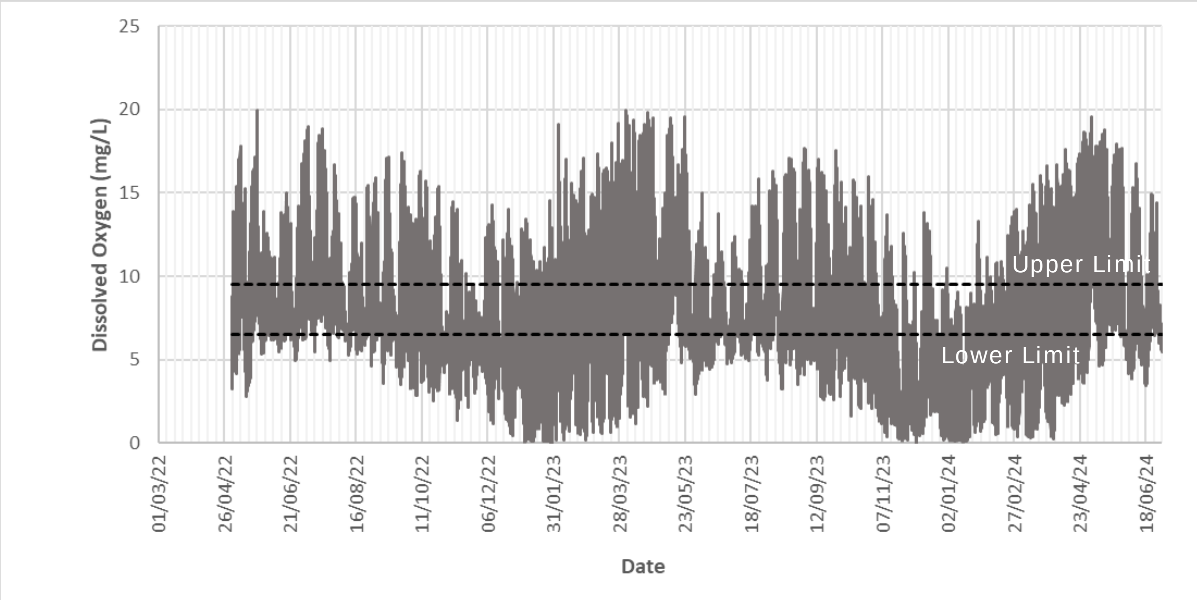


Figure 3-12 Dissolved Oxygen Readings (Concentration)

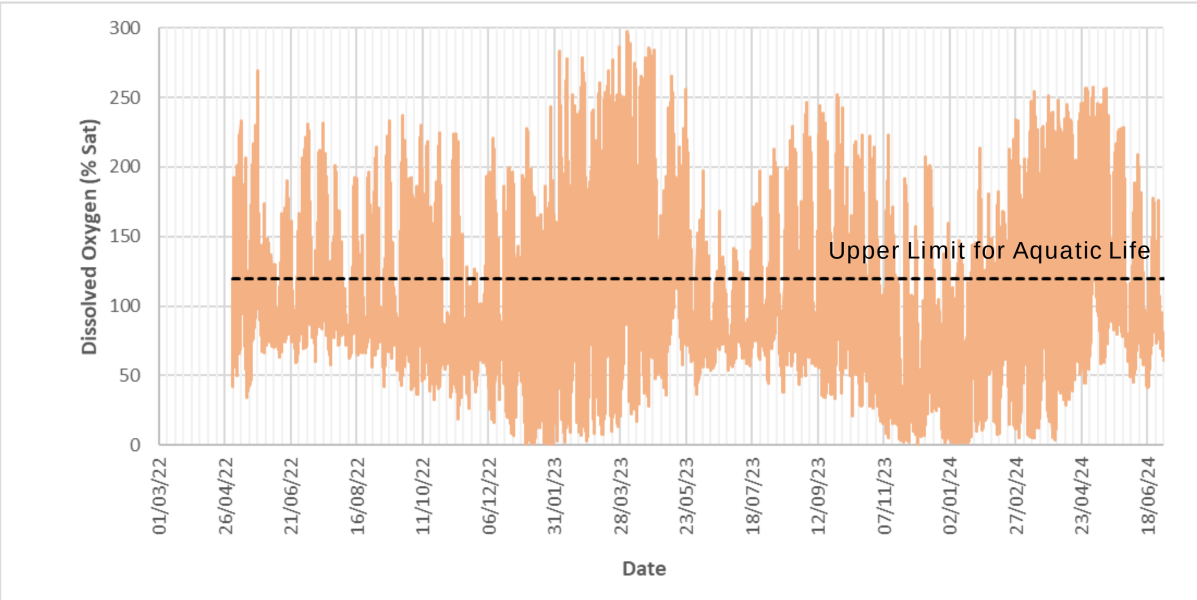


Figure 3-13 Dissolved Oxygen Readings (Percentage Saturation)

3.3 BDC Channel Sampling

Water quality samples were collected at 4 locations in the BDC Channel on 4 December 2023. The results of the sampling are presented in Table 7 of Appendix A.

The results of the sampling can be summarised as follows:

- Relatively high salinity in the channel samples (with a lower salinity at the outlet);
- Low suspended solids concentrations (equal to or less than 13 mg/L);
- High Total Nitrogen concentrations (between 2.0 and 3.8 mg/L);
- High Total Phosphorus concentrations (between 0.16 and 0.47 mg/L); and
- Relatively low chlorophyll 'a' concentrations (between 1 and 10 mg/m^3).

It is noted that although high, the nutrient concentrations were either the same or (typically) lower than the concentrations recorded at Point 4 (Channel) and Point 5 (Thompson Creek).

4 Interpretation of Results

4.1 Overview

The water quality monitoring is being undertaken to inform the design of a pumped saline lake system. The quality of water available for the lakes will determine the level of treatment required and influence the quality of water in the lakes.

This section interprets results in terms of anticipated acceptable conditions for urban lakes based on available guidelines.

4.2 Nutrients and Chlorophyll 'a'

4.2.1 Chapman Creek

Table 4-1 presents the range and medians of readings collected in Chapman Creek for Total Nitrogen, Total Phosphorus and chlorophyll 'a' (the primary indicators of water quality and potential for algal outbreaks) at Point 1 (Mouth of Chapman Creek) and Point 2 (Upstream Chapman Creek).

It is noted that, with the exception of Total Phosphorus, the monitoring completed since November 2022 (after the completion of the first monitoring report) and since October 2023 (after the completion of the second monitoring report) has provided results consistent with the information collected from March 2022. Total Phosphorus levels in Chapman Creek have been found to be generally higher in Chapman Creek in the latter part of 2023 and 2024 than in the preceding period. There is no apparent cause for the change and could be due to natural variation over time or changes in discharges associated with land uses (with corresponding changes in runoff quality) or the Bolivar STP.

Table 4-1 **Nutrients and Chlorophyll 'a' Levels**- Chapman Creek

Parameter	Mouth (Point 1)		Upstream (Point 2)	
	Range	Median	Range	Median
Total Nitrogen (mg/L)	<0.1-4.4	0.8	0.1-7.2	0.6
Total Phosphorus (mg/L)	0.02-1.45	0.1	0.02-0.40	0.16
Chlorophyll 'a' (mg/L)	<1-2	1	<1-6	1

For comparative purposes, for urban lakes according to the Melbourne Water publication *Constructed Shallow Lake Systems, Design Guidelines for Developers* (November 2005), the following range of values (annual means) are most likely to have manageable algal growth:

- Total Nitrogen: 0.35-0.7 mg/L
- Total Phosphorus: 0.01-0.1 mg/L; and
- Chlorophyll 'a': 5-15 mg/m^3.

From other experience in relation to the operation of urban lakes, it is considered that a Total Nitrogen level of 1 mg/L could be achieved subject to low chlorophyll 'a' levels.

The results suggest that the median quality of water in Chapman Creek matches or is greater than the values nominated in the nutrient guidelines but has a chlorophyll 'a' level that is well below the range suggested in the guidelines.

In this respect, the results are somewhat contradictory in nature. The relatively high nutrient levels are at the upper end of the desirable range (and exceed the limit on multiple occasions). Considered in isolation, the level of nutrients is such that they could give rise to algal growth which would result in poor water quality in the lake.

However, the actual extent of growth (measured via the chlorophyll 'a' parameter) is minimal.

This could be attributable to the low sediment levels that provide a clear water column, allowing the penetration of light and the minimisation of algae or the component fractions of the nutrient loads. In turn, the elevated nutrient loads may be attributable to discharge from runoff from other land use or discharge from the Bolivar STP entering Chapman Creek via tidal inflow.

It is also noted that access to Chapman Creek is only possible at high tide when the depth of water over the bar at the mouth of the creek is sufficient to allow boats to pass. This could influence readings to some degree.

Additional analysis will be required as part of further design to review the quality of water discharged from the STP and identify its contribution to overall water quality relative to other catchment land uses. Based on this assessment, the need for additional treatment of the water drawn from Chapman Creek can be assessed.

4.2.2 Ocean

Table 4-2 lists the range and median of readings collected at the ocean sites for Total Nitrogen, Total Phosphorus and chlorophyll 'a', noting that data has been collected at Point 3 (Offshore) throughout the monitoring program and at Point 7 (Inshore Bolivar) since 20 June 2023.

Since the completion of the second water quality monitoring report (i.e., in the latter part of 2023 and in 2024), the concentrations of nutrients at Point 7 (Inshore Bolivar) have increased such that nutrient concentrations at Point 7 (Inshore Bolivar) are typically higher than those at Point 3 (Offshore).

Table 4-2 **Nutrients and Chlorophyll 'a' Levels**- Ocean

Parameter	Offshore (Point 3)		Inshore Bolivar (Point 7)	
	Range	Median	Range	Median
Total Nitrogen (mg/L)	<0.1-5.7	0.7	0.4-5.6	0.95
Total Phosphorus (mg/L)	0.02-0.56	0.15	0.04-1.11	0.55
Chlorophyll 'a' (mg/L)	<1-4.7	1	1-29	3

The results for the Point 3 (Offshore) are of a similar order as those obtained from Chapman Creek, suggesting that conditions in Chapman Creek mirror those of the Point 3 (Offshore), which in turn could be affected by discharges from the Bolivar STP and runoff from other horticultural land uses, noting the relatively higher concentrations of nutrients being recorded at Point 7 (Inshore Bolivar) in the latter part of 2023 and 2024.

4.2.3 Downstream of Future Lakes/ Thompson Creek

Table 4-3 presents the range and medians of readings collected downstream of the future lakes for Total Nitrogen, Total Phosphorus and chlorophyll 'a'.

Table 4-3 **Nutrients and Chlorophyll 'a' Levels**- Thompson Creek

Parameter	Channel (Point 4)		Thompson Creek (Point 5)	
	Range	Median	Range	Median
Total Nitrogen (mg/L)	1.5-34.5	10.9	1.6-28.4	7.6
Total Phosphorus (mg/L)	0.07-3.12	0.28	0.38-2.22	0.74
Chlorophyll 'a' (mg/L)	<1-1,100	53	<1-389	70

The recorded values are extremely high, pointing to the indirect influence of the discharges from Bolivar STP or other land use issues.

The one-off sampling in the BDC Channel determined elevated nutrient levels and generally low chlorophyll 'a' values.

It is expected that the quality of water discharged from the lakes will be significantly superior to the existing situation. This is because the quality of water in the lakes will somewhat reflect the quality of water in Chapman Creek. As the quality of water in Chapman Creek is consistently better than the quality of water in the watercourses downstream of the lakes, discharge from the lakes will reduce overall nutrient and chlorophyll concentrations in downstream areas.

4.3 Other Parameters

4.3.1 Suspended Solids and Turbidity

Table 4-4 presents the range and medians of readings collected in the vicinity of Chapman Creek with respect to suspended solids. These values are of relevance to the quality of water drawn into the lake.

Table 4-4 Suspended Sediment and Turbidity- Chapman Creek

Parameter	Mouth (Point 1)		Upstream (Point 2)	
	Range	Median	Range	Median
Suspended Solids (mg/L)	1-64	2	1-57	1

As noted in Section 3.1.3, suspended solids concentrations less than 10 mg/L are considered to be quite low. Given this, the quality of water in Chapman Creek is considered to be good, noting that screening may be necessary during periods when suspended solids levels are elevated.

The turbidity recordings at the continuous sampler varied between 0 and 68 NTU, with a median of 1.2 NTU. The values are considered to be low and consistent with the low suspended solids readings.

The monitored results for suspended solids and turbidity (both in Chapman Creek and other sites) are relatively low and are not expected to pose an issue with respect to lake water quality.

4.3.2 Salinity

Monitored salinity levels in Chapman Creek are consistently high, typically reflecting fully saline conditions. Similarly, the salinity of waters downstream of the lakes is brackish/ saline. Consequently, it is expected that it will be possible to draw saline water from Chapman Creek for use in the lakes.

4.3.3 pH

Recorded pH levels are consistent and within an acceptable (typically 6.5-9) range.

4.3.4 Dissolved Oxygen

Dissolved oxygen levels were found to be generally within acceptable limits (between 6.5 and 8.5-9.5 mg/L). However, it may be necessary to include the oxygenation of water as part of the pumping process to guarantee this during the periods when dissolved oxygen levels fall below the lower limit. These periods would appear to occur during the wet season (i.e., towards the end of each year and the early part of the following year).

4.3.5 Heavy Metals

With reference to Table 3-2 and Table 3-3, concentrations of heavy metals have been found to be consistently below guideline values for recreational water use.

Given this, it is considered that heavy metals are not of significance with respect to the lake system.

4.4 Overall

Based on the review of the collected water quality data, recorded values for many water quality parameters are considered to be acceptable for the purposes of drawing water from Chapman Creek for the future lakes.

However, attention will need to be paid to dissolved oxygen and nutrient levels.

In the case of dissolved oxygen, it may be necessary to include the (straightforward) oxygenation of water to ensure that lake water has sufficient oxygen to address observed limited periods with lower than desirable oxygen levels. Similarly, screening can be used if necessary to lower sediment levels.

The relatively high nutrient levels in Chapman Creek will require attention as part of detailed water quality modelling. As noted above, the elevated nutrient levels are accompanied by very low chlorophyll 'a' values, suggesting that the potential for algal growth is low. In the worst case, and only if necessary, treatment options are readily available to deal with elevated nutrient levels.

Noting the high nutrient concentrations recorded in Thompson Creek, it is considered that the water discharged from the lakes to Thompson Creek will be of a significantly higher quality than is currently the case, thereby producing an improvement in water quality via reduced concentrations of water quality parameters.

5 Conclusion and Recommendations

Baseline water quality monitoring is underway to inform the future design of the Riverlea lake system which will rely on the pumping of water from Chapman Creek to turnover and maintain water quality in the water bodies.

The monitoring has taken the form of discrete sampling on approximately a fortnightly (2022 and early 2023) and monthly (early 2023 onwards) basis (quarterly for heavy metals) and continuous sampling of a number of parameters in Chapman Creek in the vicinity of the likely intake point for the lake.

The results of monitoring to date can be summarised as follows with respect to Chapman Creek:

- Consistent and acceptable pH values;
- Typically, highly saline water except for short periods following local rainfall events (i.e., the recovery time will be relatively rapid);
- Very low suspended solids and turbidity levels;
- Relatively high Total Nitrogen concentrations, predominantly associated with organic Nitrogen;
- Relatively high Total Phosphorus concentrations (which have increased over the most recent sampling period);
- Very low chlorophyll 'a' values;
- Variable but typically high dissolved oxygen levels; and
- Low heavy metal concentrations (well below guideline limits for recreational waters);

In contrast, the sampling points in Thompson Creek and the Outfall Channel have indicated very high Total Nitrogen, Total Phosphorus and chlorophyll 'a' concentrations. These concentrations were found to typically (but not always) fall progressively to the Inshore Bolivar Outlet and Offshore monitoring points due to ocean mixing.

Based on the results obtained to date, it is considered that detailed design of the intake system will need to pay attention to nutrient levels and include measures to screen water and also ensure acceptable dissolved oxygen levels.

It is further expected that the quality of water discharged from the lakes to Thompson Creek will be significantly better than the current quality of water due to the relatively higher quality of water that will be drawn from Chapman Creek into the lakes.

It is recommended that monitoring continue in order that a more detailed understanding of the variation in water quality can be gained. It is considered sufficient for the general testing to be completed monthly.

Given the consistently low heavy metal readings, it is considered that sampling for heavy metals can be discontinued.

Appendix A Discrete Sampling Results

Table 1: Location 1, Mouth of Chapman Creek

Analyte grouping/Analyte	Unit	Limit of reporting	10-Mar-22	23-Mar-22	4-Apr-22	20-Apr-22	2-May-22	18-May-22	1-Jun-22	28-Jun-22	13-Jul-22	27-Jul-22	8-Aug-22	31-Aug-22	6-Sep-22	28-Sep-22	10-Oct-22
Standard Water Quality Parameters																	
pH	pH Unit	0.01	8.2														
Electrical Conductivity @ 25°C	µS/cm	1	46600	55700	68200	70500	62500	60000	54800	59200	51500	61100	57900	58200	57100	51500	55200
Suspended Solids (SS)	mg/L	1	<5	3	3	2	2	<1	23	1	2	<1	1	<1	4	64	2
Ammonia as N	mg/L	0.01	0.09	<0.02	0.06	0.01	0.1	0.12	0.02	0.09	0.01	0.08	0.05	0.18	0.13	0.14	<0.05
Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01
Nitrate as N	mg/L	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	0.15	0.05
Nitrite + Nitrate as N	mg/L	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	0.18	0.05
Total Kjeldahl Nitrogen as N	mg/L	0.1	<1.0	<0.5	1	0.3	1.6	0.2	0.4	<0.1	1.7	0.1	1.1	1.3	4.2	4.2	<1.0
Total Nitrogen as N	mg/L	0.1	<1.0	<0.5	1	0.3	1.6	0.2	0.4	<0.1	1.7	0.1	1.1	1.3	4.2	4.4	<1.0
Total Phosphorus as P	mg/L	0.01	<0.10	0.07	0.19	0.03	0.11	0.08	0.19	0.11	0.1	<0.10	0.91	0.14	<0.10	0.27	<0.10
Reactive Phosphorus as P	mg/L	0.01	0.09	0.12	0.04	0.03	0.03	0.01	<0.01	0.03	0.04	0.01	0.02	0.02	0.03	0.06	0.05
Field Tests																	
pH	pH Unit	0.01		6.33	8.16	8.19	8.09	8.02	7.94	8.06	8.24	8.45	7.99	8.51	8.19	8.45	8.44
Temperature	°C	0.1		8	20.8	19.1	18.6	16.1	12.9	11.63	11.51	12.3	11.3	15.3	12.8	16.9	20.1
Field Dissolved Oxygen	mg/L	0.1	3.87	19.5	10.22	11.72	10.03	9.84	7.73	9.81	10.37	11.7	7.06	12.3	7.05	11.39	12.04
Electrical Conductivity	µS/cm	1										56400		55347			
Chlorophyll a																	
Chlorophyll a	mg/m³	1	2	<1	<1	<1	<1	<1	2	<1	<1		<1	<1	<1	1	<1
Heavy Metals																	
Arsenic	mg/L	0.001	<0.010						<0.002						0.006		
Cadmium	mg/L	0.0001	<0.0010						<0.0002						0.0015		
Chromium	mg/L	0.001	<0.010						<0.002						<0.002		
Copper	mg/L	0.001	<0.010						<0.002						0.004		
Lead	mg/L	0.001	<0.010						<0.002						<0.002		
Nickel	mg/L	0.001	<0.010						<0.002						<0.002		
Zinc	mg/L	0.005	<0.052						<0.010						0.013		
Mercury	mg/L	0.0001	<0.0001						<0.0001						<0.0001		

Table 1: Location 1, Mouth of Chapman Creek

Analyte grouping/Analyte	Unit	Limit of reporting	16-Nov-22	30-Nov-22	15-Dec-22	11-Jan-23	09-Feb-23	21-Feb-23	15-Mar-23	29-Mar-23	04-Apr-23	17-Apr-23	05-May-23	20-Jun-23	04-Jul-23	01-Aug-23	13-Sep-23
Standard Water Quality Parameters																	
pH	pH Unit	0.01															
Electrical Conductivity @ 25°C	µS/cm	1	12700	52400	50200	55800	58000	58400	52900	52500	57700	57900	57100	54400	57100	54200	55000
Suspended Solids (SS)	mg/L	1	28	<1	<1	<1	53	<1	<1	<1	3	4	<1	----	59	4	<1
Ammonia as N	mg/L	0.01	0.15	0.18	0.09	0.15	<0.05	<0.05	<0.05	0.06	0.1	<0.02	0.16	<0.05	0.14	0.03	0.1
Nitrite as N	mg/L	0.01	0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	0.13	0.02	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.06	0.05	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	0.14	0.04	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.06	0.06	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	1.7	1.6	<1.0	1.4	<1.0	0.9	<0.5	<0.5	<0.5	0.5	0.6	0.5	0.4	0.2	0.4
Total Nitrogen as N	mg/L	0.1	1.8	1.6	<1.0	1.4	<1.0	0.9	<0.5	<0.5	<0.5	0.5	0.6	0.6	0.5	0.2	0.4
Total Phosphorus as P	mg/L	0.01	0.31	0.28	<0.10	0.24	<0.10	0.19	0.09	0.06	<0.05	0.08	0.08	1.45	<0.02	0.1	0.34
Reactive Phosphorus as P	mg/L	0.01	0.13	0.18	0.1	0.08	0.04	0.07	0.03	0.07	0.03	0.04	0.04	0.03	0.04	0.03	0.02
Field Tests																	
pH	pH Unit	0.01	7.53	8.44	8.41	8.12	8.06	7.76	8.52	8.5	8.59	8.51	8.34	8.08	8.15	8.42	8.42
Temperature	°C	0.1	16.4	18.1	16.8	23	22.9	24.1	25.2	22.6	23.1	18.7	15.4	12.2	12.5	14	18.8
Field Dissolved Oxygen	mg/L	0.1	6.25	4.44	3.3	1.88	3.4	2.17	13.99	12.7	16.79	14.55	12.76	9.09	10.61	11.23	13.88
Electrical Conductivity	µS/cm	1															
Chlorophyll a																	
Chlorophyll a	mg/m³	1	<2	2	1	0	<1	<1	<1	0	1	0	0	<1	<0.5	<1	1
Heavy Metals																	
Arsenic	mg/L	0.001		<0.005										<0.005			<0.005
Cadmium	mg/L	0.0001		<0.0005										<0.0005			<0.0005
Chromium	mg/L	0.001		<0.005										<0.005			<0.005
Copper	mg/L	0.001		<0.005										<0.005			<0.005
Lead	mg/L	0.001		<0.005										<0.005			<0.005
Nickel	mg/L	0.001		<0.005										<0.005			<0.005
Zinc	mg/L	0.005		<0.026										<0.026			<0.026
Mercury	mg/L	0.0001		<0.0001										<0.0001			<0.0001

Table 1: Location 1, Mouth of Chapman Creek

Analyte grouping/Analyte	Unit	Limit of reporting	18-Oct-23	20-Nov-23	04-Dec-23	29-Jan-24	13-Feb-24	13-Mar-24	22-Apr-24	06-May-24	03-Jun-24	02-Jul-24
Standard Water Quality Parameters												
pH	pH Unit	0.01										
Electrical Conductivity @ 25°C	µS/cm	1	60000	60700	56900	55000	55400	55500	52400	56600	56900	44400
Suspended Solids (SS)	mg/L	1	<1	<1	<1	<1	<1	1	<1	<1	<1	2
Ammonia as N	mg/L	0.01	<0.05	<0.01	<0.05	<0.05	<0.05	0.08	0.10	<0.01	0.04	0.12
Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
Nitrate as N	mg/L	0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	0.22
Nitrite + Nitrate as N	mg/L	0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	0.24
Total Kjeldahl Nitrogen as N	mg/L	0.1	0.5	0.6	0.4	<0.1	0.4	0.5	0.3	0.3	0.2	0.3
Total Nitrogen as N	mg/L	0.1	0.5	0.6	0.4	<0.1	0.4	0.5	0.3	0.3	0.3	0.5
Total Phosphorus as P	mg/L	0.01	0.63	0.20	0.21	0.18	0.12	0.23	0.26	0.21	0.11	0.18
Reactive Phosphorus as P	mg/L	0.01	0.08	0.08	0.06	0.07	0.07	0.14	0.04	0.11	0.05	0.13
Field Tests												
pH	pH Unit	0.01	8.18	8.41	8.17	8.04	7.96	7.83	8.53	8.65	8.34	8.1
Temperature	°C	0.1	16.4	20.3	21.1	23	25.2	25.6	19.9	19.1	10.7	0
Field Dissolved Oxygen	mg/L	0.1	5.28	4.15	4.82	2.43	2.08	2.25	13.52	14.55	10.18	7.93
Electrical Conductivity	µS/cm	1										
Chlorophyll a												
Chlorophyll a	mg/m³	1	1.2	<1	<1	<1	1.9	1.8	<0.5	<1	<1	<1
Heavy Metals												
Arsenic	mg/L	0.001			<0.005			<0.005			0.008	
Cadmium	mg/L	0.0001			<0.0005			<0.0005			<0.0005	
Chromium	mg/L	0.001			<0.005			<0.005			<0.005	
Copper	mg/L	0.001			<0.005			<0.005			<0.005	
Lead	mg/L	0.001			<0.005			<0.005			<0.005	
Nickel	mg/L	0.001			<0.005			<0.005			<0.005	
Zinc	mg/L	0.005			<0.026			<0.026			<0.026	
Mercury	mg/L	0.0001			<0.0001			<0.0001			<0.0001	

Table 2: Location 2, Upper Chapman Creek

Analyte grouping/Analyte	Unit	Limit of reporting	10-Mar-22	23-Mar-22	4-Apr-22	20-Apr-22	2-May-22	18-May-22	1-Jun-22	28-Jun-22	13-Jul-22	27-Jul-22	8-Aug-22	31-Aug-22	6-Sep-22	28-Sep-22	10-Oct-22
Standard Water Quality Parameters																	
pH	pH Unit	0.01	8.13														
Electrical Conductivity @ 25°C	µS/cm	1	47600	59000	69900	71200	63400	63700	52700	62400	52000	60000	58500	55600	57400	53200	57400
Suspended Solids (SS)	mg/L	1	<5	<1	2	2	<1	<1	17	3	<1	<1	<1	<1	1	16	<1
Ammonia as N	mg/L	0.01	<0.01	<0.02	0.05	0.06	0.22	0.04	0.04	0.09	0.03	0.06	0.08	0.03	0.18	<0.01	<0.05
Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.24	<0.01	<0.01	0.01	0.02	<0.01	0.08	0.01	0.05
Nitrite + Nitrate as N	mg/L	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.24	<0.01	<0.01	0.01	0.02	<0.01	0.08	0.01	0.05
Total Kjeldahl Nitrogen as N	mg/L	0.1	<1.0	7.2	1.2	1	1.5	0.3	0.5	0.2	0.1	0.8	1	1.5	5.6	2.7	<1.0
Total Nitrogen as N	mg/L	0.1	<1.0	7.2	1.2	1	1.5	0.3	0.7	0.2	0.1	0.8	1	1.5	5.7	2.7	<1.0
Total Phosphorus as P	mg/L	0.01	<0.10	0.16	0.25	0.2	<0.10	0.07	0.3	0.16	0.18	<0.10	0.21	0.2	<0.10	0.13	<0.10
Reactive Phosphorus as P	mg/L	0.01	0.09	0.07	0.07	0.05	0.03	0.03	0.05	0.04	0.02	0.03	0.02	0.02	0.05	0.04	0.05
Field Tests																	
pH	pH Unit	0.01		5.54	8.08	7.83	8.16	7.85	7.67	7.08	7.93	7.78	7.55	7.53	7.81	7.48	7.83
Temperature	°C	0.1		7.69	20.6	18.1	19.5	15.5	12.6	11.66	10.8	12.1	12.2	12.7	12.2	14.9	18.3
Field Dissolved Oxygen	mg/L	0.1	8.44	20	8.5	7.27	11.94	9.95	8.89	6.26	7.66	6.71	6.89	7.54	7.65	7.08	8.09
Electrical Conductivity	µS/cm	1										57600		53781			
Chlorophyll a																	
Chlorophyll a	mg/m³	1	<1	<1	2	<1	<1	<1	2	<1	<1		<1	<1	<1	<1	<1
Heavy Metals																	
Arsenic	mg/L	0.001	<0.010						<0.002						0.010		
Cadmium	mg/L	0.0001	<0.0010						<0.0002						0.0026		
Chromium	mg/L	0.001	<0.010						<0.002						0.004		
Copper	mg/L	0.001	<0.010						<0.002						0.006		
Lead	mg/L	0.001	<0.010						<0.002						0.003		
Nickel	mg/L	0.001	<0.010						<0.002						0.005		
Zinc	mg/L	0.005	<0.052						<0.010						<0.010		
Mercury	mg/L	0.0001	<0.0001						<0.0001						<0.0001		

Table 2: Location 2, Upper Chapman Creek

Analyte grouping/Analyte	Unit	Limit of reporting	16-Nov-22	30-Nov-22	15-Dec-22	11-Jan-23	09-Feb-23	21-Feb-23	15-Mar-23	29-Mar-23	04-Apr-23	17-Apr-23	05-May-23	20-Jun-23	04-Jul-23	01-Aug-23	13-Sep-23
Standard Water Quality Parameters																	
pH	pH Unit	0.01															
Electrical Conductivity @ 25°C	µS/cm	1	3330	49300	53400	55900	58400	61700	56400	57000	60000	60100	59900	55600	58400	54500	56000
Suspended Solids (SS)	mg/L	1	51	<1	<1	<1	57	<1	<1	<1	<1	<1	<1	<1	32	<1	5
Ammonia as N	mg/L	0.01	0.16	0.15	0.13	0.15	0.08	<0.05	<0.05	0.11	0.09	0.11	0.3	<0.05	0.2	0.11	0.16
Nitrite as N	mg/L	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	0.12	0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	<0.01	0.02	0.04	<0.01	0.04
Nitrite + Nitrate as N	mg/L	0.01	0.13	0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	<0.01	0.02	0.04	<0.01	0.04
Total Kjeldahl Nitrogen as N	mg/L	0.1	1.6	1.1	1.3	<0.2	<1.0	0.7	0.6	<0.5	<0.5	0.6	0.3	<0.5	0.4	0.3	0.4
Total Nitrogen as N	mg/L	0.1	1.7	1.1	1.3	<0.2	<1.0	0.7	0.6	<0.5	<0.5	0.6	0.3	<0.5	0.4	0.3	0.4
Total Phosphorus as P	mg/L	0.01	0.27	0.12	0.24	0.07	<0.10	0.18	0.1	0.1	0.13	0.1	0.16	<0.05	<0.02	0.1	0.38
Reactive Phosphorus as P	mg/L	0.01	0.15	0.08	0.09	0.08	0.06	0.07	0.04	0.03	0.08	0.05	0.05	0.03	0.06	0.04	0.06
Field Tests																	
pH	pH Unit	0.01	----	7.77	8.01	----	7.96	7.56	7.87	7.51	8.09	7.66	7.93	7.55	7.7	7.68	7.95
Temperature	°C	0.1	----	19.6	17.3	----	23	24.3	22.6	21.1	21.4	17	14.1	11.6	12.1	13.1	17.3
Field Dissolved Oxygen	mg/L	0.1	----	5.35	5.78	0	2.83	2.4	4.65	4.59	8.14	5.37	7.5	6.65	8.04	5.82	7.84
Electrical Conductivity	µS/cm	1															
Chlorophyll a																	
Chlorophyll a	mg/m^3	1	<2	<1	6	0	<1	<1	<1	0	1	0	0	<1	<0.5	5	0.7
Heavy Metals																	
Arsenic	mg/L	0.001		<0.005										<0.005			<0.005
Cadmium	mg/L	0.0001		<0.0005										<0.0005			<0.0005
Chromium	mg/L	0.001		<0.005										<0.005			<0.005
Copper	mg/L	0.001		<0.005										<0.005			<0.005
Lead	mg/L	0.001		<0.005										<0.005			<0.005
Nickel	mg/L	0.001		<0.005										<0.005			<0.005
Zinc	mg/L	0.005		<0.026										<0.026			<0.026
Mercury	mg/L	0.0001		<0.0001										<0.0001			<0.0001

Table 2: Location 2, Upper Chapman Creek

Analyte grouping/Analyte	Unit	Limit of reporting	18-Oct-23	20-Nov-23	04-Dec-23	29-Jan-24	13-Feb-24	13-Mar-24	22-Apr-24	06-May-24	03-Jun-24	02-Jul-24
Standard Water Quality Parameters												
pH	pH Unit	0.01										
Electrical Conductivity @ 25°C	µS/cm	1	55900	63700	59000	55300	57100	59200	50700	51600	57900	44800
Suspended Solids (SS)	mg/L	1	<1	<1	<1	<1	<1	4	4	4	<1	<1
Ammonia as N	mg/L	0.01	<0.05	<0.01	0.10	<0.05	<0.05	0.13	0.18	0.05	0.12	0.22
Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.01	<0.01
Nitrate as N	mg/L	0.01	<0.05	0.05	<0.01	<0.01	<0.01	0.01	0.07	0.04	0.14	0.07
Nitrite + Nitrate as N	mg/L	0.01	<0.05	0.05	<0.01	<0.01	<0.01	0.01	0.09	0.04	0.15	0.07
Total Kjeldahl Nitrogen as N	mg/L	0.1	0.6	1.9	0.7	<0.1	0.5	0.6	0.6	0.4	0.4	0.4
Total Nitrogen as N	mg/L	0.1	0.6	1.9	0.7	<0.1	0.5	0.6	0.6	0.4	0.4	0.4
Total Phosphorus as P	mg/L	0.01	0.40	0.30	0.24	0.36	0.16	0.22	0.36	0.32	0.15	0.17
Reactive Phosphorus as P	mg/L	0.01	0.09	0.10	0.10	0.09	0.10	0.08	0.14	0.08	0.07	0.08
Field Tests												
pH	pH Unit	0.01	7.99	8.06	8.15	8.03	7.8	7.97	7.93	8.29	7.65	7.62
Temperature	°C	0.1	16.6	20.7	22.5	23.2	25.2	27.3	17.7	17.3	11.6	0
Field Dissolved Oxygen	mg/L	0.1	4.25	5.8	5.15	2.18	1.13	5.19	5.34	8.68	4.82	5.75
Electrical Conductivity	µS/cm	1										
Chlorophyll a												
Chlorophyll a	mg/m³	1	<0.5	<1	<1	<1	0.9	1.3	1.5	<1	<1	<1
Heavy Metals												
Arsenic	mg/L	0.001			<0.005			<0.005			0.006	
Cadmium	mg/L	0.0001			<0.0005			<0.0005			<0.0005	
Chromium	mg/L	0.001			<0.005			<0.005			<0.005	
Copper	mg/L	0.001			<0.005			<0.005			<0.005	
Lead	mg/L	0.001			<0.005			<0.005			<0.005	
Nickel	mg/L	0.001			<0.005			<0.005			<0.005	
Zinc	mg/L	0.005			<0.026			<0.026			<0.026	
Mercury	mg/L	0.0001			<0.0001			<0.0001			<0.0001	

Table 3: Location 3, Offshore

Analyte grouping/Analyte	Unit	Limit of reporting	10-Mar-22	23-Mar-22	4-Apr-22	20-Apr-22	2-May-22	18-May-22	1-Jun-22	28-Jun-22	13-Jul-22	27-Jul-22	8-Aug-22	31-Aug-22	6-Sep-22	28-Sep-22	10-Oct-22	16-Nov-22
Standard Water Quality Parameters																		
pH	pH Unit	0.01	8.04															
Electrical Conductivity @ 25°C	µS/cm	1	46700	55200	68000	69600	60900	60000	57300	57100	50100	60100	57300	56600	55700	55800	56900	54600
Suspended Solids (SS)	mg/L	1	<5	<1	15	3	<1	4	26	1	3	<1	4	4	2	23	<1	7
Ammonia as N	mg/L	0.01	0.13	<0.02	0.05	0.06	0.18	0.16	<0.01	0.04	0.03	0.06	0.1	0.13	0.14	0.09	<0.05	0.22
Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01	0.02	<0.01	<0.01	0.02
Nitrate as N	mg/L	0.01	<0.01	<0.01	<0.01	0.02	0.05	0.06	<0.01	0.1	0.05	<0.01	0.01	0.02	0.1	<0.01	0.03	0.02
Nitrite + Nitrate as N	mg/L	0.01	<0.01	<0.01	<0.01	0.02	0.05	0.06	<0.01	0.1	0.06	<0.01	0.01	0.03	0.12	<0.01	0.03	0.04
Total Kjeldahl Nitrogen as N	mg/L	0.1	<1.0	5.2	<0.1	0.7	1.5	0.3	0.2	0.1	1.8	<0.1	0.2	1	5.6	3.6	<1.0	0.4
Total Nitrogen as N	mg/L	0.1	<1.0	5.2	<0.1	0.7	1.6	0.4	0.2	0.2	1.9	<0.1	0.2	1	5.7	3.6	<1.0	0.4
Total Phosphorus as P	mg/L	0.01	<0.10	0.14	0.03	0.49	<0.10	0.11	0.26	0.12	0.16	<0.10	0.56	0.1	0.18	0.12	<0.10	0.16
Reactive Phosphorus as P	mg/L	0.01	0.08	0.13	<0.01	0.02	0.05	0.03	<0.01	0.06	0.04	0.02	0.02	0.04	0.06	0.02	0.06	0.13
Field Tests																		
pH	pH Unit	0.01		1.79	8.21	8.05	8.14	8.06	7.95	8.22	8.3	8.56	8.12	8.44	8.19	8.39	8.3	----
Temperature	°C	0.1		7.72	20.5	18.8	18.8	16.1	12.7	12.5	11.83	12.5	12.4	13.9	12.9	16.1	18.6	----
Field Dissolved Oxygen	mg/L	0.1	3.62	18.5	11.88	10.71	11.18	10.4	8.18	11.22	10.94	12.29	9.29	10.55	8.6	10.94	11.79	----
Electrical Conductivity	µS/cm	1										55400		53961				
Chlorophyll a																		
Chlorophyll a	mg/m³	1	1	<1	3	2	<1	2	<1	<1	<1		<1	4	<1	<1	1	4
Heavy Metals																		
Arsenic	mg/L	0.001	<0.010						<0.002						0.007			
Cadmium	mg/L	0.0001	<0.0010						<0.0002						0.0017			
Chromium	mg/L	0.001	<0.010						<0.002						<0.002			
Copper	mg/L	0.001	<0.010						<0.002						0.003			
Lead	mg/L	0.001	<0.010						<0.002						<0.002			
Nickel	mg/L	0.001	<0.010						<0.002						0.002			
Zinc	mg/L	0.005	<0.052						<0.010						<0.010			
Mercury	mg/L	0.0001	<0.0001						<0.0001						<0.0001			

Table 3: Location 3, Offshore

Analyte grouping/Analyte	Unit	Limit of reporting	30-Nov-22	15-Dec-22	11-Jan-23	09-Feb-23	21-Feb-23	15-Mar-23	29-Mar-23	04-Apr-23	17-Apr-23	05-May-23	20-Jun-23	04-Jul-23	01-Aug-23	13-Sep-23	18-Oct-23	20-Nov-23	04-Dec-23
Standard Water Quality Parameters																			
pH	pH Unit	0.01																	
Electrical Conductivity @ 25°C	µS/cm	1	57100	51400	55500	57500	52400	53900	57900	57300	57900	57500	53600	56700	53400	52900	57400	59500	57000
Suspended Solids (SS)	mg/L	1	<1	<1	71	36	<1	<1	<1	<1	<1	<1	9	113	7	<1	<1	<1	<1
Ammonia as N	mg/L	0.01	0.2	0.09	0.21	0.08	0.18	<0.05	0.06	0.07	<0.02	0.22	<0.05	0.14	<0.01	0.14	<0.05	<0.01	0.16
Nitrite as N	mg/L	0.01	0.03	0.03	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	0.01	<0.01	0.01	0.04	0.02	<0.01
Nitrate as N	mg/L	0.01	0.14	0.17	<0.01	<0.01	0.01	<0.01	<0.01	0.06	0.02	0.14	0.24	0.09	0.01	0.43	0.05	<0.01	0.01
Nitrite + Nitrate as N	mg/L	0.01	0.17	0.2	<0.01	<0.01	0.02	<0.01	<0.01	0.06	0.02	0.16	0.26	0.1	0.01	0.44	0.09	<0.01	0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	1.7	1.4	<0.2	<1.0	1.3	<0.5	<0.5	1.1	0.5	0.6	<0.5	0.3	0.2	0.3	0.3	1.0	0.7
Total Nitrogen as N	mg/L	0.1	1.9	1.6	<0.2	<1.0	1.3	<0.5	<0.5	1.2	0.5	0.8	<0.5	0.4	0.2	0.7	0.4	1.0	0.7
Total Phosphorus as P	mg/L	0.01	0.23	0.14	<0.02	0.29	0.4	0.06	0.06	<0.05	0.1	0.17	0.07	<0.02	0.09	0.3	0.43	0.28	0.24
Reactive Phosphorus as P	mg/L	0.01	0.14	0.11	0.03	0.04	0.32	0.02	<0.01	0.04	0.04	0.09	0.08	0.04	0.04	0.09	0.20	0.20	0.17
Field Tests																			
pH	pH Unit	0.01	8.39	8.31	8.07	8.13	7.88	8.28	8.1	8.32	8.38	8.27	8.09	8.13	8.46	8.31	8.13	8.27	8.16
Temperature	°C	0.1	18.3	16.3	23.5	23.1	24.3	22.8	21.1	21.8	18.2	14.8	12	12.6	14	17.9	16.3	20.3	21.5
Field Dissolved Oxygen	mg/L	0.1	4.6	5.83	4.35	2.83	1.75	9.67	8.68	13.09	13	11.41	8.95	10.21	11.9	12.92	5.93	2.11	2.61
Electrical Conductivity	µS/cm	1																	
Chlorophyll a																			
Chlorophyll a	mg/m³	1	2	3	0	<1	2	<1	0	<1	0	0	<1	0.7	1	4.7	4.2	2	<1
Heavy Metals																			
Arsenic	mg/L	0.001	<0.005										<0.005			<0.005			<0.005
Cadmium	mg/L	0.0001	<0.0005										<0.0005			<0.0005			<0.0005
Chromium	mg/L	0.001	<0.005										<0.005			<0.005			<0.005
Copper	mg/L	0.001	<0.005										<0.005			<0.005			<0.005
Lead	mg/L	0.001	<0.005										<0.005			<0.005			<0.005
Nickel	mg/L	0.001	<0.005										<0.005			<0.005			<0.005
Zinc	mg/L	0.005	<0.026										<0.026			<0.026			<0.026
Mercury	mg/L	0.0001	<0.0001										<0.0001			<0.0001			<0.0001

Table 3: Location 3, Offshore

Analyte grouping/Analyte	Unit	Limit of reporting	29-Jan-24	13-Feb-24	13-Mar-24	22-Apr-24	06-May-24	03-Jun-24	02-Jul-24
Standard Water Quality Parameters									
pH	pH Unit	0.01							
Electrical Conductivity @ 25°C	µS/cm	1	49900	54600	51300	48700	47300	55900	42200
Suspended Solids (SS)	mg/L	1	1	<1	4	2	3	<1	<1
Ammonia as N	mg/L	0.01	0.09	<0.05	0.10	0.06	<0.01	0.05	0.13
Nitrite as N	mg/L	0.01	0.05	<0.01	0.01	0.02	0.02	0.03	0.03
Nitrate as N	mg/L	0.01	<0.01	<0.01	0.01	0.08	0.02	0.33	0.72
Nitrite + Nitrate as N	mg/L	0.01	0.04	<0.01	0.02	0.10	0.04	0.36	0.75
Total Kjeldahl Nitrogen as N	mg/L	0.1	0.2	0.3	0.8	0.3	0.1	0.4	0.4
Total Nitrogen as N	mg/L	0.1	0.2	0.3	0.8	0.4	0.1	0.8	1.2
Total Phosphorus as P	mg/L	0.01	0.24	0.25	0.30	0.19	0.12	0.16	0.22
Reactive Phosphorus as P	mg/L	0.01	0.33	0.08	0.24	0.07	0.03	0.11	0.19
Field Tests									
pH	pH Unit	0.01	8.13	7.97	7.88	8.63	8.28	8.34	8.2
Temperature	°C	0.1	23.4	25	25.3	22.1	17.5	11.8	0
Field Dissolved Oxygen	mg/L	0.1	3.32	2.55	2.85	16.11	9.55	11.58	8.72
Electrical Conductivity	µS/cm	1							
Chlorophyll a									
Chlorophyll a	mg/m³	1	<1	0.6	3.3	1.2	<1	3	<1
Heavy Metals									
Arsenic	mg/L	0.001			<0.005			0.006	
Cadmium	mg/L	0.0001			<0.0005			<0.0005	
Chromium	mg/L	0.001			<0.005			<0.005	
Copper	mg/L	0.001			<0.005			<0.005	
Lead	mg/L	0.001			<0.005			<0.005	
Nickel	mg/L	0.001			<0.005			<0.005	
Zinc	mg/L	0.005			<0.026			<0.026	
Mercury	mg/L	0.0001			<0.0001			<0.0001	

Table 4: Location 4, Channel

Analyte grouping/Analyte	Unit	Limit of reporting	10-Mar-22	22-Mar-22	4-Apr-22	20-Apr-22	2-May-22	18-May-22	1-Jun-22	28-Jun-22	13-Jul-22	27-Jul-22	8-Aug-22	31-Aug-22	6-Sep-22	29-Sep-22	10-Oct-22	16-Nov-22
Standard Water Quality Parameters																		
pH	pH Unit	0.01	9.01															
Electrical Conductivity @ 25°C	µS/cm	1	23300	16200	23700	13500	14800	13200	1860	14800	11500	11200	9690	9870	14200	8560	9380	2510
Suspended Solids (SS)	mg/L	1	46	6	<1	<1	2	<1	8	10	5	2	10	4	14	2	13	39
Ammonia as N	mg/L	0.01	0.09	0.4	0.17	0.16	0.15	0.08	<0.01	0.09	0.04	0.07	0.01	0.01	0.03	0.15	0.03	<0.01
Nitrite as N	mg/L	0.01	<0.01	0.27	0.1	0.79	0.22	0.07	0.03	0.16	0.1	0.12	0.14	0.1	0.2	0.16	0.12	0.06
Nitrate as N	mg/L	0.01	0.05	0.01	0.04	7.16	3.11	9.45	0.69	29.9	31.8	22.6	19.5	16.3	19.9	12.6	11.4	1.7
Nitrite + Nitrate as N	mg/L	0.01	0.05	0.28	0.14	7.95	3.33	9.52	0.72	30.1	31.9	22.7	19.6	16.4	20.1	12.8	11.5	1.76
Total Kjeldahl Nitrogen as N	mg/L	0.1	3.4	1.2	1.5	2.6	2.9	1.6	1	2.6	2.6	2.3	4.2	5	10.7	4.8	5	1.8
Total Nitrogen as N	mg/L	0.1	3.4	1.5	1.6	10.6	6.2	11.1	1.7	32.7	34.5	25	23.8	21.4	30.8	17.6	16.5	3.6
Total Phosphorus as P	mg/L	0.01	0.27	0.08	0.08	0.2	0.24	0.14	0.13	0.21	0.22	0.14	0.24	0.28	0.2	0.13	<0.10	0.2
Reactive Phosphorus as P	mg/L	0.01	<0.01	0.01	<0.01	0.12	0.07	0.06	<0.01	0.18	<0.01	0.12	<0.01	0.14	<0.01	0.05	<0.01	<0.01
Field Tests																		
pH	pH Unit	0.01		2.56	8.68	8.39	8.62	8.71	8.66	8.3	8.42	8.61	8.98	8.77	NR	8.77	8.94	8.95
Temperature	°C	0.1		8.72	19.2	19.5	17.7	15.3	12.3	8.5	10.88	11.4	14.9	15.6	NR	13.6	19.2	19.2
Field Dissolved Oxygen	mg/L	0.1	10.1	19	4.21	6.97	4.78	9.5	7.54	11.24	10.8	10.16	14	19.99	NR	13.93	24.53	15.77
Electrical Conductivity	µS/cm	1										10300		9461				
Chlorophyll a																		
Chlorophyll a	mg/m³	1	59	19	30	25	40	34	3	15	23		61	88	54	10	64	122
Heavy Metals																		
Arsenic	mg/L	0.001	0.008						0.001						0.002			
Cadmium	mg/L	0.0001	<0.0001						<0.0001						<0.0001			
Chromium	mg/L	0.001	<0.001						<0.001						<0.001			
Copper	mg/L	0.001	0.001						0.003						0.008			
Lead	mg/L	0.001	<0.001						0.002						<0.001			
Nickel	mg/L	0.001	0.014						<0.001						0.007			
Zinc	mg/L	0.005	<0.005						0.006						0.014			
Mercury	mg/L	0.0001	<0.0001						<0.0001						<0.0001			

