Appendix J – Land Capability Assessment

Montarosa Pty Ltd

Integrated Eco-Tourism Resort, Princetown

Land Capability Assessment

September 2016

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1. Introduction

1.1 Site overview

Montarosa Pty Ltd wish to establish an integrated tourism facility with accommodation, restaurant, adventure hub and other facilities at a site located at Old Coach Road, Princetown, Victoria (referred to as the project, the site or proposed development herein).

The proposal seeks to establish an integrated eco-tourism facility on the subject site with the following components:

Accommodation precinct:

- Eco-lodge with ancillary office, function room, pool and day spa
- Eco-cabins

Restaurant / Day Centre / Activity Precinct:

- Restaurant with a total capacity of 300 persons with ancillary souvenir sales, reception and briefing facilities
- Panoramic lookout structure
- Informal recreation activities, including:
  - Walking/cycling tours and trails, including boardwalks and picnic areas
  - Wildlife viewing
  - Kids playground

Water-based pleasure activities from proposed jetty pontoon:

- Canoe, kayak, stand up paddle board and small boat eco tours and hire

1.2 Purpose of this report

Montarosa plan to treat wastewater generated from the proposed development to at least Class B standard (Class B though actual parameters may be Class A)[1] and to irrigate the treated wastewater to land at the site. To assess the feasibility of irrigation of wastewater at the site, a land capability assessment (LCA) is required to demonstrate that there is sufficient land available to take the projected volume of reclaimed water and nutrient loads from the wastewater and to verify that the winter storage is sized appropriately. This document details the LCA completed by GHD for submission to the EPA as part of the Works Approval Application for the site.

1.3 Scope of works

The LCA has been prepared with reference to relevant guidelines and standards, including, but not limited to: EPA Publication 464.2 – Guidelines for Environmental Management: Use of Reclaimed Water and EPA Publication 168 – Guidelines for Wastewater Irrigation. The EPA's works approval application guidelines specifies information that must be provided for the proposed re-use of treated wastewater. To address these requirements, the land capability assessment includes:

[1] In accordance with EPA Publication 464.2 Guidelines for Environmental Management: Use of Reclaimed Water

- A desktop review of existing hydrology and hydrogeology to characterise the existing surface water, geology and groundwater environments relevant to the site. This desktop review is required to identify the hydrology systems and associated beneficial uses, receptors and water users for the site in accordance with the State environment protection policy (Groundwaters of Victoria) (SEPP (GoV)).
- An assessment of risks to the hydrogeological environmental associated with the construction and operation of the project, in particular the proposed water re-use scheme with management actions identified as required.
- Identification of the size of the area required for irrigation based on a water balance (taking into account a 90th percentile rainfall event) and an assessment of the capacity of the parcel of land for irrigation to receive the volume of water proposed and the associated nutrient load (as developed by a nutrient balance).
- An assessment of the suitability of the proposed winter storages to hold excess water prior to irrigation in a 90th percentile rainfall year supported by the water balances which rely on information on inflow volumes from the wastewater treatment plant and climate data for the site.
- An assessment of the longer-term sustainability of irrigation with wastewater and risks to soil health associated with the wastewater irrigation with management actions to reduce risks associated with wastewater re-use identified as required.

2. Methods

2.1 Information sources

The LCA was completed with reference to:

- Information provided by Montarosa related to bore water quality (which will provide the main source of water (80%) for the site, with the remainder sourced from rainwater/potable water)
- Information obtained from investigations undertaken as part of the WAA to assess occupancy levels, water treatment requirements, wastewater inflows and wastewater quality
- Data and findings presented in the preliminary LCA (Brian Consulting Pty Ltd, December 2015) with regards to soil texture and depth, depth to groundwater and permeability and drainage characteristics of the soil profile
- Publicly available published and unpublished hydrological information (such as hydrogeological reports in the proximity of the site, published geological and hydrogeological mapping, government produced literature (such as meteorological and topographical data and groundwater zones and overlays)
- State Groundwater Management System (Victorian Data Warehouse).

2.2 Land Capability Assessment Tasks

2.2.1 Capacity of the land environment to receive wastewater

The information sources listed in section 2.1 were used in conjunction with historical climate information obtained from the Bureau of Meteorology (rainfall, evaporation and evapotranspiration) to complete:

- Water balances for average, wet (90% percentile) and dry (10%) rainfall years
- Nutrient balances for phosphorus and nitrogen based on the proposed irrigation volumes per hectare of land and guidance on maximum nitrogen loadings
- A comparison of available water quality data (salinity, nutrients, etc.) for the treated wastewater against indicative values provided in EPA guidelines (EPA Publications 168 and 464.2).

The information obtained from the above tasks was then used to undertake a preliminary assessment of the feasibility of the proposed wastewater irrigation at the site.

2.2.2 Characterisation of the groundwater environment and potential impacts from wastewater irrigation

The information sources in section 2.1 (and further resources summarised in Appendix A) were used to characterise the groundwater environment to provide a concise summary of:

- Site geology and stratigraphy
- Identified aquifers
- Local groundwater bores, groundwater uses, bore yields, groundwater depth and quality
- The presence of groundwater management units (GMU), Groundwater Dependant Ecosystems (GDE) or acid sulphate soils

- Beneficial uses for protection under the State environment protection policy (Groundwaters of Victoria)

2.3 Assumptions

This LCA has been prepared during the concept design phase for the proposed development. A more detailed assessment of wastewater flows, treatment and volumes will be undertaken at the detailed design phase of the project to refine the project design and further reduce the risks to the environment, including those identified as part of this LCA.

Additional data used to compile this LCA was sourced from Montarosa Pty Ltd and GHD technical specialists.

Information regarding soil texture and depth is based on the limited site investigations undertaken by Brian Consulting (2015). It is assumed this information is correct.

No soil chemistry data was provided but it is assumed this information will be obtained during the detailed design stage.

Water balances have been undertaken on the basis that climate information obtained from Bureau of Meteorology (BOM) sites accurately reflects the conditions at the project site. The nearest BOM weather station is located close by in Princetown, Victoria.

An Environmental Improvement Plan (EIP) will be required for the site before irrigation occurs. This LCA does not constitute an EIP but will assist in the development of any subsequent EIP at the detailed design stage.

3. Legislation and policy

This section provides an overview of the key legislation and policy documents, which form the regulatory framework for this assessment.

3.1 Relevant legislation

The framework for the management of groundwater in Victoria is established primarily through the:

- *Water Act 1989*
- *Environment Protection Act 1970*

In the context of groundwater, the Water Act principally deals with the sustainable, efficient and equitable management and allocation of the resource. It also provides a means for the protection and enhancement of all elements of the terrestrial phase of the water cycle.

The Environment Protection Act empowers the Environment Protection Authority Victoria (EPA Victoria) to implement regulations, maintain State Environment Protection Policies (SEPPs) and protect the environment from pollution and the management of wastes. The Act regulates the discharge or emission of waste to water, land or air by a system of Works Approvals and licences. It has the objectives of preventing and managing pollution and environmental damage, and the setting of environmental quality goals and programs.

A number of subordinate legislation and guidelines exist which further expand on the general tenets of the Water Act and the Environmental Protection Act. SEPPs set out Victorian Government policies that control and reduce environmental pollution and have been formulated for discharges to atmosphere, water, land and noise emissions. These policies protect the environment and human activities (beneficial uses) from pollution caused by waste discharges and noise and are subordinate documents to the Environment Protection Act.

3.2 Groundwater quality

Under the Environment Protection Act and on the recommendation of the EPA Victoria, the Victorian Government enacted the State Environment Protection Policy (SEPP) (*Groundwaters of Victoria*). This policy aims to maintain and, where possible, improve groundwater quality to protect beneficial uses. Groundwater with higher concentrations of salinity (measured as mg/L TDS) is deemed to have fewer beneficial uses.

SEPP (*Groundwaters of Victoria*) forms the primary guide to determining existing impacts and the risk of impacts to groundwater quality. The policy is based on a number of principles, which include:

- Groundwater is an undervalued resource and all Victorians have a shared responsibility for its protection.
- Protection of groundwater (and aquifers) is fundamental to the protection of connected surface waters.
- Groundwater (and aquifers) should be protected to the greatest extent practicable from serious or irreversible damage arising from human activity.
- Inter-Governmental Agreement on the Environment (IGAE) principles are applicable (e.g. polluter pays, intergenerational equity and the precautionary principle).

The policy provides that groundwater be categorised into segments, with each segment having particular identified uses. The segments and their beneficial uses are summarised in Table 1.

Table 1 Protected beneficial uses and groundwater segments

Beneficial use	Segment (mg/L TDS)				
	A1	A2	B	C	D
	0–500	501–1,000	1,001–3,501	3,501–13,000	>13,000
Maintenance of ecosystems	✓	✓	✓	✓	✓
Potable water					
Desirable	✓				
Acceptable		✓			
Potable mineral water supply	✓	✓	✓		
Agriculture, parks and gardens	✓	✓	✓		
Stock watering	✓	✓	✓	✓	
Industrial water use	✓	✓	✓	✓	✓
Primary contact recreation (e.g. swimming / bathing)	✓	✓	✓	✓	
Buildings and structures	✓	✓	✓	✓	✓

Note: TDS – Total Dissolved Solids (mg/L). Source EPA 1997

EPA Victoria may determine these beneficial uses do not apply to groundwater where:

- There is insufficient yield.
- The background level of a water quality indicator other than TDS precludes a beneficial use.
- The soil characteristics preclude a beneficial use.
- A Groundwater Quality Restricted Use Zone (GQRUZ) has been declared.

The SEPP (*GoV*) requires that occupational health and safety, odour and amenity also be considered, due to the fact that vapours sourced from impacted groundwater may present a potential risk to workers, and that odours or discolouration may result in degradation of overall beneficial use.

3.3 Wastewater irrigation

3.3.1 National guidelines

Under a National Water Quality Management Strategy (NWQMS), guidelines for water recycling have been prepared to enable a nationally consistent approach to the management of health and environmental risks from water recycling. The guidelines, NRMMC *et al* (2006) are not mandatory and have no formal legal status however the States are encouraged to adopt them.

The guidelines deal with the theory and practice of water recycling and include:

- The risk management framework
- Managing health risks

- Managing environmental risks
- Monitoring
- Consultation and communication

3.3.2 Victorian approach

Under the *Environment Protection Act* (1970) (Act) discharges to the environment must be managed so that they do not adversely affect the receiving environment, e.g. land, surface water or groundwater. This Act includes works approval and licensing requirements administered by EPA Victoria, for the appropriate control of such discharges.

Government declares the SEPP and Industrial waste management policy (IWMP) under the Act. The SEPP provides ambient environmental quality objectives and attainment programs for achieving these objectives. Compliance with the relevant policies must be attained for all activities that involve reclaimed water treatment and use.

Whilst waste discharges to the environment are typically subject to works approvals and licensing, the EPA can however, provide for exemptions where reclaimed water can be considered a resource. EPA guideline 464.2 (Use of Reclaimed Water) defines acceptable discharge, deposit and operation specifications that are required for the determination of an exemption, i.e.:

- Reclaimed water treatment and quality
- Site selection and management
- Permitted end uses and restrictions
- Monitoring, reporting auditing
- Environmental improvement plans (EIPs)

EPA guideline 464.2 specifies measures to meet performance objectives for re-use schemes for reclaimed water however, it notes that the guidelines are not inflexible. As such, alternative measures may be proposed provided it is demonstrated that the alternative measures achieve the required performance objectives. EPA guideline 464.2 applies to the use of reclaimed water from sewerage treatment plants. However, the guidelines state that the principles (performance objectives and suggested measures) may be applied to the reuse of appropriately treated industrial water such as that generated from intensive animal industries (feedlots, piggeries and dairies) and food and beverage manufacturing.

EPA Publication 168 (Guidelines for Wastewater Irrigation) provides details on designing and operating a wastewater irrigation scheme that is sustainable and minimises the risk of pollution to land, water and groundwater. EPA Publication 168 provides guidance on how to create a water balance to reduce the risk of excessive application of wastewater and how to assess nutrient inputs to soil from wastewater against crop requirements. It also provides information on the potential impacts of salts, nutrients, pH and heavy metals in wastewater on soil and crop health, which are important factors in assessing the feasibility and longer-term sustainability of a wastewater re-use scheme.

4. Existing conditions

4.1 Site setting

4.1.1 Study area

The subject area is located in the township of Princetown, Victoria.

The site lies near the mouth of the Gellibrand River (which is located approximately 600 m downstream of the site), which forms a natural boundary in three directions.

Access to the site is via Old Coach Road, which is currently an unsealed road that connects directly to Great Ocean Road via a bridge crossing Gellibrand River with a 3.6 metre width. An undeveloped road is visible on the Title Plan and dissects the site. This ‘Paper Road’ is Crown Land, managed by the Department of Environment, Land, Water and Planning.

4.1.2 Neighbouring land use

Based upon a desktop review of aerial photography the site is bounded by the Gellibrand River to the north, east and west. Coastal Crown land (foreshore reserve) and the Princetown oval and recreation grounds abuts the southern boundary.

The township of Princetown lies west of the Gellibrand River. The town of Princetown is situated above the level of the Gellibrand River and is not supplied with a piped sewer system (sewage contained by septic tanks).

It is understood that beef and dairy farmers graze cattle along the river upstream of the site. Montarosa has advised that a review of aerial photography has indicated expanding areas of phragmites (Common or Ditch reed) along the Gellibrand River over the last 100 years. Disturbance of wetlands and waterways that removes competitors and enriches nutrients strongly promotes the spread of phragmites[2]. An assessment of local flora is outside the scope of this report however, the presence of phragmites may therefore be a possible indicator of nutrient enrichment of the water from activities upstream of the proposed development site.

4.1.3 Site topography

Princetown is located on the low-lying coastal fringe abutting the Gellibrand River mouth. The site topography is slightly undulating with a minor fall northward.

4.1.4 Neighbouring waterways

The Gellibrand River encircles the property to the north, east and west. The river rises from the Otway Ranges to the north and flows southwest to its mouth at Princetown. It receives some of the stormwater flows from Princetown and meanders through the Great Otway and Port Campbell National Park. The estuarine environment of the Gellibrand River mouth is located approximately 250 m downstream to the south of the site.

4.1.5 Flood potential

As part of the preliminary LCA undertaken for the site (Brian Consulting Pty Ltd, December 2015) a request was sent to the Corangamite Catchment Management Authority (Corangamite CMA) for information on the 100 year and 20 year ARI flood levels. The Corangamite CMA responded by letter in October 2015 (Corangamite Catchment Management Authority, 2015) and advised that the CMA does not have detailed flood modelling for this location but that this

[2] Flora Database – the Western Australian Flora, https://florabase.dpaw.wa.gov.au/browse/profile/555, accessed 31 May 2016.

site is regularly (annually) subject to estuarine flooding during dry weather and when the mouth of the estuary is closed.

Subsequently, a flood assessment was undertaken of the site (GHD, 2016),which provides indicative flood levels for flood events of a frequency of 1:2, 1:5, 1:10, 1:20, 1:50 and 1:100 years (ARI). Correspondence that followed between GHD on behalf of Montarosa and Corangamite Catchment Management Authority in March 2016 concluded that treated wastewater must only be dispersed above the 1:20 ARI flood level, assessed to be 2.02 mAHD (GHD, 2016).

The advice provided by the Corangamite CMA was used to assess the potential area for irrigation available, situated above 2.02 m AHD (refer to section 6.1).

4.1.6 Climate data

Climate data was obtained from the Victorian Bureau of Meteorology from Station 90071 located at Princetown. The mean data is summarised in Table 2 which is based on a 127 year period of rainfall record. The long term annual rainfall for the site is 885 mm.

Table 2 Summary of Climate Data

Month	Temperature (ºC)		Record 1889 - 2015			
	Maximum	Minimum	Average Rainfall	90% Percentile (wet year)	10% Percentile (dry year)	Evaporation (daily average, mm)
Jan	22.4	12.8	39.7	74.03	10.11	12.8
Feb	22.8	13.4	37.5	75.62	9.05	13.4
Mar	21.2	12.4	52	91.59	15.44	12.4
Apr	18.4	10.6	72.8	122.37	28.37	10.6
May	15.8	8.9	91.1	143.1	37.76	8.9
Jun	13.6	7.2	100.2	156.88	49.88	7.2
Jul	13.1	6.5	108.1	156.18	61.96	6.5
Aug	13.9	6.8	108.7	165.92	61.4	6.8
Sep	15.4	7.7	89.9	126.34	47.08	7.7
Oct	17.3	8.8	78.7	127.34	38.64	8.8
Nov	18.9	10.2	60.2	100.12	27.3	10.2
Dec	20.7	11.5	51.6	91.94	16.8	11.5
Annual	17.8	9.7	885.1	1116.87	735.16	9.7

Note: 1 Record length: Rainfall: 1899 – present, Site elevation: 7 m

4.2 Geology

4.2.1 Geological setting

The site in question is located on the Victorian Geological Survey's Port Campbell Embayment (1:250,000) Zone 54 geological map sheet. The underlying site lies upon (Quaternary age) sediments. These sediments consist of coastal dune deposits, redeposited dunes, quartz and calcareous sands, well sorted and unconsolidated, silts and clays.

4.3 Soil conditions

A preliminary soil survey at the site has been performed to determine the suitability of soils for irrigation with treated wastewater (Brian Consulting Pty Ltd, December 2015). This assessment described the soil profile in the eastern section of the site as dark brown soft, clayey sand topsoil overlaying dark grey stiff highly plastic sandy clay, light grey silty clay marl and light brown calcareous sand of medium density.

The soil profile in the western section of the site consisted of dark brown, soft, sandy topsoil overlying dark brown coarse medium dense calcareous sand.

Brian Consulting (2015) undertook percolation testing at the eastern and western portion of the site. The average percolation rate at the eastern site was 378 mm/hr (9.07 m/day) indicating rapid draining characteristics. This compared to the calcareous sands of the western site, where the average percolation rate was 2440 mm/hr (58.6 m/day) with very rapid draining characteristics.

5. Groundwater assessment

The desktop hydrogeological assessment, including referenced figures, is in Appendix A. The results are summarised in Table 3.

