Revised Water Cycle Management Report

Central Victoria Livestock Exchange

Prepared For

RLX Investment Company Pty Ltd

12 June 2015

• Civil, Environmental & Structural Engineering • Surveying • Environmental • Planning • Architecture

REVISED WATER CYCLE MANAGEMENT REPORT

CENTRAL VICTORIA LIVESTOCK EXCHANGE

PREPARED FOR:

RLX INVESTMENT COMPANY PTY LTD

JUNE 2015

GEOLYSE

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TABLE OF CONTENTS

APPENDICES

TABLES

FIGURES

Witness Statement

1.1 NAME, POSITION AND ADDRESS

Name: Martin David Haege

Position: Principal Environmental Engineer/Director, Geolyse Pty Ltd

Address: 154 Peisley Street, Orange, NSW 2800

1.2 QUALIFICATIONS, EXPERIENCE AND AREA OF EXPERTISE

- Bachelor of Natural Resources, University of New England
- Bachelor of Engineering (Civil) (Hons), University of Newcastle
- Master of Environmental Engineering Science, University of New South Wales
- Soil and Water Management for Urban Development

I have 25 years' experience in the fields of water cycle assessment, hydrologic and hydraulic studies, catchment assessment and planning, engineering feasibility studies, engineering design, environmental impact assessment, soil and water management, environmental monitoring and environmental management systems.

1.3 EXPERTISE TO PREPARE REPORT

I have completed a wide range of similar studies, investigations and designs as detailed below.

- Development of integrated water and waste management plans for intensive livestock developments (saleyards, cattle feedlots and dairies), municipal sewage treatment plants (incorporating effluent reuse) and urban water supplies. These studies require assessment of the water cycle, capability and suitability, design of the waste management scheme, economic assessment, development of environmental control measures including environmental management plans and environmental monitoring. Specific examples of this work include:
  - Central Tablelands Livestock Exchange – development of an integrated water cycle management strategy incorporating water harvesting and reuse, design of wetland system and irrigation reuse scheme.
  - Tamworth Regional Livestock Exchange – development of an integrated water cycle management strategy incorporating water harvesting and reuse and design of wetland system.
  - Northern Victoria Livestock Exchange – development of an integrated water cycle management strategy incorporating water harvesting and reuse, design of wetland system and irrigation reuse scheme.
  - Ballarat saleyards – preparation of a site water balance model to investigate opportunities for trade waste discharge reduction.
  - South East Livestock Exchange – development of an integrated water cycle management strategy incorporating water harvesting and reuse and design of wetland system with effluent recycling for truck wash use. Preparation of environmental impact assessment.
  - Oakey (Queensland) livestock exchange – development of an integrated water cycle management strategy incorporating water harvesting, reuse and effluent irrigation.
  - Bathurst Regional Council Saleyards – review of existing water and waste management systems and development of strategic plan for upgrade.

  - Rural Funds Management – water and waste water assessment for 24 shed broiler farm.
  - Forbes Stock Selling Centre – development of an integrated water cycle management strategy incorporating water harvesting, reuse, design of wetland systems nad effluent reuse through irrigation.
  - Dubbo Regional Livestock Markets – review and redesign of surface water and wastewater management systems to meet EPA criteria.
  - Moxey Farms – design of waste management system for 2,000 head free stall dairy including effluent reuse through irrigation.
  - Gundamain Pastoral Company – design of integrated waste management plan for 6,000 head cattle feedlot including effluent reuse through irrigation.
  - Fletcher International Exports – design of effluent treatment ponds and effluent reuse scheme incorporating treated effluent from Council's Sewage Treatment Plant.
  - Orange City Council – assessment and design of a two large scale stormwater harvesting schemes, one incorporating four constructed stormwater wetland systems.
  - Development of an integrated water balance model to assess water supply options for Orange City Council.
  - Thomas Foods International – approvals, assessment and design of an effluent system upgrade for mixed stock abattoir in Murray Bridge. This included covered anaerobic lagoons for biogas recovery, facultative ponds, aerobic ponds and a large scale effluent reuse scheme.
- Completed a wide range of environmental engineering projects including: an assessment of urban stormwater quality in Dubbo which examined the effect of land use on stormwater quality; assessment of groundwater contamination below an effluent storage dam and development of mitigation measures; assessment and design of surface water pollution controls for a large regional saleyards facility; implementation and monitoring of a groundwater pollution capture scheme for an intensive livestock facility; and design of a leachate barrier and collection scheme for a large regional solid waste management facility.
- I provide specialist technical input relating to hydrologic and hydraulic assessment and catchment planning. These studies require assessment of catchment characteristics, catchment modelling, prediction of catchment changes and the development of mitigation measures. Such studies include: hydrologic studies where the impacts of changes in land use are predicted through numerical modelling; flood studies where the pattern of flooding and its impacts are assessed; floodplain management studies where flood mitigation options are assessed; assessment of water quality changes resulting from changes in land use; and catchment yield studies.
- Preparation of Environmental Impact Statements, Review of Environmental Factors and Statement of Environmental Effects for a range of developments. These studies require sound working knowledge of environmental legislation and the impacts of developments within the environment.
- Preparation of impact assessment report for cases heard in the NSW Land and Environment Court and NSW Civil and Administrative Tribunal. These reports relate to the assessment of hydrologic/hydraulic impacts and impacts arising from pollution events, such as the discharge of effluent to rivers. These assessments require sampling and monitoring of sources and receiving waterways and consideration of the environmental setting, the nature of the pollutant, pollutant movement pathways and receptors.