Table 4: Location 4, Channel

Analyte grouping/Analyte	Unit	Limit of reporting	30-Nov-22	15-Dec-22	11-Jan-23	09-Feb-23	21-Feb-23	15-Mar-23	29-Mar-23	04-Apr-23	17-Apr-23	05-May-23	20-Jun-23	04-Jul-23	01-Aug-23	13-Sep-23	18-Oct-23	20-Nov-23
Standard Water Quality Parameters																		
pH	pH Unit	0.01																
Electrical Conductivity @ 25°C	µS/cm	1	13100	13700	17200	17700	18000	15200	16500	11400	6780	10100	4410	11900	9270	11800	12800	16000
Suspended Solids (SS)	mg/L	1	<1	<1	48	39	36	18	10	20	<1	12	5	24	22	11	10	24
Ammonia as N	mg/L	0.01	0.18	0.13	0.6	0.11	<0.01	0.2	0.11	0.02	0.06	0.09	0.05	0.17	0.04	0.12	0.13	0.10
Nitrite as N	mg/L	0.01	0.36	0.35	1.96	0.78	1.55	0.96	0.45	0.46	0.27	0.21	0.03	0.31	0.06	0.16	0.38	1.88
Nitrate as N	mg/L	0.01	15.8	14	2.92	4.13	0.33	0.62	4.21	5.1	6.09	14.7	9.33	16.3	16.2	13.9	15.7	7.01
Nitrite + Nitrate as N	mg/L	0.01	16.2	14.4	4.88	4.91	1.88	1.58	4.66	5.56	6.36	14.9	9.36	16.6	16.3	14.1	16.1	8.89
Total Kjeldahl Nitrogen as N	mg/L	0.1	8.7	3	5.8	1.8	9.7	2.7	4	4.6	1.9	1.4	1.2	2.5	2.4	1.8	2.7	5.6
Total Nitrogen as N	mg/L	0.1	24.9	17.4	10.7	6.7	11.6	4.3	8.7	10.2	8.3	16.3	10.6	19.1	18.7	15.9	18.8	14.5
Total Phosphorus as P	mg/L	0.01	0.31	<0.10	0.3	0.27	1.19	0.4	0.64	0.65	0.79	0.8	0.34	0.07	0.25	0.16	0.30	1.08
Reactive Phosphorus as P	mg/L	0.01	<0.01	0.01	0.02	<0.01	<0.01	0.24	0.47	0.31	0.61	0.76	0.39	0.14	0.12	0.1	0.21	0.30
Field Tests																		
pH	pH Unit	0.01	8.87	8.94	8.89	9.26	8.96	8.95	7.2	8.62	7.53	8.54	8.13	8.35	8.94	8.75	8.89	8.89
Temperature	°C	0.1	21.1	18.3	23.6	25.6	24.1	26	22.6	20.6	17.6	15	12.4	12.8	15.7	19.9	15.8	21.6
Field Dissolved Oxygen	mg/L	0.1	12.58	17.59	7.1	25.39	15.47	24.06	1.6	21.17	6.98	15.84	8.15	13.88	21.35	20.31	11.97	7.45
Electrical Conductivity	µS/cm	1																
Chlorophyll a																		
Chlorophyll a	mg/m³	1	4	138	0	346	1100	98	0	254	0	0	20	39	154	39	150	67
Heavy Metals																		
Arsenic	mg/L	0.001	0.002										0.002			0.002		
Cadmium	mg/L	0.0001	<0.0001										<0.0001			<0.0001		
Chromium	mg/L	0.001	<0.001										<0.001			<0.001		
Copper	mg/L	0.001	0.005										0.004			0.005		
Lead	mg/L	0.001	<0.001										<0.001			<0.001		
Nickel	mg/L	0.001	0.008										0.003			0.006		
Zinc	mg/L	0.005	0.02										0.007			<0.005		
Mercury	mg/L	0.0001	<0.0001										<0.0001			<0.0001		

Table 4: Location 4, Channel

Analyte grouping/Analyte	Unit	Limit of reporting	04-Dec-23	29-Jan-24	13-Feb-24	13-Mar-24	22-Apr-24	06-May-24	03-Jun-24	02-Jul-24
Standard Water Quality Parameters										
pH	pH Unit	0.01								
Electrical Conductivity @ 25°C	µS/cm	1	5620	12700	15100	17800	14600	27000	11300	1690
Suspended Solids (SS)	mg/L	1	17	43	82	40	9	48	1	5
Ammonia as N	mg/L	0.01	0.05	0.06	0.02	0.06	0.48	0.15	0.07	0.04
Nitrite as N	mg/L	0.01	0.13	0.02	<0.01	<0.01	0.44	0.20	0.21	0.02
Nitrate as N	mg/L	0.01	0.85	0.24	<0.01	0.03	2.34	0.53	8.83	1.78
Nitrite + Nitrate as N	mg/L	0.01	0.98	0.26	<0.01	0.03	2.78	0.73	9.04	1.80
Total Kjeldahl Nitrogen as N	mg/L	0.1	2.8	6.1	7.2	7.0	2.8	10.3	2.6	1.4
Total Nitrogen as N	mg/L	0.1	3.8	6.4	7.2	7.0	5.6	11.0	11.6	3.2
Total Phosphorus as P	mg/L	0.01	0.57	0.88	3.12	0.66	0.54	1.52	0.59	0.31
Reactive Phosphorus as P	mg/L	0.01	0.31	0.04	<0.01	0.02	0.39	0.10	0.49	0.22
Field Tests										
pH	pH Unit	0.01	8.34	9.07	8.03	9.06	8.85	8.13	7.91	8.5
Temperature	°C	0.1	25.3	25.9	24	24.7	16.8	21.8	13.4	0
Field Dissolved Oxygen	mg/L	0.1	14.00	18.24	4.73	0.12	8.16	9.51	2.14	8.07
Electrical Conductivity	µS/cm	1								
Chlorophyll a										
Chlorophyll a	mg/m³	1	14	398	710	290	89	72	53	36
Heavy Metals										
Arsenic	mg/L	0.001	0.002			0.007			0.004	
Cadmium	mg/L	0.0001	<0.0001			<0.0001			<0.0001	
Chromium	mg/L	0.001	<0.001			0.001			<0.001	
Copper	mg/L	0.001	0.004			0.003			0.013	
Lead	mg/L	0.001	<0.001			<0.001			<0.001	
Nickel	mg/L	0.001	0.004			0.015			0.007	
Zinc	mg/L	0.005	0.005			0.008			0.009	
Mercury	mg/L	0.0001	<0.0001			<0.0001			<0.0001	

Table 5: Location 5, Thompson Creek

Analyte grouping/Analyte	Unit	Limit of reporting	10-Mar-22	23-Mar-22	4-Apr-22	20-Apr-22	2-May-22	18-May-22	1-Jun-22	28-Jun-22	13-Jul-22	27-Jul-22	8-Aug-22	31-Aug-22	6-Sep-22	29-Sep-22	10-Oct-22
Standard Water Quality Parameters																	
pH	pH Unit	0.01	9.13														
Electrical Conductivity @ 25°C	µS/cm	1	25900	23400	29900	12700	11600	12100	7330	15000	14300	11800	13400	14000	13400	13800	12200
Suspended Solids (SS)	mg/L	1	113	34	20	11	17	26	32	13	5	<1	5	10	8	10	<1
Ammonia as N	mg/L	0.01	0.07	0.08	0.16	2.8	0.13	1.8	0.03	0.9	0.47	0.5	0.73	0.56	0.88	0.9	0.7
Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	0.29	0.26	0.25	0.25	0.47	0.36	0.41	0.44	0.52	0.45	0.56	0.67
Nitrate as N	mg/L	0.01	<0.01	<0.01	<0.01	0.24	0.42	0.45	2.47	24.1	26.4	9.69	14.3	13.1	12.4	10.7	4.95
Nitrite + Nitrate as N	mg/L	0.01	<0.01	<0.01	<0.01	0.53	0.68	0.7	2.72	24.6	26.8	10.1	14.7	13.6	12.8	11.3	5.62
Total Kjeldahl Nitrogen as N	mg/L	0.1	4.5	3.7	4.8	7	5.8	5.3	2.4	2.6	1.6	1.5	4.8	5.8	8.4	5.3	4.1
Total Nitrogen as N	mg/L	0.1	4.5	3.7	4.8	7.5	6.5	6	5.1	27.2	28.4	11.6	19.5	19.4	21.2	16.6	9.7
Total Phosphorus as P	mg/L	0.01	0.52	0.45	0.55	0.87	0.55	1.43	0.6	0.4	0.39	0.5	0.48	0.78	0.71	0.38	1.17
Reactive Phosphorus as P	mg/L	0.01	0.08	0.49	0.12	0.54	0.36	0.9	0.48	0.34	0.4	0.48	0.39	0.25	0.41	0.38	0.47
Field Tests																	
pH	pH Unit	0.01		1.3	8.99	9.05	9.57	9.24	9.09	8.55	8.54	8.7	8.94	8.66	NR	8.74	8.77
Temperature	°C	0.1		8.96	21.8	19.9	18.9	17.7	11.8	8.28	11.25	11.4	14.9	16.9	NR	15.1	20.4
Field Dissolved Oxygen	mg/L	0.1	6.61	18.4	7.73	5.33	21.5	21.8	13.7	11.51	11.79	12.5	18.17	19.39	NR	14.2	19.71
Electrical Conductivity	µS/cm	1										10700		14222			
Chlorophyll a																	
Chlorophyll a	mg/m³	1	110	28	51	25	211	58	205	74	18		34	78	38	16	23
Heavy Metals																	
Arsenic	mg/L	0.001	0.009						0.003						0.003		
Cadmium	mg/L	0.0001	<0.0001						<0.0001						<0.0001		
Chromium	mg/L	0.001	0.002						0.002						<0.001		
Copper	mg/L	0.001	0.002						0.004						0.006		
Lead	mg/L	0.001	<0.001						0.005						<0.001		
Nickel	mg/L	0.001	0.017						<0.001						0.012		
Zinc	mg/L	0.005	0.006						0.008						0.012		
Mercury	mg/L	0.0001	<0.0001						<0.0001						<0.0001		

Table 5: Location 5, Thompson Creek

Analyte grouping/Analyte	Unit	Limit of reporting	16-Nov-22	30-Nov-22	15-Dec-22	11-Jan-23	09-Feb-23	21-Feb-23	15-Mar-23	29-Mar-23	04-Apr-23	17-Apr-23	05-May-23	20-Jun-23	04-Jul-23	01-Aug-23	13-Sep-23	18-Oct-23
Standard Water Quality Parameters																		
pH	pH Unit	0.01																
Electrical Conductivity @ 25°C	µS/cm	1	7820	14000	13300	12700	11000	14600	13200	16100	13400	11500	12200	12400	14100	13400	11700	11800
Suspended Solids (SS)	mg/L	1	11	43	3	100	27	61	14	35	49	25	71	17	33	52	15	131
Ammonia as N	mg/L	0.01	0.03	0.1	0.81	0.08	0.03	<0.01	<0.01	<0.01	0.1	0.01	0.06	0.27	0.13	0.04	0.44	0.07
Nitrite as N	mg/L	0.01	0.48	0.56	0.61	<0.01	<0.01	<0.01	<0.01	<0.01	0.14	0.25	0.49	0.32	0.28	0.41	0.47	0.55
Nitrate as N	mg/L	0.01	2.04	3.15	1.45	<0.01	<0.01	<0.01	<0.01	<0.01	0.33	1.73	5.08	15.3	17.5	17.5	6.88	4.11
Nitrite + Nitrate as N	mg/L	0.01	2.52	3.71	2.06	<0.01	<0.01	<0.01	<0.01	<0.01	0.47	1.98	5.57	15.6	17.8	17.9	7.35	4.66
Total Kjeldahl Nitrogen as N	mg/L	0.1	3.1	6.9	5.2	12.2	1.6	7.4	3.6	4.5	4.7	4.5	6.5	2	2.7	2.6	2.3	10.4
Total Nitrogen as N	mg/L	0.1	5.6	10.6	7.3	12.2	1.6	7.4	3.6	4.5	5.2	6.5	12.1	17.6	20.5	20.5	9.6	15.1
Total Phosphorus as P	mg/L	0.01	0.72	2.22	0.39	2.03	0.75	1.77	0.81	0.78	0.66	0.87	0.91	0.64	0.49	0.39	0.38	1.38
Reactive Phosphorus as P	mg/L	0.01	0.5	0.06	0.01	0.23	0.38	0.97	0.5	0.23	0.07	0.26	<0.01	0.59	0.59	0.09	0.29	0.02
Field Tests																		
pH	pH Unit	0.01	8.85	9.26	9.43	9.56	9.34	8.73	9.19	9.08	9.33	9.25	9.57	8.88	8.56	9.17	9.12	9.2
Temperature	°C	0.1	20.4	21.3	20.8	25.2	30.8	25.9	28.8	25.2	24.6	20.8	17.1	13.2	13.7	16.2	23.3	16.5
Field Dissolved Oxygen	mg/L	0.1	13.86	24.15	31.14	11.27	1.47	0.2	0.27	9.19	31.19	25.58	32.04	19.98	17.35	29.83	16.44	20.20
Electrical Conductivity	µS/cm	1																
Chlorophyll a																		
Chlorophyll a	mg/m³	1	120	121	197	0	4	76	59	0	199	0	0	70	89	389	51	1100
Heavy Metals																		
Arsenic	mg/L	0.001		0.005										0.003			0.003	
Cadmium	mg/L	0.0001		<0.0001										<0.0001			<0.0001	
Chromium	mg/L	0.001		<0.001										<0.001			<0.001	
Copper	mg/L	0.001		0.005										0.004			0.005	
Lead	mg/L	0.001		<0.001										<0.001			<0.001	
Nickel	mg/L	0.001		0.013										0.008			0.01	
Zinc	mg/L	0.005		0.013										0.019			0.013	
Mercury	mg/L	0.0001		<0.0001										<0.0001			<0.0001	

Table 5: Location 5, Thompson Creek

Analyte grouping/Analyte	Unit	Limit of reporting	20-Nov-23	04-Dec-23	29-Jan-24	13-Feb-24	13-Mar-24	22-Apr-24	06-May-24	03-Jun-24	02-Jul-24
Standard Water Quality Parameters											
pH	pH Unit	0.01									
Electrical Conductivity @ 25°C	µS/cm	1	10900	10200	12300	16700	22300	16800	18000	19700	7190
Suspended Solids (SS)	mg/L	1	84	58	63	64	40	41	32	28	5
Ammonia as N	mg/L	0.01	0.59	0.03	0.03	0.02	0.09	0.21	0.10	0.05	0.37
Nitrite as N	mg/L	0.01	0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.21	0.58
Nitrate as N	mg/L	0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.58	9.13
Nitrite + Nitrate as N	mg/L	0.01	0.14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.79	9.71
Total Kjeldahl Nitrogen as N	mg/L	0.1	1.5	5.0	5.1	7.6	8.0	8.0	5.7	5.9	2.1
Total Nitrogen as N	mg/L	0.1	1.6	5.0	5.1	7.6	8.0	8.0	5.7	6.7	11.8
Total Phosphorus as P	mg/L	0.01	0.95	0.72	1.16	1.34	0.86	1.35	0.94	0.78	0.73
Reactive Phosphorus as P	mg/L	0.01	0.67	0.11	0.43	0.56	0.22	0.52	0.26	0.04	0.70
Field Tests											
pH	pH Unit	0.01	9.36	9.45	9.25	9.16	9.24	9.17	----	9.37	8.94
Temperature	°C	0.1	23.6	26.9	25.7	26.2	24.2	18.8	----	9.7	0
Field Dissolved Oxygen	mg/L	0.1	8.77	26.67	13.75	2.57	0.22	17.03	----	28.6	11.86
Electrical Conductivity	µS/cm	1									
Chlorophyll a											
Chlorophyll a	mg/m³	1	12	129	226	140	210	400	69	143	32
Heavy Metals											
Arsenic	mg/L	0.001		0.004			0.007			0.008	
Cadmium	mg/L	0.0001		<0.0001			<0.0001			<0.0001	
Chromium	mg/L	0.001		<0.001			0.002			<0.001	
Copper	mg/L	0.001		0.003			0.003			0.003	
Lead	mg/L	0.001		<0.001			<0.001			<0.001	
Nickel	mg/L	0.001		0.006			0.018			0.008	
Zinc	mg/L	0.005		<0.005			0.007			<0.005	
Mercury	mg/L	0.0001		<0.0001			<0.0001			<0.0001	

Table 6: Location 7, Inshore Bolivar Outlet

Analyte grouping/Analyte	Unit	Limit of reporting	20-Jun-23	4-Jul-23	1-Aug-23	13-Sep-23	18-Oct-23	20-Nov-23	4-Dec-23	29-Jan-24	13-Feb-24	13-Mar-24	22-Apr-24	6-May-24	3-Jun-24	2-Jul-24
Standard Water Quality Parameters																
pH	pH Unit	0.01														
Electrical Conductivity @ 25°C	µS/cm	1	50400	57200	51900	45500	56900	61100	55300	39500	34200	51900	45200	41600	43600	36600
Suspended Solids (SS)	mg/L	1	<1	122	6	43	4	<1	6	1	2	5	4	12	17	8
Ammonia as N	mg/L	0.01	<0.05	0.15	0.18	0.4	0.08	0.03	0.34	0.32	0.31	0.14	0.07	0.04	0.29	0.28
Nitrite as N	mg/L	0.01	0.02	0.01	0.03	0.1	0.05	0.10	0.06	0.17	0.08	0.03	0.02	0.12	0.34	0.08
Nitrate as N	mg/L	0.01	0.34	0.09	0.37	0.17	0.35	0.18	0.36	0.17	0.02	0.02	0.12	0.33	3.67	2.60
Nitrite + Nitrate as N	mg/L	0.01	0.36	0.1	0.4	0.27	0.40	0.28	0.42	0.34	0.10	0.05	0.14	0.45	4.01	2.68
Total Kjeldahl Nitrogen as N	mg/L	0.1	<0.5	0.3	0.5	1.6	0.2	3.8	1.4	0.4	1.1	0.7	0.5	0.6	1.6	0.9
Total Nitrogen as N	mg/L	0.1	<0.5	0.4	0.9	1.9	0.6	4.1	1.8	0.7	1.2	0.8	0.6	1.0	5.6	3.6
Total Phosphorus as P	mg/L	0.01	0.08	0.04	0.22	0.65	0.47	0.83	0.64	1.11	0.85	0.40	0.28	0.21	0.97	0.62
Reactive Phosphorus as P	mg/L	0.01	0.12	0.06	0.17	0.48	0.31	0.32	0.60	0.92	1.00	0.38	0.10	0.21	0.85	0.58
Field Tests																
pH	pH Unit	0.01	8.13	8.26	8.27	8.36	8.12	8.3	8.18	8.08	7.91	7.9	8.25	8.5	8.28	8.11
Temperature	°C	0.1	12.4	12.9	14.6	18.7	16.6	19.8	21.2	23.2	25	25.7	19.3	19.7	11	0
Field Dissolved Oxygen	mg/L	0.1	9.95	12.53	10.71	13.1	5.06	2.74	2.17	1.95	1.57	2.54	10.99	13.1	10.96	8.3
Electrical Conductivity	µS/cm	1														
Chlorophyll a																
Chlorophyll a	mg/m³	1	1	1	7	29	18	2	7	4	2.1	3.5	1.9	<1	6	<1
Heavy Metals																
Arsenic	mg/L	0.001	<0.005			<0.005			<0.005			<0.005			0.006	
Cadmium	mg/L	0.0001	<0.0005			<0.0005			<0.0005			<0.0005			<0.0005	
Chromium	mg/L	0.001	<0.005			<0.005			<0.005			<0.005			<0.005	
Copper	mg/L	0.001	<0.005			0.009			<0.005			<0.005			0.007	
Lead	mg/L	0.001	<0.005			<0.005			<0.005			<0.005			<0.005	
Nickel	mg/L	0.001	<0.005			<0.005			<0.005			<0.005			0.005	
Zinc	mg/L	0.005	<0.026			<0.026			<0.026			<0.026			0.042	
Mercury	mg/L	0.0001	<0.0001			<0.0001			<0.0001			<0.0001			<0.0001	

Table 7: BDC Channel, 4 December 2023

Analyte grouping/Analyte	Unit	Limit of reporting	BDC Channel Out	BDC Channel 1	BDC Channel 2	BDC Channel 3
Standard Water Quality Parameters						
Electrical Conductivity @ 25°C	µS/cm	1	10500	60300	111000	144000
Suspended Solids (SS)	mg/L	1	8	7	6	13
Ammonia as N	mg/L	0.01	0.04	0.31	1.08	0.19
Nitrite as N	mg/L	0.01	0.04	0.02	0.02	<0.01
Nitrate as N	mg/L	0.01	0.04	0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	0.08	0.03	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	2.8	2.2	2.0	3.8
Total Nitrogen as N	mg/L	0.1	2.9	2.2	2.0	3.8
Total Phosphorus as P	mg/L	0.01	0.47	0.36	0.16	0.37
Reactive Phosphorus as P	mg/L	0.01	0.35	0.11	<0.01	0.07
Field Tests						
pH	pH Unit	0.01	7.5	7.22	6.94	7.39
Temperature	°C	0.1	24.9	24.2	25.6	33.6
Field Dissolved Oxygen	mg/L	0.1	10.35	1.18	8.4	10.23
Dissolved Oxygen	% Sat	1	152.5	21.3	164.8	351
Chlorophyll a						
Chlorophyll a	mg/m³	1	10	4	1	2

Appendix B Daily Rainfall Record

Table B.1 2022 Daily Rainfall Record, Edinburgh RAAF Base

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	0	0	0	0	0.4	0.2	0	2.4	0	0	14.4	0
2nd	0	0	0	0	0.2	0.2	0	0	0	0	7.6	0
3rd	0	0	0	0	0	0	0	1.8	0	0	2.2	0
4th	0	0	0	0	1.6	1.6	0	0.2	0	4.4	0	0
5th	0	0	0	0	11.2	15	0	1.2	0	8.2	0	0
6th	0	0	0	1.8	4.8	7.8	0	5.4	0	0	0	0
7th	2	0	0	0.2	0.6	3	1	1.6	0	4.6	0	0
8th	0	0	0	0	5.4	0.4	0.4	0	13.2	2.4	0	0
9th	0	2.2	0	0	0	0.6	3	0	10.6	0	0	0
10th	0	0	0	0	0	1	0.2	1	6	0	2.2	0
11th	0	0	0	0	0	0.8	0	5.4	0	0	0.2	0
12th	0	0	0	0	0	0.2	1.4	2.4	0.2	0	2.6	10.8
13th	0	0	0	0	0	0	2.6	4.4	0	4.4	39	0.6
14th	0	0	0	0	0.4	0	0.2	0	0.2	11	5.6	0.2
15th	0	0	0	0	0.2	0.4	0	0.2	6	0	0.2	0
16th	0	0	0	0	1.6	3.4	0	1	2.6	0	0.2	0
17th	0	1.4	5	0	1	0	4	0	7.8	0	0	0
18th	0	0	0	15.2	5.6	0	3.6	2	5.2	1	0	0
19th	0	0	0	0	0	0	0.2	3.2	0.4	0.2	13	0
20th	0	0	0	3.2	0	2	0	1.8	0	0	5.2	0
21st	0	0	0	0.6	0	1.8	0	0.2	10.6	0	3.8	3.2
22nd	0	0	0	0	0	1.2	0	0.2	0	0.2	0.2	1.6
23rd	19.6	0	1.4	0	0	0.2	0	11.6	0	3.6	0.4	0
24th	17.2	0	0	0	0	0	0	1	0	9.8	0.2	0
25th	0	0	0	0	4.6	0.8	3.8	0.2	0	1	0	0
26th	2	0	0	0	5.2	0.8	1.8	0.4	4.4	1.2	0	0
27th	7.2	0	0	0	3	0.8	0	0.2	10.2	1.4	0.6	0
28th	0	0.2	0	0	1.2	0.2	0	0	0.2	0	0	1.6
29th	0		0	0	12.8	0	0	0	0	0.4	0	0
30th	0		0	0.4	46.4	2	0	5.4	0	0	0	0
31st	0		0		6.6		0.2	0		2.6		0

Table B.2 2023 Daily Rainfall Record, Edinburgh RAAF Base

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	0	0	0	1.2	3.4	0	0.8	1	0.2	0	0	0
2nd	0	0	0	0	2	0	0	0	0	0	0	0
3rd	0	4.2	0	0	2.6	0	0	0	0	1.4	0	0
4th	0	1.2	0	0	0	0	0.6	3.2	1.2	1	0	0
5th	0	0	0	0	0	0	0	0	4	0.2	0	0
6th	0	0	1.8	0.8	4.4	0	1.4	0	0	0.6	0	0
7th	0	0	0.6	4.8	0.2	11.2	4.8	0	7.4	0.2	0	0
8th	0	0	0.8	1	0	0	1.8	0	4.2	0	0	0
9th	0	0	0.4	3.6	1.2	14	1.6	0	0.2	0	0	4.6
10th	0	0	0	0	0	0	0.8	1.8	0	0	0	28.4
11th	0	0	0	0	0	0	0	0	0	0	0	12.2
12th	0	0	0	4.8	0	0	0.2	3.4	0	1.4	0	9.4
13th	0	0	0	0	0	0	0	1.2	0	0	0	0.4
14th	0	0	0	0	0	0	0	0	0	0	0	0.8
15th	0	0	0	7	0	0	0	0.2	0	0	0	0
16th	0	0	0	16.4	0	0	0	0	0	2.6		0
17th	0	0	0	0.2	0.8	0	0	8	0	0	0	0
18th	0.8	0	0	0	0	13.8	0	8.4	0	0	0	0
19th	0	0	0	0.4	0.8	3.2	0	0.4	0	0	0	0
20th	0	0	0	0	8.8	8	0	0.2	0.2	0	0	0
21st	0		0	0	5.6		1.6	0.2	0.4	0	0	0
22nd	0	0	0	0	1.6		0	18.8	0	0.2	0	0
23rd	0	0	0	0	0		2	0.2	0	0	0	0
24th	5	0	0	0	0		0	0	0	0	10.8	0
25th	0.2	13.4	0	0	0		0	0	0	0.2	0	0
26th	0	0	0	0	23		0	0	0	0.2	0	0
27th	0	0	3.4	2.4	2.2		0	0	0	0	0	0
28th	0	0	4.2	3.2	4.2	0	3	0	0	0	21.6	0
29th	11		5.4	3.6	3.6	1.6	0.2	0	0	0	5.4	1.2
30th	0		0	3	0	1.8	0	1	0	0	0	0.2
31st	0		1		5		2	1.2		0.6		0

Table B.3 2024 Daily Rainfall Record, Edinburgh RAAF Base

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	0	0	0	0	0	7	0					
2nd	0	0	0		0	0.2	0					
3rd	0	0	0	0	0	0						
4th	0	0	0	1.2	0	0						
5th	0	0	0	0	0	0						
6th	0	0	0	0	0	0						
7th		0	0	0	0	0						
8th		0	0	0	0	0						
9th		0	0	0	0	0						
10th		0	0.8	0	0	0						
11th		0	0	0	0	0.8						
12th		0	0	0	0	0.2						
13th		0	0	0	0	0						
14th		0	0	0	0	12.4						
15th		0	0.4	0	0	1.4						
16th		0	0	0	0	0						
17th		0	5.6	0	0	0						
18th		0	0.2	0	0	1.6						
19th		0	0	2.6	0	0						
20th		0	0	0	0	2.4						
21st		0	0	0	0	1						
22nd		0	0	0	0	0						
23rd		0	0	0	0	0.2						
24th		0	0	0	0	0						
25th		0	0	0	0	0						
26th		0	0	0.2	0	9.2						
27th		0	0	0	0	0						
28th	0	0	0	0	0	0						
29th	0	0	0	0	0	12.4						
30th	0		0	0	4.6	3.2						
31st	0		0		9.6							

Table B.1 2022 Daily Rainfall Record, Edinburgh RAAF Base

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	0	0	0	0	0.4	0.2	0	2.4	0	0	14.4	0
2nd	0	0	0	0	0.2	0.2	0	0	0	0	7.6	0
3rd	0	0	0	0	0	0	0	1.8	0	0	2.2	0
4th	0	0	0	0	1.6	1.6	0	0.2	0	4.4	0	0
5th	0	0	0	0	11.2	15	0	1.2	0	8.2	0	0
6th	0	0	0	1.8	4.8	7.8	0	5.4	0	0	0	0
7th	2	0	0	0.2	0.6	3	1	1.6	0	4.6	0	0
8th	0	0	0	0	5.4	0.4	0.4	0	13.2	2.4	0	0
9th	0	2.2	0	0	0	0.6	3	0	10.6	0	0	0
10th	0	0	0	0	0	1	0.2	1	6	0	2.2	0
11th	0	0	0	0	0	0.8	0	5.4	0	0	0.2	0
12th	0	0	0	0	0	0.2	1.4	2.4	0.2	0	2.6	10.8
13th	0	0	0	0	0	0	2.6	4.4	0	4.4	39	0.6
14th	0	0	0	0	0.4	0	0.2	0	0.2	11	5.6	0.2
15th	0	0	0	0	0.2	0.4	0	0.2	6	0	0.2	0
16th	0	0	0	0	1.6	3.4	0	1	2.6	0	0.2	0
17th	0	1.4	5	0	1	0	4	0	7.8	0	0	0
18th	0	0	0	15.2	5.6	0	3.6	2	5.2	1	0	0
19th	0	0	0	0	0	0	0.2	3.2	0.4	0.2	13	0
20th	0	0	0	3.2	0	2	0	1.8	0	0	5.2	0
21st	0	0	0	0.6	0	1.8	0	0.2	10.6	0	3.8	3.2
22nd	0	0	0	0	0	1.2	0	0.2	0	0.2	0.2	1.6
23rd	19.6	0	1.4	0	0	0.2	0	11.6	0	3.6	0.4	0
24th	17.2	0	0	0	0	0	0	1	0	9.8	0.2	0
25th	0	0	0	0	4.6	0.8	3.8	0.2	0	1	0	0
26th	2	0	0	0	5.2	0.8	1.8	0.4	4.4	1.2	0	0
27th	7.2	0	0	0	3	0.8	0	0.2	10.2	1.4	0.6	0
28th	0	0.2	0	0	1.2	0.2	0	0	0.2	0	0	1.6
29th	0		0	0	12.8	0	0	0	0	0.4	0	0
30th	0		0	0.4	46.4	2	0	5.4	0	0	0	0
31st	0		0		6.6		0.2	0		2.6		0

Table B.2 2023 Daily Rainfall Record, Edinburgh RAAF Base

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	0	0	0	1.2	3.4	0	0.8	1	0.2	0	0	0
2nd	0	0	0	0	2	0	0	0	0	0	0	0
3rd	0	4.2	0	0	2.6	0	0	0	0	1.4	0	0
4th	0	1.2	0	0	0	0	0.6	3.2	1.2	1	0	0
5th	0	0	0	0	0	0	0	0	4	0.2	0	0
6th	0	0	1.8	0.8	4.4	0	1.4	0	0	0.6	0	0
7th	0	0	0.6	4.8	0.2	11.2	4.8	0	7.4	0.2	0	0
8th	0	0	0.8	1	0	0	1.8	0	4.2	0	0	0
9th	0	0	0.4	3.6	1.2	14	1.6	0	0.2	0	0	4.6
10th	0	0	0	0	0	0	0.8	1.8	0	0	0	28.4
11th	0	0	0	0	0	0	0	0	0	0	0	12.2
12th	0	0	0	4.8	0	0	0.2	3.4	0	1.4	0	9.4
13th	0	0	0	0	0	0	0	1.2	0	0	0	0.4
14th	0	0	0	0	0	0	0	0	0	0	0	0.8
15th	0	0	0	7	0	0	0	0.2	0	0	0	0
16th	0	0	0	16.4	0	0	0	0	0	2.6		0
17th	0	0	0	0.2	0.8	0	0	8	0	0	0	0
18th	0.8	0	0	0	0	13.8	0	8.4	0	0	0	0
19th	0	0	0	0.4	0.8	3.2	0	0.4	0	0	0	0
20th	0	0	0	0	8.8	8	0	0.2	0.2	0	0	0
21st	0		0	0	5.6		1.6	0.2	0.4	0	0	0
22nd	0	0	0	0	1.6		0	18.8	0	0.2	0	0
23rd	0	0	0	0	0		2	0.2	0	0	0	0
24th	5	0	0	0	0		0	0	0	0	10.8	0
25th	0.2	13.4	0	0	0		0	0	0	0.2	0	0
26th	0	0	0	0	23		0	0	0	0.2	0	0
27th	0	0	3.4	2.4	2.2		0	0	0	0	0	0
28th	0	0	4.2	3.2	4.2	0	3	0	0	0	21.6	0
29th	11		5.4	3.6	3.6	1.6	0.2	0	0	0	5.4	1.2
30th	0		0	3	0	1.8	0	1	0	0	0	0.2
31st	0		1		5		2	1.2		0.6		0

Table B.3 2024 Daily Rainfall Record, Edinburgh RAAF Base

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	0	0	0	0	0	7	0					
2nd	0	0	0		0	0.2	0					
3rd	0	0	0	0	0	0						
4th	0	0	0	1.2	0	0						
5th	0	0	0	0	0	0						
6th	0	0	0	0	0	0						
7th		0	0	0	0	0						
8th		0	0	0	0	0						
9th		0	0	0	0	0						
10th		0	0.8	0	0	0						
11th		0	0	0	0	0.8						
12th		0	0	0	0	0.2						
13th		0	0	0	0	0						
14th		0	0	0	0	12.4						
15th		0	0.4	0	0	1.4						
16th		0	0	0	0	0						
17th		0	5.6	0	0	0						
18th		0	0.2	0	0	1.6						
19th		0	0	2.6	0	0						
20th		0	0	0	0	2.4						
21st		0	0	0	0	1						
22nd		0	0	0	0	0						
23rd		0	0	0	0	0.2						
24th		0	0	0	0	0						
25th		0	0	0	0	0						
26th		0	0	0.2	0	9.2						
27th		0	0	0	0	0						
28th	0	0	0	0	0	0						
29th	0	0	0	0	0	12.4						
30th	0		0	0	4.6	3.2						
31st	0		0		9.6							

WALKER CORPORATION

RIVERLEA SALT WATER LAKES

ASSESSMENT OF THE IMPACT ON FLORA AND FAUNA

V1.2

COOE Pty Ltd ABN 65 147 909 751

www.cooe.com.au | +61 8 8398 5090 | info@cooe.com.au

Document Information

Client	Walker Corporation
Project	Riverlea Salt Water Lakes
Document Title	Assessment of the Impact on Flora and Fauna
Document Distribution Date	6/12/2023
Document Version	V1.2
File Name	WAL.RIV.001_SWL _Flora & Fauna_v1.2_6Dec2023

Document Control

Version	Issue Date	Author/s	Reviewer/s	Date Reviewed	Amendment Type
V1.0	22/11/2023	JM	PM	28/11/2023	Draft for client review
V1.1	4/12/2023	JM	PM	4/12/2023	Final Draft
V1.2	5/12/2023	JM	NJ	6/12/2023	Final

Distribution

Version	Issue Date	Copies, Format	Recipient/s
V1.0	22/11/2023	Soft copy via email	Patrick Mitchell
V1.1	4/12/2023	Soft copy via email	Patrick Mitchell
V1.2	5/12/2023	Soft copy via email	Patrick Mitchell

Document Owner

COOE Pty Ltd
ABN 65 147 909 751
PO Box 591
Littlehampton, South Australia, 5250
Tel: +61 8 8398 5090
Email: info@cooe.com.au | www.cooe.com.au

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

1. INTRODUCTION

Walker Corporation engaged COOE Pty Ltd (COOE) to assess the potential impacts of the proposed Riverlea Saltwater Lakes project on local ecosystems. This report is a response to concerns and requests regarding the environmental implications, with a primary focus on its effects on the local flora and fauna. The project involves the construction and operation of the Chapman Creek intake and Thompson Creek outflow, both playing roles in the area's ecosystem, warranting careful consideration.

Our goal is to address the concerns and provide essential information related to the environmental impact of the Riverlea Saltwater Lakes (SWL) on flora and fauna. The SWL project is designed to enhance urban amenity, utilising three ornamental lakes strategically located within the subdivision’s footprint. These lakes not only serve as a social gathering place but also contribute to visual amenity and recreational facilities.

The SWL project also serves a practical purpose by receiving local stormwater and floodwater to safeguard properties and infrastructure of the Riverlea development. Additionally, the use of fill material from the lakes aims to elevate surrounding blocks, mitigating sea level rise and flood risk. This approach reduces the environmental impact of importing fill and overall project costs.

The Chapman Creek and Thompson Creek are important components of the local ecosystem. Thus, our report aims to provide insights and practical solutions to ensure the project's sustainability while minimising adverse effects on the environment.

1.1 Background

Riverlea Park, located approximately 30 kilometres north of the Adelaide CBD, has undergone significant development in recent years. The proposed modification to Precinct 2, introducing the SWL, is drawing attention due to its unparallel enhancement of urban amenities within the region, but also the need to balance potential impacts on the ecological balance within its local environment.

Of specific relevance are the Chapman Creek intake and Thompson Creek outflow, important components of the local hydrological system. These water bodies play a role in managing stormwater and flooding from the Gawler River, while also sustaining the surrounding flora and fauna.

While the saltwater lakes project aims to enhance urban amenity and improve floodwater management, there is an awareness of the potential to alter the equilibrium of these waterways. This study is therefore dedicated to a comprehensive examination of how the project will influence the local environment, particularly focusing on the flora and fauna dependent on Chapman Creek intake and Thompson Creek outflow.

The Chapman Creek in a relatively natural coastal estuary subject to the ebb and flow of tidal movements from the Gulf St Vincent.

The Thompson Creek outfall is a highly modified environment comprising a constructed open channel system wedged between the Cheetham Salt Field operations and the Bolivar outfall. Thompson Creek outfall receives stormwater flows from three tributaries, including flows from rural and horticultural land surrounding Thompson Creek, flows from another unnamed channel flanking more intensive horticultural and industrial land uses extending from Buckland Park through Virginia to Andrews Farm and beyond and a drainage channel abutting the eastern aspect of the Cheetham Salt Field operations in Buckland Park.

The assessment aims to identify potential ecological disturbances and determine the necessary measures to safeguard the local ecosystem.

1.2 Relevant legislation and Guidelines

The relevant legislation within the scope for this flora and fauna impact assessment are:

- Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)
- Native Vegetation Act 1998 (NV Act)
- National Parks and Wildlife Act 1972 (NPW Act)
- Environment Protection Act 1993 (EP Act)
- Environment Protection (Water Quality) Policy 2015 (Water Quality Policy)

1.2.1 Outside scope of this study

The following guidelines are outside the scope of this study. The proposed Riverlea SWL will implement stormwater management measures in conjunction with an expert Water Quality Specialist that will meet the Environment Protection Authority (EPA) code of practice (EPA, 1999).

The Water Quality Guideline (EPA, June 2021) for the environmental management of dewatering during construction activities guides proponents on their obligations under the EP Act and the Water Quality Policy, with respect to environmental management of dewatering during construction activities.

2. SITE DESCRIPTION

The Riverlea development spans an area of approximately 1,340 hectares, historically used for agriculture. The topography is characterised by a low-lying coastal plain, with the Gawler River to the north and Thompson Creek to the south. Geologically, it consists mainly of Quaternary sediments, with variations in soil composition and depth. Saline groundwater influences soil productivity in the southwest.

Hydrologically, the Gawler River and Thompson Creek are the main drainage sources. The Gawler River, a perched system, controls surface water hydrology. Stormwater runoff is directed southwest towards the Thompson Creek Outfall Channel. The proposed development includes several catchment areas, with plans for stormwater quantity management, including SWL for the central catchment.

The central catchment, covering 412 hectares, involves a 40.4 ha lake with a 250,000 m^3 storage volume. Discharge during extreme events may flow to Thompson Creek and then to the Thompson Outfall Channel. Other catchment areas include the southern catchment (302 hectares), where runoff will be diverted through parkland corridors, and the eastern external catchment (161 hectares), draining via channels to Thompson Creek. Overall, the development aims to manage stormwater effectively across the diverse landscape of the site.

Groundwater levels and drainage around the lakes contribute to the overall impact assessment of the SWL on the environment, considering the interplay between groundwater levels, drainage systems around the lakes, and the intended water levels of the lakes themselves.

2.1.1 Groundwater Levels

The site's topography influences groundwater levels, especially in the southwest portion where saline groundwater tables affect soil profiles. As the land descends below 10 m AHD toward the southwest, saline groundwater becomes a factor, impacting soil productivity potential. In areas where the land drops to low-lying coastal flats, associated with saline water courses, poorly drained soils and shallow saline water tables are observed. This leads to recognisable land salinisation, either as saline subsoils or surface seepage, with the presence of salt-tolerant vegetation.

2.1.2 Drainage Around the Lakes

The proposed development outlines a comprehensive stormwater management plan (BMT, February 2022). The lakes occupying around 40.4 ha within the Central Catchment, with a 250,000 m^3 storage capacity, will also provide detention storage for the southern and eastern areas. During extreme events, discharge can occur from the lakes to the Thompson Creek Outfall Channel.

2.2 Salt Water Lakes

The proposed Riverlea Concept Plan includes a saltwater lakes system (SWL) comprising a total surface area of over 40 hectares once fully completed. Walker intends to stage the construction of the saltwater lakes system over approximately 15 years, with each phase delivered at about 5-year intervals. Each phase of the SWL is designed to operate independently of one another.

The Riverlea SWL will be excavated, and the spoil used to elevate the residential areas for protection from 1:100-year flood levels and projected sea level rise. The excavation will be lined with a 500 mm compacted clay liner to separate the lakes from groundwater. The lakes water level will be 0.6 m below standing groundwater to reduce the risk of seawater entering the groundwater. Stormwater from the central catchment of Precinct 2 will run into the SWL during rain events after passing through the stormwater treatment devise (BMT, February 2022).

The lakes will be built in three Phases over a period of 15 years and designed for a total water holding capacity of 1,110 ML.

- Phase 1 will hold 408 ML
- Phase 2 will hold 386 ML (combined volume to end of Phase 2- 794 ML)
- Phase 3 will hold 318 ML (combined volume of all lakes- 1,110 ML).

To achieve a 40 day lake turnover period the cumulative volume of water required per day will be 10.2 ML/day in Phase 1, 19.9 ML/day in Phase 2 and 27.8 ML/day thereafter.

A conceptual engineering design of the Riverlea SWL circulation system (WSP, Februry 2022) proposed submersible pumps, one pumping at 240 L/s for phase 1 and 640 L/s (using 2x 320 L/s pumps) for phase 2 and phase 3. These pumps will meet the required daily volumes in around 12 hours of pumping.

During the operational phase flowmeters will be used to monitor seawater abstraction volumes and reported to the EPA. Cleaning and maintenance of pipelines to remove significant marine growth in the first 100m or so of pipeline will be managed via a number of ways, including Pigging and Chemical dosing. Pump removal for inspection and maintenance will require a hard stand for a crane.

2.3 Seawater Intake structure

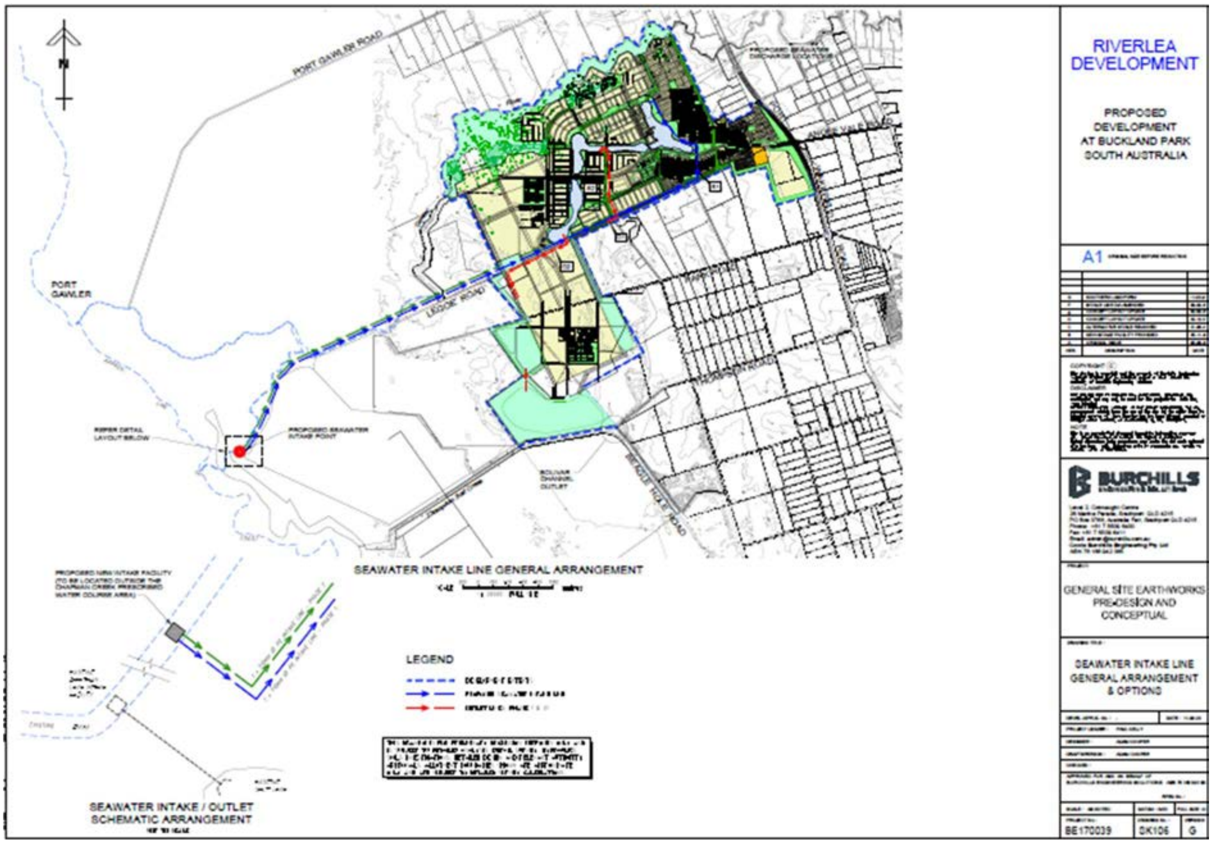
The proposed Riverlea seawater intake structure will be located upstream of the Cheetham Lake intake facility and outside the prescribed water course defined for the creek, Figure 1.

