Appendix V

Surface water impact assessment

Surface water assessment

Woodlawn Advanced Recovery Centre

Prepared for Veolia Environmental Services (Australia) Pty Ltd

July 2022

Surface water assessment

Woodlawn Advanced Recovery Centre

Veolia Environmental Services (Australia) Pty Ltd

J200931 RP13

July 2022

Version	Date	Prepared by	Approved by	Comments
1	7 October 2021	Chris Kuczera	Chris Kuczera	Draft for Veolia review
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3	9 June 2022	Chris Kuczera	Chris Kuczera and Kate Cox	Draft for Veolia review
4	12 July 2022	Chris Kuczera	Chris Kuczera and Kate Cox	EIS submission

Approved by

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12 July 2022

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Executive Summary

ES1 Introduction

Veolia Environmental Services (Australia) Pty Ltd (Veolia) owns and operates the Woodlawn Eco Precinct (the Eco Precinct), located on Collector Road, approximately 6 kilometres (km) west of Tarago, 50 km south of Goulburn and 70 km north of Canberra.

The Eco Precinct was established at the former Woodlawn mine site and has prioritised sustainable and innovative waste management practices for the last 20 years and currently includes multiple waste management and renewable energy operations. It is an important waste management site for NSW, accepting approximately 40% of Sydney's residual putrescible waste. It forms a key part of a waste management system which comprises two transfer terminals in Sydney (Clyde and Banksmeadow) where municipal waste is sorted and loaded into rail containers for transport by rail to the Crisps Creek Intermodal Facility and then on to Woodlawn by truck.

The Woodlawn Advanced Energy Recovery Centre (ARC) (the project) is an energy recovery facility (ERF) that is proposed as the next phase of development at the Eco Precinct. The project is classified as a State significant development (SSD) under the *Environmental Planning and Assessment Act 1979* (EP&A Act) in accordance with clauses 20 and 23 of Schedule 1 of *State Environmental Planning Policy* (Planning Systems) *2021*.

An environmental impact statement (EIS) for the project has been prepared by EMM Consulting Pty Limited (EMM) on behalf of Veolia. This Surface Water Assessment supports the EIS for the project. It describes the existing surface water environment, the proposed water management approach and residual impacts. The assessment has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) for the project, issued 2 July 2021, and considers relevant government and industry guidelines.

ES2 Project description

The project involves the construction and operation of the ARC and ancillary infrastructure. Key components of the project include:

- The ARC building – will house the energy recovery plant and will be fully enclosed.
- The incinerator bottom ash (IBA) area – provides for the processing of IBA for reuse and or disposal and includes screening, metals recovery and maturation.
- The encapsulation cell – a lined and engineered landfill cell for encapsulation stabilised air pollution control residues (APCr) from the flue gas treatment system. The encapsulation cell will be located approximately 1.8 km north-west of the ARC building within an existing evaporation dam known as Evaporation Dam 1 (ED1).

A more detailed project description is provided in Chapter 2.

ES3 Existing environment

ES3.1 Surface water environment

The Eco Precinct is in the Southern Tablelands region of NSW, which has a sub-humid temperate climate characterised by hot summers, cold winters and no dry season. The Eco Precinct is located on the Great Dividing Range. The western and southern portions of the Eco Precinct drain to the west through several small watercourses that flow into Lake George. The northern and eastern portions of the precinct are within the Crisps Creek catchment. Crisps Creek is a tributary to the Mulwaree River. The Mulwaree River is a major tributary of the Wollondilly River, which ultimately flows into Lake Burragorang (also known as Warragamba Dam). Lake Burragorang is a major water supply dam for the Sydney metropolitan region and is managed by WaterNSW.

The project, including both the ARC and encapsulation cell, is within the Crisps Creek catchment. Hence, Crisps Creek is the only receiving watercourse described in this assessment. It is noted that runoff from existing disturbed areas within the development footprint is currently captured in the Eco Precinct's water management system and does not enter Crisps Creek.

The ARC building and incinerator bottom ash (IBA) area will be located within the existing catchment area to the Plant Collection Dam (PCD). The PCD was originally established to manage water from an ore processing plant and has a contributing catchment area of 31.3 ha that comprises: the former processing plant area, Woodlawn BioEnergy Power Station and various internal roads and unused areas. Metalliferous waste from former activities is present in some areas and water collected in the PCD is known to have a low pH and elevated salinity levels and metal concentrations. Currently all water collected in the PCD is pumped to ED1, which is described below. Veolia has not observed the PCD to overflow during the 20 years that they have operated the site.

ES3.2 Existing water management system

The Eco Precinct's existing water management system comprises several runoff capture dams, pumped reticulation systems, a leachate treatment plant and several evaporation dams. Veolia operates the system to manage:

- separated leachate and surface water runoff that is pumped from the Bioreactor landfill;
- surplus water from the Waste Rock Dam, which receives seepage from waste rock dumps located to the south of the Bioreactor landfill; and
- surplus water that accumulates in the PCD, which receives runoff from the PCD catchment.

The overall water management system comprises the following components, which are operated independently:

- ED1 system – receives direct rainfall, runoff from the surrounding area, a catchment area to the west of the Bioreactor landfill and water pumped from the Waste Rock Dam and PCD. Water accumulation is managed via natural and assisted evaporation from ED1.
- Evaporation Dam 3S system – receives direct rainfall, runoff from the surrounding area and runoff captured in the Bioreactor landfill. Water accumulation is managed via natural evaporation from ED3S.
- Leachate management system – manages leachate that is pumped from the Bioreactor landfill. Leachate is initially treated in the Leachate Treatment Plant and dam. Six evaporation dams are used to manage the accumulation of treated leachate via natural and assisted evaporation.
- ED2 system – ED2 is located to the west of ED1. ED2 is part of the Woodlawn Mine operation.

The potential impacts of the project on the operational effectiveness of ED1 due to construction and operation of the encapsulation cell within ED1 and other aspects of the project are addressed in this report. The project will not interact or impact the operational effectiveness of the ED3S, leachate management or ED2 systems.

ES4 Proposed water management system

A water management system will be developed for the project to manage stormwater runoff during construction and operations, supply water to the project and manage contaminated water streams and wastewater (ie sewage). Table ES1 provides as summary of the water management approach.

Table ES1 Water management approach summary

	Management approach
Water management during construction	
Construction water management	• The northern portion of the access road will be constructed downstream of the PCD catchment in an area that drains to Crisps Creek. Surface water runoff from the area disturbed by the construction of the road will be managed in accordance with the methods recommended in *Managing Urban Stormwater: Volume 1* (Landcom 2004). • Aside from the northern portion of the access road, the ARC will be constructed within the PCD catchment, and the encapsulation cell will be constructed within ED1. All surface water runoff and any water produced by construction activities will be managed in the PCD and ED1 system. No off-site discharges are expected.
Water management during operations	
Stormwater system	The following stormwater management systems will be developed: • **Access road stormwater system (1.1 ha)** – this system will manage stormwater runoff from the northern portion of the access road that is not within the PCD catchment. Runoff will be managed in vegetated roadside swales and will discharge to the Crisps Creek catchment. • **ARC stormwater system (9.8 ha)** – this system will manage stormwater runoff from the ARC and surrounding hardstand and landscaped areas. The system will include source controls to minimise stormwater contamination risks and a stormwater harvesting system that will capture stormwater runoff for use in the process water system. During the initial operating period, the system will overflow to the PCD. However, the system will be developed such that it can be integrated into a future stormwater system in the PCD catchment, that overflows to the receiving environment • **IBA area stormwater system (2.2 ha)** – this system will manage stormwater runoff from the IBA area which may be potentially contaminated. Accordingly, a stormwater capture and harvesting system is proposed that has capacity to capture all runoff during a 1% Annual Exceedance Probability (AEP) event.

Table ES1 Water management approach summary

	Management approach
Process water system	**Overview** The operation of the ARC will require water for steam generation, steam conditioning, ash quenching, APCr stabilisation, operation of the flue gas treatment system (FGT system), dust suppression within the IBA area and other miscellaneous uses. A process water system will be established to meet these operational water requirements and manage associated contaminated water streams. **Water supply arrangements** The operation of the project will require an ongoing water supply of approximately 245 kL/day or 90 ML/year. This water will be sourced from stormwater harvesting (when available) and the Willeroo Borefield (when stormwater is not available) via existing pipeline infrastructure at the Eco Precinct which connects the ARC development footprint to the Willeroo Borefield. During drought conditions, it is anticipated that the Willeroo Borefield will meet the project's full water supply requirements for extended periods of time. **Contaminated water management** The process water system will utilise potentially contaminated stormwater runoff captured in the IBA area stormwater system and recycled process water that could comprise a mixture of raw water, brine and return water from the wash down and steam cycle systems. Under certain circumstances (such as extended wet weather) there may be surplus process water that requires management via dewatering to ED1. This contingency arrangement will ensure that all contaminated stormwater or recycled process water is managed in either the process water system or ED1, with no discharges to the stormwater system expected.
Wastewater system	A new on-site wastewater system will be established to manage wastewater (ie sewage) produced within the ARC's amenities. The system will be designed and operated in accordance with the methods described in *Designing and Installing On-Site Wastewater Systems (WaterNSW 2019b)*

ES5 Residual surface water impacts

The project's water management system will be integrated with parts of the Eco Precinct's water management system, which may evolve over time for a variety of reasons such as completion of rehabilitation works. Three water management objectives have been established to enable a clear and concise assessment of the project's residual impacts. The three objectives are:

- Objective 1 – achieve a neutral or beneficial effect (NorBE) on the operational effectiveness of ED1;
- Objective 2 – achieve a NorBE on receiving water quality; and
- Objective 3 – provide a drought secure water supply for the project.

Table ES2 describes how these objectives are addressed in this report.

Table ES2 Compatibility with water management objectives

	Management approach
Objective 1 – achieve a NorBE on the operational effectiveness of ED1	ED1 is an evaporation dam that is currently used to manage contaminated water from the PCD and the Waste Rock Dam. Under the current operating arrangement, surplus water from the PCD and Waste Rock Dam is pumped to ED1 to prevent overflows to the receiving environment. Water accumulation in ED1 is managed via natural and assisted evaporation, which is a gradual process that varies seasonally. Accordingly, the operational effectiveness of ED1 to manage surplus water from the PCD and Waste Rock Dams is a function of the dam's ability to store water during extended wet periods and manage water accumulation via evaporation. The project will result in the following changes to the ED1 water balance: • **Mechanism 1** - The encapsulation cell will be constructed in the western portion of ED1. This will reduce the storage volume and evaporation area of ED1, reducing its operational effectiveness. • **Mechanism 2** – Surplus process water may be dewatered to ED1. This will utilise some of the storage and evaporation capacity, reducing the capacity available to manage pumped inflows from the PCD and Waste Rock Dam. • **Mechanism 3 -** Stormwater harvesting will be incorporated into the proposed ARC and IBA area stormwater systems. This will reduce (relative to existing conditions) the runoff volume to the PCD. The lower runoff volumes to PCD will reduce the storage and evaporation capacity required in ED1 to manage pumped inflows from the PCD, thereby increasing the available capacity in the dam. Achieving a NorBE on the operational effectiveness of ED1 is a water management objective for the project. A NorBE can be achieved if one of the following criteria is met: 1. the cumulative changes due to the project result in lower water levels in ED1, for a full range of weather conditions; or 2. the cumulative changes due to the project result in higher water levels in ED1, but there is no impact to the operational effectiveness of the dam, in that it can still receive pumped inflows from the PCD and Waste Rock Dam for a full range of weather conditions. Consistency with this objective is demonstrated using water balance modelling of the ED1 system.
Objective 2 – achieve a NorBE on receiving water quality	The water management system will be developed to have a NorBE on receiving water quality. This can be achieved by a water management system that: • separates potentially contaminated water from stormwater runoff; • includes a stormwater management system that is consistent with industry best practice (also referred to as current recommended practices) for an industrial area; and • includes a wastewater (ie sewage) management system that is designed and operated in accordance with the methods described in *Designing and Installing On-Site Wastewater Systems (WaterNSW 2019b).* Consistency with this objective is demonstrated by establishing best practice and MUSIC water quality modelling to address WaterNSW's NorBE assessment criteria.
Objective 3 – provide a drought secure water supply for the project	The operation of the project will require an ongoing water supply of approximately 245 kL/day or 90 ML/year. This water will be sourced from stormwater harvesting (when available) and the Willeroo Borefield (when stormwater is not available). During drought conditions, it is anticipated that the Willeroo Borefield will meet the project's full water supply requirements for extended periods of time, supplied to the ARC via existing pipeline infrastructure. Accordingly, this EIS assumes that the Willeroo Borefield will provide up to 90 ML/year to the project. Refer to the Groundwater Assessment (EIS Appendix U) for detailed information on the Willeroo Borefield, an assessment of sustainable yields and water licencing provisions.

TABLE OF CONTENTS

Appendices

Tables

Figures

Photographs

1 Introduction

1.1 Report context

Veolia Environmental Services (Australia) Pty Ltd (Veolia) own and operate the Woodlawn Eco Precinct (the Eco Precinct), located on Collector Road, approximately 6 kilometres (km) west of Tarago, 50 km south of Goulburn and 70 km north of Canberra. The Eco Precinct is in the Goulburn Mulwaree local government area (LGA). The regional setting is shown in Figure 1.1.

The Eco Precinct was established at the former Woodlawn mine site and has prioritised sustainable and innovative waste management practices for the last 20 years and currently includes multiple waste management and renewable energy operations. It is an important waste management site for NSW, accepting approximately 40% of Sydney's residual putrescible waste. It forms a key part of a waste management system which comprises two transfer terminals in Sydney (Clyde and Banksmeadow) where municipal waste is sorted and loaded into rail containers for transport by rail to Crisps Creek and then on to Woodlawn by truck.

The Woodlawn Advanced Energy Recovery Centre (ARC) (the project) is an energy recovery facility (ERF) that is proposed as the next phase of development at the Eco Precinct. The project is classified as a State significant development (SSD) under the *Environmental Planning and Assessment Act 1979* (EP&A Act) in accordance with clauses 20 and 23 of Schedule 1 of *State Environmental Planning Policy* (Planning Systems) *2021*.

An environmental impact statement (EIS) for the project has been prepared by EMM Consulting Pty Limited (EMM) on behalf of Veolia. This Surface Water Assessment forms part of the EIS for the project.

1.2 Report purpose and assessment requirements

This Surface Water Assessment supports the EIS for the project. It describes the existing surface water environment, the proposed water management approach and residual impacts. The assessment has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) for the project, issued 2 July 2021, and considers relevant government and industry guidelines.

Table 1.1 lists SEARs relevant to soil and water and notes where they are addressed in this report or other parts of the EIS.

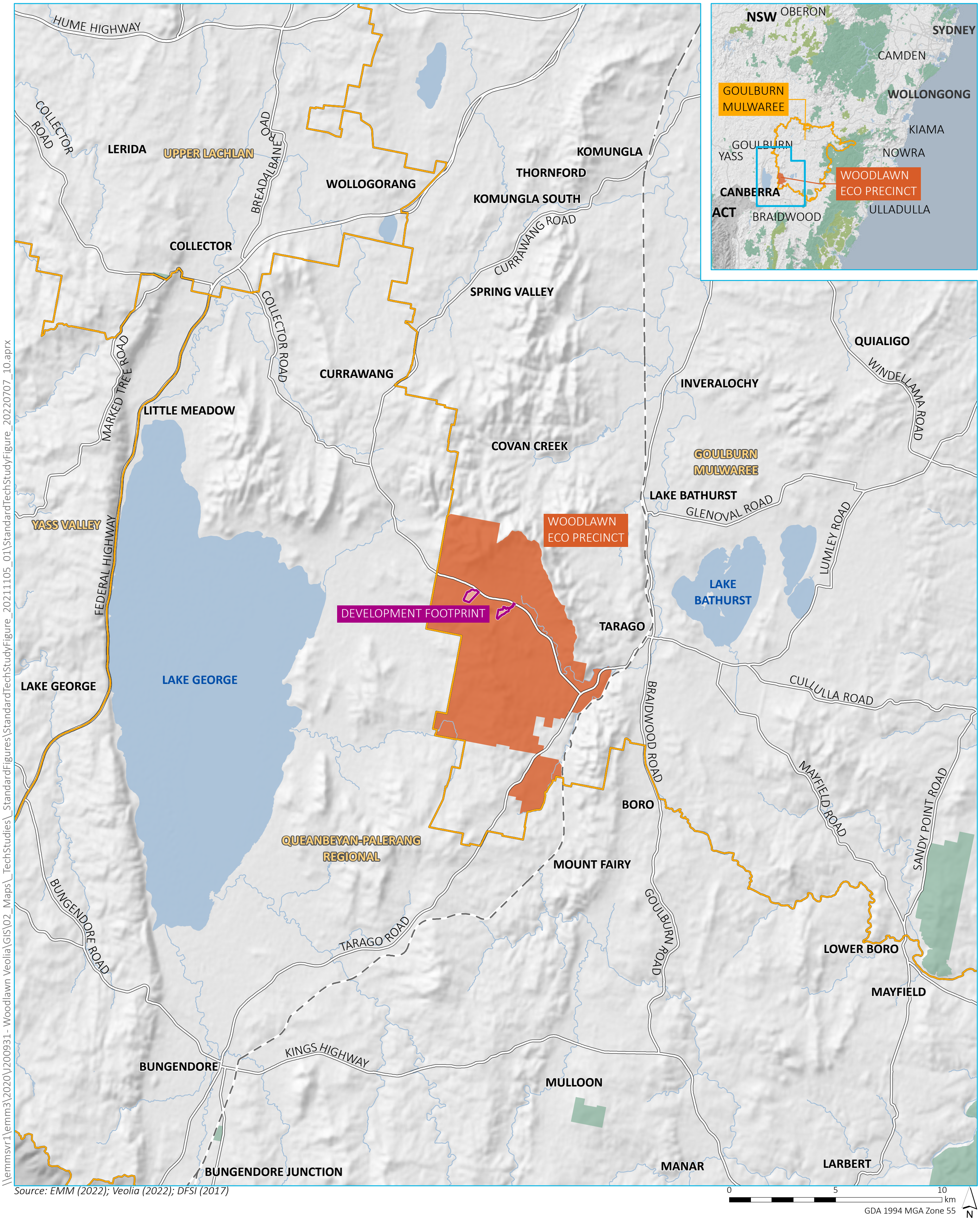
Table 1.1 Assessment requirements

SEARs	Report section / EIS reference
An assessment of potential surface and groundwater impacts associated with the development, including potential impacts on watercourses (Crisps Creek and the Mulwaree River sub-catchment), riparian areas, groundwater, and groundwater dependent communities.	• Residual impacts to the surface water environment are described in Chapter 6. • Residual impacts to the groundwater environment are described in the Groundwater Assessment (EMM 2022), which is provided as Appendix U to the EIS.
A detailed site water balance including a description of the water demands and breakdown of water supplies, any water licensing requirements, identification of an adequate and secure water supply for the life of the project and details of how the proposal will interact with the existing water management system for the Eco Precinct.	• A water balance for the project's water management system is provided in Chapter 5. • Water licensing requirements are described in Chapter 7 and in the Groundwater Assessment (EIS Appendix U). • Residual impacts to the Eco Precincts existing water management system are described in Chapter 6.
Details of the stormwater/wastewater management system including the capacity of the onsite detention system(s), onsite sewage management system and measures to treat, reuse or dispose of water.	• A description of the proposed water management approach is provided in Chapter 5.
Demonstration of a Neutral or Beneficial Effect on water quality in accordance with State Environmental Planning Policy (Biodiversity and Conservation) 2021	• An assessment against Water NSW's Neutral or Beneficial Effect on water quality is provided in Chapter 6.
A detailed flooding assessment.	• Flood risks are addressed in Section 4.2.1.
A geotechnical assessment of land capability, ground stability and soil suitability for the development, including the placement of air pollution control residues.	• A Reference Design of the encapsulation cell is provided in the Encapsulation cell design (Golder 2022a), which is provided as Appendix F of the EIS.
A site contamination assessment in accordance with relevant EPA guidelines.	• A Preliminary Site Investigation report (Golder 2022b) is provided as Appendix W of the EIS
Description of the proposed erosion and sediment controls during construction.	• Water management during construction is described in Section 5.3.
Details of all soil and water management, mitigation and monitoring measures.	• Proposed management and monitoring plans are described in Chapter 8.

1.3 Report structure

This report is structed as follows:

- Chapter 2 describes the existing Eco Precinct and the project;
- Chapter 3 describes regulations and government and industry and guidelines that have been considered in this assessment;
- Chapter 4 describes the existing environment, as relevant to this assessment;
- Chapter 5 describes the water management approach for the project;
- Chapter 6 describes residual impacts to the surface water environment;
- Chapter 7 addresses water licensing requirements; and
- Chapter 8 describes proposed water management and monitoring plans.



Source: EMM (2022); Veolia (2022); DFSI (2017)

KEY

- Development footprint
- Woodlawn Eco Precinct
- Rail line
- Major road
- Watercourse
- Named waterbody
- NPWS reserve
- Local government area

Regional setting

Woodlawn Advanced Energy Recovery Centre
Surface water assessment
Figure 1.1

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2 Project and site description

This chapter provides an overview of the site history and describes the existing Eco Precinct and the project.

2.1 Site history

Historically, metalliferous ore were extracted at the Eco Precinct site to produce copper, lead and zinc concentrates. Historic mining at the Eco Precinct was undertaken by Denehurst Limited. Between 1978 and 1987 mining was open cut, and from 1987 to 1998 underground mining was also undertaken. The open cut mine void was approximately 200 m deep and 700 m wide, while underground mining extended 460 m below the base of the pit. The former mine workings extend below Evaporation Dam 1 (ED1), at depths of around 690 m AHD (Parsons Brinckerhoff 2012).

In 2001 following the closure of the former mining operations, Veolia (then Collex) purchased the Woodlawn property with the intention of establishing the site for waste management purposes whilst also rehabilitating the degraded mine site and broader mine-related area.

While mining operations ceased in the late 1990s, the rights to Special Mining Lease (SML) 20, were transferred to the mine operator under an agreement with Veolia to determine responsibilities for the site management and rehabilitation. Mining operations at the Eco Precinct were approved in 2013 for the area covered by SML 20, and operations commenced in 2015. The mine is currently in care and maintenance.

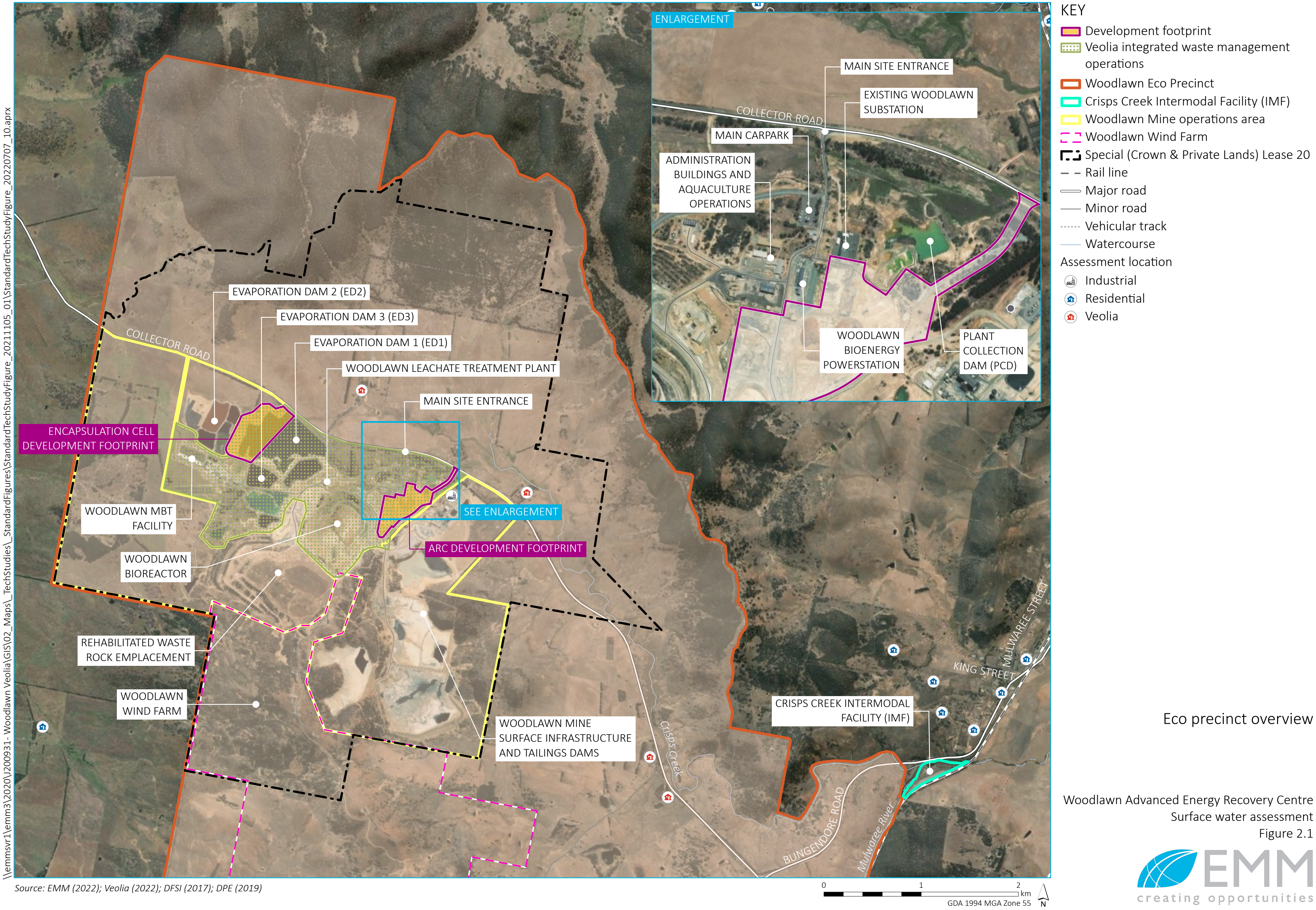
2.2 Eco Precinct description

The Eco Precinct comprises the following integrated waste management operations, energy recovery technologies and energy generation, and other sustainable land uses:

- Woodlawn Bioreactor (the Bioreactor landfill) – a putrescible residual waste landfill in which leachate is recirculated to help bacteria break down the waste, enhancing the early generation of gas, enabling more efficient capture and extraction of landfill gas, including leachate and landfill gas management systems.
- Woodlawn BioEnergy Power Station – utilises landfill gas from the Bioreactor to generate electricity.
- Woodlawn Mechanical Biological Treatment (MBT) Facility – processes MSW to extract the organic content for use in tailings dam remediation.
- Agriculture – a working farm (sheep and cattle) that applies sustainable management practices.
- Aquaculture and horticulture – operation which uses captured waste heat from the BioEnergy Power Station for use in sustainable fish farming and hydroponic horticulture at the Eco Precinct.
- Renewable energy generation – the Woodlawn Wind Farm (operated by Iberdrola) which has an installed capacity of 48.3 MW, and a solar farm (operated by Veolia) with an installed capacity of 2.3 MW.

Veolia also operates the Crisps Creek Intermodal Facility (IMF) which is located approximately 6 km east of the Eco Precinct. The Eco Precinct also includes the Woodlawn Mine operated by the mine operator.

Contaminated water produced by the Bioreactor and Woodlawn Mine is managed in a series of evaporation dams that are located to the north of the Bioreactor. The existing water management system is described in Chapter 4. Figure 2.1 shows the layout of the Eco Precinct and the abovementioned features.



Source: EMM (2022); Veolia (2022); DFSI (2017); DPE (2019)

Eco precinct overview

Woodlawn Advanced Energy Recovery Centre
Surface water assessment
Figure 2.1

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2.3 Project development footprint

The project's development footprint encompasses the extent of surface disturbance proposed by the project and assessed in the EIS. All works and disturbance for the project will occur within the development footprint and they are:

- The ARC – portion of the development footprint encompassed by the main ARC building and ancillary infrastructure, IBA area and new access road and intersection. This area currently contains former mine plant infrastructure, water management infrastructure (plant collection dam) and other disturbed areas used for ancillary waste management operations.

- Encapsulation cell – the area encompassed by the dedicated lined and engineered cells for the encapsulation of stabilised air pollution control residues (APCr) from the flue gas treatment system (FGT system), and associated management of leachate. This area is disturbed and currently comprises water management infrastructure (Evaporation Dam 1, known as ED1).

The development footprint is shown in Figure 2.2, and is also noted on most figures presented in this report.

2.4 Project description

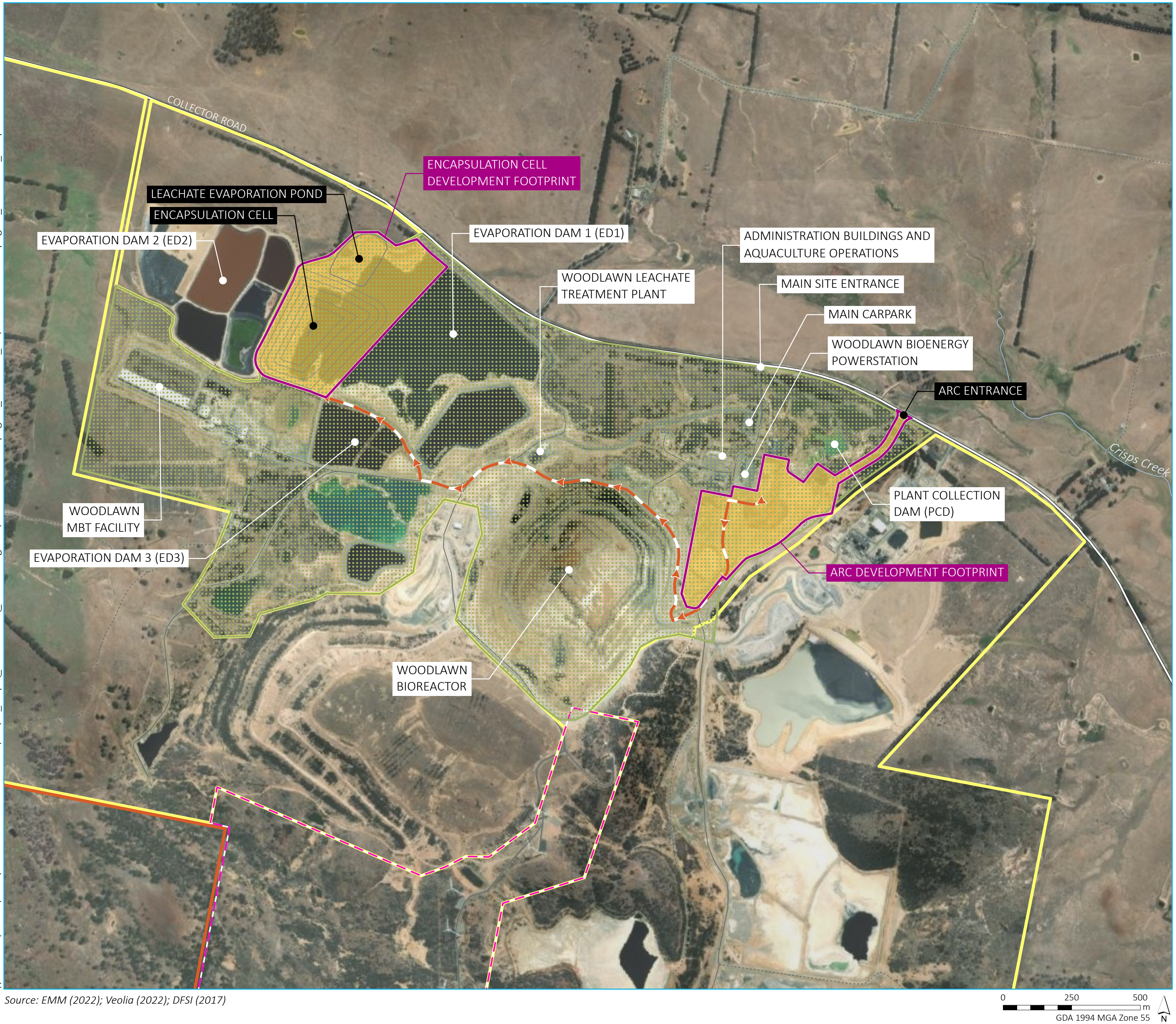
The project involves the construction and operation of the ARC and ancillary infrastructure. Table 2.1 provides a description of the key project elements. Figure 2.3 and Figure 2.4 show the layout of the ARC and encapsulation cell. Some aspects of the project that are relevant to water management are described in further detail in Chapter 5.

Table 2.1 Project description

Project element	Summary of the project
The ARC building	The ARC building will house the energy recovery facility and will be fully enclosed. The building will be approximately 54 m at the highest point of the roof, with a stack of approximately 85 m in height. Residual waste feedstock will be processed within the ARC building to generate electricity. The ARC process will generate residual by-products (IBA and APCr) that will be managed on site. An enclosed transfer conveyor will move the IBA from the ARC building to the IBA area.
Annual throughput	The ARC will have the capacity to process up to 380,000 tpa of residual waste feedstock and will have an installed capacity of approximately 30 MW.
Incinerator bottom ash (IBA) area	The IBA area provides for the processing of IBA for reuse and or disposal and includes screening, metals recovery and maturation. Construction and use of the IBA area, located to the west of the ARC building, will include: • the IBA processing building; • IBA maturation pad (for IBA stockpiling); and • associated infrastructure for wastewater and leachate management.
Encapsulation cell	The encapsulation cell will involve staged construction and operation of a lined and engineered landfill cell for encapsulation of stabilised APCr from the FGT system. The encapsulation cell will be located approximately 1.8 km north-west of the ARC building. Stabilised APCr will be transported via the internal road network from the ARC building by truck to the encapsulation cell. The development footprint includes a leachate pond for the management of leachate generated by the encapsulation cell.

Table 2.1 Project description

Project element	Summary of the project
Ancillary infrastructure	Construction and use of ancillary infrastructure will include: • an administration and education building; • sub-contractors lay down area; • a new substation for export of generated electricity; and • utilities.
Development footprint	The project development footprint is 38.4 ha, shown on Figure 2.2.
Water management	Water management systems will include: • construction stormwater management; • operational stormwater management systems for the access road, ARC building and IBA area; • operational water management including water supply, process water management and wastewater management; and • surface water and leachate management at the encapsulation cell.
Fire control	The ARC will include a fire safety system and will be designed in accordance with the Building Code of Australia.
Fuel and chemical storage	Construction and use of diesel and chemical stores.
Transport and access	Construction and use of: • a new site access road and intersection with Collector Road; • internal access roads, car and bus parking facilities; • a container marshalling area; and • weighbridges for inbound and outbound vehicles.
Workforce	Construction: approximately 300 construction jobs. Operation: approximately 40 full time equivalent operational jobs.
Hours	Construction: 24 hours per day, seven days a week. Operation: 24 hours per day, seven days per week. Receival of residual waste feedstock via road to the ARC: 6.00 am to 10.00 pm, Monday to Saturday.



KEY

- Development footprint
- Veolia integrated waste management operations
- Woodlawn Eco Precinct
- Woodlawn Mine operations area
- Woodlawn Wind Farm
- APCr transport route
- Major road
- Minor road
- Vehicular track
- Watercourse

Project development footprint

Woodlawn Advanced Energy Recovery Centre
Surface water assessment
Figure 2.2

EMM creating opportunities

Source: EMM (2022); Veolia (2022); DFSI (2017)

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Source: *EMM (2022); Veolia (2022); DFSI (2017)*

0 100 200 m
GDA 1994 MGA Zone 55
N

KEY

- Development footprint
- Site layout detail
- Mezzanine level 1
- Mezzanine level 2

Proposed operations

1 Existing Woodlawn substation
2 Existing plant collection dam (PCD)
3 HV connection point
4 Existing Woodlawn bioenergy power station
5 ARC substation
6 Existing hub 2 power station expansion
7 ARC stormwater retention dam
8 Outbound weighbridge
9 Sub-contractors area
10 Air cooled condenser (ACC)
11 Store
12 Fire water tanks
13 Turbine hall
14 APCr stabilisation plant
15 IBA stormwater settling pond
16 Waste water irrigation
17 Flue gas treatment (FGT)
18 Maintenance access corridor
19 Workshop
20 Boiler hall
21 Incoming weighbridge
22 Waste bunker
23 Entry and reception
24 IBA conveyor
25 Tipping hall
26 Bus drop-off
27 IBA area
28 Carpark
29 Container marshalling area
30 IBA processing building
31 Diesel tanks
32 Raw water feed tank
33 Office and administration (Mezzanine level 1)
34 Central control room (CCR) (Mezzanine level 2)
35 Administration and education area (Mezzanine level 2)

Woodlawn advanced recovery centre

Woodlawn Advanced Energy Recovery Centre
Surface water assessment
Figure 2.3

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Source: EMM (2022); Veolia (2022); DFSI (2017)

0 100 200 m
GDA 1994 MGA Zone 55
N

KEY
- Development footprint
- APCr transport route
- Encapsulation cell
- Leachate evaporation pond
- Major road

The encapsulation cell

Woodlawn Advanced Energy Recovery Centre
Surface water assessment
Figure 2.4

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3 Regulations and guidelines

This chapter describes regulations and guidelines that have been considered in this assessment.

3.1 NSW regulatory framework

3.1.1 NSW Water Management Act 2000

The NSW *Water Management Act 2000* (WM Act) sets out the legislative requirements for the sustainable and integrated management of water sources within the State, for the benefit of both present and future generations. The WM Act is based on the principles of ecologically sustainable development and recognises that water management must consider economic, environmental, social, cultural and heritage factors.

The principal instruments for the management of rivers within NSW, under the WM Act, are management plans that: manage water sharing, water use, floodplains, drainage, environmental protection, controlled activities, and aquifer interference.

The Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011 is the only plan under the WM Act that is relevant to surface water management at the site. The Upper Nepean & Upstream Warragamba water source and Mulwaree River management zone apply to the Eco Precinct.

There are additional Water Sharing Plans relevant to groundwater resources that are described in the Groundwater Assessment (EIS Appendix U).

Water licensing for the project is addressed in Chapter 7.

3.1.2 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) establishes the NSW environmental regulatory framework and includes licensing requirements for certain activities. Environment Protection Licences (EPLs) are administered by the NSW Environment Protection Authority (EPA) under the POEO Act. The Eco Precinct is currently regulated by two EPLs: EPL no. 11436 applies to the Bioreactor and EPL no. 20476 applies to the MBT facility.

3.2 Guidelines

The following government and industry guidelines have been considered in this assessment.

3.2.1 Stormwater management guidelines

The following guidelines are referenced when describing the surface water management approach during the construction and operational phases of the project (see Chapter 5):

- Erosion and sediment control guidelines:
  - *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom 2004).
  - *Managing Urban Stormwater: Soils and Construction Volume 2E* (DECC 2008).
- Bunding and spill management guidelines: Storing and Handling Liquids: Environmental Protection: Participant's Manual (DECC 2007) describes best practice storage, handling and spill management procedures for liquid chemicals.

3.2.2 NorBE guidelines

The SEARs require a demonstration of a Neutral or Beneficial Effect (NorBE) on water quality in accordance with State Environmental Planning Policy (Biodiversity and Conservation) 2021 (see Table 1.1). The following guidelines have been considered when addressing this assessment requirement:

- *Neutral or Beneficial Effect on Water Quality Assessment Guideline* (WaterNSW 2021) – this guideline describes the assessment and approval process developed by WaterNSW for applying the principles of NorBE. Achieving a NorBE on water quality means any water introduced to an offsite water source will be comparable to or will have better quality than the receiving water body, thereby having no identifiable negative impact on the receiving water quality.

- *Using MUSIC in Sydney Drinking Water Catchment* (WaterNSW 2019a) – this guideline describes MUSIC modelling approaches and assumptions that can be used to assess a project's NorBE on water quality.

- *Designing and Installing On-Site Wastewater Systems* (WaterNSW 2019b) – this guideline describes a best practice approach to designing, installing and operating on-site wastewater systems in Sydney drinking water catchments.

NorBE assessment requirements are addressed in Chapter 6.

3.2.3 Water quality guidelines

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018) provide a framework for:

- assessing and managing water quality for environmental values;

- establishing water quality objectives; and

- establishing protection levels, water quality indicators and Default Guideline Values (DGVs) for water quality indicators and toxicants.

ANZG 2018 includes frequent references to *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000). ANZG 2018 and (where relevant) ANZECC/ARMCANZ 2000 have been applied to establish water quality and environmental values for receiving watercourses based on default guideline values (DGVs) for slightly-to-moderately disturbed upland river system.

3.2.4 Guidelines for works on waterfront land

The WM Act defines waterfront land as the bed of any river, lake or estuary and any land within 40 m of the riverbanks, lake shore or estuary mean high water mark. These guidelines provide information on design and construction principles for controlled activity, and other ways to protect waterfront land.

The project does not include any works on waterfront land (see Section 4.1.3). Hence, these guidelines do not apply to the project and are not addressed further in this SWA.

4 Existing setting

This chapter describes aspects of the existing environment and Eco Precinct that are relevant to this SWA. It includes descriptions of climate, the receiving watercourse (Crisps Creek), the existing setting within the ARC and encapsulation cell areas and the existing water management system.

4.1 Climate

The Eco Precinct is in the Southern Tablelands region of NSW, which has a sub-humid temperate climate characterised by hot summers, cold winters and no dry season. Rainfall and evaporation characteristics are relevant to this assessment and are described in this section.

4.1.1 Available data

Rainfall and evaporation data that is representative for the Eco Precinct is available from the following sources:

- Local weather stations – the Bureau of Meteorology (BoM) Station 70036 at Lake Bathurst that is located approximately 8.5 km north-east of the Site. Daily rainfall data is available from November 1931 onwards, providing an approximate 90-year record.
- Scientific Information for Land Owners (SILO) Australian climate database – The SILO database is a spatially and temporally complete climate database established by interpolated processing of climate records from BoM weather stations. Point rainfall and evaporation data was extracted from a central location within the Site.

The following sections describe rainfall and evaporation regimes at the Eco Precinct and the weather conditions over the 2017 to September 2021 period (the recent period).

4.1.2 Rainfall and evaporation trends

i Annual trends

Table 4.1 provides key annualised rainfall statistics calculated from the Lake Bathurst gauge record and the SILO data. Annualised pan evaporation statistics calculated from the SILO data are also provided.

Table 4.1 Annual rainfall and evaporation statistics

	Units	Lake Bathurst (70036)	SILO data	
		Rainfall	Rainfall	Pan evaporation
Gauge information				
– Location		8.5 km north-west of the Eco Precinct	Project area	
– Elevation	m AHD	668	780 (approx.)	
Statistics				
– Lowest	mm/year	318	334	973
– 10th percentile	mm/year	442	473	1,041
– Median	mm/year	673	665	1,223
– 90th percentile	mm/year	954	940	1,410
– Maximum	mm/year	1,305	1,298	1,664

ii Monthly trends

Figure 4.1 compares the median, 10th and 90th percentile monthly pan evaporation rates to similar monthly rainfall statistics. The chart shows that:

- There are no significant seasonal trends in rainfall. However, higher rainfall tends to occur from late spring to early autumn (October to March), and late autumn to early spring (April to September) is generally drier.
- The evaporation rate varies seasonally. Evaporation typically exceeds rainfall during spring and summer, with 10th percentile evaporation exceeding 75th percentile rainfall between September and March. From May to August rainfall typically exceeds evaporation.

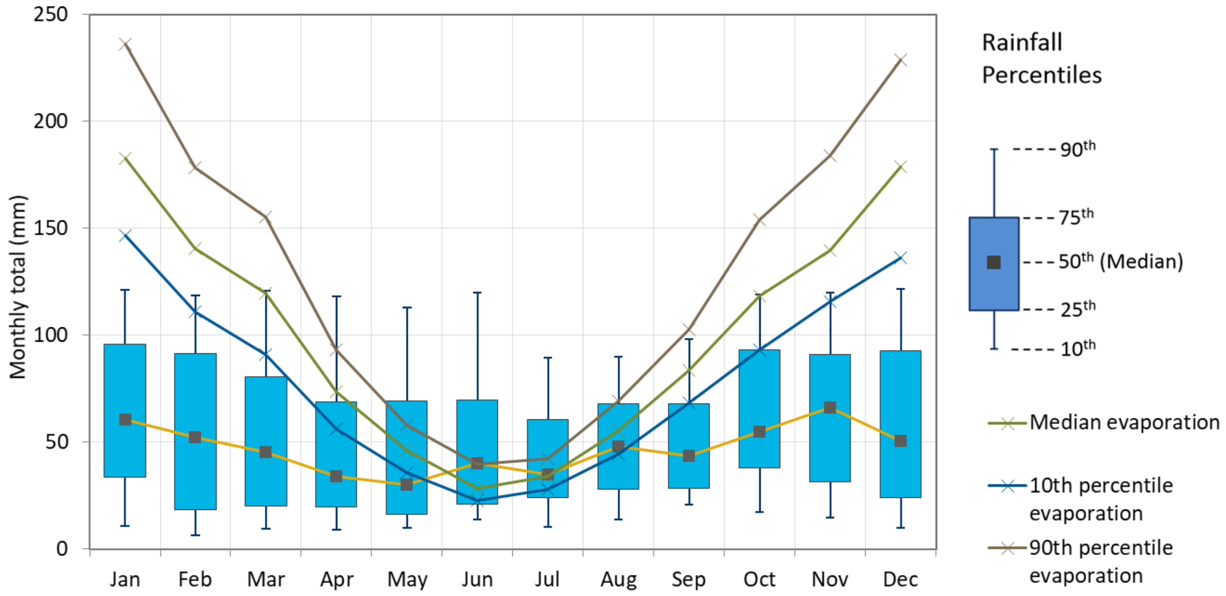


Figure 4.1 Monthly rainfall and evaporation

iii Recent rainfall

Figure 4.2 compares the recorded monthly rainfall at Lake Bathurst (BoM 70036) from 2017 to December 2020, and SILO data from December 2020 to September 2021 (the recent period) to the median monthly rainfall calculated from the 90-year gauge record. This chart shows that the recent period was characterised by below median rainfall between 2017 to the end of 2019. During this time, monthly rainfall totals exceeded the median monthly rainfall in only 11 of 36 months. This period coincided with a severe drought in NSW.