Table 3 Hydrogeological summary

Conceptual Element	Description	Figure reference (Appendix A)
Relevant surface water features [2]	Gellibrand River straddles the perimeter of the site, while its tributary, Latrobe Creek, is situated immediately west of the site. The site lies within, and is surrounded by, swampland near the site. The Southern Ocean is located approximately 50 km southeast of the site at Cape Otway.	Figure 1
Outcrop geology [1]	Alluvial sediments of the Gellibrand River comprise the surficial geology. This unit varies in thickness and is likely to be around 5 m thick at this location.	Figure 2

<table>
<tr><th>Conceptual Element</th><th>Description</th><th>Figure reference

(Appendix A)</th></tr>
<tr><td>Hydrogeological setting [3]</td><td>An indicative hydrogeological setting of the project site is shown below.
<table>
<tr><th>Period</th><th>Sub Period</th><th>Geological Formation</th><th>Hydrostratigraphic Unit</th><th>Lithology</th><th>Indicative Salinity (mg/L TDS)</th><th>Indicative Depth (m)</th></tr>
<tr><td>Quaternary</td><td></td><td></td><td>Quaternary Aquifer (QA)</td><td>sand, gravels, clay, silts</td><td>500 – 1,000</td><td>0 - 4</td></tr>
<tr><td>Tertiary</td><td>Miocene</td><td>Gellibrand Marl</td><td>Upper-Mid Tertiary Aquitard (UMTD)</td><td>clay, silt, marl (fractured rock) and minor sand</td><td>Unknown</td><td>4 - 30</td></tr>
<tr><td></td><td>Eocene-Oligocene</td><td>Clifton Formation</td><td>Lower Mid-Tertiary Aquifer (LMTA)</td><td>sand, gravel, limestone (fractured rock), minor clay, occasional coal</td><td>< 500</td><td>30 -31</td></tr>
<tr><td></td><td>Mid-Lower Eocene</td><td>Mepunga Formation, Dilwyn Formation, pebble Point Formation, Moomowroong Sands and Wiridjil Gravel.</td><td>Lower Tertiary Aquifer (LTA)</td><td>sand, gravel, clay and silt, minor coal</td><td>< 500</td><td>31 -370</td></tr>
<tr><td>Mesozoic to Palaeozoic</td><td>Cretaceous and Permian</td><td>Sherbrook Group

Otway Group (Eumeralla Formation)</td><td>Cretaceous and Permian Sediments Aquitard (CPS)</td><td>Sandstone, mudstone, siltstone (all fractured rock), sand and minor coal</td><td>Unknown</td><td>370 -500</td></tr>
<tr><td>Palaeozoic</td><td></td><td>Basement rocks</td><td>Basement rocks Aquifer (BSE)</td><td>sedimentary and igneous rocks</td><td>500 – 1,000</td><td>500 -700</td></tr>
</table></td><td>Figure 3</td></tr>
</table>

Conceptual Element	Description	Figure reference (Appendix A)
Relevant aquifer/s[1, 3]	The shallowest aquifer at the site is the outcropping Quaternary Aquifer (QA), this is separated from Lower-Mid Tertiary Aquifer (UMTA)/Lower Tertiary Aquifer (LTA) by the Upper-Mid Tertiary Aquitard (UTMD). The water table is likely to occur within the Quaternary Aquifer (QA) at the site. This inference is supported by DELWP data[1] (refer to section 5.1.1)	Figure 3
Depth to water table [3]	Available desktop information indicates the depth to groundwater is likely to be less than 5 m below ground level across the majority of the site.	Figure 4
Groundwater quality & beneficial uses[1,3]	Groundwater salinity is less than 500 mg/L TDS in the LMTA and LTA; and falls under Segment A1 of the State Environment Protection Policy (SEPP) *Groundwaters of Victoria 1997 (GoV)*. Groundwater salinity is between 501 – 1,000 mg/L TDS in the QA, and falls within Segment A2 of the SEPP *GoV.* SAFE mapping data indicates a higher salinity range (1,000 mg/L to 3,500 mg/L TDS) for the majority of the site in the water table aquifer (i.e. the QA) which would classify the groundwater within Segment B of the SEPP *GoV*.	Figure 5
Groundwater users[4]	Seven existing bores were identified within a 1.5 km radius of Princetown. Two of the identified bores did not specify use. Two of the bores were drilled for domestic purposes, another two of the bores were used for industrial purposes and the remaining bore was used for commercial purposes. Only four bores record depth information, with depths ranging from 97 m to 625 m. Most bores show depths of less than 130 m deep, indicating that typically, the LTA is developed.	Figure 2
Groundwater yields / aquifer parameters[4]	No groundwater yield information was available for bores located within 1.5 km of Princetown.	Figure 2

Conceptual Element	Description	Figure reference (Appendix A)
Groundwater flow[4,1]	No groundwater level information was available from WMIS and no regional hydrogeological mapping information was available. On a local scale based on the SAFE mapping, groundwater flow in the water table aquifer is likely to be towards the main surface water features such as the Gellibrand River and Latrobe Creek.	
Groundwater management arrangements	The site occurs within the Newlingrook Groundwater Management Area (GMA), which pertains to all geological units at this location. The permissible consumptive volume (PCV) for the Newlingrook GMA is 1,977 ML/year.	Figure 1
Potential for GDEs[5]	The Gellibrand River, Latrobe Creek, Boggy Creek and surrounding wetlands (deep marsh, shallow marsh, permanent saline and semi saline) are situated within 1.5 km of the site and are identified as Groundwater Dependant Ecosystems (GDEs) ecosystems that rely in the surface expression of groundwater.	

(1) Department of Environment, Land, Water and Planning (DELWP): Victorian Aquifer Framework (VAF) Secure Allocation Future Entitlements (SAFE) project data

(2) DELWP VicMap spatial data

(3) DELWP Groundwater Resource Report tool. Accessed online @ http://www.depi.vic.gov.au/water/groundwater/groundwater-resource-reports

(4) DELWP Water Measurement Information System (WMIS). Accessed online @ http://data.water.vic.gov.au/monitoring.htm

(5) Bureau of Meteorology: GDE Groundwater Dependent Ecosystems Atlas

5.1.1 Assumptions and limitations

The hydrogeological investigations relied on a number of assumptions related to data sources and their availability, these assumptions and limitations are provided in Appendix A.

5.2 Interaction with the proposed development with groundwater

The following main points have been summarised from the hydrogeological assessment in the sections above and in Appendix A:

- The water table is within the Quaternary Aquifer (QA), with an indicative depth of 0-4 m bgl. The Upper-Mid Tertiary Aquitard (UMTD) underlies the QA as a low permeability layer and separates the QA from the lower aquifers (including the LTA).
- There is some inconsistency in the regional mapping of the groundwater quality in the water table aquifer directly beneath the site (i.e. the QA) with it either being in the range:
  - 501 mg/L to 1,000 mg/L TDS, Segment A2 (DELWP ,2015), or
  - 1,000 mg/L to 3,500 mg/L TDS, Segment B (SAFE dataset).

  As a conservative measure, for the purpose of this assessment, the groundwater within the water table aquifer at the site has been classified as Segment A2 under the SEPP (GoV) (refer to Appendix A).
- There is limited groundwater flow information available in the area. Based on the SAFE mapping of the water table aquifer, it is likely that groundwater flows are influenced at the site by the Gellibrand River, which largely encircles the site.
- The water table (QA) near the site is likely to interact with three GDEs within 1.5 km of the site. Irrigation at the site must be managed to prevent the discharge of contaminated groundwater to the QA, which may in turn impact nearby GDEs (i.e., the beneficial uses of maintenance of ecosystems and primary contact recreation).
- Groundwater quality was also tested from a LTA bore near Princetown (refer to section 6.2) this bore showed salinity in the order of 400 mg/L TDS (Segment A1, SEPP GoV).
- Only four bores record depth information, with depths ranging from 97 m to 625 m. Most bores show depths of less than 130 m deep, indicating that typically, the LTA is developed for groundwater extraction. The shallow water table (QA) is unlikely to be suitable for bores for consumptive purposes (i.e., drinking water and stock, agriculture, parks and gardens and domestic purposes). The UMTD (aquitard) separates the water table from the LTA and therefore is unlikely to interact with groundwater extracted from local bores.
- The site is within the Newlingrook GMA and has a permissible consumptive volume of 1,977 ML/year (DELWP 2016) and licences cannot be issued to extract above this amount.

6. Proposed irrigation scheme

6.1 Area available for irrigation

As discussed in section 4.1.5, the proposed development site is immediately adjacent the estuarine environment of the Gellibrand River mouth and is located approximately 600 m downstream to the south of the site. As such, the site is subject to periodic flooding on an annual basis. Corangamite CMA has recommended that the proposed wastewater irrigation area be located above 2.02 metres AHD. Available information (as provided by Corangamite CMA and mapping as shown in Appendix C) has subsequently been used to define the following:

- Total site area (land owned by Montarosa) = 48.42 ha
- Site area below flood level = 37.5 ha
- Site area above flood zone (RL 2.06 mAHD, approximately 1:20 ARI) = 11 ha
- Total available area for irrigation (including the dunes but excluding building and road areas above the flood level and excluding the recreational reserve) = 9.0 ha
- Total area for irrigation (excluding the dune area of 1.5 ha, building and road areas above the flood level and the recreational reserve) = 7.5 ha

This information is presented in Appendix C..

It is considered that the recreational reserve will not be available for irrigation. It is noted that the likely vegetation structure (and potential for water use) will vary dependent on the types of areas used for irrigation. There are approximately 1.5 ha of dune areas covered with native vegetation that could potentially be used as additional area to dispose of wastewater in a wet year if required (situated at a RL > 3 mAHD).

6.2 Wastewater quality

Water for use within the proposed development would be sourced predominantly from groundwater (approximately 80%) with the remainder planned to be sourced from rainwater (treated to a suitable standard). Wastewater will be treated to at least Class B standard (in accordance with EPA Publication 464.2) prior to use for irrigation. EPA Publication 464.2, Table 1, specifies the requirements for Class B and Class A water as summarised in Table 4.

Class B water will be suitable for irrigation at the site in accordance with EPA Publication 464.2 provided the additional controls required by EPA Publication 464.2 for Class B water (urban – with public access restrictions) compared with Class A water (urban - uncontrolled public access) are implemented. Montarosa retains the option to treat the wastewater to Class A standard, if deemed required at a later stage in the project.

Table 4 Requirements for Class A and Class B Water (EPA Publication 464.2)

Class	Water quality objectives[1,2]	Treatment processes[3]	Range of uses
A	< 10 E. coli org/100 mL Turbidity < 2 NTU[4] < 10 mg/L BOD and 5 mg/L SS[5] pH 6 -9[6] 1 mg/L Cl_2 residual (or equivalent disinfection)[7]	Tertiary and pathogen reduction with sufficient log reductions to achieve: < 10 E. coli per 100 mL < 1 helminth per litre < 1 protozoa per 50 litres < 1 virus per 50 litres	Urban: (non-potable): with uncontrolled public access Agricultural: e.g. human food crops consumed raw Industrial: open systems with worker exposure potential
B	< 100 E. coli org/100 mL < 20 mg/L BOD and 30 mg/L SS[5] pH 6 -9[6]	Secondary and pathogen (including helminth reduction if required for water to be suitable for cattle grazing)[8]	Urban (non-potable): with controlled public access Agricultural: e.g. dairy cattle, grazing, human food crops cooked/processed, irrigation of fodder, non-food crops including turf, woodlots and flowers. Industrial: e.g. wash-down water

[1] Median determined over a 12-month period

[2] Refer also to Chapters 6 and 7, and EPA Publication 168 for additional guidance on water quality criteria for salts, nutrients and toxicants

[3] Guidance on pathogen reduction measures and required pre-treatment levels for individual disinfection processes are described in GEM: Disinfection of Reclaimed Water (EPA Victoria, 2003, Publication 730.1)

[4] Turbidity is a 24-hour median value measured pre-disinfection. Maximum is 5 NTU

[5] BOD = biological oxygen demand; SS = suspended solids

[6] pH range is 90th percentile

[7] Chlorine residual limit of greater than 1 mg/L after 30 minutes (or equivalent pathogen reduction level) is suggested where there is significant risk of human contact or where reclaimed water will be within the distribution system for prolonged periods. Applies at the end point of use.

[8] Guidance on pathogen reduction measures and required pre-treatment levels for individual disinfection processes are described in GEM: Disinfection of Reclaimed Water (EPA Victoria, 2003, Publication 730.1). Helminth reduction is either detention in a pondage system for greater than or equal to 30 days, or by an EPA Victoria approved disinfection system (for example, sand or membrane filtration).

Future groundwater testing will be undertaken once a new bore is established at the site and a groundwater extraction licence is in place. A groundwater bore that services the town has been sampled to provide an indication of groundwater quality that will be available at the site. The town bore is located approximately 300 m from the proposed location of the new bore and is considered to provide a reasonable approximation of groundwater that will be available for the site. The groundwater quality (as sampled on 24 March 2016) is summarised in. From it is noted that:

- Manganese is higher than the guideline limit specified for health in the Australian Drinking Water Guidelines (0.5 mg/L)
- Iron is higher than the guideline limit specified for aesthetics in the Australian Drinking Water Guideline (0.3 mg/L)

Total nitrogen (TN, mg/L) and total phosphorus (TP, mg/L) are not listed in Table 5, however, for the purposes of this LCA assessment, it has been advised that the expected TN and TP concentrations of the wastewater post-treatment will be approximately 86 mg/L of TN and 12 mg/L TP. A conservative range of 50 – 100 mg/L for TN and 8-16 mg/L TP have been used to calculate the nutrient balances as provided in section 6.5.

It has been advised (by GHD's Process Engineering team designing the Wastewater Treatment System) that the TDS of the wastewater (approximately 700 mg/L) will be approximately 300 mg/L higher than that of the groundwater supply.

Table 5 Estimated groundwater quality

Parameter	Total concentration (mg/L)
Arsenic	0.001
Barium	0.052
Bicarbonate	210
Boron	0.13
Bromide	0.4
Carbonate	<2
Chloride	140
Copper	0.006
Fluoride	0.2
Iron Total	1.3
Manganese Total	0.18
Nickel	0.001
Nitrate	0.1
Strontium	0.64
Sulphate	25
Zinc	0.017
TDS	440
pH (in pH units)	7.6
Electrical conductivity (µS/cm)	950
Suspended solids	4

6.3 Irrigation system design and operation

6.3.1 Irrigation system design

The design of the irrigation system has not yet been finalised. Irrigation will most likely occur by the supply of the treated wastewater by pipe, with water to be delivered by sprinklers and/or drippers. The design of the irrigation system will be dependent on the total number of hectares to be irrigated and the classification of the water irrigated (i.e., if Class B is used irrigation will need to be managed to minimise the risk of exposure to staff and visitors). An assessment of how many hectares are required to be irrigated, to use the wastewater inflows plus rainfall to storages each year, has been undertaken as part of the water balances.

6.4 Water balances

Based on the Princetown weather station rainfall data (refer to Table 2), a water balance has been calculated for the area available for irrigation at the project site (refer to section 6.1). The details of the water balance are provided in Appendix B with the results summarised below.

Water balances have been calculated for three different climatic conditions to identify the land area needed to use the water available for irrigation in an average rainfall year and under climatic extremes associated with a wet year and a dry year. The long-term average, 90% and 10% percentile values provided in Table 2 were used for the water and nutrient balances provided in section 6.5.

Two different sets of water balances for the three climatic conditions are shown in Table 6 to provide an indication of the difference in water use for an area entirely planted to turf grass (a combination of a winter grass (rye grass) and a summer grass (Couch/Bermuda Grass)) that may be typically used on a sports field and a mixture of grass and immature trees (such as may be more representative of the entire area available for irrigation in the early years of tree establishment). An additional water balance using Lucerne, to demonstrate the impact that plant selection may have on increasing water use over the applied area. The water balances are indicative and subject to a series of estimates and assumptions as provided in Table 7.

Table 6 Water balances for proposed irrigated area

Rainfall	Total number of hectares needed for irrigation	Months of irrigation
Irrigation of a combination of 40% immature trees (i.e., eucalyptus) and 60% turf grasses		
Mean Rainfall	7.4	6 months (October – March)
90th Percentile rainfall (wet year)	10.5	6 months (October – March)
10th Percentile rainfall (dry year)	5.6	6 months (October – March)
Irrigation of 100% turf grass species		
Mean Rainfall	5.7	6 months (October – March)
90th Percentile rainfall (wet year)	7.8	6 months (October – March)
10th Percentile rainfall (dry year)	4.5	6 months (October – March)
Irrigation of 100% Lucerne pasture		
Mean Rainfall	3	6 months (October – March)
90th Percentile rainfall (wet year)	3.8	6 months (October – March)
10th Percentile rainfall (dry year)	2.5	6 months (October – March)

- The above calculations are based on information provided in EPA Publication 168 and a number of other assumptions, which are summarised in Table 7.
- The detailed water balance calculations are provided in Appendix B.
- In addition to the information provided in Table 7, the water balances assumed that the soils are suitable for irrigation and that the top 2 – 3 m of soil is not sodic or saline.
- The top 1 -1.5 m of soil is not saturated or waterlogged during the six month irrigation period.

An interpretation of the water balances is provided in section 6.4 and further discussion on the assumptions made and the viability of irrigation at this site, are provided in later sections in this report.

Table 7 Assumptions and limitations of the water balances

Code[1]	Description	Assumption/limitations
R1	Rainfall	Rainfall data is from data obtained from the Princetown weather station, data from 1889 – 2015. Rainfall values for an average year are based on the mean value for each month over the data period. For the 90th and 10th percentile years, the 90th and 10th percentile years have been identified based on the total annual rainfall. The 90th percentile year was 2013 (approx. 1117 mm/annum); the 10th percentile year was 1961 (736.6 mm/annum). The monthly values for the 90th and 10th percentile years was obtained by allocation of a percentile of the total annual rainfall based on the average rainfall percentage for each month (for example, 10th of rainfall occurs in September 10% x 1117 mm = 112.81 mm). The distribution of rainfall in the 20% wettest and driest year is similar to that of average year.
R2	Effective rainfall	Calculated as 70% of R1, as described in EPA Publication 168. EPA Publication provides a table of effectiveness of rainfall on pasture to allow effective rainfall to be determined based on soil texture and plant root depth. However, similar information was not available for turf grass or trees for this assessment. As provided for in EPA Publication 168, it was assumed for the water balances that for monthly rainfall > 25 mm that effective rainfall = 70%; for monthly rainfall < 25 mm, effective rainfall =50%. All months in all climatic conditions had rainfall > 25 mm. This approach is limited as it does not allow for calculations based on the variance in root depth (which is greater for trees) and water holding capacity of the soils (Brian Consulting Pty Ltd, December 2015), assessed the site soils

Code[1]	Description	Assumption/limitations
		as a clayey sand and/or coarse sand and with a high permeability (and a low water holding capacity).
A	EPan	Monthly pan evaporation in mm, based on data from the weather station. EPan data does not correlate with rainfall (i.e., EPan in an average year similar to that in a wet year or dry year).
I	Crop factor	Crop factor for eucalyptus in EPA Publication used for immature trees, this approach is conservative, as younger trees will have lower water requirements. Crop factors for turf grass species were obtained from available online resources (University of California , 2016). Crop factors from Lucerne from EPA Publication 168. Assumed six months each of summer grass and winter grass. Crop factors for modelled scenarios with trees and grasses derived by a percentage of the area anticipated to planted to each crop type.
C1	ET	Evapotranspiration, I x A
C2	Irrigation requirement	Equal to C1 – B2, in mm
D	Monthly evaporation from lagoon storage	Calculated from total rainfall and evaporation data and the surface area of the storage, which was assumed as 50 m x 80 m = 0.4 ha. Was assumed storage depth was 2.5 m, if a deeper storage can be used, the surface area (and therefore rainfall catchment area) would be reduced.
E	Wastewater input	Based on peak wastewater flows and occupancy rates provided for the preferred wastewater treatment option (Scenario 2) in Appendix B. Full calculations provided in Appendix B. Wet year calculations assume occupancy and wastewater flows equal to those in an average or dry year. This is conservative, as occupancy rates are likely to decline in a wet year (but cannot yet be quantified).
F	Total volume for irrigation	F = E – D. In months where D is negative, there is a net accumulation of water in storages (evaporation < rainfall).

6.4.1 Viability of irrigation based on water balances

The above scenarios indicate that in all except a wet year with a combination of immature trees and turf grasses, that there is sufficient irrigation area for the wastewater volumes predicted under the peak wastewater flows modelled. With reference to Table 7 and Appendix B, the following caveats on the water balance and the potential for irrigation at the site are made.

The water balances may underestimate the water use of the plant-types modelled

There is limited information on the vegetation that will be used at the site and the method used to calculate the effectiveness of rainfall in the water balances does not take into account the root depth of the trees, which is likely to significantly greater than that of grasses (0.2 – 0.3 m). Further modelling of water use based on specific crop factors for the preferred plant types (such as deep-rooted coastal grasses) may improve the outcome of the water balance (i.e., reduce the irrigation area required). In this sense, the preliminary water balances provided in this assessment are considered conservative.