(BMT, February 2022)

Figure 1. Seawater intake location upstream of Cheatham Lake intake for the Riverlea SWL

Based on the conceptual plan in Figure 1, the intake structure will require a permanent area to support the pump, power supply and a hard pad for ongoing maintenance. It is estimated that during construction a vegetation clearance area of around 600 m^2 will be required, the proposed site comprises of low dense mangal woodland habitat. Annual or more frequent pipe maintenance will be required to remove marine growth, which will need to be undertaken in a professional manner to minimise any impacts on the receiving environment.

The seawater inflow pipelines will cross the access track to the edge of the Cheetham Salt Fields as shown in Figure 1 and travel along the infrastructure access corridors and via Legoe Road to the Riverlea SWL, Figure 2. Clearance of vegetation along these corridors will be required to lay the seawater pipeline, vegetation appears to be highly degraded in this corridor; a detailed survey of vegetation will be required to confirm this observation.



(WSP, Februry 2022)

Figure 2. Seawater inflow access corridor to the Riverlea SWL

2.4 Discharge from the Saltwater Lakes

Overflow from the SWL will be discharged into the Thomson Creek Outfall Channel via a system of pipes and open drains Figure 3. The Thompson Creek outflow channel merges with the Bolivar Channel which contains treated effluent from the Bolivar Wastewater Treatment Plant.

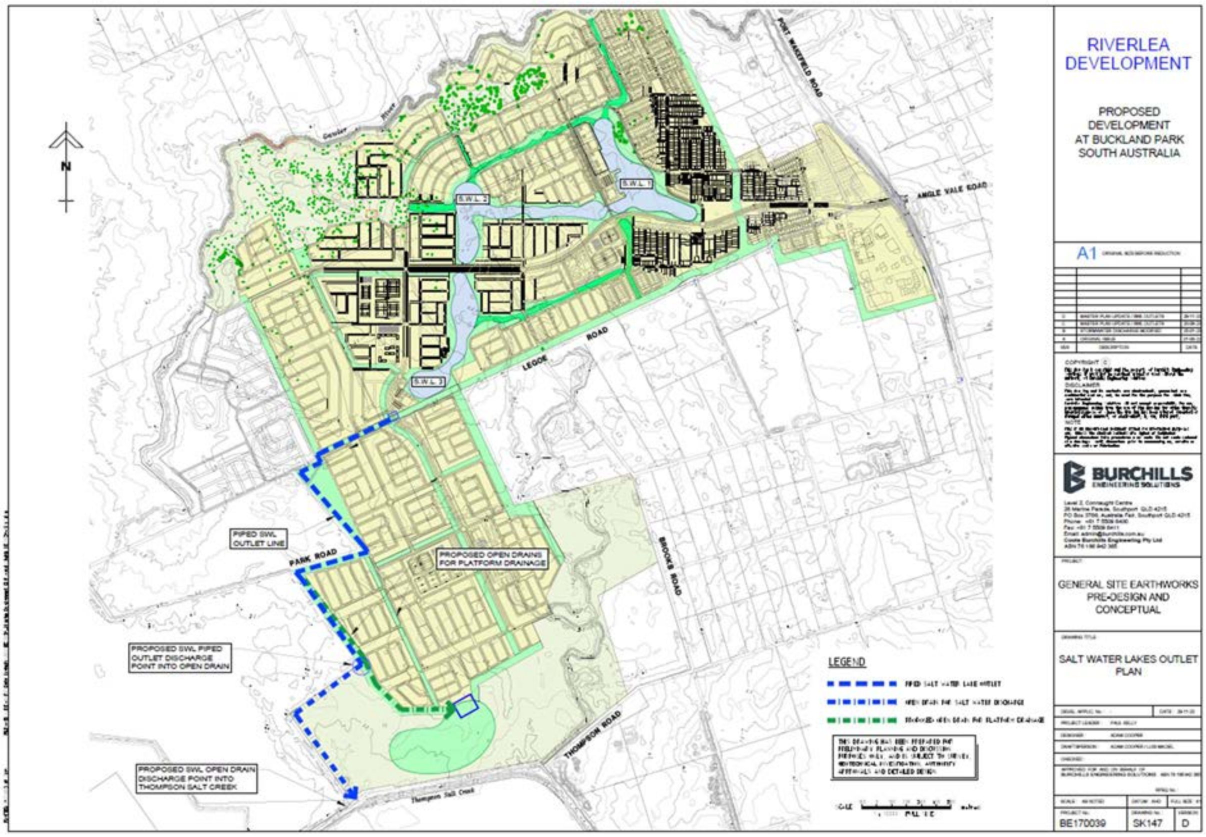


Figure 3. Discharge from the Lakes

3. FLORA AND FAUNA WITHIN THE LAKES FOOTPRINT

3.1 Baseline Assessment for Riverlea Project and Intake Pipeline Corridor

Baseline flora and fauna surveys in areas potentially impacted by the Riverlea Project were conducted by Walkers and their consultants (Walker, April 2023). EBS Ecology, a Native Vegetation Council (NVC) - Accredited Consultant, was engaged by Walker to conduct additional assessments for native vegetation clearance approvals.

EBS Ecology prepared a Flora and Fauna Management Plan (FFMP) for Precinct 2 documented in Appendix C of the Amended Development Application (Walker, April 2023). This plan includes the findings from the vegetation survey for Precinct 2 as well as a database search to identify protected matters under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *National Parks and Wildlife Act 1972* (NPW Act).

The survey identified *Maireana rohrlachii* (Rohrlach's Bluebush), listed as Rare under the NPW Act, as the only species potentially present in the survey area. Although no specimens were found on-site, the possibility of its presence was not ruled out. EBS Ecology identified three Vegetation Associations dominated by exotic grasses and other herbaceous species, with scattered or connected canopies of *Eucalyptus camaldulensis var. camaldulensis*. Eleven weed species, including three declared species, were also identified.

During the 2022 flora and fauna survey of Precinct 2, seventeen bird species were observed (Table 1). No other animal classes were documented during this survey.

Table 1. Birds observed in Precent 2 in 2022

Species Name	Common Name
Cacatua galerita	Sulphur-crested Cockatoo
Chenonetta jubata	Maned Duck
Chroicocephalus novaehollandiae	Silver Gull
Corvus coronoides	Australian Raven
Gavicalis virescens	Singing Honeyeater
Gymnorhina tibicen	Australian Magpie
Hirundo neoxena	Welcome Swallow
Ocyphaps lophotes	Crested Pigeon
Pardalotus punctatus	Spotted Pardalote
Pardalotus striatus	Striated Pardalote
Platycercus elegans	Crimson Rosella
Psephotus haematonotus	Red-rumped Parrot
Rhipidura leucophrys	Willie Wagtail
Sturnus vulgaris	*Common Starling
Tadorna tadornoides	Australian Shelduck
Threskiornis moluccus	Australian White Ibis
Threskiornis spinicollis	Straw-necked Ibis

Furthermore, EBS Ecology prepared a *Native Vegetation Clearance Data Report* for the Buckland Park Intake Pipeline, detailing the removal of scattered trees and native vegetation for the installation of underground pipelines and seawater intake. The report identified and mapped four native vegetation associations along the pipeline corridor (EBS, March 2022).

- A1 - *Tecticornia sp*. shrubland over *Disphyma crassifolium ssp. Clavellatum*
- *A2* - Mangroves (*Avicennia marina ssp. marina*)

- A3 - *Duma florulenta* Shrubland over *Tecticornia sp*. With emergent *Eucalyptus camaldulensis ssp. camaldulensis*
- A4 - *Duma florulenta* Shrubland over *Tecticornia sp*. riparian system

The Threatened Species Assessment within the intake and pipeline corridor highlighted the presence of Subtropical and Temperate Coastal Saltmarsh ecological community in the Intake Pipeline corridor. Specifically, 0.42 ha of vegetation association A1 within this ecological community is proposed for removal, with efforts made to minimise clearance.

No species listed under the EPBC Act were identified as potentially occurring within the Pipeline corridor. However, three NPW Act listed threatened species were considered within 5 km, with none assessed as potentially occurring in the Pipeline corridor.

The database search found 43 species listed under the EPBC Act as potentially within 5 km, with the Slender-billed Thornbill (*Acanthiza iredalei rosinae*) assessed as likely to occur in the Pipeline corridor. Additionally, 29 NPW Act listed threatened species were potentially within 5 km, and six were assessed as potentially occurring in the pipeline corridor. The Little Egret (*Egretta garzetta nigripes*) was observed during the survey of the pipeline corridor.

Considering the presence of suitable habitat, thirty-two fauna species were deemed possible in the pipeline corridor. While interactions with these species may occur, the project was assessed as unlikely to have a significant impact on them.

3.2 Habitat Description

The soils within the seawater flow corridors and at the discharge points exhibit a predominant composition of clay loams to loamy soils, as depicted in the surface soil texture map provided in Appendix A. In the coastal areas of Gulf St Vincent, potential acid sulfate soils (PASS) are prevalent, with PASS classifications outlined in the NatureMap database-derived map presented in Appendix A. Acid sulfate soils in this region are effectively neutralised by tidal activities and carbonates, resulting in either a complete absence or a very low risk.

Within the coastal hinterland, specifically at the coastal terminus of Legoe Road and behind the Buckland Lakes, potential acid sulfate soils are present in the subsoil below 50 cm, extending up to 1 metre in thickness, presenting a moderate to low risk. In the upper intertidal regions at the creek mouths, subsoils exhibit potential acid sulfate characteristics below 20 cm, with a thickness extending up to 1 metre, classifying them as a moderate risk. Tidal stream substrates are deemed potential acid sulfate soils with a moderate risk rating, while mangrove soils, encompassing potential acid sulfate attributes, are identified as high risk.

The coastal habitats encompass diverse ecosystems, including supratidal estuarine samphire featuring Atriplex and grassland, intertidal samphire, intertidal mangrove, and cyanobacterial mat, as delineated in the coastal Saltmarsh and Mangrove map found in Appendix A.

Subtidal habitats consist of unconsolidated bare substrate, and seagrass characterised by varying densities and patchiness, as shown in the State benthic map, Appendix A.

3.3 Seawater inflow and outflow corridors

In addition to the baseline survey by EBS for the seawater Intake pipeline corridor covering the area between the intake pumps on Chapman Creek and Legoe Road, this flora and fauna impact assessment expanded the NatureMaps database search to include flora and fauna in Thompson Creek (the proposed open drainage channel from the SWL to the sea).

The database search includes all plants and animals that have been reported within the potential impacted areas and discovered that many species had been identified in surveys over the preceding decades.

3.3.1 Flora and fauna within the seawater inflow and outflow corridors

The proposed seawater intake pumping station will be located north of the Cheetham Salt lake intake structure and extends to the Riverlea site via buried pipelines along Legoe Road to the SWL, shown in green in Figure 4. The outflow from the SWL will traverse along Legoe Road in a piped system following the western boundary of Riverlea until flowing into an open channel to Thompson Creek, shown in orange Figure 4.

Figure 4. SWL and reticulation system

3.4 Threatened Species assessment

The Protected Matters Search Tool (PMST) was used to generate a list of threatened plants and animals that may occur within the area of interest for matters protected under the EPBC Act.

A search of the Protected Matters Tool (DCCEEW, 2023) of the area that may be impacted by seawater intake and discharge from the SWL identified one Threatened ecological community, the Subtropical and Temperate Coastal Saltmarsh, and three state and territory reserves these are:

- Adelaide International Bird Sanctuary-Winaityinaityi Pangkara National Park
- St Kilda-Chapman Creek Aquatic Reserve
- Adelaide Dolphin Sanctuary

The SWL discharge point is at the northern extent of the St Kilda Champman Creek Aquatic Reserve (Figure 5) intended for the conservation of mangrove seagrass communities and the protection of nursery areas for major commercial and recreational fish species (Wikipedia, 2023). This area is considered to be an important fish nursery habitat and breeding grounds (PIRSA, 2023).

A total of 44 listed threatened species and 62 migratory species were identified by the PMST as potentially occurring or having suitable habitat potentially occurring within the Pipeline corridors. Appendix B presents the results of PMST.

The South Australian Government NatureMap database was used to hone on species that physically occur within the intake and discharge corridors. This database provides a list of historic flora and fauna that have been observed within the pipeline corridor. Flora observation points are shown in Appendix C, Figure 12. A list of the plants identified at these historic observation points are presented in Appendix C, Table 2. No species of national or state significance were found in previous surveys within the pipeline and discharge corridors. Of the 44 species recorded in these observation sites, 22 were non-natives and 22 were native. None of the plant species recorded were classified as threatened species.

Fauna recorded within the pipeline corridor are shown in Appendix C, Figure 13, and consisted of 163 animal species (Appendix C Table 3), of which 151 were native species and 12 non-natives. Most (142) animals observed were birds, with 13 mammals, 6 reptiles and 2 amphibians also observed.

The curlew sandpiper (*Calidris ferruginea*), last observed in March 2002, and the Far Eastern Curlew (*Numenius madagascariensis*), last observed in March 2005, are listed as a critically endangered species The Fairy Tern (*Sternula nereis nereis*) is listed as vulnerable under the EPBC Act.

In addition the Red Knot (*Calidris canutus rogersi ssp. rogersi*) and the Lesser Sand Plover (*Charadrius mongolus mongolus*) and the Fairy Tern (*Sternula nereis nereis*) are listed as endangered under the NPM Act. The Little eagle (*Hieraaetus morphnoides*) was the only vulnerable species under the NPW Act sighted in the field survey by EBS.

(PIRSA, 2023)

Figure 5. St Kilda - Chapman Creek Aquatic Reserve

3.5 Hydrological Impact Assessment

This section assesses potential alterations to the hydrological system arising from the establishment of saltwater lakes, intake structures, and outflow drains. The construction of the lakes, situated below the natural groundwater levels, necessitates dewatering during construction activities to facilitate machinery operations.

The envisioned groundwater regime has been planned to accommodate the unhindered flow of existing groundwater, allowing it to circumnavigate the proposed lakes both underneath and around them. The prescribed construction methodology involves interconnecting the pre-existing groundwater network beneath the lake footprints, facilitated by a robust waterproof clay liner designed to surpass the projected lifespan of the proposed lakes.

The proposed lake system is engineered to include a clay liner, with a recommended thickness of 500 mm. Consequently, it is anticipated that there will be no discernible losses to the groundwater system. To ensure the suitability of the clay material available at the site, additional assessments are proposed and scheduled for validation (BMT, December 2021).

The introduction of the proposed saltwater lakes may provide a new habitat for saltwater-tolerant flora and fauna. This presents an opportunity to enhance biodiversity in the region, potentially supporting unique ecological communities adapted to the saline environment. Further ecological studies and monitoring should be conducted to assess the specific impact on local flora and fauna and ensure the sustainable development of this new habitat.

The hydrological impact assessment affirms that the proposed construction activities, guided by a robust methodology and clay liner, are designed to minimise any potential disruptions to the groundwater system. The anticipated benefits include the creation of a novel habitat that can contribute positively to the regional biodiversity. Ongoing assessments and ecological monitoring will be integral to ensuring the long-term sustainability of this human-made seawater lake project.

3.6 Water Quality Assessment

In support of the design of the saltwater exchange system, Walker have implemented a baseline water quality monitoring program to track the variation in water quality over several seasons. A good understanding of the seasonal and diurnal fluctuation on natural marine water quality will provide monitoring management tools for maintaining key environmental water quality parameters.

ALS Hydrographics undertakes water quality sampling, BMT provided the first report Water Quality Monitoring Program Results to 16 November 2022. A second report of the water quality monitoring summarised the full dataset to 13 September 2023 (Water Engineering Plus, October 2023). The monitoring sites are shown in Figure 6.

In this section, the results of water quality sampling reported by Water Engineering Plus are interpreted from an ecological perspective. The reports did not provide information on quality control therefore it is assumed that the data has been audited and confirmed as acceptable. Notwithstanding this, there were some instances where fluctuations and oddities occurred within the results that did not appear to be representative of actual conditions due to no evidence or absence of reasoning behind such spikes at the location. The results could be inferred to be in error and ongoing monitoring and collaboration of equipment is recommended to understand and properly validate the reasoning.

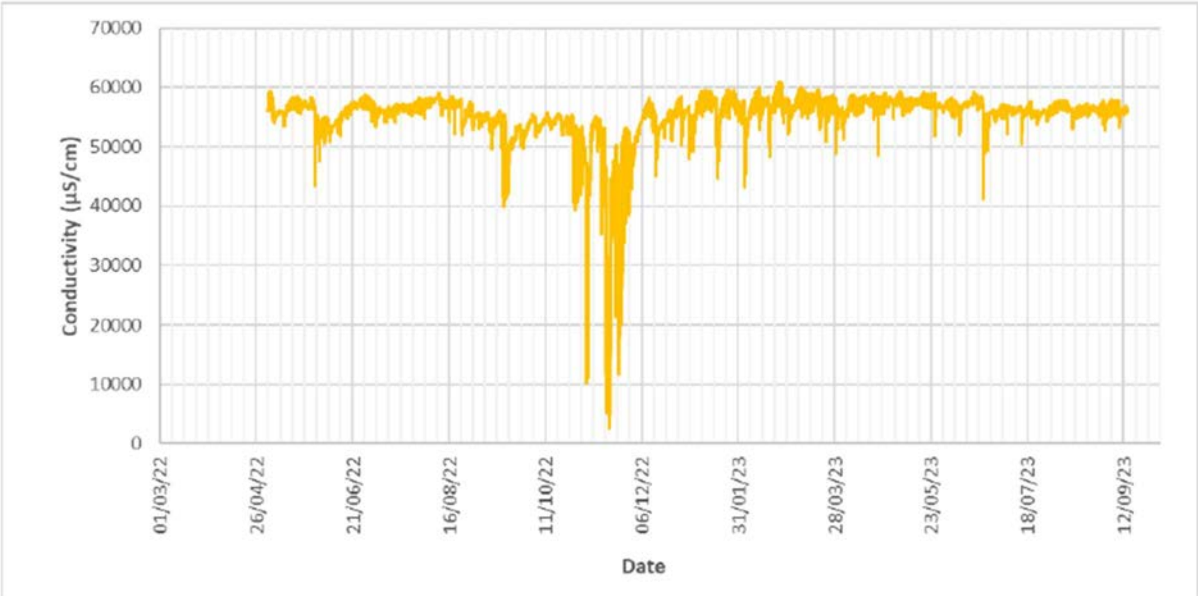
To comprehensively assess the impacts on flora and fauna in a human-made seawater lake, it is essential to monitor a range of water quality parameters. The following assessment of parameters is considered.

Figure 6. Water Quality Monitoring Stations for the Riverlea SWL intake and discharge system

3.6.1 Salinity

Salinity levels are critical for assessing the compatibility of the water with saltwater-tolerant flora and fauna. It is essential to ensure that salinity remains within the acceptable range for the species that may establish within the SWL and the receiving environment.

The electrical conductivity data of potential seawater from the proposed Intake in Chapman Creek, between March 2022 and September 2023, show that the intake location is influenced by rain events (Water Engineering Plus, October 2023).



* as reported by ALS Hydrographic it is assumed that the conductivity is normalised to 25 °C

Figure 7. Conductivity data at site 6 near the proposed Chapman Creek seawater intake structure

Estuarine fish and crustaceans have varying tolerances to salinity levels, and the acceptable range can depend on the specific species. For example, the tolerance of aquatic organisms to salinity is closely linked to their ability to regulate osmotic balance in changing salinity conditions. It is important to note that salinity levels can fluctuate naturally in estuarine environments due to tidal influences and other factors.

Many species can adapt to salinities ranging from brackish water to full marine conditions. Similarly crustaceans found in estuarine environments, also exhibit a range of salinity tolerances. Some species may tolerate a broader range of salinities (euryhaline), while others may have more specific requirements.

Sudden or extreme changes in salinity can stress or harm estuarine organisms, emphasising the importance of maintaining a stable and suitable salinity range for the well-being of the ecosystem.

3.6.2 Temperature:

Water temperature influences the metabolic rates and behaviours of aquatic organisms. Monitoring temperature variations can help understand the thermal preferences of varied species and detect potential temperature-related stress.

The water temperature within the SWL may increase during summer compared to the receiving environment. Increases by 2°C are generally considered as potentially detrimental to the receiving environment. It is therefore recommended that the seawater temperature in the SWL be regulated to be within natural environmental range of the receiving environment in Thompson Creek at the time of release.

Similarly seawater temperature at the intake should be within 2°C prior to pumping water into the SWL to avoid temperature shocks.

3.6.3 Dissolved Oxygen (DO)

Adequate levels of dissolved oxygen are crucial for the survival of aquatic organisms. DO levels can be affected by factors such as temperature, salinity, and the presence of aquatic plants. DO concentration requirements vary among plants and animals in marine and estuarine environments, as varied species have adapted to thrive within specific ranges. Estuarine environments are dynamic, with varying salinity levels, temperature, and tidal influences impacting the dissolved oxygen levels. Here are general guidelines for the range of dissolved oxygen concentrations preferred by various organisms in estuarine environments:

Plants (Seagrasses and Macroalgae)

Seagrasses and macroalgae typically thrive in DO concentrations ranging from 5 to 15 mg/L. These plants are important contributors to SWL and receiving estuarine ecosystems, providing habitat and serving as primary producers.

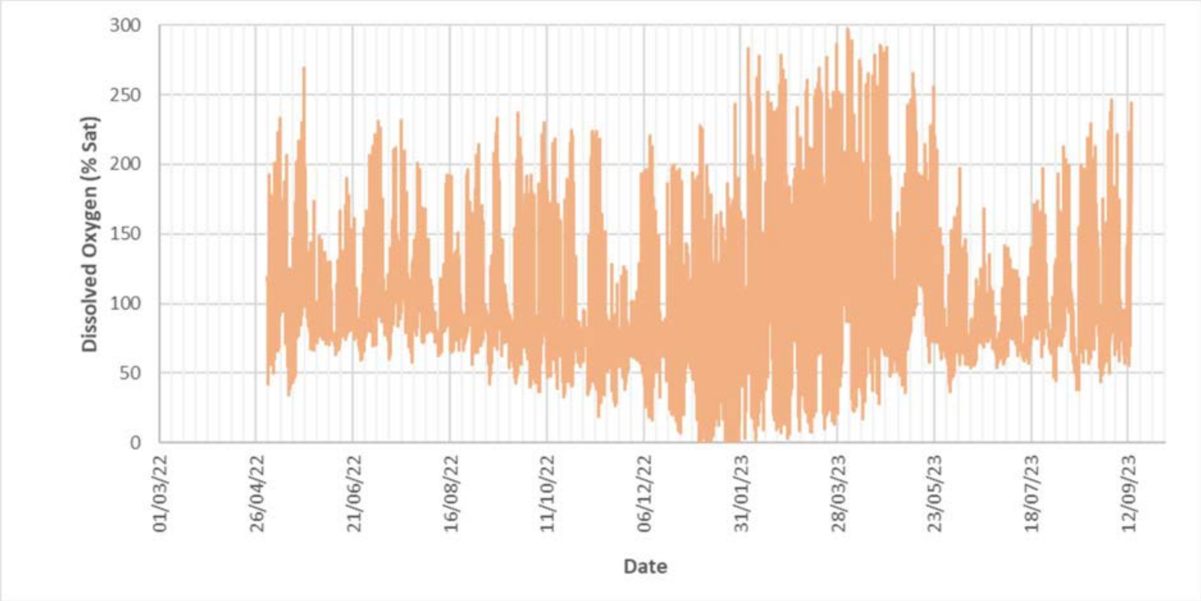
While they are not as dependent on DO levels, seagrasses and macroalgae are can be sensitive to low dissolved oxygen conditions. Prolonged exposure to low DO levels can negatively impact their growth and overall health. In extreme cases, when dissolved oxygen concentrations drop significantly, it can lead to stress, decline, or even mortality of these plants.

Fish and Invertebrates

The dissolved oxygen requirements of fish and invertebrates can vary widely among species, but most estuarine organisms require levels between 4 and 6 mg/L for survival. However, some species are more tolerant of lower oxygen concentrations, especially during certain life stages or acclimation periods.

Continuous monitoring at the Chapman Creek Intake (Site 6) has shown a period of wildly fluctuating DO levels (between 0 mg/L and 20 mg/L) and DO saturation (between 0 to around 260 %) in January through to March 2023, Figure 8. Low DO levels are of greater concern with respect to fish and crustaceans.

Considering this sampling location is a natural ecosystem and that there were no reported fish kills during the monitoring period, it is unlikely that the data truly reflects the natural background conditions. It is very likely that these DO fluctuations are caused by the entrainment of air bubbles in the seawater due to rapid tidal currents moving through a narrow and shallow channel at the monitoring point. The results could be inferred to be in error, suggesting ongoing monitoring and calibration of equipment to properly validate the results.



(Water Engineering Plus, October 2023)

Figure 8. Dissolved oxygen saturation at the proposed Riverlea seawater intake location

The current data indicates adverse DO conditions for the intake seawater, with this assessment supported by Water Engineering Plus:

> "Dissolved oxygen percentages exceeding about 120 % can be harmful to aquatic life. About 19 percent of the readings are in this category to 13 September 2023."

However, it is recommended that at least one more summer season of data is collected with more frequent DO calibrations to ensure accurate data, before a proper impact assessment on fish can be made.

Benthic organisms, which inhabit sediments, may have specific DO preferences. Some organisms, such as burrowing invertebrates, may be adapted to lower oxygen concentrations, while others may require higher levels.

Crustaceans, including crabs and shrimp, generally prefer DO concentrations above 3 mg/L. However, optimal levels can vary depending on the species and life stage.

It is important to note that dissolved oxygen levels can fluctuate due to factors such as tidal cycles, temperature changes, and organic matter decomposition. Organisms in estuaries have evolved to tolerate or adapt to these variations the final composition of species in the SWL ecosystem may reflect these tolerances to DO fluctuations.

Local and species-specific studies are essential for a more precise understanding of dissolved oxygen requirements in a particular estuarine environment, as conditions can vary significantly from one estuary to another.

3.6.4 pH (Acidity/Alkalinity)

The pH of the water affects the solubility of nutrients and metals, influencing the overall health of aquatic ecosystems. Fluctuations outside the optimal pH range can impact the survival and reproduction of aquatic organisms. Seawater pH is usually highly buffered in the natural marine environment however, it was reported to fluctuate more widely in Chapman Creek (Water Engineering Plus, October 2023).

The expected pH range for seawater is between 8.0 and 8.2, Figure 10 shows that the range in Chapman Creek sits between 7.5 and 9.5, which is an unexpected result of the natural estuarine habitat in this area. When water pH is around 9.5 units cationic ammonia (NH_4^+) will convert to toxic gaseous ammonia NH_3 (Millero, 1996). The ANZECC trigger values for pH in a marine ecosystem are >8.0 and <8.5.

Given the significance of this oddity, the results were questioned with the Water Sampling company managing the sampling and data. They subsequently confirmed that during October and November 2022 they experienced a fault with the pH sensor installed on the Water Quality Buoy. The sensor was replaced with a new sensor during the November service visit. Following our discussions, they increased the period of invalidated pH data to cover the entire period between the September and November service visits, including the period of high pH data in question. The period in question (showing high pH invalidated data) is in the orange section in the screenshot of the plot below.

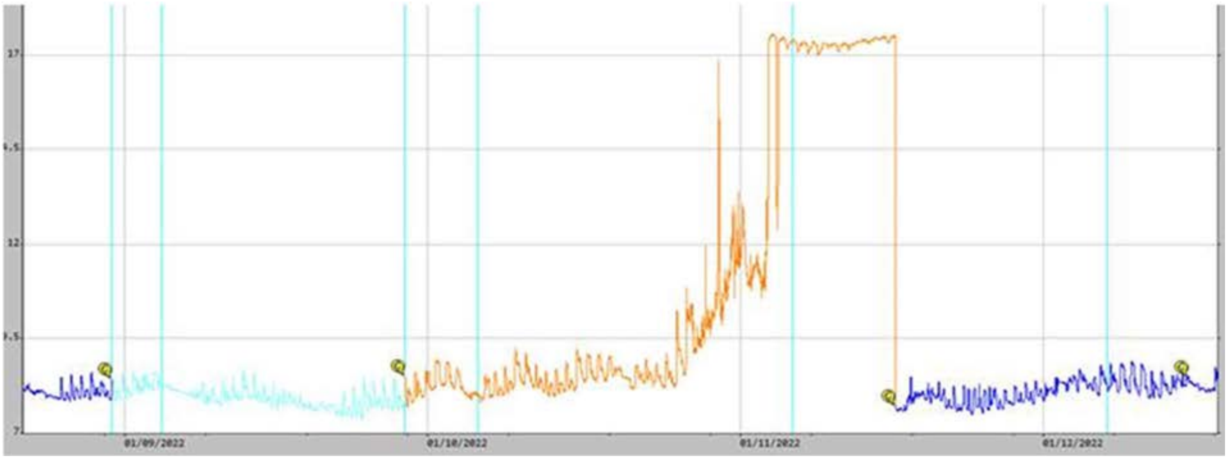


Figure 9. Seawater pH at Site 6 showing invalid data due to faulty sensor

Outside of this period, they were confident in the data, as there was a good correlation between the logger values and the field readings collected with the calibrated reference sensor. Based on this new information, an adjusted graph (Figure 9.1) reflects the pH range more accurately.

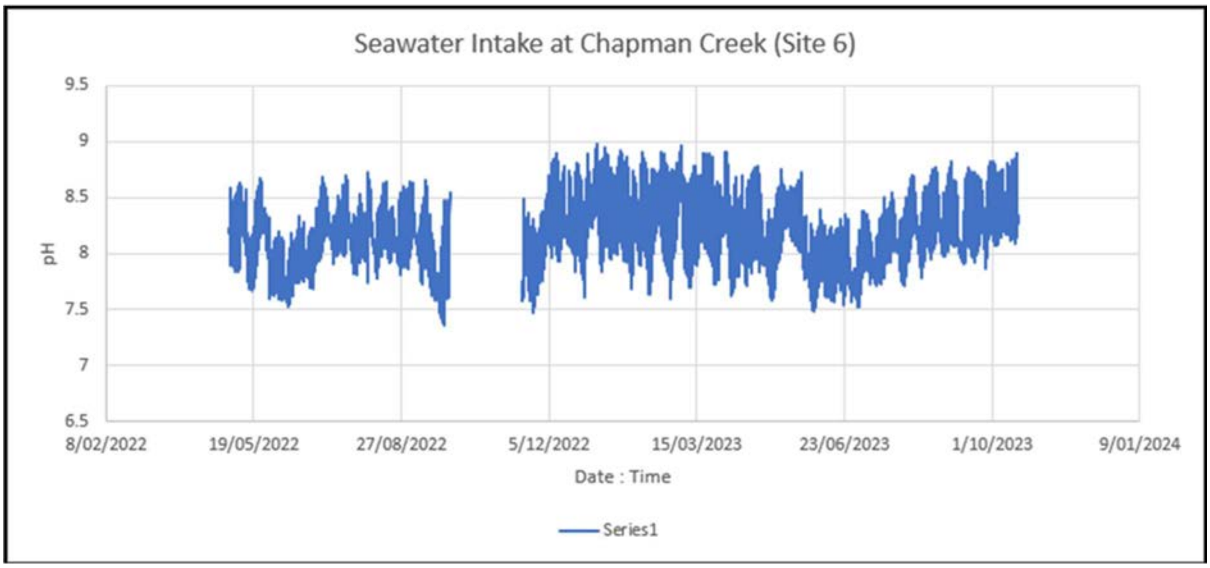


Figure 10. Seawater pH in Chapman Creek proposed intake location

3.6.5 Nutrient Levels (Nitrogen and Phosphorus)

Nitrogen (N) and phosphorus (P) are essential building blocks for plant and animal growth. Nitrogen is an integral component of organic compounds such as amino acids, proteins, DNA and RNA. Phosphorus is found in nucleic acids and phospholipids (OzCoasts, 2023). Monitoring nutrient levels is important to prevent eutrophication, which can lead to algal blooms and oxygen depletion. Excessive nutrients can negatively impact water quality and the balance of the ecosystem.

The recorded discharge of nutrients from the unnamed Channel (site 4) and the Thompson Creek (site 5) significantly surpasses anticipated levels for marine or estuarine environments. Almost all total nitrogen values exceed 1 mg/L, the trigger value stipulated by the ANZECC South Central Region Table 3.3.8, with three instances where total nitrogen values exceeded 30 mg/L out of 29 observations. Nitrate emerges as the predominant form of nitrogen in the water samples. Similarly, total phosphorus levels exceeded the trigger value of 0.1 mg/L in all but two observations

While the seawater intake location in Chapman Creek exhibits lower nutrient pollution in the water sample, it remains elevated when compared to ANZECC trigger values for Gulf St Vincent waters. Median nitrogen concentrations stand at 0.8 mg/L and 0.7 mg/L at the creek's mouth (Site 1) and upstream from the intake point (site 2), respectively. Median phosphate concentrations at these sites hover around trigger values or slightly exceed them.

The nutrient levels at the intake point suggest a potential risk of eutrophication in the SWL, which could lead to fish kills and unpleasant odours. Consequently, it is recommended to closely monitor pumping times and conduct regular water quality testing. This is best managed through implementation of a comprehensive Management Plan for the lakes (based on the advice of a Water Quality Specialist) that specifically addresses this issue.

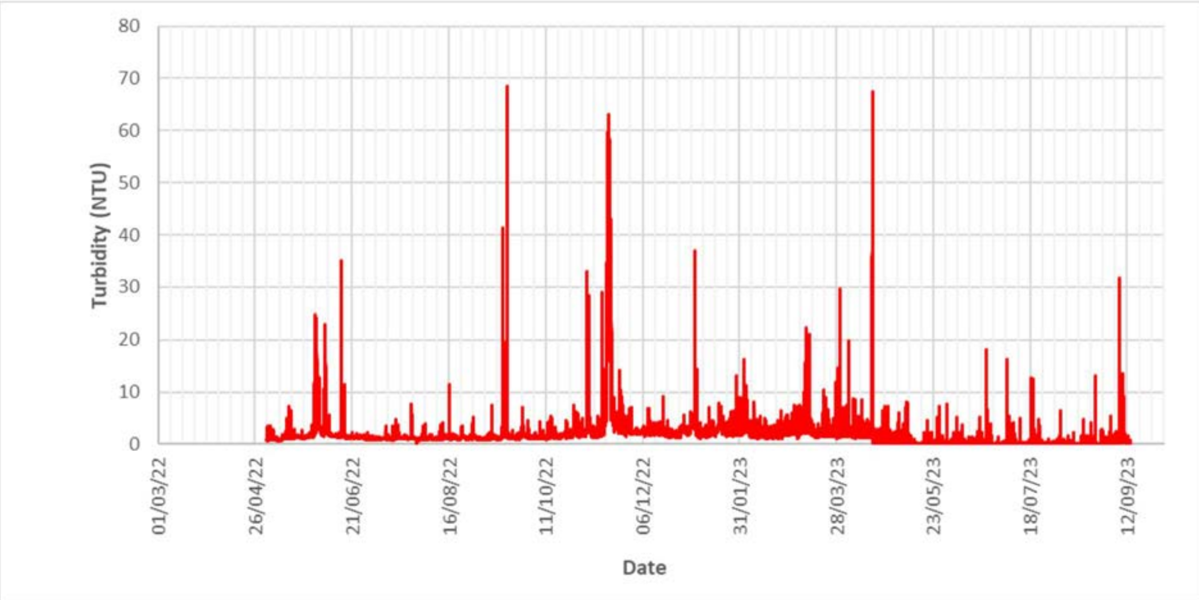
While the eventual resident populations of flora and fauna in the lakes remain uncertain, there is a likelihood that some Syngnathidae species (pipefish and seahorse) listed on the threatened species list Appendix B may establish themselves if the appropriate benthic habitat evolves in the lake.

In evaluating the impact of the Riverlea SWL on flora and fauna, primary concern centres around the discharge point. Given that the SWL represent artificial habitats, the establishment of threatened species within these lakes would be considered a positive influence on species abundance and biodiversity. Nutrient concentrations at the discharge points (sites 4 and 5) far exceed ANZECC trigger values, and the documented environmental impact downstream of the Bolivar discharge is well-established. While the discharge of seawater from the Riverlea SWL may mitigate the environmental impact caused by the Bolivar Discharge near the Thompson Creek outlet and near shore coastal environment, it would not alter the nutrient load over time.

3.6.6 Turbidity and Total Suspended Solids

Turbidity measures the cloudiness or clarity of the water and can affect light penetration. Changes in turbidity may impact the growth of aquatic plants and the visual hunting abilities of some fauna.

Turbidity monitoring at the proposed seawater intake location was between 0 and 68 NTU during the monitoring period between April 2022 and September 2023, with a median of 1.4 NTU (Water Engineering Plus, October 2023). The recorded values are consistent with the low suspended solids readings with the occasional spikes as would be expected after a storm event.



(Water Engineering Plus, October 2023)

Figure 11. Turbidity records at the proposed Riverlea seawater intake station

The monitored results for suspended solids and turbidity (both in Chapman Creek and other sites) are relatively low and are not expected to pose an issue with respect to lake water quality.

Total suspended solids (TSS) measurements can indicate the presence of sediment in the water, which may affect light penetration, habitat quality, and the feeding behaviour of aquatic organisms. Monitoring of TSS is being undertaken at six locations (Figure 6). The data showed considerable fluctuations.

TSS concentrations in Chapman Creek were generally at low levels with occasional spikes, particularly in 2023. Water Engineering Plus suggested that there may be an association of the elevated TSS values with local runoff events, but advised caution in interpreting the data, especially in relation to recorded rainfall (Water Engineering Plus, October 2023).

3.6.7 Heavy Metals:

Monitoring concentrations of heavy metals is crucial, as these pollutants can accumulate in organisms and pose a risk to both flora and fauna. Riverlea has been monitoring water quality since April 2022. The water quality report, particularly focusing on heavy metals, suggests that the concentrations of various heavy metals in the sampled water are consistently below the guideline values for recreational use (Water Engineering Plus, October 2023).

The concentrations of heavy metals (Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Zinc, and Mercury) from March 10, 2022, to September 13, 2023, are compared to the ANZECC guideline values for recreational purposes.

The water quality monitoring indicates that the concentrations of heavy metals in the sampled water are consistently below guideline values for recreational use. This suggests that heavy metals are not expected to pose a significant threat to the flora and fauna in the Riverlea development area.

3.6.8 Toxicants and Pollutants:

LBWco undertook preliminary site investigations (PSI), comprising a site history for all stages within Precinct 2 of the Riverlea Development (LBWco, October 2022). A subsequent environmental audit undertaken by ERM in 2012 indicated the presence of elevated concentrations of molybdenum, fluoride, nitrate and selenium identified in groundwater beneath the Stage 1 development area were considered to be related to regional groundwater quality.

The PSI recommended that intrusive soil investigation works are undertaken at the site to assess the possible complete source pathway receptor linkages identified in relation to the diesel AST and mixing of herbicides in the vicinity of the shed.

Toxicants and pollutants, such as heavy metals (some discussed in previous section), pesticides, and industrial chemicals, can contaminate soil, water, and air, posing risks to the health of plants and animals. The introduction of pollutants can contribute to a decline in biodiversity by adversely affecting the survival and reproduction of varied species, leading to imbalances in ecological communities.

Some of the interactions with toxicants and pollutants from urban developments that may impact flora and fauna include:

- Runoff from urban areas can carry pollutants into water bodies, causing water quality degradation, impacting aquatic ecosystems, and potentially harming aquatic plants and animals.
- Urban development activities may introduce contaminants into the soil, affecting soil quality and potentially harming plant life and soil-dwelling organisms.
- Urban development can facilitate the introduction and spread of invasive species, further threatening native flora and fauna by outcompeting or preying upon indigenous species.
- Pollution and toxicants can disrupt essential ecological processes such as nutrient cycling, pollination, and seed dispersal, leading to cascading effects on ecosystem health.
- Increased pollution levels may contribute to the proliferation of diseases among plants and animals, impacting their overall health and population dynamics.

- Flora and fauna may face challenges in adapting to rapidly changing environmental conditions, including increased pollutant levels, leading to potential population declines and ecosystem imbalances.

The management systems proposed by the Riverlea Project in the Development Application are intended to control the potential releases of toxicants and pollutants. It is understood these peripheral and internal management systems are to be further refined during detailed documentation, assisted with the input of a Water Quality Specialist.

The presence of fluoride, nitrate and selenium identified in groundwater under Precent 1 is not expected to contaminate the SWL as there is no clear connective pathway. However, it is recommended that regular monitoring for such heavy metals and pollutants in the SWL is essential to identify and mitigate potential sources of contamination. The presence of fluoride, selenium and molybdenum in the SWL may indicate a breech in the clay lining.

3.6.9 Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are water quality parameters that indicate the amount of oxygen required by microorganisms to break down organic matter in water. The impact of BOD and COD on aquatic flora and fauna is significant and can lead to both short-term and long-term consequences.

Depletion of Dissolved Oxygen

High BOD levels indicate the presence of organic pollutants that require oxygen for decomposition by bacteria. As microorganisms break down this organic matter, they consume dissolved oxygen in the water. The reduction in dissolved oxygen can be harmful to aquatic organisms that rely on oxygen for respiration.

Similarly, COD measures the overall oxygen demand resulting from both organic and inorganic pollutants. High COD levels suggest a greater demand for oxygen, which can lead to a reduction in dissolved oxygen concentrations.

Impact on Aquatic Organisms

Excessive BOD and COD levels can lead to the growth of oxygen-consuming bacteria, algae, and other microorganisms. Algal blooms, fuelled by nutrient-rich organic matter, can shade out submerged aquatic plants and disrupt the balance of the aquatic ecosystem.

Fish and other aquatic organisms may experience stress or mortality in low-oxygen conditions. Species with higher oxygen requirements or those unable to adapt to lower oxygen levels may be particularly vulnerable.

Alteration of Ecosystem Structure

Elevated BOD levels can alter the balance of the aquatic ecosystem by favouring the growth of certain bacteria over others. This can lead to changes in nutrient cycling, impacting the availability of resources for both flora and fauna.

The composition of pollutants contributing to COD can vary, and certain chemical compounds may have toxic effects on aquatic life, leading to changes in the abundance and diversity of species.

Long-term Consequences

Chronic exposure to high BOD and COD levels can result in the degradation of aquatic habitats over time. This degradation may lead to the decline or loss of sensitive species, impacting the overall biodiversity of the ecosystem.

Eutrophication

Elevated levels of organic matter from BOD and COD can contribute to eutrophication, a process where excessive nutrients lead to increased plant and algae growth. This, in turn, can lead to oxygen depletion as these plants and algae decay, further impacting aquatic organisms.

To mitigate the impact of BOD and COD on aquatic flora and fauna, it is crucial to implement effective wastewater treatment practices, manage nutrient inputs, and promote sustainable water management strategies. Monitoring and regulating BOD and COD levels are essential for maintaining the health and balance of aquatic ecosystems and should form part of the Management Plan for the lakes system.

3.6.10 Microbial Quality

Implementing a comprehensive Management Plan for the lakes system that includes monitoring microbial parameters, including the presence of pathogens and faecal coliforms, should ensure water safety and preventing potential risks to both aquatic organisms and human users.

Further regular and systematic monitoring of these water quality parameters will enable a comprehensive evaluation of the impacts on flora and fauna in the human-made seawater lake, facilitating adaptive management strategies to maintain a healthy and sustainable aquatic ecosystem.

3.7 Habitat Impact Assessment

The creation of saltwater lakes and alterations to intake and outflow structures may impact existing habitats. The changes in shoreline vegetation, substrate composition, and the overall structure of the aquatic environment are expected to cause minor changes from the current situation. The intake structure will remove some mangroves and change the water flow pattern around the intake structure.

The impact on the mangrove and estuarine habitat is expected to be small and confined to around 1,000 m^2 , comprising of the intake platform, and access and disruption to flow in the immediate vicinity of the intake.

The seawater intake corridor will mostly be underground and following existing tracks and roads. Laying the pipeline will temporarily disrupt and impact the existing habitat. The 8.4-kilometre intake corridor, as described in Section 3.2, is highly altered and therefore the potential impact on the habitat is evaluated low and acceptable.

The discharge corridors will run nearly 7 kilometres mostly following existing drainage lines. The seawater disposal corridor will accommodate an underground pipe for the majority of the route pipe with the remaining corridor (nearly 1km) comprising an open drainage channel. The long-term impact of discharging saline water via the open drain to the surrounding habitat is expected to be marginal because the last kilometre of drainage channel is proposed to be clay lined, Further, as the land drops to low-lying coastal flats, it is associated with saline water courses, poorly drained soils and shallow saline water tables. The distinguishable land salinisation, either as saline subsoils or surface seepage, with the presence of salt-tolerant vegetation and the abutting unlined Cheetham outfall channel suggests this is already quite a saline environment and therefore the discharge of saline waters via the channel is likely to have marginal consequences on the current habitat or long-term change of vegetation and animals supported by these corridors.

3.8 Flora Impact Assessment

The potential effects on plant life, both aquatic and riparian of the SWL system arise from changes in water levels, salinity, and nutrient availability that may affect the growth and distribution of plant species.

The SWL will result in the removal of vegetation from around 40 hectares including some large red gums (*E. camaldulensis*). EBS identified 22 native plant species, but none were listed on the threatened species list. EBS prepared two Sustainable Environmental Benefit assessment to over Precinct 2 (including the SWL) and the intake and discharge infrastructure.

This SEB is intended to offset the removal of native vegetation including significant Eucalyptus (greater than 1m base diameter) and mangroves. These SEB offsets for the removal of vegetation are approved by the Native Vegetation council of South Australia.

The PMST identified the likely presence of a potential endangered species, the Greencomb Spider-orchid, also known as the Rigid Spider-orchid (*Caladenia tensa*). However, the field survey did not encounter any specimens.

In addition, the PMST identified three vulnerable species within the area. The Bead Glasswort, also known as the Bead Samphire (*Tecticornia flabelliformis*), is likely to occur in the area. The Large-fruit Fireweed, also called the Large-fruit Groundsel (*Senecio macrocarpus*), and the Yellow Swainson-pea (*Swainsona pyrophila*) may occur in the area but were not found during the field survey. It should be noted that a search of the NatureMaps database did not have any records of these species within the area, Section 3.3.1.

Changing groundwater levels are not anticipated. However, based on the water quality results of over one year of monitoring, there is a high likelihood of increasing nutrient loads and salinity within the drains and in a halo of surrounding soils. These are expected to change the flora composition with a shift towards more salt tolerant species such as Chenopods. The response of Chenopods and other salt tolerant species to high nutrients particularly phosphates are not easily predictable, it is therefore recommended that soil monitoring will be undertaken during the proposed SWL construction period to detect any buildup of nitrates and phosphates.

The intake of seawater at Chapman Creek will reduce the amount of seagrass and macrophyte propagules, but the impact is expected to be minimal. Some of these propagules are expected to establish in the SWL provided the water quality is maintained.

3.9 Fauna Impact Assessment

In evaluating the potential impacts on aquatic and terrestrial fauna factors such as changes in breeding habitats, migration routes, and availability of food resources are considered. While a targeted survey of the intertidal habitat in Thompson or Chapman creeks were not conducted, information on fauna known or likely to inhabit in the area was obtained through a literature review and database searches, as outlined Section 3.3.1.

The anticipated water quality in the saltwater lakes should align with that of the intake location, predicated on the proposed 40-day retention time (BMT, February 2022). However, Section 3.6 indicates that the intake water quality may not be conductive to the establishment fauna within the SWL. This unexpected outcome is based on a comprehensive monitoring period exceeding one year by ALS hydrographic, a NATA certified laboratory, and reported by Water Engineering Plus. Pending further monitoring and careful evaluation of the reported data, water from Chapman Creek is currently deemed unsuitable for fauna in the SWL.