A 14-month period of above median rainfall commenced in February 2020. The 90th percentile monthly rainfall totals were exceeded in 3 out of 14 months, and median rainfall totals were exceeded in 11 out of 14 months. Overall, 1,147 mm of rainfall was recorded, which is equivalent to 93rd percentile rainfall over a 14-month period (as calculated from the gauge record).

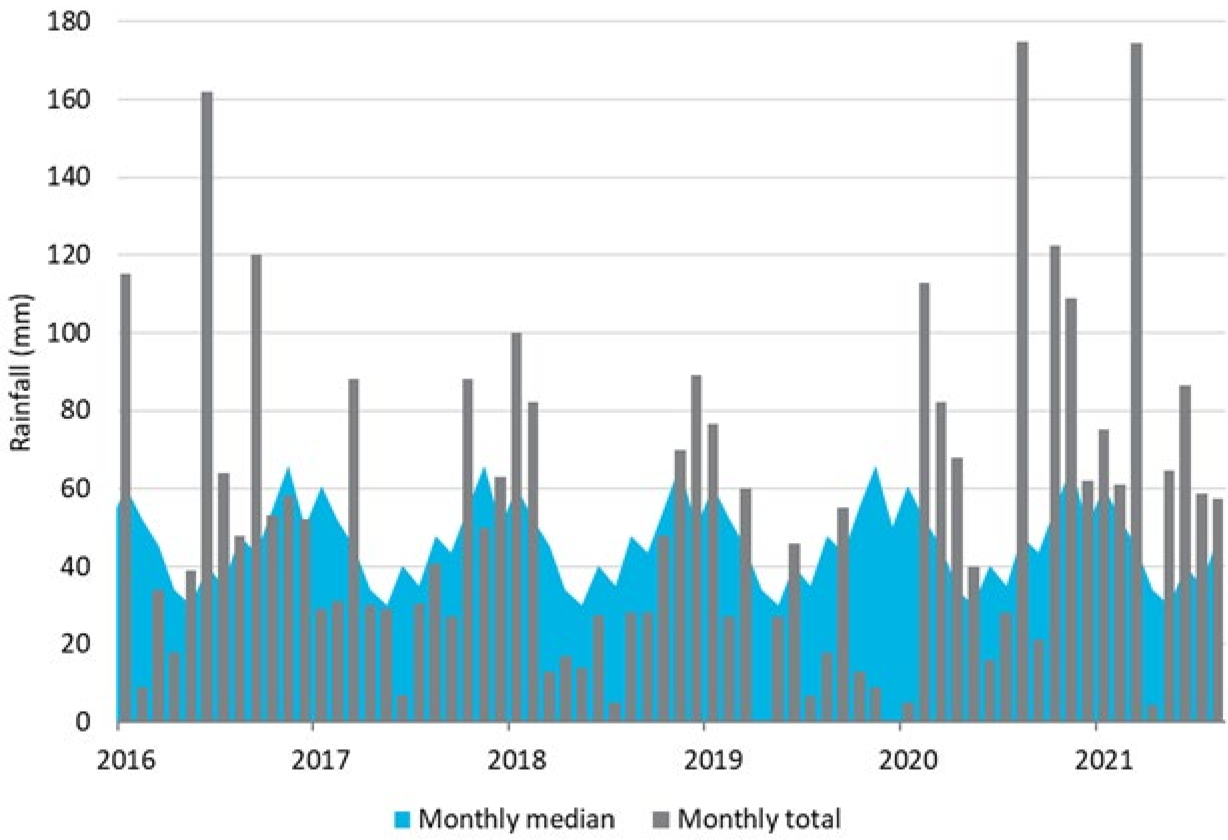


Figure 4.2 Recent rainfall – 2017 to September 2021

4.1.3 Design rainfall

Design rainfall information is used to calculate aspects of the stormwater management system. The following design rainfall information has been established for the development footprint:

- Table 4.2 provides design rainfall depths for a range of exceedances per year (EY) and annual exceedance probability (AEP) events of varying durations. This information was sourced from the ARR2016 data portal; and

- Table 4.3 presents rainfall depths for 2, 5, 10 and 20 day rainfall events. This information was sourced from *Managing Urban Stormwater: Soils and Construction – Volume 1* (Landcom 2004).

Table 4.2 Design rainfall depths from Australian Rainfall and Runoff 2016

	Annual exceedance probability (AEP) – Rainfall depths (mm)						
	1EY	**0.5EY**	**20%**	**10%**	**5%**	**2%**	**1%**
1 hour	17	21	25	30	34	40	44
2 hour	22	27	32	37	42	49	54
3 hour	25	31	36	42	48	57	63
6 hour	33	40	47	55	64	75	85
9 hour	38	47	56	66	76	91	103
12 hour	43	52	63	74	86	104	118
1 day	54	67	83	99	117	142	162
2 days	66	83	104	126	150	181	207
3 days	73	92	116	140	167	200	226
4 days	77	97	122	148	175	210	236
5 days	80	101	127	153	180	215	242
6 days	83	104	129	155	182	218	247
7 days	85	107	132	157	184	221	251

Source: Data sourced from Australian Rainfall Runoff Data Portal.

Table 4.3 Design rainfall depths for frequent events

	Rainfall duration			
	2 day	**5 day**	**10 day**	**20 day**
80th percentile event	10.0 mm	17.8 mm	30.2 mm	54.8 mm
85th percentile event	13.2 mm	22.2 mm	36.4 mm	64.3 mm
90th percentile event	18.0 mm	28.6 mm	44.8 mm	75.6 mm
95th percentile event	27.4 mm	40.8 mm	60.8 mm	97.1 mm

Source: (Landcom, 2004) Table 6.3 – values for Goulburn

4.2 Receiving watercourse

The Eco Precinct is located on the Great Dividing Range. The western and southern portions of the Eco Precinct drain to the west through several small watercourses that flow into Lake George. The northern and eastern portions of the Eco Precinct are within the Crisps Creek catchment. Crisps Creek is a tributary to the Mulwaree River. Its headwaters are primarily located within the Eco Precinct. The Creek is located on the northern side of Collector Road and flows generally to the south-east within the Eco Precinct. Downstream of the Eco Precinct it flows in an easterly direction for approximately 4.5 km before joining the Mulwaree River, just upstream of Tarago. The Mulwaree River is a major tributary of the Wollondilly River, which ultimately flows into Lake Burragorang (also known as Warragamba Dam). Lake Burragorang is a major water supply dam for the Sydney metropolitan region and is managed by WaterNSW.

The development footprint (ie the ARC and encapsulation cell areas) is within the Crisps Creek catchment. Hence, Crisps Creek is the only receiving watercourse described in this assessment. It is noted that runoff from existing disturbed areas within the development footprint is currently captured in the precinct's water management system and does not enter Crisps Creek. The precinct's existing water management system is described in Section 4.4.

Figure 4.3 shows the alignment of Crisps Creek and its tributaries relative to Eco Precinct and the development footprint. It is noted that there are no watercourses within the development footprint.

4.2.1 Crisps Creek

i Flow regime

Crisps Creek is an unregulated watercourse that has a variable streamflow regime. There are no known stream gauges within the Crisps Creek catchment. However, Veolia have recorded streamflow conditions when undertaking routine water quality monitoring in the creek. These observations indicate the creek generally maintains a steady baseflow for several months after wet weather. These baseflow characteristics are interpreted to be due to connectivity with a colluvial groundwater system which is described in the Groundwater Assessment (EIS Appendix U). The streamflow regime fits the definition of an intermittent stream.

ii Flooding regime

Within the Eco Precinct, Crisps Creek is located on the northern side of Collector Road and flows in a south-easterly direction. The creek is characterised by an intermittent channel that has a variable width and depth. The channel (where present) meanders through a floodplain that is between 50 to 150 m wide. The longitudinal grade of the channel and floodplain is approximately 1.5%. Accordingly, when in flood, the inundation extent is expected to be confined to the channel and immediate floodplain area and the flood waters are likely to be shallow and fast moving. The ARC and encapsulation cell areas are more than 10 m higher than the adjoining Crisps Creek floodplain levels and are therefore not affected by Crisps Creek flooding.

iii Water quality regime

Veolia undertake quarterly water quality monitoring at the following locations on Crisps Creek (or immediate tributaries):

- Spring 2 (also described as SP2 -MW1) – is located to the north-east of the proposed encapsulation cell and ED1. The Spring 2 site is a dam constructed on a tributary to Crisps Creek and is thought to intercept shallow groundwater, as well as receiving overland flow (EIS Appendix U).

- Site 105 – is in the eastern portion of the Eco Precinct, downstream of areas disturbed by former mining operations and current waste management operations.

Figure 4.3 shows the monitoring locations.

A summary table of Site 105 data from the recent period (ie 2017 to September 2021) is provided in Table A.1 in Appendix A. Data from Spring 2 is presented and analysed in the Groundwater Assessment (EIS Appendix U) along with relevant groundwater data and is therefore not reproduced in this report.

The water quality at Site 105 is characterised as having a near natural pH and salinity levels (as indicated by electrical conductivity) that ranged between 469 to 2,140 µS/cm (based 20th the 80th percentile values). Oxidised nitrogen and ammonia and total concentrations of aluminium, cadmium, copper, lead and zinc frequently exceeded DGVs (see Section 3.2.3).

The Groundwater Assessment (EIS Appendix U) analysed water quality data from:

- groundwater bores screened in shallow alluvium/colluvium and the deeper fractured rock groundwater systems;

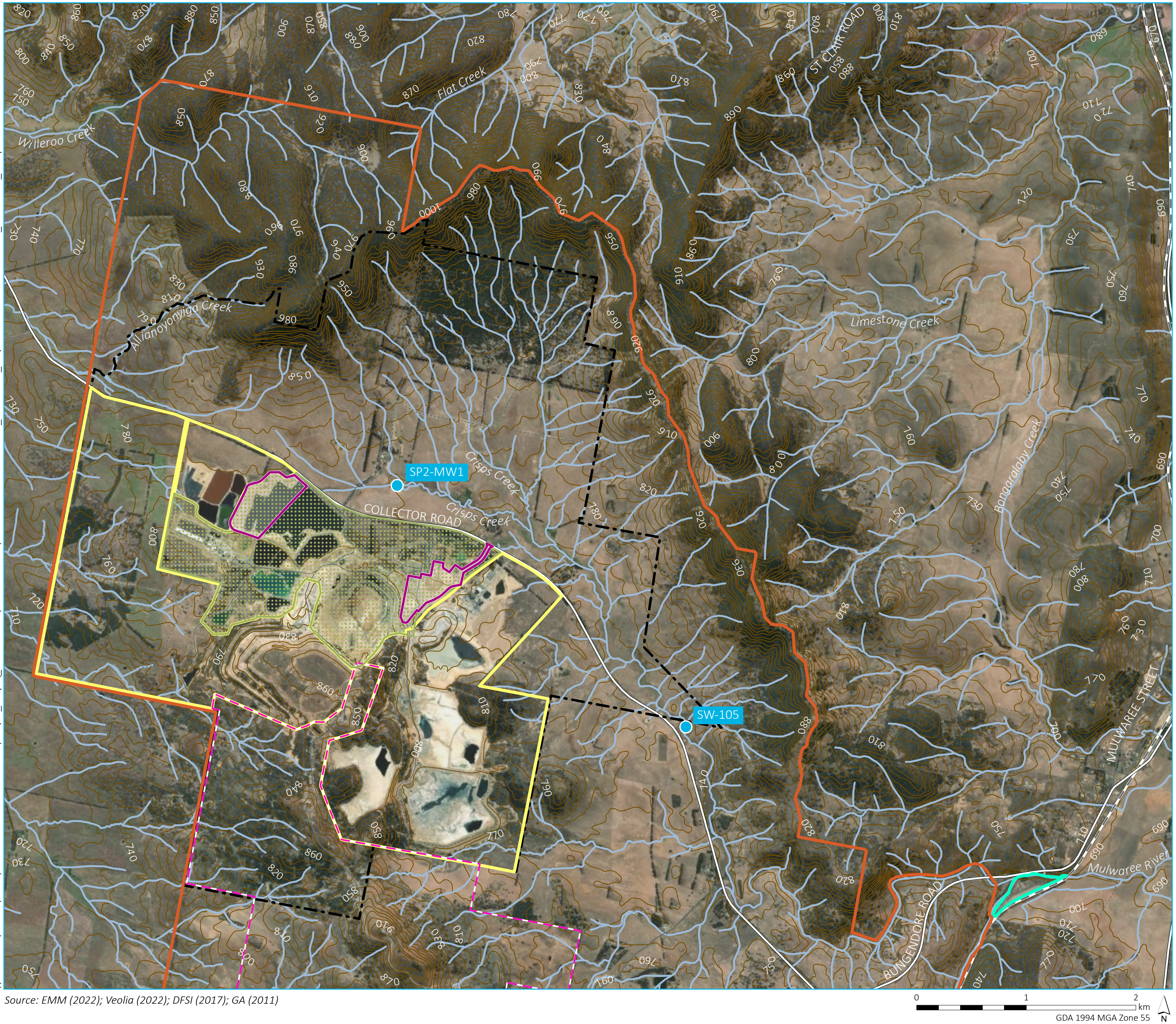
- water quality data from ED1, which is the closest evaporation dam to the Spring 2 monitoring location; and

- the Spring 2 and Site 105 surface water monitoring locations.

The assessment concluded that:

- The shallow groundwater table is elevated in the ED1 area. Some groundwater from this area flows towards Crisps Creek. However, the rate of flow is constrained by the local lithology, which comprises clays sediments that generally have low hydraulic conductivity and permeability.
- Most streamflow in Crisps Creek originates from surface water runoff (during wet weather) and discharge from the shallow colluvial groundwater systems, from the north and south, particularly after wet weather. The deeper fractured rock groundwater system may also discharge into the shallow colluvial system.
- Elevated salinity and metals are present in both the shallow colluvial groundwater systems and deeper hard rock aquifers. Similar characteristics were identified in monitoring bores that are potentially impacted by ED1 and unimpacted bores.

In summary, discharges from the shallow colluvial groundwater system are the likely source of the elevated salinity and metals in Crisps Creek (at Site 105). Land degradation and the erosion of the Crisps Creek channel may also be contributing factors.



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KEY

- Development footprint
- Sampling location
- Veolia integrated waste management operations
- Woodlawn Eco Precinct
- Crisps Creek Intermodal Facility (IMF)
- Woodlawn Mine operations area
- Woodlawn Wind Farm
- Special (Crown & Private Lands) Lease 20
- Rail line
- Major road
- Minor road
- Vehicular track
- Contour (m AHD)(10 m interval)
- Watercourse
- Named waterbody

Source: EMM (2022); Veolia (2022); DFSI (2017); GA (2011)

Crisps Creek and surface water monitoring locations

Woodlawn Advanced Energy Recovery Centre
Surface water assessment
Figure 4.3

EMM
creating opportunities

4.3 The project area

This section describes the existing setting within the ARC and encapsulation cell development footprints.

4.3.1 ARC development footprint

The ARC will be located to the north-east of the Bioreactor landfill and to the east of the site administration complex (see Figure 2.2). The ARC development footprint and surrounding areas which are relevant to surface water management can be divided into the following sub-areas based on current site characteristics:

- **Southern portion** (predominantly within the development footprint) – is an area that was formerly used to process metalliferous ore from the former Woodlawn mining operations that operated up to 1998. The ore processing plant was demolished in 1999. While some remedial works have been undertaken, metalliferous waste is present in some areas. Refer to the Preliminary Site Investigation Report (EIS Appendix W) for detailed descriptions of the existing contamination. Photograph 4.1 shows the southern portion of the ARC area, looking to the south-west towards the Bioreactor landfill.

- **Plant Collection Dam (PCD)** (outside the development footprint) – this dam was originally established to manage water from the ore processing plant. The PCD currently has a contributing catchment area of 31.3 ha that comprises: the former processing plant area, Woodlawn BioEnergy Power Station and various roads and unused areas. Water collected in the PCD dam is Acid Mine Drainage (AMD) affected and is known to have a low pH and elevated salinity levels and metal concentrations. Table A.2 in Appendix A provides a summary of recent water quality monitoring undertaken by Veolia. Currently all water collected in the PCD is pumped to ED1. Veolia has not observed the PCD to overflow during the 20 years that they have operated the site. Photograph 4.2 shows the PCD, looking to the west from the dam's embankment.

- **Northern portion** (predominantly outside the development footprint) – refers to the area located between the PCD and Collector Road and to the north-west of the site administration complex. This area receives runoff from an undisturbed catchment that is located to the south of Collector Road. An ephemeral wetland has established in the lower part of the catchment, between PCD and Collector Road. The western (or upper) portion of the wetland is near flat, while the eastern (or lower) portion grades at approximately 2%. Water drains from the eastern portion of the wetland under Collector Road via a 0.4 m x 3.6 m Reinforced Concrete Box Culvert (shown on Figure 4.4 as Collector Road Culvert). Photograph 4.3 shows the eastern portion of the wetland.

Figure 4.4 shows the existing surface water setting in the ARC development footprint and immediate surrounds, noting the abovementioned features.

Photograph 4.1 Former ore processing plant site

Photograph 4.2 Plant Collection Dam

Photograph 4.3 Existing wetland upstream of Collector Road culvert

Source: EMM (2022); Veolia (2022); DFSI (2017)

Existing ARC area –
surface water setting

Woodlawn Advanced Energy Recovery Centre
Surface water assessment
Figure 4.4

EMM creating opportunities

4.3.2 Encapsulation cell development footprint

The proposed encapsulation cell will be in the western portion of ED1 (see Figure 2.2). ED1 is an evaporation dam that receives contaminated water from the Waste Rock Dam and the PCD. Leachate from the Bioreactor is managed in other evaporation dams (refer to Section 4.4 for a description of the existing water management system).

Water held in ED1 has a low pH and elevated salinity levels and metal concentrations. Photograph 4.4 shows the western portion of ED1, looking to the north towards the proposed encapsulation cell location.

Potential impacts to the operational effectiveness of ED1 are assessed in this report (see Chapter 6). To inform this assessment an ED1 water balance has been prepared by WSP. The water balance report is provided in Appendix B. This report provides additional information on the geometry and operational aspects of ED1.

Photograph 4.4 Evaporation Dam 1

4.4 Existing water management system

The existing water management system comprises several runoff capture dams, pumped reticulation systems, a leachate treatment plant, and several evaporation dams. Veolia operates the system to manage:

- leachate and surface water runoff that is pumped from the Bioreactor landfill;
- surplus water from the Waste Rock Dam (part of Woodlawn Mine's operations), which receives runoff from the surrounding area and area to the west of the Bioreactor landfill and seepage from waste rock dumps located to the south of the Bioreactor landfill; and
- surplus water that accumulates in the PCD, which receives runoff from the PCD catchment.

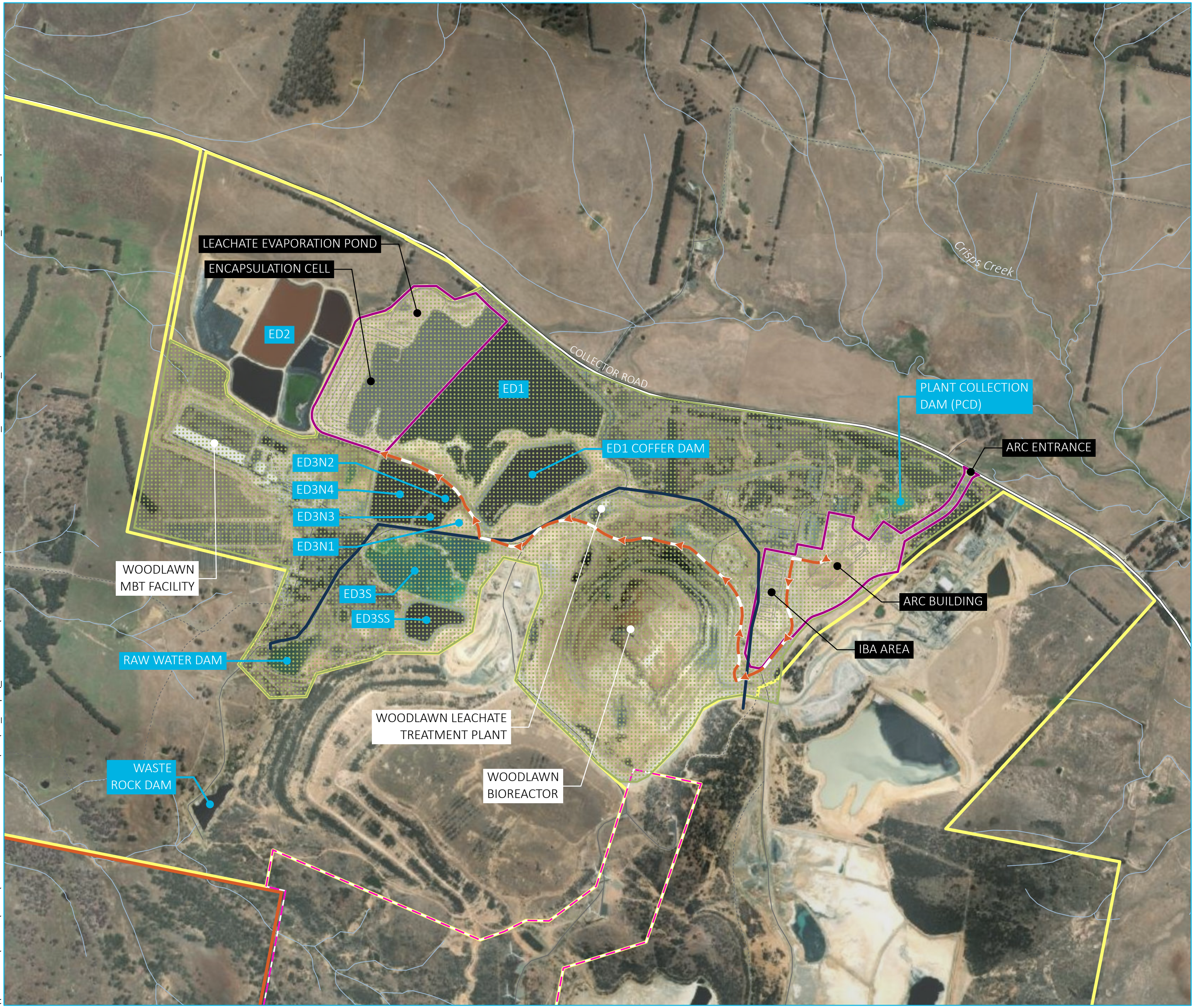
There are various overlaps in responsibilities at the Eco Precinct between the Woodlawn Mine and Veolia's integrated waste management operations. The water management system operates as an integrated system with agreements in place between Veolia and the mine operator.

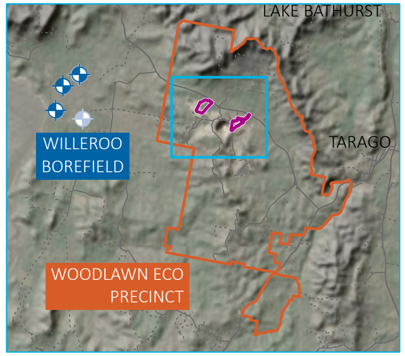
Figure 4.5 locates the runoff capture dams, leachate treatment plant and evaporation dams.

The overall water management system comprises the following components, which are operated independently:

- **ED1 system** – receives direct rainfall, runoff from the surrounding area and water pumped from the Waste Rock Dam and PCD. Water accumulation is managed via natural and assisted evaporation from ED1. The functionality of the ED1 system is described in Figure 4.6.
- **Evaporation Dam 3 South (ED3S) system** – receives direct rainfall, runoff from the surrounding area and runoff captured around the periphery of the Bioreactor landfill. Water accumulation is managed via natural evaporation from ED3S. The functionality of the ED3S system is described in Figure 4.6.
- **Leachate management system** – manages leachate that is pumped from the Bioreactor landfill. Leachate is initially treated in the Leachate Treatment Plant and Leachate Treatment Dam. Six evaporation dams (ED1 Coffer Dam, ED3N1, ED3N2, ED3N3, ED3N4 and ED3SS) are used to manage the accumulation of treated leachate via natural and assisted evaporation. The functionality of the leachate management system is described in Figure 4.6.
- **ED2 system** – is located to the west of ED1. ED2 is managed by mine operator as part of the Woodlawn Mine operation.

The operational effectiveness of ED1 may be impacted by the construction of the encapsulation cell within ED1 and other aspects of the project. These potential impacts are described in Chapter 5 (water management approach) and assessed in Chapter 6 (residual impacts). The project will not interact or impact the operational effectiveness of the ED3S, leachate management system or ED2. Hence, these systems are not described further in this report.





KEY

- Development footprint
- Veolia integrated waste management operations
- Woodlawn Eco Precinct
- Woodlawn Mine operations area
- Woodlawn Wind Farm
- APCr transport route
- Water supply pipeline
- Major road
- Minor road
- Vehicular track
- Watercourse

INSET KEY

- Production bore
- Monitoring bore

Existing water management system layout

Woodlawn Advanced Energy Recovery Centre
Surface water assessment
Figure 4.5

creating opportunities

Source: EMM (2022); Veolia (2022); DFSI (2017)

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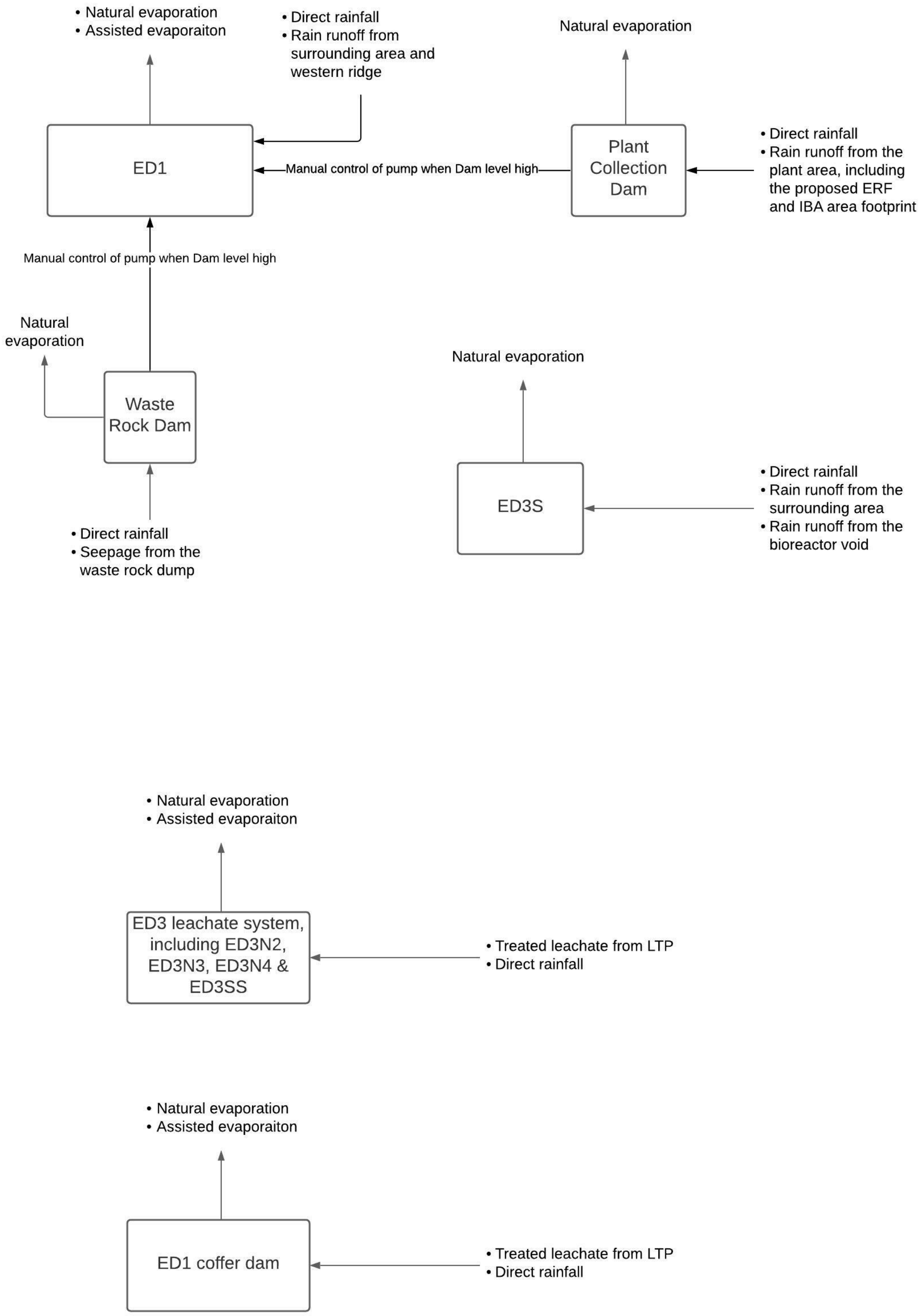


Figure 4.6 Existing water management system functionality

Source: Veolia

5 Water management approach

This chapter describes the project's operational water requirements, water supply arrangements and the approach to manage stormwater, wastewater and contaminated water streams. It includes conceptual descriptions of the proposed water management system and a water balance for the process water system.

This chapter is structured as follows:

- Section 5.1 describes the reference design and establishes water management objectives;
- Section 5.2 describes terminology and categories that have been used to describe the water management system; and
- Sections 5.3 to 5.7 describes the water management system.

Information presented in this chapter is used to describe residual impacts and the water licencing approach, which are discussed separately in Chapters 6 and 7 respectively.

5.1 Reference design and objectives

5.1.1 Context and alignment with site rehabilitation objectives

The ARC development footprint is within the southern portion of the PCD catchment. The PCD currently captures AMD affected runoff from the catchment. During wet periods, captured water is pumped to ED1 to prevent the PCD from overflowing (Section 4.4). While this approach is effective in preventing overflows from the PCD to the receiving environment, it relies on active management and requires capacity in the evaporation pond system.

Veolia proposes to remediate existing contamination within the PCD catchment as part of existing site rehabilitation obligations under development consent DA31-02-99 and MP 10_0012 (as modified). Remediation works within the development footprint will be required to facilitate the project but will be undertaken separately as described in the EIS. An overview of the process is also provided in the Preliminary Site Investigation (EIS Appendix W).

Once remediation within the PCD catchment is completed, it is envisaged that in the longer term, the PCD will be decommissioned, with stormwater flows from the catchment reinstated to the receiving environment. This could involve a stormwater control such as a constructed wetland (or another suitable alternative) established in the PCD area to achieve a stormwater management system that is consistent with industry best practice for an industrial area. These works would be undertaken in accordance with development consent DA31-02-99 (as modified) and in accordance with relevant plans developed for the management of broader rehabilitation at the Eco Precinct.

For practical reasons and in the short term, Veolia proposes to continue to utilise the PCD to manage overflows from the ARC stormwater system and runoff from areas that are outside of the ARC development footprint, but within the PCD catchment. However, to achieve alignment with the site's rehabilitation objectives, the ARC stormwater system will be developed such that it can be integrated into a future stormwater system in the PCD catchment that overflows to the receiving environment. This has been adopted as a water management objective (discussed in Section 5.1.2).

5.1.2 Water management objectives

The project's water management system will be integrated with the Eco Precinct's water management system, which may evolve over time for a variety of reasons such as completion of rehabilitation works. Three water management objectives have been established to enable a clear and concise assessment of the project's residual impacts, which is required to address the assessment requirements (see Section 1.2). The three objectives are described below and are referenced throughout this chapter.

Consistency with each of the three objectives is assessed in Chapter 6 as part of the description of residual impacts.

i Objective 1 – NorBE on the operational effectiveness of ED1

ED1 is an evaporation dam that is currently used to manage contaminated water from the PCD and the Waste Rock Dam (see Section 4.4). Under the current operating arrangement, surplus water from the PCD and Waste Rock Dam is pumped to ED1 to prevent overflows to the receiving environment. Water accumulation in ED1 is managed via natural and assisted evaporation, which is a gradual process that varies seasonally. Accordingly, the operational effectiveness of ED1 to manage surplus water from the PCD and Waste Rock Dam is a function of the dam's ability to store water during extended wet periods and manage water accumulation via evaporation.

The project will result in the following changes to the ED1 water balance:

- **Mechanism 1** - The encapsulation cell will be constructed in the western portion of ED1. This will reduce the storage volume and evaporation area of ED1, reducing its capacity to manage pumped inflows from the PCD and Waste Rock Dam.
- **Mechanism 2** - Some surplus process water may be dewatered to ED1. This will utilise some of the storage and evaporation capacity, reducing the capacity available to manage pumped inflows from the PCD and Waste Rock Dam.
- **Mechanism 3 -** Stormwater harvesting will be incorporated into the proposed ARC stormwater system. This will reduce (relative to existing conditions) the runoff volume to the PCD. The lower runoff volumes to PCD will reduce the storage and evaporation capacity required in ED1 to manage pumped inflows from the PCD, thereby increasing the available capacity in the dam.

Achieving a NorBE on the operational effectiveness of ED1 is a water management objective for the project. A NorBE can be achieved if one of the following criteria is met:

1. the cumulative changes due to the project result in lower water levels in ED1, for a full range of weather conditions; or
2. the cumulative changes due to the project result in higher water levels in ED1, but there is no impact to the operational effectiveness of the dam, in that it can still receive pumped inflows from the PCD and Waste Rock Dam for a full range of weather conditions.

This objective and associated mechanisms are discussed in this chapter when describing relevant portions of the water management system.

Compatibility with this objective is informed by a water balance modelling of ED1 and is assessed in Chapter 6 (residual impacts).

ii Objective 2 – NorBE on receiving water quality

The stormwater system in the ARC development footprint will be developed such that it can be integrated into a future stormwater system in the PCD catchment, that overflows to the receiving environment (see Section 5.1.1). To achieve this objective, the water management system will be developed to have a NorBE on receiving water quality. This can be achieved by a water management system that:

- separates potentially contaminated water from stormwater runoff (objective 2a);
- includes a stormwater management system that is consistent with industry best practice (also referred to as current recommended practices (CRP)) for an industrial area (objective 2b); and
- includes a wastewater (ie sewage) management system that is designed and operated in accordance with the methods described in Designing and Installing On-Site Wastewater Systems (WaterNSW 2019b) (objective 2c).

These water management system objectives are noted when describing relevant aspects of the water management system in this chapter. Compatibility with this objective is informed by MUSIC water quality modelling and is assessed in Chapter 6 (residual impacts).

iii Objective 3 – Drought secure water supply for the project

The project will require an external water supply to meet operational requirements. Securing a drought secure water supply is a water management objective for the project.

Compatibility with this objective and associated water regulations is addressed in this chapter and in the Groundwater Assessment (EIS Appendix U).

5.1.3 Reference design

The water management system described in this chapter was developed as part of the Reference Design for the project. The Reference Design has considered the operational requirements of the water management system, site constraints and addresses the three water management objectives established for this assessment (see Section 5.1.2).

The Reference Design will be further developed by the appointed engineering, procurement and construction contractor. Accordingly, the water management system is described conceptually in this chapter. Where possible, the system is described using design principles and objectives rather than specific information from the Reference Design.

It is noted that some variations to the Reference Design may be made during detailed design. If the variations are consistent with the principles described in this report, then the alternative design would be consistent with this Surface Water Assessment. If an alternative design solution is proposed, additional assessment may be required to demonstrate consistency with the three water management objectives established for this assessment (see Section 5.1.2). If this is achieved, the alternative design would be consistent with the residual impacts described in this Surface Water Assessment.

5.2 Chapter structure and terminology

5.2.1 Water management system description

Management categories are used to describe each unique aspect of the water and wastewater management systems. For each category, a description of the proposed management approach is provided. Table 5.1 describes each category and provides a section reference to the relevant portion of this chapter. It is noted that to enable concise descriptions, the water management systems for the ARC and encapsulation cell areas are discussed separately as they will not be integrated.

Table 5.1 Water management categories

Category name	Description	Section reference
ARC water management area		
Construction water management	Describes the approach to manage water during the construction phase of the ARC.	Section 5.3
Stormwater management during operations	Describes the approach to manage stormwater during the operational phase of the ARC.	Section 5.4
Operational water management	Describes the projects water supply requirements, the process water system and contaminated water streams that require management.	Section 5.5
Amenity water supply and wastewater (ie sewage)	Describes the proposed amenity water supply arrangements and wastewater management system.	Section 5.6
Encapsulation cell		
Summary of water management	Describes the water management aspects of the encapsulation cell design including surface water and leachate management and changes to ED1.	Section 5.7

5.2.2 Terminology

Table 5.2 lists terminology used describe the water management system.

Table 5.2 Water management terminology

Term	Description
Operational water	Is a broad term used to describe the project's operational water requirements.
Process water	Water that is used or produced by the operation of the ARC.
Recycled process water	Refers to a process water stream that includes a combination of brine, raw water and return water from other process water uses.
Demineralised water	Refers to permeate produced by a demineralising plant. Demineralised water has very low concentrations of dissolved solids and is suitable for use in steam turbines.
Brine	Refers to the reject produced by a demineralisation plant. Brine has elevated concentrations of dissolved solids.
Bore water	Refers to water sourced from the Willeroo Borefield. Information on the water quality of bore water is provided in the Groundwater Assessment (EIS Appendix U).
Stormwater	Refers to stormwater runoff from roof, hardstand and landscaped areas. Stormwater runoff is managed by the stormwater system and is suitable for off-site discharge following treatment by stormwater controls.
Raw water	Refers to water that is of suitable quality to supply the process water system. Raw water is sourced from both bore water and stormwater.
Potentially contaminated stormwater	Refers to stormwater runoff that may be contaminated due to contact with waste material that is stored within the development footprint. Potentially contaminated stormwater is not suitable for off-site discharge.
Leachate	Refers to liquid that will be dewatered from the encapsulation cell.
Potable water	Refers to water that is suitable for drinking.
Wastewater	Refers to wastewater produced by the onsite amenities (ie sewage).

5.3 Water management during construction

This section describes the approach to manage water during the construction of the ARC, which is expected to take approximately three years. During this time, a water management system will be established to:

- provide water for construction;
- manage water produced by construction activities; and
- manage surface water runoff from areas disturbed by construction.

The construction phase water management system is described separately for the areas that are upstream and downstream of the PCD catchment.

It is noted that the encapsulation cell will be progressively constructed over the project's 25-year design life. Surface water runoff and leachate management during both the construction and post construction periods is described separately in Section 5.7.

5.3.1 Downstream of PCD catchment

The northern portion of the access road will be constructed downstream of the PCD catchment. Construction activities in this area will include earthworks and the construction of the road, the intersection with Collector Road and the road drainage system.

Surface water runoff from the area disturbed by construction will be managed in accordance with the methods recommended in Managing Urban Stormwater: Volume 1 (Landcom 2004). An erosion and sediment control plan will be prepared as part of the Construction Environmental Management Plan (CEMP) for the project (see Chapter 8).

5.3.2 Within PCD catchment

Aside from the northern portion of the access road, the development footprint for the ARC is within the PCD catchment. The construction of the ARC building, IBA area and other ancillary infrastructure will require earthworks. It is expected that some surface water runoff from construction disturbance areas will be AMD affected. Accordingly, all surface water runoff from construction disturbance areas will be directed to the PCD. Water accumulation in the PCD is managed by dewatering to ED1. Hence, no off-site discharges are expected.

The ARC building will include a waste bunker that will be approximately 15 m deep. The excavation required to construct this bunker is expected to intercept the underlying fractured rock groundwater system. The Groundwater Assessment (EIS Appendix U) estimated total inflows over the duration of the construction period to be between 0.3 to 1.6 ML. This water and any other miscellaneous water produced by construction activities will also be managed in the PCD and ED1 systems.

Overall, as there will be no change to the PCD catchment area and negligible change (relative to existing conditions) to the volume of water draining to PCD during the construction phase of the ARC. Accordingly, no impacts to the operational effectiveness of ED1 are expected during the construction phase of the project.

5.3.3 Water supply during construction

During construction, water will be required for dust suppression, concrete production, earthworks and other miscellaneous uses. Water will be supplied by the Eco Precinct's existing water supply system, which sources water from surface water storages and the Willeroo Borefield (see Groundwater Assessment EIS Appendix U). Water from the Willeroo Borefield will be transported to the header tank within the ARC development footprint via existing pipeline infrastructure. The water demand during the construction phase of the project will be less than the demand for the operational phase of the project (see Section 5.5.3). Associated water licencing requirement are discussed in Chapter 7.

5.4 Stormwater management during operations

This section describes the stormwater management approach for the operational phase of the ARC. It is noted that water management aspects of the encapsulation cell design are discussed separately in Section 5.7.

5.4.1 Stormwater management areas

The following stormwater management systems will be developed:

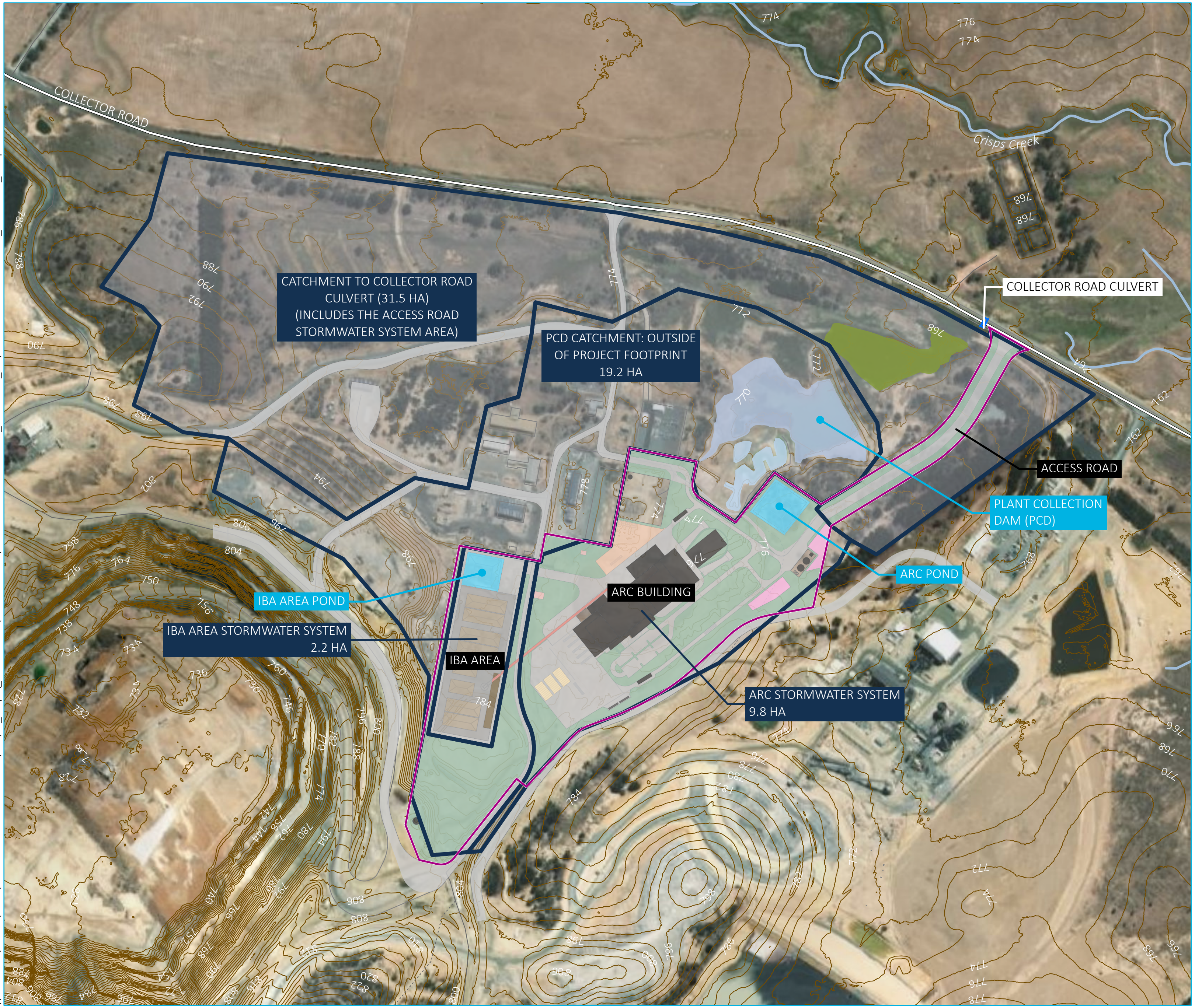
- **Access road stormwater system** – this system will manage stormwater runoff from the northern portion of the access road that is not within the PCD catchment. The contributing catchment area to this system will be approximately 1.1 ha.

- **ARC stormwater system** – this system will manage stormwater runoff from the ARC and surrounding hardstand and landscaped areas. The contributing catchment area to this system will be approximately 9.8 ha.

- **IBA area stormwater system** – this system will manage stormwater runoff from the IBA area. The contributing catchment area to this system will be approximately 2.2 ha.

Figure 5.1 shows the extent of the abovementioned stormwater systems. Collectively, the ARC and IBA area systems will manage runoff from 12 ha of catchment that currently drains to the PCD. The PCD will continue to receive runoff from a 19.2 ha catchment area that is outside of the ARC and IBA area systems. This catchment area is also noted in Figure 5.1.

Concepts for each of the stormwater systems have been prepared as part of the project's Reference Design (see Section 5.1.3). The following sections describe the stormwater management approach for each of the stormwater systems.