It is considered unlikely that Lucerne would be planted across the entire site, but the water balance created from Lucerne illustrates that selection of plants that have a high water use requirement and a deep root system (0.7 – 1.8 m from EPA Publication 168) can significantly reduce the area required for irrigation. Careful selection of plants at the detailed design stage for the creation of the EIP that are well suited to the site will be critical in providing further clarification of the area required for irrigation.

In a wet year, the occupancy rate used to calculate monthly wastewater volumes is likely to be over-estimated

In a wet year, the area adjacent the site will be flooded more often, making the location less appealing to tourists and reducing the availability/suitability of some activities at the site. It is considered that in a wet year, the rate of occupancy is likely to decrease significantly from the rates used to develop the monthly wastewater volumes for the water balance. A reduction in occupancy rate in a wet year will reduce wastewater flows and the volume that will be required to be disposed of by irrigation (and thus reduce the irrigation area required). No information on the occupancy rates in a wet year was available at the time of this assessment, although anecdotal information suggests that occupancy numbers would reduce between 10 – 20%.

Water balances do not take into account the water holding capacity of the soil

The preliminary LCA undertaken by Brian Consulting (2015) included a characterisation of soil texture, depth and permeability. The assessment undertaken by Brian Consulting (2015) observed two different soil types (refer to section 4.3), and percolation testing was conducted on both the eastern and central parts of the site to capture this difference in soil types. Percolation testing confirmed that soil on the eastern portion of the site has rapid drainage characteristics and soil on the western portion of the site has very rapid drainage characteristics. Brian Consulting (2015) concluded that the soil at the site can be categorised as Category 1 in accordance with Table 5.1 of AS/NZS 1547:2012 and concluded that due to the very permeability of the sand onsite, secondary treatment of the wastewater is required (presumably to reduce the risk of contamination of groundwater). Class B would be acceptable given that it can be demonstrated that there will be no contamination of groundwater from biological contaminants (i.e., E coli.) above relevant guideline limits. In practical terms, soil that has a low capacity to hold water has a low ability to store water and nutrients available for plant use. Such risks may be reduced by a number of management measures (such as the selection of coastal plants with deep, fibrous root systems that are endemic or otherwise suited to the conditions at the site) and are discussed further in section 8.

Water balances do not consider the potential for irrigation water to interact with groundwater

Brian Consulting (2015) observed groundwater at 1.0 – 1.2 m below ground level during bore hole development in September 2015 for two of the locations (bore hole 2 and 3 respectively). Groundwater levels are likely to be closely linked to levels of water within the estuary (refer to section 5.2) and therefore may be further elevated during periods of flooding. The coarse, sandy soil present at the site means that there is a lower potential for waterlogging of the soil around the roots of plants (provided the root zone is above the water table). However, coarse soil means that there also a higher risk that water and nutrients may percolate past the roots of plants and into the water table. Careful plant selection and management of applied wastewater volumes and nutrient loads will be required to prevent discharge of wastewater to the local water table. The plants selected should be able to tolerate periodic waterlogging of the root zone. This is discussed further in section 8.

6.5 Management of applied nutrient loads

Using the information obtained from the water balances, nutrient balances for total phosphorus (TP) and total nitrogen have been calculated assuming that the recycled water has a total phosphorus of 6 - 18 mg/L and a total nitrogen of 50 - 100 mg/L (these conservative values encompass the expected TN and TP concentrations of the wastewater post-treatment will be approximately 86 mg/L of TN and 12 mg/L TP). Nutrient balances have been performed with reference to the nutrient uptakes shown in Table 8.

Nutrient balances have assumed that the nutrients used will be based on the percentage of each plant type on site consistent with the assumptions of the water balance. It has been calculated from the percentages in Table 8 that the combination of plants onsite will extract 183 kg/ha/year of nitrogen and 37.5 kg/ha/year of phosphorus.

Table 8 Mineral uptake to trees and grasses

Plant species[1]	Nitrogen Uptake (kg/ha/yr)	Phosphorus uptake (kg/ha/yr)	% of site cover[2]
Rye grass	180	70	30
Couch/Bermuda Grass	280	40	30
Eucalypt	90	15	40
Lucerne	220 - 540	20-30	NA

[1] - Uptake figures presented from EPA Publication 464.2, Appendix F
[2] - % cover only applies to the scenario with a mixture of grass and trees as noted in water balances above. Where there is a range of uptakes, the lower value has been used in nutrient balances.

6.5.1 Nitrogen nutrient balances

Nitrogen nutrient balances are provided in Appendix B. In summary, based on the range of nitrogen concentrations in the wastewater (50 – 100 mg/L), nitrogen will accumulate or be in deficit as shown in Table 9. It should be noted that the range of nitrogen concentrations used have been taken from the concentration predicted during the peak tourist season (86 mg/L), nitrogen concentrations in wastewater will be lower when averaged over a 12 month period (76 mg/L TN).

Table 9 Nitrogen nutrient balances

Climate scenario	Irrigation ML/ha/year	Upper limit TN, mg/L	Lower limit TN, mg/L
Irrigation of a combination of 40% immature trees (i.e., eucalyptus) and 60% turf grasses			
Average rainfall	2.5	67 kg/ha/yr accumulation	58 kg/ha/yr deficit
90th percentile rainfall	1.8	3 kg/ha/yr deficit	93 kg/ha/yr deficit
10th percentile rainfall	3.4	157 kg/ha/year accumulation	13 kg/ha/yr deficit
Irrigation of 100% turf grass species			
Average rainfall	3.4	60 kg/ha/yr accumulation	110 kg/ha/yr deficit
90th percentile rainfall	2.4	40 kg/ha/yr deficit	160 kg/ha/yr deficit
10th percentile rainfall	4.4	160 kg/ha/yr accumulation	60 kg/ha/yr deficit
Irrigation of 100% Lucerne pasture (Lower limit for uptake of 220 kg/ha/year)			
Average rainfall	6.3	410 kg/ha/yr accumulation	95 kg/ha/yr accumulated
90th percentile rainfall	5.2	300 kg/ha/yr accumulation	40 kg/ha/yr accumulation
10th percentile rainfall	7.6	540 kg/ha/yr accumulation	160 kg/ha/yr accumulation

Climate scenario	Irrigation ML/ha/year	Upper limit TN, mg/L	Lower limit TN, mg/L
Irrigation of 100% Lucerne pasture (Upper limit for uptake of 540 kg/ha/year)			
Average rainfall	6.3	90 kg/ha/yr accumulation	225 kg/ha/yr deficit
90th percentile rainfall	5.2	20 kg/ha/yr deficit	280 kg/ha/yr deficit
10th percentile rainfall	7.6	220 kg/ha/yr accumulation	160 kg/ha/yr deficit

6.5.2 Phosphorus nutrient balances

Phosphorus nutrient balances are provided in Appendix B. In summary, based on the range of phosphorus concentrations in the wastewater (8 – 16 mg/L), nitrogen will be accumulated or in deficit as shown in Table 10.

It should be noted that the range of phosphorus concentrations used have been taken from the concentration predicted during the peak tourist season (12 mg/L), phosphorus concentrations in wastewater will be lower when averaged over a 12 month period (11 mg/L TP).

Table 10 Phosphorus nutrient balances

Climate scenario	Irrigation ML/ha/year	Upper limit TN, mg/L	Lower limit TN, mg/L
Irrigation of a combination of 40% immature trees (i.e., eucalyptus) and 60% turf grasses			
Average rainfall	2.5	1 kg/ha/yr accumulation	19 kg/ha/yr deficit
90th percentile rainfall	1.8	10.2 kg/ha/yr deficit	24.6 kg/ha/yr deficit
10th percentile rainfall	3.4	15.4 kg/ha/year accumulation	11.8 kg/ha/yr deficit
Irrigation of 100% turf grass species			
Average rainfall	3.4	14 kg/ha/yr accumulation	12.8 kg/ha/yr deficit
90th percentile rainfall	2.4	1.6 kg/ha/yr deficit	20.8 kg/ha/yr deficit
10th percentile rainfall	4.4	30.4 kg/ha/yr accumulation	4.8 kg/ha/yr deficit
Irrigation of 100% Lucerne pasture (Lower limit for uptake of 20 kg/ha/year)			
Average rainfall	6.3	80.8 kg/ha/yr accumulation	30.40 kg/ha/yr accumulation
90th percentile rainfall	5.2	63.2 kg/ha/yr deficit	21.6 kg/ha/yr deficit
10th percentile rainfall	7.6	101.6 kg/ha/yr accumulation	40.8 kg/ha/yr accumulation

Climate scenario	Irrigation ML/ha/year	Upper limit TN, mg/L	Lower limit TN, mg/L
Irrigation of 100% Lucerne pasture (Upper limit for uptake of 30 kg/ha/year)			
Average rainfall	6.3	70.80 kg/ha/yr accumulation	20.40 kg/ha/yr accumulation
90th percentile rainfall	5.2	53.2 kg/ha/yr accumulation	11.6 kg/ha/yr accumulation
10th percentile rainfall	7.6	91.6 kg/ha/yr accumulation	30.8 kg/ha/yr accumulation

6.5.3 Viability of irrigation based on nutrient balances

Nutrient balances in Table 9 and Table 10 indicate that accumulation of nitrogen and phosphorus in the soil profile may occur in most rainfall scenarios based on 100 mg/L TN and 16 mg/L TP and is highly dependent on the plant type selected. These nutrient balances indicate that TN and TP closer to the lower range provided in these tables is far preferable to the upper ranges. As discussed in the sections above, the forecasted peak concentrations are somewhere in the mid-range of these values and the average values are closer to the lower range. A small deficit of nutrients is preferable to an accumulation of nutrients as a deficit can be targeted by fertiliser applications, if required. A small accumulation of nutrients could be addressed by applying a small water deficit (under-watering) and spreading the available wastewater over a greater area. Wastewater could also be diluted with other sources (i.e., potable) if available. Plant selection for the site will be important to get a balance of water use requirements and nutrient uptake – for example, lucerne will use more water per hectare but result in a higher accumulation of nutrients. Given the relatively low clay and organic matter content of the soil and its coarse, free draining structure (as determined by (Brian Consulting Pty Ltd, December 2015)), there is a relatively low risk of phosphorus and nitrogen accumulating in the soil profile and contaminating the soil. However, given the free-draining nature of the soils onsite, there is the potential for nitrogen and phosphorus applied in excess to plant requirements to drain to the water table.

Section 5 of this report notes that groundwater at the site can be classified as Segment A2 under the SEPP (GoV). The beneficial uses of this groundwater segment are provided in Table 1 and it is considered that with the exception of industrial water use (which is unlikely to occur in the rural setting surrounding the site), all of the listed beneficial uses of groundwater for Segment A2 are relevant to this site and require protection.

For irrigation of wastewater to be viable, the concentration of nitrogen and phosphorus, and other potential contaminants (such as oils, greases, salts and metals) in the wastewater will need to be keep sufficiently low as to prevent discharge of contaminated water to groundwater. A detailed assessment of potential contaminant loadings against the guideline limits provided for groundwater segments in the SEPP (GoV) is beyond the scope of this assessment. Reducing nutrient loads to a concentration that will most likely result in nutrient deficiency will reduce the risk of nutrients discharging to the water table. Further investigations required and potential mitigation measures are provided in section 8 and section 9 of this report.

6.6 Management of applied salt loads, sodicity and heavy metals

6.6.1 Salts

The TDS of the treated wastewater is predicted to be approximately 700 mg/L (equivalent to an electrical conductivity of approximately 1100 µS/cm, dependent on the types of salts present in the treated wastewater). EPA Publication 168 designates wastewater of this salinity at the lower end of Class 3 (550 – 1500 mg/L TDS, 780 – 2340 µS/cm). EPA Publication 168 states that the more saline waters in this Class should not be used on soils with restricted drainage. The soils on site are sandy and free-draining and a TDS of 700 mg/L is at the lower end of this Class, which indicates that plants with a moderate to high salt tolerance may be grown. Irrigation of this water by sprinklers may cause leaf burn on more sensitive plant types and dripper irrigation is preferred where feasible.

The TDS of the groundwater is similar to the wastewater, therefore, salinization of the soil profile due to the rise of the natural groundwater table following irrigation that is more saline than the wastewater, is considered unlikely. Waterlogging of the soil profile is possible during periods of flooding that naturally occurs in this estuarine environment. The groundwater levels that occur at the site and the proposed irrigation area during periods of flood are unknown, but it is possible that water tables could rise to within 1 m of the soil surface. Use of coastal plants that are native to the area and adapted to the site conditions will reduce the risk to plant health from waterlogging at the site.

Groundwater sourced to supply the site with water will be from a deeper fresher aquifer than the groundwater table, as discussed in section 6.2. The TDS of the wastewater is within the range of that predicted for the water table (Segment A2, 500 – 1000 mg/L TDS), reducing the risk of saline irrigation water percolating through to the groundwater. However, careful selection of fertilisers will be required to prevent salts from fertiliser application impacting on groundwater.

The sodium absorption ratio (SAR – measure of the amount of sodium present relative to calcium and magnesium) of the wastewater is not known. Soils irrigated with water with a high SAR can cause deterioration in soil structure. EPA Publication 464.2 states a SAR of greater than 3 in waters is a trigger for further investigation, as irrigation with water with an SAR > 3 could negatively impact on soil structure.

Soil sampling has not been undertaken to confirm the suitability of the soil for irrigation (i.e., confirmation that the soil is not saline or sodic). Soil sampling to assess soil chemistry should be undertaken at the site.

6.6.2 Metals and other nutrients

The concentration of heavy metals in the groundwater is shown in Table 5. The concentration of metals in treated wastewater is not known at this stage, however, it is noted that the concentration of some metals in the groundwater (manganese and iron) are above relevant guideline values will need to be reduced (refer to section 6.2). Suspended solids have been measured at 4 mg/L in the groundwater and may need to be reduced to consistently achieve Class A recycled water (if Class A is selected for the site rather than Class B).

The groundwater proposed to be extracted for use onsite is within the Lower Tertiary Aquifer and available information suggests it is less saline than the groundwater within the water table aquifer (refer to section 5). Sampling of groundwater within the water table aquifer will be required for this aquifer (QA, section 5) before irrigation commences, to provide baseline data against which future groundwater monitoring results (from sampling undertaken during irrigation) can be compared to assess impacts from irrigation on groundwater.

EPA Publication 464.2 and EPA Publication 168 provides guidance on sampling parameters and frequency for heavy metals and other nutrients that should be undertaken as part of a monitoring program associated with wastewater irrigation.

6.6.3 Biological and wastewater classification parameters

Classification of wastewater under EPA Publication 464.2 is based on a limited range of parameters including biological parameters that pose a risk to human and/or livestock health (E.coli, helminth, protozoa, viruses) and pH, BOD, SS and turbidity (for Class A water only).

Montarosa has committed to treat the wastewater to at least Class B standard, and irrigation of public spaces with controlled access if permissible under the guidelines for Class B water (see Table 4). Buffer distances will be implemented between irrigation and the Gellibrand River in accordance with guideline requirements.

6.7 Management of wastewater pH

The pH of the treated wastewater has been estimated between 6 -9 (refer to Table 5). A soil pH lower than 6 or higher than 9 can cause changes in soil chemistry leading to possible nutrient/heavy metal toxicity and adversely impact crop health. The pH of the wastewater should be maintained as near as possible to 7 (range 6.5 – 8).

7. Alternatives to onsite wastewater irrigation

As discussed in sections above, there are some potential limiting factors associated with irrigation at the proposed development site, such as insufficient onsite irrigation area during a wet year (as noted from water balances in Table 6 where 10.5 ha is required to irrigate a combination of trees and turf grasses) and as yet unknown factors related to the seasonal water table at the site. As discussed in section 6.4.1, some of the identified risks associated with onsite wastewater irrigation can be reduced by careful selection of plants suited to the estuarine environment that exists onsite. Wastewater flows are also likely to reduce in a wet year due to lower visitor numbers at the site. However, it is considered prudent to have some additional contingency measures in place in the event that onsite irrigation is found to unviable under certain climatic conditions. Potential alternatives to onsite wastewater irrigation have been discussed with Montarosa, who have provided advice on the following potential alternatives to onsite irrigation:

- Negotiations to supply the wastewater to a neighbouring landholders site for irrigation – there is the potential for Montarosa to identify other landholders further from the Gellibrand River that may be able to accept wastewater. Excess wastewater held in onsite storages would be trucked or piped from site.
- Trucking of excess water held in winter storages in a wet year, offsite for disposal to sewer – may be a suitable option in instances in a wet year if not all of the water contained in the lagoon storage can be irrigated onsite.

Water balances indicate that with irrigation over the summer months (October – March) in a 90th percentile wet year the maximum volume held in storage will be approximately 8 – 8.8 ML (assuming a surface area of 0.4 ha), providing between 1.2 – 2 ML of available freeboard in the planned 10 ML onsite storage (10 – 20%). This may provide an option for trigger levels (height of freeboard in the storage) to be set that when reached trigger the requirement to find an alternative method of disposal. This approach acknowledges the potential for a very wet period to be followed by a hot, dry period, which may reduce the requirement to find an alternative method of wastewater disposal. This approach could be developed further in the EIP required prior to irrigation commencing onsite.

8. Preliminary risk assessment

8.1 Requirement

Users of reclaimed water need to identify and assess the potential exposure routes for groundwater associated with the reuse scheme in order to maximise the protection of water quality and the environment. Users of reclaimed water also need to assess potential for degradation of soil health associated with the reuse scheme.

Reclaimed water use schemes should meet a number of environment protection objectives:

- Protect the beneficial uses of groundwater and surface waters as defined in the relevant SEPP
- Avoid structural changes to the soil or contamination (for example, soil salinity or sodicity) that may reduce the (short or long term) productivity of the land
- Avoid contamination of the air environment by the production of offensive odours, spray drift and aerosols (this is beyond the scope of the groundwater assessment)

The risk assessment in the sections below has been undertaken with reference to information provided in earlier sections of this report related to wastewater quality, volume, beneficial uses of the environment for protection and the geological setting of the proposed development site.

8.2 Process

To assess the potential impacts of the reuse of treated wastewater on the groundwater environment and current and future land use, it is necessary to understand the risks. The following methodology was used to assess the groundwater impact pathways and define risk ratings for the project:

1. Assess the ‘impact pathway’ – how the project impacts on a given groundwater value or issue
2. Describe the ‘consequences’ of the impact pathway to define levels of consequence (Table 11)
3. Assess the ‘likelihood’ of the consequence occurring to the level assigned in Step 2. Likelihood descriptors are provided in Table 12
4. Assess the maximum credible ‘consequence level’ associated with the impact as defined in Table 11. The method for defining these criteria is described in section 8.2.1
5. Form the consequence and likelihood levels assigned to the impact pathway. Use the risk matrix to assess the risk rating (Table 13)
6. Define the level of data/information availability associated with the risk assessment rating (Table 14)

8.2.1 Consequence criteria

With the groundwater assessment, impacts are generally simplified into those that affect groundwater quality and/or groundwater level. Falls or rises in groundwater level affect hydraulic gradients and groundwater movement. The effect on movement or groundwater flow translates to a change in groundwater availability, be it available for environmental reserves or resource users. For the land capacity assessment, impacts are those that can affect productivity of the agricultural land under irrigation. Where a future change in land use is feasible (i.e. agriculture to residential development) impacts to those potential uses are also considered.