The seawater intake is located in an important intertidal zone, serving as a nursery for fish and prawn species and a rookery, feeding ground and breeding location for both resident and migratory birds. Additionally it serves as a habitat for dolphins (ECF, 2023).

The removal of a small area of mangrove habitat is not anticipated to significantly impact birds, mammals or reptiles listed in the NatureMap database search (Appendix C). However, the extraction of seawater to fill and to maintain the proposed 40-day retention time within the SWL is likely to impact fish and crustaceans by removing eggs and propagules from their habitat. While the impact is considered minor, it is exacerbated by the abstraction of seawater for the Dry Creek Salt fields.

Despite the assessed impact being minor, it is advisable to conduct further investigations into the potential ramifications of removing fish and crustacean eggs from this habitat. This additional scrutiny will serve to validate the current assessment and ensure a comprehensive understanding of the ecological implications associated with the proposed activities.

3.10 Ecosystem Interactions

Changes in one component of an ecosystem may have cascading effects on others. In this investigation the SWL present new roosting opportunities for migratory species, opportunistic habitat for aquatic species, subject to suitable water quality levels being achieved in the lakes, and the ingress of Chenopods along the discharge open drains displacing the less salt tolerant vegetation. While these changes are locally significant, the overall impact on aquatic organisms and migratory species is small.

While the plan is to allow for the lake ecosystem to stabilise naturally it is noted that exotic species may be inadvertently introduced. Changing water quality conditions such as decreased salinity or increased temperatures may provide favourable habitat for exotic species.

4. MITIGATION AND MANAGEMENT STRATEGIES

This section, based on the impact assessments, proposes mitigation and management strategies to minimise adverse impacts. The Riverlea Development Application amendment (DAa) has outlined strategic mitigation and management measures (Walker, April 2023). One of the main functions of the SWL is to manage storm and flood waters.

The SWL receive stormwater from a small catchment, primarily from Precinct 2, and serve as a temporary containment during flood events to manage overflow from the Gawler River. The proposed management system is designed to pump seawater from Chapman Creek to meet a 40-day turnover target. Flood events will require more seawater to be pumped into the Lakes to quickly restore the saltwater ecosystem. Flora and fauna that may establish in the SWL are likely to be estuarine species and have a higher tolerance for freshwater/brackish water. A post flood event management strategy is recommended to ensure that the freshwater is quickly displaced to avoid a fish kill, eutrophication and the associated odours.

The DAa presents details of the proposed urban landscaping and habitat replacement through a series of recreational parks around the lakes. Riverlea do not propose any habitat development within the lakes, currently they are intended to be clay lined water holding facilities. Seawater from Chapman Creek will introduce eggs and propagules of estuarine and marine species many of which are likely to establish. However, the current design of the SWL and reticulation system could be unstable due to water quality targeting secondary human contact standards and the lack of habitat.

During rain events freshwater will flow into the lakes and mix with seawater. The freshwater may kill flora and fauna if there is a prolonged exposure. The exposure time varies with species, but more than 48 hours of low salinity may kill many marine organisms. In addition stratification, given the lakes are 3 m below the standing water level, may occur when lower density freshwater flows into the lakes. This will also lead to algae blooms and eutrophication.

Pumping higher rates of water from Chapman Creek may not address the problem because water quality monitoring at the intake point shows that the salinity also drops during such events. This scenario requires a sophisticated modelling, monitoring and management approach to evaluate the length of time that a 1 in 100 year flood event will take to flush the SWL. This modelling assessment, coupled with a robust management methodology will inform and address the risks and help design implementation strategies to prevent algal blooms, fish kills, eutrophication and the build-up of nutrients and odours.

Should Riverlea decide to establish the lakes as a habitat for marine fauna (an estuarine habitat is not a feasible option without tidal flushing) additional design features should include various substrates such a sand and rock on the lake bed and provide shelter such as aggregation devises and drop offs. Should further water quality monitoring of Chapman Creek continue to show fluctuations in water quality, especially high nutrient levels, it is strongly recommended alternatives be found to protect any species that may establish in the lakes.

The water quality monitoring at the intake in Chapman Creek suggests fluctuating DO levels. Oxygen levels in the SWL need to be maintained at around 90% saturation to prevent eutrophication. Since this system does not have a diurnal tide and relies on pumped seawater intake, the 40-day retention period is also likely to exasperate the condition of anoxia. It is advised that an aeration system, or some alternative method of managing DO levels in the lake be investigated by a suitably qualified Water Quality specialist and installed.

Nutrients levels in seawater from the Chapman Creek intake are likely to be high as shown in the long-term monitoring program. Nutrients could build up in the lake and trigger algal blooms. In addition, around 20 % of the nutrients from garden fertilisers and animal faeces in stormwater runoff will enter the lakes, after passing through a series of treatment system to remove 80 % (BMT, December 2021). Another potential source of nutrients is from birds roosting on the lakes or downstream of the stormwater treatment system.

High nutrient levels will trigger algal blooms that are potentially detrimental to marine flora and fauna. An option to mitigate and control algal blooms is to install an algae control system such as Ultrasonic Algae Control and/or as advised by a recognised Water Quality Specialist.

The saltwater intake may get blocked by the buildup of fouling organisms causing poor water circulation and exasperating the capacity of the system to flush out the build-up of nutrients and other pollutants. In the final design consideration it is advised to incorporate the install copper / nickel (90/10) screens with a 3 mm aperture to maximise longevity to deal with an environment exposed continuously to saline water and enable aeration to clean the screens.

The discharge water is likely to be of a higher quality than the Bolivar discharge water at the mixing point downstream of the weir at the mouth of the creek. An appropriately qualified Water Quality Specialist should be engaged to provide the necessary advice to make any necessary improvements in water quality. The expert advice and management strategies should focus on enhancements in water quality at the intake source prior to lake entry, within the lakes, and upon exiting the lakes to the outfall location.

4.1 Monitoring and Adaptive Management

Riverlea currently plan to continue the current water quality monitoring program. This will provide essential information on the water quality of both the intake and on the receiving environment. It is recommended that the continuous monitoring station at the proposed intake location be calibrated more frequently to confirm that the monitoring over the last twelve months is real and not due to calibration drift.

No quantitative information is available on the intertidal fish and crustacean nursery at either Chapman Creek or Thompson Creek. A monitoring program to document flora and fauna within the estuary will provide a better understanding of the impact of drawing small fish, crustaceans, macroalgae and their propagules in the intake seawater.

An oceanographic monitoring program associated with bathymetric survey is recommended to model the seawater flow regimes to better plan the pumping cycles. The Cheetham salt water intake facility also needs to be included in the modelling. Oceanographic monitoring at the Thompson Creek is also recommended to model the potential impact plume of nutrients and other pollutants.

Terrestrial flora and fauna have been documented and no further monitoring is required at this stage. However, during construction and for around 15 years after the commissioning of Phase 1 it is recommended that at least bi-annual flora and fauna surveys be conducted to track changes in flora and fauna over time. The flora and fauna surveys should include exotic species, to inform management in a timely manner for preventative measures.

During the operation phase the SWL water quality should be monitored regularly (minimum monthly and more frequently following rain events and weekly during, spring, and autumn. In addition to the current suit of parameters being monitoring it is recommended to include biological oxygen demand (BOD). It is recommended that the metals reported by LWBco in groundwater, which is molybdenum, fluoride and selenium be monitored, to track potential groundwater intrusion into the SWL. It is recommended that permanent monitoring stations to track pH, salinity, DO, turbidity and water temperature are established at each of the three lakes.

5. CONCLUSION AND RECOMENDATIONS

This report has meticulously addressed concerns and requests regarding the environmental impact of the Riverlea saltwater lakes, with a specific emphasis on flora and fauna. Our investigation involved an extensive literature review and searches on the National and South Australian flora and fauna databases, incorporating data from the Riverlea Development Application, Native Vegetation Clearance authorisation, Coast Protection Board assessment, Water Quality Reports, and reports by Engineering Consultants.

The construction of the proposed SWL is anticipated to impact flora and fauna primarily through vegetation clearance, a process duly approved by the Native Vegetation Council with an accompanying SEB offset fee. While the assessment indicates minor impacts on marine fauna, including marine and migratory birds in the area, concerns arise regarding the extraction of seawater from Champman Creek potentially reducing populations of fish and crustaceans, specifically the threatened species of Syngnathidae (pipefish and seahorse).

While easily treatable, the variable levels in pH, dissolved oxygen (DO), and salinity at the intake source are currently not fully understood and need to be monitored and managed to address potential risks to water quality within the SWL. If these water quality parameters are not effectively managed issues including algae blooms, eutrophication, and odours may occur. This study also identifies potential risks stemming from nutrient build-up in the lakes, potentially exacerbated by marginally high nutrient levels from intake water and possible faecal inputs from aquatic birds, which must be monitored and managed with suitable management strategies.

To address these concerns, this study recommends the continuation of the current monitoring program, with an emphasis on more frequent instrument calibrations and oceanographic monitoring. This approach aims to establish water quality patterns at Chapman Creek and the confluence of Boliver and the SWL discharge streams in Thompson Creek.

Furthermore, the development of a detailed Lakes Management Plan in collaboration with the Water Quality Specialist, as intended by Riverlea, is endorsed by this study as an essential tool for ensuring the project's ecological sustainability and minimising adverse effects on aquatic flora and fauna.

The advice from a Water Quality Specialist underscores the importance of expertise in enhancing water quality both during extraction from the receiving environment and within the lake, before entering the Thompson Creek environment. This report underscores the critical importance of adhering to environmental best practices throughout the project's lifecycle to achieve a harmonious balance between development and ecological preservation.

6. REFERENCES

BMT. (December 2021). *Riverlea Concepts Stormwater Qaulity Management Plan.* Wlaker Corporation.

BMT. (February 2022). *Technical Memorandum- Use of Chapman Creek to Supply Saline Water to Riverlea Development.* Walker Corporation.

DCCEEW. (2023, November 15). *Protected Matters Search Tool*. Retrieved from https://pmst.awe.gov.au/

DEW. (2023, July 25). Corrrespondence from Kerrie Burmeister. *DEW-D0022861*.

DEW. (2023, November 15). *NatureMaps*. Retrieved from coast and marine - estuary habitats: http://spatialwebapps.environment.sa.gov.au/naturemaps/?locale=en-us&viewer=naturemaps

DEW. (August 2021). *Dry Creek salt fields vegetation impact mapping. Summary report* . Department for Environment and Water.

EBS. (March 2022). *Native Vegetation Clearance Buckland Park Intake Pipeline Data Report.*

ECF. (2023, 11 22). *Barker Inlet and Port River Estuary*. Retrieved from Esturay Care Foundation: https://www.estuary.org.au/the-estuary/

EPA. (1999). *Stromwater pollution prevention code of practice for the building and construction industry* . Department for Environment,Heritage and Aboriginal Affair.

EPA. (2023, July 26). Correspondence from Phil Hazell. *EPA 775-446*. South Australia.

EPA. (June 2021). *Water Quality Guideline, environmental management of dewatering during construction activities.* EPA.

LBWco. (October 2022). *Preliminary Site Investigation, Precinct 2, Riverlea Development, Riverlea Park, South Australia.* Report for Walker Buckland Park Developments Pty Ltd.

Millero, F. J. (1996). *Chemical Oceanogrpahy, 2nd Edition, .* CRC Press LLC.

OzCoasts. (2023, November). *Water column nutrients*. Retrieved from Australian Online Coastal Information: https://ozcoasts.org.au/indicators/biophysical-indicators/water_column_nutrients/

PIRSA. (2023, November 15). *St Kilda - Chapmen Creek Aquatic Reserve*. Retrieved from https://www.pir.sa.gov.au/__data/assets/pdf_file/0014/411611/CHAPMAN_CREEK_.pdf

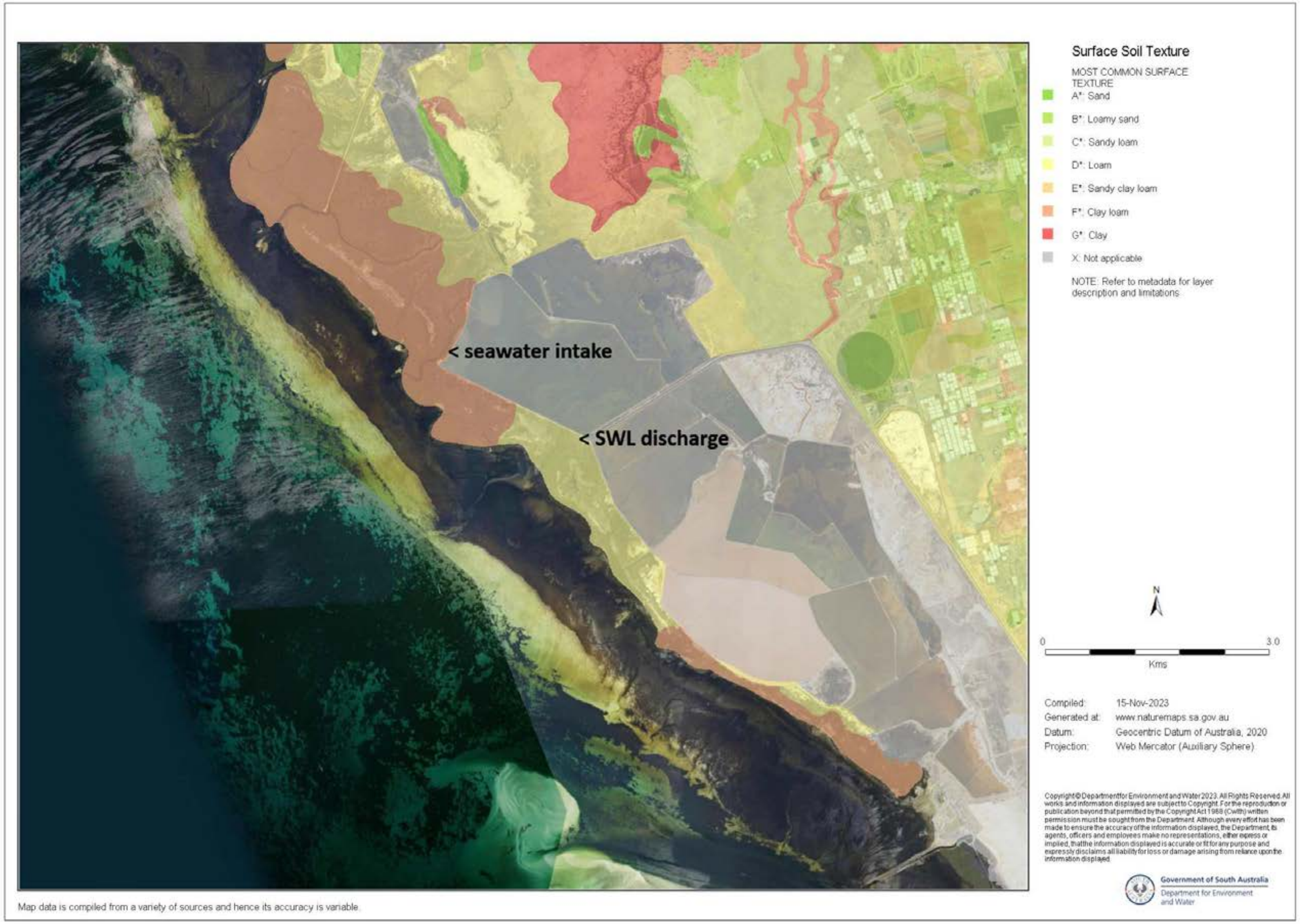
Walker. (April 2023). *Riverlea Major Development, Development Application Amendment to the EIS. Principally - Alteration to the Precinct 2 Subdivision:.* Walker.

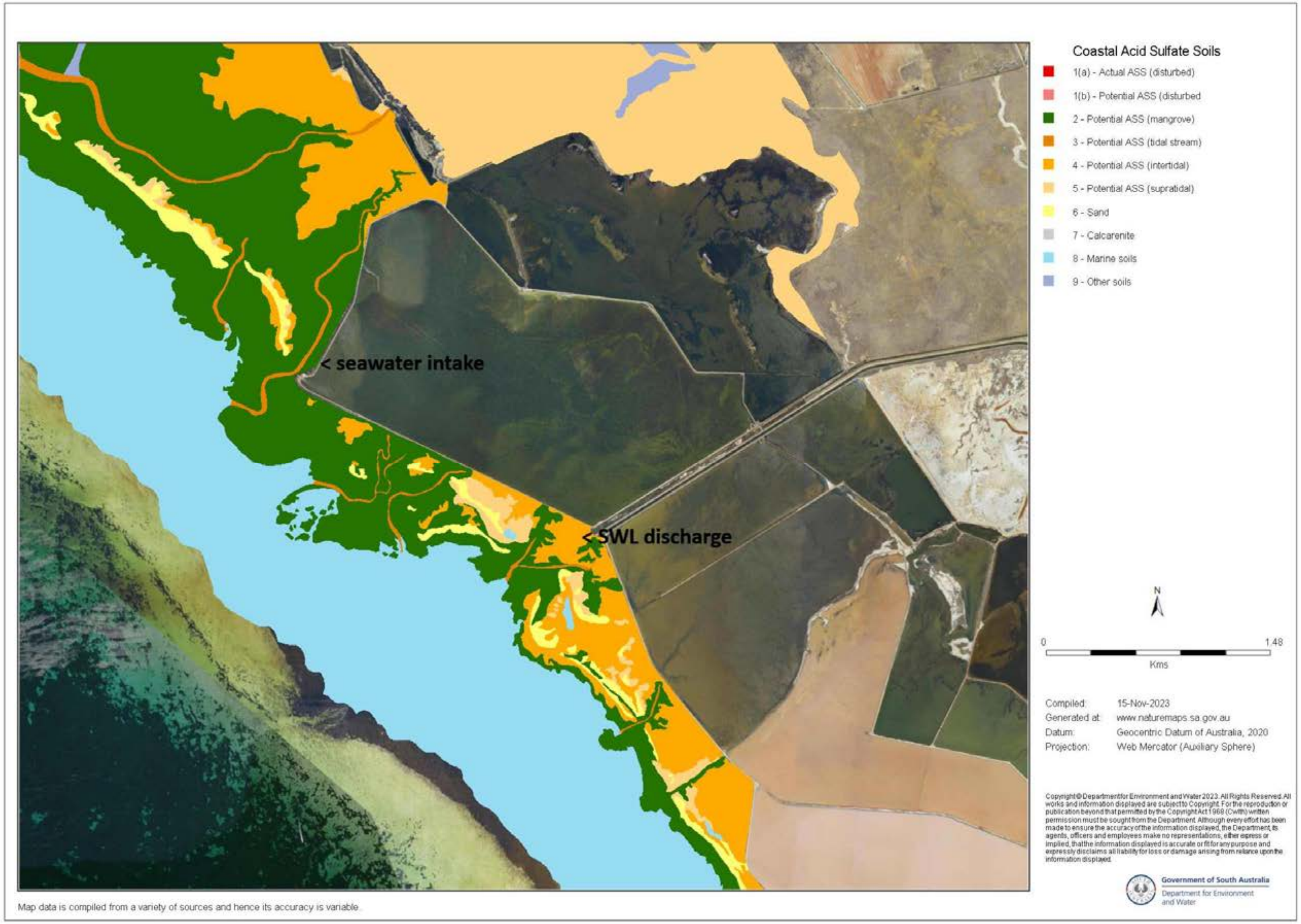
Water Engineering Plus. (October 2023). *Water Quality Monitoring Program Results to 13 September 2023.* Walker Corporation.

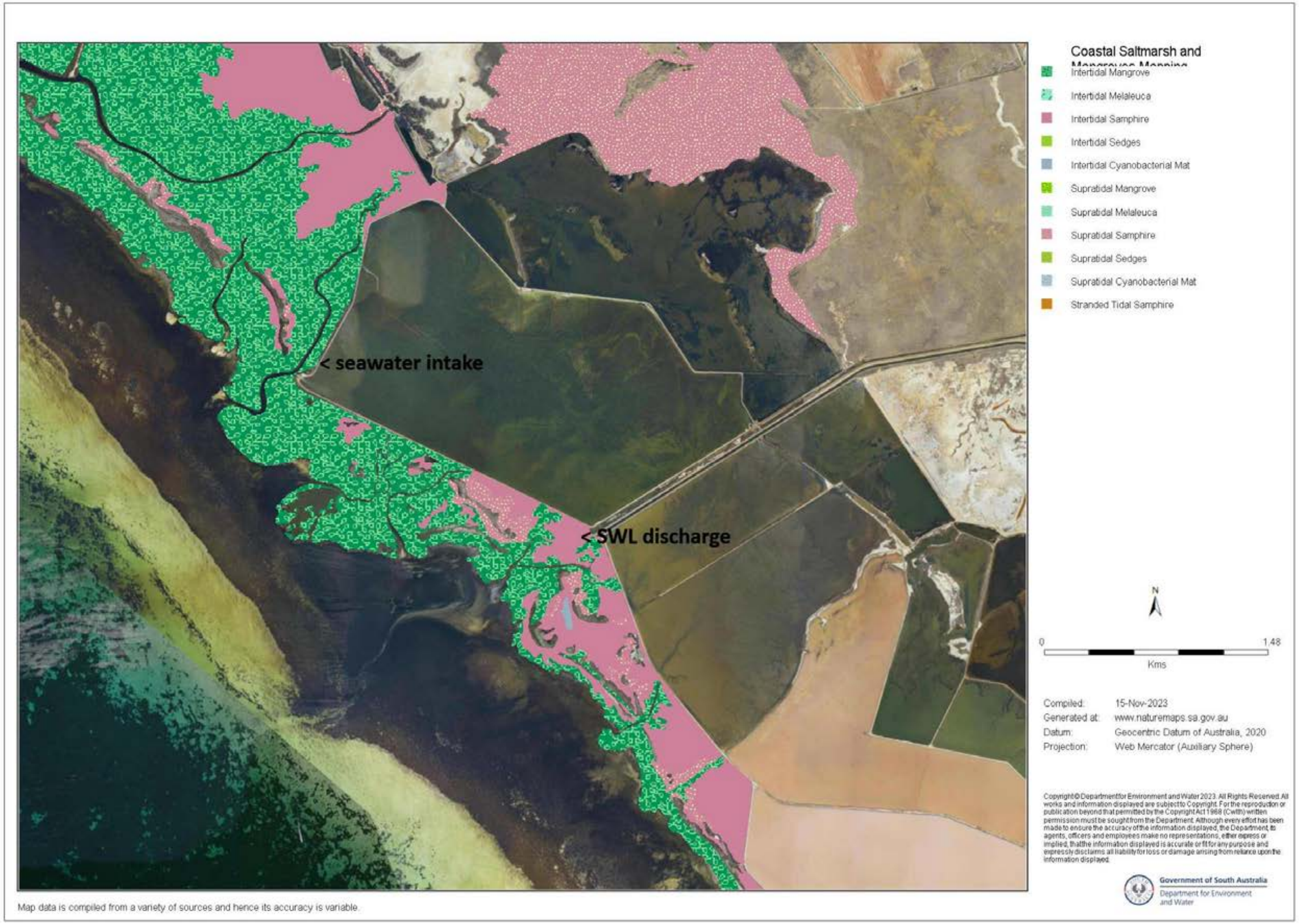
Wikipedia. (2023, November 15). *St Kilda – Chapman Creek Aquatic Reserve*. Retrieved from https://en.wikipedia.org/wiki/St_Kilda_%E2%80%93_Chapman_Creek_Aquatic_Reserve

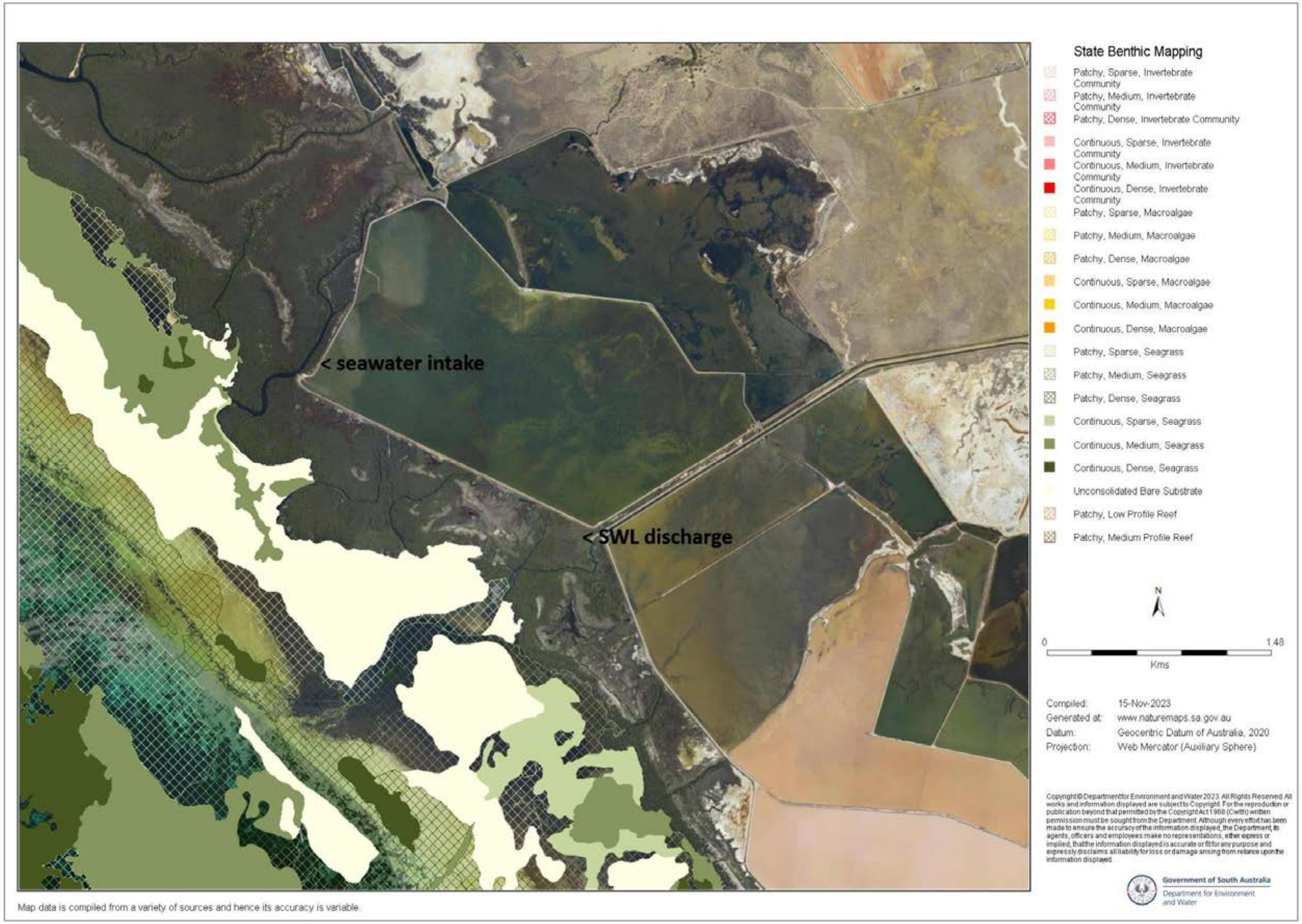
WSP. (Februry 2022). *Salt Water Lakes Circulation System Concept Review.* Walker Corporation.

Appendix A
Environmental Maps


< seawater intake
< SWL discharge
Surface Soil Texture
MOST COMMON SURFACE TEXTURE
A*: Sand
B*: Loamy sand
C*: Sandy loam
D*: Loam
E*: Sandy clay loam
F*: Clay loam
G*: Clay
X: Not applicable
NOTE: Refer to metadata for layer description and limitations
N
0
3.0
Kms
Compiled: 15-Nov-2023
Generated at: www.naturemaps.sa.gov.au
Datum: Geocentric Datum of Australia, 2020
Projection: Web Mercator (Auxiliary Sphere)
Copyright © Department for Environment and Water 2023. All Rights Reserved. All works and information displayed are subject to Copyright. For the reproduction or publication beyond that permitted by the Copyright Act 1968 (Cwlth) written permission must be sought from the Department. Although every effort has been made to ensure the accuracy of the information displayed, the Department, its agents, officers and employees make no representations, either express or implied, that the information displayed is accurate or fit for any purpose and expressly disclaims all liability for loss or damage arising from reliance upon the information displayed.
Government of South Australia
Department for Environment and Water
Map data is compiled from a variety of sources and hence its accuracy is variable.


< seawater intake
< SWL discharge
Coastal Acid Sulfate Soils
1(a) - Actual ASS (disturbed)
1(b) - Potential ASS (disturbed
2 - Potential ASS (mangrove)
3 - Potential ASS (tidal stream)
4 - Potential ASS (intertidal)
5 - Potential ASS (supratidal)
6 - Sand
7 - Calcarenite
8 - Marine soils
9 - Other soils
N
0
1.48
Kms
Compiled: 15-Nov-2023
Generated at: www.naturemaps.sa.gov.au
Datum: Geocentric Datum of Australia, 2020
Projection: Web Mercator (Auxiliary Sphere)
Copyright © Department for Environment and Water 2023. All Rights Reserved. All works and information displayed are subject to Copyright. For the reproduction or publication beyond that permitted by the Copyright Act 1968 (Cwlth) written permission must be sought from the Department. Although every effort has been made to ensure the accuracy of the information displayed, the Department, its agents, officers and employees make no representations, either express or implied, that the information displayed is accurate or fit for any purpose and expressly disclaims all liability for loss or damage arising from reliance upon the information displayed.
Government of South Australia
Department for Environment and Water
Map data is compiled from a variety of sources and hence its accuracy is variable.


Coastal Saltmarsh and
Intertidal Mangrove
Intertidal Melaleuca
Intertidal Samphire
Intertidal Sedges
Intertidal Cyanobacterial Mat
Supratidal Mangrove
Supratidal Melaleuca
Supratidal Samphire
Supratidal Sedges
Supratidal Cyanobacterial Mat
Stranded Tidal Samphire
< seawater intake
< SWL discharge
N
0
1.48
Kms
Compiled: 15-Nov-2023
Generated at: www.naturemaps.sa.gov.au
Datum: Geocentric Datum of Australia, 2020
Projection: Web Mercator (Auxiliary Sphere)
Copyright © Department for Environment and Water 2023. All Rights Reserved. All works and information displayed are subject to Copyright. For the reproduction or publication beyond that permitted by the Copyright Act 1968 (Cwlth) written permission must be sought from the Department. Although every effort has been made to ensure the accuracy of the information displayed, the Department, its agents, officers and employees make no representations, either express or implied, that the information displayed is accurate or fit for any purpose and expressly disclaims all liability for loss or damage arising from reliance upon the information displayed.
Government of South Australia
Department for Environment and Water
Map data is compiled from a variety of sources and hence its accuracy is variable.


< seawater intake
< SWL discharge
State Benthic Mapping
Patchy, Sparse, Invertebrate Community
Patchy, Medium, Invertebrate Community
Patchy, Dense, Invertebrate Community
Continuous, Sparse, Invertebrate Community
Continuous, Medium, Invertebrate Community
Continuous, Dense, Invertebrate Community
Patchy, Sparse, Macroalgae
Patchy, Medium, Macroalgae
Patchy, Dense, Macroalgae
Continuous, Sparse, Macroalgae
Continuous, Medium, Macroalgae
Continuous, Dense, Macroalgae
Patchy, Sparse, Seagrass
Patchy, Medium, Seagrass
Patchy, Dense, Seagrass
Continuous, Sparse, Seagrass
Continuous, Medium, Seagrass
Continuous, Dense, Seagrass
Unconsolidated Bare Substrate
Patchy, Low Profile Reef
Patchy, Medium Profile Reef
N
0
1.48
Kms
Compiled: 15-Nov-2023
Generated at: www.naturemaps.sa.gov.au
Datum: Geocentric Datum of Australia, 2020
Projection: Web Mercator (Auxiliary Sphere)
Copyright © Department for Environment and Water 2023. All Rights Reserved. All works and information displayed are subject to Copyright. For the reproduction or publication beyond that permitted by the Copyright Act 1968 (Cwlth) written permission must be sought from the Department. Although every effort has been made to ensure the accuracy of the information displayed, the Department, its agents, officers and employees make no representations, either express or implied, that the information displayed is accurate or fit for any purpose and expressly disclaims all liability for loss or damage arising from reliance upon the information displayed.
Government of South Australia
Department for Environment and Water
Map data is compiled from a variety of sources and hence its accuracy is variable.

Appendix B
Protected Matters Search

EPBC Act PMST report summary

Search Area (5km Buffer)	Matters of National Environmental Significance	Identified in search area
	World Heritage Properties	0
	National Heritage Places	0
	Wetlands of International Importance (RAMSAR)	0
	Great Barrier Reef Marine Park	0
	Commonwealth Marine Area	0
	Listed Threatened Ecological Communities	1
	Listed Threatened Species	41
	Listed Migratory Species	62
	Other Matters Protected by the EPBC	
	Commonwealth Lands	0
	Commonwealth Heritage Places	0
	Listed Marine Species	97
	Whales and Other Cetaceans	8
	Critical Habitats	0
	Commonwealth Reserves Terrestrial	0
	Australian Marine Parks	0
	Habitat Critical to the Survival of Marine Turtles	0
	Extra Information	
	State and Territory Reserves	3
	Regional Forest Agreements	0
	Nationally Important Wetlands	1
	EPBC Act Referrals	6
	Key Ecological Features	0
	Biologically Important Areas	2
	Bioregional Assessments	0
	Geological and Bioregional Assessments	0

Listed Threatened Species

Scientific Name	Common Name	Class	Simple Presence	Presence Text	Threatened Category	Migratory Status
Thunnus maccoyii	Southern Bluefin Tuna	Fish	Likely	Species or species habitat likely to occur within area	Conservation Dependent	
Seriolella brama	Blue Warehou	Fish	Known	Species or species habitat known to occur within area	Conservation Dependent	
Neophema chrysogaster	Orange-bellied Parrot	Bird	May	Species or species habitat may occur within area	Critically Endangered	
Calidris tenuirostris	Great Knot	Bird	Known	Roosting known to occur within area	Critically Endangered	Migratory
Calidris ferruginea	Curlew Sandpiper	Bird	Known	Species or species habitat known to occur within area	Critically Endangered	Migratory
Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	Bird	Known	Species or species habitat known to occur within area	Critically Endangered	Migratory

Pedionomus torquatus	Plains-wanderer	Bird	May	Species or species habitat may occur within area	Critically Endangered	
Rostratula australis	Australian Painted Snipe	Bird	Known	Species or species habitat known to occur within area	Endangered	
Macronectes giganteus	Southern Giant-Petrel, Southern Giant Petrel	Bird	May	Species or species habitat may occur within area	Endangered	Migratory
Melanodryas cucullata cucullata	South-eastern Hooded Robin, Hooded Robin (south-eastern)	Bird	May	Species or species habitat may occur within area	Endangered	
Neophoca cinerea	Australian Sea-lion, Australian Sea Lion	Mammal	Known	Species or species habitat known to occur within area	Endangered	
Caladenia tensa	Greencomb Spider-orchid, Rigid Spider-orchid	Plant	Likely	Species or species habitat likely to occur within area	Endangered	
Eubalaena australis	Southern Right Whale	Mammal	Known	Breeding known to occur within area	Endangered	Migratory (as Balaena glacialis australis)
Charadrius mongolus	Lesser Sand Plover, Mongolian Plover	Bird	Known	Roosting known to occur within area	Endangered	Migratory
Thalassarche cauta	Shy Albatross	Bird	Likely	Foraging, feeding or related behaviour likely to occur within area	Endangered	Migratory
Calidris canutus	Red Knot, Knot	Bird	Known	Species or species habitat known to occur within area	Endangered	Migratory
Dermochelys coriacea	Leatherback Turtle, Leathery Turtle, Luth	Reptile	Known	Foraging, feeding or related behaviour known to occur within area	Endangered	Migratory
Caretta caretta	Loggerhead Turtle	Reptile	Likely	Breeding likely to occur within area	Endangered	Migratory
Botaurus poiciloptilus	Australasian Bittern	Bird	Likely	Species or species habitat likely to occur within area	Endangered	
Pachyptila turtur subantarctica	Fairy Prion (southern)	Bird	Known	Species or species habitat known to occur within area	Vulnerable	
Acanthiza iredalei rosinae	Slender-billed Thornbill (Gulf St Vincent)	Bird	Known	Species or species habitat known to occur within area	Vulnerable	
Falco hypoleucos	Grey Falcon	Bird	Likely	Species or species habitat likely to occur within area	Vulnerable	
Thalassarche melanophris	Black-browed Albatross	Bird	Likely	Foraging, feeding or related behaviour likely to occur within area	Vulnerable	Migratory
Carcharodon carcharias	White Shark, Great White Shark	Shark	Known	Species or species habitat known to occur within area	Vulnerable	Migratory
Tecticornia flabelliformis	Bead Glasswort, Bead Samphire	Plant	Likely	Species or species habitat likely to occur within area	Vulnerable	
Macronectes halli	Northern Giant Petrel	Bird	Likely	Foraging, feeding or related behaviour likely to occur within area	Vulnerable	Migratory

Stagonopleura guttata	Diamond Firetail	Bird	Known	Species or species habitat known to occur within area	Vulnerable	
Swainsona pyrophila	Yellow Swainson-pea	Plant	May	Species or species habitat may occur within area	Vulnerable	
Limosa lapponica baueri	Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit	Bird	Known	Species or species habitat known to occur within area	Vulnerable	
Charadrius leschenaultii	Greater Sand Plover, Large Sand Plover	Bird	Likely	Species or species habitat likely to occur within area	Vulnerable	Migratory
Aphelocephala leucopsis	Southern Whiteface	Bird	Likely	Species or species habitat likely to occur within area	Vulnerable	
Neophema chrysostoma	Blue-winged Parrot	Bird	Known	Species or species habitat known to occur within area	Vulnerable	
Phoebetria fusca	Sooty Albatross	Bird	May	Species or species habitat may occur within area	Vulnerable	Migratory
Thalassarche steadi	White-capped Albatross	Bird	Known	Foraging, feeding or related behaviour known to occur within area	Vulnerable	Migratory
Thalassarche carteri	Indian, Yellow-nosed Albatross	Bird	Likely	Species or species habitat likely to occur within area	Vulnerable	Migratory
Diomedea exulans	Wandering Albatross	Bird	Likely	Foraging, feeding or related behaviour likely to occur within area	Vulnerable	Migratory
Grantiella picta	Painted Honeyeater	Bird	May	Species or species habitat may occur within area	Vulnerable	
Diomedea epomophora	Southern Royal Albatross	Bird	May	Species or species habitat may occur within area	Vulnerable	Migratory
Chelonia mydas	Green Turtle	Reptile	May	Species or species habitat may occur within area	Vulnerable	Migratory
Pteropus poliocephalus	Grey-headed Flying-fox	Mammal	Likely	Foraging, feeding or related behaviour likely to occur within area	Vulnerable	
Thalassarche impavida	Campbell Albatross, Campbell Black-browed Albatross	Bird	May	Species or species habitat may occur within area	Vulnerable	Migratory
Sternula nereis nereis	Australian Fairy Tern	Bird	Known	Species or species habitat known to occur within area	Vulnerable	
Senecio macrocarpus	Large-fruit Fireweed, Large-fruit Groundsel	Plant	May	Species or species habitat may occur within area	Vulnerable	
Diomedea antipodensis	Antipodean Albatross	Bird	Likely	Foraging, feeding or related behaviour likely to occur within area	Vulnerable	Migratory

Protected Matters Search

Rank	Group	Class	Scientific Name	Common Name	Text	Threatened Category	Migratory Status
Known	Threatened Species	Bird	*Acanthiza iredalei rosinae*	Slender-billed Thornbill (Gulf St Vincent)	Species or species habitat known to occur within area	Vulnerable	
Known	Migratory Species	Bird	*Actitis hypoleucos*	Common Sandpiper	Species or species habitat known to occur within area		Migratory
Known	Migratory Species	Bird	*Arenaria interpres*	Ruddy Turnstone	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Calidris acuminata*	Sharp-tailed Sandpiper	Foraging, feeding or related behaviour known to occur within area		Migratory
Known	Migratory Species	Bird	*Calidris alba*	Sanderling	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Calidris canutus*	Red Knot, Knot	Species or species habitat known to occur within area	Endangered	Migratory
Known	Migratory Species	Bird	*Calidris ferruginea*	Curlew Sandpiper	Species or species habitat known to occur within area	Critically Endangered	Migratory
Known	Migratory Species	Bird	*Calidris melanotos*	Pectoral Sandpiper	Species or species habitat known to occur within area		Migratory
Known	Migratory Species	Bird	*Calidris ruficollis*	Red-necked Stint	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Calidris subminuta*	Long-toed Stint	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Calidris tenuirostris*	Great Knot	Roosting known to occur within area	Critically Endangered	Migratory
Known	Migratory Species	Bird	*Charadrius bicinctus*	Double-banded Plover	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Charadrius mongolus*	Lesser Sand Plover, Mongolian Plover	Roosting known to occur within area	Endangered	Migratory
Known	Marine	Bird	*Charadrius ruficapillus*	Red-capped Plover	Roosting known to occur within area		
Known	Migratory Species	Bird	*Charadrius veredus*	Oriental Plover, Oriental Dotterel	Roosting known to occur within area		Migratory
Known	Marine	Bird	*Chroicocephalus novaehollandiae*	Silver Gull	Breeding known to occur within area		
Known	Migratory Species	Bird	*Gallinago hardwickii*	Latham's Snipe, Japanese Snipe	Species or species habitat known to occur within area		Migratory
Known	Marine	Bird	*Haliaeetus leucogaster*	White-bellied Sea-Eagle	Species or species habitat known to occur within area		
Known	Marine	Bird	*Himantopus himantopus*	Pied Stilt, Black-winged Stilt	Roosting known to occur within area		

Rank	Group	Class	Scientific Name	Common Name	Text	Threatened Category	Migratory Status
Known	Migratory Species	Bird	*Limicola falcinellus*	Broad-billed Sandpiper	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Limosa lapponica*	Bar-tailed Godwit	Species or species habitat known to occur within area		Migratory
Known	Threatened Species	Bird	*Limosa lapponica baueri*	Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit	Species or species habitat known to occur within area	Vulnerable	
Known	Migratory Species	Bird	*Limosa limosa*	Black-tailed Godwit	Roosting known to occur within area		Migratory
Known	Threatened Species	Bird	*Neophema chrysostoma*	Blue-winged Parrot	Species or species habitat known to occur within area	Vulnerable	
Known	Migratory Species	Bird	*Numenius madagascariensis*	Eastern Curlew, Far Eastern Curlew	Species or species habitat known to occur within area	Critically Endangered	Migratory
Known	Migratory Species	Bird	*Numenius minutus*	Little Curlew, Little Whimbrel	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Numenius phaeopus*	Whimbrel	Roosting known to occur within area		Migratory
Known	Marine	Bird	*Pachyptila turtur*	Fairy Prion	Species or species habitat known to occur within area		
Known	Threatened Species	Bird	*Pachyptila turtur subantarctica*	Fairy Prion (southern)	Species or species habitat known to occur within area	Vulnerable	
Known	Migratory Species	Bird	*Pandion haliaetus*	Osprey	Species or species habitat known to occur within area		Migratory
Known	Migratory Species	Bird	*Phalaropus lobatus*	Red-necked Phalarope	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Philomachus pugnax*	Ruff (Reeve)	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Pluvialis fulva*	Pacific Golden Plover	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Pluvialis squatarola*	Grey Plover	Roosting known to occur within area		Migratory
Known	Marine	Bird	*Recurvirostra novaehollandiae*	Red-necked Avocet	Roosting known to occur within area		
Known	Threatened Species	Bird	*Rostratula australis*	Australian Painted Snipe	Species or species habitat known to occur within area	Endangered	
Known	Threatened Species	Bird	*Stagonopleura guttata*	Diamond Firetail	Species or species habitat known to occur within area	Vulnerable	
Known	Threatened Species	Bird	*Sternula nereis nereis*	Australian Fairy Tern	Species or species habitat known to occur within area	Vulnerable	
Known	Migratory Species	Bird	*Thalassarche steadi*	White-capped Albatross	Foraging, feeding or related behaviour known to occur within area	Vulnerable	Migratory

Rank	Group	Class	Scientific Name	Common Name	Text	Threatened Category	Migratory Status
Known	Migratory Species	Bird	*Tringa brevipes*	Grey-tailed Tattler	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Tringa glareola*	Wood Sandpiper	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Tringa nebularia*	Common Greenshank, Greenshank	Species or species habitat known to occur within area		Migratory
Known	Migratory Species	Bird	*Tringa stagnatilis*	Marsh Sandpiper, Little Greenshank	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Tringa totanus*	Common Redshank, Redshank	Roosting known to occur within area		Migratory
Known	Migratory Species	Bird	*Xenus cinereus*	Terek Sandpiper	Roosting known to occur within area		Migratory
Likely	Threatened Species	Bird	*Aphelocephala leucopsis*	Southern Whiteface	Species or species habitat likely to occur within area	Vulnerable	
Likely	Migratory Species	Bird	*Apus pacificus*	Fork-tailed Swift	Species or species habitat likely to occur within area		Migratory
Likely	Migratory Species	Bird	*Ardenna carneipes*	Flesh-footed Shearwater, Fleshy-footed Shearwater	Foraging, feeding or related behaviour likely to occur within area		Migratory
Likely	Threatened Species	Bird	*Botaurus poiciloptilus*	Australasian Bittern	Species or species habitat likely to occur within area	Endangered	
Likely	Marine	Bird	*Chalcites osculans*	Black-eared Cuckoo	Species or species habitat likely to occur within area		
Likely	Migratory Species	Bird	*Charadrius leschenaultii*	Greater Sand Plover, Large Sand Plover	Species or species habitat likely to occur within area	Vulnerable	Migratory
Likely	Migratory Species	Bird	*Diomedea antipodensis*	Antipodean Albatross	Foraging, feeding or related behaviour likely to occur within area	Vulnerable	Migratory
Likely	Migratory Species	Bird	*Diomedea exulans*	Wandering Albatross	Foraging, feeding or related behaviour likely to occur within area	Vulnerable	Migratory
Likely	Threatened Species	Bird	*Falco hypoleucos*	Grey Falcon	Species or species habitat likely to occur within area	Vulnerable	
Likely	Migratory Species	Bird	*Gallinago megala*	Swinhoe's Snipe	Roosting likely to occur within area		Migratory
Likely	Migratory Species	Bird	*Gallinago stenura*	Pin-tailed Snipe	Roosting likely to occur within area		Migratory
Likely	Migratory Species	Bird	*Macronectes halli*	Northern Giant Petrel	Foraging, feeding or related behaviour likely to occur within area	Vulnerable	Migratory
Likely	Marine	Bird	*Sterna striata*	White-fronted Tern	Foraging, feeding or related behaviour likely to occur within area		
Likely	Migratory Species	Bird	*Thalassarche carteri*	Indian, Yellow-nosed Albatross	Species or species habitat likely to occur within area	Vulnerable	Migratory