KEY

- Development footprint
- Proposed stormwater catchment
- Collector road culvert
- Site layout detail
- Major road
- Minor road
- Vehicular track
- Watercourse
- Contour (m AHD)(2 m interval)
- Ephemeral wetland

Site layout

- ARC building
- Container marshalling area
- Diesel tank
- Existing dam
- Existing LFG pipeline and KOP area
- IBA area
- IBA conveyor
- IBA maturation structure
- IBA processing building
- Landscaping
- Plant collection dam (PCD)
- Road/carpark
- Stormwater pond
- Sub-contractors area
- Waste water irrigation

Source: EMM (2022); Veolia (2022); DFSI (2017)

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Proposed stormwater system

Woodlawn Advanced Energy Recovery Centre
Surface water assessment
Figure 5.1

EMM creating opportunities

5.4.2 Access road stormwater system

i Overview

The access road will be constructed in an area that currently drains to an existing culvert under Collector Road (see Figure 5.1). This culvert currently receives runoff from a 31.5 ha catchment (see Figure 4.5) and drains to the north-east towards Crisps Creek. An ephemeral wetland is located upstream of the culvert (see Figure 4.4).

ii Proposed measures

The access road has been aligned to avoid direct impacts to the ephemeral wetland.

Stormwater runoff from the access road will be managed in vegetated swales that will be constructed on either side of the road. The swales will receive runoff from the road pavement, road reserve and any upgradient undisturbed catchment area that drains towards the road. The swales will infiltrate some runoff. Surplus runoff will drain to a location that is near the inlet to the existing Collector Road culvert. No changes to the catchment area to this culvert or the culvert structure are proposed.

iii Stormwater discharge characteristics

Stormwater discharges from the swales is expected to have water quality characteristics that are similar most regional roads (such as Collector Road), which drain to roadside swales. Impacts to the ephemeral wetland will be minimised by avoiding direct impacts to the wetland and having the swales discharge near the Collector Road culvert inlet.

Residual impacts associated with this stormwater system are discussed further in Chapter 6.

5.4.3 ARC stormwater system

i Overview

The ARC stormwater system will manage runoff from a 9.8 ha area that includes the ARC building, ARC substation, various roads, hardstand and parking areas and landscaped areas. During the initial operating period, the stormwater system will overflow to the PCD. However, the system will be developed such that it can be integrated into a future stormwater system in the PCD catchment, that overflows to the receiving environment (see Section 5.1.1). Accordingly, the following water management objectives apply to the ARC stormwater system.

- Objective 1 – NorBE to the operational effectiveness of ED1 – during the initial operating period, the ARC stormwater system will overflow to the PCD which is dewatered to ED1. Hence, measures that reduce overflow volume will be beneficial to achieving this objective.
- Objective 2 – NorBE to receiving water quality once overflows from the PCD are reinstated. Section 5.1.2 established that this can be achieved by a water management system that:
  - separates potentially contaminated water from stormwater runoff (Objective 2a); and
  - includes a stormwater management system that is consistent with industry best practice for an industrial area (Objective 2b).

The following section describes the measures to achieve these objectives. Consistency with the above objectives is addressed assessed in Chapter 6 (residual impacts), which includes water quality modelling to address WaterNSW's NorBE assessment criteria.

ii Proposed measures

The ARC stormwater system includes a range of source controls to avoid stormwater contact with waste and to separate potentially contaminated water from stormwater runoff. Measures to contain firewater and any accidental leaks or spills that may occur are also included.

The Reference Design includes a range of stormwater controls including rainwater tanks, vegetated swales and gross pollutant traps. Stormwater runoff will drain to the ARC Pond (see Figure 5.1) via piped drainage systems and vegetated swales. The Reference Design established the ARC Pond to have a 4.5 ML volume, which is equivalent to the volume of approximately 45 mm of runoff from the 9.8 ha contributing catchment area. Water captured in the ARC Pond will be used to supply the process water system (see Section 5.5) at a rate of up to 245 kL/day. Extraction at this rate will empty the pond within a 2 to 3 week timeframe.

Allowing for a runoff coefficient of 0.6 (ie 60% of rainfall converts to runoff), the ARC Pond would have capacity to capture runoff from events that comprise up to 75 mm rainfall. This is similar to the design rainfall totals for a 1 exceedance per year multi day duration event (see Table 4.2). Hence, overflows are expected to occur approximately once per year.

It is noted that the ARC Pond capacity established in the Reference Design is approximately three times greater than the capacity required to capture the 5 day 90th percentile rainfall event, which comprises 29 mm of rainfall (see Table 4.3). This event is commonly used in NSW as a design capacity for stormwater basins that manage uncontaminated runoff from catchments that have industrial land uses.

Table 5.3 describes the proposed stormwater measures for the ARC stormwater system.

Table 5.3 ARC stormwater system – proposed measures

Aspect	Proposed measures
1. Source controls	• All waste will be handled within the ARC building, which is a fully enclosed structure. • IBA will be initially handled within the ARC building before being transported to the IBA area using methods that do not pose a stormwater contamination risk. • Stabilised APCr will be initially handled within the ARC building before being transported to the encapsulation cell using methods that do not pose a stormwater contamination risk. • All hazardous chemicals and hydrocarbon products will be stored in bunded areas in accordance with relevant Australian Standard AS1940:2004 and guidelines in Section 3.2.1. • All washdown water will be managed by the process water system (see Section 5.5). • All pervious areas will be vegetated to minimise soil erosion.
2. Stormwater conveyance and flooding	• Stormwater runoff will be managed via a combination of surface and piped drainage systems. These systems will be designed to have a non-erosive hydraulic capacity equivalent to the 5% AEP event. • Overland flow paths will be established to have a 1% AEP capacity. • The stormwater system and overall ARC will be designed to prevent stormwater ingress into the ARC building for the 1% AEP event.
3. Stormwater harvesting and water quality control	• Water quality controls such as rainwater tanks, vegetated swales and gross pollutant traps may be installed within the catchment. • Stormwater captured in the ARC Pond will be used to supply the process water system. This will minimise stormwater overflows to the PCD. • Collectively the water quality controls and the stormwater harvesting system will be configured so that the following water management objectives are achieved: – Objective 1 – NorBE to the operational effectiveness of ED1. – Objective 2 – NorBE to receiving water quality once overflows from the PCD are reinstated. The Reference Design achieves both of these objectives (see Chapter 6). If variations to the Reference Design are made at Detailed Design, further assessment will be required to demonstrate that the alternative design achieves the abovementioned objectives.
4. Fire water retention and containment	• The ARC Pond will be designed to contain any firewater runoff and leaks and spills that may occur within the ARC stormwater system. The Reference Design achieves this objective as the maximum firewater volume was established to be approximately one-third of the ARC Pond volume.

iii Stormwater discharge characteristics

Due to the capacity of the ARC Pond and the stormwater harvesting system, overflows from the ARC stormwater system are expected to occur approximately once per year, during significant rainfall events or following periods of prolonged wet weather.

When overflows do occur, the water quality is expected to be similar to treated stormwater runoff from an industrial area that has a stormwater system consistent with industry best practice. This will be achieved as the proposed source controls will separate potentially contaminated water from stormwater runoff and the water quality controls and stormwater harvesting will reduce pollutant loads in stormwater overflows to meet or exceed WaterNSW's NorBE requirements. This is assessed further in Chapter 6.

5.4.4 IBA area stormwater system

i Overview

The IBA area stormwater system will manage runoff from the IBA area, which has an area of approximately 2.2 ha. IBA will be stored in uncovered stockpiles on the pad. Hence, stormwater contact with IBA will occur. The water quality of stormwater runoff from the IBA area is unknown but is assumed to be potentially contaminated. Accordingly, the IBA stormwater system seeks to capture all runoff from the IBA area. Captured water will be primarily used with in the IBA area for dust suppression but as a contingency, can also be dewatered to ED1 to avoid an overflow. This is consistent with Water Management Objective 2a (separation of potentially contaminated water from stormwater runoff – see Section 5.1.2).

ii Proposed measures

All runoff from the IBA area will be conveyed to the IBA Pond via surface drains. The Reference Design established the IBA Pond to have a capacity of 4.7 ML, which is equivalent to the volume of approximately 213 mm of runoff from the 2.2 ha contributing catchment area. Allowing for a conservative runoff coefficient of 0.8 (ie assuming 80% of rainfall converts to runoff), the IBA Pond would have capacity to capture runoff from events that comprise up to 270 mm rainfall. This exceeds the rainfall depth of a 1% AEP 7-day design storm event (251 mm of 7 days – see Table 4.2).

Water captured in the IBA Pond will be used within the IBA area for dust suppression. This is expected to be an effective means to manage water accumulation between September and March, when evaporation rates generally exceed rainfall (see Section 4.1.1). There will be less opportunity to manage water accumulation in the IBA Pond between April and October, when rainfall typically exceeds evaporation. If required, surplus water from the IBA Pond can be dewatered to ED1 to avoid overflows due to water accumulation. This is only expected to be required to restore basin capacity if a significant rainfall event or a prolonged period of above average rainfall occurs between April and October.

Drainage will also be established to divert runoff from any upgradient areas around the IBA area. These drainage systems will have a 1% AEP capacity to ensure there is no stormwater ingress into the IBA area stormwater system.

iii Stormwater discharge characteristics

The IBA Pond will have capacity to capture all runoff during a 1% AEP event and water accumulation in the pond will primarily be used with in the IBA area for dust suppression (when conditions are suitable) but can also be dewatered to ED1 to avoid an overflow. Accordingly, no overflows from the IBA area stormwater system are expected.

5.5 Operational water management

5.5.1 Management approach

The operation of the ARC will require water for steam generation, steam conditioning, ash quenching, APCr stabilisation, operation of the FGT system, dust suppression within the IBA area and other miscellaneous uses. A process water system will be established to meet these operational water requirements and manage associated contaminated water streams.

The Reference Design of the process water system considers the water quality requirements of the various water uses and seeks to utilise recycled process water and potentially contaminated stormwater to manage these water streams and reduce the project’s water supply requirements.

The Reference Design established that the operation of the project will require an ongoing water supply of approximately 245 kL/day or 90 ML/year. This water will be sourced from stormwater harvesting (when available) and the Willeroo Borefield (when stormwater is not available). The system will utilise potentially contaminated stormwater runoff captured in the IBA Pond (see Section 5.4.4) and recycled process water streams. Under some circumstances, surplus brine from the demineralising plant may need to be managed externally to the ARC. If this is required, the surplus brine would be reticulated to ED1.

Figure 5.2 shows the framework of the operational water management system. It describes the functionality of the process water system and its integration with the ARC and IBA area stormwater systems and components of the existing Eco Precinct water management system. Average annual inflows and outflows from the process water system are also noted on the figure, these water fluxes were established by a water balance of the process water system that was undertaken for the Reference Design.

Table 5.4 provides a description of the key inflows and outflows from the process water system.

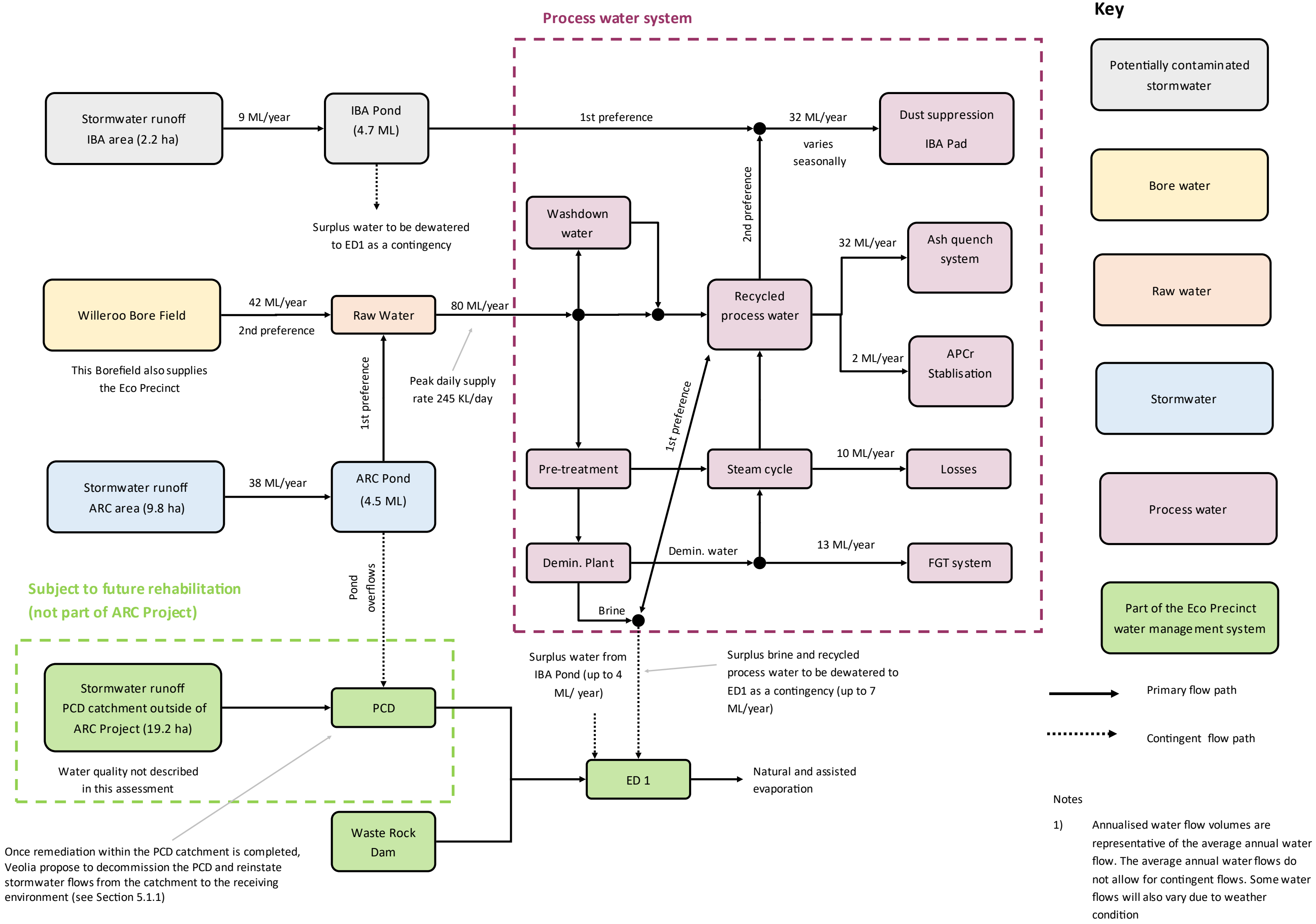

Figure 5.2 Operational water management framework

Table 5.4 Description of process water inflows and demands

	Description	Water quality description	Comments
Water inflows			
Stormwater harvesting (ARC Stormwater System)	Runoff from the 9.8 ha ARC stormwater system will be reticulated to the ARC Pond. Water captured in this pond will be used to supply the process water system. When full the ARC Pond will overflow to the PCD or a future alternative arrangement. Refer to Section 5.4.3 for further information on ARC stormwater system.	**Stormwater**, suitable for: • use in the process water system; or • offsite discharge following stormwater treatment	Stormwater harvesting from the ARC stormwater system will be a controlled inflow into the process water system. The ARC stormwater harvesting system will meet the overall process water demand (estimated to be 245 kL/day) in approximately 120 days /per year (on average). The system will provide minimal inflows during dry conditions and is not considered to be a drought secure water supply. Overflows from the ARC Pond will occur occasionally (approximately once per year).
Stormwater harvesting (IBA area system)	Runoff from the 2.2 ha IBA area stormwater system will be reticulated to the IBA Pond. Water captured in this pond will primarily be used within the IBA area for dust suppression (when conditions are suitable) but can also be dewatered to ED1 to avoid an overflow. Refer to Section 5.4.4 for further information on IBA area stormwater system.	**Potentially contaminated stormwater** that requires management to avoid mixing with uncontaminated stormwater. The water quality will be suitable for dust suppression use within the IBA area.	Stormwater harvesting from the IBA stormwater system is a key measure to prevent overflows from this system. Water balance model results provided in Figure 5.2 indicate that stormwater harvesting will provide less than 30% of the IBA area dust suppression water requirements. The system will provide minimal inflows during dry conditions and is not considered to be a drought secure water supply.
Willeroo Borefield	The Willeroo Borefield currently supplies water to the Eco Precinct. The Borefield will provide a drought secure water supply to the project that will be utilised when stormwater harvesting is not available. Borewater will be supplied via existing pipeline infrastructure at the Eco Precinct which connects the ARC development footprint to the Willeroo Borefield. Refer to the Groundwater Assessment (EIS Appendix U) for detailed information on the existing bores, sustainable yields and water licencing provisions.	**Borewater**, that is suitable for use in the process water system.	The Willeroo Borefield is the drought secure water supply for the project. Accordingly, during dry conditions it is expected to meet the full project water supply requirements (245 kL/day) or 90 ML/ year.

Table 5.4 Description of process water inflows and demands

	Description	Water quality description	Comments
Process water uses			
IBA area dust suppression	Water from the IBA Pond will be sprayed onto the IBA stockpiles to suppress dust.	There are no water quality requirements for this water use.	The Reference Design established that the average annual water use for dust suppression will be 32 ML/year (or 88 kL/day). However, the dust suppression demand will vary seasonally in line with evaporation rates and will be lower during and shortly after wet weather. The dust suppression demand will generally exceed the availability of water from the IBA stormwater system. Hence, top-up from the recycled process water will be required most of the time (see Figure 5.2). As noted in Section 5.4.4, occasionally surplus water from the IBA Pond may need to be dewatered to ED1 to avoid overflows due to water accumulation. This is only expected to be required to restore basin capacity if a significant rainfall event or a prolonged period of above average rainfall occurs between April and October.
Ash quench system	Recycled process water will be used to cool IBA that is produced by the energy recovery process.	There are no water quality requirements for this water use.	The Reference Design established that the average annual water use for the ash quench system will be 32 ML/year (or 88 kL/day), which coincidentally is the same water use rate as IBA area dust suppression. Water use for ash quenching is expected to be constant.
APCr Stabilisation	Recycled process water will be mixed with a soil binding agent (ie cement) to stabilise APCr, prior to its transportation to the encapsulation cell.	There are no water quality requirements for this water use.	The Reference Design established that the average annual water use for the APCr stabilisation will be 2 ML/year (or 5 kL/day). This water use is expected to be constant.
Steam cycle losses	Water will be used in the steam cycle process for steam generation and cooling.	Only **demineralised water** can be used for steam generation. Demineralised water will be produced by a demineralisation plant (see Figure 5.2)	The Reference Design established the average annual net steam cycle losses to be 10 ML/year (or 27 kL/day). This water use is expected to be constant.
FGT system	Water will be used in the FGT system.	Only **demineralised water** can be used in the FGT system. Demineralised water will be produced by a demineralisation plant (see Figure 5.2)	The Reference Design established that the average annual water use for the FGT system will be 13 ML/year (or 35 kL/day). This water use is expected to be constant.

5.5.2 Contaminated water management

The process water system will utilise potentially contaminated stormwater runoff captured in the IBA Pond (see Section 5.4.4) and recycled process water that could comprise a mixture of raw water, brine and return water from the wash down and steam cycle systems. As noted in Figure 5.2, under certain circumstances (such as extended wet weather) there may be surplus process water that requires management via dewatering to ED1. Water balance modelling undertaken for the Reference Design estimated that up to 4 ML/year from the IBA Pond and 7 ML/year of surplus brine may need to be dewatered to ED1 in some years. These contingency arrangements are indicated in Figure 5.2. It is noted that these are upper bound estimates and will only be required in some years.

The contingency arrangements will ensure that all contaminated stormwater or recycled process water is managed in either the process water system or ED1, with no discharges to the stormwater system expected. This is consistent with Water Management Objective 2a (separation of potentially contaminated water from stormwater runoff- see Section 5.1.2).

5.5.3 Drought secure water supply

The Reference Design established that the operation of the project will require an ongoing water supply of approximately 245 kL/day or 90 ML/year. This water will be sourced from stormwater harvesting (when available) and the Willeroo Borefield (when stormwater is not available) via existing pipeline infrastructure at the Eco Precinct which connects the ARC development footprint to the Willeroo Borefield. During drought conditions, it is anticipated that the Willeroo Borefield will need to meet the project's full water supply requirements for extended periods of time. Accordingly, this EIS assumes that the Willeroo Borefield will provide up to 90 ML/year to the project. Refer to the Groundwater Assessment (EIS Appendix U) for detailed information on the Willeroo Borefield, an assessment of sustainable yields and water licencing provisions.

The provision of the Willeroo Borefield as a drought secure water supply to the project addresses Water Management Objective 3 (see Section 5.1.2).

5.6 Amenities water supply and wastewater management

Site amenities will be supplied by rainwater tanks, which will capture runoff from select roof areas within the ARC. Water will be treated to a suitable quality for use in amenities. Alternative supplies (such as trucked in water) may be required during drought conditions.

A new on-site wastewater system will be established to manage wastewater (ie sewage) produced within the ARC's amenities. The system will be designed and operated in accordance with the methods described in Designing and Installing On-Site Wastewater Systems (WaterNSW 2019b). This is consistent with the requirements of Water Management Objective 2c (see Section 5.1.2).

An On-Site Wastewater Report was prepared by Broadcrest Consulting Pty Ltd (Broadcrest) as part of the Reference Design. The report recommended that wastewater produced by the ARC can be managed in an on-site wastewater system that comprises:

- an aerated wastewater treatment system (AWTS) with disinfection (or an equivalent system); and
- a sub-surface drip irrigation system to manage the treated effluent.

Broadcrest identified an area located to the east of the ARC that would be suitable for both the AWTS and effluent irrigation system. An irrigation area of 1,945 m^2 was calculated for the assumed wastewater load of 4,380 L/day.

The proposed effluent irrigation area is shown in Figure 5.1 and the Broadcrest report is provided as Appendix C.

5.7 Encapsulation cell – water management

The encapsulation cell will be a lined and engineered landfill cell for the encapsulation of stabilised APCr. It will be constructed in the western portion of ED1 in a staged manner over the 25-year project design life. The layout of the encapsulation cell is provided in Figure 2.4.

An encapsulation cell design has been prepared by Golder and is described in the Encapsulation Cell Design Report (EIS Appendix F).

The following sections provide a summary of the proposed water management approach and changes to ED1.

5.7.1 Water management

The following water management aspects of the encapsulation cell are relevant to this surface water assessment:

- Surface water runoff – will occur from completed portions of the encapsulation cell, which will be capped and vegetated. The water quality of runoff is expected to be clean but will drain to ED1, due to the encapsulation cell's location within ED1.

- Leachate management – the encapsulation cell will incorporate an engineered leachate barrier and collection system, which will be double lined on the floor and walls. The upper liner will provide leachate collection and the lower layer will be used for leak detection. Collected leachate will be pumped to a leachate pond that will be located to the north of the cell (see Figure 2.4). The pond will be lined and will not receive any inflows other than leachate and direct rainfall and will manage leachate accumulation via evaporation.

Refer to Encapsulation Cell Design Report (EIS Appendix F) for further information on the surface water runoff and leachate management approach.

5.7.2 ED1 changes

i Existing dam

ED1 is an existing evaporation dam that receives direct rainfall, runoff from the surrounding area and water pumped from the Waste Rock Dam and PCD. Water accumulation is managed via natural and assisted evaporation from ED1 (see Section 4.4). The dam location is shown in Figure 4.5. Table 5.5 provides the key dam levels and the storage and surface area at the dam's full supply level.

Table 5.5 ED1 – key characteristics

Characteristic	Value	Relates to
Spillway crest level	788.8 m AHD	The spillway crest level. It is noted that the existing spillway crest level may be revised prior to the construction of the encapsulation cell and leachate pond to meet dam safety obligations.
Full Supply Level (FSL)	788.3 m AHD	The maximum operating level (ie the maximum level that the dam can be filled to). The FSL allows for a 0.5m freeboard to the spillway crest. It is noted that this level may change if the spillway crest level changes.
Maximum Water Level (MWL)	789.3 m AHD	The probable maximum water level that can occur in the dam. For example, if an extreme rainfall event occurs when the dam is at FSL which results in the dam spilling. It is noted that this level may change if the spillway crest level changes.
Storage capacity	977 ML	The storage volume at FSL
Maximum surface area	43 ha	The surface area at FSL

ii Changes to ED1 volume and area

The encapsulation cell will be constructed in the western portion of ED1 in a staged manner over the 25-year design life. The layout of the encapsulation cell shown in Figure 2.4 relates to the final landform. Staging information is provided in the Encapsulation Cell Design Report (EIS Appendix F).

The construction of encapsulation cell and leachate pond will reduce both the evaporation area and storage capacity of ED1. Figure 5.3 shows the ED1 elevation/storage and elevation/area curves for existing and future scenarios. The future scenario curves are based on the final encapsulation cell landform. The curves show that the construction of the encapsulation cell and leachate pond will reduce the maximum surface area from approximately 43 to 28 ha (a 34% reduction) and the maximum storage volume from approximately 977 ML to 657 ML (a 33% reduction). The lower evaporation area and storage volume will reduce ED1's capacity to manage pumped inflows (Mechanism 1 – see Section 5.1.2). An ED1 water balance has been prepared to assess the cumulative impact of the project on the operational effectiveness of ED1. The reduction in surface area and storage volume in ED1 is one of the factors assessed in the water balance. The ED1 water balance is discussed further in Chapter 6 (residual impacts).

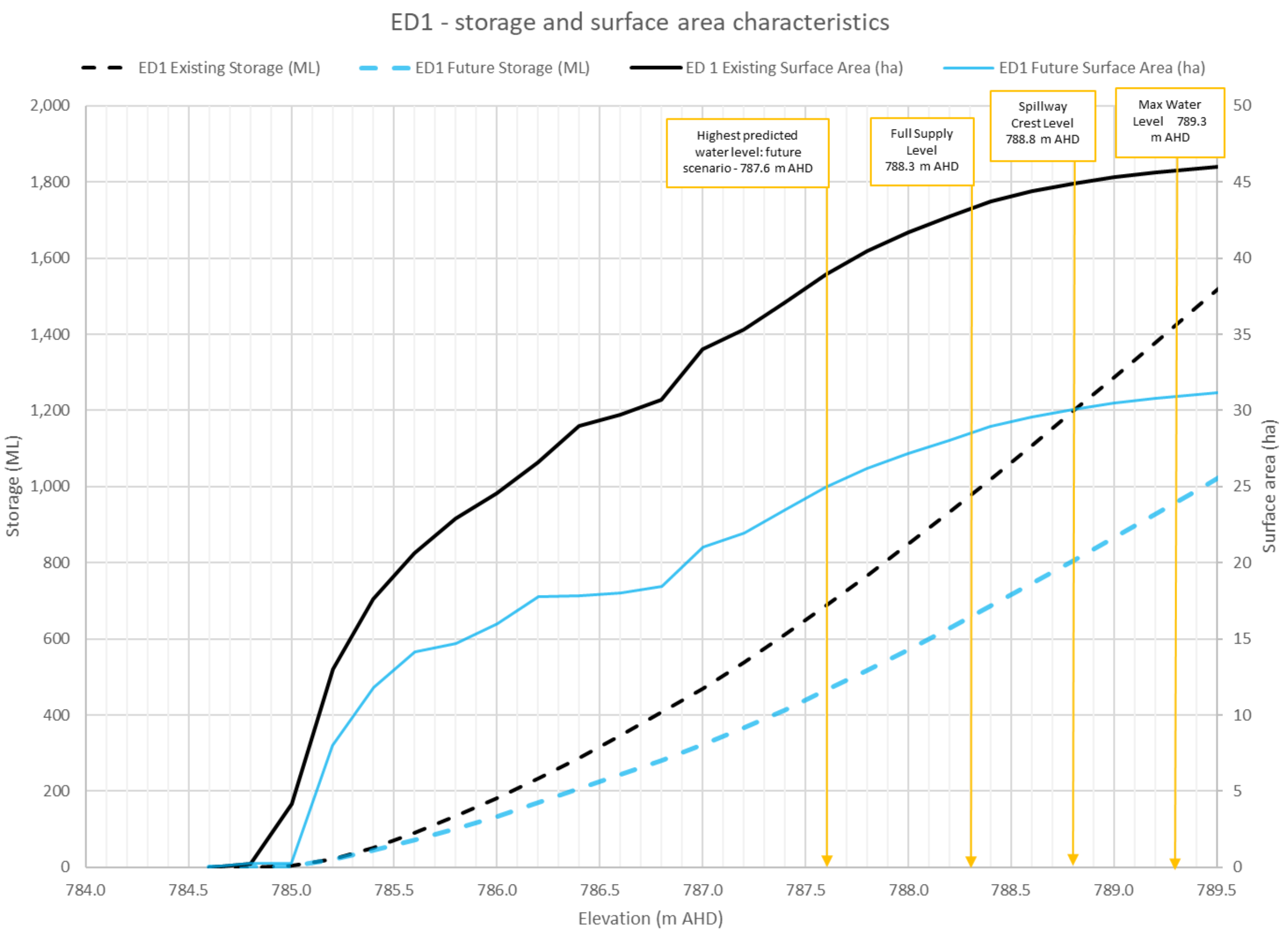

Figure 5.3 Storage and surface area characteristics: existing and proposed scenarios

Source: Woodlawn ARC water balance (WSP 2022) – Provided as Appendix B. See Section 6.1.3 for notes on minor adjustments made.

iii Impacts to full supply level

The Encapsulation Cell Design Report (EIS Appendix F) describes the ED1 Maximum Water Level as the design water level for the encapsulation cell and leachate pond. The Maximum Water Level is the probable maximum water level that can occur in the dam (see Table 5.5). Accordingly, there will be no impact to the ED1 FSL due to the construction of the encapsulation cell and leachate pond within ED1.

iv Impacts to ED1 water quality

No impacts to ED1 water quality are expected as the encapsulation cell will have a full base liner with a leachate collection system and the leachate pond will be fully lined with the pond embankment crest constructed above the ED1 Maximum Water Level.

6 Residual impacts

The project's water management system will be integrated with parts of the Eco Precinct's water management system, which may evolve over time for a variety of reasons such as completion of rehabilitation works. Three water management objectives have been established to enable a clear and concise assessment of the project's residual impacts, which is required to address the assessment requirements (see Section 1.2). The three objectives are described in Chapter 5 and are reproduced below:

- Objective 1 – achieve a NorBE on the operational effectiveness of ED1;
- Objective 2 – achieve a NorBE on receiving water quality; and
- Objective 3 – provide a drought secure water supply for the project.

Objective 3 is addressed in Section 5.5.3 and associated residual impacts are described in the Groundwater Assessment (EIS Appendix U). Objectives 1 and 2 are addressed in this chapter. Impacts associated with the access road are also described separately in this chapter as the access road is located outside of the Eco Precinct's existing water management system and has different potential impacts.

It is noted that this report describes overflows from the proposed ARC stormwater system as being managed in the PCD and ED1 systems, with no discharges to the receiving environment expected. Section 5.1.1 notes that once remediation within the PCD catchment is completed, Veolia proposes to decommission the PCD and reinstate stormwater flows from the catchment to the receiving environment. A stormwater control such as a constructed wetland (or another suitable alternative) may be established in the PCD area to achieve a stormwater management system that is consistent with industry best practice for an industrial area. The timing of these works is subject to the completion of remediation works and separate regulatory approvals. To achieve alignment with the site's rehabilitation objectives, the ARC stormwater system will be developed such that it can be integrated into a future stormwater system in the PCD catchment that overflows to the receiving environment. This has been adopted as a water management objective. This chapter describes residual impacts associated with the project (ie ARC stormwater system overflows managed in the PCD and ED1 systems) as well as consistency with Objectives 1 and 2.

6.1 Operation effectiveness of ED1

ED1 is an evaporation dam that is currently used to manage contaminated water from the PCD and the Waste Rock Dam (see Section 4.4). Under the current operating arrangement, surplus water from the PCD and Waste Rock Dam is pumped to ED1 to prevent overflows to the receiving environment. Water accumulation in ED1 is managed via natural and assisted evaporation, which is a gradual process that varies seasonally. Accordingly, the operational effectiveness of ED1 to manage surplus water from the PCD and Waste Rock Dam is a function of the dam's ability to store water during extended wet periods and manage water accumulation via evaporation.

Achieving a NorBE on the operational effectiveness of ED1 is a water management objective for the project. A NorBE can be achieved if one of the following criteria is met:

1. the cumulative changes due to the project result in lower water levels in ED1, for a full range of weather conditions; or
2. the cumulative changes due to the project result in higher water levels in ED1, but there is no impact to the operational effectiveness of the dam, in that it can still receive pumped inflows from the PCD and Waste Rock Dam for a full range of weather conditions.

A water balance model of the ED1 system has been prepared by WSP to assess consistency with this objective. The following sections describe:

- the water balance modelling approach, with reference to descriptions of the water management system that are provided in Chapter 5; and
- key model results and conclusions.

A water balance report prepared by WSP is provided as Appendix B.

6.1.1 Impact mechanisms and water balance model approach

WSP applied a water balance approach that is consistent with previous studies undertaken for Veolia to assess the evaporation pond system. Refer to Appendix B for a description of the modelling approach and assumptions.

Chapter 5 established three project mechanisms that will impact the water balance for ED1. Mechanisms 1 and 2 will negatively impact the water balance (ie reduce the capacity of ED1) while mechanism 3 will have a positive impact. Table 6.1 describes the impact mechanisms and water balance approach.

Table 6.1 Impact mechanisms and water balance approach

Mechanism	Description	Water balance model approach
Mechanism 1 – reduction in evaporation area and storage due to the encapsulation cell.	The encapsulation cell will be constructed in the western portion of ED1. This will reduce the storage volume and evaporation area by approximately 33 and 34% respectively (see Section 5.7.2).	The WSP water balance model has accounted for a reduction in the ED1 storage volume and evaporation area by adjusting the elevation/storage and elevation/area curves applied to the model for the future scenario. The adjustments are based on the final landform and are therefore conservative as the final landform will not be established until near the end of the project. It is noted that a minor change to the final landform was made following completion of the WSP water balance model (see Section 6.1.3). The modelling approach also conservatively accounts for the initial displacement of water during the construction phase of the cell by applying the same initial water volume to the existing and future scenarios. This results in a higher initial water level in the future scenario as the same volume of water is a stored in a smaller storage (ie the future ED1). This approach is also conservative as the displacement of water during construction would occur in stages over the 25-year project life. The model assumes this occurs at the commencement of the project.
Mechanism 2 – discharges from the process water system.	Water balance modelling undertaken for the Reference Design estimated that up to 4 ML/year from the IBA Pond and 7 ML/year of surplus brine may be dewatered to ED1 in some years. It is noted that these are upper bound estimates and will only be required in some years (see Section 5.5.2 for further information).	These additional inflows have been accounted for in the WSP water balance model through the following assumptions: • 75% of the upper bound estimate of surplus process water was applied to the wet weather sequence; and • 50% of the upper bound estimate of surplus process water was applied to the average and dry weather sequences.

Table 6.1 Impact mechanisms and water balance approach

Mechanism	Description	Water balance model approach
Mechanism 3 – reduced pumped inflows from the PCD.	Stormwater harvesting will be incorporated into the proposed ARC and IBA area stormwater systems (see Section 5.4). This will reduce (relative to existing conditions) the runoff volume to the PCD. The lower runoff volumes to PCD will reduce the storage and evaporation capacity required in ED1 to manage pumped inflows from the PCD, thereby increasing the available capacity in the dam. It is also noted that Veolia proposes to decommission the PCD and reinstate stormwater flows from the catchment to the receiving environment (see Section 5.1.1). These future works are not considered in the water balance model as they will be undertaken separately to the ARC project. Once completed these works will be beneficial to the ED1 water balance as there will be no pumped inflows from PCD.	The following assumptions were applied to the existing and future scenario models to account for the project changes. **PCD inflows – existing scenario** • Runoff from the existing PCD catchment (31.3 ha). **PCD inflows – future scenario** • Runoff from the remaining PCD catchment (19.2 ha). • Overflows from the ARC stormwater system. It is noted that the IBA area stormwater system was not included in the future scenario model as it is a zero-discharge system (see 5.4.4).

6.1.2 Description of residual impacts

The ED1 water balance model assessed the existing and future scenarios for dry, average and wet weather sequences. Each sequence applied a 10-year daily rainfall time-series extracted from historical records.

The model results concluded that the cumulative changes due to the project will be beneficial to the ED1 water balance as the reduction in pumped inflows from the PCD (Mechanism 3) will more than offset the reduction in evaporation and surface area (Mechanism 1) and discharge of surplus process water (Mechanism 2). However, water levels in ED1 may be higher for an initial period (up to 5 years) due to the displacement of water required to construct the encapsulation cell and leachate pond.

The model estimated that the highest water level in ED1 for the future scenario is 787.6 m AHD, which is 0.7 m below the FSL (788.3 m AHD) and is equivalent to 70% of the future capacity of ED1.

Accordingly, the water balance model results demonstrate that the project will be consistent with Objective 1 on the basis that there will be no impact to the operational effectiveness of ED1, in that it can still receive pumped inflows from the PCD and Waste Rock Dam for a full range of weather conditions.

6.1.3 Minor change to final landform

A minor change to the combined footprint of the encapsulation cell and leachate pond was made following the completion of the WSP water balance model in late 2021. The change relates to a revision to the leachate pond design which resulted in a larger footprint that increases the reduction in ED1 storage volume from approximately 30% to 33% and evaporation area from approximately 32% to 34% (at full supply level). Figure 6.1 shows ED1 level storage and level surface area curves for the: existing dam, future scenario (as applied to the water balance model) and future scenario (based on revised footprint). It is noted that the future scenario revised footprint curves are used in Section 5.7.1 to describe the changes in ED1.

The water balance modelling was not updated to incorporate this minor change to the project footprint as the model results demonstrated that there is significant unutilised capacity in ED1 (ie only 70% of future capacity of ED1 would be utilised). Hence, a minor reduction in the storage and evaporation area would not change the assessment conclusion that there will be no impact to the operational effectiveness of ED1, in that it can still receive pumped inflows from the PCD and Waste Rock Dam.

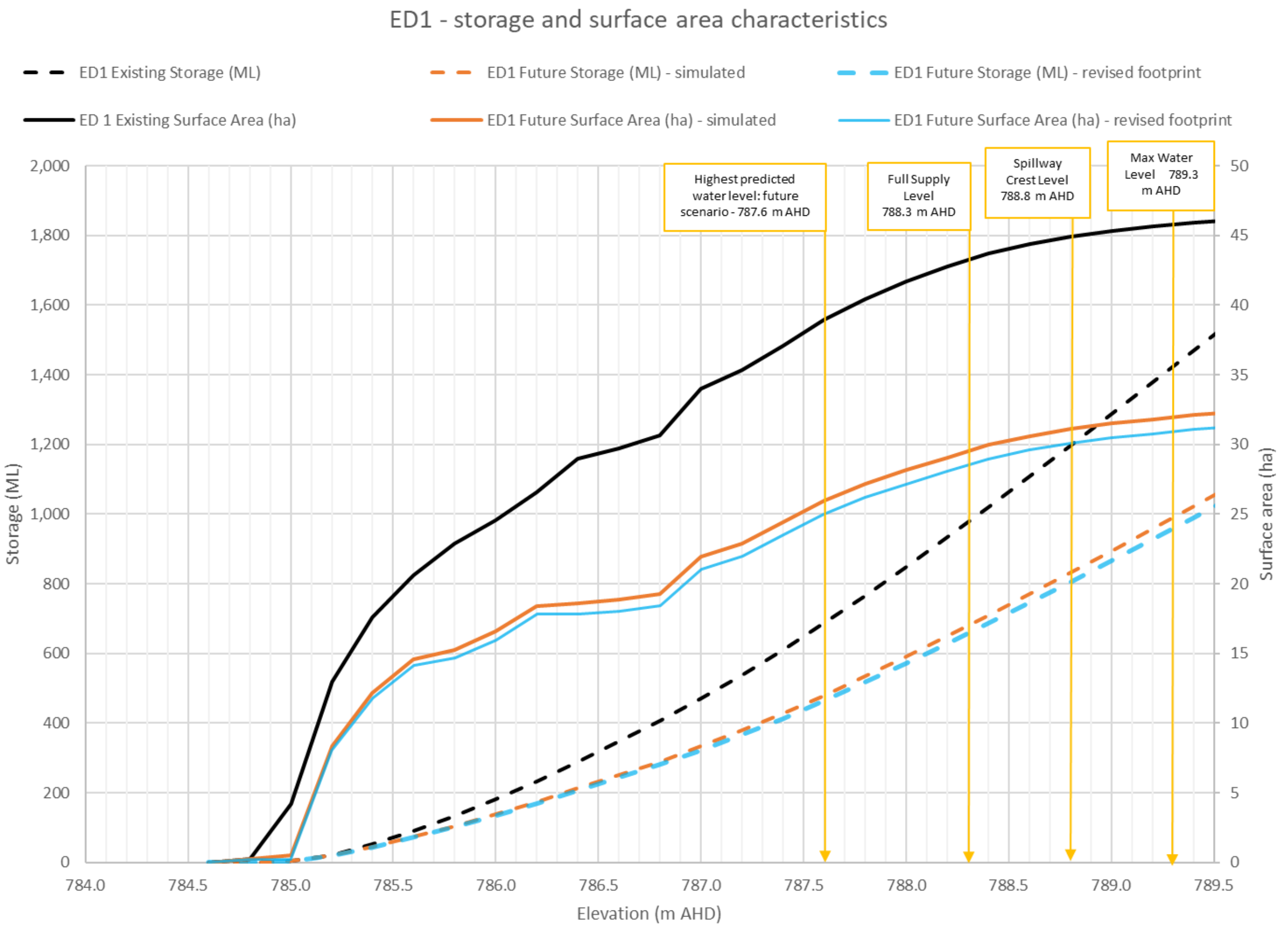

Figure 6.1 **Storage and surface area characteristics: existing and proposed scenarios**

Source for existing and future (simulated) curves: Woodlawn ARC water balance (WSP 2022) – provided as Appendix B.

6.2 NorBE on receiving water quality

The SEARs require that a NorBE on receiving water quality is demonstrated (see Table 1.1). Section 5.1.2 established that a NorBE on receiving water quality can be achieved by a water management system that meets the following objectives:

- Objective 2a – separates potentially contaminated water from stormwater runoff;
- Objective 2b – includes a stormwater management system that is consistent with industry best practice (also referred to as current recommended practices (CRP)) for an industrial area; and
- Objective 2c - includes a wastewater (ie sewage) management system that is designed and operated in accordance with the methods described in *Designing and Installing On-Site Wastewater Systems* (WaterNSW 2019b).

Consistency with these water management system objectives is discussed below.

6.2.1 Consistency with Objective 2a

The water management system includes the following measures to separate potentially contaminated stormwater and recycled process water from the stormwater system:

- During construction surface water runoff from areas that may have existing contamination and any water produced by construction activities will be managed in the PCD and ED1 system. No off-site discharges are expected (see Section 5.3.2).

- The ARC stormwater system includes a range of source controls to avoid stormwater contact with waste and to separate potentially contaminated water from stormwater runoff. Measures to contain firewater and any accidental leaks or spills that may occur are also included (see Section 5.4.3).

- The IBA area stormwater system will manage potentially contaminated stormwater from the IBA area. The system will have capacity to capture all runoff during a 1% AEP event and water accumulated in the IBA Pond will primarily be used with in the IBA area for dust suppression (when conditions are suitable) but can also be dewatered to ED1 to avoid an overflow. Accordingly, no overflows from the IBA area stormwater system are expected (see Section 5.4.4).

- The process water system will utilise potentially contaminated stormwater runoff captured in the IBA Pond and recycled process water that could comprise a mixture of raw water, brine and return water from the wash down and steam cycle systems. Under certain circumstances (such as extended wet weather) there may be surplus process water that requires management via dewatering to ED1. This contingency arrangement will ensure that all contaminated stormwater or recycled process water is managed in either the process water system or ED1, with no discharges to the stormwater system expected (see Section 5.5.2).

Measures have been established to minimise stormwater contact with waste and manage all potentially contaminated water streams. The ability to manage any contaminated water in ED1 also provides significant contingency for the overall system. Accordingly, the water management system is expected to be effective in minimising stormwater contamination risks associated with the construction and operation of the ARC and therefore is consistent with Objective 2a.

6.2.2 Consistency with Objective 2b

Objective 2b requires the stormwater management system to be consistent with industry best practice for an industrial area. This is addressed via an overview of the stormwater management approach to establish best practice and water quality modelling to address WaterNSW's quantitative NorBE assessment criteria.

i Stormwater management approach

Table 6.2 provides an overview of the stormwater management approach and explains why the proposed approach is consistent with industry best practice for an industrial area. Reference is made to guidelines that are listed as CRP and standards on WaterNSW's website (WaterNSW 2021b). Refer to Section 5.4 for more detailed descriptions of the stormwater approach.

Table 6.2 Stormwater systems – comparison to best practice

	Discharges to	Proposed controls	Consistent with best practice
Access road stormwater system (1.1 ha)	Crisps Creek catchment, upstream of the Collector Road culvert.	• All runoff will be treated in vegetated roadside swales.	**Yes**, runoff from most regional roads is managed in roadside swales. Vegetated swales are also described as a stormwater management option in *Guidelines for treatment of stormwater runoff from Road Infrastructure AP R232/03* (Austroads 2003). This guideline is listed on WaterNSW's website (WaterNSW 2021b) as a CRP and standard.
ARC stormwater system (9.8 ha)	The ARC stormwater system will overflow to the PCD but may be integrated into a future stormwater system in the PCD catchment that overflows to the Crisps Creek catchment.	• Source controls to minimise stormwater contamination risks. • Various stormwater controls including rainwater tanks, vegetated swales and gross pollutant traps. • Stormwater harvesting system that captures stormwater runoff for use in the process water system. It is noted that the system established by the Reference Design has a capacity that is approximately three times greater than the capacity required to capture the 5 day 90th percentile rainfall event.	**Yes**, on the basis that source controls are proposed and the stormwater harvesting system capacity exceeds the 5 day 90th percentile rainfall event, which is commonly used in NSW as a design capacity for stormwater basins that manage uncontaminated runoff from catchments that have industrial land uses. The proposed controls are also generally consistent with the guidelines that are listed in WaterNSW's website (WaterNSW 2021b) as CRP and standards. However, it is noted that these guidelines do not have specific requirements for industrial sites.
IBA area stormwater system (2.2 ha)	Zero-discharge system	• A stormwater capture and harvesting system that has capacity to capture all runoff during a 1% AEP event.	**Yes**, on the basis that the system is a zero-discharge system.