Direct impacts to the groundwater environment may take the form of changes to water quality, changes to water level or changes to access (extractive use) or an environmental asset or function, such as a Groundwater Dependent Ecosystem (GDE). Direct impacts to the land under irrigation may involve salinization or contamination with nutrients and/or heavy metals or a change in soil chemistry that adversely alter soil structure.

Consequence criteria (Table 11) range on a scale of magnitude from ‘insignificant’ to ‘catastrophic’. Magnitude was considered a function of the size of the impact (the spatial area affected and expected recovery time of the environmental system or soil health).

Consequence criteria descriptions indicating a minimal size impact over a local area, and with a recovery time potential within the range of normal variability were considered to be at the negligible end of the scale. Conversely, catastrophic consequence criteria describe scenarios involving a very high magnitude event, affecting a catchment area, or requiring several years to reach functional recovery.

Table 11 Consequence criteria

Criteria	Insignificant	Minor	Moderate	Major	Catastrophic
Direct impacts to the groundwater environment Direct impacts to land capacity and productivity	Negligible change to groundwater regime, quality and availability. Negligible change to soil health and productivity.	Temporary or highly localised changes to groundwater regime, quality and availability but no significant implication for groundwater users or the environment. Temporary or highly localised changes to soil health and productivity but no significant implication on current and future land use.	Changes to groundwater regime, quality and availability with minor implications (localised) (reduction in available volume or quality but existing users still viable or negligible impact to receiving environments) Changes to soil health that impact productivity over a limited area (i.e. 10% or less of total) for a moderate length of time (i.e. months).	Groundwater regime, quality or availability significantly compromised (existing uses of groundwater no longer viable, and/or impact on waterway flows/receiving environment) Significant impacts to soil over the entire irrigated area that significantly impact productivity for a moderate length of time (i.e. months) or over a limited area for a longer time period (1 -2 years).	Widespread groundwater resource depletion, groundwater quality degradation or contamination. Widespread changes to soil health over the irrigated area that prevent or restrict current or future potential agricultural land use in the medium to long-term due to soil contamination, salinization, soil structural collapse, etc.

The probability or likelihood of a consequence occurring (refer to Table 12) has also been assigned a qualitative descriptor. Risks are ranked from ‘Negligible’ through to ‘Extreme’, and are derived from the risk matrix (Table 13). The risk ranking therefore indicates the need for management intervention. This could include:

- Further assessment, investigation
- Management actions, implementation of mitigation measures (if available)

The severity of the risk ranking also provides an indication of the timing or prioritisation of the intervention. For example, an 'Extreme' risk ranking may require immediate attention, further assessment and/or mitigation measures to be implemented within short time frames to reduce the risk to an acceptable ranking. Conversely, a 'Negligible' risk ranking may require a watching brief only.

Table 12 Likelihood categories

Descriptor	Explanation
Almost Certain	The event is expected to occur in most circumstances >50% chance of occurring
Likely	The event will probably occur in most circumstances 25–50% chance of occurring
Possible	The event could occur 5–25% chance of occurring
Unlikely	The event could occur but not expected 1–5% chance of occurring
Rare	The event may occur only in exceptional circumstances Less than 1% chance of occurring

Table 13 Risk rating matrix

	Consequence				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Negligible	Low	Medium	High	High
Unlikely	Negligible	Low	Medium	Medium	High
Rare	Negligible	Negligible	Low	Medium	Medium

The level of data/information availability relating to the assessment of risk was considered in the following categories shown in Table 14. The rating of data/information availability was used to assess where any additional focus was required in mitigating the risk. For example, if a risk has a 'catastrophic' consequence and a low level of data or information available then more effort should be focussed on understanding and mitigating this risk, than an 'insignificant' consequence with a high level of data and information available.

Table 14 Data / information availability ratings

Criteria	Low Availability	Medium Availability	High Availability
Data / Information	Data and information is not specific to the region, conditions and industry and has very limited historical records or statistical support.	Data and information has some aspects specific to project region and conditions but not all. Historical records / statistical data are limited in some areas.	Data and information is specific to the region and conditions, and industry has sufficient historical records / statistics to support risk rating.

8.3 Risk rankings

The results of the risk assessment completed by GHD have been summarised in Table 15. Measures to mitigate risks have been included in the assessment. In some cases, further investigations may be required to select a preferred mitigation measure, after consideration of its particular cost and time implications.

Table 15 Risk Register

Risk	Pathway / Issue	Likelihood	Consequence	Risk Ranking	Data / Information availability	Mitigation Options
Groundwater/surface water						
GW1	Groundwater beneficial uses are impacted, by wastewater irrigation	Possible	Major	High	Medium	Investigations to characterise groundwater quality within the quaternary aquifer (QA), which is the water table aquifer. Comparison of wastewater quality against limits provided for in the SEPP (GoV) for the applicable groundwater segment. Development of controls to prevent discharge of water exceeding trigger limits for relevant beneficial uses in the QA near the site (protection of ecosystems, primary contact recreation) to groundwater. Final treatment and classification of wastewater (i.e., Class B or Class A) determined with regards to the risks associated with the use of Class B water at the site. Lower aquifers are confined beneath a low permeability layer (UMTD) and are unlikely to be directly impacted by irrigation of wastewater at the site. Plant selection to maximise water and nutrient use. Irrigation scheduled with reference to plant water use requirements and soil moisture probes to prevent discharge of irrigation drainage to groundwater. Use of an alternative site to dispose of the wastewater if preferred site proves unsuitable in a wet year due to flooding. Use of the dune area as a contingency disposal area if required. Environmental Improvement Plan (EIP) (which specifies controls for irrigation management practices based on guidance in EPA Publication 168).
GW2	Irrigation run-off enters drainage lines and waterways	Unlikely	Major	Medium	Medium	Environmental Improvement Plan (EIP) (which specifies controls for irrigation management practices based on guidance in EPA Publication 168). Available information suggests that due to the high

Risk	Pathway / Issue	Likelihood	Consequence	Risk Ranking	Data / Information availability	Mitigation Options
						permeability of the soil, surface run-off is unlikely (Brian Consulting Pty Ltd, December 2015) Irrigation limited to areas above the 1:20 year ARI with water balances indicating there is sufficient land above this extent available for irrigation Options to re-use wastewater or further reduce final wastewater volumes if further investigations indicate there is a significant risk to surface water and/or groundwater from irrigation in some of the area flagged as dispersal area in this report. Selection of final wastewater quality (Class B or A) based on an assessment of risks to surface water and irrigation type and buffer distances to surface water required to minimise risk.
GW3	Excavations expose and activate potential ASS	Possible	Major	High	Low	A review of the Victorian mapping of Coastal Acid Sulfate Soils Distribution (Map 2, for West Coast Victoria)[3] indicates a high potential for Acid Sulfate Soils (ASS) near the project site. Investigations to characterise the presence of ASS materials prior to excavation, with reference to applicable guidance documents[4]. Implementation of an ASS management plan if required.
Land capacity/irrigation management						
LP1	Contamination of soils/toxicity to crops/plantings due to excess levels of heavy metals or nutrients in wastewater	Unlikely	Moderate	Medium	Low	Soil toxicity considered unlikely due to relatively low nutrient load in wastewater and free draining, sandy soils. Test wastewater for nutrients and heavy metal concentrations prior to commencement of irrigation. Comparison of concentrations against guideline limits. Baseline soil testing prior to commencement of irrigation (for creation of EIP) and periodically thereafter in accordance

[3] Victorian Resources Online ww.dpi.vic.gov.au/vro
[4] Victorian Coastal Acid Sulfate Soil Strategy and Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils,

Risk	Pathway / Issue	Likelihood	Consequence	Risk Ranking	Data / Information availability	Mitigation Options
						with general guidance provided in EPA Publications 168 and 464.2. Irrigation with consideration to nutrient balances.
LP2	Over irrigation resulting in waterlogging and possible salinization of soils due to rise of saline water table suspected within 2 – 5 m of surface	Unlikely	Major	Medium	Low	Investigations to further characterise the site groundwater level in areas to be used for irrigation (particularly during periods of flooding adjacent the irrigation area, which is when groundwater levels will be highest. Careful selection of plantings best suited to the site environment (i.e., deep rooted, high water use and tolerant of periodic waterlogging) – update of the water balances and nutrient balances for the selected plant species at the EIP development stage prior to irrigation commencement. Creation of Environmental Improvement Plan (EIP) for irrigation with recycled water. Irrigation in accordance with water balances, monitoring of soil water moisture and application rates calculated in accordance with guidance provided in EPA Publication 168. Use of an alternative site to dispose of the wastewater if preferred site proves unsuitable in a wet year. Use of the dune area as a contingency disposal area if required.
LP3	Insufficient land onsite to irrigate all wastewater in onsite storage lagoons each year (overflow and onsite flooding)	Possible	Major	High	Low	The likelihood rating of ‘possible’ has been assigned based on uncertainty around the final choice of plants that will occur at a later stage in the project. Careful selection of plants with deep roots and high water use can reduce this ranking. Size onsite storages to hold 100% of wastewater and rainfall in a 90^{th} percentile wet year + 10% contingency. Current 10 ML provides more than a 10% contingency (as per water balances, refer to Appendix B). Use of the dune area as a contingency disposal area if required. Monitor of freeboard in the winter storage to implement a

Risk	Pathway / Issue	Likelihood	Consequence	Risk Ranking	Data / Information availability	Mitigation Options
						plan for alternative disposal if trigger levels within the storage is reached. Contingency option to truck/pipe excess water from site to alternative farmer's site (contingency options to be further assessed in future planning/EIP for site). Minimal water held in lagoons at start of wet season (April) so all incoming wastewater can be held over winter until irrigation can recommence (October).
LP4	Degradation of surface soil structure due to irrigation leading to increased erosion, hard setting, decrease in permeability and poor plant growth	Unlikely	Major	Medium	Low	Wastewater relatively low in salt, but sodium and other salts yet unknown. Free-draining, sandy soil reduces the risk of structural problems. Investigations to characterise the soil structure and chemistry (e.g. Sodium Adsorption Ratio (SAR), pH, salinity, etc.) prior to commencement of wastewater irrigation. Addition of top soil or fertilisers to improve top soil condition. Initial and periodic monitoring of wastewater and soil. Use of an alternative site to dispose of the wastewater if preferred site proves unsuitable in a wet year.
LP5	Poor plant growth due to excess or inadequate nutrients in wastewater	Possible	Moderate	Medium	Low	Irrigation with consideration to water and nutrient balances. Soil moisture monitoring and soil sampling to detect nutritional issues on a regular basis, as provided for in the EIP. Additional fertiliser inputs as required.

Risk	Pathway / Issue	Likelihood	Consequence	Risk Ranking	Data / Information availability	Mitigation Options
LP6	Risks to human health from irrigation.	Unlikely	Moderate	Medium	Low	Adherence to EPA guideline requirements for minimising human and animal exposure to Class B water (i.e., no access to areas during irrigation and until the area is dry, use of drippers, low-level micro-sprays or sub-surface drip to risk of access and exposure is minimal). Colour-coding of pipes in accordance with relevant standards and removal of tap heads to prevent people accessing recycled water (tap heads available to maintenance staff only). Reduce risk to human health by option to increase water treatment to Class A water if deemed necessary. Indirect risks to human health from impacts of groundwater discharge to the estuary and primary contact recreation could occur, but are unlikely. Risk to human health mitigated by careful application of wastewater irrigation to prevent discharge of wastewater in excess of guideline limits to groundwater. Training of staff/landholders that will come in contact with water so they are aware of risks. Clear signage in accordance with relevant guidelines to reduce risk of exposure (i.e. drinking of wastewater from taps).

9. Conclusions and next steps

9.1 Conclusions

The groundwater assessment determined that the proposed Princetown Resort site is located on quaternary age sediments and that these sediments consist of coastal dune deposits, redeposited dunes, quartz and calcareous sands, well sorted and unconsolidated, silts and clays. The water table at the site is shallow (less than 5 m below ground level) and situated within the Quaternary Aquifer (QA). The site is within 1.5 km of Groundwater Dependant Ecosystems including the Gellibrand River, La Trobe Creek, Boggy Creek and the surrounding wetlands. Groundwater levels within the QA are influenced by water levels within the Gellibrand River estuary and the site is subject to periodic flooding. Groundwater within the local area is extracted from the Lower Tertiary Aquifer (> 31 m below ground level) which is separated from the water table by an aquitard between 4 – 30 m below ground level. The site occurs within the Newlingrook Groundwater Management Area (GMA), which pertains to all geological units at this location. The permissible consumptive volume (PCV) for the Newlingrook GMA is 1,977 ML/year. Groundwater quality within the water table aquifer has been assessed as Segment A2 for the purpose of this assessment.

The soils at the site have been assessed as sand or clayey sand and that the coarse, calcareous sands at the site have a very high permeability and a very low water holding capacity. This information, along with the presence of a shallow water table indicates that there is high potential for irrigation water to leach to groundwater unless carefully managed.

Water balances completed for the site indicates that there is sufficient land, including 7.76 ha at the site plus a possible 1.5 ha of dunes (covered with native vegetation) to irrigate wastewater at the site. It is considered likely that the best vegetation for the site will be a combination of native, deep rooted plants that are endemic or otherwise well suited to the coastal environment. Specific crop factors for such plant species were not available for this assessment, with water balances completed using a number of different plant types to illustrate the potential range of water use of different plant species that could be utilised onsite. Initial nutrient balances indicate that the proposed wastewater quality is not prohibitive to irrigation, provided that appropriate measures are put in place to monitor and manage nutrient loads and fertiliser inputs to prevent discharge of contaminated drainage water to the underlying shallow groundwater table.

A risk assessment was undertaken to identify the potential impacts arising from the irrigation of the treated wastewater at the site. The risk assessment was preliminary and shows the risks prior to implementation of mitigation measures presented in the risk assessment table. Further refinement of this risk assessment will be undertaken as part of the EIP for the site.

Key groundwater risks (where a risk rating prior to mitigation measures of medium or higher was identified) include:

- Impact to groundwater beneficial uses by wastewater irrigation
- Irrigation run-off entering drainage lines and waterways

Key land capability/irrigation management risks identified include:

- Contamination of soils/toxicity to crops/planting due to excess levels of heavy metals or nutrients in wastewater
- Over irrigation resulting in waterlogging and possible salinization of soils due to rise of saline water table within 2 m of the surface

- Insufficient land onsite to irrigate all wastewater in onsite storages each year (overflow and onsite flooding)
- Degradation of surface soil structure due to irrigation leading to increased erosion, hard setting, decreasing in permeability and poor plant growth
- Poor plant growth due to excess or inadequate nutrients in the wastewater
- Risks to human health from irrigation

The mitigation measures presented in the risk assessment table (Table 15) form the basis for the future works provided in the section below.

9.2 Next steps to be completed

Mitigation measures have been identified in section 8.3 as part of the risk assessment and throughout the report. In summary, further investigations will be undertaken as part of future project stages (including detailed design and development of the EIP for submission to EPA prior to irrigation) to:

- Characterise the groundwater quality within the Quaternary Aquifer (QA), which is the shallow water table aquifer at the site. Information obtained from groundwater testing will be compared with the final proposed wastewater quality and limits for water quality provided in the SEPP (GoV) and supporting guidelines.
- Identify the most appropriate plant types for irrigation at the site with consideration to suitability for planting in the sandy, free-draining soil types and tolerance to possible periodic flooding of the lower root-zone during periods of flood.
- Further soil testing (soil chemistry) of the proposed irrigation areas to assess the potential for any limitations within the soil, which may limit irrigation (such as salinity or sodicity). Soil sampling will also include the dune area, which all also require permeability testing to identify if this 1.5 ha is suitable as an alternative area for water disposal in a wet year (if required).

Following on from the above investigations, the following will completed:

- Completion of a revised water balance and nutrient balance with reference to the water and nutrient uptake of the preferred combination of plants for the site.
- Updating of the risk to the beneficial uses of groundwater based on the results of groundwater testing and comparison with wastewater quality parameters against guideline limits.
- Revision of the risk assessment to show mitigation measures and revised risk levels and formation of specific mitigation measures for inclusion in the EIP for the site to reduce the risks identified for the site.
- Further develop the contingency options for alternative disposal of excess wastewater in storages in a wet year. This may include negotiations with local landholders to accept excess water, irrigation of the dune area and provisions for continuously monitoring water levels within the winter storage against developed trigger levels. Trigger levels (metres of freeboard) will be identified against specific storage levels for both ‘watch and act’ interim levels and action levels to allow for the implementation of the contingency measures if required.
- Develop an EIP for the site with reference to the investigations listed above, EPA Publication 464.2 and EPA Publication 168. The EIP will also include:
  - Updated water and nutrient balances

- Soil and wastewater quality monitoring program
- Guidance on sustainable irrigation practices (application rates, times and duration, requirement for fertiliser program, etc.)
- Control measures to mitigate risks to soil health, the natural environment and human health as appropriate

The EIP will be submitted to EPA prior to irrigation commencing.

10. References

Brian Consulting Pty Ltd. (December 2015). *Land Capability Assessment 1 Old Coach Road Princetown.* Warranmbool, VIC: Brian Consulting.

Corangamite Catchment Management Authority. (2015). *Flood Advice 1 Old Coach Road Princetwon Victoria, 3269 .* Colac, Victoria: Corangamite Catchment Management Authority reference F-2015-0646.

GHD. (2016). *Old Coach Road Development Flood Level Report.* Melbourne, Vic: GHD Pty Ltd.

University of California . (2016). *Center for Landscape and Urban Horticulture - Turf Grass Crop Coefficients.* Retrieved May 11, 2016, from University of California Division of Agriculture and Natural Resources : http://ucanr.edu/sites/UrbanHort/Water_Use_of_Turfgrass_and_Landscape_Plant_Materials/Turfgrass_Crop_Coefficients_Kc/

11. Limitations

This report: has been prepared by GHD for Montarosa Pty Ltd and may only be used and relied on by Montarosa Pty Ltd for the purpose agreed between GHD and the Montarosa Pty Ltd as set out in section 2.3 of this report.

GHD otherwise disclaims responsibility to any person other than Montarosa Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.3 and 2.3 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

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Appendices

Appendix A – Hydrogeological assessment

Geological setting

The study site is located in the township of Princetown as shown in Figure 1. The surface geology at the project site comprises Quaternary unconsolidated sediments consisting of swamp, lake and estuarine deposits, coastal, beach and dune deposits, quartz and calcareous sands, which are well sorted and unconsolidated.

The subsurface geology and hydrostratigraphy was interpreted utilising the Geological Survey of Victoria Colac 1:250,000 mapsheet and DELWP's Victorian Aquifer Framework (VAF) datasets. A summary of the interpreted hydrostratigraphy has been provided in Table 16, while surficial geology at the site is shown in Figure 2. The units most relevant to the study area are described further in the following sections.

Table 16 Simplified stratigraphic profile

Period	Sub Period	Indicative Depth (m)	Geological Formation	Lithology	Hydrostratigraphic Unit	Aquifer?
Quaternary		0-4		sand, gravels, clay, silts	Quaternary Aquifer (QA)	Yes
Tertiary	Miocene	4-30	Gellibrand Marl	clay, silt, marl (fractured rock) and minor sand	Upper-Mid Tertiary Aquitard (UMTD)	No
	Eocene-Oligocene	30 -31	Clifton Formation	sand, gravel, limestone (fractured rock), minor clay, occasional coal	Lower Mid-Tertiary Aquifer (LMTA)	Yes
	Mid-Lower Eocene	31 - 370	Mepunga Formation, Dilwyn Formation, pebble Point Formation, Moomowroong Sands and Wiridjil Gravel.	sand, gravel, clay and silt, minor coal	Lower Tertiary Aquifer (LTA)	Yes
Mesozoic to Palaeozoic	Cretaceous and Permian	370 -500	Sherbrook Group Otway Group (Eumeralla Formation)	Sandstone, mudstone, siltstone (all fractured rock), sand and minor coal	Cretaceous and Permian Sediments Aquitard (CPS)	No
Palaeozoic		500 -700	Basement rocks	sedimentary and igneous rocks	Basement rocks Aquifer (BSE)	Yes

Figure 1 Site location

THIS DIAGRAM SHOWS THE ON SITE AREA AVAILABLE FOR THE WASTE WATER IRRIGATION FIELD
THE FINAL IRRIGATION SOLUTION WILL BE DESIGNED TO WORK WITHIN THESE CONSTRAINTS.