1.4 RELATIONSHIP WITH RLX AND OPERATORS

The report is being prepared for RLX Investment Company Pty Ltd as trustee for RLX Investment Trust (RLX). Geolyse Pty Ltd provides professional consulting services to RLX in the areas of environmental planning, environmental engineering, surveying and civil engineering. Geolyse has provided some or all of these services to RLX (or its predecessors) for the following facilities:

- Central Tablelands Livestock Exchange;
- Tamworth Regional Livestock Exchange;
- Inverell Regional Livestock Exchange;
- Northern Victoria Livestock Exchange;
- Ballarat saleyards;
- Proposed Central Victoria Livestock Exchange; and
- Oakey (Queensland) livestock exchange.

Geolyse Pty Ltd also provides consulting services to the operators of the livestock facilities, Regional Infrastructure Pty Ltd (RIPL). These services include preparation of management plans, environmental monitoring and reporting, input to and assessment of any proposed process or design changes and assistance with compliance reporting. Geolyse provides these services to the following RIPL operated facilities:

- Central Tablelands Livestock Exchange;
- Tamworth Regional Livestock Exchange;
- Inverell Regional Livestock Exchange; and
- Northern Victoria Livestock Exchange.

1.5 INSTRUCTIONS

Geolyse Pty Ltd was engaged in 2008 by Regional Infrastructure Pty Ltd on behalf of RLX Investment Company Pty Ltd as trustee for the RLX Investment Trust to assist with preliminary site layout drawings. We also undertook water cycle modelling of the existing Ballarat saleyards to assist with trade waste discharge issues.

Our engagement with RLX continued and, under the direction of Spiire, we undertook detailed water cycling modelling and assessment as part of the statutory approvals process. I prepared a report titled *Water Cycle Management Report Central Victorian Livestock Exchange* (Geolyse, 2014).

On 4 May 2015 I received a letter from Harwood Andrews Lawyers, acting on behalf of RLX Investment Company Pty Ltd, requesting me to provide expert hydrological evidence at a planning panel scheduled for the week beginning 22 June in relation to the proposed relocated Central Victoria Livestock Exchange (CVLX).

I was instructed to:

1. Review the exhibited material and submissions;
2. Review the proposed SUZ15 and advise if you consider any changes are necessary to the development plan requirements as they relate to your discipline;
3. Review your earlier report;
4. Update your work following submissions from the relevant authorities;
5. Provide any further relevant information; and
6. Prepare a written report and provide oral evidence at a planning panel proposed for the week beginning 22 June 2015.

1.6 FACTS, MATTERS AND ASSUMPTIONS

In the course of my investigations I have:

- Inspected the subject site and the surrounding areas;
- Undertaken an assessment of likely water demands through review of previous studies, discussions with operators and from data obtained from other operational sites;
- Undertaken an assessment of the likely treated effluent quality using data from other operational sites;
- Reviewed relevant drawings and documents;
- Developed a site specific water balance model based on 125 years of climate data;
- Assisted with the refinement of the site layout;
- Undertaken catchment modelling;
- Undertaken water quality modelling;
- Liaised with Douglas Partners with regards to the scope of the soil and groundwater investigations;
- Reviewed soil and groundwater data obtained by Douglas Partners;
- Review regional flooding information;
- Investigated the site suitability for effluent reuse;
- Undertaken effluent reuse water, nutrient and salt balances; and
- Undertaken preliminary sizing of the onsite domestic wastewater reuse system.

Any fact, matters and assumption made during the preparation of this report are documented or referenced in the relevant section.

1.7 DOCUMENTS CONSIDERED IN PREPARATION OF THE REPORT

I have reviewed the following documents as part of my assessment:

- Schedule 15 to the Special Use Zone;
- Geolyse Pty Ltd (July 2014) *Water cycle management report, Central Victorian Livestock Exchange*;
- Harwood Andrews letter of instruction dated 4 May 2015;
- EPA Victoria Section 22(1) Notice, 17 April 2015;
- Correspondence from Central Highlands Water, 20 March 2015;
- Correspondence from Glenelg Hopkins Catchment Management Authority, 18 March 2015
- On-site effluent disposal assessment, 21 August 2014, Douglas Partners;
- Infrastructure servicing assessment, August 2014, Spiire;
- Stormwater investigation, August 2014, Spiire;
- Traffic assessment, August 2014, Traffix Group;
- Draft environmental improvement plan, August 2014, Spiire;
- Statement of expert evidence, June 2015, Neil M Craigie Pty Ltd;
- Groundwater desktop study, 5 June 2015, Douglas Partners;
- CVLX contingency effluent disposal report, June 2015, Spiire;
- Additional soil investigation and testing, 5 June 2015, Douglas Partners;