Rank	Group	Class	Scientific Name	Common Name	Text	Threatened Category	Migratory Status
Likely	Migratory Species	Bird	*Thalassarche cauta*	Shy Albatross	Foraging, feeding or related behaviour likely to occur within area	Endangered	Migratory
Likely	Migratory Species	Bird	*Thalassarche melanophris*	Black-browed Albatross	Foraging, feeding or related behaviour likely to occur within area	Vulnerable	Migratory
May	Migratory Species	Bird	*Ardenna grisea*	Sooty Shearwater	Species or species habitat may occur within area		Migratory
May	Marine	Bird	*Bubulcus ibis*	Cattle Egret	Species or species habitat may occur within area		
May	Migratory Species	Bird	*Diomedea epomophora*	Southern Royal Albatross	Species or species habitat may occur within area	Vulnerable	Migratory
May	Threatened Species	Bird	*Grantiella picta*	Painted Honeyeater	Species or species habitat may occur within area	Vulnerable	
May	Migratory Species	Bird	*Macronectes giganteus*	Southern Giant-Petrel, Southern Giant Petrel	Species or species habitat may occur within area	Endangered	Migratory
May	Threatened Species	Bird	*Melanodryas cucullata cucullata*	South-eastern Hooded Robin, Hooded Robin (south-eastern)	Species or species habitat may occur within area	Endangered	
May	Marine	Bird	*Merops ornatus*	Rainbow Bee-eater	Species or species habitat may occur within area		
May	Migratory Species	Bird	*Motacilla cinerea*	Grey Wagtail	Species or species habitat may occur within area		Migratory
May	Migratory Species	Bird	*Motacilla flava*	Yellow Wagtail	Species or species habitat may occur within area		Migratory
May	Migratory Species	Bird	*Myiagra cyanoleuca*	Satin Flycatcher	Species or species habitat may occur within area		Migratory
May	Threatened Species	Bird	*Neophema chrysogaster*	Orange-bellied Parrot	Species or species habitat may occur within area	Critically Endangered	
May	Threatened Species	Bird	*Pedionomus torquatus*	Plains-wanderer	Species or species habitat may occur within area	Critically Endangered	
May	Migratory Species	Bird	*Phoebetria fusca*	Sooty Albatross	Species or species habitat may occur within area	Vulnerable	Migratory
May	Migratory Species	Bird	*Sternula albifrons*	Little Tern	Species or species habitat may occur within area		Migratory
May	Migratory Species	Bird	*Thalassarche impavida*	Campbell Albatross, Campbell Black-browed Albatross	Species or species habitat may occur within area	Vulnerable	Migratory
Known	Threatened Species	Fish	*Seriolella brama*	Blue Warehou	Species or species habitat known to occur within area	Conservation Dependent	

Rank	Group	Class	Scientific Name	Common Name	Text	Threatened Category	Migratory Status
Likely	Threatened Species	Fish	*Thunnus maccoyii*	Southern Bluefin Tuna	Species or species habitat likely to occur within area	Conservation Dependent	
May	Marine	Fish	*Acentronura australe*	Southern Pygmy Pipehorse	Species or species habitat may occur within area		
May	Marine	Fish	*Campichthys tryoni*	Tryon's Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Filicampus tigris*	Tiger Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Heraldia nocturna*	Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Hippocampus abdominalis*	Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse	Species or species habitat may occur within area		
May	Marine	Fish	*Hippocampus breviceps*	Short-head Seahorse, Short-snouted Seahorse	Species or species habitat may occur within area		
May	Marine	Fish	*Histiogamphelus cristatus*	Rhino Pipefish, Macleay's Crested Pipefish, Ring-back Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Hypselognathus rostratus*	Knifesnout Pipefish, Knife-snouted Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Kaupus costatus*	Deepbody Pipefish, Deep-bodied Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Leptoichthys fistularius*	Brushtail Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Lissocampus caudalis*	Australian Smooth Pipefish, Smooth Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Lissocampus runa*	Javelin Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Maroubra perserrata*	Sawtooth Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Notiocampus ruber*	Red Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Phycodurus eques*	Leafy Seadragon	Species or species habitat may occur within area		
May	Marine	Fish	*Phyllopteryx taeniolatus*	Common Seadragon, Weedy Seadragon	Species or species habitat may occur within area		
May	Marine	Fish	*Pugnaso curtirostris*	Pugnose Pipefish, Pug-nosed Pipefish	Species or species habitat may occur within area		

Rank	Group	Class	Scientific Name	Common Name	Text	Threatened Category	Migratory Status
May	Marine	Fish	*Solegnathus robustus*	Robust Pipehorse, Robust Spiny Pipehorse	Species or species habitat may occur within area		
May	Marine	Fish	*Stigmatopora argus*	Spotted Pipefish, Gulf Pipefish, Peacock Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Stigmatopora nigra*	Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Stipecampus cristatus*	Ringback Pipefish, Ring-backed Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Urocampus carinirostris*	Hairy Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Vanacampus margaritifer*	Mother-of-pearl Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Vanacampus phillipi*	Port Phillip Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Vanacampus poecilolaemus*	Longsnout Pipefish, Australian Long-snout Pipefish, Long-snouted Pipefish	Species or species habitat may occur within area		
May	Marine	Fish	*Vanacampus vercoi*	Verco's Pipefish	Species or species habitat may occur within area		
Known	Migratory Species	Mammal	*Eubalaena australis*	Southern Right Whale	Breeding known to occur within area	Endangered	Migratory (as Balaena glacialis australis)
Known	Threatened Species	Mammal	*Neophoca cinerea*	Australian Sea-lion, Australian Sea Lion	Species or species habitat known to occur within area	Endangered	
Likely	Threatened Species	Mammal	*Pteropus poliocephalus*	Grey-headed Flying-fox	Foraging, feeding or related behaviour likely to occur within area	Vulnerable	
Likely	Cetacean	Mammal	*Tursiops aduncus*	Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin	Species or species habitat likely to occur within area		
May	Marine	Mammal	*Arctocephalus forsteri*	Long-nosed Fur-seal, New Zealand Fur-seal	Species or species habitat may occur within area		
May	Marine	Mammal	*Arctocephalus pusillus*	Australian Fur-seal, Australo-African Fur-seal	Species or species habitat may occur within area		
May	Migratory Species	Mammal	*Balaenoptera edeni*	Bryde's Whale	Species or species habitat may occur within area		Migratory
May	Migratory Species	Mammal	*Caperea marginata*	Pygmy Right Whale	Species or species habitat may occur within area		Migratory
May	Cetacean	Mammal	*Delphinus delphis*	Common Dolphin, Short-beaked Common Dolphin	Species or species habitat may occur within area		

Rank	Group	Class	Scientific Name	Common Name	Text	Threatened Category	Migratory Status
May	Migratory Species	Mammal	*Lagenorhynchus obscurus*	Dusky Dolphin	Species or species habitat may occur within area		Migratory
May	Migratory Species	Mammal	*Megaptera novaeangliae*	Humpback Whale	Species or species habitat may occur within area		Migratory
May	Cetacean	Mammal	*Tursiops truncatus s. str.*	Bottlenose Dolphin	Species or species habitat may occur within area		
Likely	Threatened Species	Plant	*Caladenia tensa*	Greencomb Spider-orchid, Rigid Spider-orchid	Species or species habitat likely to occur within area	Endangered	
Likely	Threatened Species	Plant	*Tecticornia flabelliformis*	Bead Glasswort, Bead Samphire	Species or species habitat likely to occur within area	Vulnerable	
May	Threatened Species	Plant	*Senecio macrocarpus*	Large-fruit Fireweed, Large-fruit Groundsel	Species or species habitat may occur within area	Vulnerable	
May	Threatened Species	Plant	*Swainsona pyrophila*	Yellow Swainson-pea	Species or species habitat may occur within area	Vulnerable	
Known	Migratory Species	Reptile	*Dermochelys coriacea*	Leatherback Turtle, Leathery Turtle, Luth	Foraging, feeding or related behaviour known to occur within area	Endangered	Migratory
Likely	Migratory Species	Reptile	*Caretta caretta*	Loggerhead Turtle	Breeding likely to occur within area	Endangered	Migratory
May	Migratory Species	Reptile	*Chelonia mydas*	Green Turtle	Species or species habitat may occur within area	Vulnerable	Migratory
Known	Migratory Species	Shark	*Carcharodon carcharias*	White Shark, Great White Shark	Species or species habitat known to occur within area	Vulnerable	Migratory
Likely	Migratory Species	Shark	*Lamna nasus*	Porbeagle, Mackerel Shark	Species or species habitat likely to occur within area		Migratory

Appendix C
Flora and Fauna Database Search

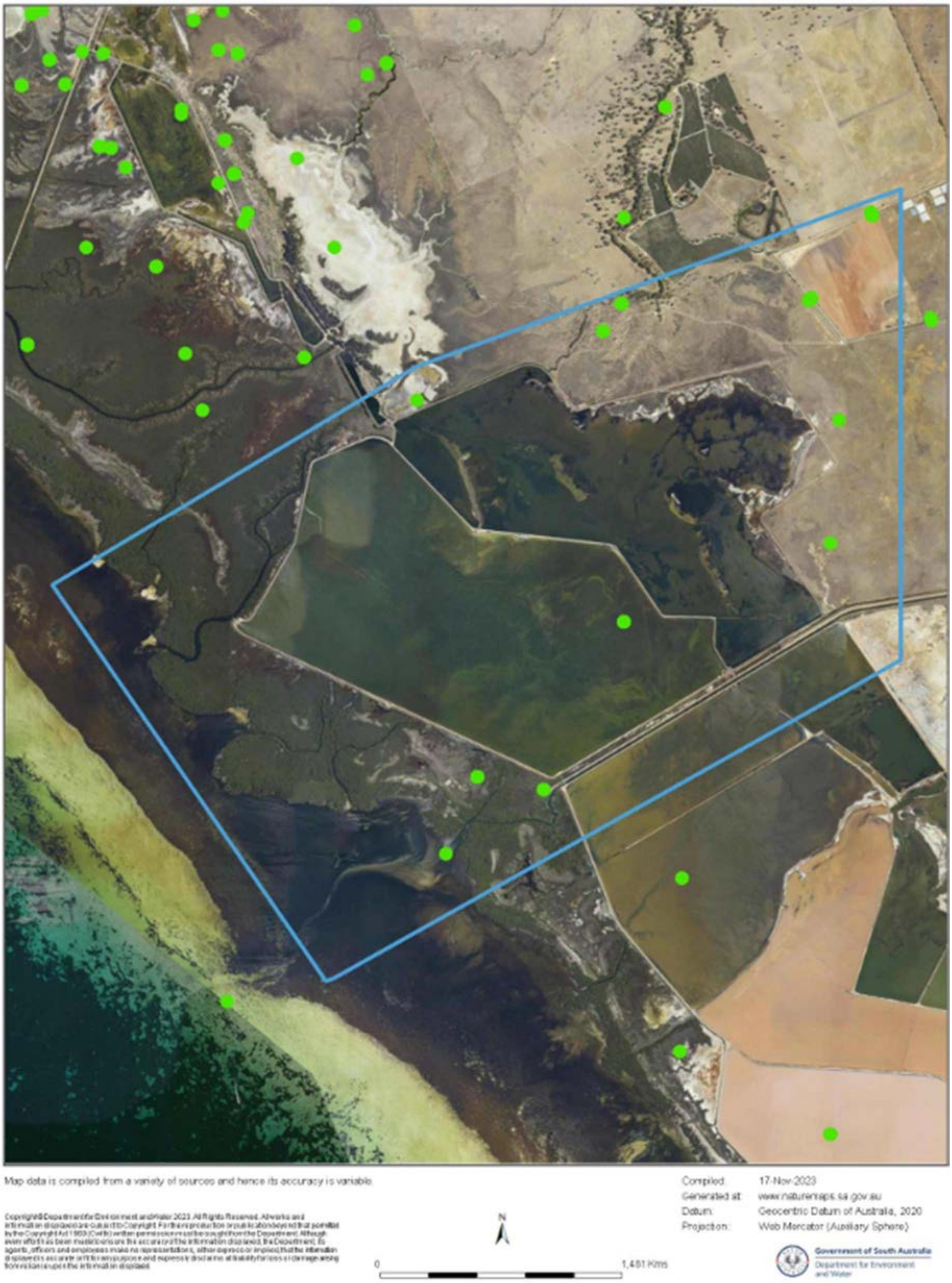


Figure 12. Flora locations within the seawater intake and SWL discharge corridors (blue rectangle)

Table 2. Flora sighted within the Seawater intake and SWL discharge corridors.

Species	Common name	Native	National rating	State rating	Number of records	Date of last record	
Aizoon pubescens	Coastal Galenia	N			6	08-Feb-1999	
Atriplex semibaccata	Berry Saltbush	Y			2	28-Jan-1993	
Maireana oppositifolia	Salt Bluebush	Y			1	28-Jan-1993	
Salicornia quinqueflora ssp. quinqueflora	Beaded Samphire	Y			2	28-Jan-1993	
Suaeda australis	Austral Seablite	Y			2	28-Jan-1993	
Tecticornia arbuscula	Shrubby Samphire	Y			1	28-Jan-1993	
Nothoscordum borbonicum		N			2	14-Nov-1996	
Foeniculum vulgare	Fennel	N			1	14-Nov-1996	
Cynara cardunculus ssp. flavescens	Artichoke Thistle	N			1	14-Nov-1996	
Senecio pterophorus	African Daisy	N			2	14-Nov-1996	
Sonchus oleraceus	Common Sow-thistle	N			1	14-Nov-1996	
Neslia paniculata	Ball Mustard	N			1	01-Dec-1933	
Rapistrum rugosum ssp. rugosum	Turnip Weed	N			1	14-Nov-1996	
Cressa australis	Rosinweed	Y			1	19-May-2017	
Dichondra repens	Kidney Weed	Y			1	01-Jul-1953	
Wilsonia humilis	Silky Wilsonia	Y			1	28-Jan-1993	
Bolboschoenus caldwellii	Salt Club-rush	Y			1	06-Nov-1920	
Carex bichenoviana	Notched Sedge	Y			2	14-Nov-1996	
Cyperus gymnocaulos	Spiny Flat-sedge	Y			1	14-Nov-1996	
Frankenia pauciflora var.	Southern Sea-heath	Y			1	28-Jan-1993	
Cynodon sp.	Couch	N			7	08-Feb-1999	
Sporobolus sp.		Y			1	28-Jan-1993	
Eucalyptus camaldulensis ssp. camaldulensis	River Red Gum	Y			1	14-Nov-1996	
Nitraria billardierei	Nitre-bush	Y			4	08-Feb-1999	
Oxalis perennans	Native Sorrel	Y			1	14-Nov-1996	
Oxalis perennans/exilis	Native Oxalis	Y			1	14-Nov-1996	
Fumaria capreolata	White-flower Fumitory	N			1	14-Nov-1996	
Glaucium flavum	Horned Poppy	N			1	08-Apr-1953	
Amphibromus nervosus	Veined Swamp Wallaby-grass	Y			2	01-Nov-1927	
Austrostipa nodosa	Tall Spear-grass	Y			1	06-Aug-1988	
Avena barbata	Bearded Oat	N			5	08-Feb-1999	

Brachypodium distachyon	False Brome	N			2	14-Nov-1996	
Bromus diandrus	Great Brome	N			1	14-Nov-1996	
Ehrharta longiflora	Annual Veldt Grass	N			2	08-Feb-1999	
Hordeum leporinum	Wall Barley-grass	N			2	14-Nov-1996	
Lolium rigidum	Wimmera Ryegrass	N			1	14-Nov-1996	
Paspalum vaginatum	Salt-water Couch	N			2	08-Feb-1999	
Phragmites australis	Common Reed	Y			1	14-Nov-1996	
Piptatherum miliaceum	Rice Millet	N			1	14-Nov-1996	
Sporobolus virginicus	Salt Couch	Y			1	08-Apr-1953	
Duma florulenta	Lignum	Y			1	14-Nov-1996	
Rumex crispus	Curled Dock	N			1	08-Feb-1999	
Ranunculus muricatus	Pricklefruit Buttercup	N			1	01-Nov-1927	
Lycium ferocissimum	African Boxthorn	N			1	14-Nov-1996	

Figure 13. Fauna sites within the seawater intake and SWL discharge corridors (blue rectangle)

Table 3. Fauna sighted within the Seawater intake and SWL discharge corridors.

Species	Common name	Native	National rating	State rating	Number of records	Date of last record
Crinia signifera	Common Froglet	Y			2	25-Nov-2014
Limnodynastes dumerilii	Banjo Frog	Y			1	15-Sep-1996
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	Y			7	06-Nov-2020
Acanthiza apicalis	Inland Thornbill	Y			2	22-Mar-2003
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	Y			2	25-Nov-2014
Acanthiza iredalei	Slender-billed Thornbill	Y	ssp	ssp	1	15-Mar-2005
Acanthiza lineata clelandi	Striated Thornbill (MLR, SE)	Y			1	07-Aug-1984
Acanthiza pusilla samueli	Brown Thornbill (MLR)	Y			3	07-Aug-1984
Accipiter cirrocephalus cirrocephalus	Collared Sparrowhawk	Y			1	26-Mar-1985
Accipiter fasciatus fasciatus	Brown Goshawk	Y			2	22-Mar-2003
Actitis hypoleucos	Common Sandpiper	Y		R	32	03-Dec-1985
Alauda arvensis arvensis	Eurasian Skylark	N			13	06-Nov-2020
Anas castanea	Chestnut Teal	Y			21	15-Mar-2005
Anas gracilis gracilis	Grey Teal	Y			31	06-Nov-2020
Anas superciliosa	Pacific Black Duck	Y			20	06-Nov-2020
Anhinga novaehollandiae novaehollandiae	Australasian Darter	Y		R	2	15-Mar-2005
Anthochaera carunculata	Red Wattlebird	Y			3	02-Jul-2007
Anthus australis	Australian Pipit	Y			2	24-Feb-1985
Aphrodroma brevirostris	Kerguelen Petrel	Y			1	30-Jul-1998
Ardea alba modesta	Great Egret	Y			14	15-Mar-2005
Arenaria interpres interpres	Ruddy Turnstone	Y		R	15	30-Jun-1985
Aythya australis	Hardhead	Y			2	03-Dec-1985
Biziura lobata menziesi	Musk Duck	Y		R	25	15-Mar-2005
Bubulcus ibis coromandus	Eastern Cattle Egret	Y		R	1	03-Apr-1984
Cacatua galerita	Sulphur-crested Cockatoo	Y			1	25-Nov-2014
Calidris acuminata	Sharp-tailed Sandpiper	Y			41	06-Nov-2020
Calidris canutus rogersi	Red Knot (ssp. rogersi)	Y	sp	E	8	15-Mar-2005
Calidris falcinellus sibirica	Broad-billed Sandpiper	Y			2	25-Nov-1979

Calidris ferruginea	Curlew Sandpiper	Y	CR	E	42	09-Mar-2002
Calidris melanotos	Pectoral Sandpiper	Y		R	6	09-Jan-2005
Calidris pugnax	Ruff	Y		R	5	15-Mar-1985
Calidris ruficollis	Red-necked Stint	Y			46	15-Mar-2005
Calidris subminuta	Long-toed Stint	Y		R	14	08-Dec-2005
Carduelis carduelis britannica	European Goldfinch	N			4	15-Oct-1984
Chalcites basalis	Horsfield's Bronze Cuckoo	Y			4	27-Nov-1984
Charadrius bicinctus bicinctus	Double-banded Plover	Y			12	30-Jun-1985
Charadrius mongolus	Lesser Sand Plover	Y	sp	E	1	26-Oct-1980
Charadrius ruficapillus	Red-capped Plover	Y			43	15-Mar-2005
Chlidonias hybrida javanicus	Whiskered Tern	Y			26	06-Nov-2020
Chroicocephalus novaehollandiae	Silver Gull	Y			33	06-Nov-2020
Cincloramphus cruralis	Brown Songlark	Y			6	13-Oct-2020
Circus approximans	Swamp Harrier	Y			20	15-Mar-2005
Cladorhynchus leucocephalus	Banded Stilt	Y		V	33	15-Mar-2005
Colluricincla harmonica	Grey Shrikethrush	Y			20	06-Nov-2020
Columba livia	Feral Pigeon	N			9	15-Mar-2005
Coracina novaehollandiae	Black-faced Cuckooshrike	Y			2	09-Mar-2002
Corvus mellori	Little Raven	Y			23	13-Oct-2020
Coturnix pectoralis	Stubble Quail	Y			1	26-Mar-1985
Cracticus torquatus leucopterus	Grey Butcherbird	Y			6	22-Mar-2003
Cygnus atratus	Black Swan	Y			23	06-Nov-2020
Dacelo novaeguineae	Laughing Kookaburra	Y			1	10-Nov-1985
Daphoenositta chrysoptera pileate	Black-capped Sittella	Y			1	25-Nov-2014
Egretta garzetta nigripes	Little Egret	Y		R	25	06-Nov-2020
Egretta novaehollandiae	White-faced Heron	Y			32	15-Mar-2005
Elanus axillaris	Black-shouldered Kite	Y			3	15-Mar-2005
Elseyornis melanops	Black-fronted Dotterel	Y			9	15-Mar-2005
Eolophus roseicapilla	Galah	Y			3	25-Nov-2014
Epthianura albifrons	White-fronted Chat	Y			27	13-Oct-2020

Erythrogonys cinctus	Red-kneed Dotterel	Y			38	15-Mar-2005
Falco berigora	Brown Falcon	Y			8	15-Mar-2005
Falco cenchroides	Nankeen Kestrel	Y			11	25-Nov-2014
Falco subniger	Black Falcon	Y		R	1	03-Dec-1985
Fulica atra australis	Eurasian Coot	Y			9	15-Mar-2005
Gallinago hardwickii	Latham's Snipe	Y		R	1	03-Feb-1980
Gallinula tenebrosa	Dusky Moorhen	Y			9	22-Mar-2003
Gavicalis virescens	Singing Honeyeater	Y			30	06-Nov-2020
Gelochelidon macrotarsa	Australian Tern	Y			2	01-Oct-2001
Geopelia cuneata	Diamond Dove	Y			1	15-Mar-1985
Grallina cyanoleuca	Magpielark	Y			27	06-Nov-2020
Gymnorhina tibicen	Australian Magpie	Y			3	25-Nov-2014
Haematopus longirostris	Pied Oystercatcher	Y		R	3	30-Jun-1985
Haliastur sphenurus	Whistling Kite	Y			19	15-Mar-2005
Hieraaetus morphnoides	Little Eagle	Y		V	3	15-Mar-2005
Himantopus leucocephalus	Pied Stilt	Y			50	06-Nov-2020
Hirundo neoxena	Welcome Swallow	Y			28	06-Nov-2020
Hydroprogne caspia	Caspian Tern	Y			17	09-Mar-2002
Limosa haemastica	Hudsonian Godwit	Y			6	01-Nov-2003
Limosa lapponica	Bar-tailed Godwit	Y	ssp	ssp	3	21-Aug-2004
Limosa melanuroides	Black-tailed Godwit	Y		R	24	15-Mar-2005
Malacorhynchus membranaceus	Pink-eared Duck	Y			1	30-Jun-1985
Malurus cyaneus leggei	Superb Fairywren (Mainland SA)	Y			26	06-Nov-2020
Malurus leucopterus leuconotus	White-winged Fairywren	Y			13	06-Nov-2020
Manorina flavigula	Yellow-throated Miner	Y	ssp	ssp	1	25-Nov-2014
Merops ornatus	Rainbow Bee-eater	Y			3	15-Mar-2005
Microcarbo melanoleucos	Little Pied Cormorant	Y			29	15-Mar-2005
Mirafra javanica	Horsfield's Bush Lark	Y			1	30-Jun-1985
Neophema elegans	Elegant Parrot	Y		R	2	26-Mar-1985
Neophema petrophila zietzi	Rock Parrot	Y		R	1	03-Dec-1985

Numenius madagascariensis	Far Eastern Curlew	Y	CR	E	30	15-Mar-2005
Numenius phaeopus variegatus	Whimbrel	Y		R	17	06-Apr-2003
Nycticorax caledonicus australasiae	Nankeen Night Heron	Y			4	15-Mar-2005
Ocyphaps lophotes	Crested Pigeon	Y			27	25-Nov-2014
Oxyura australis	Blue-billed Duck	Y		R	2	15-Oct-1984
Pachycephala fuliginosa	Western Whistler	Y			2	24-Feb-1985
Pachycephala rufiventris	Rufous Whistler	Y			2	22-Mar-2003
Passer domesticus	House Sparrow	N			11	06-Nov-2020
Pavo cristatus	Indian Peafowl	N			2	30-Jun-1985
Pelecanus conspicillatus	Australian Pelican	Y			29	06-Nov-2020
Petrochelidon ariel	Fairy Martin	Y			3	03-Dec-1985
Petrochelidon nigricans	Tree Martin	Y			18	15-Mar-2005
Phalacrocorax carbo	Great Cormorant	Y			9	15-Mar-2005
Phalacrocorax sulcirostris	Little Black Cormorant	Y			22	15-Mar-2005
Phalacrocorax varius hypoleucos	Australian Pied Cormorant	Y			23	22-Mar-2003
Phalaropus lobatus	Red-necked Phalarope	Y			1	03-Dec-1985
Phaps elegans	Brush Bronzewing	Y			3	03-Dec-1985
Platalea flavipes	Yellow-billed Spoonbill	Y			5	15-Mar-2005
Platalea regia	Royal Spoonbill	Y			16	15-Mar-2005
Platycercus elegans	Crimson Rosella	Y	ssp		3	25-Nov-2014
Platycercus elegans fleurieuensis & elegans subadelaidae	Adelaide Rosella (MN, AP, MLR)	Y			1	09-Mar-2002
Plegadis falcinellus	Glossy Ibis	Y		R	3	29-Aug-1984
Pluvialis fulva	Pacific Golden Plover	Y		R	6	22-Mar-2003
Pluvialis squatarola	Grey Plover	Y			12	22-Mar-2003
Podiceps cristatus australis	Great Crested Grebe	Y		R	11	14-Oct-2015
Poliocephalus poliocephalus	Hoary-headed Grebe	Y			26	06-Nov-2020
Poodytes gramineus goulburni	Little Grassbird	Y			12	22-Mar-2003
Porphyrio melanotus melanotus	Australasian Swamphen	Y			1	23-Dec-1984
Porzana fluminea	Australian Crake (Australian Spotted Crake)	Y			8	22-Mar-2003

Psephotus haematonotus	Red-rumped Parrot (eastern SA except NE)	Y			13	03-Dec-1985
Ptilotula penicillata	White-plumed Honeyeater	Y			3	25-Nov-2014
Recurvirostra novaehollandiae	Red-necked Avocet	Y			40	13-Oct-2020
Rhipidura albiscapa	Grey Fantail	Y			9	15-Mar-2005
Rhipidura leucophrys	Willie Wagtail	Y			30	25-Nov-2014
Sericornis frontalis	White-browed Scrubwren	Y			1	06-Nov-2020
Sericornis maculatus	Spotted Scrubwren	Y			9	15-Mar-2005
Spatula rhynchotis	Australasian Shoveler	Y		R	1	22-Mar-2003
Spilopelia chinensis	Spotted Dove	N			23	22-Mar-2003
Sternula nereis	Fairy Tern	Y	VU	E	5	06-Nov-2020
Sturnus vulgaris	Common Starling	N			26	06-Nov-2020
Tadorna tadornoides	Australian Shelduck	Y			24	06-Nov-2020
Thalasseus bergii cristatus	Greater Crested Tern	Y			7	09-Mar-2002
Threskiornis molucca	Australian White Ibis	Y			29	25-Nov-2014
Threskiornis spinicollis	Straw-necked Ibis	Y			1	15-Mar-2005
Todiramphus sanctus	Sacred Kingfisher	Y			17	16-Oct-2015
Tribonyx ventralis	Black-tailed Nativehen	Y			19	15-Mar-2005
Tringa brevipes	Grey-tailed Tattler	Y		R	3	21-Aug-2004
Tringa glareola	Wood Sandpiper	Y		R	9	05-Apr-1981
Tringa nebularia	Common Greenshank	Y			51	12-Oct-2015
Tringa stagnatilis	Marsh Sandpiper	Y			30	22-Mar-2003
Tringa totanus	Common Redshank	Y			1	02-Jan-1984
Turdus merula	Common Blackbird	N			5	15-Mar-2005
Vanellus miles	Masked Lapwing	Y			51	13-Oct-2020
Vanellus tricolor	Banded Lapwing	Y			5	30-Jun-1985
Xenus cinereus	Terek Sandpiper	Y		R	5	27-Nov-2003
Zosterops lateralis	Silvereye	Y			11	22-Mar-2003
Austronomus australis	White-striped Free-tailed Bat	Y			4	07-Nov-2022
Cervus dama	Fallow Deer	N			4	05-Jan-2021
Chalinolobus gouldii	Gould's Wattled Bat	Y			5	07-Nov-2022

Chalinolobus morio	Chocolate Wattled Bat	Y			2	15-Oct-2015
Macropus fuliginosus	Western Grey Kangaroo	Y			1	24-Nov-2014
Mormopterus petersi	Inland Free-tailed Bat	Y			1	07-Nov-2022
Mormopterus planiceps	Southern Free-tailed Bat	Y			5	07-Nov-2022
Mus musculus	House Mouse	N			2	14-Oct-2015
Nyctophilus geoffroyi	Lesser Long-eared Bat	Y			4	06-Feb-2022
Rattus rattus	Black Rat (Ship Rat, Roof Rat)	N			2	16-Oct-2015
Vespadelus darlingtoni	Large Forest Bat	Y			4	07-Nov-2022
Vespadelus regulus	Southern Forest Bat	Y			2	13-Oct-2015
Vulpes vulpes	Fox (Red Fox)	N			1	14-Oct-2015
Chelodina longicollis	Eastern Long-necked Turtle	Y			1	13-Oct-2015
Hemiergis peronii	Four-toed Earless Skink	Y			3	16-Oct-2015
Pseudemoia entrecasteauxii	Southern Grass Skink	Y			1	16-Oct-2015
Pseudonaja textilis	Eastern Brown Snake	Y			3	13-Oct-2015
Tiliqua rugosa	Sleepy Lizard	Y			1	15-Oct-2015
Tiliqua scincoides	Eastern Bluetongue	Y			1	16-Oct-2015

COOE Pty Ltd   ABN 65 147 909 751

www.cooe.com.au | +61 8 8398 5090 | info@cooe.com.au

Riverlea Park

Flora and Fauna Management Plan: Precinct 2

Riverlea Park Flora and Fauna Management Plan: Precinct 2

5 October 2023

Version 2.1

Prepared by EBS Ecology for Walker Buckland Park Developments Pty Ltd

Document Control					
Revision No.	Date issued	Authors	Reviewed by	Date Reviewed	Revision type
1	17/11/2022	H. Merigot & J. Thorsteinsson	Dr. M. Louter	18/11/2022	Draft
2	8/12/2022	H. Merigot & J. Thorsteinsson	-	5/12/2022	Final
2.1	5/10/2023	H. Merigot	-	-	Final

Distribution of Copies			
Revision No.	Date issued	Media	Issued to
1	23/11/2022	Electronic	Patrick Mitchell, Walker Buckland Park Developments Pty Ltd
2	8/12/2022	Electronic	Patrick Mitchell, Walker Buckland Park Developments Pty Ltd
2.1	5/10/2023	Electronic	Patrick Mitchell, Walker Buckland Park Developments Pty Ltd

EBS Ecology Project Number: EX220909 / EX230813

CITATION: EBS Ecology (2023) Riverlea Park Flora and Fauna Management Plan: Precinct 2. Report to Walker Buckland Park Developments Pty Ltd. EBS Ecology, Adelaide.

Cover photograph: Scattered tree within Riverlea Park Precinct 2.

EBS Ecology
112 Hayward Avenue
Torrensville, South Australia 5031
t: 08 7127 5607
http://www.ebsecology.com.au
email: info@ebsecology.com.au

GLOSSARY AND ABBREVIATION OF TERMS

BDBSA	Biological Database of South Australia
CEMMP	Construction Environmental Management and Monitoring Plan
DEW	Department of Environment and Water (South Australia)
EBS	Environmental and Biodiversity Services Pty Ltd, trading as EBS Ecology
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FFMP	Flora and Fauna Management Plan
ha	Hectare(s)
IBRA	Interim Biogeographical Regionalisation of Australia
km	Kilometre(s)
LSA Act	*Landscape South Australia Act* 2019
NatureMaps	Initiative of DEW that provides a common access point to maps and geographic information about South Australia's natural resources in an interactive online mapping format
NPW Act	*National Parks and Wildlife Act 1972*
Project	Riverlea Park Development
Project Area	Riverlea Park Development Precinct 2
Proprietor	Walker Buckland Park Developments Pty Ltd
SA	South Australia
Search Area	5 km buffer of the Project Area considered in database searches
sp.	Species
spp.	Species (plural)
ssp.	Sub-species
TPZ	Tree Projection Zone
Walker	Walker Buckland Park Developments Pty Ltd
WoNS	Weed of National Significance

Table of Contents

List of Tables

List of Figures

1 INTRODUCTION

EBS Ecology (EBS) was commissioned by Walker Buckland Park Developments Pty Ltd (Walker) to prepare a Flora and Fauna Management Plan (FFMP) for Precinct 2 of the Riverlea Park residential development.

1.1 Objectives of the FFMP

The FFMP will form a component of the Construction Environmental Management and Monitoring Plan (CEMMP) and aims to provide a framework for the effective management of issues regarding native flora and fauna within Precinct 2 during the pre-construction, construction and operational phases of the development.

The key purpose of the FFMP is to outline potential issues and propose practical actions for the management of:

- Native vegetation (including significant trees, species of conservation significance and any ecologically sensitive areas)
- Native fauna
- Weeds and plant pathogens
- Feral animals

2 PROJECT BACKGROUND AND CONTEXT

The Riverlea Park project is a multi-staged residential development situated approximately 35 kilometres (km) north of the Adelaide CBD in the City of Playford (Figure 1). Precinct 2 is the second stage in the Riverlea Park development and encompasses an area of approximately 250 ha. Precinct 2 is expected to comprise of residential allotments, sport and community parks, school, roads, associated infrastructure.

This FFMP applies specifically to Precinct 2 which is situated in the northern section of the development site (Figure 1) and forms a component of the entire proposed Riverlea Park development. For the FFMP for Precinct 1, see Flora and Fauna Management Plan: Precinct 1 (EBS Ecology 2020).

2.1.1 Previous works undertaken

Previous work undertaken for the Riverlea Park project have collated a comprehensive record of the biodiversity, threats and management activities associated with the entire Riverlea Park project. These are listed below:

- Anderson, B. (2009) Buckland Park Proposal Fauna Technical Report. Prepared for Walker Corporation Ltd.
- EBS (2010) Buckland Park Proposed Residential Subdivision: Achieving a Significant Environmental Benefit. Report to Walker Corporation. EBS Ecology, Adelaide
- EBS (2011) Buckland Park Stage 1 Tree Assessment. Report to Walker Buckland Park Developments Pty Ltd. EBS Ecology, Adelaide
- EBS Ecology (2020) Riverlea Park Flora and Fauna Management Plan: Precinct 1. Report to Walker Corporation Pty Ltd. EBS Ecology, Adelaide.
- EBS Ecology (2022a) Riverlea Residential sub-division Data Report. Prepared for Walker Corporation Ltd.
- EBS Ecology (2022b) Riverlea TPZ PDI Act Report. Prepared for Walker Corporation Ltd.

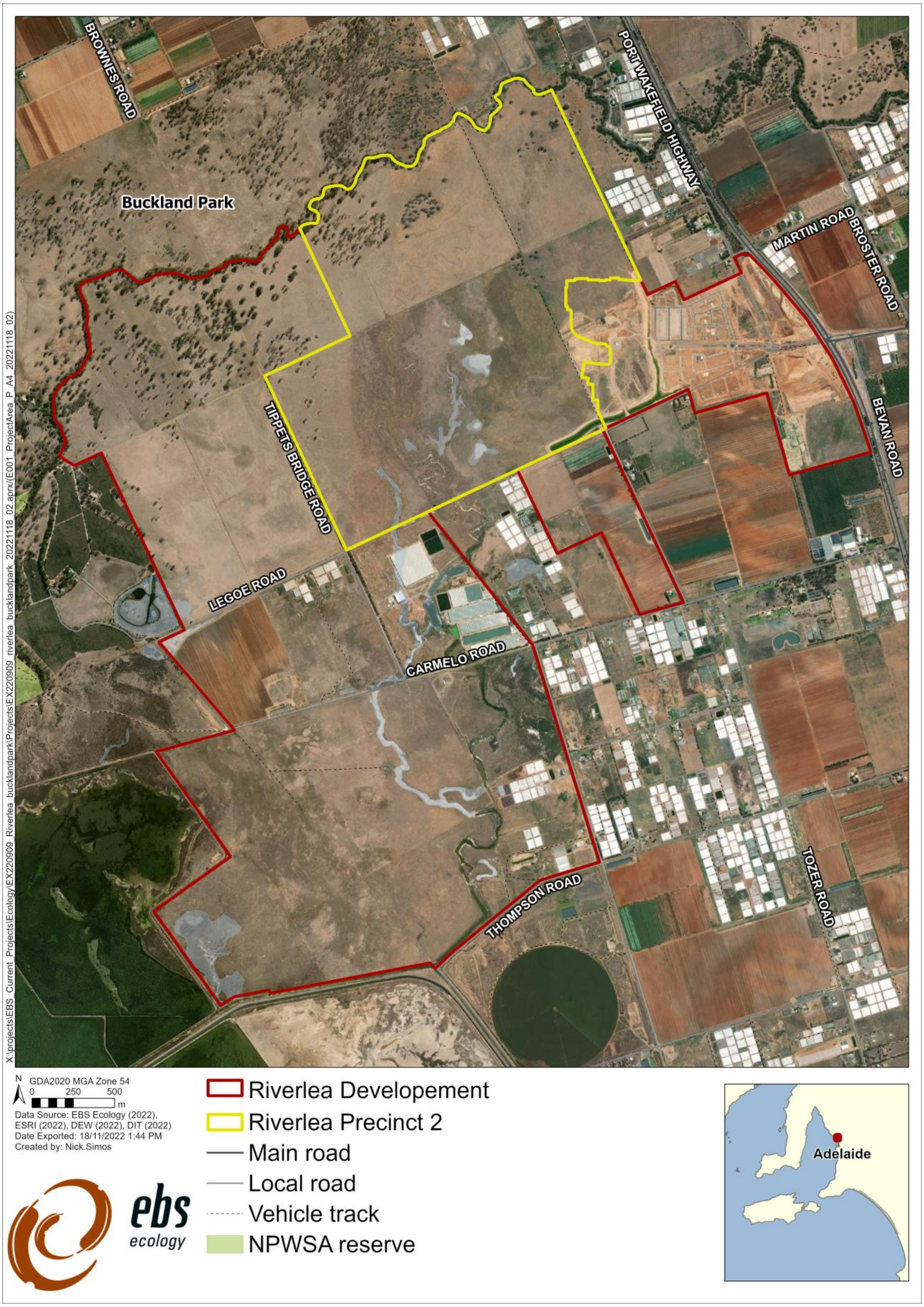


Figure 1. Location of the Riverlea Park residential development and Precinct 2 of Riverlea Park.

2.2 Landform and physical description

Precinct 2 is located on the Gawler River floodplain area and is bounded by Port Wakefield Highway to the east, the Gawler River to the north, Cheetham Salt Ltd saltpans to the south-west and is between 2.5 and 4 km from the Gulf St Vincent coastline (Figure 1). The site and surrounding area are relatively flat arable land primarily used for low intensity grazing.

2.2.1 Interim Biogeographical Regionalisation of Australia (IBRA) zones and remnancy

Precinct 2 is located within the Eyre Yorke Block IBRA Bioregion, the St Vincent IBRA Subregion and the Mallala Environmental Association, summarized in Table 1.

Table 1. IBRA bioregion, subregion, and environmental association environmental landscape summary.

Eyre Yorke Block IBRA bioregion	
Archaean basement rocks and Proterozoic sandstones overlain by undulating to occasionally hilly calcarenite and calcrete plains and areas of aeolian quartz sands, with mallee woodlands, shrublands and heaths on calcareous earths, duplex soils and calcareous to shallow sands, now largely cleared for agriculture.	
St Vincent IBRA subregion	
Most of this region consists of with calcrete development and shallow reddish earths. The plain is mainly dune free but isolated areas are overlain by low indistinct sand dunes. Near the Mt Lofty ranges the plains have a definite westerly gradient and merge eastwards with the alluvial fans from the Mt Lofty ranges. Moderately deep red mallee-yorrell (*Eucalyptus socialis*, *E. gracilis*) association occurs throughout the region with some woodland of *E. porosa* on the plains or *E. odorata* on the hills and foot slopes. The subregion has been extensively cleared and sown to crops or exotic pastures so little of the natural vegetation remains. What does exist on road verges and a few isolated blocks.	
Remnant vegetation	Approximately 8% (87402 ha) of the subregion is mapped as remnant native vegetation, of which 5% (4732 ha) is formally conserved.
Landform	Alluvial and littoral plains with NW-SE longitudinal dunes, mainly stabilized, in isolated areas. Near the Mt Lofty Ranges the plains have a detritic westerly gradient and merge eastwards with the alluvial fans of the Ranges.
Geology	Calcrete development; some variably oriented dunes in northwest of unit beyond Port Augusta. Calcareous loams. Clay rich soils, both plastic & cracking varieties.
Soil	Cracking clays, Brown calcareous earths, highly calcareous loamy earths, Plastic saline clay soils, Hard setting loamy soils with red clayey subsoils.
Vegetation	Mixed chenopod, samphire or forblands.
Conservation significance	125 species of threatened fauna, 103 species of threatened flora. 5 wetlands of national significance.
Mallala IBRA environmental association	
Remnant vegetation	Approximately 3% (5874 ha) of the association is mapped as remnant native vegetation, of which 2% (103 ha) is formally conserved.
Landform	Undulating plain with occasional dunes.
Geology	Alluvium and sand.
Soil	Brown calcareous loams, hard pedal red duplex soils and brownish sands.
Vegetation	Grasslands.
Conservation significance	73 species of threatened fauna, 32 species of threatened flora. 3 wetlands of national significance.

2.2.2 Climate

The nearest weather station (with adequate data) to Precinct 2 is located at the Edinburgh RAAF Base, approximately 10 km south-east of the site. The data in Table 2 and Figure 2, is provided by the Bureau of Meteorology (Commonwealth of Australia 2022).

Table 2. Mean maximum monthly temperature (°C) and mean rainfall (in millimetre (mm)) at the Edinburgh RAAF Base, South Australia (SA).

Month	Temperature °C (mean maximum)	Rainfall mm (mean)
January	30.1	21.5
February	29.9	17.7
March	27.0	23.5
April	23.2	30.2
May	19.2	46.1
June	15.9	52.9
July	15.3	52.6
August	16.5	49.7
September	19.0	47.3
October	22.4	37.5
November	25.9	24.3
December	28.1	24.3

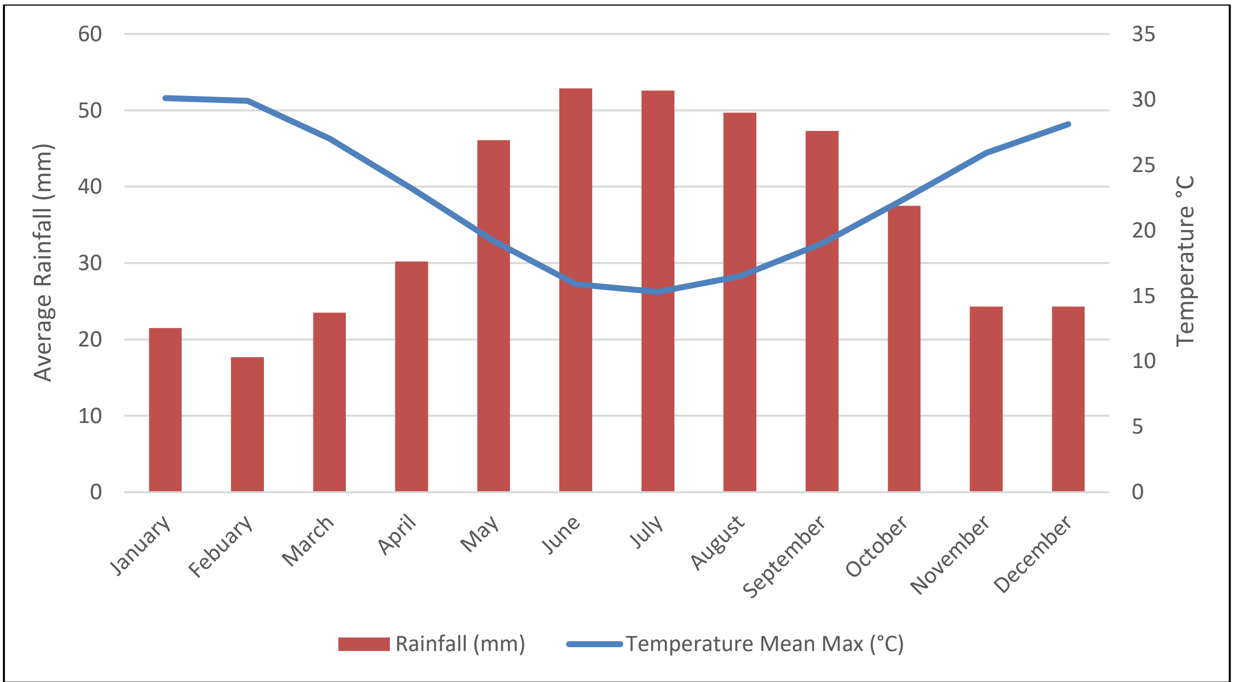


Figure 2. Long term average monthly rainfall and mean maximum temperature data, Edinburgh RAAF Base, SA (Data from Bureau of Meteorology).

2.3 Pre-European settlement

Kraehenbuehl (1996) lists the Buckland Park area as being on the western side of the ‘Peachey Belt’. This was an area of heavily wooded country which gave way to the west an open grassland dominated by species such as *Enneapogon nigricans* (Black Heads), *Aristida behriana* (Wire Grass) and *Austrostipa* spp. (Spear Grass). The area adjacent to the Gawler River consisted primarily of *Eucalyptus camaldulensis* (River Red Gum) and *E. largiflorens* (Black Box), the remnants of which can still be seen following broad scale clearance for fence posts and wood fuel. The area along the coastal fringe was, and still is dominated by Samphire species.

2.4 Post-European settlement

Precinct 2 of the Riverlea Park area has been utilised for agricultural practices involving the clearance of much of the indigenous vegetation and the Precinct 2 area is now predominantly used for grazing by cattle. Exotic flora species occupy large areas of the grazing lands, brought about by improved pasture management and invasion through a variety of vectors including livestock, transport and contaminated soils and seed.

3 BIODIVERSITY SUMMARY PRECINT 2

3.1 Native vegetation

The overall biodiversity of Precinct 2 is considered very low due to the absence of native understorey vegetation and the current land use practice of grazing.

3.1.1 Indigenous vegetation

Because Precinct 2 is situated on the Gawler River flood plain, pre-existing vegetation most likely consisted of *Eucalyptus camaldulensis var. camaldulensis* (River Red Gum) and *E. largiflorens* (Black Box) Open Woodland communities over common species such as *Maireana aphylla* (Cotton Bush), *Nitraria billardierei* (Nitre Bush) and *Austrostipa spp.* (Spear Grass).

Much of the remaining vegetation is highly degraded and limited to scattered individual trees and small patches of vegetation largely dominated by exotic species.

Seven native flora species were detected during a field survey on 14 July 2022 in Precinct 2 (Table 3) and it is likely that many of these are remnant or have regenerated from local seed source within Precinct 2.

Table 3. Native flora species recorded within Precinct 2 during the field survey.

Species Name	Common Name
Enchylaena tomentosa var.	Ruby Saltbush
Eucalyptus camaldulensis ssp.	River Red Gum
Eucalyptus largiflorens	River Box
Eucalyptus odorata	Peppermint Box
Maireana brevifolia	Short-leaf Bluebush
Salsola australis	Buckbush
Sclerolaena sp.	Bindyi

3.1.2 Vegetation associations

There are three vegetation associations present within Precinct 2 (Figure 3).