AREA AVAILABLE FOR IRRIGATION IS 9ha (EXCLUDES BUILT AREA OF 2ha)

Provisional Irrigation Areas

Princetown Resort

For Information

Original Size: A3

Drawing No: 31-33908-SK001

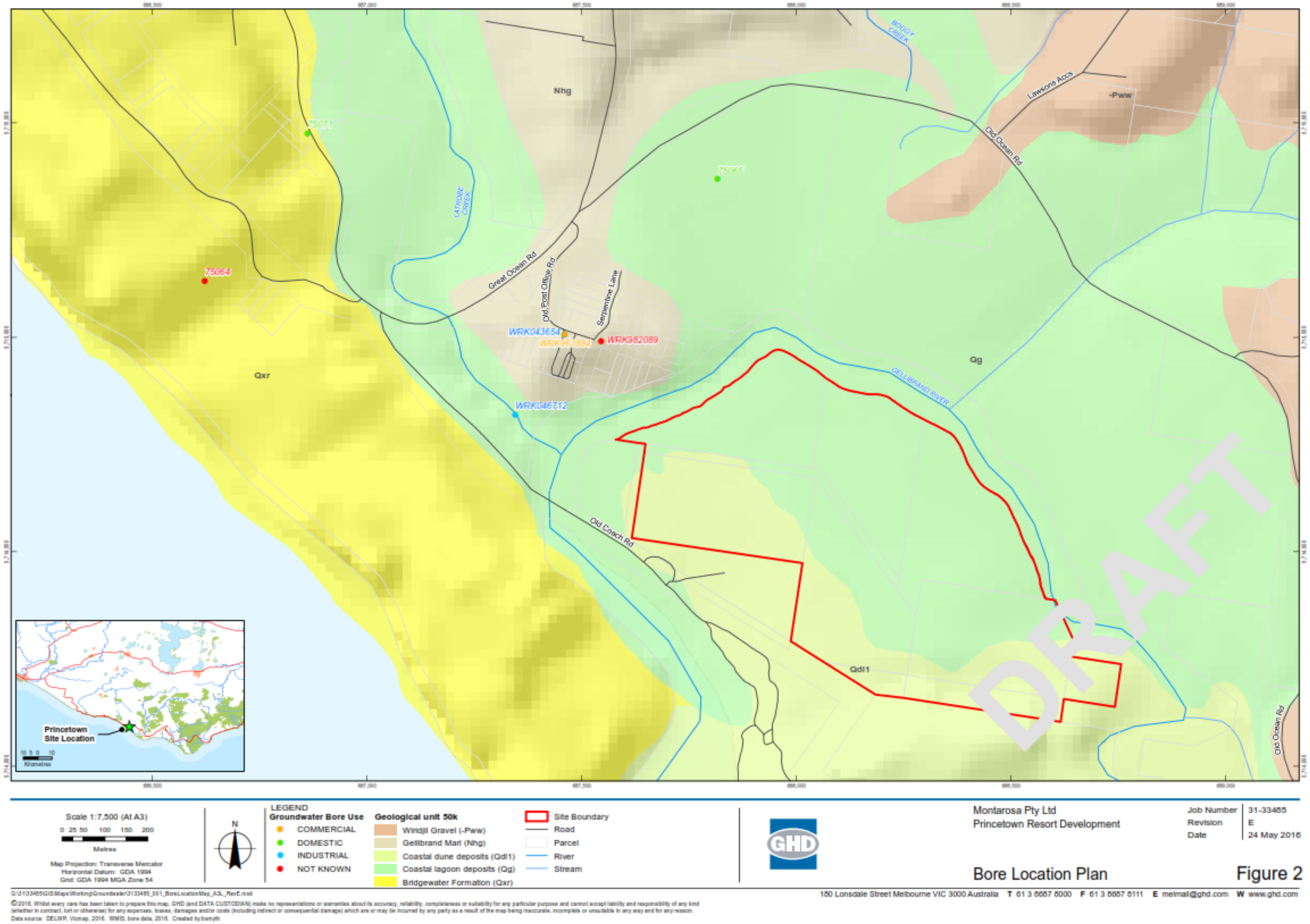
Approved: PT

Rev: M

GHDWOODHEAD

Level 8, 180 Lonsdale Street, Melbourne VIC 3000

Figure 2 Site location, surface geology and identified groundwater bores



Relevant aquifers and nature of confinement

Stratigraphic formations that contain or can transmit groundwater are termed aquifers. The Department of Environment, Land, Water and Planning (DELWP) VAF Secure Allocation Future Entitlements (SAFE) project data was used to identify the occurrence, thickness and salinity of aquifers (and aquitards) near the project site; the results of which are shown in Table 17. The SAFE mapping indicates a number of aquifers and aquitards beneath the site. The shallow aquifers of relevant to the site are the:

- **Quaternary Aquifer (QA).** The QA is likely to form the water table aquifer across the site (refer Figure 3).
- **Lower Mid-Tertiary Aquifer (LMTA) and Lower Tertiary Aquifer (LTA).** The LMTA is approximate only 1 m thick in the area so it is considered along with the LTA, which is around 31 to 371 m below ground. These aquifers are confined by the Upper Mid-Tertiary Aquitard, which is around 25 m thick in the region. The LTA is also considered to be a water table aquifer to the north and east of the site.

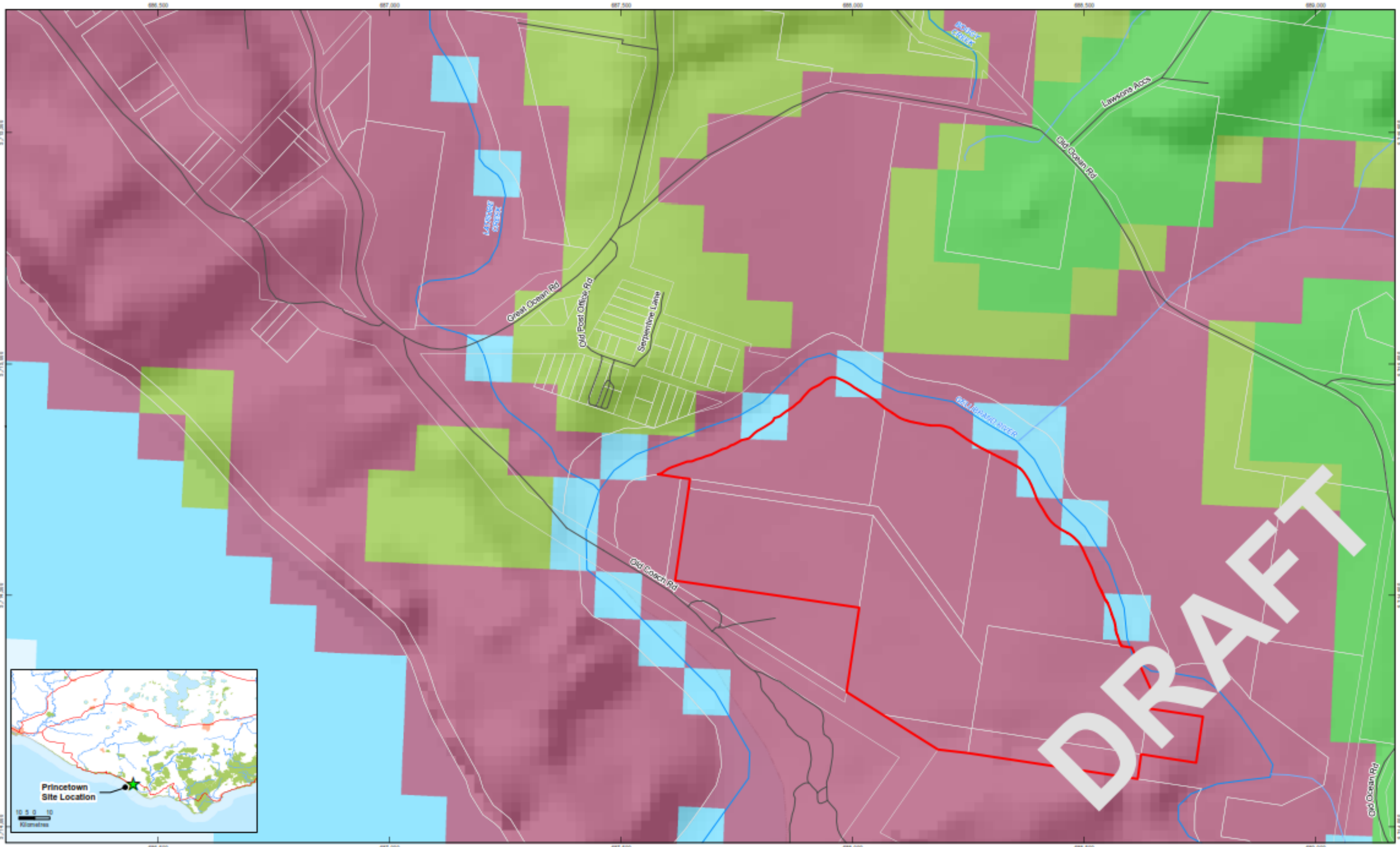
The water table aquifers (i.e. the shallowest saturated hydrogeological units) that are relevant to the site are shown in Figure 3.

Table 17 SAFE groundwater layers

Groundwater Layers	Layer description	Depth below surface (m)		Groundwater Salinity (mg/L)
		From	To	
Quaternary Aquifer (QA)	sand, gravels, clay, silts	0	4	501 to 1,000
Upper Mid-Tertiary Aquitard (UMTD)	clay, silt, marl, minor sand	4	30	Unknown
Lower Mid- Tertiary Aquifer (LMTA)	Sand, gravel, limestone, minor clay, occasional coal	30	31	<500
Lower Tertiary Aquifer (LTA)	sand, gravel, clay and silt, minor coal	31	371	<500
Cretaceous and Permian Sediments (CPS)	Sandstone, mudstone, siltstone, sand, minor coal	371	497	Unknown
Basement rocks Aquifer (BSE)	sedimentary and igneous rocks	497	>700	501 to 1,000

Source: DELWP (2016)

Figure 3 Water table aquifers



Scale 1:7,500 (At A3)
0 25 50 100 150 200
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

N

LEGEND
Aquifer intersected by watertable
- Surface water
- Lower Tertiary Aquifer (LTA)
- Quaternary Aquifer (QA)
- Upper-Mid Tertiary Aquitard (UMTD)
- Site Boundary
- Road
- Parcel
- River
- Stream

Montarosa Pty Ltd
Princetown Resort Development

Job Number 31-33485
Revision C
Date 24 May 2016

Watertable Aquifer Map
Figure 3

G:\31\33485\GIS\Maps\Working\Groundwater\3133485_003_WaterTableMap_A3L_RevC.mxd

Data source: DELWP, Vicmap, 2016. Created by:bsmyth

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Groundwater management

DELWP has recognised areas of intensive groundwater use throughout Victoria. The principle management unit for groundwater resources in Victoria is the Groundwater Management Unit (GMU). A GMU may be a Groundwater Management Area (GMA), a Water Supply Protection Area (WSPA) or an Unincorporated Area (UA). These are declared under the *Water Act 1989* to provide sustained management of the groundwater resources.

A WSPA is essentially a GMA with a management plan, which may include caps or moratoriums on the issue of additional extraction licenses. WSPAs have been developed in areas that require more intensive management due to extensive use of groundwater. An unincorporated area is a region falling outside of a GMA or WSPA.

The site lies within the Newlingrook GMA and has a permissible consumptive volume of 1,977 ML/year (DELWP 2016). The groundwater licensing authority throughout the study area is Southern Rural Water (SRW).

Drilling data

Drilling data was collated from DELWP's Water Measurement Information System (WMIS), which contains records for existing boreholes near the site. Lithological logs were available for one bore in the site vicinity and has been summarised in Table 18.

Table 18 Lithological logs of bore WRK963884

Bore	Depth (m)		Description
	From	To	
Bore WRK963884	0	1	Top soil
	1	20	Clay
	20	45	Cemented sands
	45	58	Black clay
	58	97	Marley sand

Groundwater bore information

WMIS bores

A search of the WMIS was undertaken to identify and characterise groundwater and geology in the site area. Based on a search of the WMIS data, seven bores were identified within 1.5 km of Princetown. These bore are shown in Figure 2 and the bore details are summarised in Table 19.

Groundwater use

Two of the identified bores did not specify use. Two of the bores were drilled for domestic purpose, another two of the bores were used for industrial purposes and the remaining one bore was used for commercial purposes. Figure 2 shows bore use for bores identified in the site vicinity. Some of these bores have groundwater information including construction details, logs and chemistry as included in Table 19.

Bore yields

Bore yield can be used as a guide to the hydraulic character of aquifers. It should be noted that bore yield is dependent upon bore construction and aquifer penetration/intersection, and that many stock and domestic bores may not necessarily have been constructed as high yielding bores. Bore yield data was not recorded for the seven bores identified within 1.5 km of Princetown.

Table 19 Summary of nearby WMIS groundwater bores

Bore ID	Easting (MGA 54)	Northing (MGA 54)	Constructed Date	Constructed Depth (m)	Elevation at ground level (mAHD)	Bore Use	Screen From (m)	Screen To (m)	Screened Lithology	Electrical Conductivity (µS/cm)
75064	686622.3	5715132	31/12/1963	625.75	38	Not known	-	-	-	-
75065	687817	5715369	9/05/1968	128.02	Unknown	Domestic	0	128.02	-	816
75071	686861.3	5715477	1/01/1988	Unknown	25	Domestic	-	-	-	-
WRK043654	687461.6	5715006	Unknown	Unknown	22.24	Industrial	-	-	-	-
WRK046712	687345	5714820	Unknown	Unknown	1.96	Industrial	-	-	-	-
WRK963884	687461.6	5715006	20/12/2003	97	22.4	Commercial	66	93	Marley sand	-
WRK982089	687546	5714993	Unknown	100	21.98	Not known	-	-	-	-

Groundwater levels

The depth to groundwater near the site is shown on Figure 4. Based on this review, groundwater level data was not identified from existing neighbouring bores.

Figure 4 shows that based on regional mapping, the water table is likely to occur at depths of less than 5 m below the ground surface, within the QA.

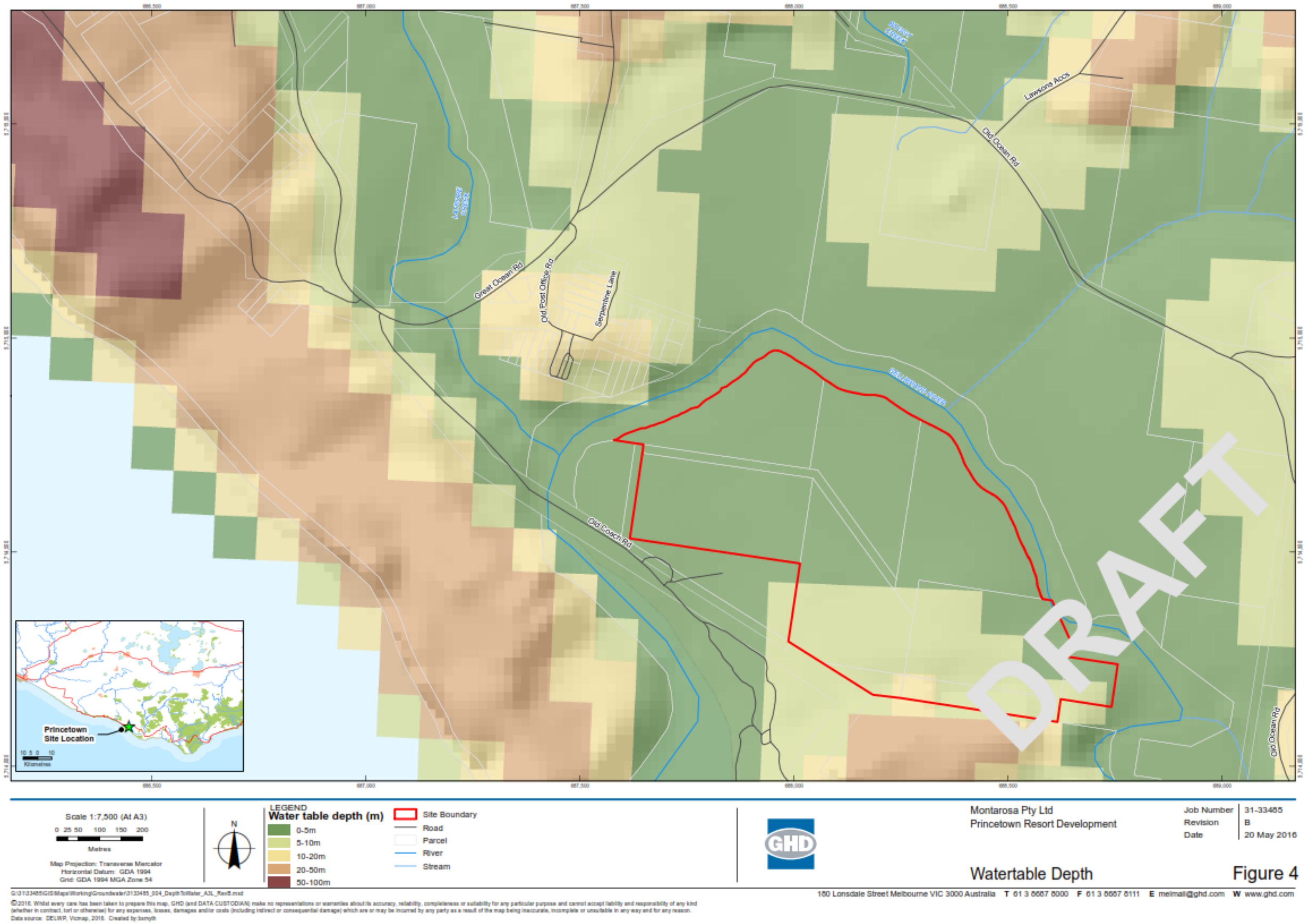
State groundwater observation bores

There were no identified state observation network (SON) bores located within 1.5 km of the site, although there is an extensive network of SON bores across the Newlingrook GMA.

Groundwater recharge and flow systems

There is limited groundwater flow information available in the area. Based on the SAFE mapping of the watertable aquifer, it is likely that groundwater flows are influenced at the site by the Gellibrand River, which largely encircles the site. Shallow groundwater flow in the water table aquifer is likely to be locally influenced by this surface water feature. Regionally, groundwater flow in the LTA occurs southerly towards Bass Strait.

Figure 4 Depth to water table



Groundwater quality

Local groundwater quality

At the time of reporting, there was no available groundwater quality information available for the water table aquifer at the site.

The only bore within 1.5 km which recorded salinity information was bore 75065, screened in the LTA, which recorded an electrical conductivity value of 816 µS/cm (or approximately 490 mg/L TDS, using a conversion factor of 0.6).

Groundwater quality was also tested from a LTA bore near Princetown (refer Section 6.2). This bore showed salinity in the order of 380 mg/L TDS.