The descriptions provided in Table 6.2 establish that the stormwater management approach is consistent with industry best practice for an industrial area.

ii Water quality modelling

Water quality modelling of the access road and ARC stormwater systems was undertaken to address WaterNSW's NorBE assessment criteria. This section provides an overview of the assessment approach and results. More detailed information is provided in a water quality modelling technical report that is provided in Appendix D.

a Assessment criteria

The *Neutral or Beneficial Effect on Water Quality Assessment Guideline* (WaterNSW 2021) provides direction on what NorBE means and how to assess it in a development application. The guideline recommends the use of the *Model for Urban Stormwater Improvement Conceptualisation* (MUSIC) for all developments with an impervious area greater than or equal to 2,500 m^2. MUSIC simulates sediment and nutrient generation from land surfaces and the performance of stormwater controls and mitigation measures. The application of MUSIC modelling within the Sydney drinking water catchments is described in *Using MUSIC in the Sydney Drinking Water Catchment* (WaterNSW 2019a), which outlines the following criteria for achieving NorBE:

- The mean annual pollutant loads for the post-development case (including mitigation measures) should aim to be 10% less than the pre-development case for total suspended solids (TSS), total phosphorus (TP) and total nitrogen (TN).
- Pollutant concentrations for TP and TN for the post-development case (including mitigation measures) must be equal to or better compared to the pre-development case for between the 50th and 98th percentiles over a five-year modelling period. Periods of zero flow are not to be accounted for in the statistical analysis as there is no downstream water quality impact during no flow periods. To demonstrate this, comparative cumulative frequency graphs, which use the flow-based sub-sample threshold for both the pre- and post-development cases, must be provided. As meeting the pollutant percentile concentrations for TP generally also meets the requirements for TSS, cumulative frequency analysis is not required for TSS.

b Modelling approach

The MUSIC model has been developed based on the Reference Design (see SWA Section 5.1.3) and includes access roads, buildings, landscaped area, and stormwater management infrastructure. The following scenarios have been assessed using the MUSIC model:

- Scenario 1 – Stormwater discharges from the access road only. This scenario represents the proposed project, which describes overflows from the ARC stormwater system as being managed in the PCD and ED1 systems, with no discharges to the receiving environment expected.
- Scenario 2 – Stormwater discharges from the road plus future ARC stormwater overflows. This scenario represents a potential future scenario and is included to demonstrate that the ARC stormwater system can be integrated into a future stormwater system in the PCD catchment that overflows to the receiving environment. It is noted that Scenario 2 does not include the IBA area stormwater system as it will be established as a zero-discharge system for the project life (see Section 5.4.4).

The results for both scenarios are compared to simulated water quality from a theoretical catchment that has agricultural land use and an equivalent catchment area (the pre-development results). Refer to Appendix D for detailed information on the modelling approach and assumptions.

c Results

Model results are presented to address the abovementioned assessment criteria. Mean annual pollutant loads for existing and developed conditions are provided in Table 6.3. The mean annual flows are also provided for context. Pollutant concentration results are provided in Table 6.4. The associated cumulative frequency graphs are provided in Appendix D. The results are discussed following the tables.

Table 6.3 Model results – mean annual pollutant loads

	Units	Pre-development	Post development (before measures)	Post development (after measures)	Change in load[1]	NorBE target achieved?
Scenario 1 – access road only (proposed project)						
Mean annual flow	ML/yr	0.8	3.5	3.5	+347%	NA
Total suspended solids	kg/yr	95	1,200	50	-47%	Yes
Total phosphorus	kg/yr	0.36	2.00	0.46	+28%	No
Total nitrogen	kg/yr	2.0	8.2	5.5	+172%	No
Scenario 2 – access road plus ARC stormwater system overflows (future scenario)						
Mean annual flow	ML/yr	7.9	38.3	7.1	-10%	NA
Total suspended solids	kg/yr	945	9,490	591	-37%	Yes
Total phosphorus	kg/yr	4.1	17.1	1.6	-61%	Yes
Total nitrogen	kg/yr	20.0	87.1	13.2	-34%	Yes

Notes: 1. Pre-development vs post development (after measures)

Table 6.4 Model results - concentration targets

	Flow conditions for which NorBE are achieved		
	NorBE target	**Model results**	**NorBE target achieved?**
Scenario 1 – access road only (proposed project)			
Total phosphorus	50 to 98th percentile	89 to 100th percentile	No
Total nitrogen	50 to 98th percentile	80 to 100th percentile	No
Scenario 2 – access road plus future ARC stormwater system overflows (future scenario)			
Total phosphorus	50 to 98th percentile	89 to 100th percentile	No
Total nitrogen	50 to 98th percentile	80 to 100th percentile	No

d Results discussion

The water quality model results indicate that Scenario 1 (proposed project) will meet the pollutant load reductions for total suspended solids but not for total phosphorus and nitrogen or the concentration targets. The increase in total phosphorus and nitrogen loads is due to the more than three-fold increase in runoff volume from the impervious road area (see Table 6.3). Typically, roadside swales would mitigate this increase in runoff volume via infiltration. However, using MUSIC in the Sydney Drinking Water Catchment (WaterNSW 2019a) recommends that no seepage (or exfiltration) is applied to swales represented in the MUSIC model. As the recommended approach was applied to the model (see Appendix D), the results provide a conservative estimate of potential pollutant load increases due to the access road. It is expected that some runoff would be infiltrated in the swales and infiltrated water would seep slowly to the adjoining ephemeral wetland (see Figure 5.1) which would remove water via evapotranspiration and/or provide water quality treatment. A NorBE on water quality would likely be achieved if these processes were accounted for.

Scenario 2 relates to a potential future scenario where the ARC Stormwater system is integrated into a future stormwater system for the PCD catchment that overflows to the receiving environment. A stormwater control such as a constructed wetland may be established in the PCD area to achieve a stormwater management system (for the greater PCD catchment) that is consistent with industry best practice for an industrial area. Scenario 2 assesses the water quality profile associated with stormwater discharges from the access road and overflows from the ARC stormwater system. The results indicate that:

- The pollutant load reductions are achieved by a significant margin (see Table 6.3). This is due to the ARC stormwater harvesting system which will remove most runoff and associated pollutants from the water cycle.
- The concentration target results are the same as Scenario 1. This is because the ARC stormwater system will only occasionally overflow and the concentration results primarily relate to discharges from the access road, which will occur more frequently, but at lower rates. It is likely that the concentration targets will be achieved in a future PCD catchment that incorporates an appropriately sized constructed wetland (or other suitable control).

Overall, these results indicate that the ARC stormwater system can be integrated into a future stormwater system in the PCD catchment that overflows to the receiving environment and achieves a NorBE on receiving water quality.

iii Conclusion

This section establishes that the:

- stormwater management approach is consistent with industry best practice for an industrial area; and
- the ARC stormwater system can be integrated into a future stormwater system in the PCD catchment that overflows to the receiving environment and achieves a NorBE on receiving water quality.

Accordingly, the proposed stormwater management approach is consistent with Objective 2b.

6.2.3 Consistency with objective 2c

A new on-site wastewater system will be established to manage wastewater (ie sewage) produced within the ARC's amenities. The system will be designed and operated in accordance with the methods described in Designing and Installing On-Site Wastewater Systems (WaterNSW 2019b), which is consistent with Objective 2c. Refer to Section 5.6 for further information on the proposed on-site wastewater system.

6.3 Impacts associated with the access road

The northern portion of the access road will be constructed within the contributing catchment area to the Collector Road culvert that is located to the north of PCD. The road will be located adjacent to an ephemeral wetland (see Figure 4.4). This section describes potential impacts due to the construction and operation of the access road.

6.3.1 Water management approach

i During construction

Surface water runoff from the area disturbed by construction will be managed in accordance with the methods recommended in Managing Urban Stormwater: Volume 1 (Landcom 2004). An erosion and sediment control plan will be prepared as part of the CEMP for the project (see Chapter 8).

ii During operations

Stormwater runoff from the access road will be managed in vegetated swales that will be constructed on either side of the road. The swales will receive runoff from the road pavement, road reserve and any upgradient undisturbed catchment area that drains towards the road. The swales will infiltrate some runoff. Surplus runoff will drain to a location that is near the inlet to the existing Collector Road culvert.

6.3.2 Potential impacts

Table 6.5 provides a description of potential impacts associated with the construction and operation of the access road.

Table 6.5 Potential impacts – access road

Potential impact	Description
Impacts to Collector Road culvert	No impacts to the Collector Road culvert are expected as there will be no change to the catchment area to the culvert and the proposed footprint of the access road (1.1 ha) is less than 5% of catchment area to the Collector Road culverts (31.5 ha).
Impacts to ephemeral wetland	Impacts to the ephemeral wetland will be minimised by avoiding direct impacts and having the swales discharge near the Collector Road culvert inlet.
Impacts due to stormwater discharges	The water management approach during the construction and operation of the access road is consistent with best practice (see Section 6.2.2). Accordingly, stormwater discharges from the access road are expected to have water quality characteristics that are similar to runoff from most regional roads (such as Collector Road), which drain to roadside swales.

7 Water regulation

7.1 Approvals

Clause 4.41 (1g) of the EP&A Act exempts an SSD authorised by a development consent from requiring a water use approval under Section 89, a water management work approval under Section 90, or an activity approval (other than an aquifer interference approval) under Section 91 of the WM Act. These exemptions apply to the project as it has been declared an SSD and therefore there is no requirement to obtain approvals under the WM Act, including water use, water management work or controlled activity approvals.

7.2 Excluded works

Dams that are solely for the capture, containment or recirculation of drainage, consistent with best management practice to prevent the contamination of a water source, that are located on a minor stream are excluded works under Schedule 1, item 3 of the NSW Water Management (General) Regulation 2018. The existing PCD and proposed ARC and IBA area ponds are excluded works under this definition as the primary use of the storages is for water quality control purposes.

Water stored within the proposed ARC and IBA area ponds will be used to supply the process water system. The take of water from the water management system is exempt from requiring a licence under Schedule 4, item 12 of the NSW Water Management (General) Regulation 2018.

7.3 Willeroo Borefield

Water regulations associated with the Willeroo Borefield are addressed in the Groundwater Assessment (EIS Appendix U).

8 Management and monitoring plans

Table 8.1 lists the potential impacts to surface water and the proposed management measures. Management and monitoring plans will be prepared post approval in accordance with consent conditions.

Table 8.1 Surface water management and mitigation measures

Potential impact	ID	Measure	Timing
Impacts to water quality during construction	SW1	Construction water management plan. This plan will: • provide and erosion and sediment control plan for construction of the access road (which is outside of the PCD catchment); • describe how water will be managed to achieve compliance with consent and EPL conditions; and • establish surface water quantity and quality monitoring requirements.	Construction
Impacts to water quality during operation	SW2	Operational water management plan. This plan will: • describe how water will be managed to achieve compliance with consent and EPL conditions; and • establish surface water quantity and quality monitoring requirements. The operational water management plan may be integrated with the existing water management plan for the Eco Precinct. Additional management plans will be required for the encapsulation cell.	Operation
Stormwater measures – source controls	SW3	• All waste will be handled within the ARC building, which is a fully enclosed structure. • IBA will be initially handled within the ARC building before being transported to the IBA area using methods that do not pose a stormwater contamination risk. • Stabilised APCr will be initially handled within the ARC building before being transported to the encapsulation cell using methods that do not pose a stormwater contamination risk. • All hazardous chemicals and hydrocarbon products will be stored in bunded areas in accordance with relevant Australian Standard AS1940:2004 and other relevant guidelines. • All washdown water will be managed by the process water system. • All pervious areas will be vegetated to minimise soil erosion.	Operation
Stormwater management – Stormwater conveyance and flooding	SW4	• Stormwater runoff will be managed via a combination of surface and piped drainage systems. These systems will be designed to have a non-erosive hydraulic capacity equivalent to the 5% AEP event. • Overland flow paths will be established to have a 1% AEP capacity. • The stormwater system and overall ARC will be designed to prevent stormwater ingress into the ARC building for the 1% AEP event.	Operation

Table 8.1 Surface water management and mitigation measures

Potential impact	ID	Measure	Timing
Fire water retention and containment	SW5	• The ARC Pond will be designed to contain any firewater runoff and leaks and spills that may occur within the ARC stormwater system. The Reference Design achieves this objective as the maximum firewater volume was established to be approximately one-third of the ARC Pond volume.	Operation
Access road stormwater system (discharges to Crisps Creek catchment, upstream of the Collector Road culvert)	SW6	• All runoff will be treated in vegetated roadside swales.	Operation
ARC stormwater system (overflows to the PCD catchment)	SW7	• Source controls to minimise stormwater contamination risks. • Various stormwater controls including rainwater tanks, vegetated swales and gross pollutant traps. • Stormwater harvesting system that captures stormwater runoff for use in the process water system. It is noted that the system established by the Reference Design has a capacity that is approximately three times greater than the capacity required to capture the 5 day 90th percentile rainfall event.	Operation
IBA area stormwater system (zero discharges)	SW8	• A stormwater capture and harvesting system that has capacity to capture all runoff during a 1% AEP event.	Operation

References

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2021b, https://www.waternsw.com.au/water-quality/catchment/development/crp).

Abbreviations

AEP	Annual Exceedance Probability
AIP	Aquifer Interference Policy
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
AHD	Australian Height Datum
ALS	Australian Laboratory Services
AMD	Acid Mine Drainage
APC	air pollution control
APCr	air pollution control residues
ARC	Woodlawn Advanced Energy Recovery Centre
AWTS	Aerated wastewater treatment system
Bioreactor	Woodlawn Bioreactor
BoM	Bureau of Meteorology
CRP	Current recommended practices
DGV	Default guideline values
Eco Precinct	Woodlawn Eco Precinct
ED	Evaporation Dam
EIS	Environmental Impact Statement
EfW	Energy from Waste
EMM	EMM Consulting Pty Limited
EMPs	environmental monitoring programs
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
EPL	Environment protection licence
ERF	energy recovery facility
EY	Exceedances per year
FSL	Full supply level
GDE	Groundwater dependent ecosystem
Heron	Heron Resources Ltd
IBA	incinerator bottom ash
IMF	Crisps Creek Intermodal Facility
km	Kilometres
LGA	Local government area
LFG	landfill gas
LTP	leachate treatment plant
mAHD	meters Australian Height Datum
mbgl	meters below ground level
MBT	Woodlawn Mechanical Biological Treatment Facility
MSW	municipal solid waste

Mtpa	Million tonnes per annum
MW	Mega watt
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
NorBE	Neutral or Beneficial Effect
PCD	Plant Collection Dam
POEO Act	*Protection of the Environment Operations Act 1997*
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SML	Special Mine Lease
SSD	State significant development
Veolia	Veolia Environmental Services (Australia) Pty Ltd
WAL	Water Allocation Licence
WM Act	Water Management Act

Appendix A
Water quality data

creating opportunities

Table A.1 Site105 water quality summary

Parameter	Units	DGV	Number of samples	Minimum	20th percentile	Median	80th percentile	Maximum	Frequent exceedance	Infrequent exceedance	Magnitude of exceedance (median)	Magnitude of exceedance (80th percentile)
Laboratory results												
Physico-chemical stressors												
pH	pH	6.5–8.0	16	6.6	7.2	7.6	8.0	8.1		✓		
Conductivity	µS/cm	350	16	215	469	1065	2140	4290	✓		3x	6x
Dissolved Oxygen	mg/L	–	7	7.4	7.54	9.0	9.16	10.25				
Oxidation-Reduction Potential	mV	–	7	120	177	237	271	289				
Total Dissolved Solids	mg/L		16	202	338	804	1430	2500				
Total Organic Carbon	mg/L		16	13	14	17.5	22	31				
Biochemical Oxygen Demand	mg/L	–	15	2	2	2	3.2	7				
Nitrogen (ammonia) as N	mg/L	0.013	13	0.100	0.100	0.100	0.100	0.800	✓		8x	8x
Nitrate as N	mg/L	–	4	0.05	0.05	0.155	0.34	0.46				
Nitrite as N	mg/L	–	3	0.01	0.01	0.01	0.016	0.02				
Nitrate + Nitrite (oxidised nitrogen) as N	mg/L	0.015	4	0.050	0.056	0.160	0.348	0.480	✓		11x	23x
Major ions												
Total Potassium	mg/L	–	16	0	1	2	4	24				
Sulphate	mg/L	–	13	30	43	101	129	199				

Table A.1 Site105 water quality summary

Parameter	Units	DGV	Number of samples	Minimum	20th percentile	Median	80th percentile	Maximum	Frequent exceedance	Infrequent exceedance	Magnitude of exceedance (median)	Magnitude of exceedance (80th percentile)
Chloride	mg/L	–	3	54	60	68	229	336				
Calcium	mg/L	–	4	18	21	36	66	91				
Total Magnesium	mg/L	–	10	16	23	44	85	112				
Total Sodium	mg/L	–	10	20	30	74	103	158				
Alkalinity (as CaCO3)	mg/L	–	3	36	44	55	150	214				
Bicarbonate	mg/L	–	3	36	44	55	151	214				
Carbonate	mg/L	–	3	0.1	0.1	0.1	0.1	0.1				
Total metals												
Aluminium	mg/L	0.055	2	0.050	0.096	0.165	0.234	0.280	✓		3x	4x
Arsenic	mg/L	0.013	8	0.001	0.001	0.002	0.003	0.008				
Barium	mg/L	–	2	0.023	0.029	0.038	0.047	0.053				
Cadmium	mg/L	0.0002	5	0.0003	0.0006	0.0009	0.0018	0.0028	✓		5x	9x
Chromium	mg/L	0.001	2	0.001	0.001	0.001	0.001	0.001				
Cobalt	mg/L	0.0014	2	0.0003	0.0004	0.0007	0.0009	0.0010				
Copper	mg/L	0.0014	13	0.0024	0.0154	0.0200	0.0236	0.0500	✓		14x	17x
Iron	mg/L	–	9	0.18	0.29	0.41	0.93	1.12				
Lead	mg/L	0.0034	13	0.0005	0.0020	0.0048	0.0147	0.0600	✓		1x	4x

Table A.1 Site105 water quality summary

Parameter	Units	DGV	Number of samples	Minimum	20th percentile	Median	80th percentile	Maximum	Frequent exceedance	Infrequent exceedance	Magnitude of exceedance (median)	Magnitude of exceedance (80th percentile)
Manganese	mg/L	1.9	2	0.08	0.11	0.15	0.20	0.23				
Zinc	mg/L	0.008	13	0.033	0.209	0.282	0.360	0.680	✓		35x	45x

Notes: DGV = default guideline value as described in Section 3.2.3. Exceedances are described as frequent if the DGV value was exceeded in 20% or more of samples; Exceedances are described as occasional if the DGV value was exceeded in at least one sample, but in less than 20% of samples.

Table A.2 PCD water quality

			PCD	PCD (silt trap)	PCD	Range
Parameter	**Units**	**WQO**	**13/2/2020**	**25/3/2021**	**25/3/21**	
Field measurements						
pH	pH	6.5–8.0	**4.07**	**3.71**	**5.72**	**3.71–5.72**
Conductivity	µS/cm	350	**1,551**	**1,718**	**1,704**	**1,551–1,718**
Temperature	°C	–	21.3	21.1	16.3	16.3–21.3
Dissolved Oxygen	mg/L	–	NA	NA	8.6	8.6–8.6
Oxidation-Reduction Potential	mV	–	256	222	341	222–341
Laboratory results						
Physico-chemical stressors						
pH	pH	6.5–8.0	**3.64**	**3.63**	**3.35**	**3.35–3.64**
Conductivity	µS/cm	350	**1,620**	**1,960**	**2,060**	**1,620–2,060**
Dissolved Oxygen	mg/L	-	7.7	8	7.8	7.7–8
Reduction-Oxidation Potential	mV	-	497	393	583	393–583
Total Dissolved Solids	mg/L	-	1,540	2,130	2,010	1,540–2,130
Total Organic Carbon	mg/L	-	5	3	4	3–5
Nutrients						
Nitrogen (ammonia)	mg/L	0.013	**2.5**	**2.5**	**1.1**	**1.1–2.5**
Nitrate	mg/L	-	0.63	0.92		0.63–0.92
Nitrite	mg/L	-	<0.01	0.04		0.04–0.04
Nitrate + Nitrite (oxidised nitrogen)	mg/L	0.015	**0.63**	**0.96**		**0.63–0.96**
Biochemical Oxygen Demand	mg/L	-	<2	<2	<2	0–0
Major ions						
Potassium	mg/L	-	1.6	2.2	2.3	1.6–2.3
Sulphate	mg/L	-	820	1190	1340	820–1340
Magnesium	mg/L	-	78.5	104	NA	78.5–104
Sodium	mg/L	-	29.8	30.2	NA	29.8–30.2
Total metals						
Arsenic	mg/L	0.013	0.002	0.003		0.002–0.003
Barium	mg/L	-	0.576	0.819		0.576–0.819
Copper	mg/L	0.0014	**15.1**	**28.8**	**19**	**15.1–28.8**
Iron	mg/L	-	11.1	14.7	16	11.1–16

Table A.2 PCD water quality

			PCD	PCD (silt trap)	PCD	Range
Parameter	Units	WQO	13/2/2020	25/3/2021	25/3/21	
Lead	mg/L	0.0034	**259**	**379**	**0.259**	**0.259–379**
Zinc	mg/L	0.008	**113**	**156**	**164**	**113–164**

Appendix B
ED1 Water Balance

EMM
creating opportunities

MEMO

TO:	Ark Du, Andrew Race, Pablo Gonzalez Carrasco
FROM:	Luana Stefanon, Rob Leslie
SUBJECT:	**Woodlawn Bioreactor Facility Water Balance**
OUR REF:	PS126263-HYD-MEM-002_Woodlawn_Water_Balance_Modelling_Rev6.docx
DATE:	**12 July 2022**

1. INTRODUCTION

WSP was appointed by Veolia to perform an assessment of the water balance performance at the Woodlawn Eco Precinct to include the proposed construction of the Woodlawn Advanced Energy Recovery Centre (ARC), an energy recovery facility (ERF) (herein referred to as the Project).

This report is a technical appendix to the Surface Water Assessment (SWA). It describes the water balance modelling of the Evaporation Dam 1 (ED1) system and the project's potential impacts on the operational effectiveness of ED1 considering a 10-year period of wettest, average and driest climate sequences.

A report summarising the water balance modelling methodology and results was originally issued in November 2021. Recent field investigations have highlighted that ED1 Full Supply Level (FSL) is set at 788.3 mAHD as opposed to 790 mAHD as originally stated in the November 2021 report. For this reason, the plots and tables summarising the modelling results have been updated to reflect the changes in ED1 FSL. The report has been updated to reflect these changes and re-issued as the June 2022 version of the report.

The SWA establishes the context for this report and uses information from this report to address relevant assessment requirements.

2. SCOPE OF WORK

Achieving a neutral or beneficial effect (NorBE) on the operational effectiveness of ED1 is a water management objective for the project. A NorBE can be achieved if one of the following criteria is met:

- The cumulative changes due to the project result in lower water levels in ED1, for a full range of weather conditions; or
- The cumulative changes due to the project result in higher water levels in ED1, but there is no impact to the operational effectiveness of the dam, in that it can still receive pumped inflows from the Plant Collection Dam (PCD) and Waste Rock Dam (WRD) for a full range of weather conditions.

The scope of work consists of water balance modelling of the existing and future Woodlawn Eco Precinct site conditions in order to assess the impacts of the proposed works on ED1 water levels and storage.

The main objectives of the water balance assessment are as follows:

1. Provide advice on whether the reduced evaporation capacity of ED1 is balanced by the reduction in surface water runoff due to the project.
2. If required, provide advice on the potential mitigation options aimed at managing the reduction in capacity of ED1.

3. PREVIOUS STUDIES

A number of water balance studies have been conducted by WSP for the Woodlawn Eco Precinct, of which the April 2021 Performance Review is the most recent. The purpose of the November 2021 performance review is to assess the impacts of the project on the future capacity of ED1.

The recent previous studies undertaken by WSP in order to assess water balance at the Woodlawn Bioreactor Facility include:

1. *Woodlawn Bioreactor Facility Water Balance Performance Review*, April 2021 (WSP reference: PS123866-WAT-MEM-Final-V1)
2. *Woodlawn Water Balance Performance Review*, April 2020 (WSP reference: PS118674-WAT-MEM-003 RevC)
3. *Leachate management by mechanical evaporators and the proposed ED1 coffer dam*, September 2017 (WSP reference: PS105723-RES-LTR-01 RevA)
4. *Woodlawn Bioreactor Water Balance for Proposed Amendment to Surface Water Management*, November 2015 (WSP reference: 2269623A-WAT-REP-001 RevA)

A summary of these previous studies is provided in Appendix A.

4. DESCRIPTION OF EVAPORATION DAM 1 SYSTEM

4.1 Existing ED1 system

The Woodlawn Eco Precinct is shown in Figure 4.1, with water flow diagrams of the evaporation dams provided in Figure 4.2 and Figure 4.3. Veolia manages putrescible waste at the bioreactor located at the former open cut mine. Methane gas is captured at the bioreactor and used to generate power.

The Woodlawn site is a shared facility between Heron and Veolia. Heron operate a below ground mine facility and associated tailings and evaporation dams.

ED1 receives inflows from direct rainfall, runoff from the surrounding area, a catchment area to the west of the Bioreactor (the western ridge) and water pumped from the WRD and PCD. Water accumulation at ED1 is managed by natural evaporation and assisted evaporation via mechanical evaporators and the evaporation pan located within the footprint of ED1.

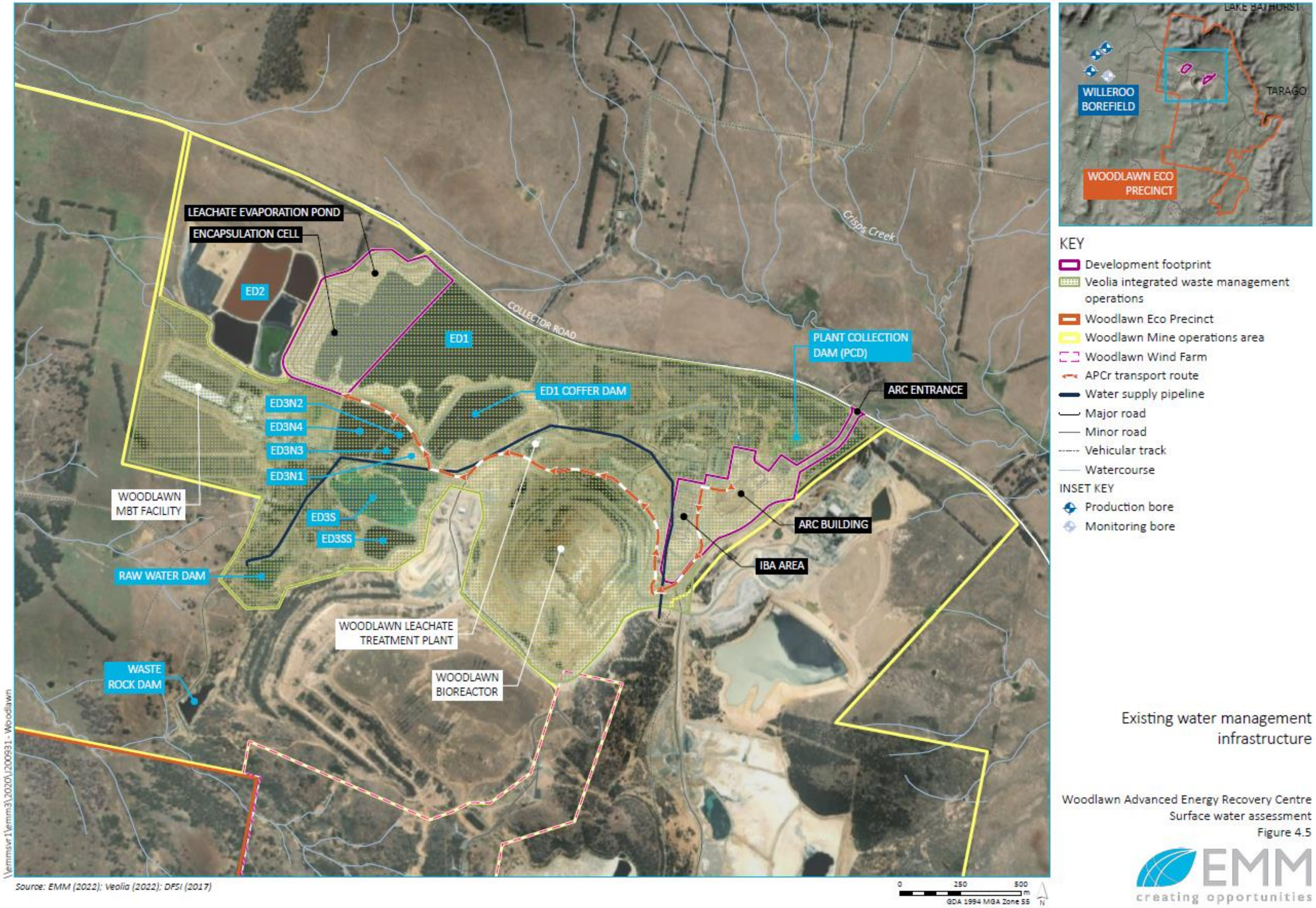

Figure 4.1 Evaporation pond system at Woodlawn Bioreactor Facility

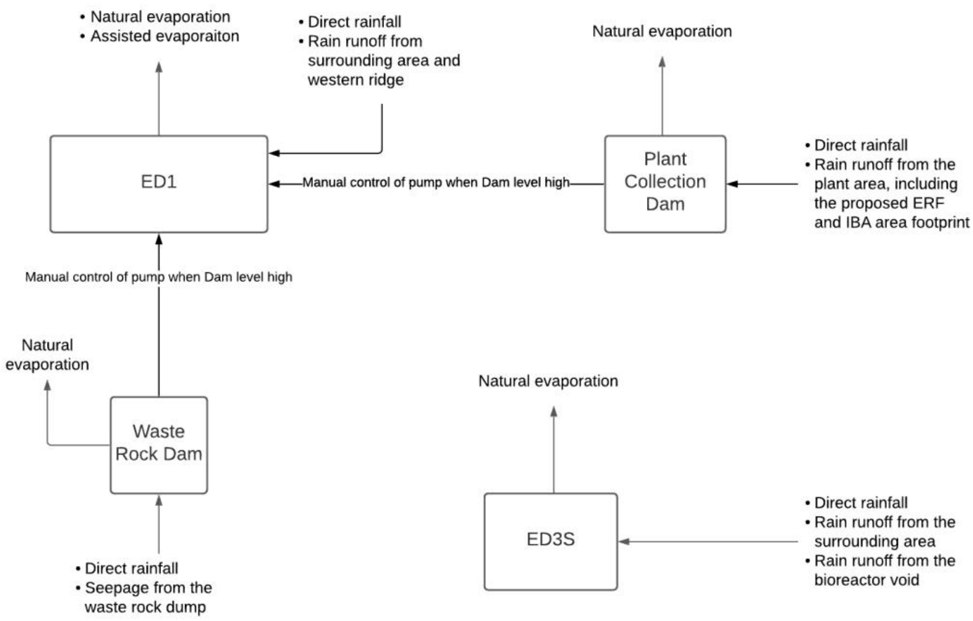

Figure 4.2 Water flow diagrams of ED1 and ED3S systems (Source: Veolia)

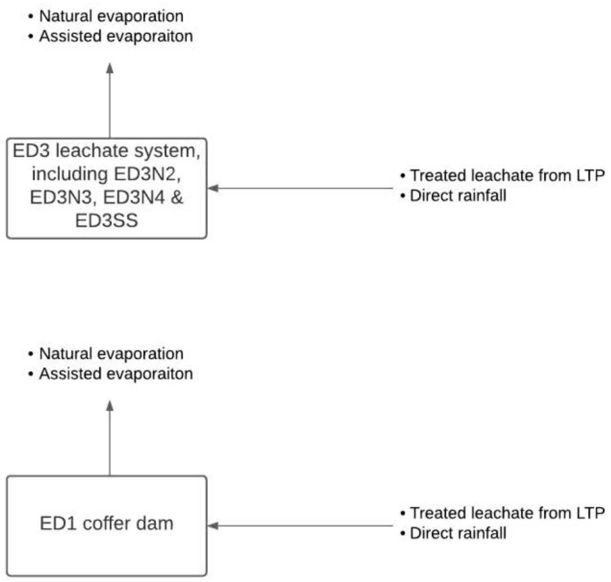

Figure 4.3 Water flow diagrams of ED3N leachate system and ED1 Coffer Dam (Source: Veolia)

4.2 Proposed Changes to ED1 operational performance by the project

The changes proposed for the project and water balance model can be summarised as follows:

1. An encapsulation cell (an engineered landfill cell for the encapsulation of stabilised air pollution control residues (APCr) from the ARC flue gas treatment system) and leachate pond will be constructed in the north-western portion of ED1 (please refer to Figure 4.1). The proposed encapsulation cell and leachate pond will reduce in the volumetric capacity of ED1. In addition to the reduction of volumetric capacity, the evaporation rate of ED1 will also be reduced due to the removal of the evaporation pan and loss of the dam surface footprint.

   The encapsulation cell will be constructed and filled in four different phases over a period of 25 years as per following schedule:

   a) Phase 1: The construction of the first cell will start in Aug 2024 and will be completed by Aug 2025. The filling will take place between Aug 2025 and Aug 2032.

   b) Phase 2: The construction of the second cell will start in Aug 2031 and be completed by Aug 2032. The filling will take place between Aug 2032 and Aug 2038.

   c) Phase 3: The construction of the third cell will start in Aug 2037 and be completed by Aug 2038. The filling will take place between Aug 2038 and Aug 2044.

   d) Phase 4: The construction of the fourth cell will start in Aug 2043 and be completed by Aug 2044. The filling will take place between Aug 2044 and Aug 2050.

   e) The associated leachate pond will be completely constructed between Aug 2024 and Aug 2025.

   f) A temporary separation bund running east/west will be constructed separating the phased cells from ED1. A permanent bund will be built progressively on the eastern edge of the cells until it is required to run east/west along the top edge of the final cells.

2. At present, the runoff generated in the proposed ERF catchment is discharged into PCD, which in turn is discharged into ED1. The project proposes to construct an ERF and incinerator bottom ash (IBA) maturation pad east of the bioreactor as shown in Figure 4.1.

   Two stormwater systems are proposed in the existing PCD catchment:

   a) The IBA area stormwater system will manage potentially contaminated runoff from the IBA area (2.2 ha). All stormwater runoff will be captured and used in the process water system and no overflows to PCD are expected.

   b) The ARC system will manage stormwater runoff from the ARC and surrounding hardstand and landscaped areas (9.8 ha). The system will include a stormwater harvesting system that will capture stormwater runoff for use in the process water system. The system will overflow to the PCD when the ARC Pond is full. This is expected to occur approximately once per year.

The remaining catchment area to the PCD (excluding the above stormwater systems) is 19.2 ha (reduced from 31.3 ha).

c) Process water system - The process water system will utilise potentially contaminated stormwater runoff captured in the IBA area stormwater system and recycled process water that could comprise a mixture of raw water, brine and return water from the wash down and steam cycle systems. Under certain circumstances (such as extended wet weather) there may be surplus process water that requires management via dewatering to ED1. This contingency arrangement will ensure that all contaminated stormwater or recycled process water is managed in either the process water system or ED1, with no discharges to the stormwater system expected. Water balance modelling undertaken for the Reference Design estimated that up to 11 ML/year of surplus process water may need to be dewatered to ED1 in some years.

The construction of the proposed ERF is planned to start in 2023 and be completed by Aug 2025.

3. The inflows from WRD and PCD into ED1 were deemed by Veolia to be negligible and were not included in previous water balance studies. However:

   a) To assess the projects impacts, the inflows from WRD into ED1 are included in the water balance performance.

   b) PCD dam needs to be included in the water balance model in order to assess the impacts of the impact of the project on ED1 water levels and storage.

5. METHODOLOGY OVERVIEW

The water balance assessment was performed by applying the following methodology and steps:

1. Updated the Woodlawn Water Balance Model in the existing condition configuration by including WRD and PCD.
2. Calibrated the seepage rate of WRD by simulating the water balance among inflows, outflows and water level data recorded at the dam.
3. Developed a future worst-case scenario of ED1 by modelling the reduction in ED1 capacity due to the proposed encapsulation cell and leachate pond construction, refine the modelling of the ARC stormwater system overflow to PCD, include surplus process water discharged to ED1 and reduce the catchment area contributing to the runoff in PCD induced by the proposed ERF.
4. Assessed the predicted capacity of ED1 in both the existing and future worst-case scenarios by simulating three climate sequences corresponding to the wettest, average and driest 10-year periods recorded in the past 100 years. The adopted climate sequences are described as follows:
   a) Wettest sequence (1950 – 1959), characterised by annual rainfall > 1000 mm;
   b) Average sequence (1963 – 1972), characterised by annual rainfalls < 900 mm and annual pan evaporation between 1000 mm and 1500 mm;
   c) Driest sequence (1979 – 1988), characterised by annual pan evaporation > 1500 mm.
5. Assessed the impacts of the project on the water balance performance of ED1.

6. CALIBRATION OF WRD

The calibration of the seepage gain rate from Waste Rock Dump into the WRD was performed through water balance modelling among inflows, outflows and water levels recorded at WRD between 03/12/2019 and 23/08/2021. A summary of the data adopted in the water balance modelling for the calibration of WRD is provided in Table 6.1.

WRD calibration was performed by adjusting the seepage rate in order to improve the match between simulated and recorded water levels. The comparison between simulated and recorded water levels at WRD is shown in Figure 6.1.

It is noted that additional inflows are pumped into WRD, however, neither recorded water volume data nor general criteria about seepage inflow pumping operations were available for the water balance modelling and calibration of WRD. For this reason, the contribution to the increase in WRD water levels produced by additional inflows was implicitly modelled in the formula used for the seepage gain rate as follows:

— Calibrated seepage rate = 3 mm/day + 1.6 * rainfall rate

The adopted formula for the seepage rate produced a reasonable match between simulated and recorded water levels.

It is recommended to review WRD calibration in the Woodlawn Water Balance Model in case any recordings of additional inflow pumping operations in WRD would become available in the future.

Table 6.1 Data used in WRD model calibration

TYPE OF DATA	DATA DESCRIPTION
Inflows (direct rainfall and catchment runoff)	Rainfall recorded from 15/08/2017 to 23/08/2021.
Outflows	Natural evaporation recorded from 15/08/2017 to 23/08/2021.
	Volume of water pumped by Veolia from WRD into ED1 between 03/12/2019 and 01/09/2021.
Water levels	Water levels recorded in WRD by Veolia from 03/12/2019 to 01/09/2021.

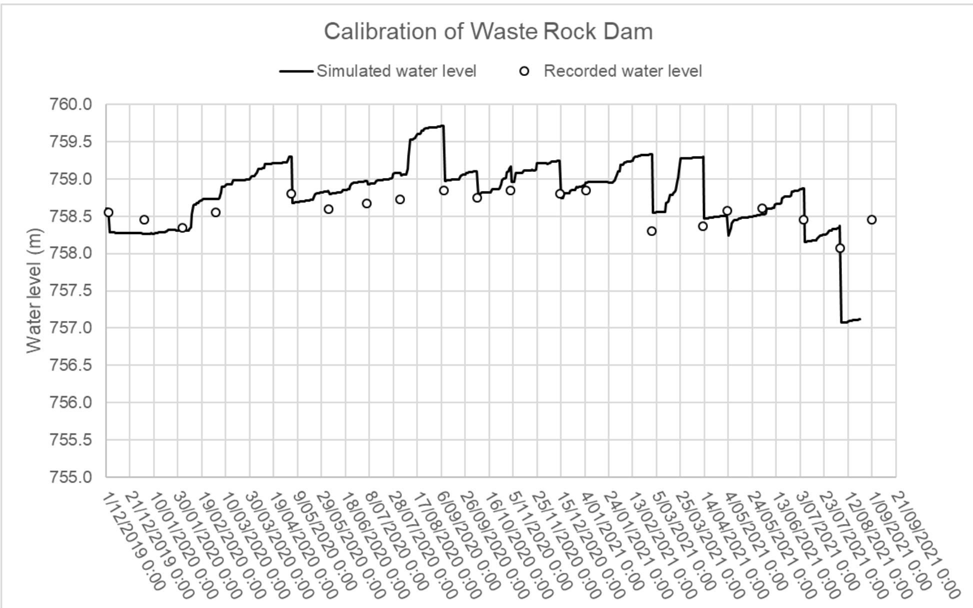

Figure 6.1 Simulated vs recorded water levels at WRD

7. WATER BALANCE MODELLING

7.1 Modelled scenarios

The water balance assessment of ED1 was performed by considering two configuration scenarios for the Woodlawn Eco Precinct as follows:

1. Existing condition scenario, featuring ED1 dam in the present conditions and including the inflows from WRD and PCD.
2. Future worst-case scenario, which is characterised by the following two conditions:
   a) The maximum reduction in capacity of ED1, which will be achieved in year 2050 when the proposed encapsulation cell will be completely filled and the evaporation pan completely removed from ED1. This scenario represents the worst-case conditions for ED1, which are characterised by the maximum reduction in ED1 capacity and maximum reduction in ED1 evaporation rates due to the complete removal of the evaporation pan.
   b) The completed construction of ERF and IBA maturation pad, which will be achieved in year 2023 and characterised by a significant reduction in the contributing catchment runoff area discharging into PCD and, in turn, into ED1.

These two scenarios were then compared to assess the overall impacts of the proposed works on the future capacity and water balance performance of ED1.

7.2 Modelling inputs and assumptions

The modelling input parameters and assumptions applied to ED1, WRD and PCD for the assessment of ED1 water balance performance are summarised in Table 7.1 for the existing scenario simulations and in Table 7.2 for the future worst-case scenario simulations.

The following assumptions were also applied to the updated water balance model:

- Design simulations for the existing climatic sequences were set to start in the month of July. Since the encapsulation cell will not affect ED1 until after mid 2024, the volume of water ED1 is adopted as the initial volume of water in ED1 for the impact assessment. Thus, an initial existing conditions model applied the water level measured on 29 July 2021 and corresponding water volume as the initial volume in ED1. The predicted ED1 storage volume results from the 1 July 2024 was then adopted as the simulation start date for subsequent existing and future worse case climatic sequences water balance models.
- A leachate rate of 4 l/s was adopted for ED1 Coffer Dam. However, it is noted that this parameter does not have any impacts on ED1 water level, storage volume and performance.
- No changes in ED1 mechanical evaporator performances were applied in both the existing and future worst-case scenarios. It is assumed that the mechanical evaporators will be relocated within ED1 when considering the future worst-case scenario simulations.
- The overflow volume from the ARC stormwater system into PCD was applied by input of daily flow time series generated by the MUSIC model for modelling water balance of the ARC Stormwater System (refer to SWA).
- Surplus process water transferred to ED1 was included in the future worse case climatic sequences water balance models.

Table 7.1 Existing condition scenario - Inflows, outflows and assumptions adopted in the water balance model to assess storage capacity of existing ED1 during 10-year climate sequences

DAM	INFLOWS	OUTFLOWS	ASSUMPTIONS
PCD	Rainfall from a 10-year period of wettest, average and driest climate sequences. Existing total catchment area contributing to rainfall-runoff of 31.3 ha (Source: SWA November 2021).	Natural evaporation corresponding to a 10-year period of wettest, average and driest climatic sequence. Water volume pumped by Veolia from PCD into ED1.	Storage-area-elevation relationship of PCD sourced from WSP 2015 water balance modelling. Plots of the adopted elevation-area-volume relationship are provided in Appendix B. Dam spillway level at RL772.4 m. Runoff coefficient of 37% from contributing catchment area (source: WSP 2015 report). Initial water level of PCD set at RL 770 m. Pump operations between PCD and ED1: Pump starts when the water level in PCD achieves RL 771 m; Pump stops when the water level in PCD achieves RL770 m; Pump flow rate of 2.16 ML/day (i.e. 25 l/s).
WRD	Rainfall from a 10-year period of wettest, average and driest climate sequences. Existing total catchment area contributing to rainfall-runoff of 1.5 ha was estimated as follows: 1.25 ha (i.e. dam surface at RL 761 m) + 0.25 ha (i.e. western road catchment). Seepage from Waste Rock Dump. Additional inflows from other sources have been included in the seepage rate estimation.	Natural evaporation corresponding to a 10-year period of wettest, average and driest climatic sequence. Water volume pumped by Veolia from WRD into ED1.	Storage-area-elevation relationship of WRD between RL 761 m and RL 759 m was estimated by adopting contours provided by Veolia. Storage-area-elevation relationship of WRD below RL 759 m was estimated by assuming a bank slope of 3.4H:1V. The bank slope was estimated by calculating the average bank slope between 761 m and 759 m contours provided by Veolia. Plots of the adopted elevation-area-volume relationship are provided in Appendix B. Dam spillway level at RL 761 m. Initial water level of WRD set at RL 758.5 m. The seepage rate was derived from calibration of WRD model. The calibrated seepage rate was estimated as: 3 mm/day + 1.6 * rainfall rate. Pump operations between WRD and ED1: Pump starts when the water level in WRD achieves RL 759.3 m; Pump stops when the water level in WRD achieves RL 758.3 m; Pump flow rate of 5.4 ML/day (i.e. 62.5 l/s). The flow rate was estimated by calculating the average value of Veolia’s pumping data.