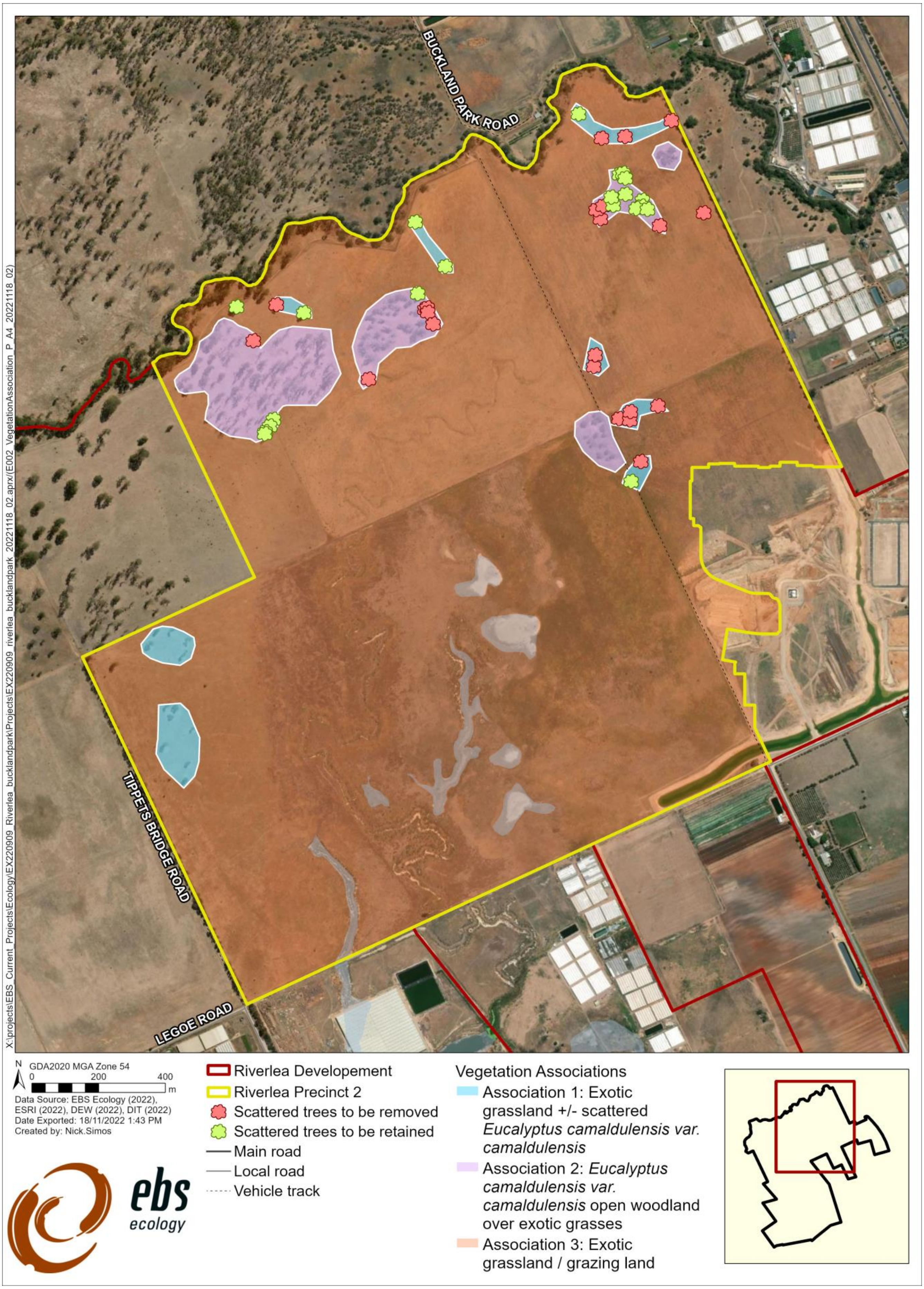


Figure 3. Vegetation associations within the Precinct 2 Project Area.

Vegetation association 1

Exotic grassland +/- scattered *Eucalyptus camaldulensis var. camaldulensis*.

This vegetation association is dominated by exotic grasses and other exotic herbaceous species. The area was previously used for livestock grazing and has been heavily modified by introduction of exotic species for pasture improvement, and most likely received phosphorus-based fertilizer applications which have decimated any native species previously present. Scattered *Eucalyptus camaldulensis var. camaldulensis* (River Red Gum) remain present within this vegetation association. The current understory is comprised almost wholly of introduced flora species, with a high abundance of the woody weed *Lycium ferocissimum* (African Boxthorn). The scattered trees represent remaining remnant vegetation that is no longer intact. Images of this association are provided in Figure 4.

Figure 4. Example of two large remnant scattered *Eucalyptus camaldulensis var. camaldulensis* (River Red Gum) trees within this vegetation association.

Vegetation association 2

***Eucalyptus camaldulensis var. camaldulensis* open woodland over exotic grasses.**

The dominant overstorey species of this vegetation association is *Eucalyptus camaldulensis var. camaldulensis* (River Red Gum). Vegetation association is similar to association 1, as it has also previously been used for livestock grazing. However, trees within vegetation association 2 have been retained in larger patches with connected canopies in some places.

It is deemed likely that a combination of grazing pressure, pasture improvement, soil disturbance, and phosphorous based fertilizer applications has resulted in an absence of native understory within this association. The understory currently present is comprised almost wholly of introduced flora species, with a high abundance of the woody weed *Lycium ferocissimum* (African Boxthorn). Images of patches of trees within this association are provided in Figure 5.

Figure 5. Example of vegetation association 2: *Eucalyptus camaldulensis var. camaldulensis* (River Red Gum) open woodland over exotic grasses.

<u>**Vegetation association 3**</u>

Exotic grassland / grazing land

This vegetation association consists of introduced grasses and other non-native herbs, likely introduced to the area for pasture or through transport on livestock, vehicles or through soil movement. This area is dominated by the weed species *Avena barbata* (Bearded Oat), *Cynara cardunculus spp. flavescens* (Artichoke Thistle), *Phalaris aquatica* (Phalaris) and *Piptatherum miliaceum* (Rice Millet). Examples of this association are provided in Figure 6.

Figure 6. Examples of vegetation association 3: exotic grassland / grazing land.

3.1.3 Threatened flora species

Threatened flora species are be protected under either the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) or *National Parks and Wildlife Act 1972* (NPW Act).

One NPW Act listed species was assessed in EBS Ecology 2022a as possibly occurring within the Precinct 2 area, in EBS Ecology (2022a):

- *Maireana rohrlachii* (Rohrlach's Bluebush) (NPW Act: Rare).

No threatened flora species either at a national or state level were observed during the field survey in July 2022, although the whole area was not covered in this assessment. Given the previous land-use and highly degraded nature of the vegetation inside the Project Area, this species is unlikely to be present.

3.1.4 Threatened Ecological Communities

Threatened Ecological Communities (TEC) are protected under the EPBC Act. Two TEC's were assessed as potentially occurring within a 5 km search area of the site in EBS Ecology 2022a:

- Subtropical and Temperate Coastal Saltmarsh (EPBC Act: Vulnerable);
- Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia (EPBC Act: Critically Endangered).

Although both of these TEC's are nearby, no vegetation within Precinct 2 qualifies as these TEC's.

3.1.5 Vegetation condition

The Precinct 2 area consists of highly degraded vegetation in poor condition. The vegetation is dominated by exotic species and has no intact understorey, midstory or overstorey strata due to historical land clearance, agricultural use and livestock grazing practices. Many trees within Precinct 2 have previously undergone stress which has resulted in extensive dieback in some cases. However, many scattered trees had new growth at the time of the 2022 survey.

3.2 Weeds

The heavily modified nature of Precinct 2 has resulted in an extensive invasion of declared and environmental weed species listed under *Landscape South Australia Act 2019*.

During the 2022 field survey, not all of the Precinct 2 area was covered on foot. Eleven weed species have been identified as occurring within Precinct 2 (Table 4). Other weed species may be present within the Project Area and should be surveyed and treated appropriately.

Table 4. Weed species observed within the Project Area during the field survey.

Species Name	Common Name	Environmental (E)/Declared(D)
Avena barbata	Bearded Oat	E
Cynara cardunculus ssp. Flavescens	Artichoke Thistle	D
Dactylis glomerata	Cocksfoot	E
Echium plantagineum	Salvation Jane	D
Gomphocarpus fruticosus	Narrow-leaf Cotton-bush	E
Lycium ferocissimum	African Boxthorn	D (WoNS)
Malva parviflora	Cheeseweed	E
Oxalis pes-caprae	Soursob	E
Phalaris aquatica	Phalaris	E
Piptatherum miliaceum	Rice Millet	E
Sisymbrium officinale	Hedge Mustard	E

WoNS = Weed of National Significance.

Every landowner in South Australia has legal responsibilities to control and report declared weed species (Government of South Australia, 2022). These weed species have the potential to cause significant environmental impacts, however their control is not legislated. Management of invasive weed species is further discussed in Section 4.4 and details on weed management techniques/timings for these weed species are included in Appendix 3.

3.3 Native fauna

3.3.1 Database records

There are 144 fauna species and subspecies identified from records using the Biological Databases of South Australia (BDBSA) search via NatureMaps within a 5 km search area around Precinct 2 (Appendix 1).

Of the NatureMaps species records within 5 km of Precinct 2, five species listed as nationally threatened or state threatened were identified as potentially occurring within the Project Area in EBS Ecology (2022a):

- *Pteropus poliocephalus* (Grey-headed Flying-fox) (Aus.: VU, SA: R).
- *Hieraaetus morphnoides* (Little Eagle) (SA: V);
- *Neophema elegans elegans* (Elegant Parrot) (SA: R);
- *Ninox connivens connivens* (Barking Owl) (SA: R); and
- *Trichosurus vulpecula* (Common Brushtail Possum) (SA: R).

3.3.2 Fauna observed within Precinct 2

Seventeen (17) fauna species (all birds) were observed during the field survey within Precinct 2 in 2022, consisting of 16 native and one exotic species (Table 5). None of the observed fauna was threatened at a national or state level.

Table 5. Fauna species recorded within the project area during the 2022 field survey.

Common Name	Species Name
Sulphur-crested Cockatoo	*Cacatua galerita*
Maned Duck	*Chenonetta jubata*
Silver Gull	*Chroicocephalus novaehollandiae*
Australian Raven	*Corvus coronoides*
Singing Honeyeater	*Gavicalis virescens*
Australian Magpie	*Gymnorhina tibicen*
Welcome Swallow	*Hirundo neoxena*
Crested Pigeon	*Ocyphaps lophotes*
Spotted Pardalote	*Pardalotus punctatus*
Striated Pardalote	*Pardalotus striatus*
Crimson Rosella	*Platycercus elegans*
Red-rumped Parrot	*Psephotus haematonotus*
Willie Wagtail	*Rhipidura leucophrys*
*Common Starling	*Sturnus vulgaris*
Australian Shelduck	*Tadorna tadornoides*
Australian White Ibis	*Threskiornis moluccus*
Straw-necked Ibis	*Threskiornis spinicollis*

***Introduced species.**

3.3.3 Fauna habitat

Habitat for terrestrial fauna species within the area of Precinct 2 is considered limited due to the degraded nature of the native vegetation within the Project Area. The remaining native vegetation of the area are mature remnant trees, which provide habitat for birds found within the area.

Of the bird species observed within Precinct 2, the following 5 species represent significant fauna that would use the scattered trees, particularly those with hollows, in the Precinct 2 area:

- Sulphur-crested Cockatoo (*Cacatua galerita*);
- Maned Duck (*Chenonetta jubata*);
- Crimson Rosella (*Platycercus elegans*);
- Red-rumped Parrot (*Psephotus haematonotus*); and
- Australian Shelduck (*Tadorna tadornoides*).

4 MANAGEMENT ISSUES AND ACTIONS

4.1 Native vegetation

As part of the Precinct 2 development, nineteen scattered trees have been approved by the Native Vegetation Council for clearance (Application number 2022/3217/292). The remaining mature remnant trees have been retained within proposed open-space areas, or reserves within Precinct 2 to retain habitat within the area. The Native Vegetation Data Report (EBS Ecology 2022a) contains information about which specific trees are to be removed versus retained.

Detailed construction management plans are to be prepared for Precinct 2, which should clearly identify all areas of vegetation and individual trees to be retained during construction. A construction activity zone boundary, including an appropriate buffer zone should be clearly marked with fencing and bunting prior to constructions works; and Tree Protection Zones (TPZ) should be identified and marked for any trees to be retained within development areas.

4.1.1 Key Management actions to assist with the management of native vegetation within Precinct 2

Table 6 outlines Key Management Actions relating to the removal, retention or relocation of native vegetation and remnant trees within Precinct 2 during all phases of construction.

Table 6. Key Management actions to assist with the management of native vegetation within Precinct 2.

Native Vegetation Management				
Issue	**Strategy**	**Key Actions**	**Project phase/timing**	**Responsibility**
Clearing of native vegetation and remnant trees.	Minimise impacts on native vegetation and remnant trees.	Retain native vegetation and remnant trees where possible through incorporation into open space areas, road reserves and/or large residential blocks.	Design and planning	Proprietor
	Prevent unintentional clearing of native vegetation and remnant trees.	• Preparation of detailed construction plans that clearly identify all areas of vegetation and individual trees to be retained. • Establish a construction activity zone and clearly mark the boundaries of the activity zone with fencing and bunting. • Clearly mark all areas where vegetation is to be retained (including appropriate buffer zones) with fencing and bunting. • Clearly mark and bund all trees (including appropriate TPZ) to be retained. • Ensure all staff and contractors are clearly instructed on the native vegetation to be removed and retained. • Maintain a register of all vegetation (including trees) that are removed during construction.	Pre-construction	Proprietor / Contractor
Potential damage to retained native vegetation and remnant trees during construction works.	Prevent damage to retained native vegetation and remnant trees.	• Ensure no construction works are undertaken outside the defined activity zone. • Ensure all staff and contractors are clearly instructed on the native vegetation to be retained. • Restrict vehicle and machinery traffic to designated access tracks that is delineated from retained vegetation. • Restrict parking and storage of vehicles and machinery to designated areas that are away from retained vegetation. • Restrict storage of any materials and stockpiles to designated areas that are away from retained vegetation. • Prevent the storage of vehicles, machinery, materials, or stockpiles against trees or within TPZ of trees to be retained. • Implement correct chemical storage and handling protocols to avoid unintentional contamination of soil within or near retained vegetation. • Conduct tree clearance in a manner which does not damage surrounding tree roots, trunks or branches. • Branches of nearby trees likely to be affected by construction works are to be trimmed to the branch collar with a clean saw cut.	During Construction	Contractor

Native Vegetation Management				
Issue	**Strategy**	**Key Actions**	**Project phase/timing**	**Responsibility**
		• Any exposed roots in excavations are to be trimmed with a clean saw cut.		
Accidental damage or removal of native vegetation or remnant trees outside of the activity zone.	Establish appropriate reporting protocols for accidental damage or removal of native vegetation or remnant trees.	• The Construction Manager will be notified immediately if trees are damaged. • The area of native vegetation will be protected from further damage immediately, via appropriate fencing or other barriers. • The Construction Manager shall review the incident and determine its cause. Actions to modify the construction practice that led to the incident may be required to limit the risk of a repeat occurrence.	During Construction	Contractor

4.2 Native fauna management

The Northern boundary of Precinct 2 is bordered by the extent of the Gawler River and the remnant *E. camaldulensis* (River Red Gum) trees, which provide valuable habitat to many common fauna species and may provide habitat for threatened local fauna species.

Most of the fauna species identified in desktop studies are unlikely to inhabit the area of Precinct 2 given the lack of habitat and degraded state of remnant vegetation, with exception of the remnant trees within Precinct 2 (located in the *E. camaldulensis* open Woodland, and along the Gawler River) likely providing a moderate level of habitat to some local fauna species, such as the bird species observed during the 2022 field survey.

4.2.1 Fauna habitat

The cleared agricultural/horticultural and grazing lands within Precinct 2 are generally of poor quality in terms of fauna habitat, with limited food resources for fauna. However, many of the scattered trees contain hollows that could be used by fauna for roosting, resting or breeding.

4.2.2 Key Management Actions for the management of native fauna within Precinct 2

Table 7 outlines native fauna management actions during all phases of construction.

Table 7. Key Management Actions for the management of native fauna within Precinct 2 of the Riverlea Park Development.

Native Fauna Management				
Issue	**Strategy**	**Key Actions**	**Project phase/ timing**	**Responsibility**
Removal of native fauna habitat	Minimise impacts on native fauna habitat by the minimising the disturbance of native vegetation and remnant trees.	Retain native vegetation and remnant trees where possible through incorporation into open space areas, road reserves and/or large residential blocks.	Design and planning	Proprietor
	Revegetate retained areas to recreate habitat suitable for native fauna species.	Where possible, revegetate open space areas, road reserves with indigenous flora species that will aim to recreate similar habitat to that which was present prior to clearance.	Pre-construction During construction and post-construction. Timing of revegetation is dependent on species, site conditions and the construction master plan.	Proprietor / Contractor
	Prevent or minimise any stress, injury, or death of fauna.	Pre-inspection of the construction site should be conducted by a suitably qualified fauna ecologist to identify fauna at risk of stress, injury or death and facilitate their relocation to a similar habitat in a safe and ethical way. Tree removal during spring should be avoided where possible as this is the breeding period for a range of arboreal fauna. Any native fauna encountered during construction are to be captured by a suitably qualified fauna ecologist and relocated to a similar habitat in a safe and ethical manner. Untrained employees or contractors are not to approach or handle fauna.	Pre-construction During construction	Contractor
Potential stress, injury or death of fauna during construction works.	Ethical treatment of stressed or injured fauna.	If stressed or injured fauna are located on-site, a qualified fauna rescue officer or vet shall be notified immediately. Untrained employees or contractors are not to approach or handle injured fauna.	During construction	Contractor
	Establish appropriate reporting protocols for incidents involving the stress, injury or death of fauna.	The Construction Manager will be notified immediately. The Construction Manager shall review the incident and determine the cause. Actions to modify the construction practice that led to the incident may be required to limit the risk of a repeat occurrence.	During construction	Contractor

4.3 Feral fauna

It is deemed likely that feral animals such as cats and foxes are established in the area, due to the modified landscape.

Invasive predators like the European Red Fox (*Vulpes vulpes*), and domestic/feral cats (*Felis catus*) have been recorded on site during previous surveys (Anderson, 2009). These species are damaging to the landscape as they predate on a range of native bird, reptile, amphibian and mammal species.

Other invasive species observed on site include House Mouse (*Mus domesticus*) and European Rabbit (*Oryctolagus cuniculus*) (Anderson 2009), and Fallow Deer (*Cervus dama*) (EBS 2022 field survey). These exotic animals may harm the remaining native landscapes through grazing pressure upon regenerating vegetation.

The Brown Rat (*Rattus norvegicus*) and Black Rat (*Rattus rattus*) have not been recorded on site, but these species are highly likely to be present within Precinct 2. These species compete with native fauna for food, shelter, and other resources. In additional they are known to predate on avian hatchlings, and eggs from nests (Banks and Hughes, 2012).

Every landowner in South Australia has legal responsibilities to control and report declared animal species under the Landscape South Australia Act 2019 (LSA Act). These introduced species have the potential to cause significant environmental impacts. Management of introduced fauna species is further discussed in Section 4.3.1 below.

4.3.1 Key Management Actions for the management of feral animals within Precinct 2

Table 8 outlines feral animal management actions during all phases of construction.

Table 8. Key Management Actions for the management of feral animals within Precinct 2 of the Riverlea Park Development.

Feral Animal Management				
Issue	**Strategy**	**Key Actions**	**Project phase/ timing**	**Responsibility**
Potential increase in feral animal populations or individuals on site	Prevent new feral animal populations or individuals from inhabiting the site	Prevent scavenging opportunities for feral animals by storing all on-site domestic waste in sealed bins. Ensure the adequate removal of all domestic waste from site on a regular basis. Any new or increased feral animal activity observed on site is to be reported immediately to the Site Environment Officer and Construction Manager.	Ongoing	Contractor
	Control existing feral animal populations	Support / Participate in any landscape delivered control programs.	Ongoing	Contractor

4.4 Weeds and soil pathogens

A principal management issue is the proliferation of Declared and Environmental Weeds throughout the Precinct 2 development area.

It is presumed that residents within Precinct 2 had managed previous weed infestations. However, weed control management has likely been sporadic, and the extent of weed control works undertaken is unknown.

4.4.1 General Principles of Weed Management

- Prioritise controlling smaller infestations to eliminate the risk of further potential spread; before managing larger established infestations.
- Start weed controlling activities in vegetation areas of better condition, working towards the areas of poor conditions.
- Prioritise containing further spread of large infestations, before progressing to elimination of the infestation.
- Prioritise control on boundaries where infestations pose a risk of spreading into neighbouring properties and impact on primary production.
- Target Declared and Environmental weed species which are known to have high levels of invasiveness.
- Rate of weed elimination should be guided by available resources available for follow-up activities (e.g., rehabilitation) to ensure new invasions not take place.

4.4.2 Prioritisation of Weed Management

A total of 5 Declared weeds or Weeds of National Significance have been recorded within the Precinct 2 development area. These pest plants are a significant threat to agriculture, and the environment and therefore a priority for weed management within Precinct 2:

- *Cynara cardunculus ssp. Flavescens (*Artichoke Thistle);
- *Echium plantagineum (*Salvation Jane);
- *Lycium ferocissimum (*African Boxthorn);
- *Olea sp*. (Olive); and
- *Xanthium spinosum* (Bathurst Burr).

See Appendix 2 for recommended weed control techniques of the above listed weeds.

4.4.3 Plant pathogens

Phytophthora cinnamomi (Phytophthora) poses a serious threat to biodiversity and cannot be eradicated from an area once it has become infected. It can irreversibly destroy the structure and diversity of plant communities. Phytophthora is a soil borne fungus which attacks and destroys the root systems of plants, so that they are unable to absorb water and eventually die of water stress. It is known to kill a range of plants from woody natives, such as Eucalypts, Banksias (*Banksia marginata*), Hakea (*Hakea rostrata*), Cone Bush (*Isopogon ceratophyllus*), Bush-Pea (*Pultenaea involucrata*) and Myrtle Wattle (*Acacia myrtifolia*). One of the most susceptible species is Yacca (*Xanthorrhoea sp*), which is often a good indicator that the root fungus is present. Some exotic fruits and vegetables are also susceptible.

Phytophthora can spread from plant to plant, but also has the potential to spread rapidly across the landscape carried by water. Infected soil can also be transported by humans via dirty footwear, bikes, vehicles and machinery, and even hand-pulled weeds from infested sites. Therefore, it is imperative that good standards of hygiene be practiced by all relevant employees and contractors.

Hygiene principles and procedures is located within Appendix 4 and have been developed by *Phytophthora Management Guidelines – Phytophthora Technical Group* (2006).

In the case of a possible Phytophthora infection it is important to categorize the Riverlea Park site into risk management zones to determine the most appropriate hygiene principles to adhere to; see Table 9 for reference.

Table 9. Phytophthora Risk Management Zones

Risk Management Zone	Definition
High	An area where the presence of *Phytophthora* is confirmed or suspected from a visual inspection by two or more trained staff members. This Zone should also include a Buffer Zone of 100 m.
Moderate	An area where *Phytophthora* has not yet been suspected or confirmed, but has the potential to become established. The Moderate Risk Management Zone is within 2 kms of a High Risk Management Zone
Low	An area where *Phytophthora* has not been suspected or confirmed and the potential to become established is very low.
High Conservation Value	Extreme care must be taken to ensure *Phytophthora* is not introduced into these areas.

Source: Adapted from Standard Operating Procedure for Phytophthora Threat Management in South Australia (DEH 2002)

The Precinct 2 area has not had *Phytophthora* suspected or confirmed and so qualifies as a ‘Low Risk Management Zone’. In *Low Risk Zones* – minimal *Phytophthora* management procedures are required, however if entering a Low Risk Zone from a High Risk Zone, strict hygiene measures, including disinfection, should be applied to ensure machinery, equipment, vehicles and footwear are free of mud and soil. See Appendix for a summary of hygiene principles and procedures.

4.4.4 Key Management Actions for the management of weeds and plant pathogens

The current FFMP aims to prioritise the weed management issues within Precinct 2. Table 10 lists key management actions in relation to weeds and plant pathogens during all phases of construction.

Table 10. Key Management Actions for the management of weeds and plant pathogens within Precinct 2 of Riverlea Park development

Weed and Plant Pathogen Management				
Issue	**Strategy**	**Key Actions**	**Project phase/timing**	**Responsibility**
Occurrence of Declared & important Environmental weed species on site	Eradicate or control existing weed species on-site	• Weeds have been categorized according to management priority with higher priority given to Declared and Weeds of National Significance. • Contractors should be employed to implement best practice weed control techniques to eradicate existing weeds. The method of control will vary according to the species and degree of infestation – see - Appendix 3. • Follow up weed control activities should be planned to prevent any re-establishment of weed species. • Any areas of the site that are not subject to immediate construction works should be maintained and manages to reduce the spread of weeds. This may include active weed control techniques or passive control such as continued stock grazing or cropping.	Pre-construction During construction Ongoing	Proprietor / Contractor
Possible spread of weed species and plant pathogens to and from the site	Limit distribution and numbers of vectors for spread.	• Conduct on-site inductions for all staff and contractors regarding on-site weed and pathogen management related issues. Weed identification sheets should be always made available to all on-site staff and contractors. • Any new outbreaks of weeds or plant pathogens are to be reported immediately to the Site Environment Officer and Construction Manager. • No declared or environmental weeds are to be mulched. • Declared and environmental weeds to be disposed of at a licensed waste facility (noting that movement of weeds, including contaminated soil, on a public road is restricted under the LSA Act and requires a permit from PIRSA or a Regional Landscape Board). • Weed propagules or weed infested topsoil should not be imported to site. • Stockpiled soil should be sprayed and covered to prevent weed growth and pathogen spread.	Pre-construction During construction Ongoing	Proprietor / Contractor

Weed and Plant Pathogen Management				
Issue	**Strategy**	**Key Actions**	**Project phase/timing**	**Responsibility**
		• Spoil load leaving the site should be covered to prevent spread of contaminated soil. • Cleaning of all machinery and equipment prior to site entry and exit in dedicated was down bays (to be located at the Pt Wakefield entrance and egress site). Water and waste collected from wash down bays to be disposed of appropriately. • Restrict construction machinery and vehicles to designated access tracks. Car parks for staff and contractors to be gravelled or sealed to prevent contact with exposed soil. • Ensure that all plants brought onto the site are free of *Phytophthora* and other plant pathogens. • Control feral rabbits and deer as animals are vectors of weed spread.		
Potential damage to native flora during weed management activities	Employ sensitive methods of weed control	Appropriately experienced and licensed contractors should be employed to implement all weed control activities and follow up activities. Best practice weed control methods should be used to prevent any off-target effects. This includes the correct storage of chemicals, appropriate weather conditions during spraying, and management of chemical run-off around draining lines.	Ongoing	Contractor

See Appendix 3 for a summary of weed control techniques.

5 SUMMARY OF ACTIONS

The below section summarises all the management actions for the different phases of the proposed Precinct 2 project.

5.1 Design and planning

Table 11 outlines the management actions for design phase of Precinct 2.

Table 11. Summary of management actions for the design and planning phase of Precinct 2.

Management issue	Strategy	Key Actions
Native vegetation management		
Clearing native vegetation and remnant trees.	Minimise impacts on native vegetation and remnant trees.	Retain native vegetation and remnant trees where possible through incorporation into open space areas, road reserves and/or large residential blocks.
Native fauna management		
Removal of native fauna habitat	Minimise impacts on native fauna habitat by minimising the disturbance of native vegetation and remnant trees.	Retain native vegetation and remnant trees where possible through incorporation into open space areas, road reserves and/or large residential blocks.
Feral fauna management		
Potential increase in feral animal populations or individuals on site	Prevent new feral animal populations or individuals from inhabiting the site	Prevent scavenging opportunities for feral animals by storing all on-site domestic waste in sealed bins. Ensure the adequate removal of all domestic waste from site on a regular basis. Control existing feral animal populations, particularly feral rabbits and deer as they can be vectors of weed spread. Any new or increased feral animal activity observed on site is to be reported immediately to the Construction Manager.

5.2 Pre-construction

Table 12 outlines the management actions for pre-construction phase of Precinct 2.

Table 12. Summary of pre-construction management actions for Precinct 2.

Management issue	Strategy	Key Actions
Native vegetation management		
Clearing native vegetation and remnant trees.	Prevent unintentional clearing of native vegetation and remnant trees.	• Preparation of detailed construction plans that clearly identify all areas of vegetation and individual trees to be retained • Clearly mark all areas where vegetation is to be retained (including appropriate buffer zones) with fencing and bunding. • Establish a construction activity zone and clearly mark the boundaries of the activity zone with fencing and bunding. • Clearly mark and bund all trees (including appropriate TPZ) to be retained.
Native animal management		
Removal of native fauna habitat	Revegetate retained areas to recreate similar habitat for native fauna species.	Where possible, revegetate open space areas, road reserves with indigenous flora species that will aim to recreate similar habitat to which was present prior to clearance.
	Prevent or minimise any stress, injury, or death of fauna.	Pre-inspection of the construction site should be conducted by a fauna ecologist to identify fauna at risk of stress, injury or death and facilitate their relocation to a similar habitat in a safe and ethical way.
Feral fauna management		
Potential increase in feral animal populations or individuals on site	Prevent new feral animal populations or individuals from inhabiting the site	Prevent scavenging opportunities for feral animals by storing all on-site domestic waste in sealed bins. Ensure the adequate removal of all domestic waste from site on a regular basis. Control existing feral animal populations, particularly feral rabbits and deer as they can be vectors of weed spread. Any new or increased feral animal activity observed on site is to be reported immediately to the Construction Manager.
Weed management		
Occurrence of Declared & important Environmental weed species on site	Eradicate or control existing weed species on-site	Weeds have been categorized according to management priority with highest priority given to Declared and Environmental weeds that are known to have high levels of invasiveness.

5.3 Construction

Table 13 outlines the management actions for the construction phase of Precinct 2.

Table 13. Summary of construction management actions for Precinct 2.

Management issue	Strategy	Key Actions
Native vegetation management		
Clearing native vegetation and remnant trees.	Prevent unintentional clearing of native vegetation and remnant trees.	• Ensure all staff and contractors are clearly instructed on the native vegetation to be retained. • Maintain a Register of all vegetation (including trees) that are removed during construction.
Potential damage to retained native vegetation and remnant trees during construction works.	Prevent damage to retained native vegetation and remnant trees.	• Ensure no construction works are undertaken outside the defined activity zone. • Ensure all staff and contractors are clearly instructed on the native vegetation to be retained. • Restrict vehicle and machinery traffic to designated access tracks that is delineated from retained vegetation. • Restrict parking and storage of vehicles and machinery to designated areas that are away from retained vegetation. • Restrict storage of any materials and stockpiles to designated areas that are away from retained vegetation. • Prevent the storage of vehicles, machinery, materials or stockpiles against trees or within the TPZ (Tree Protection Zone) of trees to be retained. • Implement correct chemical storage and handling protocols to avoid unintentional contamination of soil within or near retained vegetation and trees. • Conduct tree clearance in a manner which does not damage surrounding tree roots, trunks or branches. • Branches of nearby trees likely to be affected by construction works are to be trimmed to the branch collar with a clean saw cut. • Any exposed roots in excavations are to be trimmed with a clean saw cut.
Accidental damage or removal of native vegetation or remnant trees outside of the activity zone.	Establish appropriate reporting protocols for accidental damage or removal of native vegetation or remnant trees.	• Maintain a register of all vegetation (including trees) that are removed accidentally during construction. • The area of native vegetation will be protected from further damage immediately, via appropriate fencing or another barrier. • The Construction Manager shall review the incident and determine its cause. Actions to modify the construction practice that led to the incident may be required to limit the risk of a repeat occurrence.
Native fauna management		

Management issue	Strategy	Key Actions
Removal of native fauna habitat.	Revegetate retained areas to recreate similar habitat for native fauna species.	Where possible revegetate open space areas, road reserves with indigenous flora species that will aim to recreate similar habitat to which was present prior to clearance.
	Prevent or minimise any stress, injury, or death of fauna.	• Tree removal during spring should be avoided where possible as this is the breeding period for a range of arboreal fauna. • Fauna encountered during construction are to be captured by a fauna ecologist and relocated to a similar habitat in a safe and ethical way. Untrained employees or contractors are not to approach or handle fauna.
Potential stress, injury, or death of fauna during construction works.	Ethical treatment of stressed or injured fauna.	If stressed or injured fauna are located on-site, a qualified fauna rescue officer or vet shall be notified immediately. Untrained employees or contractors are not to approach or handle injured fauna.
	Establish appropriate reporting protocols for incidents involving stress injury or death of fauna.	• Construction Manager shall review the incident and determine its cause. Actions to modify the construction practice that led to the incident may be required to limit the risk of a repeat occurrence. • If the incident involves injury or death of a conservational significant species listed by either *NPW Act* (1972) or *EPBC Act* (1999), the Construction Manager will report the matter to Department for Environment and Water (DEW) within 24 hours.
Feral fauna management		
Potential increase in feral animal populations or individuals on site	Prevent new feral animal populations or individuals from inhabiting the site	Prevent scavenging opportunities for feral animals by storing all on-site domestic waste in sealed bins. Ensure the adequate removal of all domestic waste from site on a regular basis. Any new or increased feral animal activity observed on site is to be reported immediately to the Construction Manager. Control existing feral animal populations, particularly feral rabbits and deer as they can be vectors of weed spread.
Weed management		
Occurrence of Declared & important Environmental weed species on site.	Eradicate or control existing weed species on-sire	• Contractors should be employed to implement best practice weed control techniques to eradicate existing weeds. The method of control will vary according to the species and degree of infestation- see Appendix 2. • Follow up weed control activities should be planned to prevent any re-establishment of weed species. • Any areas of the site that are not subject to immediate construction works should be maintained and managed to reduce the spread of weeds. This may include active weed control techniques or passive control such as continued stock grazing or cropping.

Management issue	Strategy	Key Actions
Possible spread of weed species and plant pathogens to and from the site.	Limit distribution and numbers of vectors for spread	• Conduct on-site inductions for all staff and contractors regarding on-site weed and pathogen management issues. Weed identification sheets should be always made available to on-site staff and contractors. • Any new outbreaks of weeds or plant pathogens are to be reported immediately to the Construction Manager. • No declared or environmental weeds are to be mulched. • Declared and environmental weeds to be disposed of at a licensed waste facility. • Weed propagules or weed infested topsoil should not be imported to site. • Stockpiled soil should be sprayed and covered to prevent weed growth or pathogen spread. • Spoil loads leaving the site should be covered to prevent spread of contaminated soil. • Cleaning of all machinery and equipment prior to site entry and exit in dedicated wash down bays (to be located at egress of Precinct 2 construction zone). Water and waste collected from wash down bays to be disposed of appropriately. • Restrict construction machinery and vehicles to designated access tracks. Car parks for staff and contractors to be gravelled or sealed to prevent contact with exposed soil. • Ensure that all plants brought onto the site are free of Phytophthora and other plant pathogens.

5.4 Post construction / Ongoing management

Table 14 outlines the management actions for the post construction phase of Precinct 2.

Table 14. Summary of post construction management actions for Precinct 2.

Management issue	Strategy	Key Actions
Fauna management		
Removal of native fauna habitat.	Revegetate retained areas to recreate similar habitat for native fauna species.	Where possible, revegetate open space areas, road reserves with indigenous flora species that will aim to recreate similar habitat to that which was present prior to clearance.
Feral fauna management		
Potential increase in feral animal populations or individuals on site.	Prevent new feral animal populations or individuals from inhabiting the site.	• Prevent scavenging opportunities for feral animals by storing all on-site domestic waste in sealed bins • Ensure the adequate removal of all domestic waste from site on a regular basis. • Any new or increased feral animal activity observed on site is to be reported immediately to the Site Construction Manager.
Feral fauna management		
Potential increase in feral animal populations or individuals on site	Prevent new feral animal populations or individuals from inhabiting the site	Prevent scavenging opportunities for feral animals by storing all on-site domestic waste in sealed bins. Ensure the adequate removal of all domestic waste from site on a regular basis. Any new or increased feral animal activity observed on site is to be reported immediately to the Site Environment Officer and Construction Manager. Control existing feral animal populations, particularly feral rabbits and deer as they can be vectors of weed spread.
Weed management		
Occurrence of weed species on site.	Eradicate or control existing weed species on-site.	• Contractors should be employed to implement best practice weed control techniques to eradicate existing weeds. The method of control will vary according to the species and degree of infestation - see Appendix 2. • Follow up weed control activities should be planned to prevent any re-establishment of weed species. • Any areas of the site that are not subject to immediate construction works should be maintained and managed to reduce the spread of weeds. This may include active weed control techniques or passive control such as continued stock grazing or cropping.

Management issue	Strategy	Key Actions
Potential damage to native flora during weed management activities.	Employ sensitive methods of weed control.	• Appropriately experienced and licensed contractors should be employed to implement all weed control activities and follow up activities. • Best practice weed control methods should be used to prevent any off-target effects. This includes the correct storage of chemicals, appropriate weather conditions during spraying, management of chemical runoff around drainage lines etc.

6 REFERENCES

Anderson, B. (2009) Buckland Park Proposal Fauna Technical Report. Prepared for Walker Corporation Ltd.

Australian Government Department of Agriculture, Fisheries and Forestry (AGDAFF) Online resource available at: https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/pest-animals-and-weeds [Accessed on 04/11/2022].

Banks, P. B., & Hughes, N. K. (2012) A review of the evidence for potential impacts of black rats (*Rattus rattus*) on wildlife and humans in Australia. *Wildlife Research*, **39**(1), pp. 78-88.

EBS (2010) Buckland Park Proposed Residential Subdivision: Achieving a Significant Environmental Benefit. Report to Walker Corporation. EBS Ecology, Adelaide.

EBS (2011) Buckland Park Stage 1 Tree Assessment. Report to Walker Buckland Park Developments Pty Ltd. EBS Ecology, Adelaide.

EBS Ecology (2020) Riverlea Park Flora and Fauna Management Plan: Precinct 1. Report to Walker Corporation Pty Ltd. EBS Ecology, Adelaide.

EBS Ecology (2022a) Riverlea Residential sub-division Data Report. Prepared for Walker Corporation Ltd.

EBS Ecology (2022b) Riverlea TPZ PDI Act Report. Prepared for Walker Corporation Ltd.

Government of South Australia (2022) *Declared Plants of SA Brochure.* Accessible at https://www.pir.sa.gov.au/__data/assets/pdf_file/0018/237330/PIRSA_Declared_Plants_SA.pdf.

Government of South Australia (2006) *Phytophthora Management Guidelines – Phytophthora Technical Group 2006* Online resource available at: untitled (environment.sa.gov.au) [Accessed on 07/11/2022].

Kraehenbuehl, D.N. (1996) Pre-European vegetation of Adelaide: a survey from the Gawler River to Hallett Cove. 317 pp. *Nature Conservation Society of South Australia*: Adelaide.

7 APPENDICES

7.1 Appendix 1. NatureMaps extract of fauna species within a 5 km search area of Precinct 2.

Scientific Name	Common Name	Conservation Status	
		EPBC	NPW
Amphibia			
Crinia signifera	Common Froglet		
Limnodynastes tasmaniensis	Spotted Marsh Frog		
Litoria peronii	Peron's Tree Frog		
Aves			
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		
Acanthiza pusilla samueli	Brown Thornbill (MLR)		
Acrocephalus australis australis	Australian Reed Warbler		
Actitis hypoleucos	Common Sandpiper		**R**
Anas castanea	Chestnut Teal		
Anas gracilis gracilis	Grey Teal		
Anas superciliosa	Pacific Black Duck		
Anas superciliosa x platyrhynchos	Pacific Black Duck x Mallard hybrid		
Anthochaera carunculata woodwardi	Red Wattlebird		
Anthus australis	Australian Pipit		
Apus pacificus pacificus	Pacific Swift		
Ardea alba modesta	Great Egret		
Ardea pacifica	White-necked Heron		
Arenaria interpres interpres	Ruddy Turnstone		**R**
Artamus cyanopterus	Dusky Woodswallow		
Aythya australis	Hardhead		
Barnardius zonarius barnardi	Australian Ringneck		
Biziura lobata menziesi	Musk Duck		**R**
Bubulcus ibis coromandus	Eastern Cattle Egret		**R**
Cacatua galerita	Sulphur-crested Cockatoo		
Cacatua sanguinea gymnopis	Little Corella		
Calidris acuminata	Sharp-tailed Sandpiper		
Calidris bairdii	Baird's Sandpiper		
Calidris falcinellus sibirica	Broad-billed Sandpiper		
Calidris ferruginea	Curlew Sandpiper	**CE**	**E**
Calidris melanotos	Pectoral Sandpiper		**R**
Calidris minuta	Little Stint		
Calidris pugnax	Ruff		**R**
Calidris ruficollis	Red-necked Stint		
Calidris subminuta	Long-toed Stint		**R**
Cereopsis novaehollandiae novaehollandiae	Cape Barren Goose		**R**
Charadrius bicinctus bicinctus	Double-banded Plover		
Charadrius ruficapillus	Red-capped Plover		
Chenonetta jubata	Maned Duck		

Scientific Name	Common Name	Conservation Status	
		EPBC	**NPW**
Chlidonias hybrida javanicus	Whiskered Tern		
Chroicocephalus novaehollandiae novaehollandiae	Silver Gull		
Cincloramphus cruralis	Brown Songlark		
Circus approximans	Swamp Harrier		
Circus assimilis	Spotted Harrier		
Cladorhynchus leucocephalus	Banded Stilt		**V**
Coracina maxima	Ground Cuckooshrike		
Coracina novaehollandiae	Black-faced Cuckooshrike		
Corvus mellori	Little Raven		
Coturnix pectoralis	Stubble Quail		
Coturnix ypsilophora australis	Brown Quail		**V**
Cracticus torquatus leucopterus	Grey Butcherbird		
Cygnus atratus	Black Swan		
Daphoenositta chrysoptera pileata	Black-capped Sittella		
Dendrocygna eytoni	Plumed Whistling Duck		
Egretta garzetta nigripes	Little Egret		**R**
Egretta novaehollandiae	White-faced Heron		
Elanus axillaris	Black-shouldered Kite		
Elseyornis melanops	Black-fronted Dotterel		
Eolophus roseicapilla	Galah		
Epthianura albifrons	White-fronted Chat		
Erythrogonys cinctus	Red-kneed Dotterel		
Falco berigora berigora	Brown Falcon		
Falco cenchroides cenchroides	Nankeen Kestrel		
Falco longipennis murchisonianus	Australian Hobby		
Fulica atra australis	Eurasian Coot		
Gallinago hardwickii	Latham's Snipe		**R**
Gallinula tenebrosa tenebrosa	Dusky Moorhen		
Gavicalis virescens	Singing Honeyeater		
Grallina cyanoleuca cyanoleuca	Magpielark		
Gymnorhina tibicen	Australian Magpie		
Haematopus longirostris	Pied Oystercatcher		**R**
Haliastur sphenurus	Whistling Kite		
Hieraaetus morphnoides	Little Eagle		**V**
Himantopus leucocephalus	Pied Stilt		
Hirundo neoxena neoxena	Welcome Swallow		
Hydroprogne caspia	Caspian Tern		
Ixobrychus dubius	Black-backed Bittern (Australian Little Bittern)		**E**
Limosa haemastica	Hudsonian Godwit		
Limosa lapponica	Bar-tailed Godwit		
Limosa limosa melanuroides	Black-tailed Godwit		**R**
Malacorhynchus membranaceus	Pink-eared Duck		
Malurus cyaneus leggei	Superb Fairywren (Mainland SA)		
Malurus leucopterus leuconotus	White-winged Fairywren		
Manorina flavigula	Yellow-throated Miner		

Scientific Name	Common Name	Conservation Status	
		EPBC	NPW
Manorina melanocephala	Noisy Miner		
Microcarbo melanoleucos melanoleucos	Little Pied Cormorant		
Milvus migrans affinis	Black Kite		
Neophema elegans elegans	Elegant Parrot		**R**
Numenius madagascariensis	Far Eastern Curlew	**CE**	**E**
Nymphicus hollandicus	Cockatiel		
Ocyphaps lophotes lophotes	Crested Pigeon		
Oxyura australis	Blue-billed Duck		**R**
Pardalotus striatus substriatus	Striated Pardalote		
Pelecanus conspicillatus	Australian Pelican		
Petrochelidon ariel	Fairy Martin		
Petrochelidon nigricans neglecta	Tree Martin (all of SA)		
Phalacrocorax carbo	Great Cormorant		
Phalacrocorax sulcirostris	Little Black Cormorant		
Phalaropus lobatus	Red-necked Phalarope		
Phylidonyris novaehollandiae novaehollandiae	New Holland Honeyeater (mainland SA)		
Platalea flavipes	Yellow-billed Spoonbill		
Platalea regia	Royal Spoonbill		
Platycercus elegans	Crimson Rosella		
Platycercus elegans fleurieuensis & elegans subadelaidae	Adelaide Rosella (MN, AP, MLR)		
Plegadis falcinellus	Glossy Ibis		**R**
Pluvialis fulva	Pacific Golden Plover		**R**
Pluvialis squatarola squatarola	Grey Plover		
Podiceps cristatus australis	Great Crested Grebe		**R**
Poliocephalus poliocephalus	Hoary-headed Grebe		
Pomatostomus superciliosus superciliosus	White-browed Babbler (southern SA)		
Poodytes gramineus goulburni	Little Grassbird		
Porzana fluminea	Australian Crake (Australian Spotted Crake)		
Psephotus haematonotus haematonotus	Red-rumped Parrot (eastern SA except NE)		
Ptilotula penicillata penicillata	White-plumed Honeyeater (northern YP, MN, AP, MLR, LNE, MM, SE)		
Recurvirostra novaehollandiae	Red-necked Avocet		
Rhipidura albiscapa alisteri	Grey Fantail (southern SA)		
Rhipidura leucophrys leucophrys	Willie Wagtail		
Smicrornis brevirostris occidentalis	Weebill (Yellabinna, Gawler Ranges, EP, YP, southern FR, MN, MLR, MM)		
Spatula clypeata	Northern Shoveler		
Sternula nereis nereis	Fairy Tern	**VU**	**E**
Stictonetta naevosa	Freckled Duck		**V**
Stiltia isabella	Australian Pratincole		
Tadorna tadornoides	Australian Shelduck		
Taeniopygia guttata castanotis	Zebra Finch		
Threskiornis molucca molucca	Australian White Ibis		

Scientific Name	Common Name	**Conservation Status**	
		EPBC	**NPW**
Threskiornis spinicollis	Straw-necked Ibis		
Todiramphus sanctus sanctus	Sacred Kingfisher		
Tribonyx ventralis	Black-tailed Nativehen		
Tringa Glareola	Wood Sandpiper		**R**
Tringa nebularia	Common Greenshank		
Tringa stagnatilis	Marsh Sandpiper		
Vanellus miles	Masked Lapwing		
Vanellus tricolor	Banded Lapwing		
Xenus cinereus	Terek Sandpiper		**R**
Zosterops lateralis pinarochrous	Silvereye ssp.		
Mammal			
Austronomus australis	White-striped Free-tailed Bat		
Chalinolobus gouldii	Gould's Wattled Bat		
Macropus fuliginosus	Western Grey Kangaroo		
Mormopterus planiceps	Southern Free-tailed Bat		
Nyctophilus geoffroyi	Lesser Long-eared Bat		
Pteropus poliocephalus	Grey-headed Flying-fox	**VU**	**R**
Trichosurus vulpecula	Common Brushtail Possum		**R**
Vespadelus darlingtoni	Large Forest Bat		
Reptilia			
Hemiergis peronii	Four-toed Earless Skink		
Pseudonaja textilis	Eastern Brown Snake		

EPBC – Environment Protection and Biodiversity Conservation Act 1999
NPW – National Parks and Wildlife Act 1972
Conservation Codes:
CE: Critically Endangered
EN/E: Endangered
VU/V: Vulnerable
R: Rare
U: Uncommon

7.2 Appendix 2. Species specific techniques for the control of weeds observed within Precinct 2 of the Riverlea Park development.