Regional groundwater quality

Regional mapping (DELWP, 2015) indicates fresh groundwater quality (501 mg/L to 1,000 mg/L TDS) in the QA and BSE and fresher groundwater quality (<500 mg/L TDS) in the LMTA and LTA aquifers (which is consistent with results from bore 75065).

SAFE mapping data indicates a higher salinity range (1,000 mg/L to 3,500 mg/L TDS) for the water table aquifer (i.e. the QA) across the site (refer to Figure 5).

Therefore, there is some inconsistency in the regional mapping of the groundwater quality in the water table aquifer directly beneath the site (i.e. the QA) with it either being in the range:

- 501 mg/L to 1,000 mg/L TDS (DELWP ,2015); or
- 1,000 mg/L to 3,500 mg/L TDS (SAFE dataset).

The installation of a shallow, groundwater monitoring bore at the site would be required to further assess the shallow groundwater at the site specifically, with a higher degree of confidence.

Beneficial uses

Groundwater quality data from Groundwater Resource Report and SAFE mapping has been used to appraise regional groundwater quality characteristics for each major aquifer that occurs beneath the site.

Under the *Environment Protection Act 1970* and upon recommendation of the EPA, the State of Victoria enacted a SEPP *Groundwaters of Victoria 1997*, which has the objective to maintain and where possible, improve groundwater quality sufficient to protect existing and potential beneficial uses.

The policy forms the primary guide to assessing existing impacts and risk of impacts to groundwater quality. It categorises groundwater into segments based on the groundwater salinity, with each segment having particular identified uses. The segments and their beneficial uses are summarised in Table 20.

Table 20 SEPP groundwater segments

Use	Segment (mg/L TDS)				
	A1	A2	B	C	D
	0 – 500	501 – 1,000	1,001 – 3,501	3,501 – 13,000	>13,000
Maintenance of Ecosystems	✓	✓	✓	✓	✓
Potable Water					
Desirable	✓				
Acceptable		✓			
Potable Mineral Water Supply	✓	✓	✓		
Agriculture, parks and gardens	✓	✓	✓		
Stock Watering	✓	✓	✓	✓	
Industrial water use	✓	✓	✓	✓	✓
Primary contact recreation (e.g. swimming / bathing)	✓	✓	✓	✓	
Buildings and structures	✓	✓	✓	✓	✓

The EPA may determine that these beneficial uses do not apply to groundwater where:

- There is insufficient yield
- The background level of a water quality indicator other than TDS precludes a beneficial use
- The soil characteristics preclude a beneficial use, or
- A groundwater quality restricted use zone has been declared.

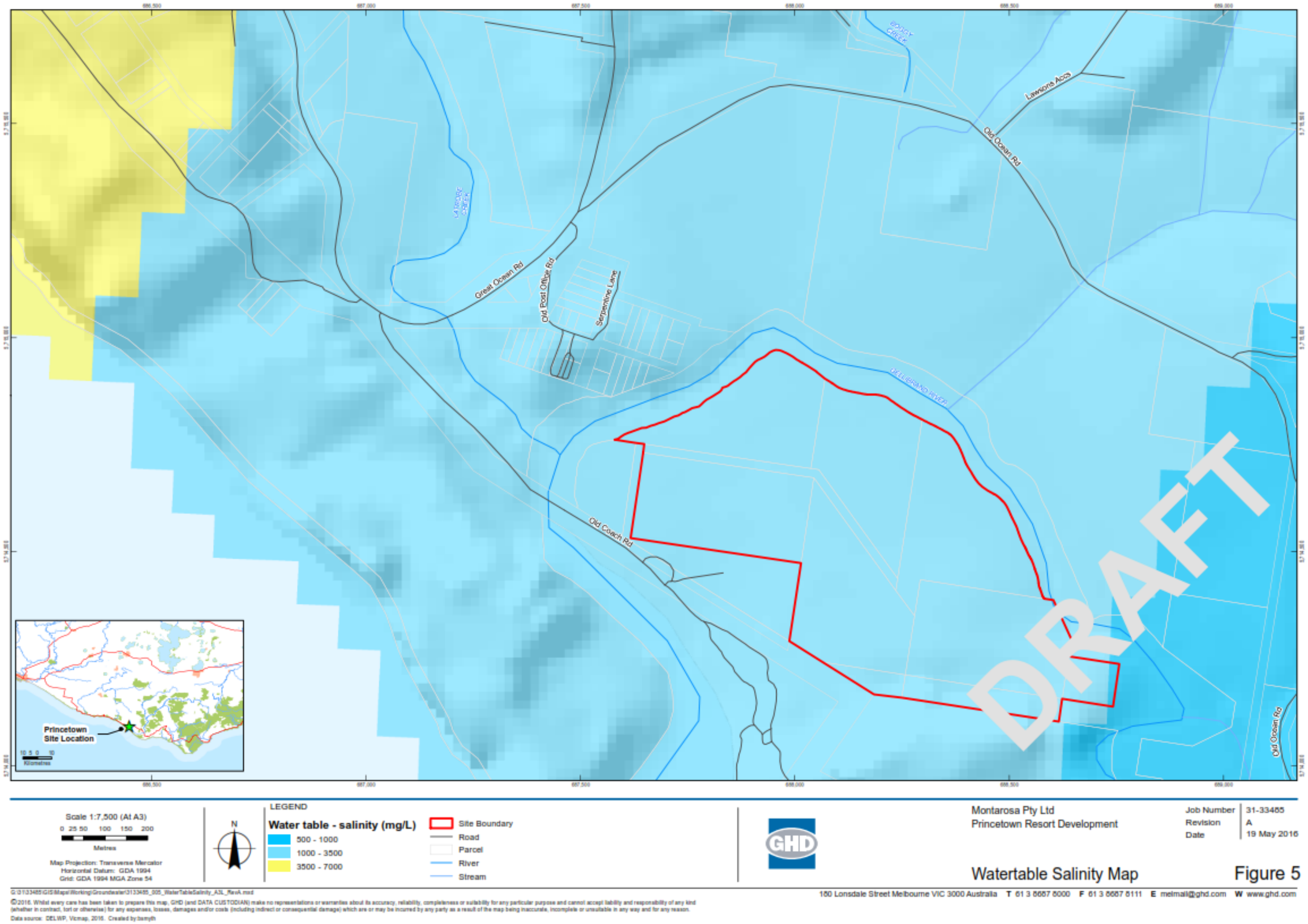
The SEPP (*Groundwaters of Victoria*) also requires that occupational health and safety and odour and amenity be considered, due to the fact that vapours sourced from impacted groundwater may present a potential risk to workers and that odours or discolouration may result in the degradation of the overall beneficial use.

Based on the groundwater salinity data obtained from the SAFE mapping layers, the groundwater in the water table aquifer (ie QA) beneath the site is likely to be ***either segment A2 or B based on the SEPP (Groundwaters of Victoria).*** As such, the identified beneficial uses of groundwater to be protected in the water table aquifer include:

- Potable Water (Acceptable)
- Maintenance of ecosystems, which includes groundwater discharges to the environment
- Potable mineral water supply
- Agriculture, parks and gardens
- Stock watering
- Industrial water use
- Primary contact recreation
- Buildings and structures.

As noted, there is some inconsistency in the mapped groundwater salinity in the water table aquifer at the site, and further work would be required to confirm the groundwater salinity and the protected beneficial use segment.

Figure 5 Groundwater salinity



Groundwater dependent ecosystems

Definition

A groundwater dependent ecosystem (GDE) is an ecosystem, which has its species composition and natural ecological processes determined by groundwater. That is, they are natural ecosystems that require access to groundwater to meet all, or some of their water requirements to maintain their communities of plants and animals, ecological processes and ecosystem services. If the availability of groundwater to GDEs is reduced, or if the quality is allowed to deteriorate, these ecosystems will be impacted.

It is widely acknowledged that a poor understanding exists in recognising GDEs, or understanding the hydrogeological processes affecting GDEs, or their environmental water requirements. GDEs can be broadly grouped into three categories:

1. Ecosystems that depend on the surface expression of groundwater:
   - Swamps and wetlands can be sites of groundwater discharge and may represent GDEs. The sites may be permanent or ephemeral systems that receive seasonal or continuous groundwater contribution to water ponding or shallow water tables. Tidal flats and inshore waters may also be sites of groundwater discharge. Wetlands can include ecosystems on potential acid sulphate soils and in these cases maintenance of high water levels may be required to prevent waters from becoming acidic.
   - Permanent or ephemeral stream systems may receive seasonal or continuous groundwater contribution to flow as base flow. Interaction would depend upon the nature of stream bed and underlying aquifer material and the relative water level heads in the aquifer and the stream.
2. Ecosystems that depend on the subsurface presence of groundwater. Terrestrial vegetation such as trees and woodlands may be supported either seasonally or permanently by groundwater. These may comprise shallow or deep rooted communities that use groundwater to meet some or all of their water requirements. Animals may depend upon such vegetation and therefore indirectly depend upon groundwater. Groundwater quality generally needs to be high to sustain the vegetation growth.
3. Ecosystems that reside within a groundwater resource. These are referred to as hypogean ecosystems. Micro-organisms in groundwater systems can exert a direct influence on water quality, for example, stygofauna typically found in karstic, fractured rock or alluvial aquifers.

GDEs in the study area

To assess if there are identified GDE sites located in the Princetown area, a search was undertaken using the National Atlas of Groundwater Dependent Ecosystems (BOM, 2016). The search identified three GDEs within 1.5 km of the site. Identified GDEs include:

- Gellibrand River (surface expression), situated less than 50 m from, and largely bordering, the site. The river has been identified as having a high potential for groundwater interaction.

- Latrobe Creek (surface expression), situated less than 100 m north-west of the site. The creek has been identified as having a high potential for groundwater interaction.
- Boggy Creek (surface expression), situated less than 850 m north of the site. The creek has been identified as having a high potential for groundwater interaction.
- Wetlands (surface expression), situated partly over the site and around the neighbouring rivers and creeks. These wetlands have been identified as generally a high to moderate potential for groundwater interaction.

Assumptions and limitations of the hydrogeological review

Hydrogeology data sources

The hydrogeological investigations have relied on a number of different data sources, these included:

- Published geological maps and reports
- Victorian Government data including the SAFE mapping system, topographic data, meteorological data and Water Measurement Information System (WMIS)
- National GDE datasets from the BoM.
- GHD, 2006, "Newlingrook GMA, Review of Groundwater Resources" Report for Department of Sustainability and Environment

Dealing with data / information availability

The hydrogeological assessment had been used to identify potential risks to the groundwater environment. There is a degree of uncertainty involved in the assignment of risks that is dependent on the availability of site specific information (i.e., groundwater levels, lithology logs and groundwater quality information). Uncertainty regarding data/information availability has been managed through using a conservative approach when assigning consequences associated with risks.

Notes regarding WMIS data

- Bores installed prior to the proclamation of the original *Water Act 1989* may not be registered as there was no mandatory requirement to licence bores prior to this date
- The WMIS does not provide information regarding the operational status or casing condition status of groundwater bores
- Bores installed without a bore construction licence are unlikely to be registered on the WMIS

- Many bores have not been surveyed for location
- The information registered on the WMIS is subject to the accuracy of bore completion reports submitted by drilling contractors
- Information registered on the WMIS is subject to change since the completion of a bore e.g. water level information, pump setting depth, groundwater quality
- Some information is not available on the WMIS (e.g. pump setting depth, bore ownership)
- The WMIS does not provide information regarding the currency of bores with licensable extractive use, i.e. a bore indicated as being an irrigation bore may not have any allocation attached to it. That is, the intended use may have altered due to identified low yield or poor quality groundwater. These use changes are not reflected in the WMIS.

Appendix B – Water and nutrient balances

NUTRIENT BALANCES

Scenario modelled (information provided) **combination of turf grass and immature trees scenario**

Email from Tim indicates 50 - 100 mg/L N and 8 - 16 mg/L P in the wastewater

	Lower	Upper		
N	50	100	mg/L	(kg/ML)
P	8	16	mg/L	(kg/ML)

*Note: 1 mg/L = 1 kg/ML

*percentages are based on scenario assumptions, see other spreadsheets in workbook

	Guideline		
Nitrogen	kg/ha/yr	kg/ha/yr	kg/ha/yr
Rye grass	180	54	30%
Couch (Bermuda)	280	84	30%
Eucalypt	90	36	40%
		174	
Phosphorus	**Guideline**		
Nitrogen	kg/ha/yr	kg/ha/yr	
Rye grass	70	21	30%
Couch (Bermuda)	40	12	30%
Eucalypt	15	6	40%
		39	

Average Year, Scenario 2, upper limit	
Nitrogen	
100	kg/ML
2.5	ML/ha/year
250	kg/ha/yr applied
183.00	kg/ha/yr extracted
67.00	**accumulated nitrogen**
Average Year, Scenario 2, lower limit	
50	kg/ML
2.5	ML/ha/year
125	kg/ha/yr applied
183.00	kg/ha/yr extracted
-58.00	**deficit nitrogen**
Phosphorus	
Average Year, Scenario 2, upper limit	
16	kg/ML
2.5	ML/ha/year
40	kg/ha/yr applied
39.00	kg/ha/yr extracted
1.00	**accumulated phosphorus**
8	kg/ML
2.5	ML/ha/year
20	kg/ha/yr applied
39.00	kg/ha/yr extracted
-19.00	**deficit phosphorus**

Wet year, Scenario 2, lower limit	
Nitrogen	
100	kg/ML
1.8	ML/ha/year
180	kg/ha/yr applied
183.00	kg/ha/yr extracted
-3.00	**deficit nitrogen**
Wet Year, Scenario 2, lower limit	
50	kg/ML
1.8	ML/ha/year
90	kg/ha/yr applied
183.00	kg/ha/yr extracted
-93.00	**deficit nitrogen**
Phosphorus	
Wet Year, Scenario 2, upper limit	
16	kg/ML
1.8	ML/ha/year
28.8	kg/ha/yr applied
39.00	kg/ha/yr extracted
-10.20	**deficit phosphorus**
8	kg/ML
1.8	ML/ha/year
14.4	kg/ha/yr applied
39.00	kg/ha/yr extracted
-24.60	**deficit phosphorus**

Dry year, Scenario 2, lower limit		
Nitrogen		
100	kg/ML	
3.4	ML/ha/year	
340	kg/ha/yr	applied
183.00	kg/ha/yr	extracted
157.00	**accumulation nitrogen**	
Dry Year, Scenario 2, lower limit		
50	kg/ML	
3.4	ML/ha/year	
170	kg/ha/yr	applied
183.00	kg/ha/yr	extracted
-13.00	**deficit nitrogen**	
Phosphorus		
Dry Year, Scenario 2, upper limit		
16	kg/ML	
3.4	ML/ha/year	
54.4	kg/ha/yr	applied
39.00	kg/ha/yr	extracted
15.40	**accumulation phosphorus**	
8	kg/ML	
3.4	ML/ha/year	
27.2	kg/ha/yr	applied
39.00	kg/ha/yr	extracted
-11.80	**deficit phosphorus**	

*above calculations doesn’t take into account a dilution factor of rainfall

*can be calculated by annual rainfall - evaporation, calculated as a percentage dilution factor of total volumes irrigated

NUTRIENT BALANCES

Scenario modelled (information provided) **100% Turf grass scenario**

	Guideline	
Nitrogen	kg/ha/yr	
Couch (Bermuda)	280	100%
*100% for Couch as Winter Grass is not irrigated		
Phosphorus	**Guideline**	
Nitrogen	kg/ha/yr	
Couch (Bermuda)	40	100%

Email from Tim indicates 50 - 100 mg/L N and 8 - 16 mg/L P in the wastewater

	Lower	Upper		
N	50	100	mg/L	(kg/ML)
P	8	16	mg/L	(kg/ML)

*Note: 1 mg/L = 1 kg/ML

*percentages are based on scenario assumptions, see other spreadsheets in workbook

Average Year, Scenario 2, upper limit		
Nitrogen		
100	kg/ML	
3.4	ML/ha/year	
340	kg/ha/yr	applied
280.00	kg/ha/yr	extracted
60.00	**accumulation nitrogen**	
Average Year, Scenario 2, lower limit		
50	kg/ML	
3.4	ML/ha/year	
170	kg/ha/yr	applied
280.00	kg/ha/yr	extracted
-110.00	**deficit nitrogen**	
Phosphorus		
Average Year, Scenario 2, upper limit		
16	kg/ML	
3.4	ML/ha/year	
54.4	kg/ha/yr	applied
40.00	kg/ha/yr	extracted
14.40	**accumulated phosphorus**	
8	kg/ML	
3.4	ML/ha/year	
27.2	kg/ha/yr	applied
40.00	kg/ha/yr	extracted
-12.80	**deficit phosphorus**	

Wet year, Scenario 2, lower limit		
Nitrogen		
100	kg/ML	
2.4	ML/ha/year	
240	kg/ha/yr	applied
280.00	kg/ha/yr	extracted
-40.00	**deficit nitrogen**	
Wet Year, Scenario 2, lower limit		
50	kg/ML	
2.4	ML/ha/year	
120	kg/ha/yr	applied
280.00	kg/ha/yr	extracted
-160.00	**deficit nitrogen**	
Phosphorus		
Wet Year, Scenario 2, upper limit		
16	kg/ML	
2.4	ML/ha/year	
38.4	kg/ha/yr	applied
40.00	kg/ha/yr	extracted
-1.60	**deficit phosphorus**	
8	kg/ML	
2.4	ML/ha/year	
19.2	kg/ha/yr	applied
40.00	kg/ha/yr	extracted
-20.80	**deficit phosphorus**	

Dry year, Scenario 2, lower limit		
Nitrogen		
100	kg/ML	
4.4	ML/ha/year	
440	kg/ha/yr	applied
280.00	kg/ha/yr	extracted
160.00	**accumulation nitrogen**	
Dry Year, Scenario 2, lower limit		
50	kg/ML	
4.4	ML/ha/year	
220	kg/ha/yr	applied
280.00	kg/ha/yr	extracted
-60.00	**deficit nitrogen**	
Phosphorus		
Dry Year, Scenario 2, upper limit		
16	kg/ML	
4.4	ML/ha/year	
70.4	kg/ha/yr	applied
40.00	kg/ha/yr	extracted
30.40	**accumulation phosphorus**	
8	kg/ML	
4.4	ML/ha/year	
35.2	kg/ha/yr	applied
40.00	kg/ha/yr	extracted
-4.80	**deficit phosphorus**	

NUTRIENT BALANCES

Scenario modelled (information provided) **100% lucerne scenario**

Using lower limits for nitrogen and phosphorus uptake of lucerne

	Guideline	
Nitrogen	kg/ha/yr	
Lucerne	220 - 540	100%
Lower value used for calculations		
Phosphorus	**Guideline**	
Nitrogen	kg/ha/yr	
Lucerne	20-30	100%

Email from Tim indicates 50 - 100 mg/L N and 8 - 16 mg/L P in the wastewater

	Lower	Upper		
N	50	100	mg/L	(kg/ML)
P	8	16	mg/L	(kg/ML)

*Note: 1 mg/L = 1 kg/ML

*percentages are based on scenario assumptions, see other spreadsheets in workbook

Average Year, Scenario 2, upper limit

Nitrogen

100	kg/ML	
6.3	ML/ha/year	
630	kg/ha/yr	applied
220.00	kg/ha/yr	extracted
410.00	**accumulated nitrogen**	

Average Year, Scenario 2, lower limit

50	kg/ML	
6.3	ML/ha/year	
315	kg/ha/yr	applied
220.00	kg/ha/yr	extracted
95.00	**accumulated nitrogen**	