DAM	INFLOWS	OUTFLOWS	ASSUMPTIONS
ED1 – Existing configuration	Rainfall from a 10-year period of wettest, average and driest climate sequences. No changes to catchment area contributing to rainfall-runoff (90 ha). Inflow water volume pumped from PCD into ED1. Inflow water volume pumped from WRD into ED1. No water transfer from Heron's mining operations.	Mechanical Evaporation Unit Type B1 x 1 Unit, 90% operation time at a pumping rate of 68 l/s. Natural evaporation corresponding to a 10-year period of wettest, average and driest climatic sequence. Assisted evaporation via evaporation pan.	No changes to the storage-area-elevation relationship of ED1. Initial storage volumes of ED1, based on the predicted 1 July 2024 results, were set to 408 ML (wettest climate sequence), 1 ML (average climate sequence) and 6 ML (driest climate sequence). Applied calibrated site pan evaporation value of 0.6. Evaporation Pan: Water is constantly pumped into the pan to keep topping up the pan (excess water overflows back to the main water body through overflow pipe). The purpose is to maximize the surface evaporation area. The pan is always maintained to be full.

Table 7.2 Future worst-case scenario - Inflows, outflows and assumptions adopted in the water balance model to assess storage capacity of future ED1 during 10-year climate sequences

DAM	INFLOWS	OUTFLOWS	ASSUMPTIONS
PCD	Rainfall from a 10-year period of wettest, average and driest climate sequences. Total catchment area contributing to rainfall-runoff of 19.2 ha after construction of ERF plant (source: SWA November 2021). Overflow water volume from ARC stormwater system.	Natural evaporation corresponding to a 10-year period of wettest, average and driest climatic sequence. Water volume pumped by Veolia from PCD into ED1.	As per assumptions summarized in Table 7.1. Overflow from ARC stormwater system estimated by input of daily overflow time series. This time series is generated from the MUSIC model which is modified from the MUSIC model used to model the water balance of the ARC stormwater system (refer to the SWA). The original MUSIC model using 6 minutes timestep and predicting an average of overflow volume of 3.6 ML/year to PCD for the 1995-1999 simulation period. The MUSIC model was converted into a daily timestep model. The increase in timestep introduced buffer effect and resulted in reduction of average annual overflow volume. Thus, the storage volume in the stormwater system is reduced to match the 3.6 ML/year overflow volume for the 1995 to 1999 simulation period. This modified MUSIC model was then employed to generate daily overflow time series for the dries, average and wettest climatic sequences.
WRD	Rainfall from a 10-year period of wettest, average and driest climate sequences. Existing total catchment area contributing to rainfall-runoff of 1.5 ha. Seepage from Waste Rock Dump. Additional inflows from other operations have been included in the seepage rate estimation.	Natural evaporation corresponding to a 10-year period of wettest, average and driest climatic sequence. Water volume pumped by Heron from WRD into ED1.	As per assumptions summarised in Table 7.1.

DAM	INFLOWS	OUTFLOWS	ASSUMPTIONS
ED1 – Future worst-case configuration	Rainfall from a 10-year period of wettest, average and driest climate sequences. Area contributing to catchment runoff estimated by excluding the area covered by proposed encapsulation cell and leachate pond. Runoff from proposed encapsulation cell footprint. Inflow water volume pumped from PCD into ED1. Inflow water volume pumped from WRD into ED1. Surplus process water including surplus brine water and water from the IBA pond transferred to ED1. No water transfer from Heron's mining operations.	Mechanical Evaporation Unit Type B1 x 1 Unit, 90% operation time at a pumping rate of 68 l/s. Natural evaporation corresponding to a 10-year period of wettest, average and driest climatic sequence. No evaporation pan.	The reduced capacity of ED1 was estimated by excluding the proposed encapsulation cell and leachate pond volumes. Plots of the estimated elevation-area-volume relationship of ED1 adopted in GoldSIM are provided in Appendix B. Runoff from proposed encapsulation cell directed into ED1 consists of 1% of rainfall falling into the encapsulation cell footprint (Source: HELP model developed by Golder). Initial storage volumes of ED1, based on the predicted 1 July 2024 results, were set to 408 ML (wettest climate sequence), 1 ML (average climate sequence) and 6 ML (driest climate sequence). Applied calibrated site pan evaporation value of 0.6. Surplus process water transferred to ED1 at: — 75% of 11 ML/year (wettest climate sequence), and; — 50% of 11 ML/year (driest and average climate sequence).

7.3 Modelling results

The modelling results for the wettest, average and driest climate sequence simulations are summarised in Table 7.3 for the existing condition scenario and Table 7.4 for the future worst-case scenario. A summary table of the yearly average water balance for each climate sequence is provided in Appendix B, Table B.1.

Plots of the modelling results over the 10-year period are also provided as follows:

- Plots of the water levels, storage volume, inflows and outflows in ED1 for all the analysed scenarios are provided in Appendix C.
- Plots showing the comparison between existing and future worst-case simulation results in terms of water levels and storage volume are provided in Appendix D.
- Plots showing the comparison between existing and future worst-case simulation results in terms of percentage of total dam storage volume are also provided in Appendix D.

The key outcomes of the water balance modelling can be summarised as follows:

- The predicted water levels and storage volume in ED1 existing scenario for all the analysed climate sequences are higher than those resulting from April 2021 water balance performance review. This result is due to the inclusion of WRD and PCD inflow contributions into the updated water balance model.
- The predicted storage volumes in the future worst-case scenario are on average lower than the storage volumes predicted for the existing scenario. However, the reduced capacity of ED1 in the future worse-case scenario has resulted in a higher predicted water level to store the lower predicted volumes. A comparison of the ED1 volume-elevation relationship for the existing and future worse-case scenarios is presented in Appendix B, Figure B-9.7. A detailed assessment of the differences in ED1 water levels between the existing and future worst-case scenario over the simulation period is summarised in Table 7.5.
- The future worst-case scenario simulations highlighted an overall reduction in the predicted ED1 water levels when compared to the existing scenario simulations. The reduction in catchment area contributing to the runoff in PCD and, hence, in ED1 is predicted to be balanced by the reduction in ED1 storage capacity due to the proposed encapsulation cell and leachate pond construction.

Table 7.3 Predicted water levels and storage in ED1 in the existing scenario

SCENARIO	CLIMATE SEQUENCE	MODELLING RESULTS	ADDITIONAL COMMENTS
ED1 existing scenario	Scenario 1: Wettest climate sequence	Max water level = 787.37 m Max storage volume = 600.28 ML 61% of total dam capacity	The results for the wettest climatic sequence for ED1 existing scenario are presented in Appendix C, Figure C-1 and C-2. ED1 is predicted to be never dry out when considering the wettest climate sequence. The predicted percentage of occupied storage volume ranges from a lower bound of 21% to a higher bound of 61%.
ED1 existing scenario	Scenario 2: Average climate sequence	Max water level = 785.66 m Max storage volume = 103.94 ML 11% of total dam capacity	The results for the average climatic sequence for ED1 existing scenario are presented in Appendix C, Figure C-3 and C-4. The maximum predicted water level and storage volume occurs in November 2030 and is strongly affected by the increase in direct rainfall. ED1 is predicted to stay below 11% of the dam capacity during the average climate sequence.
ED1 existing scenario	Scenario 3: Driest climate sequence	Max water level = 786.03 m Max storage volume = 187.66 ML 19% of total dam capacity	The results for the driest climatic sequence for ED1 existing scenario are presented in Appendix C, Figure C-5 and C-6. The maximum predicted water level and storage volume occurs in September 2029 and is strongly affected by the increase in direct rainfall. ED1 is predicted to stay below 19% of the dam capacity during the driest climate scenario.

Table 7.4 Predicted water levels and storage in ED1 in the future worst-case scenario

SCENARIO	CLIMATE SEQUENCE	MODELLING RESULTS	ADDITIONAL COMMENTS
ED1 future worst-case scenario	Scenario 1: Wettest climate sequence	Max water level = 787.57 m Max storage volume = 472.89 ML 70% of total (reduced) dam capacity	The results for the wettest climatic sequence for ED1 future worst-case scenario are presented in Appendix C, Figure C-7 and C-8. The predicted water levels and storage volume in ED1 are lower than in the existing scenario during most of the 10-year period simulation.
ED1 future worst-case scenario	Scenario 2: Average climate sequence	Max water level = 785.41 m Max storage volume = 46.07 ML 7% of total (reduced) dam capacity	The results for the average and driest climatic sequences for ED1 future worst-case scenario are presented in Appendix C, from Figure C-9 to C-12. The predicted water levels and storage volume in ED1 are lower than in the existing scenario during most of the 10-year period simulation.
ED1 future worst-case scenario	Scenario 3: Driest climate sequence	Max water level = 785.81 m Max storage volume = 106.67 ML 16% of total (reduced) dam capacity	

Table 7.5 Differences in predicted water levels between existing and worst-case scenario

<table>
<tr><th rowspan="2">CLIMATE SEQUENCE</th><th colspan="3">DIFFERENCE IN WATER LEVELS (EXISTING MINUS WORST-CASE SCENARIO)</th><th rowspan="2">ADDITIONAL COMMENTS</th></tr>
<tr><th>MAXIMUM DIFFERENCE</th><th>AVERAGE DIFFERENCE</th><th>MINIMUM DIFFERENCE</th></tr>
<tr><td>Wettest climate sequence</td><td>+0.37 m</td><td>-0.11 m</td><td>-0.53 m</td><td>Plots showing the comparison between existing and future worst-case scenario results in terms of water levels, storage volumes and % of dam total storage volume are provided in Figure D-1 and D-2, Appendix D.

Water levels in the future worst-case scenario are on average lower than in the existing scenario of 0.11 m over the 10-year period simulations.</td></tr>
<tr><td>Average climate sequence</td><td>+0.54 m</td><td>+0.07 m</td><td>-0.52 m</td><td rowspan="2">Plots showing the comparison between existing and future worst-case scenario results in terms of water levels, storage volumes and % of dam total storage volume are provided from Figure D-3 to Figure D-6, Appendix D.

Water levels in the future worst-case scenario are on average lower than in the existing scenario of 0.07 m and 0.11 m over the 10-year period simulations for the average and driest climate sequences, respectively.

In few instances, the future worst-case scenario produces higher peaks compared to those predicted for the existing scenario. However, these peaks occur when ED1 is almost empty.</td></tr>
<tr><td>Driest climate sequence</td><td>+0.60 m</td><td>+0.11 m</td><td>-0.47 m</td></tr>
</table>

8. CONCLUSION AND RECOMMENDATIONS

The key conclusions of the Woodlawn water balance review can be summarised as follows:

- The future worst-case scenario simulations predict that ED1 has enough capacity to cater for future rainfall and inflow inputs from WRD and PCD.
- The water balance modelling indicates beneficial impacts of the proposed project on the overall site water balance. The beneficial reduction in the catchment area contributing to the runoff into PCD and, in turn, into ED1 is predicted to balance the adverse impact of the reduction in ED1 capacity due to the proposed encapsulation cell and leachate pond construction, thus producing an overall positive water balance for ED1.
- The predicted storage volumes in the future worst-case scenario are on average lower than the storage volumes predicted for the existing scenario. However, the reduced capacity of ED1 in the future worse-case scenario has resulted in a higher predicted water level to store the lower predicted volumes. A comparison of the ED1 volume-elevation relationship for the existing and future worse-case scenarios is presented in Appendix B, Figure B-9.7.

The herein described water balance modelling is based on the assumptions described in Sections 6 for the calibration of WRD and in Section 7 for the site water balance modelling. The contribution of additional inflow pumping operations was implicitly included in WRD seepage gain rate derived from WRD model calibration because of lack of recorded inflow data. It is recommended to reassess WRD seepage rate in future water balance assessments and modelling in case recorded inflows from additional pumping operations would become available in the future.

The current revision (Rev 6) of this water balance report reflects our understanding of relevant current and future site conditions in November 2021.

9. REFERENCES

WSP, 2021. Woodlawn Water Balance Performance Review, Veolia, April 2021.

WSP, 2020. Woodlawn Water Balance Performance Review, Veolia, April 2020.

WSP, 2017. Leachate Management by Mechanical Evaporators and the Proposed ED1 Coffer Dam, Veolia, September 2017.

WSP, 2015. Woodlawn Bioreactor Water Balance for Proposed Amendment to Surface Water Management, Veolia, November 2015.

LIST OF APPENDICES

Appendix A – Previous studies

Appendix B – Data & assumptions

Appendix C – Modelling results for ED1

Appendix D – Existing vs future worst-case simulation results

APPENDIX A – PREVIOUS STUDIES

A.1 Woodlawn Water Balance Performance Review (WSP, April 2021)

In April 2021, WSP reassessed the leachate management system performance by incorporating the following changes in the Water Balance Model:

- The ED1 main dam evaporation system was modified to enable to 24/7 work.
- The operation of the evaporation pan was included within the ED1 footprint.
- The location of the floating evaporation units was changed in the ED3SS and ED3N system.

The leachate management system performance was assessed for three climatic sequence characterised by low, medium and high rainfall conditions as follows:

- Wettest sequence (1950 – 1959), characterised by annual rainfall > 1000 mm;
- Driest sequence (1979 – 1988), characterised by annual pan evaporation > 1500 mm;
- Average sequence (1963 – 1972), characterised by annual rainfalls < 900 mm and annual pan evaporation between 1000 mm and 1500 mm.

A.1.1 Key modelling outcomes

The future design simulation results indicated that dams ED3N2, ED3N3 and ED3N4 collectively have enough capacity to cater for future leachate and rainfall inputs. The mechanical evaporators at ED3N2 dry out this dam in 2025 based on the average climatic sequence and in 2023 based on the driest climatic sequence. The mechanical evaporators almost dry out ED3N3 dam in 2026 based on the average climatic sequence and in 2025 based on the driest climatic sequence. ED3N4 dam is dried out by the mechanical evaporators in 2022 based on the average and driest climatic sequence and in 2023 based on the wettest climatic sequence.

At dam ED3SS, based on the assumption that the 3 mechanical evaporators are operating 40% of the time, the mechanical evaporators gradually reduce the volume of water in the dam but do not dry out this dam within the simulation period for all climatic sequences tested.

ED3S dam has capacity issues. The dam frequently reaches spillway volume and spills for long durations for all climatic sequences, refer to Appendix A A.5. Diversion of storage water to other dams or providing an additional mechanical evaporator is required to reduce spill frequency.

Dam ED1 does not completely empty by 2023 for the wettest climatic sequence. This dam dries out in 2022 for the average and driest climatic sequences.

While the ED1 Coffer Dam is filled up by 2022 for the wettest climate sequences based on a leachate inflow rate of 4 l/s, the dam is predicted to fill up, respectively, to 89% and 57% of the freeboard level volume by January 2023 for the average and driest climate sequence. The dam fill up by July 2023 for the average climate sequence and May 2024 for the driest climatic sequence. With a leachate rate of 3 l/s, the fill levels are reduced to 78%, 61% and 29% by January 2023 for the wettest, average and driest climate sequences respectively. The dam fills up in mid 2023 for the wettest climate sequence and, 2025 and 2026 respectively for the average and driest climate sequences. Additional evaporators will be required to reduce the ED1 Coffer Dam fill rate.

A.2 Woodlawn Water Balance Performance Review (WSP, April 2020)

In February 2020, WSP reassessed the leachate management system performance by incorporating the following changes in the Water Balance Model:

- The rate of treated leachate extraction was assumed to be less than 4 L/s.
- The constructed volume and shapes of the ED1-Cofferdam were updated.
- The ED3N1 cell was assumed to be emptied for Heron's use.
- New evaporation systems were incorporated into ED1.
- The dam elevation, area and volume relationships were updated for ED1-Coffer Dam and ED1North.

A.2.1 Water Balance Model calibration

The calibrated water balance simulations indicate a site PAN value of 0.6 is appropriate for the Woodlawn site.

At dam ED1 Coffer Dam, the geomembrane lining may be increasing the rate of natural evaporation. The calibrated water balance simulation estimated a PAN of 1.6 was required to match measured water levels to modelled water levels. However, water levels in ED1 Coffer Dam are currently shallow with the effect of the geomembrane on evaporation at its greatest. The future design simulations applied an average PAN of 1.1 based on site PAN (0.6) and the ED1 Coffer Dam calibrated PAN (1.6). By averaging the PAN value this will take into consideration the higher PAN value is only applicable when the water levels are very shallow.

The calibration simulation found the mechanical evaporators at ED3N4 were not operating to full capacity. Veolia confirmed this may be due to maintenance and repair issues experienced on site. However, Veolia provided the assumption that all mechanical evaporators are now operating to full capacity and this assumption was applied to the future design simulations.

All other dams calibrated reasonably well, although short term operating rules and pumping between dams influenced some results over the calibration period. As the future design scenarios are based on long term operations, adjusting model parameters to accommodate the short-term operations over the calibration period was not carried out.

A.2.2 Future design simulations

The future design simulation results indicated dams ED3N2, ED3N3 and ED3N4 collectively had enough capacity to cater for future leachate and rainfall inputs. The mechanical evaporators at ED3N4 dried out this dam in 2022 based on the average climatic sequence and in 2024 based on the wettest climatic sequence.

At dam ED3SS and based on the assumption the mechanical evaporators operation time is to increase to 40%, the mechanical evaporators dried out this dam and maintained shallow water depths between drying. Depending on the climatic sequence this dam will first empty in either 2022 based on average and driest climatic sequence or in 2023 for the wettest climatic sequence.

Capacity issues at dam ED3S occur most prominently when Heron water usage was assumed at 0 l/s. The dam frequently reaches spillway volume and spills for long durations for all climatic sequences. While capacity issues remain for the scenario that Heron uses 2 l/s of water from this dam, Heron's water usages results in much fewer breaches occurring over a shorter duration.

Dam ED1 does completely empty by 2023 for the driest climatic sequences. Considering this dam receives stormwater runoff from external catchments, sustaining this dam as completely empty may be difficult. For the wettest climatic sequence, the dam requires 27% of its total storage capacity to cater for direct rainfall and catchment runoff at the end of 2023. Modelling of this dam could be further refined if information regarding water transfer from Heron and the Old PCD (if any) were provided. Also, details and assumptions for the new evaporation pad may provide further storage capacity.

ED1 Coffer Dam, is not predicted to fill up to 80% of the freeboard level volume in any climatic sequence based on the assumed evaporator capacity. Assuming no water usage by Heron, the peak predicted water storage in the dam occurs during the wettest climatic scenario when 84.97 ML is stored (approximately 54% of the total dam capacity to freeboard level). By 2023 less than 40% of the dam capacity to freeboard volume is reached during the wettest climatic sequence.

Following Veolia's review of the ED1 Coffer Dam water balance model results, Veolia confirmed the system being installed will be modified such that the total mechanical evaporators output will be similar to the total leachate input of 4 l/s. This proposed operating arrangement will increase the predicted water levels in the ED1 Coffer Dam. Modifying the water balance model to incorporate this proposed operating arrangement is not included in the current water balance model results.

A.3 Leachate management by mechanical evaporators and the proposed ED1 Coffer Dam (WSP, September 2017)

WSP investigated the Veolia's strategy to use ED1 exclusively for its leachate management. A geomembrane lined coffer dam within the footprint of ED1, named ED1 Coffer Dam, was proposed to manage the storage and evaporation of treated leachate. By using ED1 Coffer Dam to manage leachate, the remainder of the ED1 dam will be allowed to dry up with the use of mechanical evaporators.

Once ED1 is empty, it is proposed this dam will be relined to avoid seepage and used subsequently for leachate storage and management. The water balance assessments results indicated the following:

- Required number of proposed mechanical evaporators to manage leachate from September 2017 to December 2019 at ED3SS and ED3N lagoons:
  - 1 x Type A at ED3N1, ED3N2, ED3N3 operating for 70% of the year at a flow rate of 126 L/min
  - 3 x Type B at ED3SS operating for 70% of the year at a flow rate of 86 L/min
  - 5 x Existing Mechanical Evaporator operating for 34% of the year at a flow rate of 168 L/min and 11 x Type A operating for 70% of the year at a flow rate of 126 L/min at ED3N4 or
  - 5 x Existing Mechanical Evaporator operating for 40% of the year at a flow rate of 336 L/min and 3 x Type A operating for 70% of the year at a flow rate of 126 L/min at ED3N4.
- Size of proposed ED1 Coffer Dam:

- The proposed 150 ML Coffer Dam may be able to service for the intended 4-year period, if Heron uses water from the coffer dam at a rate of 2 L/s and 4 x Type A Evaporators are used simultaneously for 70% of the time every year.
- One and a half cells of 150 ML Coffer Dam may be required to service the intended 4-year period, if Heron does not use water from the coffer dam and a total of 5 x Type A Evaporators are used simultaneously for 70% of the time every year.
- Three cells of 150 ML Coffer Dam may be required to service the intended 4-year period, if Heron does not use water from the coffer dam and evaporators are not used.

— Required number of Mintek mechanical evaporator units to dry up ED1 North Dam in ten years. Two units of Minetek 75kw Evaporator with 1500 L/min flow operating for at least 34% every year will be able to dry up the ED1 North Dam to 10 ML within:

- 6 years in the wettest climate
- 2 years in the driest climate
- 3 years in the average climate used in the simulation.

These results are subject to the climatic sequences, dam and mechanical evaporator characteristics data used in water balance modelling.

Table A.1 lists the characteristics for the Existing Minetek, Type A and Type B Evaporators provided by Veolia. The seasonal variation of water loss through Existing Mechanical Evaporators were related to monthly potential evaporation based on data provided by Veolia that were used in the June 2016 assessment (Table A.2). The Existing Mechanical Evaporators are expected to be similar to TurboMist (http://www.turbomist.com/products). The same relationship was used for the Minetek unit without scaling.

The monthly evaporation characteristics for the floating evaporator Type A and Type B units were scaled from the characteristics for Existing Mechanical Evaporators to achieve Veolia's estimated average annual rate of water loss from the volume passing through the units for 2016-2017 period. Refer to Table C.2 for the monthly scaled evaporation loss rates for Type A and Type B and Minetek units.

Table A.1 Characteristics of modelled mechanical evaporator types

EVAPORATOR TYPE	MINETEK 400/200	TYPE A	TYPE B	EXISTING MECHANICAL EVAPORATOR
Applied quantity	1	1	1	1
Rated flow (L/min)	1500	126	86	350
Expected loss rate (L/min) at 100% availability	420	25	6.0	98
Availability % planned	Up to 70	70	70	Up to 70
Actual flow through (L/min) in 2016-2017 (source: Veolia)	Not installed	126	86	168 (due to pump restrictions)
Availability % in 2016-2017	Not installed	80	50	34
Evaporator flow (L/s) in 2016-2017	Not installed	1.68	0.72	0.95

EVAPORATOR TYPE	MINETEK 400/200	TYPE A	TYPE B	EXISTING MECHANICAL EVAPORATOR
Average loss (L/s) in 2016-2017	Not installed	0.33	0.05	0.27
% loss /year in 2016-2017	Not installed	20%	7%	28%
Achieved loss rate (L/ min) in 2016-2017	Not installed	19.9	3.0	16.20

Source: WSP (September 2017)

Table A. 2 Monthly relationship between potential evaporation and evaporation as % of the inflow volume through the mechanical evaporators

MONTH	POTENTIAL EVAPORATION (MM/DAY)	POTENTIAL EVAPORATION (MM/MONTH)	% OF INFLOW EVAPORATED BY THE EXISTING MECHANICAL EVAPORATOR	% OF INFLOW EVAPORATED BY THE TYPE A EVAPORATOR	% OF INFLOW EVAPORATED BY THE TYPE B EVAPORATOR
1	5.9	180.1	40.0	28.8	7.3
2	4.5	136.4	36.8	26.5	6.7
3	3.9	119.2	35.3	25.4	6.4
4	2.3	71.2	30.2	21.8	5.5
5	1.4	43.4	26.1	18.8	4.8
6	0.9	27.9	22.8	16.4	4.2
7	1.1	32.0	23.8	17.2	4.4
8	1.7	52.5	27.6	19.9	5.0
9	2.6	79.7	31.3	22.6	5.7
10	3.7	112.4	34.7	25.0	6.3
11	4.6	139.8	37.0	26.7	6.8
12	5.8	175.1	39.6	28.5	7.2

Source: WSP (September 2017)

A.4 Woodlawn Bioreactor Water Balance for proposed amendment to surface water management (WSP, November 2015)

WSP|Parsons Brinckerhoff (now WSP) undertook a water balance assessment in June 2016 for Veolia's application for regulatory approval to utilise the ED1 and ED2 evaporation dams for treated leachate storage and evaporation (2269623B-RES-LTR-03 Rev0). The main objective of the Veolia nominated scenarios was to assess whether ED1 will overflow over a period of 40 years, if the treated leachate is discharged as per projected schedule (refer to Figure A.1) for comparison between 2016 and 2017 estimates) under the following three scenarios:

— Scenario A: ED1 does not receive runoff from the Plant Containment Dam (PCD) catchment and groundwater from pit dewatering.

— Scenario B: Condition of Scenario A and water transfer from ED3N and ED3S cells at 1 L/s.

— Scenario C: Condition of Scenario B and groundwater transfer from pit dewatering with concurrent water use by Heron Resources for mineral processing.

The June 2016 modelled assessment suggested that Heron's mining operation may assist Veolia in reducing the water storage requirement for the planned leachate production from 2018 for the next 40 years by using some of the water stored in the dam.

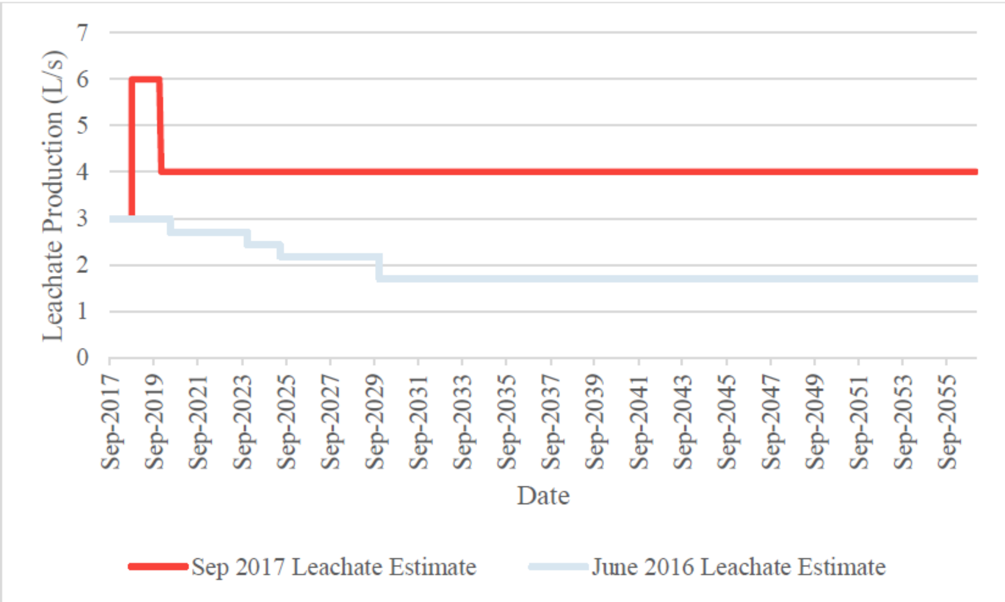

Figure A-9.1 Comparison of leachate rates between June 2016 and Sep 2017 estimates (source: Veolia)

APPENDIX B – DATA & ASSUMPTIONS

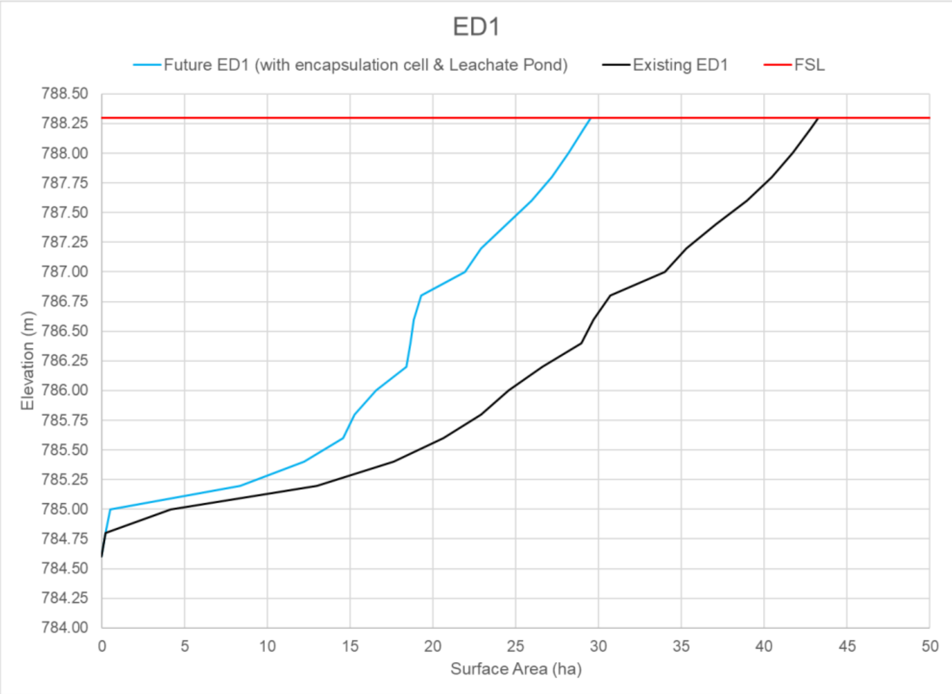

Figure B-9.2 Area-elevation relationship adopted to model ED1 in GoldSIM. "Existing ED1" corresponds to the existing scenario, whereas "Future ED1 (with encapsulation cell & leachate pond") corresponds to the future worst-case scenario.

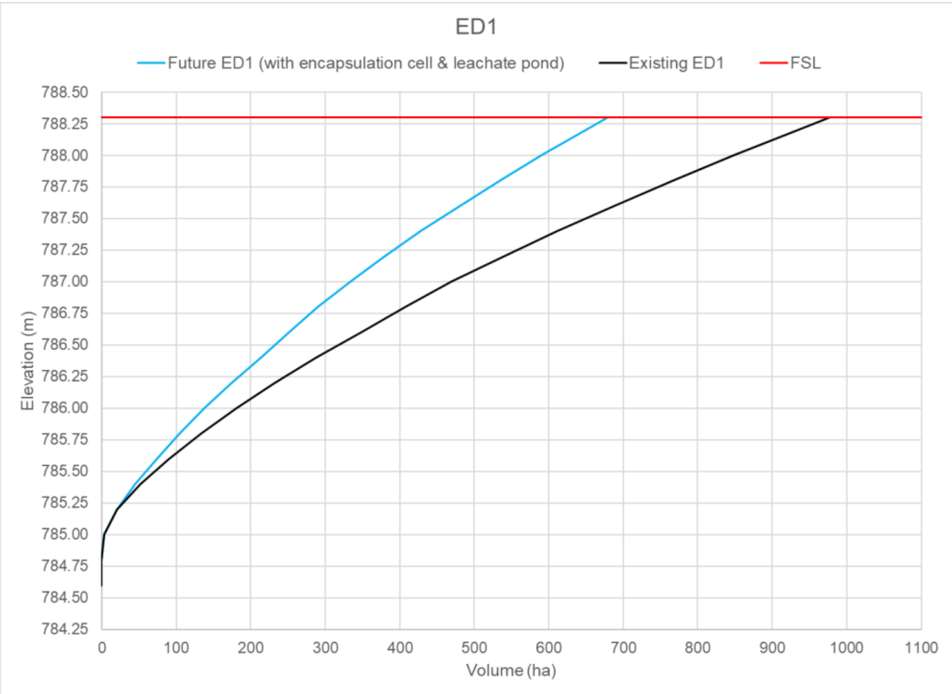

Figure B-9.3 Volume-elevation relationship adopted to model ED1 in GoldSIM. "Existing ED1" corresponds to the existing scenario, whereas "Future ED1 (with encapsulation cell & leachate pond") corresponds to the future worst-case scenario.

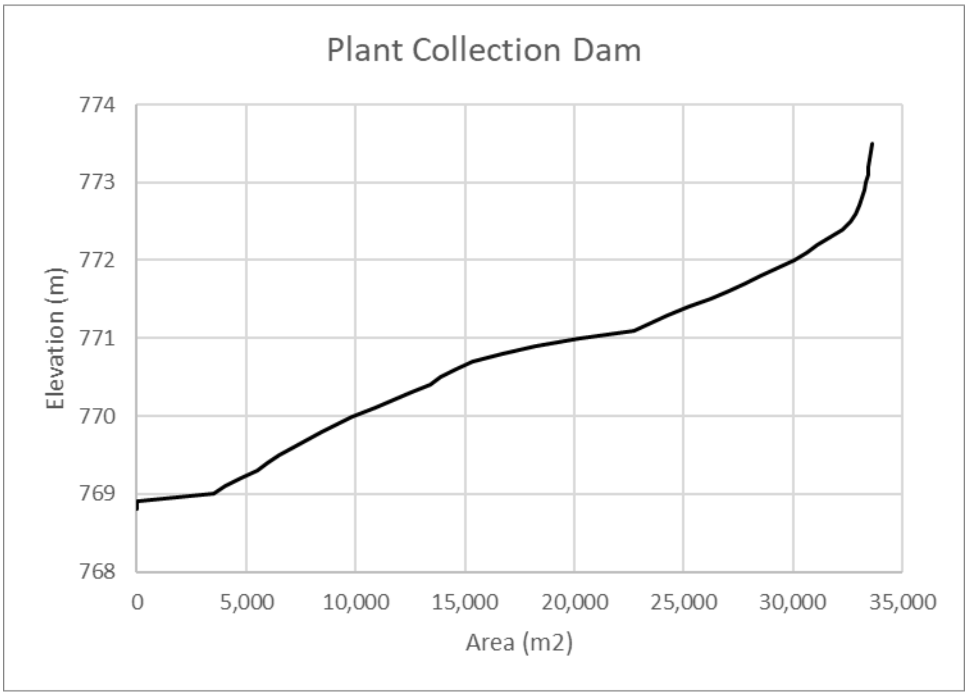

Figure B-9.4 Area-elevation relationship adopted to model PCD in GoldSIM.

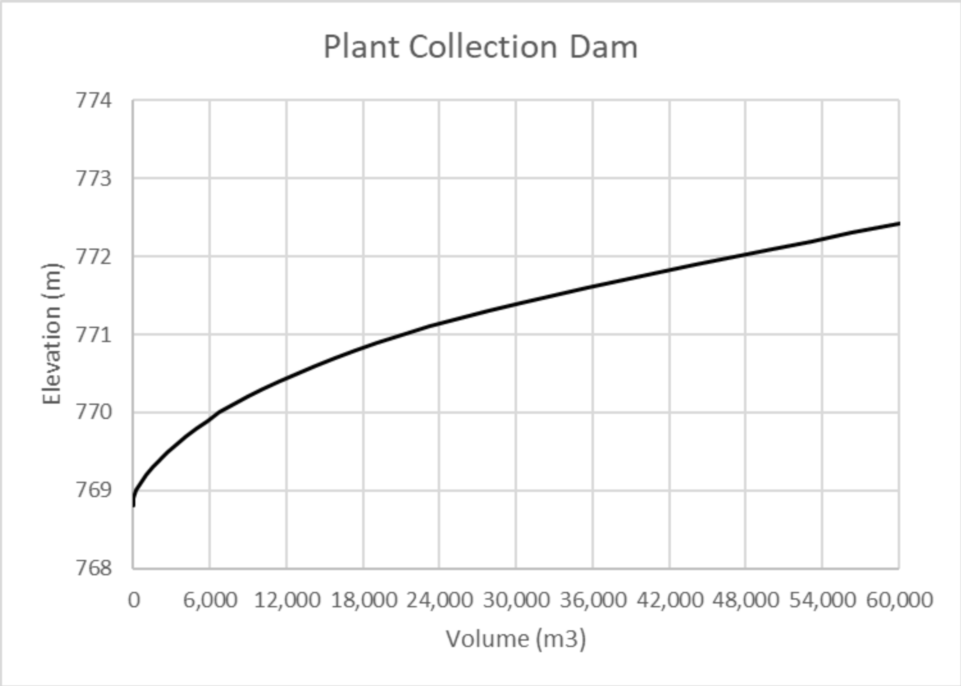

Figure B-9.5 Volume-elevation relationship adopted to model PCD in GoldSIM.

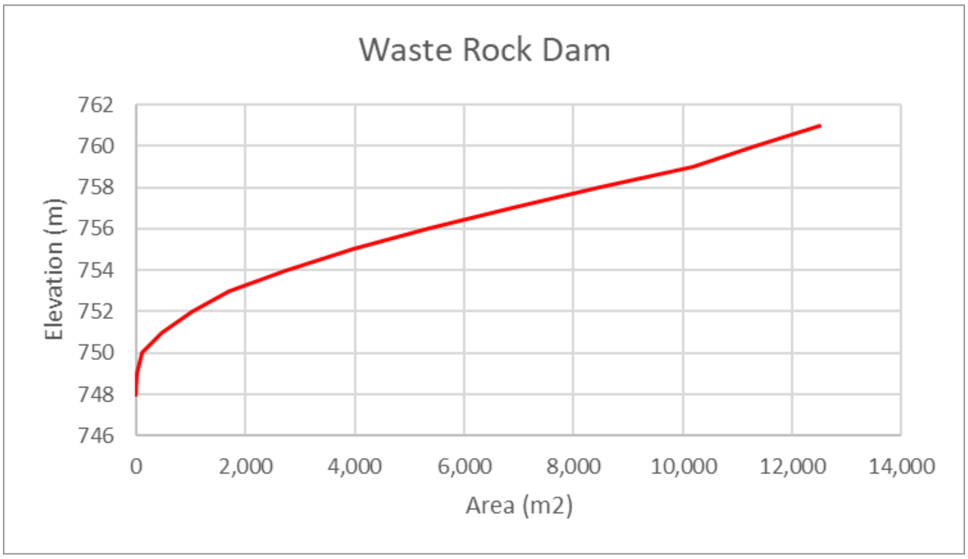

Figure B-9.6 Area-elevation relationship adopted to model WRD in GoldSIM.

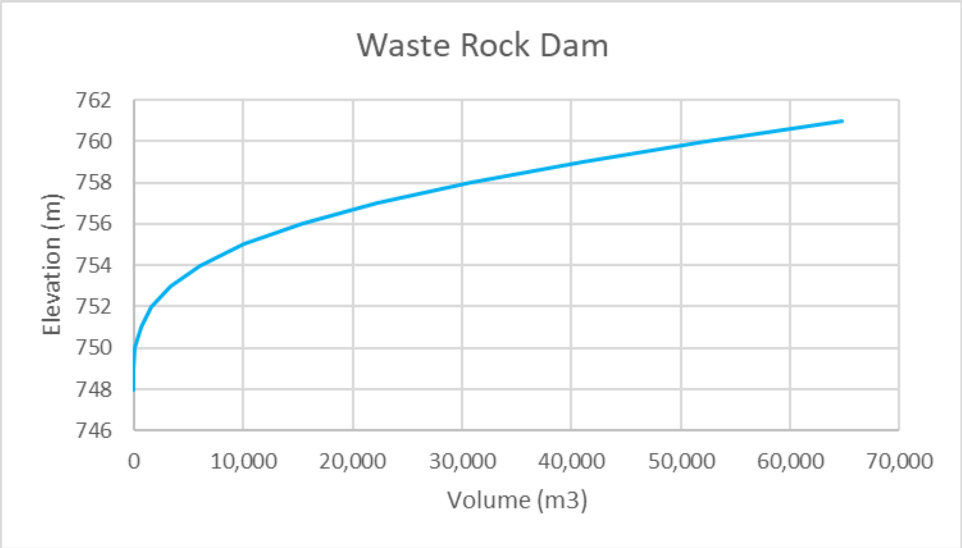

Figure B-9.7 Volume-elevation relationship adopted to model WRD in GoldSIM.