Species	Declared/ Environmental/WoNS	Size or stage of plants	Weed Control Method	Timing of application	Comments
Avena barbata (Bearded Oat)	Environmental	Any	Slashing	Autumn – early spring (before seed set)	Establishing a slashing, or mowing (before seed set) regime for at least 3-5 years recommended. Completely stopping seed set for 2 years is expected to severely reduce the population
			Target spray		Recommended use of grass-selective herbicide (e.g. Verdict) for spraying.
			Slash and spray		Slash before spraying with grass-selective herbicide if seed heads are starting to develop. If seed is set, it is recommended to collect seeds to reduce seed-load.
Cynara cardunculus ssp. Flavescens (Artichoke Thistle)	Declared	Juvenile	Grubbing	Rosette stage (juvenile)	Ensure removal of root system to a depth of 150mm.
		Juvenile	Target spray	Rosette stage (juvenile)	Recommended use of non-selective group M herbicide (e.g. glyphosate) surfactant may be required.
		Large	Slash and spray	Pre-flowering	Slash plant down to rosette removing flowering spikes. Allow 2-4 weeks for or regrowth, then spray.
Dactylis glomerata (Cocksfoot)	Environmental	Small	Grubbing	All year (while still green) before seed formation	Remove by grubbing out only if able to do so without generating excessive soil disturbance.
		Small/large	Target spray		Use of a grass selective herbicide recommended if native vegetation is present

Species	Declared/ Environmental/WoNS	Size or stage of plants	Weed Control Method	Timing of application	Comments
			Slash and spray		Slashing before spray only recommended before seed sets, to control seed load upon seedbank
Echium plantagineum (Salvation Jane)	Declared	All	Target spray	When actively growing, before seed set.	Use of non-selective herbicide, surfactant may be required.
Lycium ferocissimum (African Boxthorn)	WoNS	Small	Mechanical removal	Any time	Tree poppers work well removing smaller shrubs
		Large	Cut and swab/ Frill and fill	Any time	Recommended use of glyphosate + triclopyr herbicide mixture for these control methods. Cut plant at base of stem, immediately apply herbicide. Frill and fill method may be used as an alternate control.
			Target spray	July-September	Non-selective herbicide recommended (e.g. glyphosate, triclopyr). Repeat application will usually be required.
Phalaris aquatica (Phalaris)	Environmental	Small	Hand pulling/ Grubbing	Autumn - Winter	Manual removal is usually difficult, if possible controlled burn of infestation, then treatment of regrowth with herbicides recommended. Remove and bag seed heads before manual removal. If plant is still small hand removal is a viable control, mature plants develop extensive root systems which may cause excessive soil disturbance when removed. Collected seed heads and rhizomes from plants to be collected and burnt.
			Target spray		Control of seedlings with grass-selective herbicide (e.g. haloxyfop)

Species	Declared/ Environmental/WoNS	Size or stage of plants	Weed Control Method	Timing of application	Comments
		Large	Target Spray	All year	Remove and bag seed heads for disposal if present. Recommended use of Glyphosate herbicide with addition of penetrant chemical (e.g. Pulse) to kill rhizome. Follow-up treatment of any regrowth as required.
Piptatherum miliaceum (Rice Millet)	Environmental	Any	Slash and Spray	Spring and Summer	Slash approximately 3-4 weeks prior to spraying, allows plant to be actively growing and reduces old growth material while promoting fresh new growth.

***(WoNS) – abbreviation for Weed of National Significance**

Declared weeds and Weeds of National Significance that may occur on the property but have not been identified in this plan should be controlled according to the management actions listed at the following website: http://weeds.org.au/weeds-profiles/

7.3 Appendix 3 – Weed control techniques

A variety of weed control methods have been created and are each favourably suited to controlling disparate types of weeds.

Weed control methods that will be discussed further below are:

- Hand Pulling;
- Grubbing;
- Tree Popper;
- Cut and Swab;
- Wiping application;
- Drill and fill;
- Basal Bark treatment;
- Target (spot) spraying; and
- Biological control.

7.3.1 Mechanical removal

An effective method for removing juvenile invasive weeds, requiring the minimum amount of equipment to perform.

Some weeds may be removed using machinery, this may be done on a broad scale where there is a high level of soil disturbance (e.g. using an excavator) or on a smaller scale using equipment such as a 'tree popper'.

Hand pulling

Specific care is to be provided when hand pulling weeds, to ensure there is minimal soil disturbance caused as disturbed soil areas invite weed infestation.

Best to be performed when soil is slightly moist, as dry soil can become excessively disturbed; or stem of plant may break away from roots, allowing for later regrowth.

- Remove weed by placing a had flat on the ground with the weed between two fingers.
- With other hand grasp weed at base of stem
- While applying downwards pressure with your flat hand carefully pull the weed out with your other, ensuring to not separate the stem from taproot in the process.
- If soil is disturbed during process, tamp back in place to minimise opportunity for future weed infestation.

It is recommended in cases of dry soil, or to perform 'cut and swab' technique instead of hand-pulling weeds.

Grubbing

Is the removal of vegetation by the digging up of roots; this is usually performed with the aid of a hand tool such as a mattock.

Whenever digging up a pest plant it is advised to ensure removal of all parts of the plant from the soils, paying special attention if the plant has corms or rhizomes.

As with all mechanical removal methods it is recommended to utilise this method only if it may be performed without excessive soil disturbance.

'Tree popper'

A similar method of manual removal to *'Hand Pulling'* used to remove juvenile woody weed saplings (e.g., African Boxthorn, European Olive) with a stem diameter up to 60 mm, up to 3 m in height.

A purpose-built tool for woody weed removal, the "*Tree Popper"* uses the same principles of removal as *"Hand pulling"*, by grasping the plant stem and using mechanical advantage to lever the root system out of the soil.

It is recommended in cases of dry soil where it is difficult to remove a weed without causing excessive soil disturbance, to perform another control method instead of mechanical removal.

Slashing

This method is best used to control annual and perennial weed grasses.

Annual grasses should be slashed to approx. 10 cm above the ground. This is usually performed in late winter before seed heads start to develop and may require follow-up slashing after 4-6 weeks.

Perennial grasses are best slashed during winter, and spring growing seasons; but may be slashed any time of year.

Slashing prevents production of seeds, with the goal of reducing their presence in the soil seedbank over time.

Care is to be taken when using heavy machinery for the slashing technique, to ensure no off-target damage harms surrounding native vegetation.

7.3.2 Chemical controls

This section contains weed management techniques which rely on the use of herbicides. Training in the safe and appropriate use of chemicals should always be undertaken prior to their use. Appropriate personal protective equipment must always be used to protect the user.

It is important to choose the correct method for different types of weeds and ensure the correct herbicide and rate of application are used, as herbicides may be selective or non-selective or properties or may develop resistances to types of herbicides if improper rates are used.

When using chemical control methods, it is essential to read and understand the labels on each product before use, follow listed instructions.

The most effective time of year to use chemical controls on each weed is when the plant is actively growing.

Exceptional care is to be taken when using chemicals near creeks or other water bodies, as they may have negative effects on fauna or other not-targeted-plants.

Techniques such as 'Drill and fill', 'Frill and fill' and 'Basal Bark Spray' provide ecological advantages not afforded to other methods. This advantage is in retention of the tree as a habitat structure which allows fauna to continue using the tree as shelter as it dies over time. Retaining habitat structures allows animals to re-locate to new areas that provide suitable shelter, while '*slashing'* or *'cut and swab'* techniques result in removals of potential shelter areas.

Targeted spraying

Targeted (or sometimes referred to as *'spot')* spraying, is an effective method for controlling many weeds over a wide area.

This is usually performed with a person-carried, hand-pumped device to administer a diluted herbicide mixture directly onto targeted weeds.

It is important to consider weather conditions if spraying is the chosen method of weed control, as excessively windy days may cause spray-drift which may unintentionally eliminate native plants. Never spray before forecast rain, as this can cause run-off of applied herbicides reducing effectiveness of treatment, or sometimes causing off-target damage.

When targeting weeds with a waxy leaf surface a surfactant may be added to the herbicide mixture to assist with uptake of herbicides within the targeted plants. Surfactants are particularly harmful to aquatic fauna and should not be used close to creeks or other water bodies, it is highly recommended to use more accurate methods of control such as *'cut and swab'* or *'drill and fill'* techniques when controlling weeds close to water bodies.

Another useful additive to the herbicide mixture are dyes, which can help indicate areas that have been previously sprayed, which is useful when working in large or public areas.

When spraying look out for native plants in the vicinity of targeted weeds, either cover native plants with a non-absorbent material when spraying, or switch control methods to reduce off-target damage, or potential spray-drift.

For tall weeds, or weeds with narrow vertical leaves it is recommended to use the ‘wiping’ method of application as spraying may result in herbicide runoff.

Wiping

Wiping is an extremely useful technique to reduce off-target damage especially when weed species are intermixed with good quality native vegetation, this method is particularly useful in eliminating plants with bulbs, tubers or corms.

Application of a herbicide to a purpose-built tongs with absorbent pads are then ‘wiped’ across the foliage of desired weeds administering the chemicals upon contact.

Slashing and spraying

Most effectively used with tall herbaceous plants, and some woody weeds (e.g. Blackberry) to first slash the area, and only spray the regrowth. This is effective as most herbicides work best when plants are actively growing, and the chemicals may be translocated throughout the plant.

This method is appealing as the slashing clears space and can result in less herbicides required to control desired weeds.

- Slash weeds to approximately 10cm above ground;
- Allow 3-4 weeks of new growth;
- Spray with appropriate chemicals for targeted weed.

Basal bark treatment

‘Basal Bark Treatment’ is generally suitable to woody weeds with thin bark, or juveniles.

This method is performed by completely coating the base of plant, trunk and stems with a herbicide/surfactant mixture to a certain height, which will be translocated throughout the targeted weed.

Follow-up is usually required to prevent any reshooting or regrowth after application has had a chance to take effect.

Cutting and swabbing

This technique is generally used when either the soil is too dry, or the weed too large for efficient manual removal. This technique is effective in removal of herbaceous weeds, shrubs, or juvenile trees without lignotubers.

Lignotubers are lumpy stem protuberances at the base of some woody weeds, which hold moisture and nutrients in reserve, for use of the plant during times of stress.

The steps of this method are simple to perform, and therefore this technique can be quite efficient when performed properly:

- Cut stem close to ground;
- Apply herbicide to cut stem.

Due to the ability of some weeds to begin sealing wounds within seconds, which will reduce absorption and effectiveness of herbicide applications. With this consideration it is recommended this method can be performed in pairs; one person to cut stems and the other to provide herbicide application.

It is recommended if a lignotuber is present to alternatively perform 'Drill and Fill' technique, to ensure effective weed control.

Drill and fill

'Drilling and filling' is a very useful technique in the removal of large woody weeds and is exceptionally effective in eliminating trees that have lignotubers (e.g. Olive trees) when compared to other methods.

Plants will generally drop their leaves within 6 weeks and completely die within a few months.

The steps for performing this method are listed below:

- Clear soil, and debris from base of plant in order to expose base (and lignotuber if present in plant);
- Drill a hole angled downwards at the base of tree (or directly in lignotuber) on an approximate 45° angle (downwards) past the plant's cambium layer;
- Immediately fill hole with herbicide;
- Repeat every 2.5 - 5 cm until holes encircle the circumference of plant;
- Repeat drilling process for another row encircling plant, below first row of holes (make sure to offset holes of second row from first to be effective); and
- Monitor plant for resprouts, repeat process if necessary.

If regrowth is present in plant during later inspection, the process will need to be repeated with extra attention provided around the areas of regrowth.

Frill and fill

'Frilling and filling' is quite similar to the *'Drill and fill'* method and may be used to control woody weeds with no lignotubers present.

This actions for this method are listed below:

- Using a hatchet or chisel create a 'frill' or chip into the outer layers of the trunk on an approximate 45° angle, exposing the cambium layer;
- Continue to frill circumference of trunk at 5 cm intervals, ensuring not to ringbark the plant (as this will reduce translocation of herbicide within plant);
- Treat created 'frills' with herbicide as soon as possible for maximum effect.

7.4 Appendix 4 – Hygiene principles

Use visual inspections of vehicles, machinery, equipment, and protective gear to ensure they are clean of any soil, mud, or plant materials before entering the Project Area.

Create and use facilities dedicated for the cleaning vehicles, plant and equipment or footwear where possible, or select a hard well-drained site (such as a road) preferably away from native vegetation so that Phytophthora isn't introduced to an uninfected area.

Ensure that vegetation, and raw materials arriving onsite (such as gravel, sand, soil and water), are checked and fee of Phytophthora.

7.4.1 Principles to reduce routes of infestation

Soil disturbance creates an opportunity for invasive weeds to spread to previously uninfected areas. Seeds are usually brought in from elsewhere, either through contaminated dirt or plant materials on clothing, equipment or machinery, as well as through the flow of water from previously infected areas.

Due to the nature of construction soil disturbance is unavoidable therefore, to ensure no unintentional spread occurs a few principles to take into consideration are:

- Restrict vehicles to designated roads and tracks;
- Avoid crossing through sites prone to flooding or ponding, into others;
- Prevent transportation of plant materials;
- Use of hygiene stations provided when moving to or from Project Area;
- Ensure vehicles, equipment and footwear are clean and disinfected before entering Project Area.

7.4.2 Cleaning and disinfection procedures

The recommended cleaning procure consists of two steps:

- Dry brushing to remove mud and soil:
    - Remove all mud, or soil with a hard brush or similar tool, pay particular attention to wheels, mudflaps and undercarriage of vehicles or large equipment/machinery.
- Disinfection to kill any Phytophthora or other fungus and plant diseases that may not have been removed by dry brushing.

Disinfecting vehicles, machinery and large equipment:

- Using a pressurised spray unit disinfect vehicle or machinery (again paying specific attention to wheels, mudflaps, undercarriage and other areas of difficult access) using disinfectant applied at rates described the label, examples of disinfectants and rates are:
    - **Phytoclean** (biodegradable and non-corrosive): mix at a rate of 1 part of Phytoclean to 50 parts of water.
    - **Sodium hypochlorite** (pool chlorine): mix at a rate of 1 part *sodium hypochlorite* to 1500 parts of water.
  - Pressurised spray units recommended for cleaning as less water will be used, therefore runoff may be minimal.
  - After application, disinfectant should be allowed at least one minute (ten minutes preferred) before equipment departs.
  - Clean dry brushes used in removal of soil, or plant materials
  - Do not drive through runoff when leaving area.
  - Do not allow mud, plant debris, or run-off to drain into surrounding bushland or surface waters; if necessary, dig a trench or retaining area to contain run-off and detritus.

Disinfecting footwear, small equipment and hand tools:

- Disinfect sole of footwear using a spray bottle containing premixed disinfectant:
  - Recommended disinfectants either 70-100% methylated spirits, or 1 part bleach combined to 4 parts water.
- Allow the sole to dry for approximately one minute.
- Step forwards to avoid recontamination of footwear, then repeat disinfection steps on other foot.
- Disinfect dry brush used to remove soil before disinfection.

Use of above procedure is applicable for disinfection of small equipment and hand tools.

When large groups of people need to disinfect their footwear at one location, an acceptable alternative is to create a footbath containing disinfectant. When using this method ensure soil has been removed from footwear before using footbath, care is to be taken to ensure footbath is never left unattended.

7.4.3 Road construction and maintenance

To reduce likelihood of contamination of vehicles, equipment, and footwear the following general procedures are recommended:

- Keep vehicles and people to designated road and tracks.
- Establish dedicated hygiene/disinfection points for enacting disinfection procedures.
- Ensure vehicles, equipment and footwear are clean and disinfected before entering the Project Area
- If vehicles and/or equipment are kept in the Project Area, they will not be subject to subsequent cleaning procedures until they are to leave the Project Area.
- Avoid construction of roads in areas prone to flooding or ponding.
- Restrict newly constructed roads to lower parts of the landscape.
- Prevent transportation of infested soil, grave or plant materials across Project Area at all times.
- Ensure raw materials for construction of road base are free of Phytophthora.
- Work any quarries or pits, from low slow to prevent entire source becoming infected.
- Ensure all roads are in good condition and improve drainage, by covering wet areas or filling in puddles with material to make surface solid.
- Regularly maintain or improve drainage systems, to prevent flooding or spread of drainage water across Project Area.
- Keep grading frequency to a minimum, while ensuring tracks are maintained to a standard to promote good water drainage.
- Avoid grading roadside batters, slashing or mowing is the preferred method of maintaining roadside batters/shoulders as this keeps soil disturbance to a minimum.
- Maintain roadside vegetation to ensure overgrowth does not hinder road-drainage or spread invasive plant material into undesired areas.

EBS Ecology
112 Hayward Avenue
Torrensville, SA 5031
www.ebsecology.com.au
t. 08 7127 5607

Construction Methodology SLW1

Walker Corporation – Riverlea Salt Water Lake Liner Design & Construction

GEOTEST PTY LTD | 53 South Terrace Wingfield SA 5013 | 08 8264 5802 | WWW.GEOTEST.NET.AU

Table of Contents

Introduction

This construction methodology report outlines the approach and procedures for the design and installation of the lining system for Salt Water Lake 1 at Riverlea Park. Integral to our construction methodology is the integration of the lake dewatering strategy and the proposed construction sequencing and program of Walker Corporation. By aligning our processes with these critical elements, we ensure a coordinated approach that optimises efficiency and minimises disruptions. Our goal is to facilitate a smooth progression of the project phases, ensuring that each stage is completed on schedule and to the highest standards of quality.

Our aim is to ensure that the lining system for Salt Water Lake 1 is designed and installed with the utmost attention to quality, safety, and environmental responsibility. Through meticulous planning and execution, we aim to contribute to the successful development of Riverlea Park, enhancing its functionality.

Scope of Works

Geotest Scope of Work entails the below activities/deliverables but not limited to:

- Quality Control
- Quality Assurance
- Supply and Delivery
- Installation of geomembrane
    - Subgrade Surface Inspection
    - Deployment
    - Qualification Welds
    - Field Production Seaming
    - Field Nondestructive Testing
    - Field Destructive Testing
- Electric Leak Survey
- Details, Defects and Repairs
- Final Inspection and acceptance
- Completion of works: deployment, seaming, repairs, testing and site clean-up, have been completed. Submission of all the required certifications and test records to the main contractor

Out of Scope of Works

The following items are out of Scope of Works of Geotest. It is expected that the Principal/Head Contractor takes responsibility for providing these services:

- Provision of site office, crib, and ablution facilities for Geotest personnel.
- A suitable enclosed storage facility for our equipment.
- All earthworks, including maintenance of the subgrade and excavation and backfilling of anchor trenches.
- Construction of the any internal pipework system such as inlet, outlet, sludge removal etc.
- Management of storm water, including the provision of pumping equipment and the prevention of ingress by and removal of stormwater.
- De-watering.
- Any water required for the works, including dust control.
- Waste bins for disposal of Geotest's waste, and disposal of waste.
- Provide sufficiently suitable 'free flowing' sand or similar suitable ballast for the filling of sandbags used as ballast, and any other ballast, during installation.
- Set out and survey, including surveyed panel placement drawings.
- Site security and traffic control.
- Suitably prepared laydown area to unload the material. The laydown area/s should be located adjacent to the section of works to eliminate unnecessary material handling. The laydown area should be prepared by others and should be flat, smooth, free draining and free of rocks, sticks, sharp matter, or undulations.
- Provision of permanent ballast that may be required to secure the lining system due to potential wind uplift.

Project Assumptions

Geotest does the following assumptions:

- Clear and unlimited access to and around the site.
- The site will be made available prior to first light, such that lining works can commence at first light.
- The lining works would be completed as a continuous uninterrupted process.
- The materials will be fully approved before installation commences.
- No night shift work is required.
- Works will be executed during the driest period of the year.

Standards

American Society for Testing and Materials Standards

Relevant American Society for Testing and Material (ASTM) standards are as follows:

- D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by

Displacement

- D1004 Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting
- D1204 Standard Test Method for Linear Dimensional Changes of Non-rigid Thermoplastic Sheeting or Film at Elevated Temperature
- D1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
- D1505 Standard Test Method for Density of Plastics by the Density Gradient Technique
- D1603 Standard Test Method for Carbon Black in Olefin Plastics
- D3895 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Colorimetry
- D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
- D4354 Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
- D4437 Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes
- D4439 Standard Terminology for Geosynthetics
- D4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
- D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
- D5199 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
- D5397 Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
- D5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
- D5641 Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
- D5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes
- D5820 Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
- D5885 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Colorimetry
- D5994 Standard Test Method for Measuring the Core Thickness of Textured Geomembranes
- D6370 Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)
- D6392 Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
- D6395 Standard Practice for Non-destructive testing of Geomembrane Seams using Spark Test
- D6693 Standard Test Method for Determining Tensile Properties of Non-Reinforced Polyethylene and Non-Reinforced Flexible Polypropylene Geomembranes
- D7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
- D7466 Standard Test Method for Measuring Asperity Height of Textured Geomembranes

Geosynthetic Research Institute Standards

Relevant Geosynthetic Research Institute (GRI) standards are as follows:

- GM9 Standard Practice for Cold Weather Seaming of Geomembranes
- GM10 Specification for the Stress Crack Resistance of Geomembrane Sheet
- GM13 Standard Specification for Test Methods, Test Properties, and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
- GM14 Standard Guide for Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes
- GM17 Standard Specification for Test Methods, Test Properties, and Testing Frequency for Linear Low-Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
- GM19 Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes
- GM20 Standard Guide for Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using Control Charts
- GM29 Standard Practice for Field Integrity Evaluation of Geomembrane Seams (and Sheet) Using Destructive and/or Non-destructive Testing

Submittals

Prior to delivery of geomembrane to site

Geotest will submit the following documentation for review and acceptance prior to delivery of geomembrane to site:

- Manufacturer’s certificate of compliance outlining conformance with the requirements of project Specification.
- Manufacturer’s quality control and assurance test results.

Prior to installation of geomembrane

Geotest will submit the following documentation for review and acceptance prior to the installation of geomembrane:

- Delivery, storage and handling log for all geomembrane rolls to be used in the Works, including delivery dockets, roll number and identification, delivery inspection checklist, details of storage and handling.
- Proposed panel placement drawing, showing the location and reference number of all panels and expected seams, connections and penetrations, panel dimensions and layout, and the order of panel installation.

Following installation of geomembrane

Geotest will submit the following documentation for review and acceptance following installation of the geomembrane:

- Panel placement log, providing details on panel number and associated roll number, date and time placed, condition of receiving surface, weather conditions and precipitation events, QA checks performed, and all other relevant information.
- Trial weld log, recording all trial welds and testing undertaken.
- Field welding log providing details of all field welding undertaken.
- Field sampling and testing results, including non-destructive and destructive tests.
- Finalised panel placement drawing showing the as-built location of all panels, seams, connections, and penetrations.
- Defects and repairs log, showing details of all defects identified and repairs completed.

Installation

Weather conditions

Geotest will consider the weather conditions on a daily basis to confirm they are suitable for placement of geomembrane. It shall not be placed or seamed:

- If moisture prevents proper subgrade preparation, panel placement and/or panel seaming.
- During precipitation, during hail, during periods of excessive fog, during periods of excessive dust, in standing water, on excessively wet surfaces, in the presence of excess moisture (such as dew and/or ponded water).
- During periods of excessive winds (>30 kph) or when gusting wind conditions interfere with handling operations.
- When sheet temperatures are lower than 0° or higher than 65° as measured by a calibrated infrared thermometer or surface thermocouple.

Figure 1. Monthly climate statistics EDINBURGH RAAF (34.71 °S, 138.62 °E). *Bureau of Meteorology*.

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	
Temperature															
Mean maximum temperature (°C)	30.2	29.9	27.0	23.2	19.1	16.0	15.3	16.5	19.1	22.4	25.8	28.0	22.7	51	1972 2024
Mean minimum temperature (°C)	16.6	16.6	14.6	11.8	9.2	6.9	6.1	6.5	8.1	10.1	12.9	14.8	11.2	51	1972 2024
Rainfall															
Mean rainfall (mm)	21.4	17.4	23.1	30.6	46.6	52.9	52.0	49.7	46.7	37.0	26.0	24.8	429.0	49	1972 2024
Decile 5 (median) rainfall (mm)	15.0	9.7	12.4	27.0	45.4	53.6	49.0	53.4	44.4	31.0	25.4	18.0	423.8	51	1972 2024
Mean number of days of rain ≥ 1 mm	2.4	2.0	3.3	4.8	8.0	9.4	10.3	9.6	7.8	6.3	4.1	3.7	71.7	51	1972 2024
Other daily elements															
Mean daily sunshine (hours)															
Mean number of clear days	5.6	8.5	7.1	4.5	2.9	2.6	2.9	3.2	3.5	4.1	4.3	3.7	52.9	30	1972 2010
Mean number of cloudy days	3.6	4.2	5.7	7.8	9.9	9.3	10.1	9.9	9.0	9.1	7.5	4.7	90.8	30	1972 2010
9 am conditions															
Mean 9am temperature (°C)	21.9	21.6	19.7	17.3	13.6	10.5	9.8	11.3	14.0	16.7	18.9	20.8	16.3	38	1972 2010
Mean 9am relative humidity (%)	51	52	56	61	75	84	83	78	69	58	53	50	64	38	1972 2010
Mean 9am wind speed (km/h)	14.2	11.7	12.0	13.0	12.1	12.1	13.4	15.7	17.9	18.4	16.4	16.1	14.4	37	1972 2010
3 pm conditions															
Mean 3pm temperature (°C)	27.9	28.5	25.7	21.8	18.2	14.9	14.3	15.4	17.5	20.4	23.9	25.5	21.2	38	1972 2010
Mean 3pm relative humidity (%)	35	34	39	45	56	65	64	59	54	46	39	38	48	38	1972 2010
Mean 3pm wind speed (km/h)	23.3	21.1	20.8	19.3	17.6	17.8	19.1	21.7	22.5	22.7	22.8	24.1	21.1	31	1972 2010

Working Hours

Our working hours will be based on 6 days' work per week, 10 hours a day, with Sundays being a rest day.

Plant and Equipment

- Deployment trailer.
- Telehandler.
- Generator.
- Welding equipment: extrusion welder, wedge welder.
- Punch Press.
- Field Tensiometer.
- Vacuum Box.
- Gauge and Air Pump.
- Miscellaneous equipment: small tools will include hook blade utility knives, scissors with rounded points and silicone or rubber rollers.

Construction Methodology

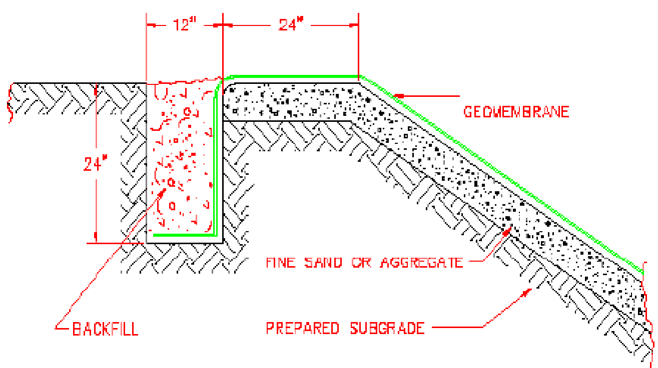
Subgrade Preparation by others

1. The foundation area for flexible membrane liners shall be smooth and free of projections that might damage the liner. All stumps and roots shall be removed. Rocks, hard clods, coarse gravel and other such material shall be removed or shall be rolled so as to provide a smooth surface or shall be covered with a cushion of fine soil. Subgrade must be compacted to comply with design specifications and include a stable base to support equipment and necessary vehicle weight and shall be free of standing water.
2. Geotest will perform a visual inspection of the subgrade surface to determine that it is suitable to be lined.

Anchoring

1. An anchor trench shall be excavated by others around the area to be lined at the planned elevation of the top of the lining. Attention must be paid to the stability of the soil being excavated. Excavation of trenches should be coordinated with the geomembrane installation to avoid excessive exposure to weathering prior to installation.
2. Upon placement of geomembrane panels, the anchor trench must be partially backfilled immediately to prevent panel slippage, wind uplift or blowout that could result in liner damage. If immediate backfilling of trenches is not possible, sandbag loading should be used to provide temporary ballast. Final backfilling and compaction, by others, should commence only after the geomembrane has had time to dissipate manufacturing orientation and settle into its final position.

Figure 2. Sample of a typical anchor trench. It must be constructed according to the specifications of the design drawing.



TYPICAL ANCHOR TRENCH

Panel Deployment, placement, and seaming

1. Geomembrane rolls are unrolled using a front-end loader or forklift, and specially designed lifting apparatus that is attached to the bucket or forks of the equipment. Any final adjustment to the

positioning of the liner was carried out by hand.

2. Once positioned, geomembrane panels along the lake floor must be temporarily secured via the use of sandbags located along the edges of the panel, primarily to secure the panel from overturning / moving out of position due to wind. For the batter slopes, geomembrane panels must be secured into position by anchoring the geomembrane into a trench positioned at the top of the batter slope.

    - Installation shall progress from the highest elevations to the lowest.
    - Only those geomembrane rolls which can be seamed or permanently anchored on at least two sides on the same day shall be placed on a daily basis. All other sides shall be temporarily anchored.
    - Geomembrane placement shall be limited to that which can be seamed in one day.
    - Compensation for thermal contraction of the geomembrane shall be provided as necessary during the liner installation.

3. Anchor trenches backfilling shall be programmed when the temperature is coolest to minimise effects of material expansion.

4. Prior to welding, the surface of the geomembrane shall be wiped with a clean cloth to remove moisture, dust, dirt, debris, or other potential contaminants that would inhibit welding.

5. Welding.

6. After welding, a close visual inspection of the seam is made. This is done as soon as possible after the weld has been completed. The inspection is to include weld alignment.

7. Conduct Electric Leak Survey to minimise leakage rates.

8. Defective areas are marked and repaired then the repairs are inspected and approved. This inspection/repair process is carried out in a systematic manner as soon as possible to ensure that no defective area goes unrepaired.

Construction methodology sequencing

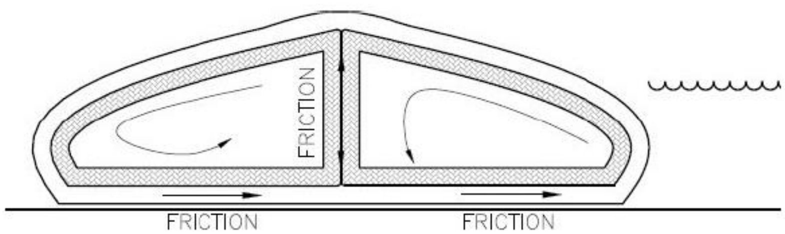
Geotest recommends using cofferdams for the installation of geosynthetics in each bay. Cofferdams are structures built within or across a body of water, creating an enclosed area that can be dewatered. This approach allows for a dry and controlled environment to install geosynthetics, eliminating the need to repeatedly install and remove containment bunds.

Temporary cofferdams - AquaDam®

The use of the temporary cofferdams is a key component in providing an environmentally safe and successful installation of the geomembrane as it provides major cost savings to the contractor and project owner. AquaDam® Cofferdams are lightweight, easy to handle, and can be used virtually anywhere. This unique combination of properties makes AquaDam® ideal for a wide range of applications, including stream crossings during pipeline installation, water containment during repairs to bridges, or used as a barrier to prevent erosion control through diversion or containment.

AquaDam® consists of two geomembrane tubes contained by a high strength woven textile outer tube. The two inner tubes are filled with water which creates a stable, non-rolling water-controlled structure. A center baffle curtain is installed for stability, reducing movement or tipping as a result of hydrodynamic loading.

Figure 3. Stability of water filled dam to hydrodynamic loading.

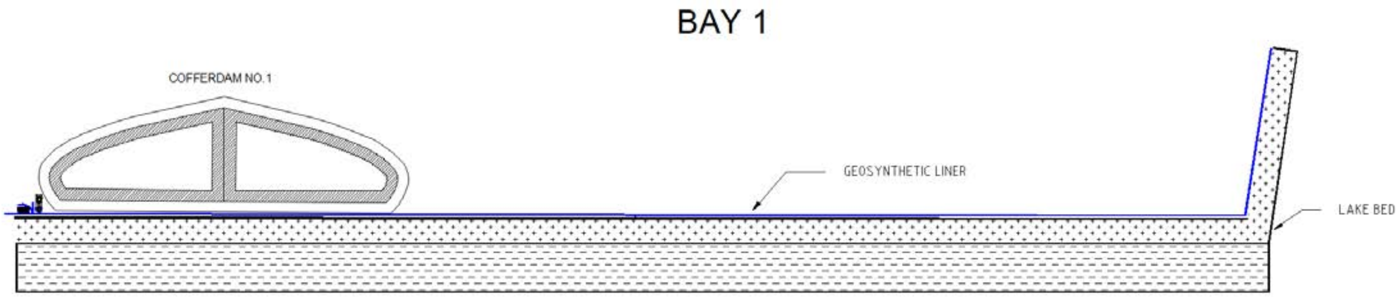


AquaDams® are delivered to the job site prefabricated in a compact roll. The first dam is unrolled as it is inflated with water, often with the assistance of ropes to control the rate of unrolling. The key to the installation of AquaDam® barriers is to elevate the open end of the inlet tubes above the maximum filled height of the barrier.

Sequencing

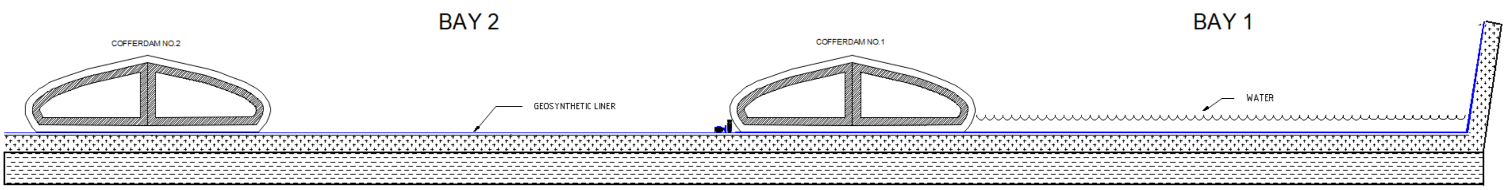
Bay 1

I. Proceed to install the liner as per above description.
II. Inspection.
III. Electric Leak Survey.
IV. Conduct repairs.
V. Installation of cofferdam no.1. (position 1)
VI. Fill bay 1 with water.



Bay 2

I. Proceed to install the liner attached to the bay 1 liner.
II. Inspection.
III. Electric Leak Survey.
IV. Conduct repairs.
V. Installation of cofferdam no.2. (position 2)
VI. Remove cofferdam no.1.
VII. Fill bay 1 and 2 with water.



Bay 6*

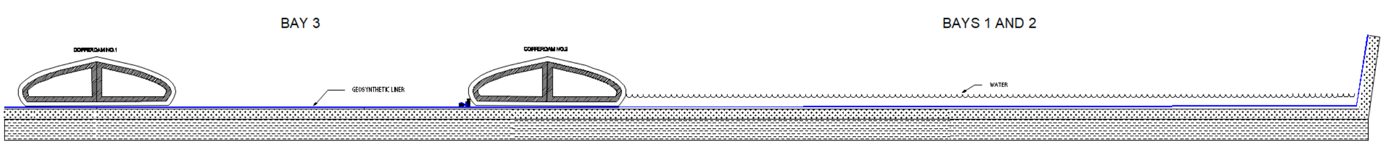
I. Proceed to install the liner.
II. Inspection.
III. Electric Leak Survey.
IV. Conduct repairs.
V. Fill bay 6 with water.

**subject to check SWL1 design details*

Bay 3 and 4

I. Proceed to install liner bay 3 attached the bay 2 liner.
II. Inspection.
III. Electric Leak Survey.
IV. Conduct repairs.
V. Reinstallation of cofferdam no.1 (position 3)

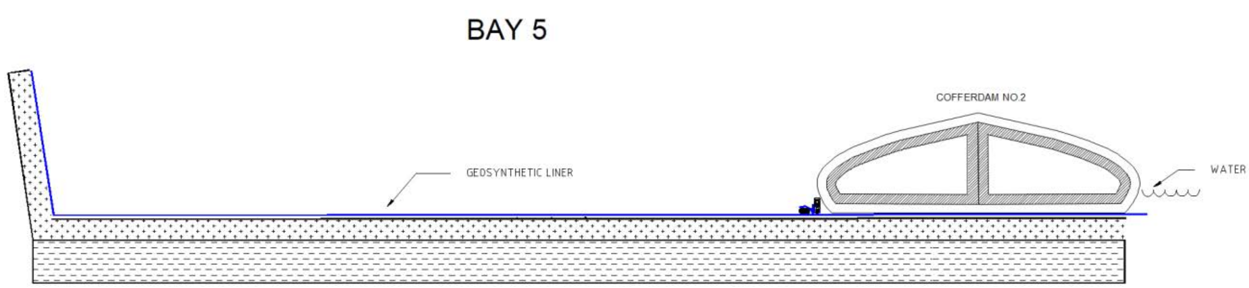
VI. Remove cofferdam no.2.
VII. Fill bay 1, 2 and 3 with water.
VIII. Proceed to install liner bay 4 attached the bay 3 liner.
IX. Inspection.
X. Electric Leak Survey.
XI. Conduct repairs.
XII. Reinstallation of cofferdam no.2. (position 4)
XIII. Remove cofferdam no.1.
XIV. Fill bay 1, 2 3, and 4 with water.



Same procedure for bay 4

Bay 5

I. Proceed to install the liner attached to the bay 4 liner.
II. Inspection.
III. Electric Leak Survey.
IV. Conduct repairs.
V. Remove cofferdam no.2.
VI. Fill bay 1, 2, 3, 4 and 5 with water.



The table below presents an approximate duration of the construction sequencing:

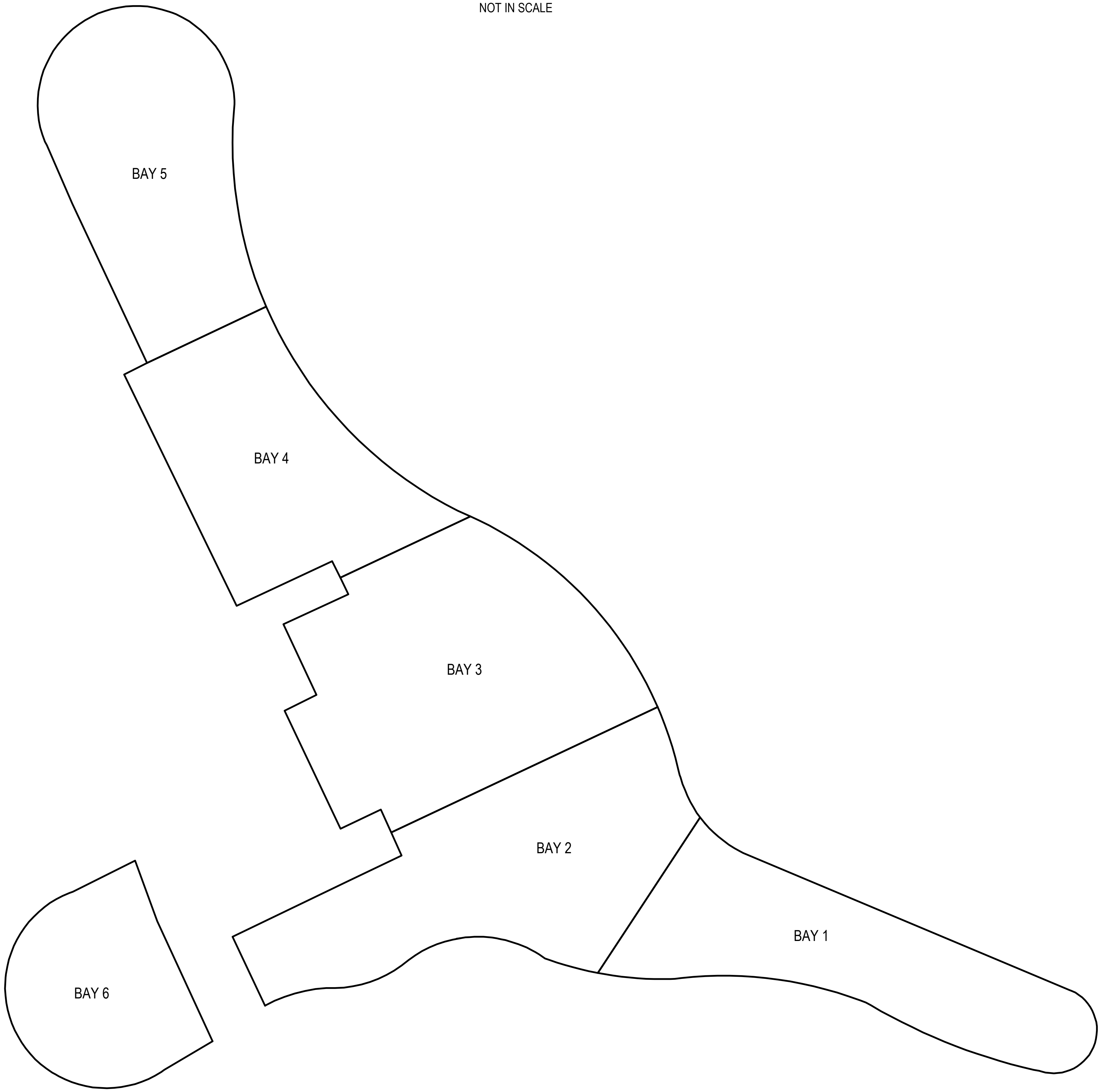
Table 1. Approximate installation duration for SWL1.

SLW1 Bays	Net area	Installation days
Bay 1	30,440 m^2	20
Bay 2	31,300 m^2	21
Bay 3	37,645 m^2	25
Bay 4	26,300 m^2	17
Bay 5	29,050 m^2	20
Bay 6	12,880 m^2	9

- *Production rate of 1,500m^2/day in conservative conditions.19*
- *Areas need to be verified and confirmed by the provision of CAD file drawings.*
- *Construction methodology and duration of installation are subject to know water table level from each bay.*

DO NOT SCALE

NOT IN SCALE



PRELIMINARY ISSUE

REFERENCES

DRAWING	TITLE

REVISIONS

No.	REVISION DESCRIPTION	DRAWN	CHECKED	APPROVED	DATE
A	DESIGN - FOR REVIEW	M.A.	P.B.	P.B.	03.06.24

53 South Terrace
Wingfield SA 5013

WALKER CORPORATION
SALTWATER LAKE 1
CONSTRUCTION SEQUENCING

DRAWN	DESIGNED	APPROVED	SCALES:
M. ANDREU	P. BENNETT		PLAN 0.000330 SECTION HORIZ. VERT. 0.000330 Scale for A3 sheet
DRAFTING CHECK	DESIGN CHECK		
P. BENNETT	P. BENNETT		

F.C.

FILE No.

DRG No. 2404-1165 - 001

DRAWING DISCIPLINE: CIVIL AND SURVEY

SHEET NO. 01 of 5

A3

Plot Date: 4 June 2024 - 11:45 AM

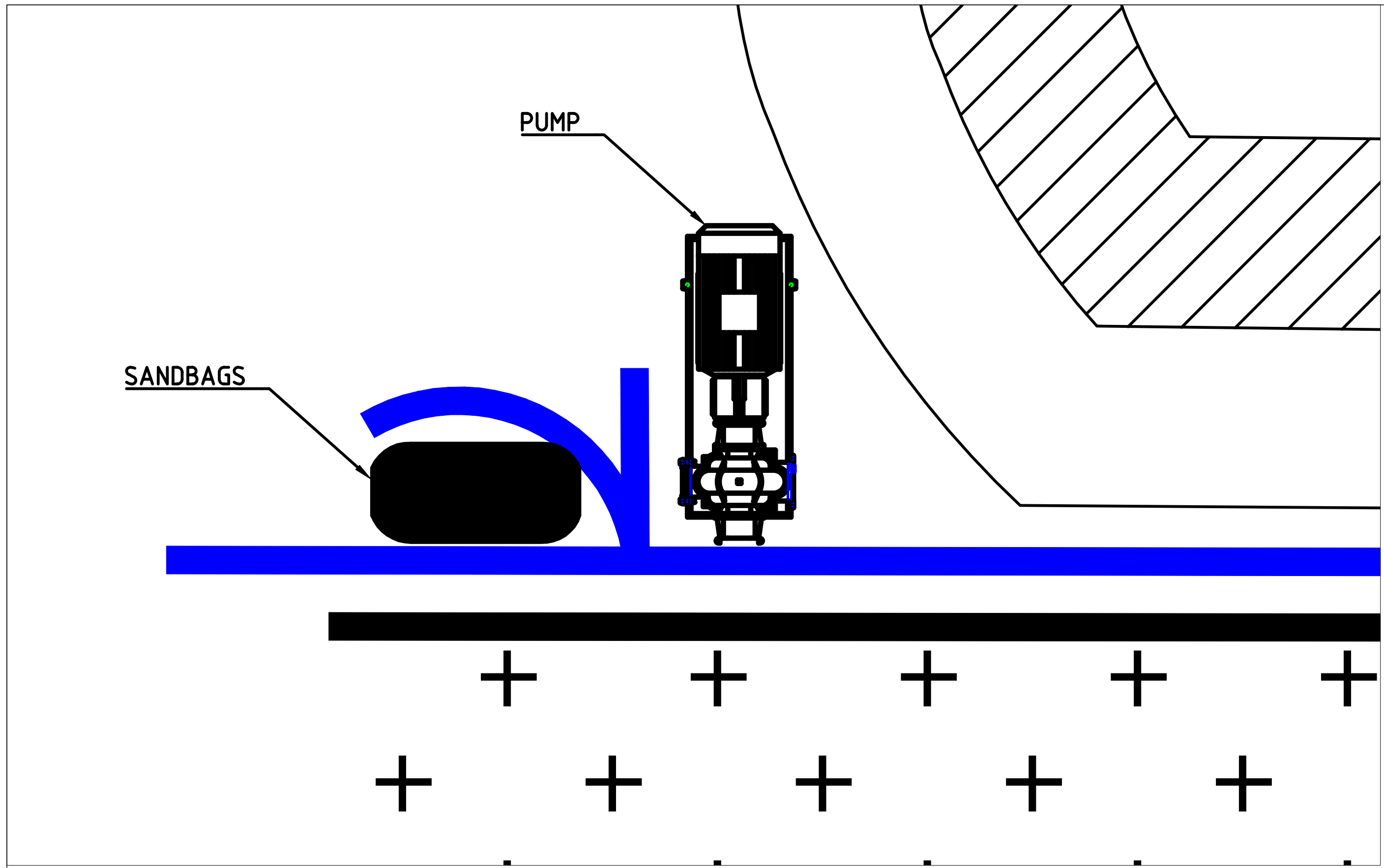
Plotted by: Marina

Cad File No: C:\Users\Marina\OneDrive - Geotest\Desktop\2404-1165 WalkerCorp Riverlea Salt Water Lakes\2404-1165 WalkerCorp Riverlea Salt Water Lakes.dwg

Note: * indicates signatures on original issue or last revision of drawing

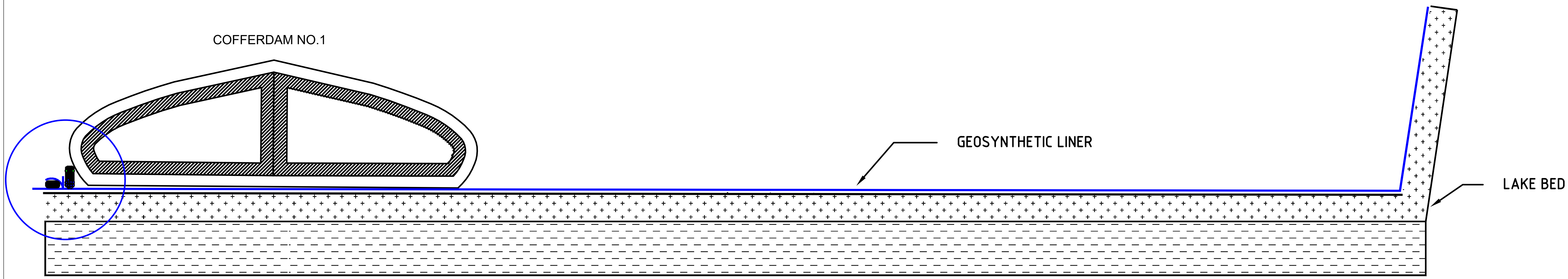
DO NOT SCALE

NOT IN SCALE



ADDITIONAL MECHANISM TO PREVENT ANY LEAKAGE FROM THE COFFERDAM

BAY 1



PRELIMINARY ISSUE

REFERENCES	
DRAWING	TITLE

REVISIONS					
No.	REVISION DESCRIPTION	DRAWN	CHECKED	APPROVED	DATE
A	DESIGN - FOR REVIEW	M.A.	P.B.	P.B.	03.06.24

53 South Terrace
Wingfield SA 5013

WALKER CORPORATION
SALTWATER LAKE 1
CONSTRUCTION SEQUENCING

DRAWN M. ANDREU	DESIGNED P. BENNETT	APPROVED	SCALES: PLAN 2.728566 SECTION HORIZ. VERT. 2.728566 Scale for A3 sheet	F.C.
DRAFTING CHECK P. BENNETT	DESIGN CHECK P. BENNETT			FILE No. A3

DRG No. 2404-1165 - 001

DRAWING DISCIPLINE: CIVIL AND SURVEY
SHEET NO. 02 of 5

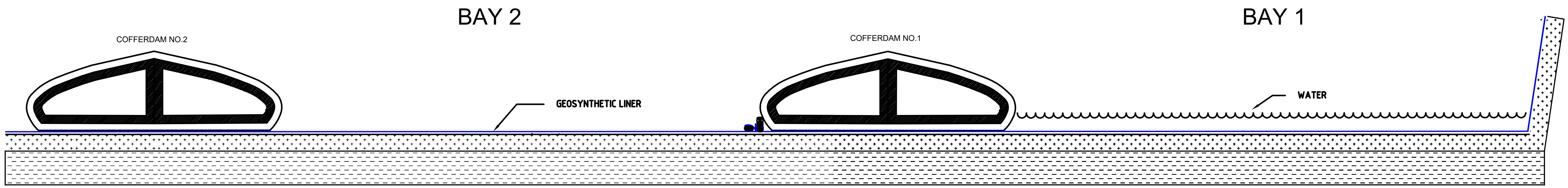
Note: * indicates signatures on original issue or last revision of drawing

Plot Date: 4 June 2024 - 11:46 AM Plotted by: Marina

Cad File No: C:\Users\Marina\OneDrive - Geotest\Desktop\2404-1165 WalkerCorp Riverlea Salt Water Lakes\2404-1165 WalkerCorp Riverlea Salt Water Lakes.dwg

DO NOT SCALE

NOT IN SCALE



PRELIMINARY ISSUE

REFERENCES	
DRAWING	TITLE

REVISIONS

No.	REVISION DESCRIPTION	DRAWN	CHECKED	APPROVED	DATE
A	DESIGN - FOR REVIEW	M.A.	P.B.	P.B.	03.06.24

53 South Terrace
Wingfield SA 5013

WALKER CORPORATION
SALTWATER LAKE 1
CONSTRUCTION SEQUENCING

DRAWN	DESIGNED	APPROVED	SCALES:
M. ANDREU	P. BENNETT		PLAN 1.692796
DRAFTING CHECK	DESIGN CHECK		SECTION HORIZ.
P. BENNETT	P. BENNETT		VERT. 1.692796

Scale for A3 sheet

F.C.