Phosphorus

Average Year, Scenario 2, upper limit

16	kg/ML	
6.3	ML/ha/year	
100.8	kg/ha/yr	applied
20.00	kg/ha/yr	extracted
80.80	**accumulated phosphorus**	
8	kg/ML	
6.3	ML/ha/year	
50.4	kg/ha/yr	applied
20.00	kg/ha/yr	extracted
30.40	**accumulated phosphorus**	

Wet year, Scenario 2, lower limit

Nitrogen

100	kg/ML	
5.2	ML/ha/year	
520	kg/ha/yr	applied
220.00	kg/ha/yr	extracted
300.00	**accumulated nitrogen**	

Wet Year, Scenario 2, lower limit

50	kg/ML	
5.2	ML/ha/year	
260	kg/ha/yr	applied
220.00	kg/ha/yr	extracted
40.00	**accumulated nitrogen**	

Phosphorus

Wet Year, Scenario 2, upper limit

16	kg/ML	
5.2	ML/ha/year	
83.2	kg/ha/yr	applied
20.00	kg/ha/yr	extracted
63.20	**deficit phosphorus**	
8	kg/ML	
5.2	ML/ha/year	
41.6	kg/ha/yr	applied
20.00	kg/ha/yr	extracted
21.60	**deficit phosphorus**	

Dry year, Scenario 2, lower limit

Nitrogen

100	kg/ML	
7.6	ML/ha/year	
760	kg/ha/yr	applied
220.00	kg/ha/yr	extracted
540.00	**accumulation nitrogen**	

Dry Year, Scenario 2, lower limit

50	kg/ML	
7.6	ML/ha/year	
380	kg/ha/yr	applied
220.00	kg/ha/yr	extracted
160.00	**accumulated nitrogen**	

Phosphorus

Dry Year, Scenario 2, upper limit

16	kg/ML	
7.6	ML/ha/year	
121.6	kg/ha/yr	applied
20.00	kg/ha/yr	extracted
101.60	**accumulation phosphorus**	
8	kg/ML	
7.6	ML/ha/year	
60.8	kg/ha/yr	applied
20.00	kg/ha/yr	extracted
40.80	**accumulation phosphorus**	

Average rainfall scenario (based on data from Princetown weather station (1889-2016) **Combination of turf grass and immature, native trees (eucalyptus)**

#	Item	Calculation	unit	January	February	March	April	May	June	July	August	September	October	November	December	Totals
B1	R_{actual} (average year)		mm	39.7	37.5	52	72.8	91.1	100.2	108.1	108.7	89.9	78.7	60.2	51.6	891
B2	$R_{effective}$	70% B1	mm	27.79	26.25	36.4	50.96	63.77	70.14	75.67	76.09	62.93	55.09	42.14	36.12	623
A	E_{Pan} (monthly)		mm	196.3	166.6	134	82.6	54.7	39.9	45.4	60.9	77.7	109.6	134.1	169.7	1272
I	cf		mm	0.52	0.52	0.52	0.64	0.64	0.64	0.64	0.64	0.64	0.52	0.52	0.52	
C1	ET_{crop}	I x A	mm	102.08	86.63	69.68	52.86	35.01	25.54	29.06	38.98	49.73	56.99	69.73	88.24	
C2	Ireq	C1-B2	mm	74.3	60.4	33.3	1.9	0.0	0.0	0.0	0.0	0.0	1.9	27.6	52.1	444
	Ireq per ha	C2 x 0.01	ML/ha	0.74	0.60	0.33	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.28	0.52	2.5
D2	Levap x 1000	(10(0.8A -B1) x LA)/1000	ML	0.4694	0.3831	0.2208	-0.0269	-0.1894	-0.2731	-0.2871	-0.2399	-0.1110	0.0359	0.1883	0.3366	
D	L_{evap}	D2 x 1000	kL	469	383	221	-27	-189	-273	-287	-240	-111	36	188	337	18235
E	Wastewater input		kL	2759	1764	1674	960	868	690	558	713	960	1674	1890	2759	17269
	Wastewater input	E /1000	ML	2.759	1.764	1.674	0.96	0.868	0.69	0.558	0.713	0.96	1.674	1.89	2.759	17
F	Total for irrigation	E - D	kL	2290	1381	1453	987	1057	963	845	953	1071	1638	1702	2422	
H	L_{vol} without irrigation		kL	14385	16137	17799	987	2044	3007	3852	4805	5876	7514	9216	11638	
H	L_{vol} with irrigation	F + Balance - (10C2 x G)	kL	3421	717	-72	987	2044	3007	3852	4805	5876	7410	7258	6160	
G	Area required to use available water		Ha	7.4												

Corresponds to numbered columns in EPA Publication 168

R_{actual} monthly rainfall in mm (Bureau of Meteorology)

$R_{effective}$ effective monthly rainfall available to crop in mm calculated as per EPA Publication 168
(months with rainfall > 25 mm effective is 70% of monthly rainfall - approach is accepted for wootlots in Table 7 and pasture in Table 7A)

$E_{pan\ (monthly)}$ monthly pan evaporation in mm (Bureau of Meterology)

ET_{crop} monthly crop evapotranspiration in mm, equivalent to E_{pan} multiplied by cf

cf crop factor for estimating water usage by the plants irrigated in mm.
cf taken from EPA Publication 168, CSIRO, and FAO, Evaporation measured in Epan

I_{req} monthly irrigation requirement in mm representing monthly water usage by plants irrigated,
equivalent to: Et_{crop} minus $R_{effective}$ or zero if $ET_{crop} < R_{effective}$.

L_{evap} montly evaporation from a lagoon 2m x 50 m x 100 m in kL using equation (iii)Table 7, EPA Publication 168. Negative value = water gain (rainfall > evap)

L_{vol} cumulative storage in lagoons. Calculated from April to March assuming volume starts at 0 in April following summer irrigation period.

<u>Assumptions:</u>

E Wastewater Inflows are based on occupancy rates for individual months: N:\AU\Melbourne\Projects\31\33485\Technical\LCA materials_JS\SILO data Princetown.xlsx

LA surface area of required winter storage lagoons calculated as 0.4 ha Storage volume 10000 kL

Rainfall and evaporation data obtained from Princetown weather station, values calculated from historical records.
Assumes no irrigation will occur over winter months from May to September and that storage start empty in May
(no irrigation requirement over winter months therefore storage is required)

Wet (90th percentile) rainfall scenario (based on data from Princetown weather station (1889-2016) **Combination of turf grass and immature, native trees (eucalyptus)**

#	Item	Calculation	Unit	January	February	March	April	May	June	July	August	September	October	November	December	Totals
B1	R_{actual}		mm	49.86	47.06	65.19	91.34	114.29	125.72	135.56	136.31	112.81	98.71	75.58	64.73	1117
B2	$R_{effective}$	70% B1	mm	34.901	32.94086	45.63338	63.93668	80.00474	88.00729	94.89171	95.41517	78.96475	69.09934	52.90616	45.3109	782
A	E_{Pan} (monthly)		mm	184.42	156.7	126.8	75.14	48.04	37.12	41.52	55.24	72.88	103.88	126.52	165.12	1193
I	cf		mm	0.52	0.52	0.52	0.64	0.64	0.64	0.64	0.64	0.64	0.52	0.52	0.52	
C1	ET_{crop}	I x A	mm	95.90	81.48	65.94	48.09	30.75	23.76	26.57	35.35	46.64	54.02	65.79	85.86	
C2	Ireq	C1-B2	mm	61.0	48.5	20.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.9	40.6	444
	Ireq per ha	C2 x 0.01	ML/ha	0.61	0.49	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.41	1.8
D2	Levap x1000	(10(0.8A -B1) x LA)/1000	ML	0.3907	0.3132	0.1450	-0.1249	-0.3034	-0.3841	-0.4094	-0.3685	-0.2180	-0.0624	0.1025	0.2695	
D1	L_{evap}	D2 x 1000	kL	391	313	145	-125	-303	-384	-409	-368	-218	-62	103	269	18235
E	Wastewater input		kL	2759	1764	1674	960	868	690	558	713	960	1674	1890	2759	17269
	Wastewater input	E /1000	ML	2.759	1.764	1.674	0.96	0.868	0.69	0.558	0.713	0.96	1.674	1.89	2.759	17
F	Total for irrigation	E - D		2368	1451	1529	1085	1171	1074	967	1081	1178	1736	1787	2490	
H	L_{vol} without irrigation		kL	15318	17070	18732	1085	2256	3330	4298	5379	6557	8294	10081	12571	
H	L_{vol} with irrigation	F + Balance - (10C2 x G)	kL	3686	353	-105	1085	2256	3330	4298	5379	6557	8294	8831	7332	
G	Area required to use available water		Ha	10.5												

Corresponds to numbered columns in EPA Publication 168

R_{actual} monthly rainfall in mm (Bureau of Meteorology)

$R_{effective}$ effective monthly rainfall available to crop in mm calculated as per EPA Publication 168
(months with rainfall > 25 mm effective is 70% of monthly rainfall - approach is accepted for wootlots in Table 7 and pasture in Table 7A)

$E_{pan\ (monthly)}$ monthly pan evaporation in mm (Bureau of Meterology)

ET_{crop} monthly crop evapotranspiration in mm, equivalent to E_{pan} multiplied by cf

cf crop factor for estimating water usage by the plants irrigated in mm.
cf taken from EPA Publication 168, CSIRO, and FAO, Evaporation measured in Epan

I_{req} monthly irrigation requirement in mm representing monthly water usage by plants irrigated,
equivalent to: Et_{crop} minus $R_{effective}$ or zero if ET_{crop} < $R_{effective}$.

L_{evap} montly evaporation from a lagoon 2.5 m x 50 m x 90 m in kL using equation (iii)Table 7, EPA Publication 168. Negative value = water gain (rainfall > evap)

L_{vol} cumulative storage in lagoons. Calculated from March to February assuming volume starts at 0 in April following summer irrigation period.

Assumptions:

E Wastewater Inflows are based on occupancy rates for individual months: N:\AU\Melbourne\Projects\31\33485\Technical\LCA materials_JS\SILO data Princetown.xlsx

LA surface area of required winter storage lagoons calculated as 0.4 ha Storage volume 10000 kL

Rainfall and evaporation data obtained from Princetown weather station, values calculated from historical records.
Assumes no irrigation will occur over winter months from April to October and that storage start empty in April
(as in these months there is no irrigation crop requirement so water needs to be stored)

Dry rainfall scenario (based on data from Princetown weather station (1889-2016) **Combination of turf grass and immature, native trees (eucalyptus)**

#	Item	Calculation	unit	January	February	March	April	May	June	July	August	September	October	November	December	Totals
B1	R_{actual}		mm	32.87695	31.03049	42.98692	60.22874	75.36495	82.9034	89.38856	89.88166	74.38527	65.092	49.83792	42.68314	891
B2	$R_{effective}$	70% B1	mm	23.01387	21.72134	30.09084	42.16012	52.75546	58.03238	62.57199	62.91716	52.06969	45.5644	34.88655	29.8782	623
A	E_{Pan} (monthly)		mm	208.78	175.7	139.6	89.06	58.28	41.64	47.4	65.04	86.84	118.24	145.36	184.76	1272
I	cf		mm	0.52	0.52	0.52	0.64	0.64	0.64	0.64	0.64	0.64	0.52	0.52	0.52	
C1	ET_{crop}	I x A	mm	108.57	91.36	72.59	57.00	37.30	26.65	30.34	41.63	55.58	61.48	75.59	96.08	
C2	Ireq	C1-B2	mm	85.6	69.6	42.5	14.8	0.0	0.0	0.0	0.0	3.5	15.9	40.7	66.2	444
	Ireq per ha	C2 x 0.01	ML/ha	0.86	0.70	0.43	0.15	0.00	0.00	0.00	0.00	0.04	0.16	0.41	0.66	3.4
D2	Levap x 1000	(10(0.8A -B1) x LA)/1000	ML	0.5366	0.4381	0.2748	0.0441	-0.1150	-0.1984	-0.2059	-0.1514	-0.0197	0.1180	0.2658	0.4205	
D	L_{evap}	D2 x 1000	kL	537	438	275	44	-115	-198	-206	-151	-20	118	266	420	18235
E	Wastewater input		kL	2759	1764	1674	960	868	690	558	713	960	1674	1890	2759	17269
	Wastewater input	E /1000	ML	2.759	1.764	1.674	0.96	0.868	0.69	0.558	0.713	0.96	1.674	1.89	2.759	17
F	Total for irrigation	E - D	kL	2222	1326	1399	916	983	888	764	864	980	1556	1624	2339	
H	L_{vol} without irrigation		kL	13661	15413	17075	916	1899	2787	3551	4416	5395	6951	8575	10914	
H	L_{vol} with irrigation	F + Balance - (10C2 x G)	kL	2808	672	-34	916	1899	2787	3551	4416	5395	6178	5788	4840	
G	Area required to use available water		Ha	5.6												

Corresponds to numbered columns in EPA Publication 168

R_{actual} monthly rainfall in mm (Bureau of Meteorology)

$R_{effective}$ effective monthly rainfall available to crop in mm calculated as per EPA Publication 168
(months with rainfall > 25 mm effective is 70% of monthly rainfall - approach is accepted for wootlots in Table 7 and pasture in Table 7A)

$E_{pan\ (monthly)}$ monthly pan evaporation in mm (Bureau of Meterology)

ET_{crop} monthly crop evapotranspiration in mm, equivalent to E_{pan} multiplied by cf

cf crop factor for estimating water usage by the plants irrigated in mm.
cf taken from EPA Publication 168, CSIRO, and FAO, Evaporation measured in Epan

I_{req} monthly irrigation requirement in mm representing monthly water usage by plants irrigated,
equivalent to: Et_{crop} minus $R_{effective}$ or zero if ET_{crop} < $R_{effective}$.

L_{evap} montly evaporation from a lagoon 2.5 m x 50 m x 80 m in kL using equation (iii)Table 7, EPA Publication 168. Negative value = water gain (rainfall > evap)

L_{vol} cumulative storage in lagoons. Calculated from April to March assuming volume starts at 0 in May following summer irrigation period.

<u>Assumptions:</u>

E Wastewater Inflows are based on occupancy rates for individual months: N:\AU\Melbourne\Projects\31\33485\Technical\LCA materials_JS\SILO data Princetown.xlsx

LA surface area of required winter storage lagoons calculated as 0.4 ha Storage volume 10000 kL

Rainfall and evaporation data obtained from Princetown weather station, values calculated from historical records.
Assumes no irrigation will occur over winter months from May to September and that storage start empty in May
(no irrigation requirement over winter months therefore storage is required)

Average rainfall scenario (based on data from Princetown weather station (1889-2016) **Turf species over the entire area**

#	Item	Calculation	unit	January	February	March	April	May	June	July	August	September	October	November	December	Totals
B1	R_{actual} (average year)		mm	39.7	37.5	52	72.8	91.1	100.2	108.1	108.7	89.9	78.7	60.2	51.6	891
B2	$R_{effective}$	70% B1	mm	27.79	26.25	36.4	50.96	63.77	70.14	75.67	76.09	62.93	55.09	42.14	36.12	623
A	E_{Pan} (monthly)		mm	196.3	166.6	134	82.6	54.7	39.9	45.4	60.9	77.7	109.6	134.1	169.7	1272
I	cf		mm	0.6	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.6	0.6	
C1	ET_{crop}	I x A	mm	117.78	99.96	80.40	66.08	43.76	31.92	36.32	48.72	62.16	65.76	80.46	101.82	
C2	Ireq	C1-B2	mm	90.0	73.7	44.0	15.1	0.0	0.0	0.0	0.0	0.0	10.7	38.3	65.7	444
	Ireq per ha	C2 x 0.01	ML/ha	0.90	0.74	0.44	0.15	0.00	0.00	0.00	0.00	0.00	0.11	0.38	0.66	3.4
D2	Levap x 1000	(10(0.8A -B1) x LA)/1000	ML	0.4694	0.3831	0.2208	-0.0269	-0.1894	-0.2731	-0.2871	-0.2399	-0.1110	0.0359	0.1883	0.3366	
D	L_{evap}	D2 x 1000	kL	469	383	221	-27	-189	-273	-287	-240	-111	36	188	337	18235
E	Wastewater input		kL	2759	1764	1674	960	868	690	558	713	960	1674	1890	2759	17269
	Wastewater input	E /1000	ML	2.759	1.764	1.674	0.96	0.868	0.69	0.558	0.713	0.96	1.674	1.89	2.759	17
F	Total for irrigation	E - D	kL	2290	1381	1453	987	1057	963	845	953	1071	1638	1702	2422	
H	L_{vol} without irrigation		kL	14385	16137	17799	987	2044	3007	3852	4805	5876	7514	9216	11638	
H	L_{vol} with irrigation	F + Balance - (10C2 x G)	kL	3292	854	20	987	2044	3007	3852	4805	5876	6942	6648	5662	
G	Area required to use available water		Ha	5.7												

Corresponds to numbered columns in EPA Publication 168

R_{actual} monthly rainfall in mm (Bureau of Meteorology)

$R_{effective}$ effective monthly rainfall available to crop in mm calculated as per EPA Publication 168
(months with rainfall > 25 mm effective is 70% of monthly rainfall - approach is accepted for wootlots in Table 7 and pasture in Table 7A)

$E_{pan\ (monthly)}$ monthly pan evaporation in mm (Bureau of Meterology)

ET_{crop} monthly crop evapotranspiration in mm, equivalent to E_{pan} multiplied by cf

cf crop factor for estimating water usage by the plants irrigated in mm.
cf taken from EPA Publication 168, CSIRO, and FAO, Evaporation measured in Epan

I_{req} monthly irrigation requirement in mm representing monthly water usage by plants irrigated,
equivalent to: Et_{crop} minus $R_{effective}$ or zero if ET_{crop} < $R_{effective}$.

L_{evap} montly evaporation from a lagoon 2m x 50 m x 100 m in kL using equation (iii)Table 7, EPA Publication 168. Negative value = water gain (rainfall > evap)

L_{vol} cumulative storage in lagoons. Calculated from April to March assuming volume starts at 0 in April following summer irrigation period.