Table B.1 Summary of average inflows, outflows and storage volumes for ED1

YEAR	CLIMATE SCENARIO	EXISTING ED1			FUTURE WORSE-CASE SCENARIO ED1		
		AVERAGE INFLOW (ML/D)	AVERAGE OUTFLOW (ML/D)	AVERAGE VOLUME (ML)	AVERAGE INFLOW (ML/D)	AVERAGE OUTFLOW (ML/D)	AVERAGE VOLUME (ML)
1/07/24 – 30/06/25	Wettest	1.05	1.02	417.95	0.81	0.83	403.30
	Average	0.39	0.37	7.68	0.28	0.24	6.52
	Driest	0.21	0.24	2.32	0.16	0.16	2.78
1/07/25 – 30/06/26	Wettest	1.24	1.06	417.38	0.90	0.85	386.53
	Average	0.37	0.40	16.82	0.24	0.24	7.34
	Driest	0.38	0.31	5.59	0.23	0.18	3.57
1/07/26 – 30/06/27	Wettest	1.06	1.06	492.70	0.75	0.84	418.79
	Average	0.34	0.33	7.11	0.27	0.21	6.44
	Driest	0.46	0.55	18.60	0.28	0.29	8.04
1/07/27 – 30/06/28	Wettest	0.53	1.03	402.01	0.43	0.80	332.61
	Average	0.50	0.49	13.54	0.26	0.28	6.65
	Driest	0.34	0.31	4.95	0.25	0.19	4.16
1/07/28 – 30/06/29	Wettest	0.98	0.94	281.03	0.65	0.73	231.78
	Average	0.46	0.37	14.96	0.32	0.27	10.31
	Driest	1.08	0.86	66.63	0.74	0.63	38.81
1/07/29 – 30/06/30	Wettest	1.53	0.94	348.23	1.07	0.72	254.81
	Average	0.58	0.55	22.29	0.41	0.37	12.82
	Driest	0.69	0.84	115.90	0.44	0.59	53.61

YEAR	CLIMATE SCENARIO	EXISTING ED1			FUTURE WORSE-CASE SCENARIO ED1		
		AVERAGE INLFLOW (ML/D)	AVERAGE OUTFLOW (ML/D)	AVERAGE VOLUME (ML)	AVERAGE INLFLOW (ML/D)	AVERAGE OUTFLOW (ML/D)	AVERAGE VOLUME (ML)
1/07/30 – 30/06/31	Wettest	0.65	1.10	486.43	0.45	0.81	332.94
	Average	0.77	0.78	53.66	0.42	0.46	19.64
	Driest	0.56	0.75	56.19	0.29	0.32	7.58
1/07/31– 30/06/32	Wettest	0.72	1.04	324.20	0.52	0.77	202.76
	Average	0.63	0.79	41.60	0.31	0.37	10.25
	Driest	0.56	0.58	22.81	0.36	0.31	8.88
1/07/32 – 30/06/33	Wettest	1.08	0.93	268.66	0.73	0.70	145.67
	Average	0.37	0.38	5.54	0.27	0.25	4.80
	Driest	0.74	0.58	24.42	0.48	0.40	13.37

APPENDIX C – MODELLING RESULTS FOR ED1

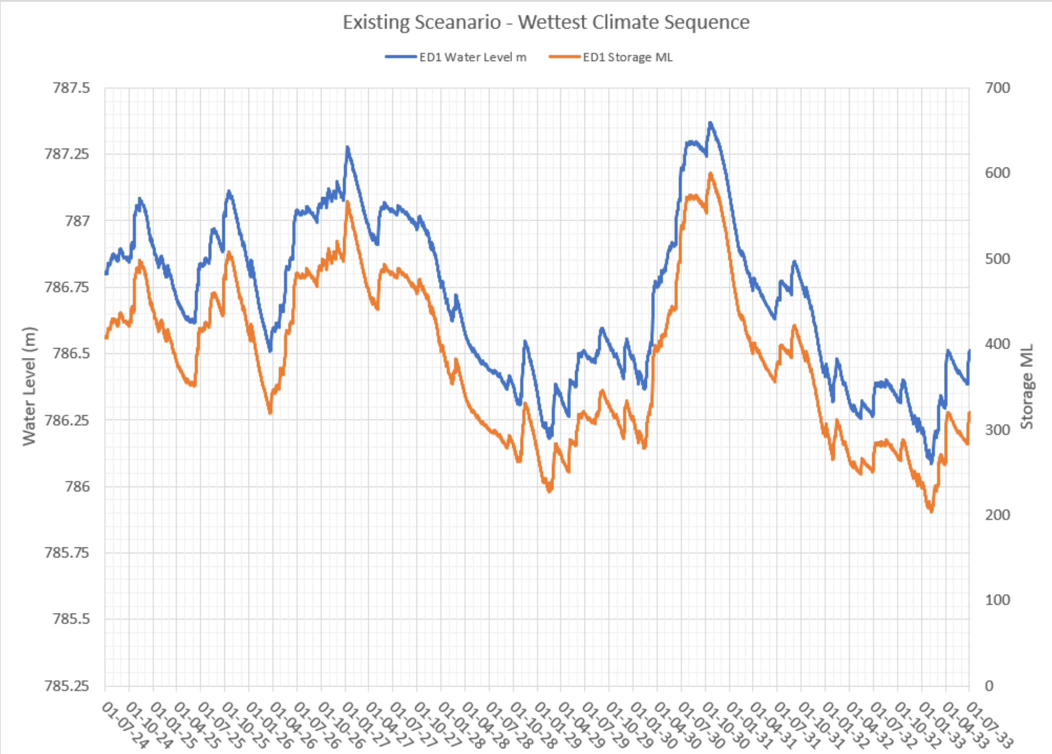

Figure C-1 ED1 water levels and storage for the existing scenario and wettest climate sequence

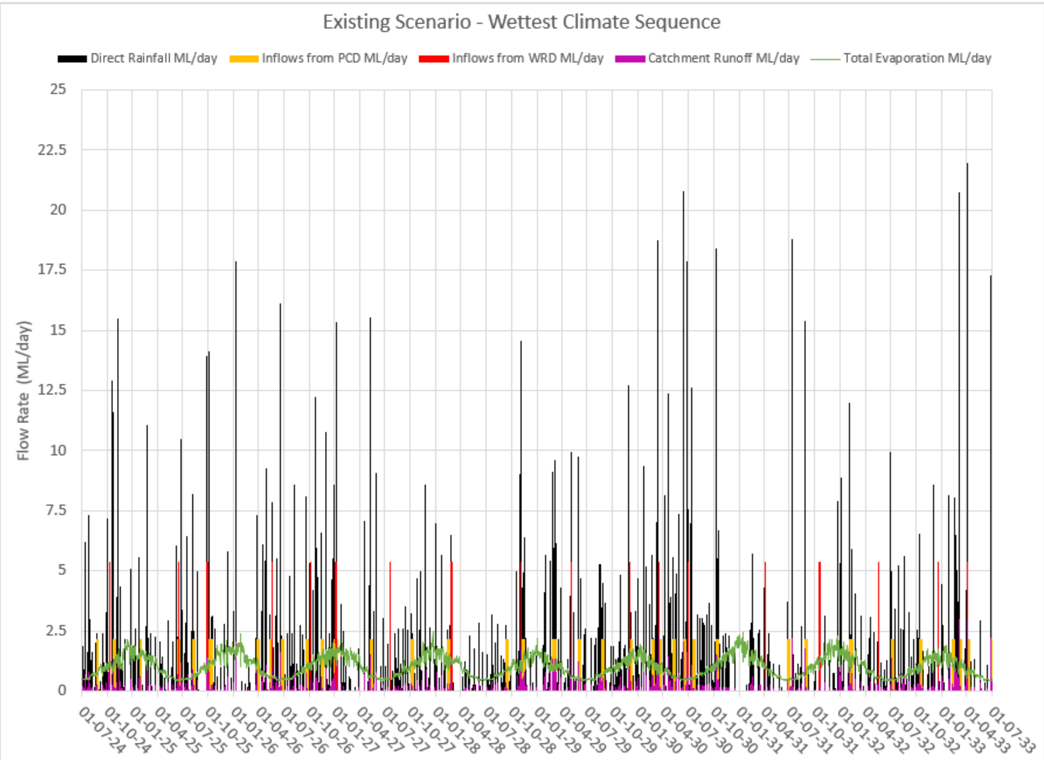

Figure C-2 ED1 inflows and outflows for the existing scenario and wettest climate sequence

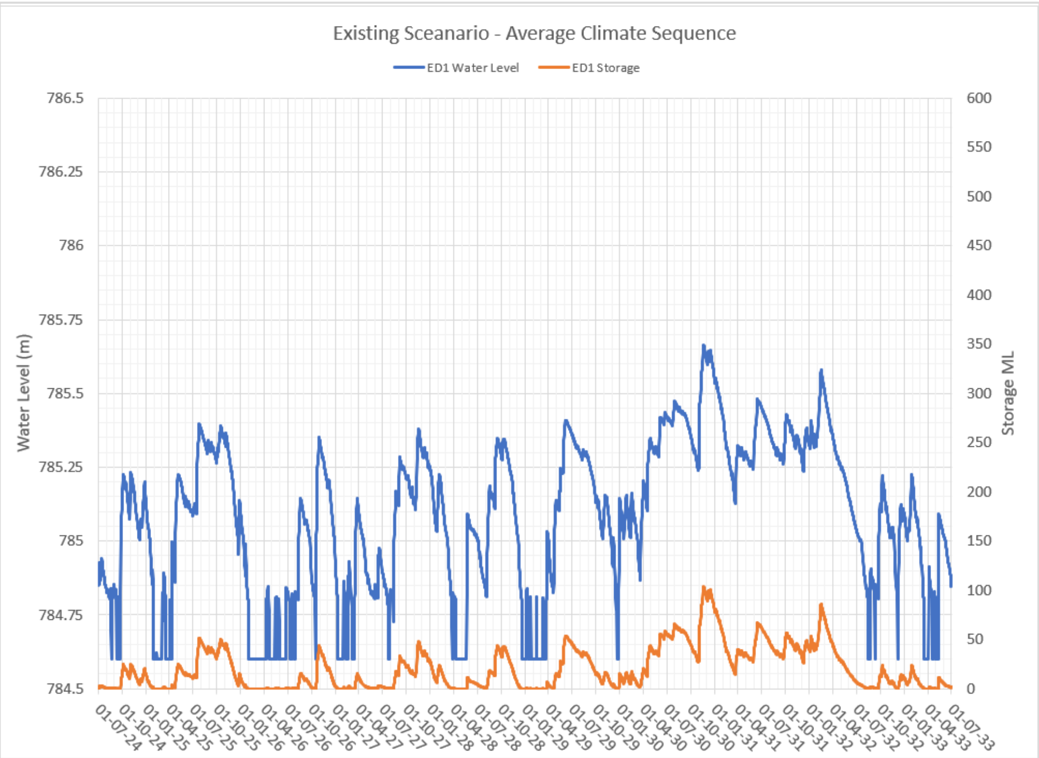

Figure C-3 ED1 water levels and storage for the existing scenario and average climate sequence

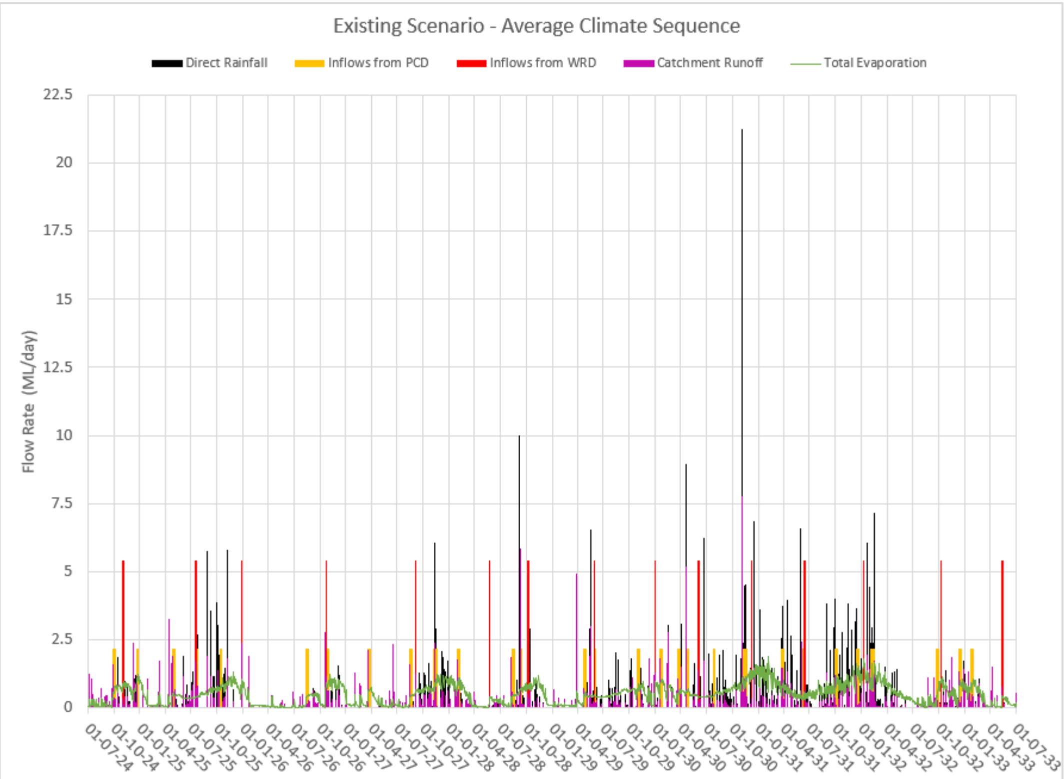

Figure C-4 ED1 inflows and outflows for the existing scenario and average climate sequence

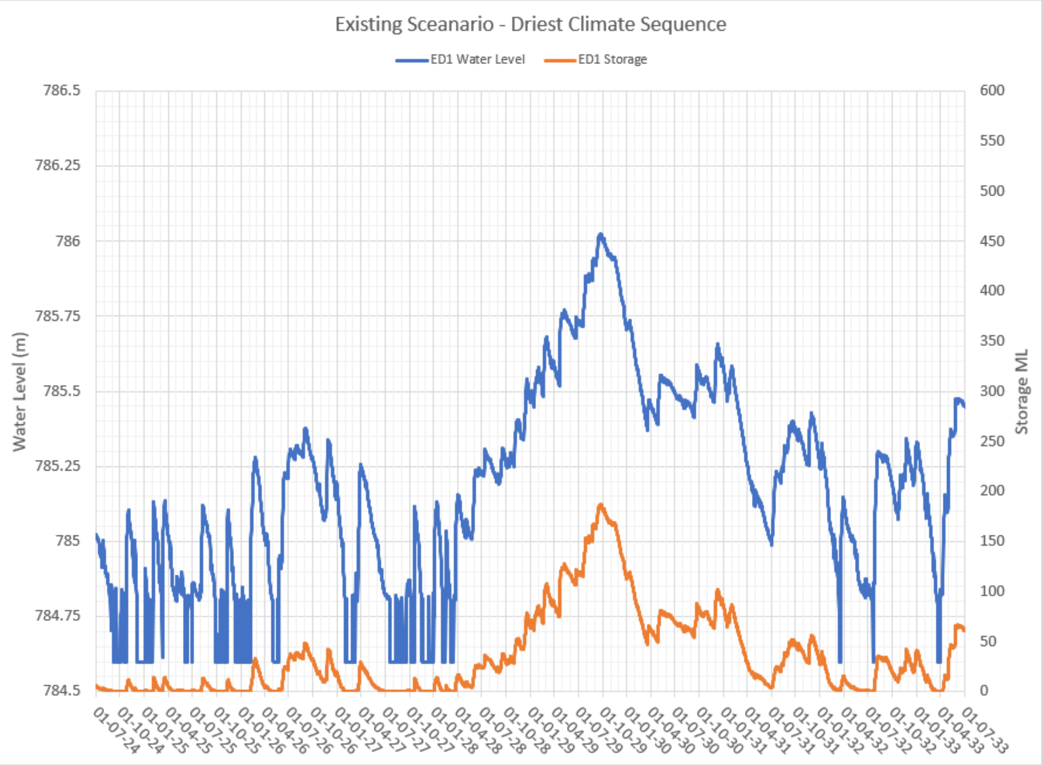

Figure C-5 ED1 water levels and storage for the existing scenario and driest climate sequence

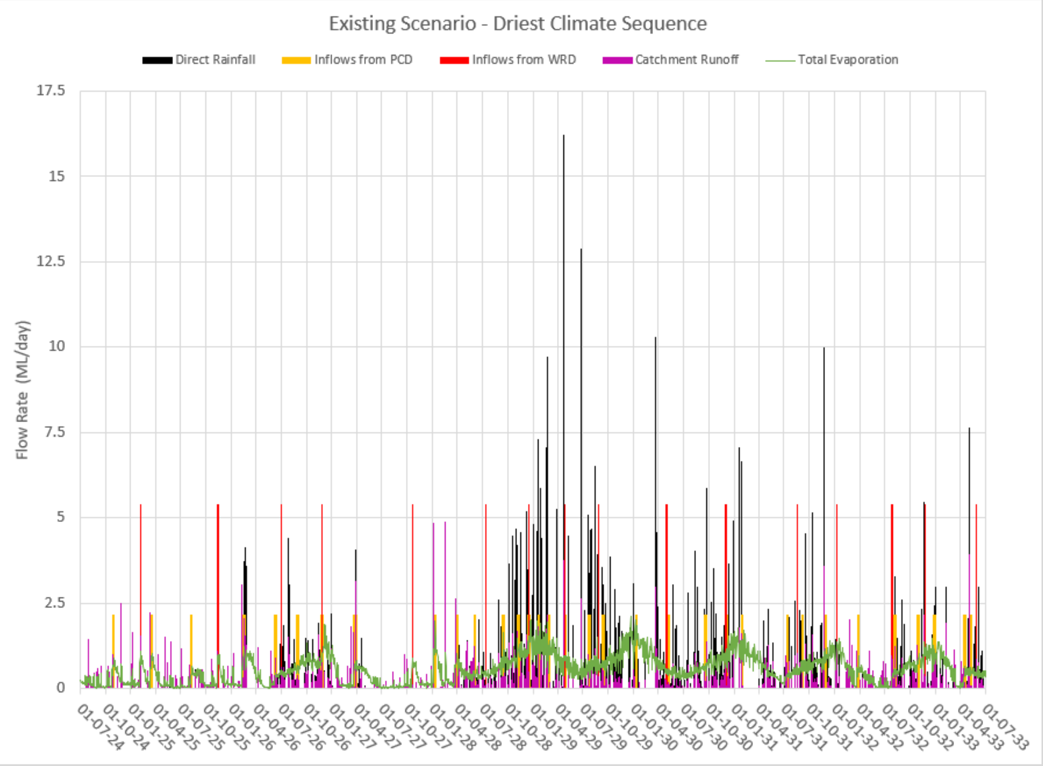

Figure C-6 ED1 inflows and outflows for the existing scenario and driest climate sequence

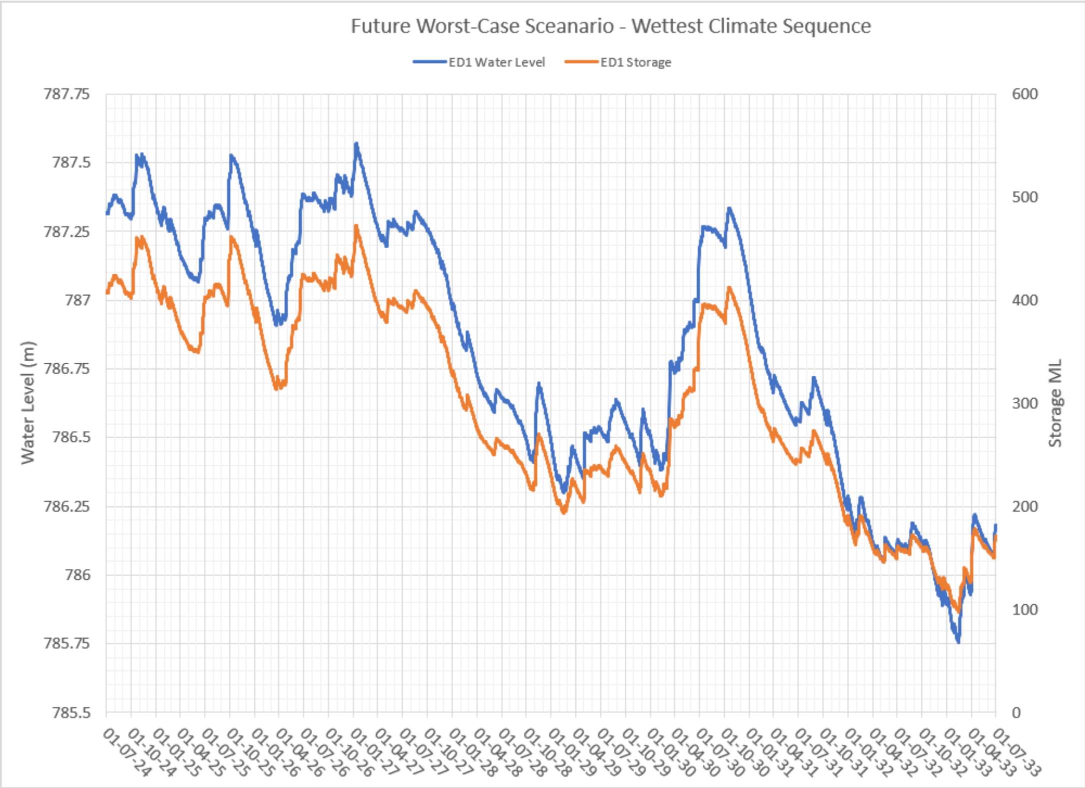

Figure C-7 ED1 water levels and storage for the future worst-case scenario and wettest climate sequence

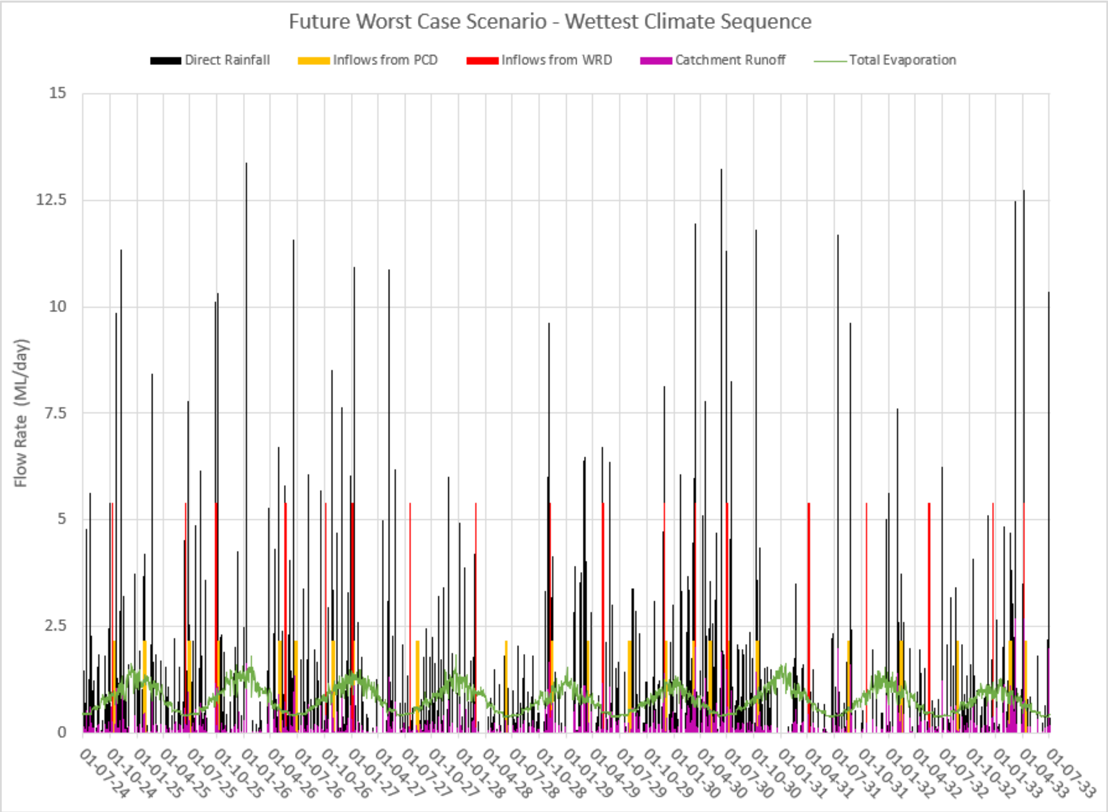

Figure C-8 ED1 inflows and outflows for the future worst-case scenario and wettest climate sequence

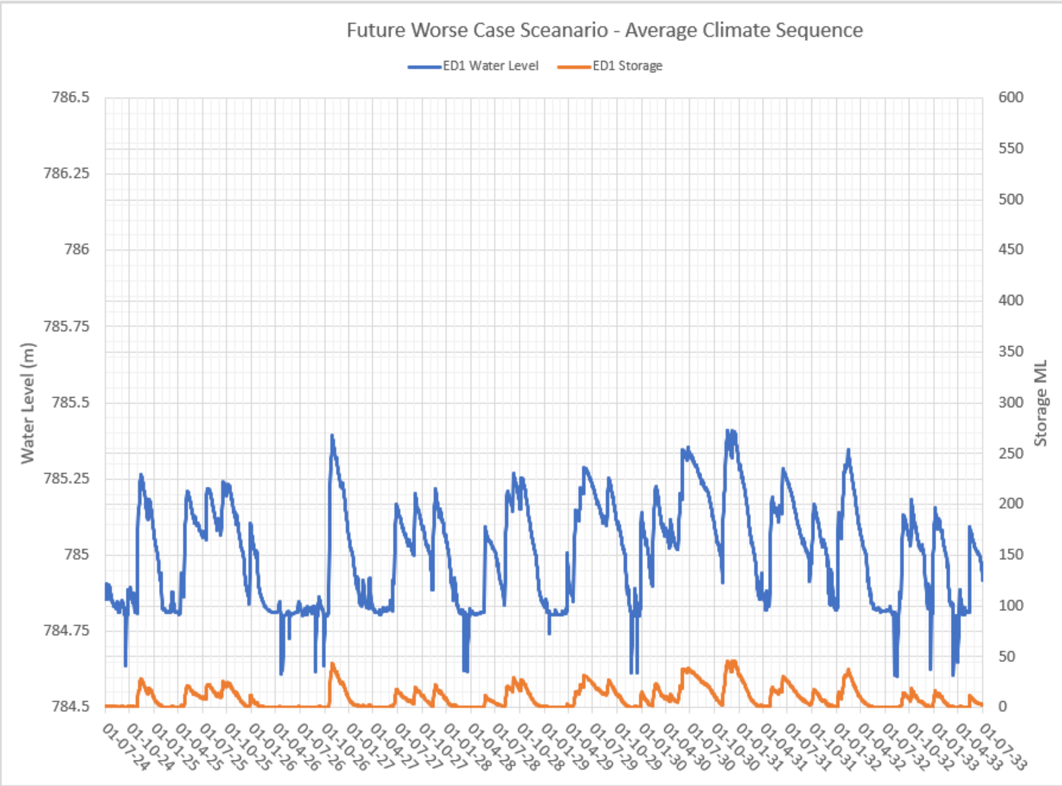

Figure C-9 ED1 water levels and storage for the future worst-case scenario and average climate sequence

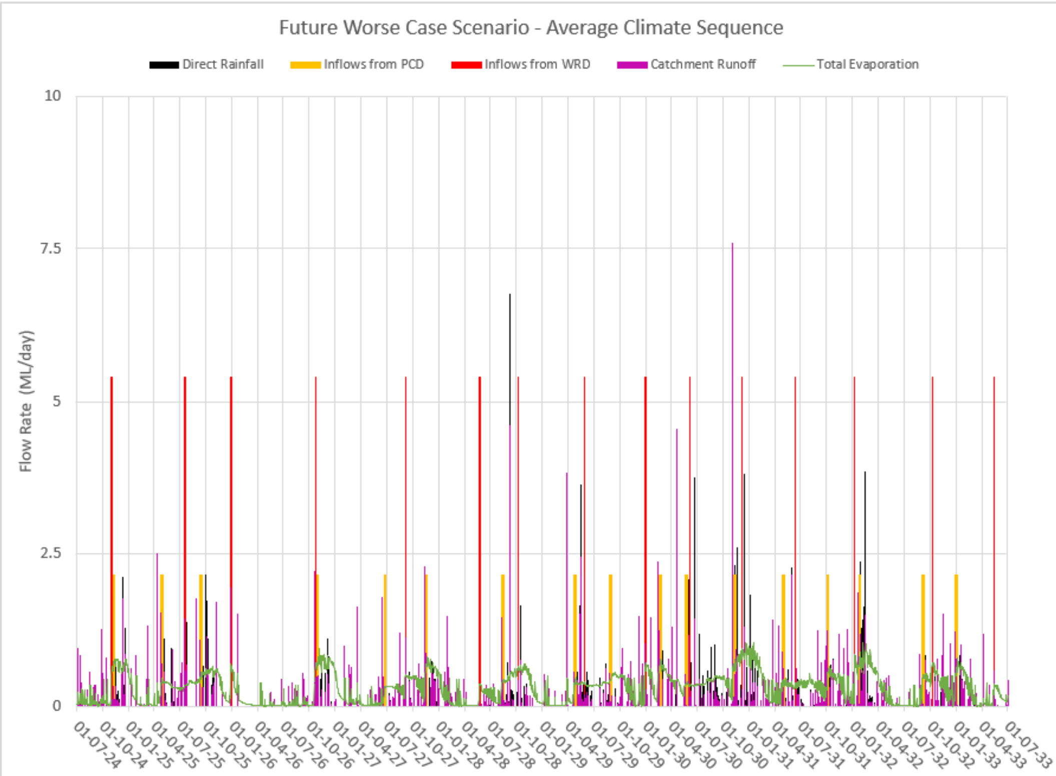

Figure C-10 ED1 inflows and outflows for the future worst-case scenario and average climate sequence

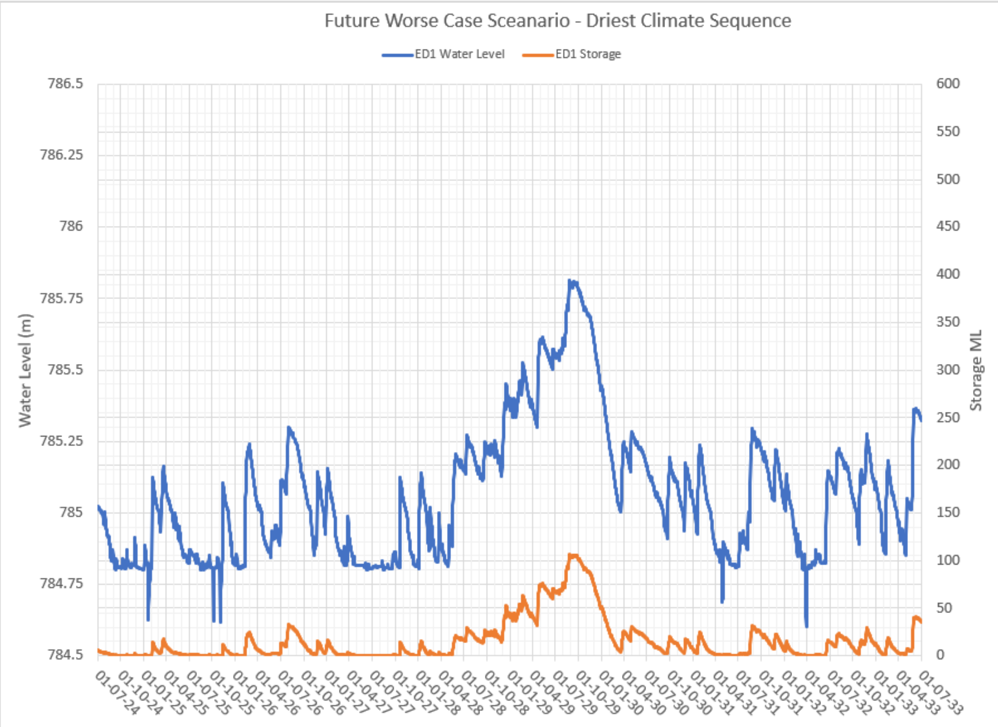

Figure C-11 ED1 water levels and storage for the future worst-case scenario and driest climate sequence

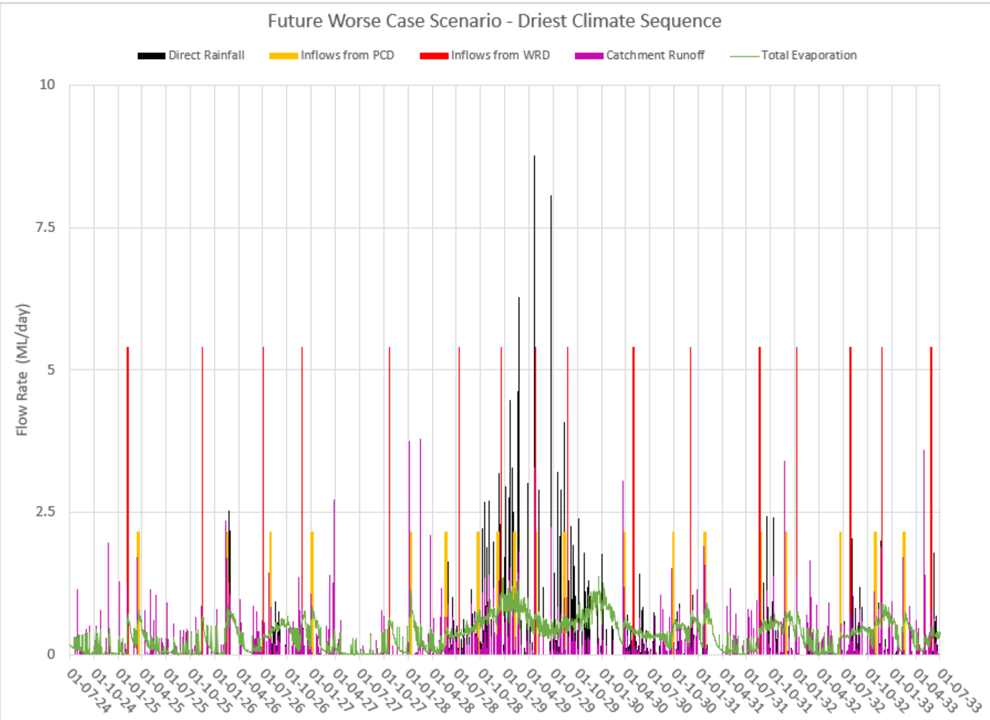

Figure C-12 ED1 inflows and outflows for the future worst-case scenario and driest climate sequence

APPENDIX D – EXISTING VS FUTURE WORST-CASE SIMULATION RESULTS

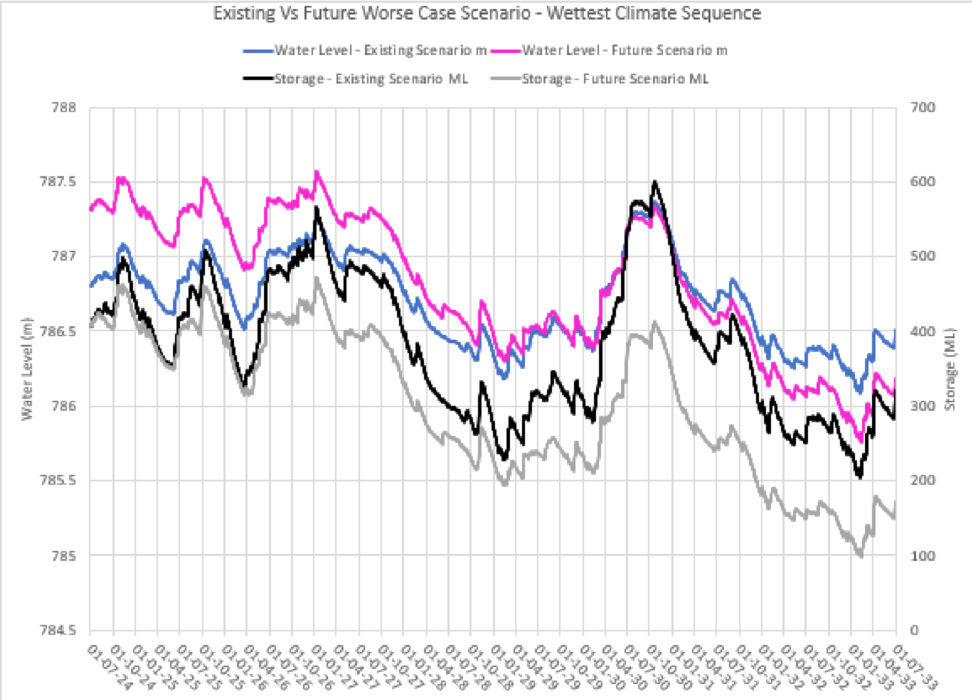

Figure D-1 Comparison of water levels and storage volume estimated for existing vs future worst-case scenario - wettest climate sequence

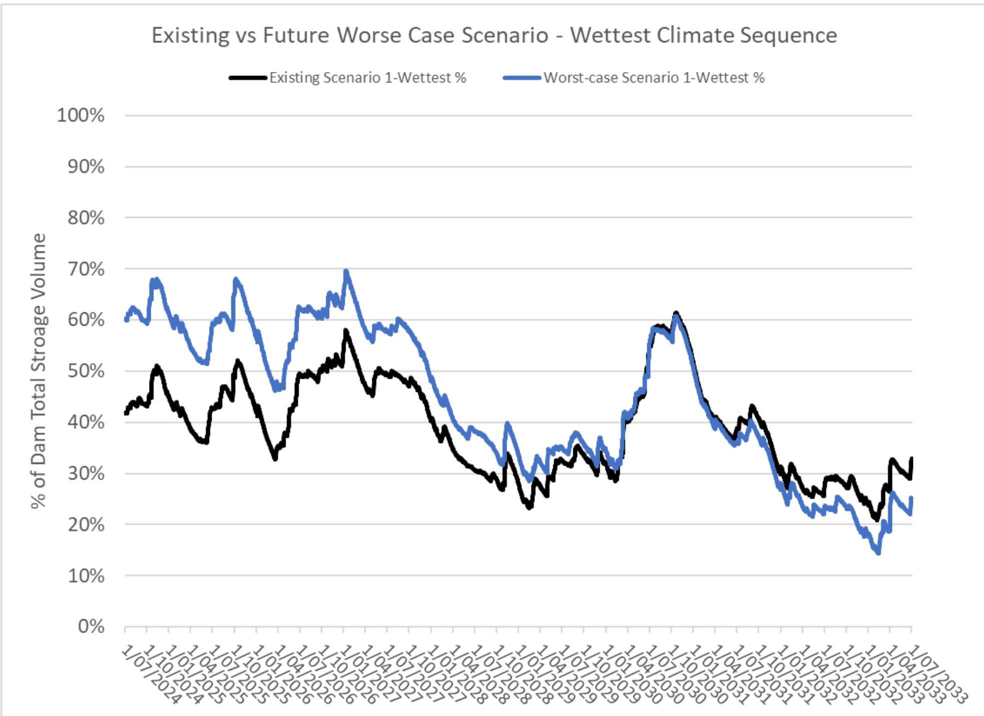

Figure D-2 Percentage of dam total storage volume estimated for existing vs future worst-case scenario - wettest climate sequence

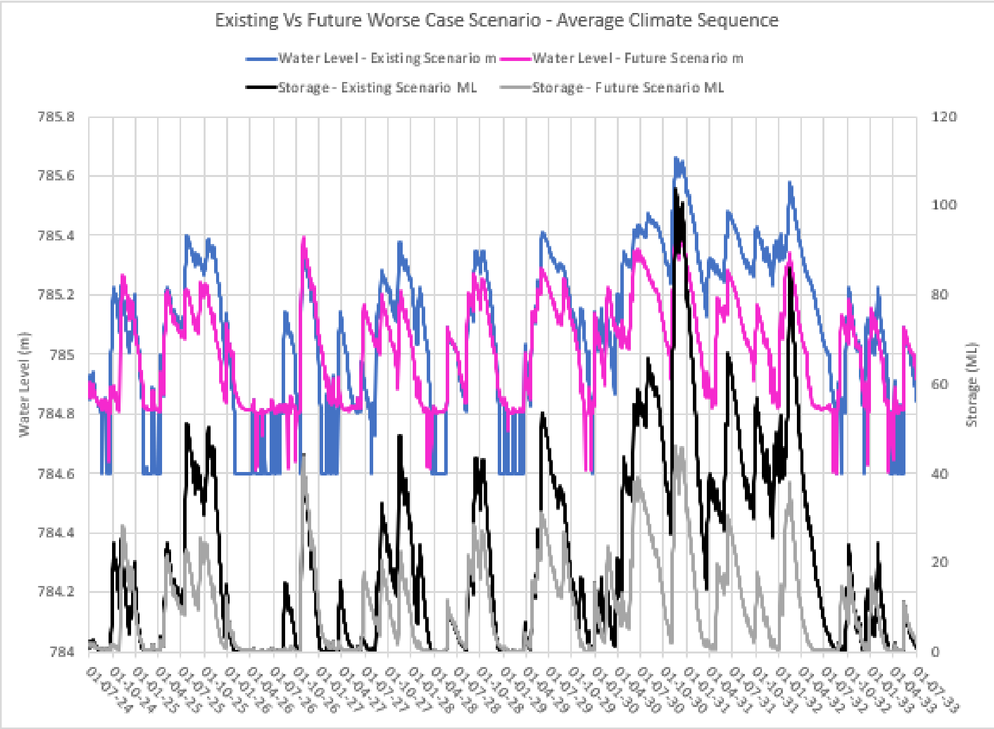

Figure D-3 Comparison of water levels and storage volume estimated for existing vs future worst-case scenario - average climate sequence

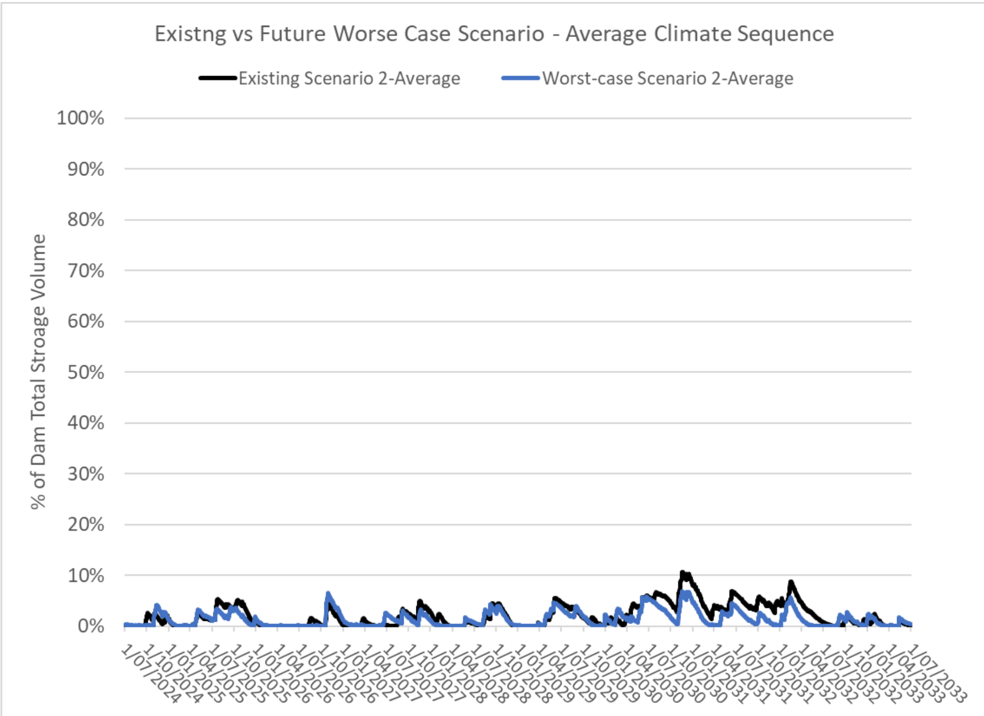

Figure D-4 Percentage of dam total storage volume estimated for existing vs future worst-case scenario - average climate sequence

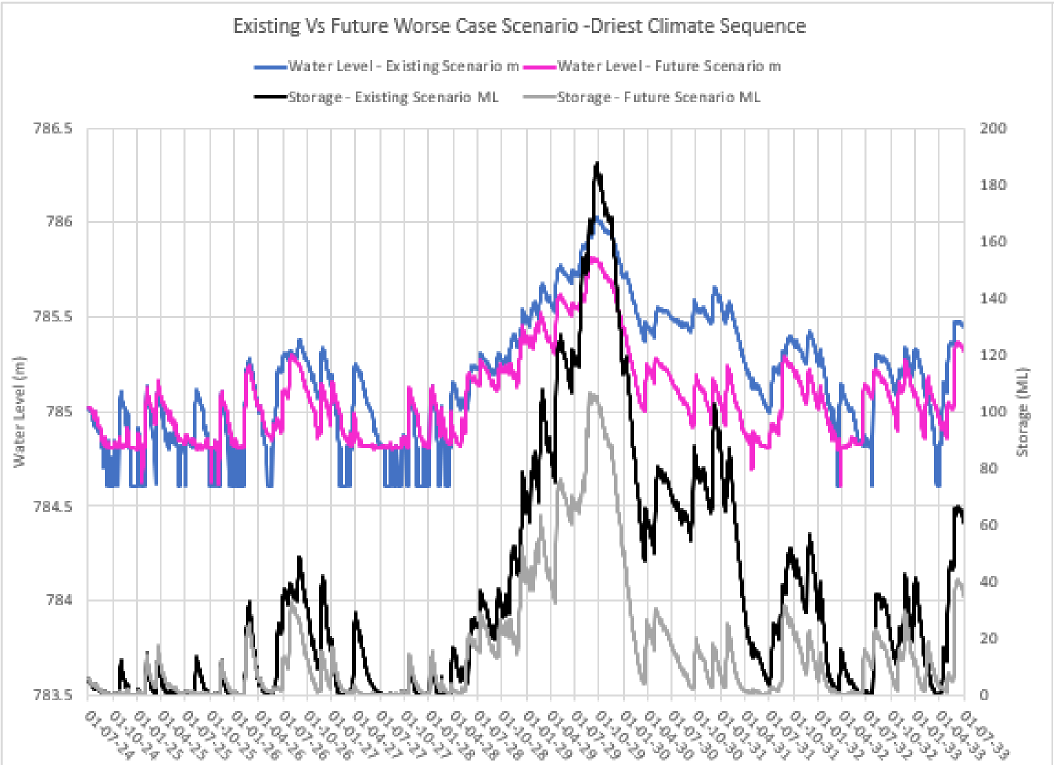

Figure D-5 Comparison of water levels and storage volume estimated for existing vs future worst-case scenario - driest climate sequence

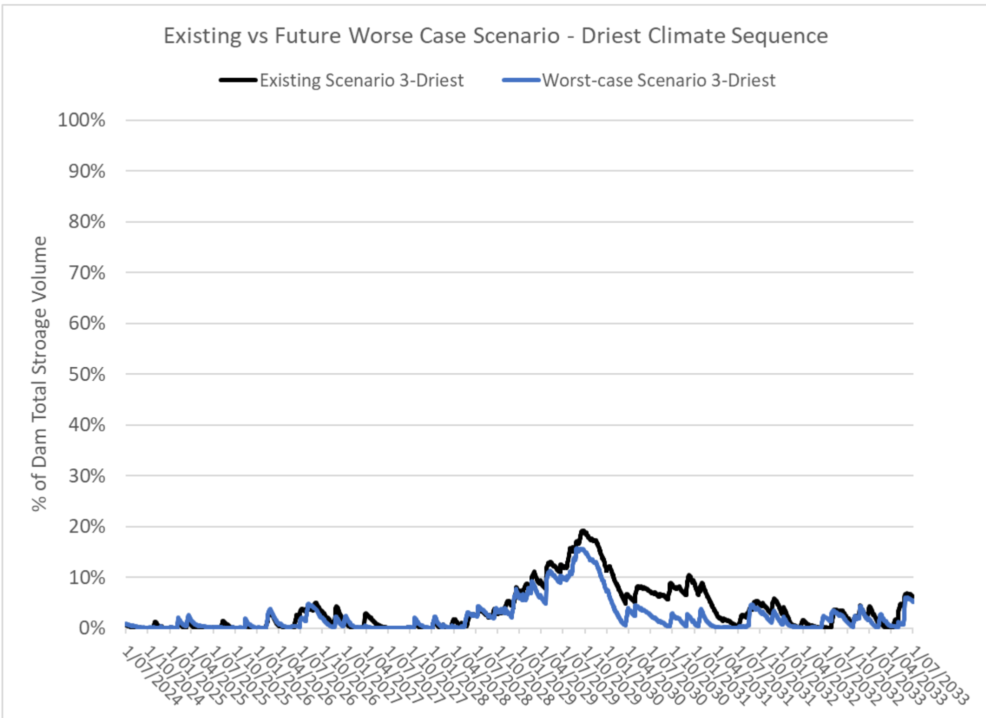

Figure D-6 Percentage of dam total storage volume estimated for existing vs future worst-case scenario - driest climate sequence

Appendix C
On-site wastewater report

creating opportunities

Broadcrest Consulting Pty Ltd

619 Collector Road, Tarago NSW

On-Site Wastewater Report

November 2021

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DOCUMENT CONTROL

Approval and Authorisation

Title	619 Collector Road, Tarago NSW On-Site Wastewater Report
Authored on behalf of Broadcrest Consulting Pty Ltd by:	Kyle Ryan Engineer | Environmental & Civil
Signed:	
Dated:	27/10/2021

Document Status

Date	Internal Reference	Document Status	Prepared by	Reviewed by
15/09/2021	1385-WW-A-01	For Release	K. Ryan	C. Hudson
29/09/2021	1385-WW-A-02	Revised Flow Rate	K. Ryan	C. Hudson
27/10/2021	1385-WW-A-03	Update Nomenclature	L. Starkey	C. Hudson

CONTENTS

1 INTRODUCTION

1.1 Foreword

An On-Site Wastewater Report is a technical document which specifies how the sewage produced on-site will be managed, treated, and then disposed. An On-Site Wastewater Report carefully considers the environment, health, cost, and long-term management options for the on-site management of sewage.

1.2 Background

Broadcrest Pty. Ltd. was engaged by Pablo Gonzalez of Veolia Environmental Services to produce an On-Site Wastewater Management Report at 619 Collector Road, Tarago NSW (the site). The report will accompany plans to construct new Woodlawn Advanced Energy Recovery Centre. A site inspection was carried out on 19 August 2021 which involved a visual assessment of the site and soil sampling. The assessment of the results, system design and recommendations are detailed in this report.

1.3 Objectives

The performance objectives of the On-Site Wastewater Assessment are to:

- Protect human health
- Protect ground and surface water
- Maintain and enhance the quality of the land and vegetation
- Maintain and enhance community amenity
- Ensure maximum re-use of resources
- Promote an ecologically sustainable development.

1.4 Scope of Works

The scope of works included the following:

- A site inspection
- Soil sampling and analysis
- Wastewater management assessment
- Drafting of the proposed system
- Reporting in accordance with the associated legislations and guidelines.

1.5 Compliance

This report has been produced in accordance with the following guiding documents:

- DLG 1998, On-site Sewerage Management for Single Households
- Australian Standard AS 1289.3.8.1:2006 Methods for testing soils for engineering purposes
- Australian Standard AS 1546.1-3:2008 On-site domestic wastewater treatment units
- Australian Standard AS 1547:2012 On-site domestic wastewater management
- Designing and Installing On-Site Wastewater Systems (WaterNSW 2019b)

2 SITE ASSESSMENT & INVESTIGATION

2.1 Site Information

Address / Locality	619 Collector Road, Tarago NSW
Lot Area:	170 Ha
Council / LGA:	Water NSW: Sydney Drinking Catchment
Intended Water Supply:	Town Water
Inspection Officer:	C. Hudson - 19/08/2021

2.2 General

The site occupies 170Ha of land zoned IN3 Heavy Industrial, within the Water NSW: Sydney Drinking Catchment. The proposed development is a waste processing facility, located on a retired mine site. At the time of inspection, the development location was largely unoccupied with remnants of previous industrial activities. An area has been set aside to be converted into an EMA once development has progressed (Figure 2.1-2.2). It is understood the location will be filled to raise RL with soil material sourced from elsewhere on site. The final soil surface will require preparation and re-vegetation prior to commissioning.