FILE No.

DRG No. 2404-1165 - 001

DRAWING DISCIPLINE: CIVIL AND SURVEY
SHEET NO. 03 of 5

A3

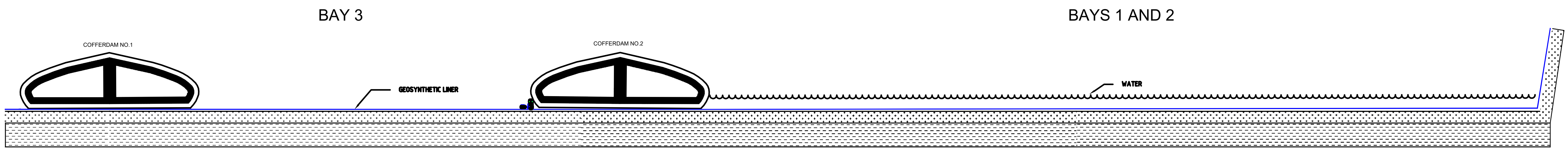
Plot Date: 4 June 2024 - 11:46 AM Plotted by: Marina

Cad File No: C:\Users\Marina\OneDrive - Geotest\Desktop\2404-1165 WalkerCorp Riverlea Salt Water Lakes\2404-1165 WalkerCorp Riverlea Salt Water Lakes.dwg

Note: * indicates signatures on original issue or last revision of drawing

DO NOT SCALE

NOT IN SCALE



Same procedure for bay 4

PRELIMINARY ISSUE

REFERENCES	
DRAWING	TITLE

REVISIONS					
No.	REVISION DESCRIPTION	DRAWN	CHECKED	APPROVED	DATE
A	DESIGN - FOR REVIEW	M.A.	P.B.	P.B.	03.06.24

53 South Terrace
Wingfield SA 5013

WALKER CORPORATION
SALTWATER LAKE 1
CONSTRUCTION SEQUENCING

DRAWN	DESIGNED	APPROVED
M. ANDREU	P. BENNETT	
DRAFTING CHECK	DESIGN CHECK	
P. BENNETT	P. BENNETT	

SCALES: PLAN 1.191137 SECTION HORIZ. VERT. 1.191137 Scale for A3 sheet

F.C. FILE No.

DRG No. 2404-1165 - 001 DRAWING DISCIPLINE: CIVIL AND SURVEY SHEET NO. 04 of 5 A3

Plot Date: 4 June 2024 - 11:46 AM Plotted by: Marina

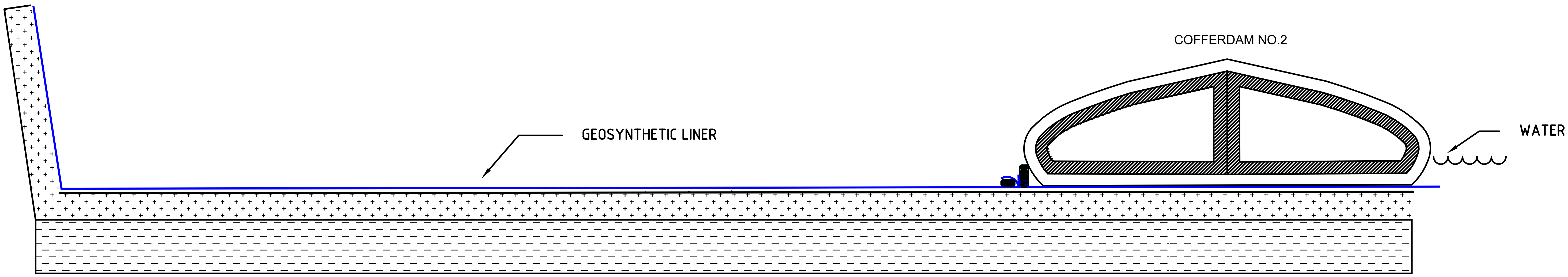
Cad File No: C:\Users\Marina\OneDrive - Geotest\Desktop\2404-1165 WalkerCorp Riverlea Salt Water Lakes\2404-1165 WalkerCorp Riverlea Salt Water Lakes.dwg

Note: * indicates signatures on original issue or last revision of drawing

DO NOT SCALE

NOT IN SCALE

BAY 5



PRELIMINARY ISSUE

REFERENCES	
DRAWING	TITLE

REVISIONS					
No.	REVISION DESCRIPTION	DRAWN	CHECKED	APPROVED	DATE
A	DESIGN - FOR REVIEW	M.A.	P.B.	P.B.	03.06.24

53 South Terrace
Wingfield SA 5013

WALKER CORPORATION
SALTWATER LAKE 1
CONSTRUCTION SEQUENCING

DRAWN M. ANDREU	DESIGNED P. BENNETT	APPROVED	SCALES: PLAN 2.657737 SECTION HORIZ. VERT. 2.657737 Scale for A3 sheet	F.C.
DRAFTING CHECK P. BENNETT	DESIGN CHECK P. BENNETT			FILE No. A3

DRG No. 2404-1165 - 001 DRAWING DISCIPLINE: CIVIL AND SURVEY SHEET NO. 05 of 5

Plot Date: 4 June 2024 - 11:46 AM Plotted by: Marina

Cad File No: C:\Users\Marina\OneDrive - Geotest\Desktop\2404-1165 WalkerCorp Riverlea Salt Water Lakes\2404-1165 WalkerCorp Riverlea Salt Water Lakes.dwg

Note: * indicates signatures on original issue or last revision of drawing

Proposed options and associated costs

Walker Corporation – Riverlea Salt Water Lake Liner Design & Construction

GEOTEST PTY LTD | 53 South Terrace Wingfield SA 5013 | 08 8264 5802 | WWW.GEOTEST.NET.AU

Table of Contents

Introduction

In response to the need for effective containment solutions in various industrial and environmental applications, this report presents proposed options for liners, specifically focusing on High-Density Polyethylene (HDPE), Linear Low-Density Polyethylene (LLDPE), Polyvinyl Chloride (PVC), and Geosynthetic Clay Liners (GCL). The primary objective of this report is to provide an initial assessment of the viability of these options from a pricing perspective, outlining their respective benefits, limitations, and estimated costs for both supply and installation.

This report serves as the foundational step towards identifying suitable liner solutions for your specific requirements. While comprehensive details will be exposed in the following Separable Portion 2, the aim here is to offer a concise yet informative overview that facilitates a comparative analysis and enables informed decision-making regarding the most cost-effective and functionally sound option for the construction of the saltwater lakes at Buckland Park Riverlea.

Geomembranes

Geomembranes are flexible polymeric sheets mainly employed as liquid and/or vapour barriers. Polymeric geomembranes are designed as relatively impermeable liners for use in a variety of containment situations in applications where natural clay or other containment options are not possible or viable. **Their expected service lives generally range from 20 to >100 years**.

As mentioned above, geomembranes are not absolutely impermeable, but they are relatively impermeable when compared to geotextiles or soils, even to clay soils. **Typical values of geomembrane permeability as measured by water-vapor transmission tests are in the range $1{\times}10^{-12}$ to $1{\times}10^{-15}$ m/s, which is three to six orders of magnitude lower than the typical clay liner.**

In its various densities polyethylene is the most widely used polymer in the manufacturing of geomembranes are:

- High-density polyethylene (HDPE) ≥ 0.941 g/cc
- Linear low-density polyethylene (LLDPE) = 0.925 to 0.919 g/cc

Geomembrane Material Selection
When selecting a geomembrane for a particular application, the choice of the **type of resin material** to be used in the manufacture of the liner and the **chemical resistance** to the contained liquid are critical factors to be considered. Other relevant aspects are:

- type of fabric reinforcement
- colour of upper ply
- thickness

- texture
- product life expectancy
- mechanical properties
- ease of installation
- Geometry of the land

Leakage rate for geomembrane liners

As mentioned above, geomembranes are not 100% impermeable, in fact, all liners leak. The fact that leakage, or at least potential leakage, is an essential consideration in the design of a lined facility implies that leakage can be quantified and controlled, likewise, the value proposed for the action leakage rate for reservoir liners must be realistic. Peggs and Giroud (2014) estate the following:

- When zero or very small values of action leakage rates are specified, extensive investigations to find holes in the geomembrane and extensive liner repairs may be required to try to meet the action leakage rate.
- Leakage from a reservoir can be acceptable if the following four requirements are met:
  a) The loss of liquid remains small enough to be economically acceptable.
  b) The leaking liquid does not cause unacceptable pollution of the ground or the ground water.
  c) The leaking liquid does not cause a degradation of the soil supporting the geomembrane.
  d) The leaking liquid does not uplift the geomembrane liner.
- The number of holes at the end of geomembrane installation with construction quality assurance is typically believed to be from 1 to 5 holes per hectare. Therefore, the proposed values for leakage rate are calculated based on 5 holes per hectare with a size of 1 mm2.

If leakage is of great concern, there are options of adequate containment systems and control available in the market for leak detection and reducing leakage risks. Electrical leak detection is a method used to identify leaks or defects in geomembranes by applying electrical testing techniques to find and locate potential breaches in the liner. Likewise, performed immediately after geomembrane installation, the rate of leakage through a geomembrane-only primary liner can be even lower. This technology is essential in all geomembrane liner installations to ensure liner quality. Geotest is the market leader in electrical leak detection having completed testing of over ten million square meters of geomembrane.

Geotest Proposal

High-density polyethylene (HDPE) Geomembrane

- ✓ HDPE is the most common field-fabricated geomembrane material primarily due to its low material cost.

- ✓ Exhibits high strength and excellent chemical resistance to a wide range of chemicals due mainly to its crystalline microstructure.
- ✓ Excellent mechanical properties.
- ✓ Offers good elongation properties allowing up to 12% deformation at its yield point. Up to this point HDPE behaves elastically without damage to the polymer's microstructure structure.
- ✓ The low material cost of HDPE resins allows for thicker lining cross-sections to be used compared to other more expensive geomembrane materials, thus providing increased resistance to puncture and abrasion.
- × HDPE is a very stiff liner with a high coefficient of thermal expansion, often requiring special design considerations.
- × HDPE is prone to environmental stress cracking (ESC) due to a crystalline lattice structure.
- × HDPE's puncture resistance is lower than most other competing materials.

Linear low-density polyethylene (LLDPE) Geomembrane

- ✓ They are more flexible than HDPE (one quarter of the stiffness of HDPE), offering better multiaxial stress resistance and better elongational resistance.
- ✓ Excellent large scale puncture resistance compared with HDPE.
- ✓ Good resistance to stress cracking.
- ✓ It can be easily and simply welded utilizing standard fusion or extrusion welding equipment and technologies.
- × It has only moderate weathering/UV resistance qualities.
- × It has only moderate chemical resistance to hydrocarbons and poor dimensional stability.
- × Susceptible to oxidation which is accelerated by the catalytic effects of multivalent transition metal ions in a chemically activated state.
- × Surface friction properties are poor unless the geomembrane is heavily textured.
- × LLDPE can be problematic to repair since this requires the use of a specialized extrusion gun which requires considerable skill to operate properly.

Polyvinyl Chloride (PVC) Geomembrane

- ✓ PVC is one of the most versatile plastics available with formulations that can provide oil resistance, UV stability, low temperature resistance and other specific properties.
- ✓ PVC offers a ductile geomembrane material at relatively low cost.
- ✓ It has high deformation capabilities and is not susceptible to environmental stress cracking.
- ✓ PVC liners are typically very flexible and readily conform to subgrade contours.
- ✓ Ease of installation compared with that of other geomembranes.
- ✓ Offer excellent interface friction without being textured. In comparison, other geomembranes, especially HDPE, offer very little surface friction unless they are finished heavily textured.

- ✓ PVC is typically prefabricated in a fabrication facility where high level quality control is easily achieved as opposed to field welding. This is an important advantage of PVC since it allows its fabrication into large sheets in a factory and requires less field seaming than HDPE membranes.
- ✓ PVC offers excellent puncture resistance compared to HDPE.
- ✗ PVC liners are typically not suitable for prolonged exposure to sunlight (UV) because they are not UV-stabillised. PVC is not resistant to UV degradation unless specially formulated.
- ✗ PVC geomembranes have a high chemical resistance to the majority of acids, bases, salts, and alcohols but the plasticizers can be affected by benzene, trichloroethylene, toluene, and strong bases such as sodium hydroxide. Certain organic liquids and solvents can also extract the plasticizer and when the PVC 'dries out' it can crack.
- ✗ PVC liners are sometimes formulated with biocides. Biocides protect PVC with inexpensive plasticizers from microbial attack. Without biocides, plasticizers will be consumed by soil borne microbes leaving the geomembrane brittle. Biocides found in PVC can be toxic to fish. Fish-grade PVC usually does not include a biocide since they use higher quality plasticizers that are not susceptible to biological attack and are usually more expensive.
- ✗ PVC has inherently lower seam strength (e.g. than HDPE) which could cause issues in cases of excessive stress on the welds.
- ✗ Field welds can be problematic and lack integrity leading to leaks due to the uncontrolled nature of the outside environment with respect to temperature/wind and to the potential for contamination.

Liners for salt evaporation ponds

Geomembranes are used to line salt evaporation ponds in warmer climates. PVC geomembranes are the liner of choice for salt evaporation ponds even in harsh environments. This is because PVC geomembranes are durable and offer excellent chemical resistance to salts, which is important because of the long-term exposure of the geomembranes to the brine.

PVC geomembranes also exhibit much smaller wrinkles than polyethylene geomembranes when installed because of a lower thermal expansion coefficient, higher subgrade/geomembrane interface strength coupled with the flexibility of PVC geomembranes. These attributes are significant in this application because the smaller wrinkles result in substantial intimate contact between the geomembrane and subgrade and the protective salt layer. The benefit of intimate contact is a reduction in the lateral flow of the brine solution from a hole or leak in the geomembrane.

Furthermore, PVC has high elongation and tends to drape around any protrusions on the compacted layer underneath and thus a PVC liner helps minimize the occurrence of small holes and brine loss.

Geosynthetic Clay Liner (GCL)

Geosynthetic clay liners (GCLs) are factory-manufactured hydraulic barriers consisting of a thin layer of bentonite supported by geotextiles and/or geomembranes, being mechanically held together by needling, stitching, or chemical adhesives. **GCLs are an alternative to compacted clays** and competitive or complementary wherever geomembranes and compacted clay liners are used because they often have very low hydraulic conductivity to water and relatively low cost. Their hydraulic conductivity ranges from 2×10^{-11} to 2×10^{-12} m/s (for geotextile-related GCLs made from sodium bentonite).

- ✓ Rapid installation/less skilled labour/low cost.
- ✓ Very low hydraulic conductivity to water if properly installed.
- ✓ Can withstand large differential settlement.
- ✓ Excellent self-healing characteristics.
- ✓ Not dependent on availability of local soils.
- ✓ Easy to repair.
- ✓ Resistance to the effects of freeze/thaw cycles.
- ✓ More airspace resulting from the smaller thickness.
- ✓ Field hydraulic conductivity testing not required.
- ✓ Hydrated GCL is an effective gas barrier.
- ✓ Reduce overburden stress on compressible substratum.
- ✗ Low shear strength of hydrated bentonite (for unreinforced GCLs).
- ✗ GCLs can be punctured during or after installation.
- ✗ Possible loss of bentonite during placement.
- ✗ Low moisture bentonite permeable to gas.
- ✗ Potential strength problems at interfaces with other materials.
- ✗ Smaller leachate attenuation capacity.
- ✗ Possible post-peak shear strength loss.
- ✗ Possible higher long-term flux due to a reduction in bentonite thickness under an applied normal stress.
- ✗ Possible increase of hydraulic conductivity due to compatibility problems with contaminant if not prehydrated with compatible water source.
- ✗ Higher diffusive flux of contaminant in comparison with compacted clay liners.
- ✗ Prone to ion exchange (for GCLs with sodium bentonite).
- ✗ Prone to desiccation if not properly covered (at least 0.6m of soil).

Table 1. Potential equivalency between geosynthetic clay liners and compacted clay liners

Category	Criterion for evaluation	Equivalency of GCL to CCL			
		GCL probably superior	GCL probably equivalent	GCL probably inferior	Site or product dependent
Construction issues	Ease of placement	X			
	Material availability	X			
	Puncture resistance			X	
	Quality assurance	X			
	Speed of construction	X			X
	Subgrade condition	X			
	Water requirements				X
	Weather constraints				X
Contaminant transport issues	Attenuation capacity			X(1)	X
	Gas permeability				X
	Solute flux and breakthrough time	X(2)		X	
Hydraulic issues	Compatibility	X(2)		X	
	Consolidation water	X			
	Steady flux of water		X		
	Water breakthrough time				X
Physical/mechanical issues	Bearing capacity				X
	Erosion				X
	Freeze–thaw	X			
	Settlement-total		X		
	Settlement-differential	X			
	Slope stability				X
	Wet–dry	X			

(1) Based only on total exchange capacity
(2) Only for GCLs with a geomembrane

Geotextiles

Geotextiles are permeable geosynthetic comprised solely of textiles used with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made product, structure, or system. The functions of geotextiles are separation, reinforcement, filtration, and drainage.

Due to the very wide range of applications and the variety of available geotextiles having widely different properties, the selection of a particular design method, or design philosophy is a critical decision that must be made before the actual mechanics of the design process are initiated.

Properties comparison between geomembranes

Table 2. Advantages and limitations of commonly used synthetic geomembranes.

Geomembranes	Advantages	Limitations
HDPE	• Broad chemical resistance • Good weld strength • Good low temperature properties • Relatively inexpensive	• Potential for stress cracking • High degree of thermal expansion • Poor puncture resistance • Poor multiaxial strain properties
LLDPE	• Better flexibility than HDPE • Better layflat than HDPE • Good multiaxial strain properties	• Inferior UV resistance to HDPE • Inferior chemical resistance to HDPE
PVC	• Good workability and layflat behaviour • Easy to seam • Can be folded so fewer field fabricated seams	• Poor resistance to UV and ozone unless specially formulated • Poor resistance to weathering • Poor performance at high and low temperatures

Table 3. Comparison of HDPE geomembrane properties with PVC

Property	HDPE	PVC
Tensile strength	✓✓✓✓	✓✓✓
Puncture resistance	✓✓	✓✓✓
Chemical resistance	✓✓✓✓	✓✓
UV resistance	✓✓✓	✓
Heat resistance	✓✓✓✓	✓
Microbial resistance	✓✓✓	✓
Ease of placement	✓	✓✓✓✓
Cold weather problems	✓✓	✓
Installed cost Moderate	Moderate	Low

Table 4. Comparison of geomembranes properties

Property	HDPE	LLDPE	PVC
Water tightness	A	A	A
UV resistance	A	D	D
Service life	A	C	D
Cold temperature impact	C	B	D
High temperature resistance	B	D	D
Flexibility	D	B	A
Elasticity	D	D	D
Tensile strength	A	B	C
Chemical resistance	A	B	C
Resistance to hydrocarbons	B	C	C
Stress crack resistance	D	B	B
Yield point	D	C	C
Resistance to plasticizer extraction	A	A	D
Root resistance	A	A	B
Resistance to microbiological attack	A	A	C
Puncture resistance	C	D	B
Surface friction	D (unless textured)	D (unless textured)	B
Slope stability	C (unless textured)	B (unless textured)	A
Thermal stability	C	B	C
Dimensional stability	D	D	B
Multiaxial strain	D	C	B
Resistance to settlements	C	B	A
Seamability	C	B	B
Seamability at cold temperatures	D	D	D
Seam strength	A	A	B
Seam testing	A	A	A
Ease of installation	C	C	A
Permeability	A	B	C
Environmental properties	A	A	D
Repairability	C	B	C
Details, design and installation	D	C	B
Conformance to substrate	D	C	B

A, excellent; B, good; C, fair; D, poor

Estimated cost of Supply and Installation

Table 5. Budget estimates

Geosynthetic	Unit Rate (AUD) ex GST
1.5mm HDPE (bespoke material) - BEPM	$9.25/m2
1.5mm LLDPE (enhanced)	$10.75/m2
0.75mm PVC	$12.75/m2
X1000 GCL	$13.25/m2

Prices are subject to the rise and fall for the USD:AUD exchange rate.
The above rates are based on the facilities being of a non-complex uniform shape.

Recommendations

After a careful revision of the Environment Protection Authority (EPA) Response of the *Buckland Park Riverlea - Amendment to EIS – Impact Assessed Development*, Geotest highlights the concern of the EPA in regards of the effectiveness of the proposed compacted clay liner will provide effective containment of the saline water in the lakes and prevent infiltration to groundwater and infiltration of groundwater into the lakes and lack of permeability information.

Geotest strongly advocates for the adoption of a geosynthetic lining system over a traditional compacted clay liner for several reasons:

- Cost-effectiveness: geosynthetic liners often prove to be more economical in both procurement and installation compared to compacted clay liners.
- Geosynthetic liners have a superior hydraulic barrier capability, which ensures enhanced containment efficacy, mitigating the risk of leakage or seepage and thereby safeguarding environmental integrity.
- High chemical resistance. This resistance shields the liner from degradation or deterioration, preserving its structural integrity and functional performance over extended periods.
- The remarkable longevity, with expected service lives typically ranging from 20 to 100 years. This extended lifespan not only underscores the durability and reliability of these liners but also underscores their sustainability and long-term value proposition.

References

Bouazza, A. (2002). Geosynthetic clay liners. *Geotextiles and Geomembranes, 20*(1), 3 - 17.

Koerner, R.M. (2012). *Designing With Geosynthetics* - 6th Edition Vol. 1

Koerner, R.M. (2012). *Designing With Geosynthetics* - 6th Edition Vol. 2

Peggs, I.D. & Giroud, J.P. (2014). *Action leakage rate for reservoir geomembrane liners*. 10th International Conference on Geosynthetics, ICG 2014.

Scheirs, J. (2009). *A Guide to Polymeric Geomembranes: A Practical Approach*. Wiley

Water Engineering Partners Pty Ltd
Level 1, 21 Quay Street Brisbane Qld 4000
PO Box 5106, West End QLD 4101

Phone:
Email: info@wep.com.au
Website: wep.com.au
ABN 47 664 596 105

Date: 15 July 2024

Walker Corporation
9 Bonnin Crescent
Riverlea Park SA 5120

Attention: Patrick Mitchell

Dear Patrick,

Updated Assessment -Riverlea and Buckland Dry Creek (BDC) Salt Water Extraction Pumping

1.0 Purpose of the Assessment

We write to provide an updated assessment of the combined effect of existing and proposed sea water extraction from Chapman Creek by the Riverlea development and by BDC. BDC was previously Cheetham Salt and it operates a salt production facility adjacent to Chapman Creek, using shallow salt fields and solar evaporation to produce salt, with the salt water pumped from Chapman Creek. The Riverlea development proposes three salt water lakes as part of the development, with salt water proposed to be pumped from Chapman Creek.

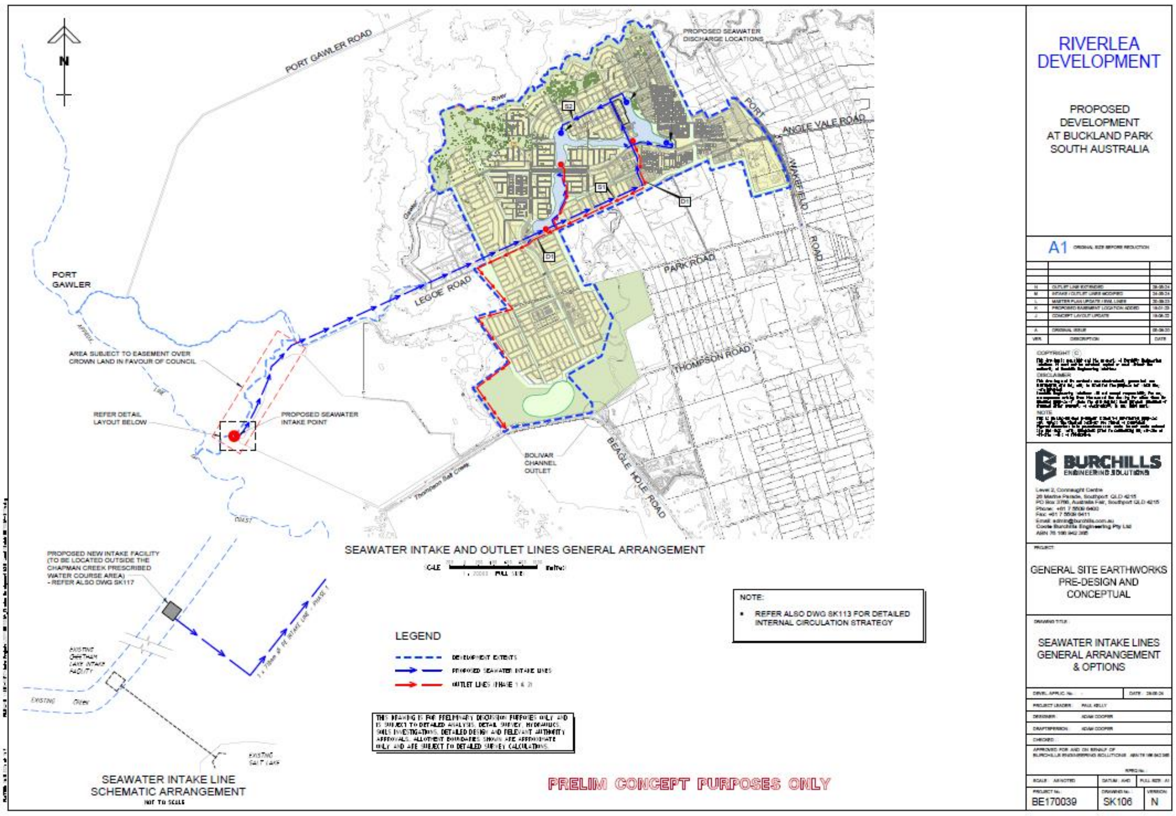
This advice has been prepared by Martin Giles and Neil Collins of Water Engineering Partners and updates and supersedes the previous advice prepared by Martin Giles detailed in BMT's Technical Memorandum '*Use of Chapman Creek to supply saline water to Riverlea Development'* dated 11 February 2022.

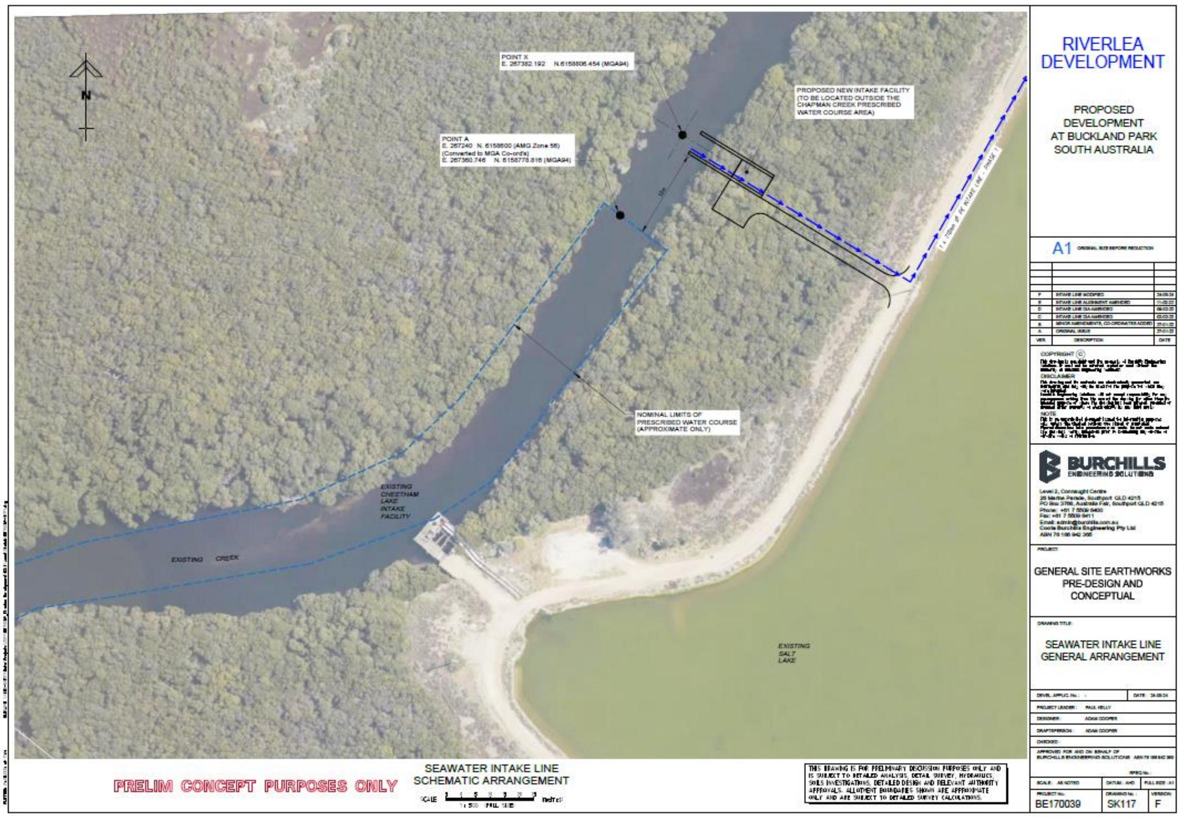
Since the completion of BMT's memorandum, the lake concept design and water circulation system for the Riverlea Development has been refined with significantly reduced salt water extraction now proposed over that assessed by BMT in 2022. The revised concept design and water circulation system is detailed in Water Engineering Partners (WEP) *'Updated Lake Concept Design Report'* dated 10 July 2024.

In addition, Council has requested consideration of the cumulative impacts of salt water extraction to service both the Riverlea development and the BDC salt fields.

2.0 Background

The BMT memorandum provides details of the existing BDC and proposed Riverlea salt water intake pump stations on Chapman Creek and details the results of hydrodynamic tidal flow modelling assessments of the impacts of several pumping options for both BDC and Riverlea. The general arrangements and locations of the pump stations and delivery pipelines are shown in the Burchill drawings below.



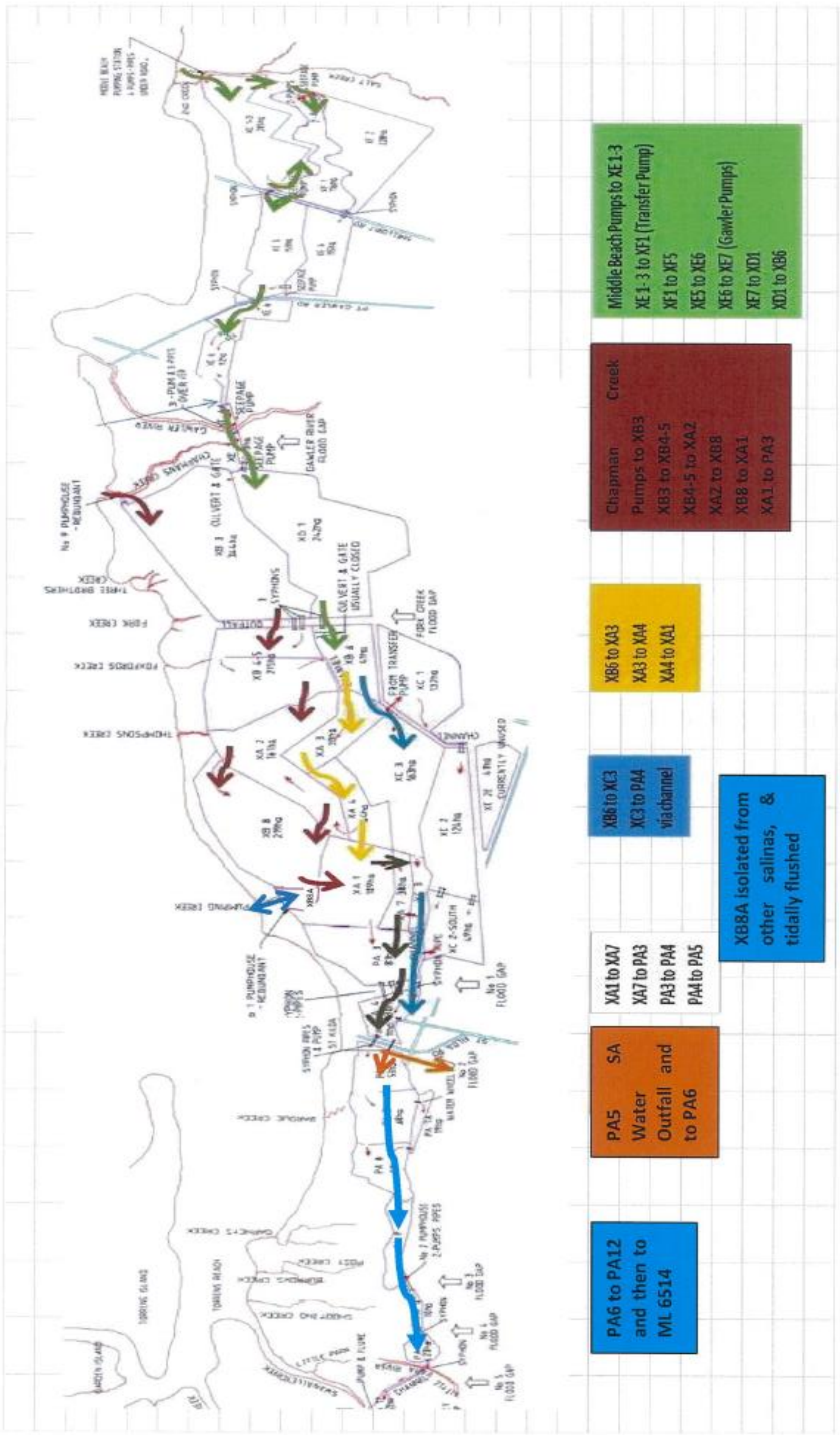


It is understood that currently BDC utilize one of their two 600mm delivery pipelines, which discharge to concrete pipes before discharge to the salt field, as shown in the photo below.

Photo1 -BDC delivery pipelines from pump station

Photo 2 – BDC outfall with only one pipe discharging at low velocity

The BDC pond layout and water holding paths are shown below.


PA6 to PA12 and then to ML 6514
PA5 SA Water Outfall and to PA6
XA1 to XA7
XA7 to PA3
PA3 to PA4
PA4 to PA5
XB6 to XC3
XC3 to PA4 via channel
XB8A isolated from other salinas, & tidally flushed
XB6 to XA3
XA3 to XA4
XA4 to XA1
Chapman Creek
Pumps to XB3
XB3 to XB4-5
XB4-5 to XA2
XA2 to XB8
XB8 to XA1
XA1 to PA3
Middle Beach Pumps to XE1-3
XE1-3 to XF1 (Transfer Pump)
XF1 to XF5
XE5 to XE6
XE6 to XE7 (Gawler Pumps)
XE7 to XD1
XD1 to XB6

The BMT memorandum estimates an existing pumping rate by BDC of 0.14 m^3/s, with 12,200 m^3 of water extracted per day from Chapman Creek, equating to 2.2 GL per annum with 365 days pumping. The water allocation licence held by BDC allows up to 65 GL per annum; however clearly only a small fraction of this allocation is actually used.

The Riverlea development proposes three lakes, which are to be progressively constructed in three phases, with lake volumes as follows:

- Lake SWL1 408 ML
- Lake SWL2 386 ML
- Lake SWL3 318 ML

Riverlea proposes a single 710mm diameter delivery pipeline from the proposed Chapman Creek pump station to the lakes, and the reduced pumping rate for the full three lakes detailed in the WEP 10 July 2024 report is 0.38 m^3/s with 10 hours pumping per day. For SWL1, the pumping rate proposed is 0.14 m^3/s with pumping for 10 hours per day. For SWL1 and 2, the pumping rate proposed is 0.27 m^3/s with pumping for 10 hours a day. With 365 days pumping in a year, this equates to 1.83GL per annum for SWL1 (phase 1), 3.55 GL per annum for SWL 1 and 2 (phase 2) and 5 GL per annum for SWL 1, 2 and 3 (phase 3).

The previous BMT memorandum assumed a lake volumetric turnover rate of 40 days, whereas the revised turnover strategy proposes an 80-day turnover rate. Hence, the previous daily extraction for Riverlea for SWL1 alone and for the combined SWL1, 2 and 3 assumed by BMT were 10,200 m^3 and 27,750 m^3 respectively. The current reduced turnover rate system detailed in the WEP 10 July 2024 report proposes daily extraction rates for SWL1 alone and for the combined SWL1, 2 and 3 of 5,100 m^3 and 13,680 m^3 respectively. This equates to 1.86 GL per annum and 5 GL per annum respectively.

3.0 Assessment of the combined impact of pumping by BDC and Riverlea development of Chapman Creek

BDC operate several seawater intakes, with Middle Beach being the main intake for salt field operations, and Chapman Creek being a secondary intake to keep ponds full for environmental reasons. It is understood that current salt water extraction from Chapman Creek by BDC is only using approximately 2.2 GL per annum, or 3.4 % of their licensed water allocation. With phase 1 (SWL1 only) of the Riverlea development operational, water use by Riverlea is proposed to be 1.86 GL per annum, which is 2.9% of the total extraction allowed by BDC under their licence. For the fully completed and operational phases 1-3 (SWL1, 2 and 3) of Riverlea, this increases to 5 GL per annum, or 7.7% of the total licensed BDC extraction.

Assuming the current extraction rate for BDC is doubled (the maximum allowable with the existing two delivery pipelines), the total combined water usage by BDC and the Riverlea development is 9.4 GL per annum, or 14.5% of the BDC licensed water allocation.

The current BDC pumping rates coupled with the ultimate 3 lake Riverlea development pumping rates is similar to (and slightly greater than) Case 4 from the BMT memorandum.

The table below is a results table from the BMT report.

Scenario	Inflow (Daily) (m^3)	Outflow (Daily) (m^3)	Effective Pump Rate (m^3/s)	Proportion of Pump Rate Supplied (%)
Case 1- No pumping- the natural condition of the creek	30,400	30,400	Nil	-
Case 2- Existing Cheetham Lake intake- the anticipated current situation	36,900	25,400	0.13	93
Case 3- With existing Cheetham Lake intake and Phase 1 of Riverlea lakes (0.12 m^3/s pump rate)	44,200	22,600	0.25	96
Case 4- With existing Cheetham Lake intake and full Riverlea lake system (0.32 m^3/s pump rate)	44,200	18,300	0.45	98
Case 5- With existing Cheetham Lake intake and sensitivity assessment of higher pump rate for Riverlea lake system (0.5 m^3/s pump rate)	66,100	14,500	0.60	94

Table 2 from BMT 11 February 2022 Memorandum

Case 4 predicts daily tidal inflows to increase over the rate with no pumping of 30,400 m^3 per day, to 44,200 m^3 per day. The BMT memo did not assess the impact of an annual 65 GL extraction rate by BDC; however this equates to 178,082 m^3 per day extraction, which is almost 6 times the daily tidal inflow and outflow. This would cause potentially a 6-fold increase in tidal velocities and significantly change the tidal range in the creek.

The existing BDC pump station and delivery pipeline system is old and of limited capacity. To fully utilize their licensed water allocation, it is estimated that they would need to build 14 new equivalent capacity pump stations (assuming two working pipelines on each), based on the estimated pumping rates. Such major works do not appear feasible, given the limited tidal flow in the creek and given the potential for environmental harm with such large increases in tidal velocity and changes in tidal range as a result of the increased pumping rate, in our view is unlikely to be able to be acceptable despite the ability to do so under the current licence.

The combined impact of the current BDC pumping and the ultimate phase 3 Riverlea development pumping is less than 10% of those impacts from BDC pumping alone if they were to expand to their maximum allocated annual extraction rate.

The existing BDC pumping reduces the daily tidal outflow in Chapman Creek by 5000 m^3 and this increases by an additional 7,100 m^3 with the full Riverlea system in place; however the daily tidal inflow increases by 13,800 m^3 with the combined existing BDC and full Riverlea system in place, which provides improved flushing with additional water from the bay brought into the creek each tide cycle. These changes are also small compared to the changes in tidal inflow and outflow that would result if the BDC pumping rate was to increase significantly, within the licensed limit.

4.0 Proximity of the existing BDC pump station and the proposed Riverlea development pump station

Both pump stations are for the extraction of salt water from the creek, which is connected to St Vincents Gulf. Neither operation discharges waters from their operations in the vicinity of these pump stations. At 150 m separation, there is no potential for the Riverlea pump station to interfere with the operation of efficacy of the BDC pump station.

5.0 Seasonal variability considerations

Whilst evaporation rates reduce considerably in the winter months, total evaporation from the Riverlea development is very minor, even in the hottest months, compared to the proposed lake turnover pumping volumes. Neap versus spring tides have a much larger effect on water exchange between Chapman Creek and St Vincents Gulf; however, over a full lunar monthly cycle, there is only a small difference in total tidal prism exchange from summer to winter.

Seasonal variability has a much more significant impact on BDC's operations, so pumping requirements will be significantly less than assumed in this advice in the winter months.

The Riverlea development's salt water extraction proposed will have no significant effect on seasonality impacts on BDC's operations.

6.0 Conclusion

Based on the above, the Riverlea development will only have a minor impact on Chapman Creek flows and velocities and when compared to the impacts of the licensed BDC extraction rate of 65 GL per annum (2.9% for phase 1 and 7.7% for phase 3 fully completed development). Realistically, the licensed BDC extraction rate is unlikely to be technically feasible to implement, as discussed below.

Tidal velocity and height impacts from the combined impact of the existing BDC salt water extraction and the proposed ultimate Riverlea development salt water extraction are minor compared to those from the current BDC licensed extraction rate. BDC currently only operate one 600mm diameter extraction line from Chapman Creek, drawing only 2.2 GL per annum. Phase 1 and ultimate phase of the Riverlea development extract 1.86 GL per annum and 5 GL per annum respectively from Chapman Creek. The Riverlea salt water extraction from Chapman Creek will not significantly impact the current BDC operations or adversely impact Chapman Creek tidal flows and flushing, based on tidal modelling to date, with improved inflow flushing for the creek predicted due to increased daily tidal inflow volumes.

There are likely to be adverse environmental impacts should BDC significantly increase their pumping operations within the licensed water extraction limit, due to unacceptable increases in tidal velocities and changes in tidal range in the creek. From a technical viewpoint, for BDC to achieve their full licensed extraction rate, major dredging works to the mouth and into the bay, to increase the creek's cross sectional area several times its existing area would be required. In addition, a minimum 14 fold increase in pumping capacity over existing pumping would be required. The modest Riverlea extraction rate in comparison to the full BDC take would have no effect on the works required by BDC to achieve increases in extraction rate.

We are advised that dredging works would trigger the need for a number of other environmental approvals and given the magnitude of works required, and the potential adverse impacts, it appears highly questionable whether such approvals would be granted.

7.0 Qualifications

This assessment draws on the results of previous hydrodynamic modelling by BMT which was uncalibrated, and as stated in BMT's memorandum, further detailed hydrodynamic and water quality modelling will be required to be undertaken to better inform the design for the lake system proposed at the Riverlea development. This should include the further definition of future pumping rates and timings for the BDC intake facility.

The full utilisation by BDC of their 65 GL per annum water allocation has not been modelled however it is apparent that major adverse changes to creek velocities and tidal range would result from such a major increase in pumping rate over the existing rate. Detailed modelling is required to determine the feasibility and impact of the change. Any major dredging works by BDC would increase the tidal flow and prism and would also affect the proposed Riverlea extraction and tidal modelling would be required to assess those impacts.

Yours faithfully

Water Engineering Partners Pty Ltd
Neil Collins Expert advisor