Assumptions:

E Wastewater Inflows are based on occupancy rates for individual months: N:\AU\Melbourne\Projects\31\33485\Technical\LCA materials_JS\SILO data Princetown.xlsx

LA surface area of required winter storage lagoons calculated as 0.4 ha Storage volume 10000 kL

Rainfall and evaporation data obtained from Princetown weather station, values calculated from historical records.
Assumes no irrigation will occur over winter months from May to September and that storage start empty in May
(no irrigation requirement over winter months therefore storage is required)

Wet (90th percentile) rainfall scenario (based on data from Princetown weather station (1889-2016) **Turf species over the entire area**

#	Item	Calculation	Unit	January	February	March	April	May	June	July	August	September	October	November	December	Totals
B1	R_{actual}		mm	49.86	47.06	65.19	91.34	114.29	125.72	135.56	136.31	112.81	98.71	75.58	64.73	1117
B2	$R_{effective}$	70% B1	mm	34.901	32.94086	45.63338	63.93668	80.00474	88.00729	94.89171	95.41517	78.96475	69.09934	52.90616	45.3109	782
A	E_{Pan} (monthly)		mm	184.42	156.7	126.8	75.14	48.04	37.12	41.52	55.24	72.88	103.88	126.52	165.12	1193
I	cf		mm	0.6	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.6	0.6	
C1	ET_{crop}	I x A	mm	110.65	94.02	76.08	60.11	38.43	29.70	33.22	44.19	58.30	62.33	75.91	99.07	
C2	Ireq	C1-B2	mm	75.8	61.1	30.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.0	53.8	444
	Ireq per ha	C2 x 0.01	ML/ha	0.76	0.61	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.54	2.4
D2	Levap x1000	10(0.8A -B1) x LA)/1000	ML	0.3907	0.3132	0.1450	-0.1249	-0.3034	-0.3841	-0.4094	-0.3685	-0.2180	-0.0624	0.1025	0.2695	
D1	L_{evap}	D2 x 1000	kL	391	313	145	-125	-303	-384	-409	-368	-218	-62	103	269	18235
E	Wastewater input		kL	2759	1764	1674	960	868	690	558	713	960	1674	1890	2759	17269
	Wastewater input	E /1000	ML	2.759	1.764	1.674	0.96	0.868	0.69	0.558	0.713	0.96	1.674	1.89	2.759	17
F	Total for irrigation	E - D		2368	1451	1529	1085	1171	1074	967	1081	1178	1736	1787	2490	
H	L_{vol} without irrigation		kL	15318	17070	18732	1085	2256	3330	4298	5379	6557	8294	10081	12571	
H	L_{vol} with irrigation	F + Balance - (10C2 x G)	kL	3805	805	104	1085	2256	3330	4298	5379	6557	8294	8389	6955	
G	Area required to use available water		Ha	7.8												

Corresponds to numbered columns in EPA Publication 168

R_{actual} monthly rainfall in mm (Bureau of Meteorology)

$R_{effective}$ effective monthly rainfall available to crop in mm calculated as per EPA Publication 168
(months with rainfall > 25 mm effective is 70% of monthly rainfall - approach is accepted for wootlots in Table 7 and pasture in Table 7A)

$E_{pan\ (monthly)}$ monthly pan evaporation in mm (Bureau of Meterology)

ET_{crop} monthly crop evapotranspiration in mm, equivalent to E_{pan} multiplied by cf

cf crop factor for estimating water usage by the plants irrigated in mm.
cf taken from EPA Publication 168, CSIRO, and FAO, Evaporation measured in Epan

I_{req} monthly irrigation requirement in mm representing monthly water usage by plants irrigated,
equivalent to: Et_{crop} minus $R_{effective}$ or zero if ET_{crop} < $R_{effective}$.

L_{evap} montly evaporation from a lagoon 2.5 m x 50 m x 90 m in kL using equation (iii)Table 7, EPA Publication 168. Negative value = water gain (rainfall > e

L_{vol} cumulative storage in lagoons. Calculated from March to February assuming volume starts at 0 in April following summer irrigation period.

Assumptions:

E Wastewater Inflows are based on occupancy rates for individual months: N:\AU\Melbourne\Projects\31\33485\Technical\LCA materials_JS\SILO dat

LA surface area of required winter storage lagoons calculated as 0.4 ha Storage volume 10000 kL

Rainfall and evaporation data obtained from Princetown weather station, values calculated from historical records.
Assumes no irrigation will occur over winter months from April to October and that storage start empty in April
(as in these months there is no irrigation crop requirement so water needs to be stored)

Dry rainfall scenario (based on data from Princetown weather station (1889-2016) **Turf species over the entire area**

#	Item	Calculation	unit	January	February	March	April	May	June	July	August	Septembe	October	November	December	Totals
B1	R_{actual}		mm	32.87695	31.03049	42.98692	60.22874	75.36495	82.9034	89.38856	89.88166	74.38527	65.092	49.83792	42.68314	891
B2	$R_{effective}$	70% B1	mm	23.01387	21.72134	30.09084	42.16012	52.75546	58.03238	62.57199	62.91716	52.06969	45.5644	34.88655	29.8782	623
A	E_{Pan} (monthly)		mm	208.78	175.7	139.6	89.06	58.28	41.64	47.4	65.04	86.84	118.24	145.36	184.76	1272
I	cf		mm	0.6	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.6	0.6	
C1	ET_{crop}	I x A	mm	125.27	105.42	83.76	71.25	46.62	33.31	37.92	52.03	69.47	70.94	87.22	110.86	
C2	Ireq	C1-B2	mm	102.3	83.7	53.7	29.1	0.0	0.0	0.0	0.0	17.4	25.4	52.3	81.0	444
	Ireq per ha	C2 x 0.01	ML/ha	1.02	0.84	0.54	0.29	0.00	0.00	0.00	0.00	0.17	0.25	0.52	0.81	4.4
D2	Levap x 1000	(10(0.8A -B1) x LA)/1000	ML	0.5366	0.4381	0.2748	0.0441	-0.1150	-0.1984	-0.2059	-0.1514	-0.0197	0.1180	0.2658	0.4205	
D	L_{evap}	D2 x 1000	kL	537	438	275	44	-115	-198	-206	-151	-20	118	266	420	18235
E	Wastewater input		kL	2759	1764	1674	960	868	690	558	713	960	1674	1890	2759	17269
	Wastewater input	E /1000	ML	2.759	1.764	1.674	0.96	0.868	0.69	0.558	0.713	0.96	1.674	1.89	2.759	17
F	Total for irrigation	E - D	kL	2222	1326	1399	916	983	888	764	864	980	1556	1624	2339	
H	L_{vol} without irrigation		kL	13661	15413	17075	916	1899	2787	3551	4416	5395	6951	8575	10914	
H	L_{vol} with irrigation	F + Balance - (10C2 x G)	kL	2735	732	-9	916	1899	2787	3551	4416	5395	5927	5462	4577	
G	Area required to use available water		Ha	4.5												

Corresponds to numbered columns in EPA Publication 168

R_{actual} monthly rainfall in mm (Bureau of Meteorology)

$R_{effective}$ effective monthly rainfall available to crop in mm calculated as per EPA Publication 168
(months with rainfall > 25 mm effective is 70% of monthly rainfall - approach is accepted for wootlots in Table 7 and pasture in Table 7A)

$E_{pan\ (monthly)}$ monthly pan evaporation in mm (Bureau of Meterology)

ET_{crop} monthly crop evapotranspiration in mm, equivalent to E_{pan} multiplied by cf

cf crop factor for estimating water usage by the plants irrigated in mm.
cf taken from EPA Publication 168, CSIRO, and FAO, Evaporation measured in Epan

I_{req} monthly irrigation requirement in mm representing monthly water usage by plants irrigated,
equivalent to: Et_{crop} minus $R_{effective}$ or zero if ET_{crop} < $R_{effective}$.

L_{evap} montly evaporation from a lagoon 2.5 m x 50 m x 80 m in kL using equation (iii)Table 7, EPA Publication 168. Negative value = water gain (rainfall > evap)

L_{vol} cumulative storage in lagoons. Calculated from April to March assuming volume starts at 0 in May following summer irrigation period.

Assumptions:

E Wastewater Inflows are based on occupancy rates for individual months: N:\AU\Melbourne\Projects\31\33485\Technical\LCA materials_JS\SILO data Princetown.xlsx

LA surface area of required winter storage lagoons calculated as 0.4 ha Storage volume 10000 kL

Rainfall and evaporation data obtained from Princetown weather station, values calculated from historical records.
Assumes no irrigation will occur over winter months from May to September and that storage start empty in May
(no irrigation requirement over winter months therefore storage is required)

Average rainfall scenario (based on data from Princetown weather station (1889-2016) **Lucerne over the entire area**

#	Item	Calculation	unit	January	February	March	April	May	June	July	August	Septembe	October	November	December	Totals
B1	R_{actual} (average year)		mm	39.7	37.5	52	72.8	91.1	100.2	108.1	108.7	89.9	78.7	60.2	51.6	891
B2	$R_{effective}$	70% B1	mm	27.79	26.25	36.4	50.96	63.77	70.14	75.67	76.09	62.93	55.09	42.14	36.12	623
A	E_{Pan} (monthly)		mm	196.3	166.6	134	82.6	54.7	39.9	45.4	60.9	77.7	109.6	134.1	169.7	1272
I	cf		mm	0.95	0.9	0.85	0.8	0.7	0.55	0.55	0.65	0.75	0.85	0.95	1	
C1	ET_{crop}	I x A	mm	186.49	149.94	113.90	66.08	38.29	21.95	24.97	39.59	58.28	93.16	127.40	169.70	
C2	Ireq	C1-B2	mm	158.7	123.7	77.5	15.1	0.0	0.0	0.0	0.0	0.0	38.1	85.3	133.6	444
	Ireq per ha	C2 x 0.01	ML/ha	1.59	1.24	0.78	0.15	0.00	0.00	0.00	0.00	0.00	0.38	0.85	1.34	6.3
D2	Levap x 1000	(10(0.8A -B1) x LA)/1000	ML	0.4694	0.3831	0.2208	-0.0269	-0.1894	-0.2731	-0.2871	-0.2399	-0.1110	0.0359	0.1883	0.3366	
D	L_{evap}	D2 x 1000	kL	469	383	221	-27	-189	-273	-287	-240	-111	36	188	337	18235
E	Wastewater input		kL	2759	1764	1674	960	868	690	558	713	960	1674	1890	2759	17269
	Wastewater input	E /1000	ML	2.759	1.764	1.674	0.96	0.868	0.69	0.558	0.713	0.96	1.674	1.89	2.759	17
F	Total for irrigation	E - D	kL	2290	1381	1453	987	1057	963	845	953	1071	1638	1702	2422	
H	L_{vol} without irrigation		kL	14385	16137	17799	987	2044	3007	3852	4805	5876	7514	9216	11638	
H	L_{vol} with irrigation	F + Balance - (10C2 x G)	kL	2490	544	-107	987	2044	3007	3852	4805	5876	6408	5741	4492	
G	Area required to use available water		Ha	3												

Corresponds to numbered columns in EPA Publication 168

R_{actual} monthly rainfall in mm (Bureau of Meteorology)

$R_{effective}$ effective monthly rainfall available to crop in mm calculated as per EPA Publication 168
(months with rainfall > 25 mm effective is 70% of monthly rainfall - approach is accepted for wootlots in Table 7 and pasture in Table 7A)

$E_{pan\ (monthly)}$ monthly pan evaporation in mm (Bureau of Meterology)

ET_{crop} monthly crop evapotranspiration in mm, equivalent to E_{pan} multiplied by cf

cf crop factor for estimating water usage by the plants irrigated in mm.
cf taken from EPA Publication 168, CSIRO, and FAO, Evaporation measured in Epan

I_{req} monthly irrigation requirement in mm representing monthly water usage by plants irrigated,
equivalent to: Et_{crop} minus $R_{effective}$ or zero if ET_{crop} < $R_{effective}$.

L_{evap} montly evaporation from a lagoon 2m x 50 m x 100 m in kL using equation (iii)Table 7, EPA Publication 168. Negative value = water gain (rainfall > evap)

L_{vol} cumulative storage in lagoons. Calculated from April to March assuming volume starts at 0 in April following summer irrigation period.

Assumptions:

E Wastewater Inflows are based on occupancy rates for individual months: N:\AU\Melbourne\Projects\31\33485\Technical\LCA materials_JS\SILO data Princetown.xlsx

LA surface area of required winter storage lagoons calculated as 0.4 ha Storage volume 10000 kL

Rainfall and evaporation data obtained from Princetown weather station, values calculated from historical records.

Assumes no irrigation will occur over winter months from May to September and that storage start empty in May

(no irrigation requirement over winter months therefore storage is required)

Wet (90th percentile) rainfall scenario (based on data from Princetown weather station (1889-2016) **Lucerne over the entire area**

#	Item	Calculation	Unit	January	February	March	April	May	June	July	August	Septembe	October	November	December	Totals
B1	R_{actual}		mm	49.86	47.06	65.19	91.34	114.29	125.72	135.56	136.31	112.81	98.71	75.58	64.73	1117
B2	$R_{effective}$	70% B1	mm	34.901	32.94086	45.63338	63.93668	80.00474	88.00729	94.89171	95.41517	78.96475	69.09934	52.90616	45.3109	782
A	E_{Pan} (monthly)		mm	184.42	156.7	126.8	75.14	48.04	37.12	41.52	55.24	72.88	103.88	126.52	165.12	1193
I	cf		mm	0.95	0.9	0.85	0.8	0.7	0.55	0.55	0.65	0.75	0.85	0.95	1	
C1	ET_{crop}	I x A	mm	175.20	141.03	107.78	60.11	33.63	20.42	22.84	35.91	54.66	88.30	120.19	165.12	
C2	Ireq	C1-B2	mm	140.3	108.1	62.1	0.0	0.0	0.0	0.0	0.0	0.0	19.2	67.3	119.8	444
	Ireq per ha	C2 x 0.01	ML/ha	1.40	1.08	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.67	1.20	5.2
D2	Levap x1000	10(0.8A -B1) x LA)/1000	ML	0.3907	0.3132	0.1450	-0.1249	-0.3034	-0.3841	-0.4094	-0.3685	-0.2180	-0.0624	0.1025	0.2695	
D1	L_{evap}	D2 x 1000	kL	391	313	145	-125	-303	-384	-409	-368	-218	-62	103	269	18235
E	Wastewater input		kL	2759	1764	1674	960	868	690	558	713	960	1674	1890	2759	17269
	Wastewater input	E /1000	ML	2.759	1.764	1.674	0.96	0.868	0.69	0.558	0.713	0.96	1.674	1.89	2.759	17
F	Total for irrigation	E - D		2368	1451	1529	1085	1171	1074	967	1081	1178	1736	1787	2490	
H	L_{vol} without irrigation		kL	15318	17070	18732	1085	2256	3330	4298	5379	6557	8294	10081	12571	
H	L_{vol} with irrigation	F + Balance - (10C2 x G)	kL	3261	917	230	1085	2256	3330	4298	5379	6557	8294	7627	5833	
G	Area required to use available water		Ha	3.8												

Corresponds to numbered columns in EPA Publication 168

R_{actual} monthly rainfall in mm (Bureau of Meteorology)

$R_{effective}$ effective monthly rainfall available to crop in mm calculated as per EPA Publication 168
(months with rainfall > 25 mm effective is 70% of monthly rainfall - approach is accepted for wootlots in Table 7 and pasture in Table 7A)

$E_{pan\ (monthly)}$ monthly pan evaporation in mm (Bureau of Meterology)

ET_{crop} monthly crop evapotranspiration in mm, equivalent to E_{pan} multiplied by cf

cf crop factor for estimating water usage by the plants irrigated in mm.
cf taken from EPA Publication 168, CSIRO, and FAO, Evaporation measured in Epan

I_{req} monthly irrigation requirement in mm representing monthly water usage by plants irrigated,
equivalent to: Et_{crop} minus $R_{effective}$ or zero if ET_{crop} < $R_{effective}$.

L_{evap} montly evaporation from a lagoon 2.5 m x 50 m x 90 m in kL using equation (iii)Table 7, EPA Publication 168. Negative value = water gain (rainfall >

L_{vol} cumulative storage in lagoons. Calculated from March to February assuming volume starts at 0 in April following summer irrigation period.

Assumptions:

E Wastewater Inflows are based on occupancy rates for individual months: N:\AU\Melbourne\Projects\31\33485\Technical\LCA materials_JS\SILO c

LA surface area of required winter storage lagoons calculated as 0.4 ha Storage volume 10000 kL

Rainfall and evaporation data obtained from Princetown weather station, values calculated from historical records.
Assumes no irrigation will occur over winter months from April to October and that storage start empty in April
(as in these months there is no irrigation crop requirement so water needs to be stored)

Dry rainfall scenario (based on data from Princetown weather station (1889-2016) **Lucerne over the entire area**

#	Item	Calculation	unit	January	February	March	April	May	June	July	August	Septembe	October	November	December	Totals
B1	R_{actual}		mm	32.87695	31.03049	42.98692	60.22874	75.36495	82.9034	89.38856	89.88166	74.38527	65.092	49.83792	42.68314	891
B2	$R_{effective}$	70% B1	mm	23.01387	21.72134	30.09084	42.16012	52.75546	58.03238	62.57199	62.91716	52.06969	45.5644	34.88655	29.8782	623
A	E_{Pan} (monthly)		mm	208.78	175.7	139.6	89.06	58.28	41.64	47.4	65.04	86.84	118.24	145.36	184.76	1272
I	cf		mm	0.95	0.9	0.85	0.8	0.7	0.55	0.55	0.65	0.75	0.85	0.95	1	
C1	ET_{crop}	I x A	mm	198.34	158.13	118.66	71.25	40.80	22.90	26.07	42.28	65.13	100.50	138.09	184.76	
C2	Ireq	C1-B2	mm	175.3	136.4	88.6	29.1	0.0	0.0	0.0	0.0	13.1	54.9	103.2	154.9	444
	Ireq per ha	C2 x 0.01	ML/ha	1.75	1.36	0.89	0.29	0.00	0.00	0.00	0.00	0.13	0.55	1.03	1.55	7.6
D2	Levap x 1000	(10(0.8A -B1) x LA)/1000	ML	0.5366	0.4381	0.2748	0.0441	-0.1150	-0.1984	-0.2059	-0.1514	-0.0197	0.1180	0.2658	0.4205	
D	L_{evap}	D2 x 1000	kL	537	438	275	44	-115	-198	-206	-151	-20	118	266	420	18235
E	Wastewater input		kL	2759	1764	1674	960	868	690	558	713	960	1674	1890	2759	17269
	Wastewater input	E /1000	ML	2.759	1.764	1.674	0.96	0.868	0.69	0.558	0.713	0.96	1.674	1.89	2.759	17
F	Total for irrigation	E - D	kL	2222	1326	1399	916	983	888	764	864	980	1556	1624	2339	
H	L_{vol} without irrigation		kL	13661	15413	17075	916	1899	2787	3551	4416	5395	6951	8575	10914	
H	L_{vol} with irrigation	F + Balance - (10C2 x G)	kL	2268	622	82	916	1899	2787	3551	4416	5395	5696	5006	3893	
G	Area required to use available water		Ha	2.5												

Corresponds to numbered columns in EPA Publication 168

R_{actual} monthly rainfall in mm (Bureau of Meteorology)

$R_{effective}$ effective monthly rainfall available to crop in mm calculated as per EPA Publication 168
(months with rainfall > 25 mm effective is 70% of monthly rainfall - approach is accepted for wootlots in Table 7 and pasture in Table 7A)

$E_{pan\ (monthly)}$ monthly pan evaporation in mm (Bureau of Meterology)

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I_{req} monthly irrigation requirement in mm representing monthly water usage by plants irrigated,
equivalent to: Et_{crop} minus $R_{effective}$ or zero if ET_{crop} < $R_{effective}$.

L_{evap} montly evaporation from a lagoon 2.5 m x 50 m x 80 m in kL using equation (iii)Table 7, EPA Publication 168. Negative value = water gain (rainfall > evap)

L_{vol} cumulative storage in lagoons. Calculated from April to March assuming volume starts at 0 in May following summer irrigation period.

Assumptions:

E Wastewater Inflows are based on occupancy rates for individual months: N:\AU\Melbourne\Projects\31\33485\Technical\LCA materials_JS\SILO data Princetown.xlsx

LA surface area of required winter storage lagoons calculated as 0.4 ha Storage volume 10000 kL

Rainfall and evaporation data obtained from Princetown weather station, values calculated from historical records.
Assumes no irrigation will occur over winter months from May to September and that storage start empty in May
(no irrigation requirement over winter months therefore storage is required)

Appendix C - Flooding Extent Site Map

THIS DIAGRAM SHOWS THE ON SITE AREA AVAILABLE FOR THE WASTE WATER IRRIGATION FIELD
THE FINAL IRRIGATION SOLUTION WILL BE DESIGNED TO WORK WITHIN THESE CONSTRAINTS.

AREA AVAILABLE FOR IRRIGATION IS 9ha (EXCLUDES BUILT AREA OF 2ha)

Provisional Irrigation Areas

Princetown Resort

For Information

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