Figure 2.1: East facing aspect of proposed EMA#1

Figure 2.2: South-west facing aspect of proposed EMA#2

2.3 Assessment Methodology

The assessment methodology of this report follows that prescribed in DLG (1998), whereby the restriction imposed by a site/soil features are categorised by severity, and their impact forms the basis for subsequent system selection, design, and recommendations (Table 2.3.1).

Table 2.3.1 - Site / soil limitation assigned per DLG (1998)

Limitation	Description
Minor	This feature has been assessed and deemed to pose no obstacle to OSSM, given the recommended system and measures are implemented.
Moderate	This feature requires consideration. It may typically be overcome by site modifications or by appropriate selection, design and sizing of treatment / application systems.
Major	This feature precludes the use of a given treatment, land application method, or Effluent Management Area (EMA). Particular Major Limitations may prevent OSSM entirely, require an off-site management approach, or re-evaluation of the development scope.

2.4 Site Assessment Summary

A summary of limitations pertinent to the suitability of the site for On-Site Sewerage Management (OSSM) is provided in Table 2.4.1 below.

Table 2.4.1 – Assessment summary of site features

Factor Assessed	Description	Limitation
Climate	Monthly evaporation exceeds rainfall for all months of the year.	Minor
Temperature	Annual mean daytime maximum > 15°C.	Minor
Flood Potential	No flood study or flood levels have been provided. Proposed effluent management area positioned above any anticipated flood level.	Minor
Exposure	Excellent wind and solar exposure.	Minor
Slope	Approximately <6.6%	Minor
Landform	Linear Planar Upper-slope	Minor
Run-on and Seepage	Limited potential interaction of stormwater within proposed EMA.	Minor
Site-drainage	No ponding or pronounced saturation identified with proposed EMA.	Minor
Erosion Potential	EMA surface is highly disturbed and currently not protected by surface vegetation coverage.	Moderate
Site and Soil Disturbances	Site soil has been disturbed due to industrial activity and clearing. Remediation the land for effluent management required	Moderate
Groundwater Bores	No domestic groundwater bores have been identified within 250 m of the proposed EMA.	Minor
Rock Outcropping	No outcropping identified.	Minor
Geology / Regolith	No geological discontinuities, fractures or highly porous regolith identified.	Minor
Buffer Distances & Available land area	Reduced buffer to a nearby roadside drainage is proposed	Moderate

2.5 Climate

Tarago has a temperate climate, with mild to warm wet summers, with a cooler drier winter. Median annual rainfall is 671.6 mm and evaporation 1241 mm. Average monthly evaporation is greater than median rainfall for the entire year. (Appendix B) (*Minor Limitation)*.

Average maximum and minimum temperatures range from 28.3°C to 0.2°C in January to July respectively. The mean annual daytime maximum of 19.8°C proves suitable for biological wastewater treatment systems (i.e. AWTS) (*Minor Limitation*).

2.6 Flood potential

No Flood study Provided . The proposed effluent management area has been positioned above any anticipated flood level (*Minor Limitation*).

2.7 Exposure

The proposed effluent management area (EMA) is well exposed to sun and wind (*Minor Limitation*).

Landform Feature	Aspect	Solar Exposure	Wind Exposure	Limitation
A	Southern	Excellent	Excellent	Minor

2.8 Slope

Slope has the potential to become a restrictive landform feature for OSSM with increased slope increasing the risk of run-off and/or erosion. Slope across the proposed effluent management was determined to be waxing from <6.6% (*Minor Limitation).*

Landform Feature	Approximate Slope Tangent (%)	Slope Classification	Limitation
A	<6.6%	Gently Inclined	Minor

Table 2.8.1 - Percentage Slope and Land Application Limitations

Slope Range [%]	Slope Classification	Limitation				
		Surface Irrigation (Spray & Drip)	Absorption Systems	Mounds	Conventional Trenches & LPEDs	Sub-surface Irrigation
0 – 1	Level	Minor	Minor	Minor	Minor	Minor
1 – 3	Very Gently Inclined	Minor	Minor	Minor	Minor	Minor
3 – 10	**Gently Inclined**	**Minor**	**Minor**	**Minor**	**Minor**	**Minor**
10 – 15	Moderately Inclined	Major	Major	Moderate	Moderate	Minor
15 – 20		Major	Major	Major	Moderate [2]	Minor
> 20	Steeply Inclined	Major	Major	Major	Moderate [3]	Moderate [1]

[1] 30% maximum slope without specific design (AS 1547:2012, p.133)
[2] >15% slope increase difficulty in construction (AS 1547:2012, Table K1)
[3] >25% slope creates difficulty in trenching, risk of erosion during construction (AS 1547:2012, Table K1)

2.9 Landform

The landform describes the surface shape and topographic position at the proposed EMA. Typical landform descriptors per AS1547:2012 are detailed below.

Landform Feature	Slope Configuration	Limitation
A	Upper Slope – Linear Planar	Minor

2.10 Surface Water and Seepage

Surface water and seepage flow is determined by the catchment preceding the EMA and the prevailing landform features. General assessment of the likely surface water interaction with the landform and EMA has been provided.

Landform Feature	Catchment		Surface Flow		Soil Moisture	Seepage Potential	Limitation
	Size	Surface Coverage	Run-on	Run-off			
A	Limited	Grass	Minor	Minor	Slightly Moist	Minor	Minor

2.11 Site drainage

The proposed effluent management area appeared to be free draining with no signs of soil saturation, surface ponding, or noted presence of macrophytes (i.e. sedges, ferns, juncus) *(Minor Limitation).*

2.12 Erosion potential

Erosion and surface soil movement results from the interaction of the existing landform, surface flows and surface coverage. The following existing erosion conditions were identified and assessed in proposing additional hydraulic loading in the form of effluent. Note that soils are potentially erodible where surface cover is broken and as such, site and soil disturbances should be minimised (See 2.13 for discussion).

Landform Feature	Surface Flow Type	Erosion Hazard		Limitation
		Surface Flow	Wind	
A	Unconcentrated	Minor	Low	Moderate

Large scale soil importation works are proposed to produce a suitable EMA, these works are to be conducted in accordance with an approved erosion and sediment control plan. Surface coverage over proposed EMA absent, it will be necessary to establish a dense grass coverage prior to commissioning (*Moderate Limitation*).

2.13 Site & Soil Disturbances

Site soil has been heavily disturbed due to previous activity, excavations and clearing. Further, it is understood the location will be filled to raise RL with soil material sourced from elsewhere on site. The final soil surface will require preparation and re-vegetation prior to commissioning *(Moderate Limitation).*

2.14 Domestic Bore

WaterNSW Realtime data indicated no domestic potable groundwater bores located within a 250m radius of the site *(Minor Limitation).*

2.15 Rock Outcropping

No rock outcrop or surface boulders were identified (*Minor Limitation)*.

2.16 Geology / Regolith

No geological discontinuities, fractures, or highly porous regolith are expected within and surrounding the EMA (*Minor Limitation*).

2.17 Buffer Distances & Available Land Area

Minimum offset distances are designated by local approval authorities within their guiding documents to ensure the ongoing protection of community health, sensitive ecosystems, and the maintenance of community amenity. Where LGA guidance on a constraint is not available, appropriate offsets have been nominated in accordance with AS1547:2012 and Table 5 DLG (1998).

The site-specific constraints for the proposed EMA and land application method have been assessed as per Table 2.17.1.

Table 2.17.1 – Minimum buffer distances from sensitive site features

Site Feature	Minimum Setback		Proposed Setback	Limitation
	If EMA is upslope of feature	If EMA is downslope / level with feature		
Property Boundaries	6m	3m	>6/3m	Minor
Roads/Driveways	6m	3m	6/3m	Minor
Buildings	6m	3m	>6/3m	Minor
Watercourses	100m		-	Minor
Domestic Bore / Well	250m from high water level		-	Minor
Dam / Drainage Depression	40m from high water level		>8.3m	Moderate [1]

[1]A reduced buffer of 8.3m is proposed to a roadside drainage located to the southeast of proposed EMA#2 and 34.6m from the constructed detention pond, the justification for a reduced setback is:

1) Slope is gentle and parallel to the drainage depression
2) An up-slope diversion bund is proposed to intercept surface soil moisture that may be headed laterally toward the roadside drainage
3) Effluent quality consistently producing ≤ 10 cfu/100 mL E. coli (secondary treated effluent with disinfection)
4) Sub-surface irrigation eliminates potential for surface water run-off pollution.

3 SOIL ASSESSMENT

3.1 Soil Assessment Summary

Investigation of the site for suitability for OSSM was accompanied by soil assessment within the proposed EMA. Soil sampling was conducted at the time of inspection with the soil characteristics assessed per AS 1547:2012, AS 1289.3.8.1:2006, and NSW DLG (1998) methodologies. The summary of the soil investigation is presented in Table 3.1.1.

Table 3.1.1 – Assessment summary of site features

Factor Assessed	Description	Limitation
Depth to bedrock / hardpan	1100 mm.	Minor
Depth to high watertable	NIL free water or waterlogging characteristics	Minor
Coarse Fragments	< 10% across all upper strata	Minor
pH	>4.5 across all samples	Moderate
Electrical Conductivity (EC)	< 2 dS/m across all samples.	Minor
Modified Emersion Aggregate Test – Dispersiveness (EAT_m)	2+	Moderate

3.2 Soil Landscape Map

1:100,000 Soil Landscape Mapping indicates the site occurs on Disturbed terrain Soil Landscape. The Landscape is undulating terrain and has been disturbed by human activity to a depth of at least 100 cm.

The original soil has been removed, greatly disturbed, or buried includes a wide variety of soil, rock, building and waste material. The original vegetation has been completely removed.

3.3 Depth to Bedrock / Hardpan

Soil depth was ascertained via three (3) bore holes within the EMA, BH 1&3 being located most centrally to the proposed EMA. Samples were extracted via direct push tube, all samples achieved approximately 1100mm depth before encountering refusal on underlying hardpan (*Minor Limitation)*.

3.4 Depth to High Watertable

No visible free water, soil saturation, grey mottling or similar was encountered within the sampling depth *(Minor Limitation).*

3.5 Soil Permeability Category

Soil permeability has been assigned per Table 5.2 of AS1547:2012 for the excavation site(s) most representative of the EMA location. The hydraulically limiting strata for the application system is bolded within Table 3.5.1 below.

Table 3.5.1: Soil permeability and Design Irrigation Rate

Excavation #		BH1		
Lower Depth (mm)	Field Texture	Structure	Indicative Permeability K_{sat} (m/day)	Design Irrigation Rate (DIR) (mm/day)
250	Loam	High	1.5 – 3.0	4.0
550	**Clay**	**Weak**	**0.12 – 0.5**	**3.0**

3.6 Soil Profiles

Table 3.6.1						
Excavation #	BH1	Sample size:	50	[mm]	Date Completed:	19/08/2021
Inspection Method:	Thin Wall Tube Sample				Water-table Encountered:	No

Layer Horizon	Lower Depth [mm]	Moisture	Colour	Field Texture	Structure	Coarse Fragment
1	200	Mod-moist	Dark Brown	Light Clay	High	<5%
2	1100	Mod-moist	Red/Grey	Medium Clay	Moderate	<5%
Refusal:	Refusal encountered on underlying hardpan					
Photo:						

Table 3.6.2						
Excavation #	BH2	Sample size:	50	[mm]	Date Completed:	19/08/2021
Inspection Method:	Thin Wall Tube Sample				Water-table Encountered:	No

Layer Horizon	Lower Depth [mm]	Moisture	Colour	Field Texture	Structure	Coarse Fragment
1	400	Mod-Moist	Dark Brown	Light Clay	Moderate	<5%
2	1100	Mod-Moist	Brown	Medium Clay	Moderate	<5%
Refusal:	Refusal encountered on underlying hardpan					
Photo:						

Table 3.6.3						
Excavation #	BH3	Sample size:	50	[mm]	Date Completed:	19/08/2021
Inspection Method:	Thin Wall Tube Sample				Water-table Encountered:	No

Layer Horizon	Lower Depth [mm]	Moisture	Colour	Field Texture	Structure	Coarse Fragment
1	400	Slightly Moist	Dark Brown	Light Clay	High	<5%
2	1100	Dry	Brown	Medium Clay	Weak	<5%
Refusal:	Refusal encountered on underlying hardpan					
Photo:						

3.7 Soil Chemistry

One sample from each horizon of the most descriptive excavation site was tested for pH, Electrical Conductivity (EC). P-sorption, Cation Exchange Capacity (CEC) and Dispersion by ALS Laboratory in Smithfield (Appendix B). The results were as follows:

Table 3.7.1: Soil Chemistry results

Excavation #		BH1			
Sample Depth (mm)	Test	Result	Description	Limitation	Recommendations
200	pH	4.5	Strongly Acidic	Moderate	Planned soil importation [1] will greatly mitigate the existing limitations.
	EC (dS/m)	0.63	Non-Saline	Minor	
	EAT_m	2	Some dispersion	Moderate	
	CEC	1.3	<5, unable to hold plant nutrients	Major	
	P-sorbed (mg/kg)	960	>6000/m depth	Minor	
700	pH	4.6	Strongly Acidic	Minor	
	EC (dS/m)	1.88	Non-Saline	Minor	
	EAT_m	6	Non-critical	Minor	
	CEC	8.6	5-15	Moderate	
	P-sorbed (mg/kg)	2210	>6000/m depth	Minor	

[1] Soil Importation

It is understood that at least 500mm of soil of Texture Category 5 light clay or lower is to be imported within the EMA at a date later in the development process. The clay will be top-dressed with an organic rich loam suitable for vegetation establishment. It should be ensured that any imported soils' chemistry properties fall within the following permissible range:

Table 3.7.2: Required Fill Chemistry Properties

Test	Result	Description	Limitation
pH	>6.0	Moderately Acidic - Neutral	Minor
EC (dS/m)	<4.0	Non-Saline	Minor
EAT_m	3+	Non-critical	Minor
CEC	>15	Able to retain specific cations	Minor
P-sorbed (mg/kg)	>580	Phosphorus balance non-critical	Minor

4 NOMINATED WASTEWATER MANAGEMENT

4.1 Proposed OSSM Summary

Site and soil constraints were evaluated in selection of appropriate treatment and effluent management method. A summary of the recommended OSSM system and application sizing is presented below:

PROPOSED OSSM SYSTEM:

Treatment	→	Effluent Management
AWTS + disinfection or equivalent	(Pumped dosing)	1,945 m^2 Sub-surface Drip Irrigation

SITE WASTEWATER LOADING:

Role	Maximum Daily Persons	Daily Usage (L/Day)
Administrative Staff		
Facility Manager	1	30[1]
Finance & Administration officer	1	30
Management Staff		
Operations Manager	1	120[2]
Maintenance Manager	1	120
Operations Staff		
Control Room Operators	12	120
Operations & Maintenance Staff	5	120
Maintenance Staff	7	120
Temporary Staff & Visitors	5	30
Subcontractors	10	30
Educational Tour Groups	25	30
Total	68	**4380**

[1] Note: Wastewater generation estimates per NSW Septic & Collection well guidelines: Factories & Offices
[2] Note: Wastewater generation estimates per AS1547 2012, domestic daily usage on tank water

- Administrative staff, temporary staff & visitors, sub-contractors and educational tour groups are low water users as their showering and laundry use is minimal. This group's water use will be typical of rural factories.
- Management staff, control rooms operators, operations & maintenance staff, are considered high water users as their showering and laundry use will be more significant. This group's water use will be similar to residential water demand.
- It is expected that there will be 1 educational tour for 25 people per week (52 per year evenly split across 12 months)
- Additional shutdown staff will use temporary facilities and will not add the ARC's potable water demand or OSWTP

Seasonal Shut-down for maintenance and repairs:

A seasonal yearly shutdown is to occur for 3x weeks and will require capacity for over 100x Contractors. To facilitate the needs for the expanded wastewater usage during this time period, it is recommended to install temporary wastewater facilities such as porta-loos.

4.2 Wastewater Treatment

It is proposed to treat all wastewater generated by the staff amenities for the proposed waste processing plant to a secondary standard via Aerated Wastewater Treatment Systems (AWTS) or equivalent. The nominated unit(s) must be capable of sustainably treating the calculated daily wastewater load of **4380 L/Day** to the DLG 1998 parameters nominated in Table 4.2.1.

Justification of the proposed treatment method is as follows:

- Accidental or deliberate discharges are less detrimental to the environment and have less potential to adversely impact on health
- Higher quality effluent produced
- High commercial availability
- Allows for irrigation methods of effluent management

Table 4.2.1: - Secondary Treatment Targets (per DLG 1998)

Biochemical Oxygen Demand (BOD^5)	Suspended Solids (TSS)	Total Nitrogen (TN)	Total Phosphorus (TP)	Faecal coliforms		Dissolved Oxygen (DO)
				Non-disinfected effluent	Disinfected effluent	
< 20 mg/L	< 30 mg/L	25 - 50 mg/L	10 - 15 mg/L	Up to 10^4 cfu/100 mL	< 30 cfu/100 mL	> 2 mg/L

4.3 Effluent Management

Given the development proposed and site and soil conditions encountered, it is proposed to dispose of effluent from the treatment system servicing the proposed residence via **Sub-surface Drip Irrigation.**

Sizing of the application method was undertaken via water and nutrient balance in accordance with DLG 1998 (see Appendix B), with a minimum **irrigation area of 1,945 m^2 required.**

In this instance the irrigation field may be provided over eight or more subfields, subject to pump and dripper capacities. To ensure even effluent application over the fields, the sub-fields are to be alternated via a sequencing valve. The irrigation fields should be positioned within the effluent management area(s) (EMA) nominated in Appendix A.

Justification of the proposed treatment method is as follows:

- Irrigation maximises the surface disposal area and evapo-transpiration.
- An irrigation area is available onsite meeting the minimum buffer distances.
- Irrigation is a suitable OSSM method for the site landform and soil properties.

4.4 Recommended Site Modifications

To address present site constraints, the following modifications are recommended:

- Following required earthworks, the irrigation fields are to be established and maintained with dense grass coverage and excluded from vehicle and livestock traffic. Irrigation on bare earth cannot be undertaken.
- Signs are to be posted around the EMA indicating effluent dispersal in the area.
- Install diversion bund as per Appendix A

5 ADDITIONAL INFORMATION

5.1 Pipework Detail

All associated plumbing / drainage work is to be in accordance with AS 3500.2:2015 *Sanitary Plumbing Drainage*. Positioning of the receiving treatment system is to ensure drainage from internal plumbing fixtures achieves the minimum grade and cover of the excerpts below.

Table 6.1 – Excerpts of AS3500.2:2015

Nominal Pipe Diameter (DN)	Minimum Grade	
(mm)	(%)	(Ratio)
65	2.50	1:40
80	1.65	1:60
100	1.65*****	1:60*****
125	1.25	1:80
150	1.00	1:100

*Drains from treatment plants may be 1.00% Min.

	Minimum depth of cover (mm)	
Location	Cast iron & Ductile iron	Other materials
Subject to vehicular loading	300	500
All other locations	NIL	300

5.2 Licensing

Operating a system of sewage management is a Prescribed Activity under the Local Government Act 1993 and clause 45 of the Local Government (Approvals) Regulation 1999. This means that an 'Approval to Operate' a system of sewage management must be obtained from Council.

5.3 Detailed Design

A detailed system design may still be requested at the 'Application to Install' stage. This design will include the size and location of all system components including tanks, distribution lines, valves, etc. These additional requirements will be furnished by the nominated treatment system suppliers / licensed installers. Additional information for the property owner is available in Appendix C.

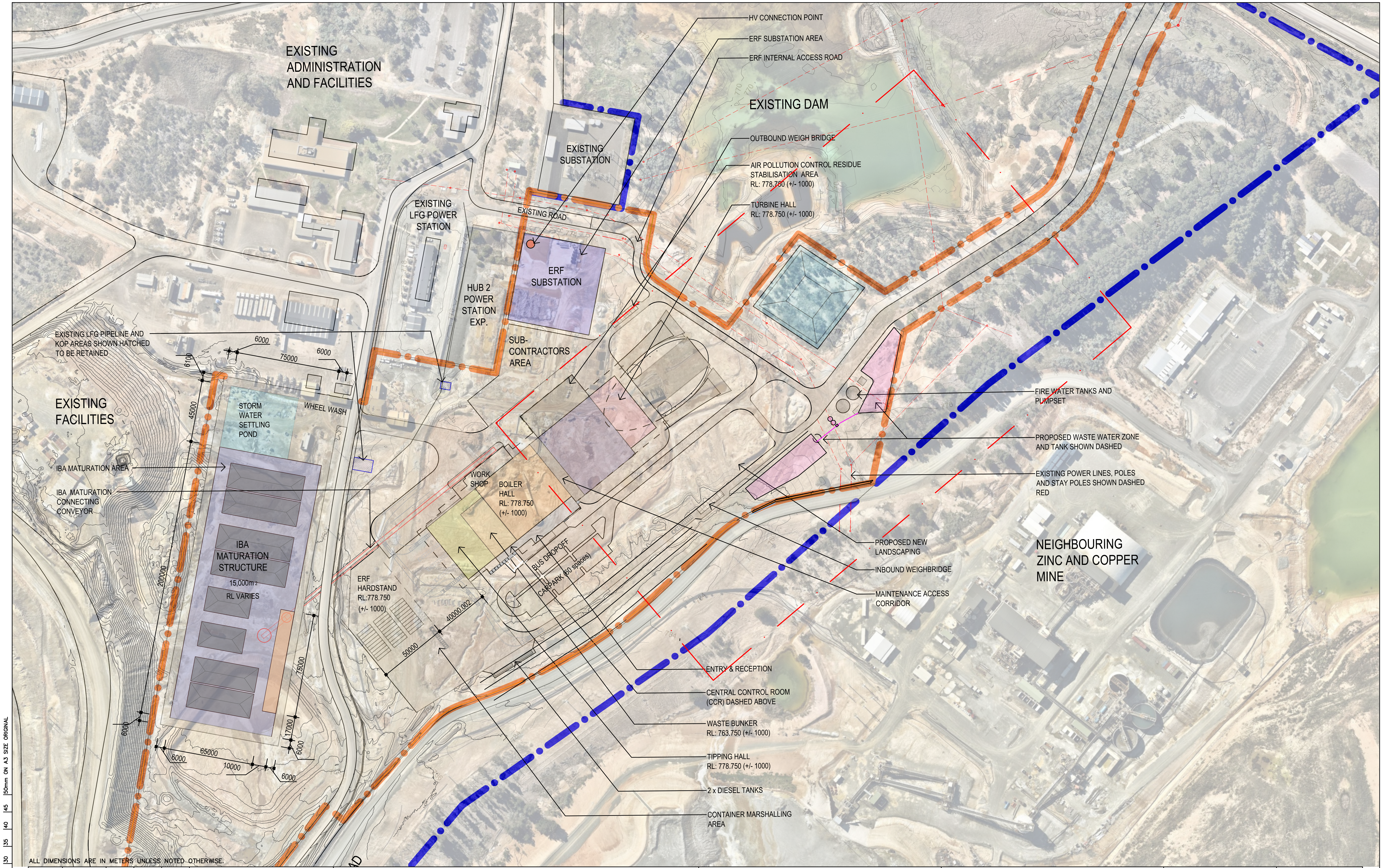
6 CONCLUSION

- A Woodlawn Advanced Energy Recovery Centre is proposed at 619 Collector Road, Tarago NSW
- The total anticipated wastewater loading rates generated by the Amenities is calculated to be **4380 L/day.**
- It is proposed to treat all wastewater generated by the amenities to a secondary standard with disinfection. This is proposed to be via a new Aerated Wastewater Treatment System (AWTS).
- Application of the effluent is proposed via **1,945 m^2 Sub-surface Drip Irrigation** within the area(s) nominated in Appendix A.

  Following required earthworks, the irrigation fields are to be established and maintained with dense grass coverage and excluded from vehicle and livestock traffic.

- The Amenities are to be fitted via standard-water reductive fixtures.

APPENDIX A: REFERENCE DESIGN



ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.

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REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A-03	27-10-21	KR	KR	LS	UPDATE NOMENCLATURE
A-02	29-09-21	KR	KR	LS	REVISED FLOW RATE
A-01	15-09-21	KR	KR	CH	FOR RELEASE

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BROADCREST CONSULTING PTY LTD | ACN 622 508 187

PROJECT: OSSM -WOODLAWN ADVANCED ENERGY RECOVERY FACILITY
PROJECT DESCRIPTION: AWTS + SUBSURFACE DRIP IRRIGATION
LOCATION: 961 COLLECTOR ROAD, TARAGO
CLIENT: VEOLIA
LGA: WATERNSW: SYDNEY DRINKING CATCHMENT

PROJECT NUMBER: 1385
REVISION: A-01
DRAWING NUMBER: 01
DATE: -
SCALE: 1:2500
PAPER SIZE: A3
SHEET No. 1 OF 2

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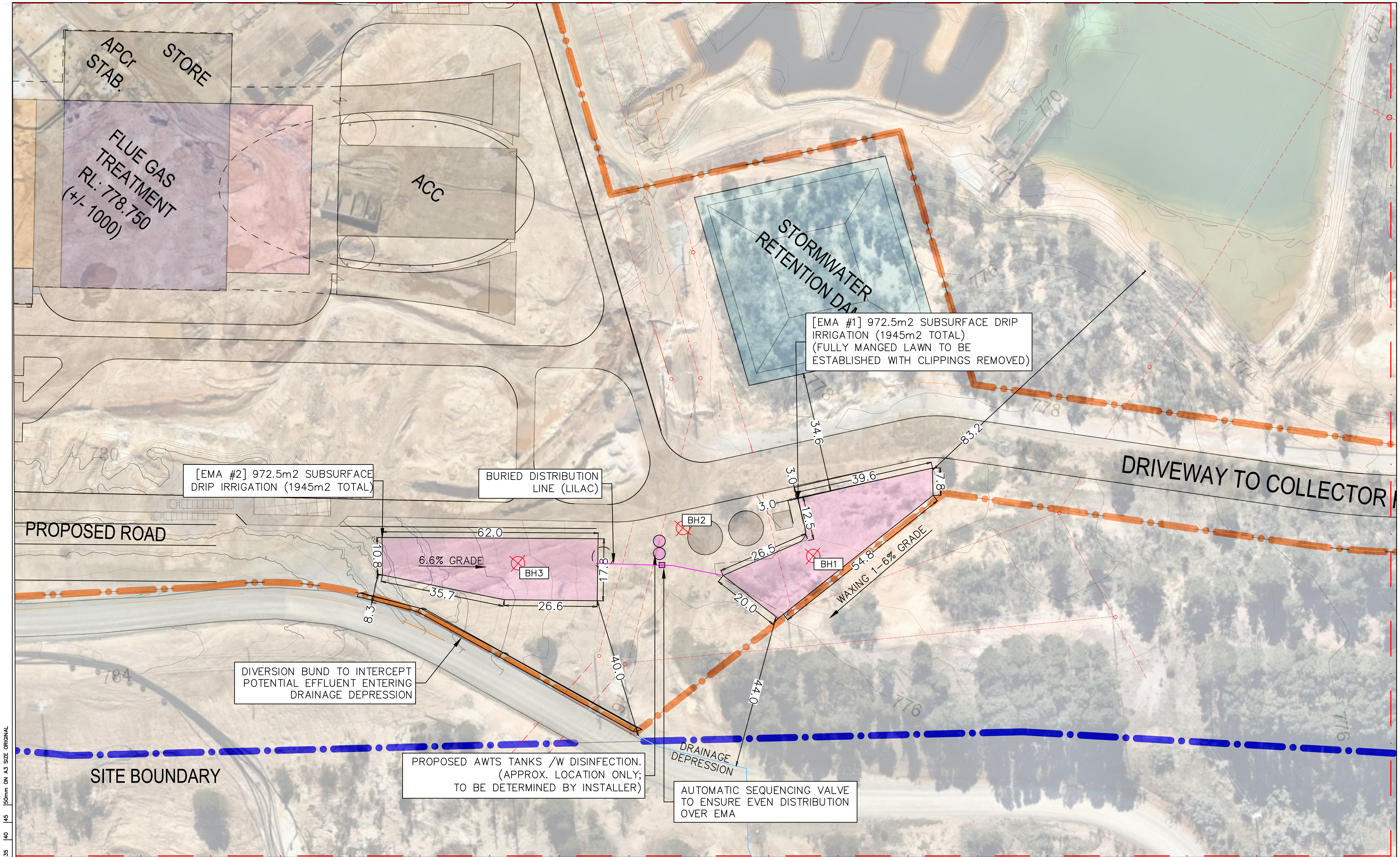

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REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
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LOCATION: 961 COLLECTOR ROAD, TARAGO

CLIENT: VEOLIA

LGA: WATERNSW: SYDNEY DRINKING CATCHMENT

PROJECT NUMBER	REVISION
1385	A-02
DRAWING NUMBER	DATE
01	-
SCALE	PAPER SIZE
1:1000	A3
SHEET No. 2 OF 2	

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APPENDIX B: CLIMATE & NUTRIENT DATA

B1. - Climate Statistics

Table B1.1. Weather Stations

Statistic	Station No.	Station Name	Distance from site [km]
Temperature	70330	GOULBURN AIRPORT AWS	30.93
Precipitation	70036	LAKE BATHURST (SOMERTON)	8.15
Evaporation	70263	GOULBURN TAFE	36.04

Figure B.1 - Monthly Cimate Statistics

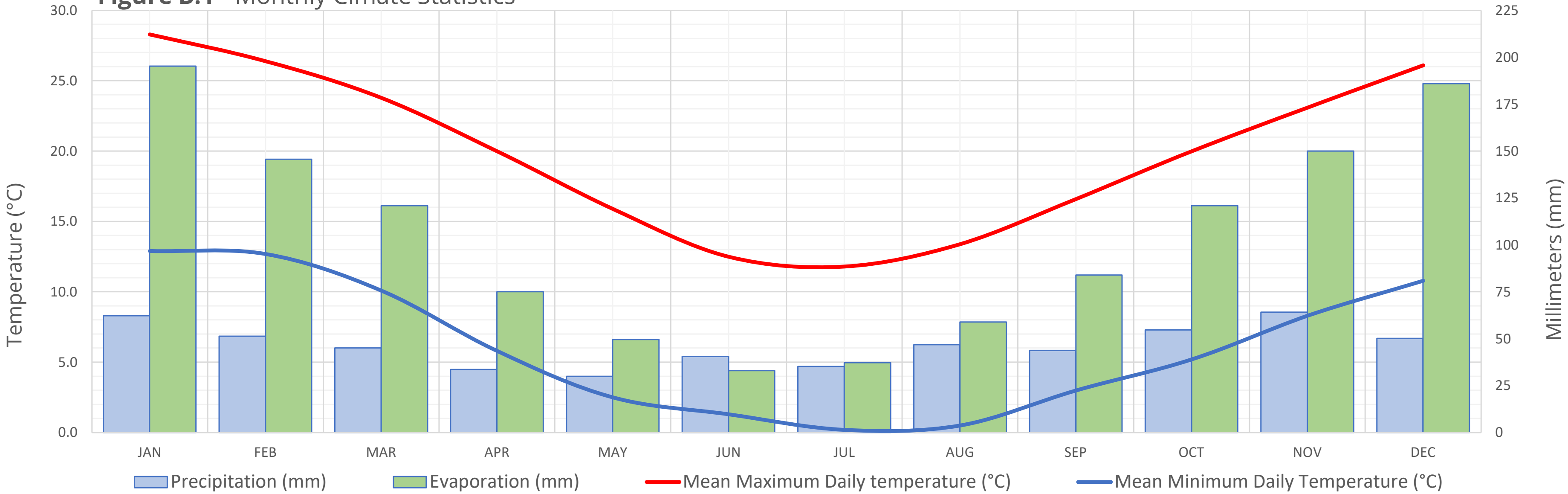


Table B1.2. Site Climate Statistics

Site Factors	Symbol	Units	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Mean Max. Temperature	[T]	[°C]	28.3	26.4	23.8	20.0	15.9	12.5	11.8	13.4	16.6	20.0	23.1	26.1	19.8
Mean Min. Temperature	[T]	[°C]	12.9	12.7	10.1	5.8	2.5	1.3	0.2	0.5	3.0	5.2	8.3	10.8	6.1
Days	[D]		31	28	31	30	31	30	31	31	30	31	30	31	365
Precipitation[1]	[P]	[mm/month]	62.3	51.4	45	33.5	30	40.6	35.1	46.8	43.8	54.7	64.1	50.2	671.6
Evaporation	[E]	[mm/day]	6.3	5.2	3.9	2.5	1.6	1.1	1.2	1.9	2.8	3.9	5	6	3.4
		[mm/month]	195.3	145.6	120.9	75	49.6	33	37.2	58.9	84	120.9	150	186	1241
Natural Site Balance[2]	[P-E]	[mm/month]	-133	-94.2	-75.9	-41.5	-19.6	7.6	-2.1	-12.1	-40.2	-66.2	-85.9	-135.8	

[1] Median historic precipitation. Note: total is not equivalent to annual median.

[2] Negative value indicates monthly mean evaporation > precipitation

B2. - Water Balance

Table B2.1. Site & Soil Parameters

Parameter	Symbols	Values	Units
Design Wastewater Flowrate	Q	4,380	L/day
Soil Texture		Light Clay	
Soil Structure		Weak	
Indicative Permeability	K_{sat}	0 to 0.06	m/day
Design Irrigation Rate	DIR_{day}	3	mm/day

Table B2.2. Effluent water balance

Site Factors	Symbol	Units	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Days per Month	D	days	31	28	31	30	31	30	31	31	30	31	30	31	365
Crop Factor	C		0.8	0.8	0.8	0.7	0.6	0.55	0.5	0.55	0.65	0.75	0.8	0.8	0.69167
Effluent Irrigation	(Q x D)	mm/month	135780	122640	135780	131400	135780	131400	135780	135780	131400	135780	131400	135780	1598700
Evapotranspiration	(E xC)	mm/month	156.2	116.5	96.7	52.5	29.8	18.2	18.6	32.4	54.6	90.7	120.0	148.8	858.4
Design Irrigation Rate	DIR_{Month}	mm/month	93	84	93	90	93	90	93	93	90	93	90	93	1095
Minmum Area Required	$A_{wb.min}$	m^2	726	823	938	1206	1464	**1945**	1775	1728	1304	1053	901	709	1247

Table B2.3. Water Balance Minimum Area Requirement

	Symbols	Area m^2
Minimum Area Required to Satisfy Water Balance:	A_{wb}	**1,945**

B3. - Nutrient Balance & Minimum irrigation area

Table B3.1. Nitrogen Balance

Parameter	**Symbols**	**Values**	**Units**
Design Wastewater Flowrate	Q	4,380	L/day
Surface Vegetation	Lawn - fully managed (clippings removed)		
Effluent Total Nitrogen (TN) Concentration[1]	TN	20	mg/L
Critical TN Loading Rate[2]	$L_{n.sfc}$	66	$mg/m^2/day$
Minimum Application Area	$A_{n.sfc}$	**1332**	m^2

[1] Nominal ATWS Nutrient Concerntrations (DLG 1998, AS1547.3:2012)

[2] Appendix 6, 'On-site sewage management for single households' (DLG 1998, AS1547.3:2012)

Table B3.2. Phosphorus Balance

Parameter	Symbols	Values	Units
Design Wastewater Flowrate	Q	4380	L/day
Surface Vegetation	Lawn - fully managed (clippings removed)		
Effluent Total Phosphorus (TP) Concentration[1]	TP	10	mg/L
Phosphorus Generated 50_{YR}	P_{gen}	799.35	kg
Soil Phosphorus Sorption Capacity	P_{sorp}	25,864	kg/Ha
Phosphorus Absorped 50_{YR}	P_{absorb}	0.862	kg/m^2
Critical TP Loading Rate[2]	$L_{p.sfc}$	8	$mg/m^2/day$
Phosphorus Uptake 50YR	$P_{uptake.sfc}$	0.150	kg/m^2
Minimum Application Area	$A_{p.sfc}$	**790**	m^2

[1] Nominal ATWS Nutrient Concerntrations (DLG 1998, AS1547.3:2012)

[2] Appendix 6, 'On-site sewage management for single households' (DLG 1998, AS1547.3:2012)

B4. - Minimum Effluent Irrigation Areas

Table B4.1. Minimum Irrigation Area Requirement

Balance	Area Required (m^2)
Water	1945
Nitrogen	1332
Phosphorus	790
Minimum Irrigation Area	**1945**

APPENDIX C: INFORMATION FOR THE PROPERTY OWNER

ON-SITE SEWAGE MANAGEMENT SYSTEMS

If you live in or rent a house that is not connected to the main sewer then chances are that your yard contains an on-site sewage management system. If this is the case then you have a special responsibility to ensure that it is working as well as it can.

The aim of this pamphlet is to introduce you to some of the most popular types of on-site sewage management systems and provide some general information to help you maintain your system effectively. You should find out what type of system you have and how it works.

More information can be obtained from the pamphlets:

Your Septic System
Your Aerated Wastewater Treatment System
Your Composting Toilet
Your Land Application Area

You can get a copy of these pamphlets from your local council or the address marked on the back of this pamphlet.

It is important to keep in mind that maintenance needs to be performed properly and regularly. Poorly maintained on-site sewage management systems can significantly affect you and your family's health as well as the local environment.

What is an on-site sewage management system?

A domestic on-site sewage management system is made up of various components which - if properly designed, installed and maintained - allow the treatment and utilisation of wastewater from a house, completely within the boundary of the property.

Wastewater may be blackwater (toilet waste), or greywater (water from showers, sinks, and washing machines), or a combination of both.

Partial on-site systems - eg. pump out and common effluent systems (CES) - also exist. These usually involve the preliminary on-site treatment of wastewater in a septic tank, followed by collection and transport of the treated wastewater to an off-site management facility. Pump out systems use road tankers to transport the effluent, and CES use a network of small diameter pipes.

How does an on-site sewage management system work?

For complete on-site systems there are two main processes:

1. treatment of wastewater to a certain standard
2. its application to a dedicated area of land.

The type of application permitted depends on the quality of treatment, although you should try to avoid contact with all treated and untreated wastewater, and thoroughly wash affected areas if contact does occur.

Treatment and application can be carried out using various methods:

Septic Tank
Septic tanks treat both greywater and blackwater, but they provide only limited treatment through the settling of solids and the flotation of fats and greases. Bacteria in the tank break down the solids over a period of time. Wastewater that has been treated in a septic tank can only be applied to land through a covered soil absorption system, as the effluent is still too contaminated for above ground or near surface irrigation.

AWTS
Aerated wastewater treatment systems (AWTS) treat all household wastewater and have several treatment compartments. The first is like a septic tank, but in the second compartment air is mixed with the wastewater to assist bacteria to break down solids. A third compartment allows settling of more solids and a final chlorination contact chamber allows disinfection. Some AWTS are constructed with all the compartments inside a single tank. The effluent produced may be surface or sub-surface irrigated in a dedicated area.

Composting Toilets
Composting toilets collect and treat toilet waste only. Water from the shower, sinks and the washing machine needs to be treated separately (for example in a septic tank or AWTS as above). The compost produced by a composting toilet has special requirements but is usually buried on-site.

These are just some of the treatment and application methods available, and there are many other types such as sand filter beds, wetlands, and amended earth mounds. Your local council or the NSW Department of Health have more information on these systems if you need it.

Regulations and recommendations

The NSW Department of Health determines the design and structural requirements for treatment systems for single households. Local councils are primarily responsible for approving the installation of smaller domestic septic tank systems, composting toilets and AWTSs in their area, and are also responsible for approving land application areas. The NSW Environment Protection Authority approves larger systems.

The design and installation of on-site sewage management systems, including plumbing and drainage, should only be carried out by suitably qualified or experienced people. Care is needed to ensure correct sizing of the treatment system and application area.

Heavy fines may be imposed under the Clean Waters Act if wastewater is not managed properly.

Keeping your on-site sewage management system operating well

What you put down your drains and toilets has a lot to do with how well your system performs. Maintenance of your sewage management system also needs to be done well and on-time. The following is a guide to the types of things you should and should not do with your system.

DO

- ✓ Learn how your sewage management system works and its operational and maintenance requirements.
- ✓ Learn the location and layout of your sewage management system.
- ✓ Have your AWTS (if installed) inspected and serviced four times per year by an approved contractor. Other systems should be inspected at least once every year. Assessment should be applicable to the system design.
- ✓ Keep a record of desludgings, inspections, and other maintenance.
- ✓ Have your septic tank or AWTS desludged every three years to prevent sludge build up, which may 'clog' the pipes.
- ✓ Conserve water. Conservative water use around the house will reduce the amount of wastewater which is produced and needs to be treated.
- ✓ Discuss with your local council the adequacy of your existing sewage management system if you are considering house extensions for increased occupancy.

DON'T

- ✗ Don't let children or pets play on land application areas.
- ✗ Don't water fruit and vegetables with effluent.
- ✗ Don't extract untreated groundwater for cooking and drinking.
- ✗ Don't put large quantities of bleaches, disinfectants, whiteners, nappy soakers and spot removers into your system via the sink, washing machine or toilet.
- ✗ Don't allow any foreign materials such as nappies, sanitary napkins, condoms and other hygiene products to enter the system.
- ✗ Don't put fats and oils down the drain and keep food waste out of your system.
- ✗ Don't install or use a garbage grinder or spa bath if your system is not designed for it.

Reducing water usage

Reducing water usage will lessen the likelihood of problems such as overloading with your septic system. Overloading may result in wastewater backing up into your house, contamination of your yard with improperly treated effluent, and effluent from your system contaminating groundwater or a nearby waterway.

Your sewage management system is also unable to cope with large volumes of water such as several showers or loads of washing over a short period of time. You should try to avoid these 'shock loads' by ensuring water use is spread more evenly throughout the day and week.

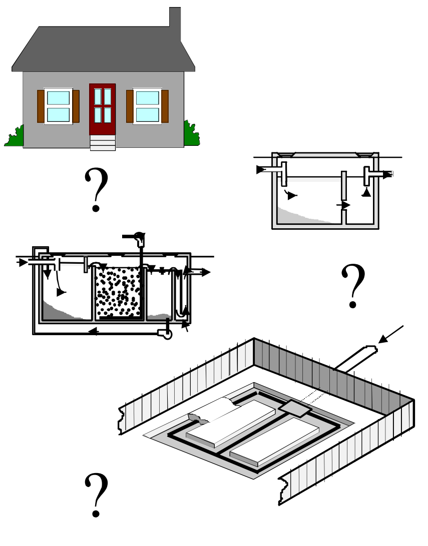
HELP PROTECT YOUR HEALTH AND THE ENVIRONMENT

Poorly maintained sewage management systems are a serious source of water pollution and may present health risks, cause odours and attract vermin and insects.

By looking after your management system you can do your part in helping to protect the environment and the health of you and your community.

For more information please contact:

Managing Wastewater In Your Backyard



Aerated Wastewater Treatment Systems (AWTS)

In unsewered areas, the proper treatment and utilisation of household wastewater on-site is critical in preserving the health of the public and the environment. AWTS have been developed as a way of achieving this.

What is an AWTS?

An AWTS is a purpose built system used for the treatment of sewage and liquid wastes from a single household or multiple dwellings.

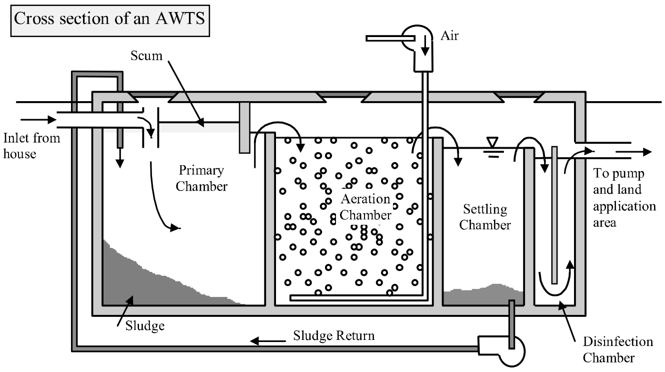
It consists of a series of treatment chambers combined with an irrigation system. An AWTS enables people living in unsewered areas to treat and utilise their wastewater.

How does an AWTS work?

Wastewater from a household is treated in stages in several separate chambers. The first chamber is similar to a conventional septic tank. The wastewater enters the chamber where the solids settle to the bottom and are retained in the tank forming a sludge layer. Scum collects at the top, and the partially clarified wastewater flows into a second chamber. Here the wastewater is mixed with air to assist bacteria to further treat it. A third chamber allows additional clarification through the settling of solids, which are returned for further treatment to either the septic chamber (as shown) or to the aeration chamber. The clarified effluent is disinfected in another chamber (usually by chlorination) before irrigation can take place.

Bacteria in the first chamber break down the solid matter in the sludge and scum layers. Material that cannot be fully broken down gradually builds up in the chamber and must be pumped out periodically.

Cross section of an AWTS



Regulations and recommendations

Local councils are primarily responsible for approving the smaller, domestic AWTSs in their area. The Environment Protection Authority (EPA) approves larger units, whilst the NSW Department of Health determines the design and structural requirements for all AWTSs.

At present AWTSs need to be serviced quarterly by an approved contractor at a cost to the owner. Local councils should also maintain a register of the servicing of each system within their area.

AWTSs should be fitted with an alarm having visual and audible components to indicate mechanical and electrical equipment malfunctions. The alarm should provide a signal adjacent to the alarm and at a relevant position inside the house. The alarm should incorporate a warning lamp which may only be reset by the service agent.

Maintaining your AWTS

The effectiveness of the system will, in part, depend on how it is used and maintained. The following is a guide on good maintenance procedures that you should follow:

DO

- ✓ Have your AWTS inspected and serviced four times per year by an approved contractor. Assessment should be applicable to the system design.
- ✓ Have your system service include assessment of sludge and scum levels in all tanks, and performance of irrigation areas.
- ✓ Have all your tanks desludged at least every three years.
- ✓ Have your disinfection chamber inspected and tested quarterly to ensure correct disinfectant levels.
- ✓ Have your grease trap (if installed) cleaned out at least every two months.
- ✓ Keep a record of pumping, inspections, and other maintenance.
- ✓ Learn the location and layout of your AWTS and land application area.
- ✓ Use biodegradable liquid detergents such as concentrates with low sodium and phosphorous levels.
- ✓ Conserve water.

DON'T

- ✗ Don't put bleaches, disinfectants, whiteners, nappy soakers and spot removers in large quantities into your AWTS via the sink, washing machine or toilet.
- ✗ Don't allow any foreign materials such as nappies, sanitary napkins, condoms and other hygiene products to enter the system.
- ✗ Don't use more than the recommended amounts of detergents.
- ✗ Don't put fats and oils down the drain and keep food waste out of your system.
- ✗ Don't switch off power to the AWTS, even if you are going on holidays

Reducing water usage

Reducing water usage will lessen the likelihood of problems such as overloading with your AWTS. Overloading may result in wastewater backing up into your house, contamination of your yard with improperly treated effluent, and effluent from your system entering a nearby river, creek or dam.

Conservative water use around the house will reduce the amount of wastewater which is produced and needs to be treated.

Your AWTS is also unable to cope with large volumes of water such as several showers or loads of washing over a short period of time. You should try to avoid these 'shock loads' by ensuring water use is spread more evenly throughout the day and week.

Warning signs

You can look out for a few warning signs that signal to you that there are troubles with your AWTS. Ensure that these problems are attended to immediately to protect your health and the environment.

Look out for the following warning signs:

- Water that drains too slowly.
- Drain pipes that gurgle or make noises when air bubbles are forced back through the system.
- Sewage smells, this indicates a serious problem.
- Water backing up into your sink which may indicate that your system is already failing.
- Wastewater pooling over the land application area.
- Black coloured effluent in the aerated tank.
- Excess noise from the blower or pumping equipment
- Poor vegetation growth in irrigated area.

Odour problems from a vent on the AWTS can be a result of slow or inadequate breakdown of solids. Call a technician to service the system.

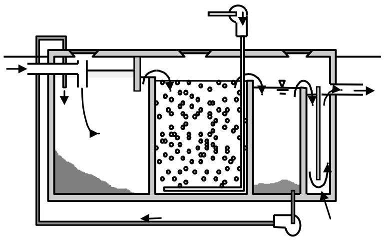
HELP PROTECT YOUR HEALTH AND THE ENVIRONMENT

Poorly maintained AWTSs are a serious source of water pollution and may present health risks, cause odours and attract vermin and insects.

By looking after your treatment system you can do your part in helping to protect the environment and the health of you and your family.

If you would like more information please contact:

Your Aerated Wastewater Treatment System



LAND APPLICATION AREAS

The reuse of domestic wastewater on-site can be an economical and environmentally sound use of resources.

What are land application areas?

These are areas that allow treated domestic wastewater to be managed entirely on-site.

The area must be able to utilise the wastewater and treat any organic matter and wastes it may contain. The wastewater is rich in nutrients, and can provide excellent nourishment for flower gardens, lawns, certain shrubs and trees. The vegetation should be suitably tolerant of high water and nutrient loads.

How does a land application area work?

Treated wastewater applied to a land application area may be utilised or simply disposed, depending on the type of application system that is used. The application of the wastewater can be through a soil absorption system (based on disposal) or through an irrigation system (based on utilisation).

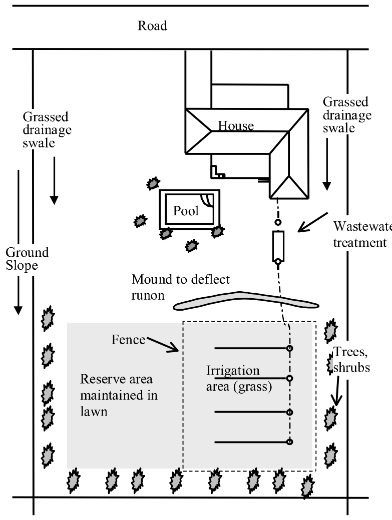
Soil absorption systems do not require highly treated effluent, and wastewater treated by a septic tank is reasonable as the solids content in the effluent has been reduced. Absorption systems release the effluent into the soil at a depth that cannot be reached by the roots of most small shrubs and grasses. They rely mainly on the processes of soil treatment and then transmission to the water table, with minimal evaporation and up-take by plants. **These systems are not recommended in sensitive areas as they may lead to contamination of surface water and groundwater.**

Irrigation systems may be classed as either subsurface or surface irrigation. If an irrigation system is to be used, wastewater needs to be pre-treated to at least the quality produced by an aerated wastewater treatment system (AWTS).

Subsurface irrigation requires highly treated effluent that is introduced into the soil close to the surface. The effluent is utilised mainly by plants and evaporation.

Surface irrigation requires highly treated effluent that has undergone aeration and disinfection treatments, so as to reduce the possibility of bacteria and virus contamination.

Typical Site Layout (not to scale)



The effluent is then applied to the land area through a series of drip, trickle, or spray points which are designed to eliminate airborne drift and run-off into neighbouring properties.

There are some public health and environmental concerns about surface irrigation. There is the risk of contact with treated effluent and the potential for surface run-off. Given these problems, subsurface irrigation is arguably the safest, most efficient and effective method of effluent utilisation.

Regulations and recommendations

The design and installation of land application areas should only be carried out by suitably qualified or experienced people, and only after a site and soil evaluation is done by a soil scientist. Care should be taken to ensure correct buffer distances are left between the application area and bores, waterways, buildings, and neighbouring properties.

Heavy fines may be imposed under the Clean Waters Act if effluent is managed improperly.

At least two warning signs should be installed along the boundary of a land application area. The signs should comprise of 20mm high Series C lettering in black or white on a green background with the words:

RECLAIMED EFFLUENT
NOT FOR DRINKING
AVOID CONTACT

Depending on the requirements of your local council, wet weather storage and soil moisture sensors may need to be installed to ensure that effluent is only irrigated when the soil is not saturated.

Regular checks should be undertaken of any mechanical equipment to ensure that it is operating correctly. Local councils may require periodic analysis of soil or groundwater characteristics

Humans and animals should be excluded from land application areas during and immediately after the application of treated wastewater. The longer the period of exclusion from an area, the lower the risk to public health.

The householder is required to enter into a service contract with the installation company, its agent or the manufacturer of their sewage management system, this will ensure that the system operates efficiently.

Location of the application area

Treated wastewater has the potential to have negative impacts on public health and the environment. For this reason the application area must be located in accordance with the results of a site evaluation, and approved landscaping must be completed prior to occupation of the building. Sandy soil and clayey soils may present special problems.

The system must allow even distribution of treated wastewater over the land application area.

Maintaining your land application area

The effectiveness of the application area is governed by the activities of the owner.

DO

- ✓ Construct and maintain diversion drains around the top side of the application area to divert surface water.
- ✓ Ensure that your application area is kept level by filling any depressions with good quality top soil (not clay).
- ✓ Keep the grass regularly mowed and plant small trees around the perimeter to aid absorption and transpiration of the effluent.
- ✓ Ensure that any run off from the roof, driveway and other impermeable surfaces is directed away from the application area.
- ✓ Fence irrigation areas.
- ✓ Ensure appropriate warning signs are visible at all times in the vicinity of a spray irrigation area.
- ✓ Have your irrigation system checked by the service agent when they are carrying out service on the treatment system.

DON'T

- ✗ Don't erect any structures, construct paths, graze animals or drive over the land application area.
- ✗ Don't plant large trees that shade the land application area, as the area needs sunlight to aid in the evaporation and transpiration of the effluent.
- ✗ Don't plant trees or shrubs near or on house drains.
- ✗ Don't alter stormwater lines to discharge into or near the land application area.
- ✗ Don't flood the land application area through the use of hoses or sprinklers.
- ✗ Don't let children or pets play on land application areas.
- ✗ Don't water fruit and vegetables with the effluent.
- ✗ Don't extract untreated groundwater for potable use.

Warning signs

Regular visual checking of the system will ensure that problems are located and fixed early.

The visual signs of system failure include:

- surface ponding and run-off of treated wastewater
- soil quality deterioration
- poor vegetation growth
- unusual odours

Volume of water

Land application areas and systems for on-site application are designed and constructed in anticipation of the volume of waste to be discharged. Uncontrolled use of water may lead to poorly treated effluent being released from the system.

If the land application area is waterlogged and soggy the following are possible reasons:

- Overloading the treatment system with wastewater.
- The clogging of the trench with solids not trapped by the septic tank. The tank may require desludging.
- The application area has been poorly designed.
- Stormwater is running onto the area.

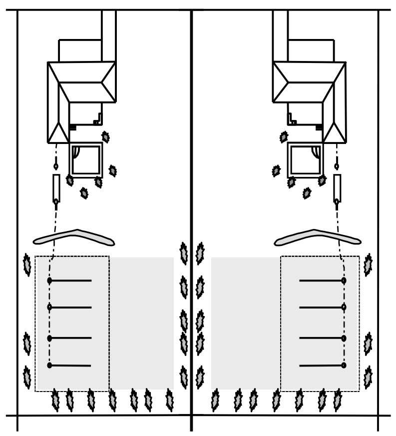
HELP PROTECT YOUR HEALTH AND THE ENVIRONMENT

Poorly maintained land application areas are a serious source of water pollution and may present health risks, cause odours and attract vermin and insects.

By looking after your sewage management system you can do your part in helping to protect the environment and the health of you and your family.

For more information please contact:

Your Land Application Area



Appendix D
Water quality modelling

EMM
creating opportunities

D.1 Introduction

This appendix describes the MUSIC modelling undertaken to complete the assessment of Neutral or Beneficial Effect (NorBE) on the water quality of stormwater discharges from the Woodlawn Advanced Energy Recovery Centre (ARC). The MUSIC modelling has been undertaken in accordance with *Using MUSIC in the Sydney Drinking Water Catchment* (WaterNSW 2019).

D.1.1 Assessment Criteria

The *Neutral or Beneficial Effect on Water Quality Assessment Guideline* (WaterNSW 2021) provides direction on what NorBE means and how to assess it in a development application. The guideline recommends the use of the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) for all developments with an impervious area greater than or equal to 2,500 m^2. MUSIC simulates sediment and nutrient generation from land surfaces and the performance of stormwater controls and mitigation measures. The application of MUSIC modelling within the Sydney drinking water catchments is described in *Using MUSIC in the Sydney Drinking Water Catchment* (WaterNSW 2019a), which outlines the following criteria for achieving NorBE:

- The mean annual pollutant loads for the post-development case (including mitigation measures) should aim to be 10% less than the pre-development case for total suspended solids (TSS), total phosphorus (TP) and total nitrogen (TN). For gross constituents, the post-development load only needs to be equal to or less than pre-development load.

- Pollutant concentrations for TP and TN for the post-development case (including mitigation measures) must be equal to or better compared to the pre-development case for between the 50^{th} and 98^{th} percentiles over a five-year modelling period. Periods of zero flow are not to be accounted for in the statistical analysis as there is no downstream water quality impact during no flow periods. To demonstrate this, comparative cumulative frequency graphs, which use the flow-based sub-sample threshold for both the pre- and post-development cases, must be provided. As meeting the pollutant percentile concentrations for TP generally also meets the requirements for TSS, cumulative frequency analysis is not required for TSS. Cumulative frequency is also not applied to gross pollutants.

D.1.2 Assessment scenarios

The MUSIC model has been developed based on the ARC Reference Design (see SWA Section 5.1.3) and includes access roads, buildings, landscaped area, and stormwater management infrastructure. The following scenarios have been assessed using the MUSIC model:

- Scenario 1 – Stormwater discharges from the access road only. This scenario represents the proposed project, which describes overflows from the ARC stormwater system as being managed in the PCD and ED1 systems, with no discharges to the receiving environment expected.

- Scenario 2 – Stormwater discharges from the road plus future ARC stormwater overflows. This scenario represents a potential future scenario and is included to demonstrate that the ARC stormwater system can be integrated into a future stormwater system in the PCD catchment that overflows to the receiving environment. It is noted that Scenario 2 does not include the IBA area stormwater system as it will be established as a zero-discharge system for the project life (see SWA Section 5.4.4).

D.2 Climate data

WaterNSW (2019a) provides meteorological templates that include the rainfall and potential evapotranspiration data for various catchments which form the basis for the hydrologic calculations in MUSIC. The appropriate climate zone for development footprint was identified as Zone 1. Template files were downloaded from the WaterNSW website. The rainfall files were at a 6-minute time step over a period of 5 years from 1995 to 1999. This period includes a range of wet and dry years to ensure conditions simulated are realistic and representative of a range of rainfall patterns. Mean annual meteorological data for the Zone 1 simulation period is presented in Table D.1. The mean annual rainfall presented in Table D.1 is comparable with the values presented Chapter 4 of the surface water assessment.

Table D.1 Zone 1 meteorological data (WaterNSW 2019)

Mean annual rainfall (mm)	Mean annual potential evapotranspiration (mm)
721	1,083

D.3 Stormwater runoff parameters

D.3.1 Impervious area parameters

Assumed pervious and impervious areas for each land use category are provided in Table D.2. Default rainfall thresholds (depth above which runoff occurs) for each land use category are provided in Table 4.3 of WaterNSW (2019a). The default rainfall threshold for each land use category has been adopted and is shown in Table D.2.

Table D.2 Adopted impervious area parameters for land use types

Land use type	Pervious percentage[1] (%)	Impervious percentage[1] (%)	Rainfall threshold[2] (mm)
Roofs	0	100	0.3
Unsealed roads	50	50	1.0
Sealed roads	50[3]	50	1.5
Vegetated landscaping	95	5	1.0
Agricultural	100	0	1.0

Notes: 1. Pervious/impervious fraction as recommended in Table 4.2 of WaterNSW (2019).
2. Rainfall threshold relates to impervious areas only.
3. 50% pervious area used to account for vegetated road shoulder.

D.3.2 Soil textures

Pervious area runoff in MUSIC is determined by parameters of soil texture properties outlined in Tables 4.4 and 4.5 of WaterNSW (2019a). The existing terrain within the development footprint is heavily disturbed which may have resulted in the original soils being disturbed, removed, or buried. Hence, for the purpose of the MUSIC model, the relevant soil types have been derived from the surrounding landscape. Several dominant soil types can be found near the development footprint. The parameters for each soil type have been obtained from Table 4.4 and 4.5 of WaterNSW (2019a) and are reproduced in Table D.3.

The parameters for silty loam result in a lower estimate of flow volume and have been applied pre-development conditions in accordance with WaterNSW (2019a).

Table D.3 Pervious area parameters for dominant soil textures

Soil texture	Loam	Silty loam	Sandy loam	Silty clay	Heavy clay
Soil storage capacity (mm)	97	100	98	54	90
Field capacity (mm)	79	87	70	51	58
Infiltration capacity coefficient-a (mm/d)	250	250	250	180	135
Infiltration capacity exponent-b	1.3	1.3	1.3	3.0	4.0
Daily recharge rate (%)	60	60	60	25	10
Daily baseflow rate (%)	45	45	45	25	10
Daily seepage rate (%)	0	0	0	0	0

D.3.3 Stormwater pollutant concentrations

MUSIC applies a stochastic approach to simulating pollutant concentrations in runoff using a mean and standard deviation value for each pollutant. Pollutant concentration values for a range of land use categories are recommended in WaterNSW (2019a). Pollutant concentrations for the baseflow component of runoff are reproduced in Table D.4 and pollutant concentrations for the stormflow component of runoff are provided in Table D.5.

Table D.4 Baseflow pollutant concentration parameters

Concentration ($mg/L-log_{10}$)	Total suspended solids		Total phosphorus		Total nitrogen	
Surface Type	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Roofs[1]	–	–	–	–	–	–
Sealed roads	1.20	0.17	-0.85	0.19	0.11	0.12
Revegetated land	1.15	0.17	-1.22	0.19	-0.05	0.12
Agricultural	1.30	0.13	-1.05	0.13	0.04	0.13

Notes: 1. Roofs have no baseflow.

Table D.5 Stormflow pollutant concentration parameters

Concentration (mg/L-log_{10})	Total suspended solids		Total phosphorus		Total nitrogen	
Surface Type	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Roofs	1.30	0.32	-0.89	0.25	0.30	0.19
Sealed roads	2.43	0.32	-0.30	0.25	0.34	0.19
Revegetated land	1.95	0.32	-0.66	0.25	0.30	0.19
Agricultural	2.15	0.31	-0.22	0.30	0.48	0.26

D.4 Pre-development conditions

The development footprint is within the broader Woodlawn Eco Precinct which currently operates as a landfill/waste recovery facility that is primarily surrounded by agricultural (grazing) lands. Pre-development conditions have been significantly altered by previous land uses at the site. Pre-development land use composition conditions and modelled soil types are presented in Table D.6.

Table D.6 Pre-development land use composition

Scenario	Disturbance area	Modelled land use composition	Modelled soil texture	Percentage impervious	Percentage pervious
Access road only	1.1 ha	100% agricultural	Silty loam	0%	100%
Access road plus ARC	10.9 ha	100% agricultural	Silty loam	0%	100%

D.5 Scenario 1 – access road assessment

D.5.1 Post-developed conditions

Access road land use condition assumptions are based on the Reference Design (see SWA Section 5.1.3). The access road is approximately 350 m in length. The access road will be sealed with vegetated shoulders. Runoff from the road drains to vegetated swales on either side of the road before discharging offsite.

It was assumed that pervious area soil parameters were consistent with the existing conditions soil textures presented in Table D.6 as cut and fill balance would likely be achieved on site rather than importing of additional fill.

The access road was represented in the MUSIC model as sealed road comprised of 50% pervious and 50% impervious area.

The MUSIC model schematic for Scenario 1 is shown in Figure D.1. It is noted that the access road was modelled as two nodes, each draining to a swale. This represents the road design, which comprises a dual crossfall road with swales on each side of the road.

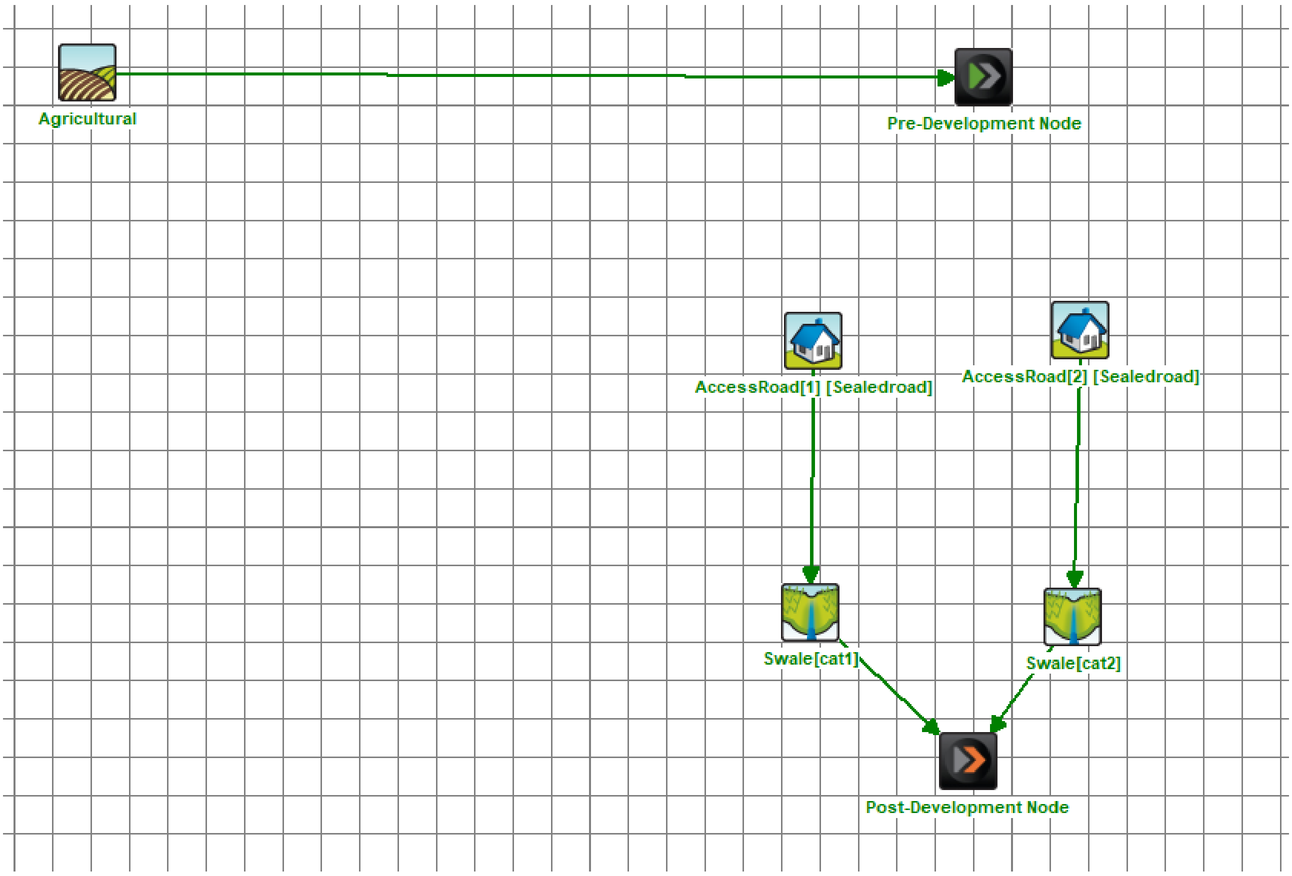


Figure D.1 MUSIC model schematic– Scenario 1

D.5.2 Treatment controls

i Swales

Grass lined swales are proposed on either side of the access road for the length of the road. Runoff from the access road will drain to the swales prior to discharging offsite. The adopted swale parameters are presented in Table D.7.

Table D.7 Adopted swale parameters

Swale properties	Adopted values
Length (m)	175[1]
Bed slope (%)	1
Base width (m)	1
Top width (m)	5
Depth (m)	0.5
Vegetation height (m)	0.25
Exfiltration rate (mm/hr)	0

Notes: 1. For modelling purposes, each swale length is assumed to be half the length of the access road.

D.5.3 Results summary

i Comparison of mean annual pollutant loads

Mean annual pollutant loads for existing and developed conditions are provided in Table D.8. Results are presented for TSS, TP and TN loads. The results presented in Table D.8 show it is possible to meet the mean annual NorBE criteria for TSS with the proposed controls. The mean annual NorBE criteria are not achieved for TP and TN.

Table D.8 Scenario 1 – mean annual pollutant loads

	Units	Pre-development	Post development (before measures)	Post development (after measures)	Change in load[1]	NorBE target achieved?
Scenario 1 – access road only (proposed project)						
Mean annual flow	ML/yr	0.8	3.5	3.5	+347%	NA
Total suspended solids	kg/yr	95	1,200	50	-47%	Yes
Total phosphorus	kg/yr	0.36	2.00	0.46	+28%	No
Total nitrogen	kg/yr	2.0	8.2	5.5	+172%	No

Notes: 1. Pre-development vs post development (after measures).

ii Comparison of pollutant concentrations between the 50th and 98th percentiles

Cumulative frequency graphs for TP and TN concentrations in runoff from the modelled construction zone scenarios are presented in Figure D.2 and Figure D.3 respectively. The graphs were filtered to only present data when runoff was generated from the models.

The NorBE criteria for pollutant concentrations were not met for 50th to 98th percentile of runoff. NorBE is achieved for the following:

- between the 89th and 100th percentile for TP; and
- between 80th and 100th percentile for TN.

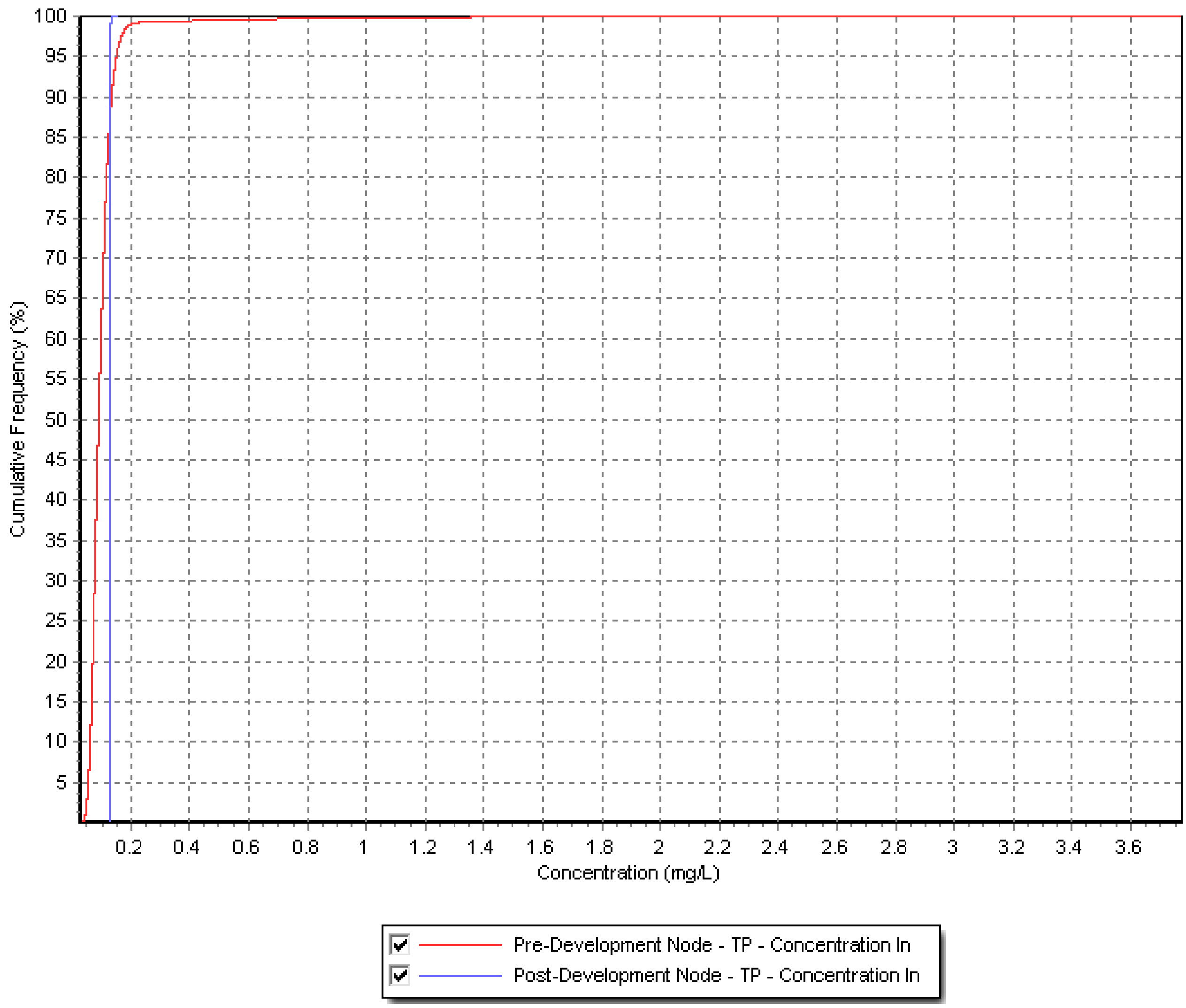


Figure D.2 Total phosphorus cumulative frequency plot – Scenario 1

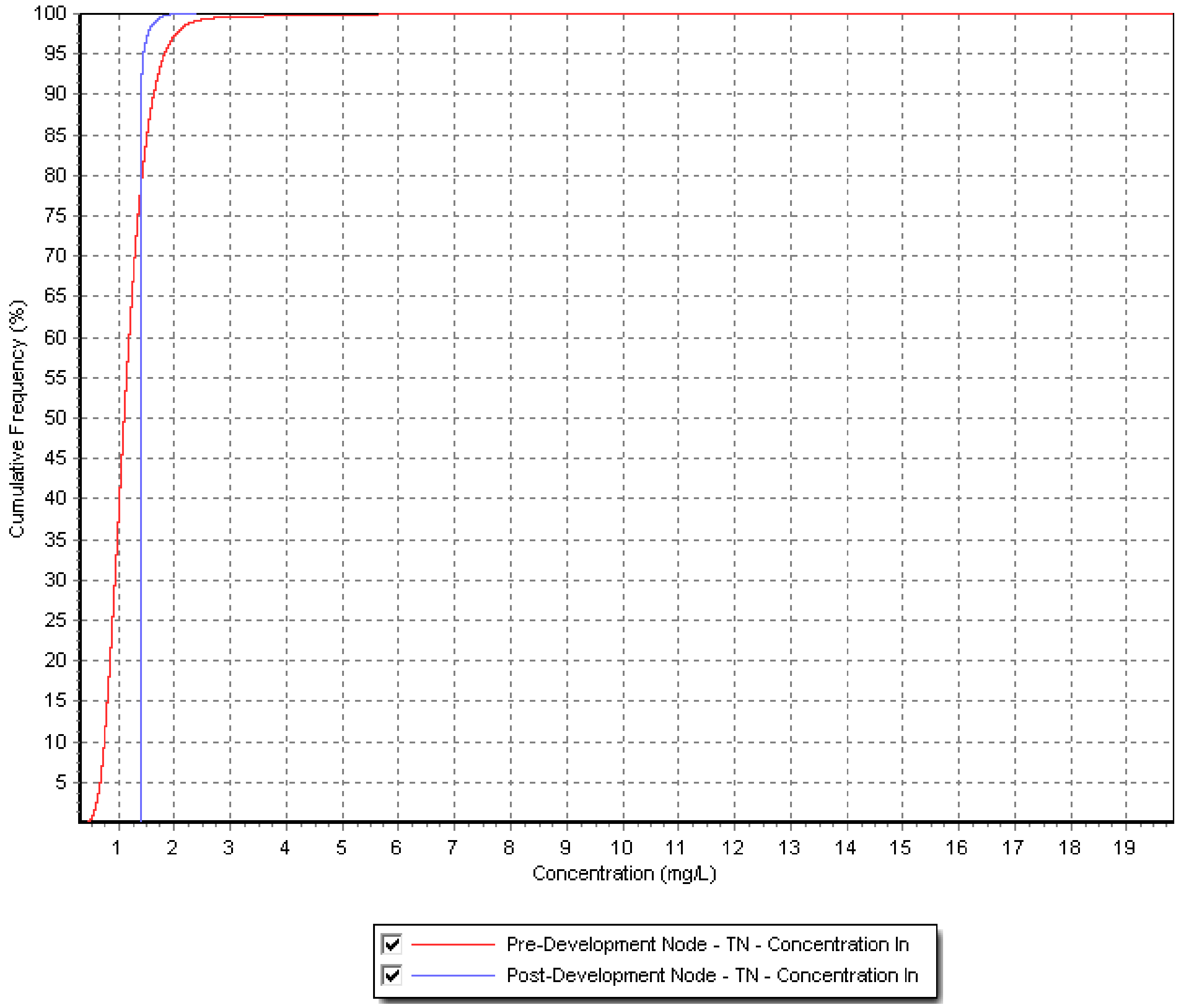


Figure D.3 Total nitrogen cumulative frequency plot – Scenario 1

D.6 Scenario 2 – access road plus ARC assessment

D.6.1 Post-developed conditions

Developed land use condition assumptions are based on the Reference Design (see SWA Section 5.1.3). The proposed development comprises of offices, workshops, the access road (described above), internal roads and car parks, stormwater infrastructure, and vegetated landscaping.

It was assumed that pervious area soil parameters were consistent with the existing conditions soil textures presented in Table D.6 as cut and fill balance would likely be achieved on site rather than importing of additional fill.

The post-development land use areas applied to the MUSIC model are provided in Table D.9. The overall percentage of pervious and impervious area for the development footprint is estimated at 44% and 56% respectively.

The MUSIC model schematic for Scenario 2 is shown in Figure D.4.

Table D.9 Post-development land use composition

Scenario	Vegetated landscaping (Revegetated land)	Access road/sealed areas (sealed road)	Buildings (roof area)	Total area
ARC stormwater system	4.5 ha	3.9 ha[1]	1.4 ha	9.8 ha
Access road	-	1.1 ha	-	1.1 ha
Total area	**4.0 ha**	**5.0 ha**	**1.4 ha**	**10.9 ha**

Notes: 1. Sealed areas such as carparks that form part of the ARC Reference Design are assumed to have the same characteristics as sealed roads with 100% impervious area.

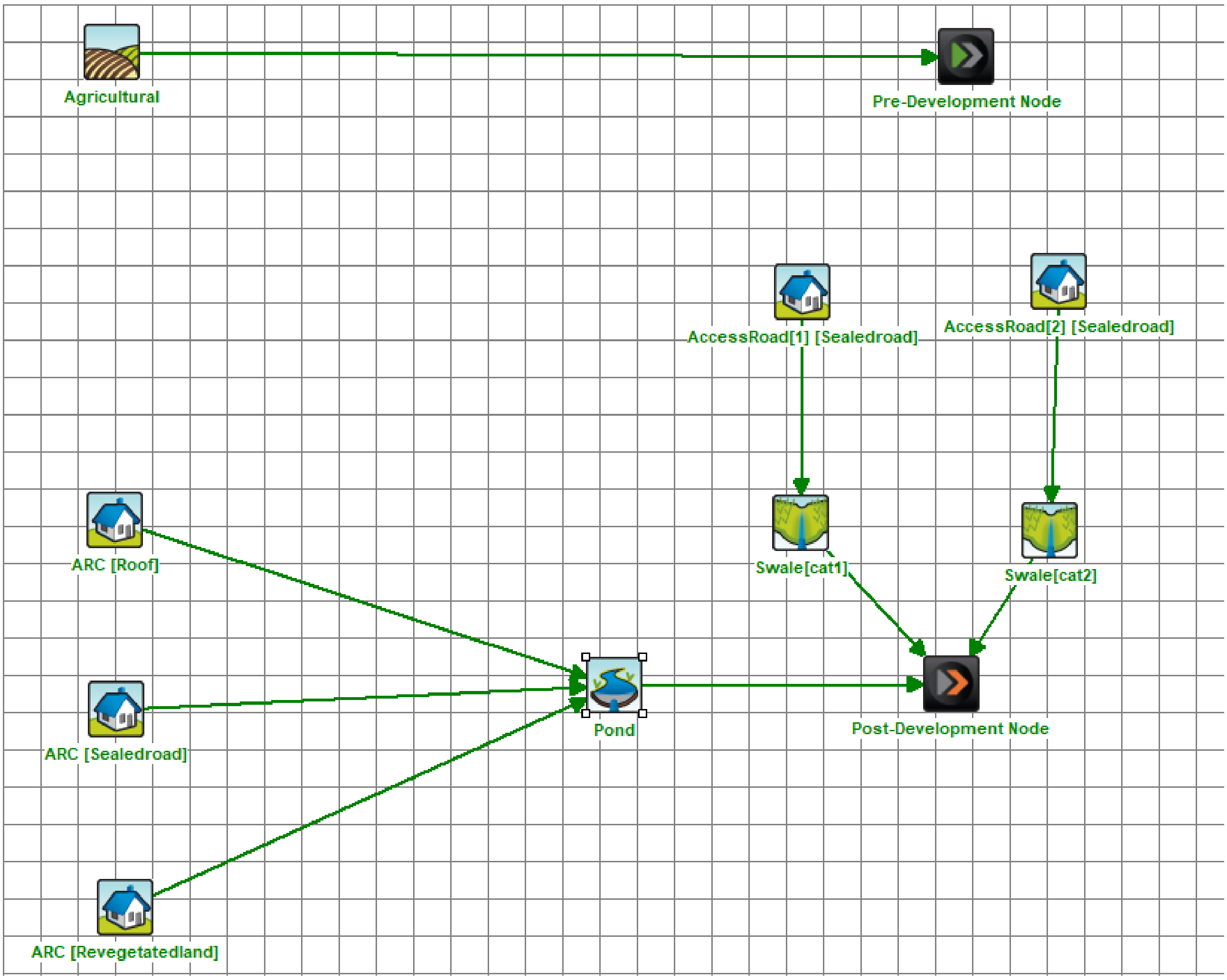


Figure D.4 MUSIC model schematic – Scenario 2

D.6.2 Treatment controls

i Rainwater tanks and swales

Treatment controls such as rainwater tanks, vegetated swales and gross pollutant traps may be installed within the catchment under the post-development scenario. However, these have not been included in the MUSIC model for the ARC development area.

The vegetated swales along the access road (described for Scenario 1) have also been applied to the access road for Scenario 2.

ii Stormwater pond

The modelled treatment controls for the ARC primarily consist of a stormwater pond sized to capture approximately 45 mm of runoff from the 9.8 ha contributing catchment area. Water is harvested from the stormwater pond to meet operational water demands. The following parameters and assumptions were applied to the stormwater pond:

- effective storage volume of 4.0 ML;
- surface areas were calculated based on the effective storage depth of 2.0 m;
- water was assumed to be harvested from the pond at a rate of 245 kL/d;
- exfiltration rates were assumed to be zero; and
- the pond was assumed to be half full at the commencement of the simulation.

D.6.3 Results summary

i Comparison of mean annual pollutant loads

Mean annual pollutant loads for existing and developed conditions are provided in Table D.10. Results are presented for TSS, TP and TN loads. The results presented in Table D.10 show it is possible to meet the mean annual NorBE criteria with the stormwater pond and stormwater harvesting controls.

Table D.10 Scenario 2 – mean annual pollutant loads

	Units	Pre-development	Post development		Change in load[1]	NorBE target achieved?
			(before measures)	(after measures)		
Scenario 2 – access road plus ARC stormwater system overflows (future scenario)						
Mean annual flow	ML/yr	7.9	38.3	7.1	-10%	NA
Total suspended solids	kg/yr	945	9,490	591	-37%	Yes
Total phosphorus	kg/yr	4.1	17.1	1.6	-61%	Yes
Total nitrogen	kg/yr	20.0	87.1	13.2	-34%	Yes

Notes: 1. Pre-development vs post development (after measures)

ii Comparison of pollutant concentrations between the 50th and 98th percentiles

Cumulative frequency graphs for TP and TN concentrations in runoff from the modelled construction zone scenarios are presented in Figure D.5 and Figure D.6 respectively. The graphs were filtered to only present data when runoff was generated from the models.

The NorBE criteria for pollutant concentrations were not met for 50th to 98th percentile of runoff. NorBE is achieved for the following:

- between the 89th and 100th percentile for TP; and
- between 80th and 100th percentile for TN.

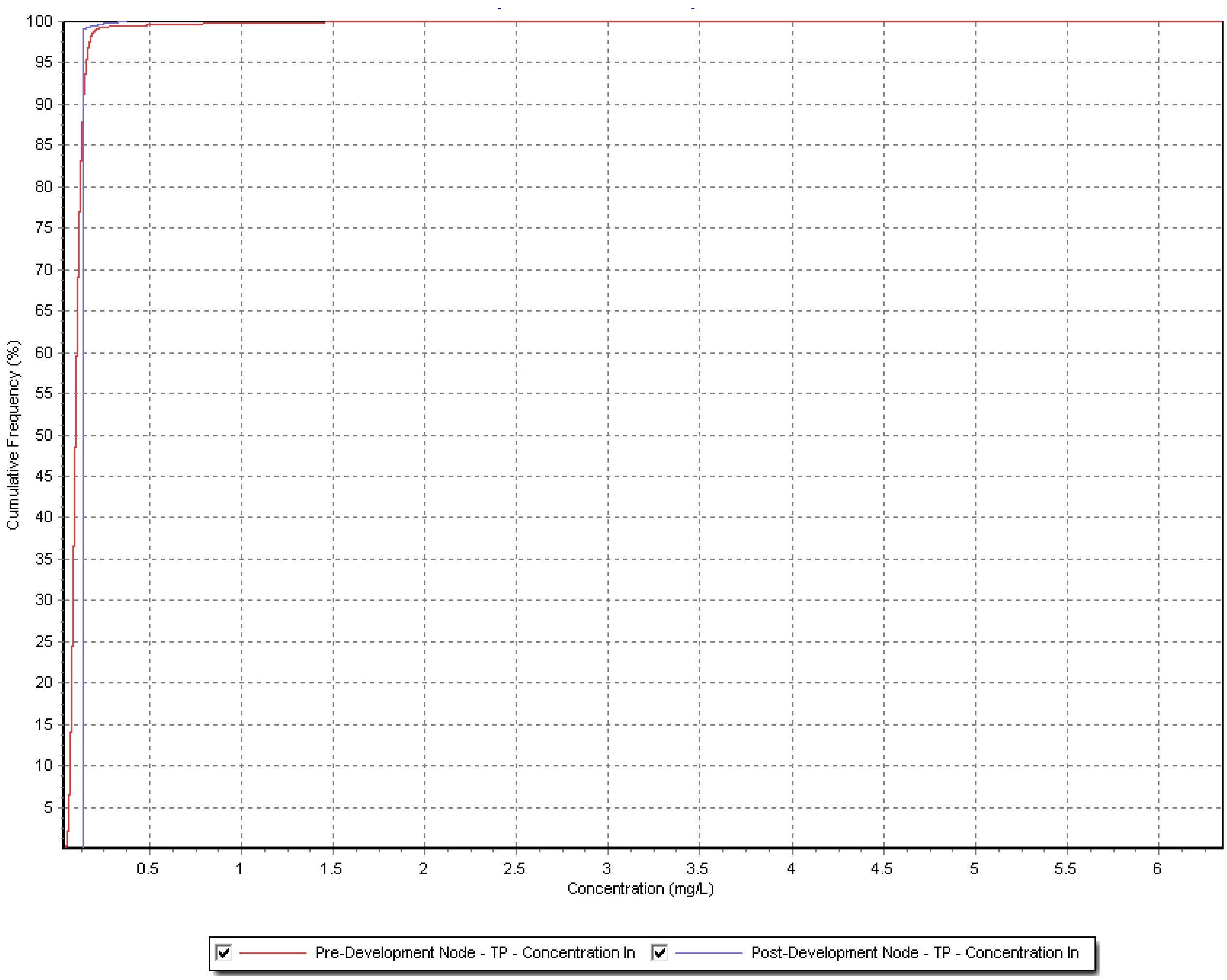


Figure D.5 Total phosphorus cumulative frequency plot – Scenario 2

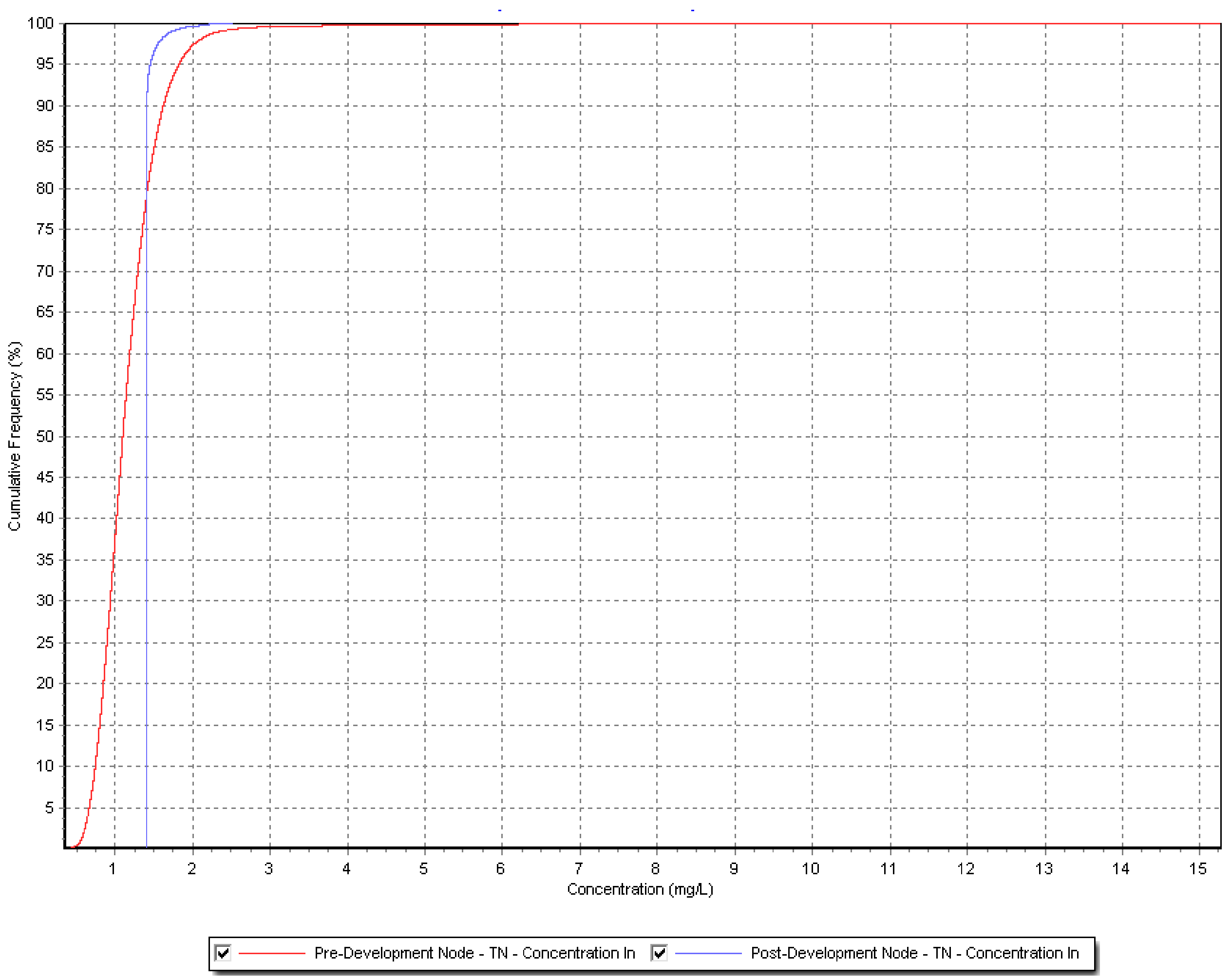


Figure D.6 Total nitrogen cumulative frequency plot – Scenario 2

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