- Flood information summary, Glenelg Hopkins CMA, 5 May 2014;
- Catchment areas, Glenelg Hopkins CMA, 21 October 2014;
- Level and feature survey, 21 February 2013, Spiire;
- SEPP (Waters of Victoria);
- EPA Publication 168: *Guidelines for wastewater irrigation;*
- EPA Publication 464.2: *Guidelines for environmental management use of reclaimed water;*
- EPA Publication 891.3: *Code of practice: Onsite wastewater management;*
- Statement of approved acceptance criteria, December 2011, Central Highlands Water;
- Submissions received by Council;
- Various relevant publications and guidelines as referenced through my report;
- Online climate data for Ballarat and surrounding areas.

1.8 IDENTITY OF PERSONS WHO CARRIED OUT TESTS OR EXPERIMENTS

Douglas Partners Pty Ltd undertook site investigations including soil test pit excavation and logging, soil infiltration testing, soil sample collection, borehole drilling, monitoring piezometer installation and groundwater sampling.

Soil and groundwater samples were analysed under subcontract to Douglas Partners.

Results are reported in Douglas Partners (5 June 2015).

1.9 STATEMENT

1.9.1 SUMMARY OF OPINION

The water and effluent management systems for the proposed development presented in this report are consistent with the system as presented and assessed in my 2014 water cycle report (Geolyse, 2014). Modelling of the system has been updated based on revisions to the proposed site layout in response to the submissions of parties and following review of some design parameters and additional site data. Updated results are presented and discussed in this report.

My report provides the following conclusions.

1.9.1.1 SUZ15

In my opinion the requirement in SUZ15 to prepare a Flood Investigation, Stormwater Management Plan and an Operations and Environmental Management Plan are appropriate and sufficient for the proposed development.

1.9.1.2 Revised Layout

The revised site layout includes more roof area and less external yards. This increases the onsite supply of roof water and reduces the volume of external yard runoff requiring treatment.

1.9.1.3 Water Cycle

Assessment of the water cycle for the proposed CVLX demonstrates that a large proportion of the water supply can be sourced through a combination of roof and surface water harvesting, with top-up provided from the reticulated potable supply. The average annual potable water demand is about 11.6 ML/year. Onsite roof and surface water harvesting supplies an average of about 36 ML/year.

Approximately 35 ML/year of treated effluent will be reused for irrigation of pasture across 26.6 ha of the site.

1.9.1.4 Surface Water Management

Surface Water Management System

Surface water management will be based on separating catchments and treating runoff according to the level of potential contamination present. Peak site discharge and quality will be managed through a treatment train approach utilising grass swales and a constructed wetland. The constructed wetland system will also be used to supplement non-potable water demand.

The surface water management system will:

- limit post-development peak discharge to less than existing site peak discharge;
- ensure that future stormwater pollutant loads (total suspended solids, total phosphorous and total nitrogen) will be much lower than under existing conditions;
- ensure stormwater runoff volumes are less than existing; and
- supply a portion of the site water demand through roof and surface water harvesting.

Some surface water will continue to be discharged from the site. This discharge will occur in the same location as it currently does. The volume, peak flow and velocity of the discharge will be less than existing conditions and the water will be better quality.

Flooding

There is no infrastructure proposed in the eastern part of the site that will alter peak site runoff. As such, there will be no significant change to flooding patterns in the drainage line that runs past the eastern end of the site towards Miners Rest. There will be no flooding impacts on the western edge of Miners Rest from this existing drainage line.

The main drainage outfall for the CVLX is to the western drainage line. The proposed surface water management system will limit peak discharge to less than existing. This can only help improve flooding albeit in a very minor sense given the relative size of the contributing catchments.

The western drainage line discharges to Burrumbeet Creek well downstream of Miners Rest. It is not possible for discharge from the CVLX site to change flooding patterns in Miners Rest.

Effluent Ponds

All wastewater treatment ponds (and the rainwater pond) will include embankments that are a minimum of 600 mm above the 1% AEP flood level. This will provide adequate protection to prevent the entry of flood water to the wastewater treatment ponds.

Location of Surface Water Wetland

The proposed surface water wetland can be located in the 1% AEP floodplain without impacting on flooding patterns. A low bank on the western edge would allow greater flexibility for hydraulic control in the wetland and would prevent the ingress of flood water. I am satisfied that a low bank would be preferred and that it could be incorporated into the design without detrimentally impacting on flooding patterns in the location.

1.9.1.5 Effluent Management

Land Capability

The site investigations and laboratory testing identifies that the land is suitable for managed effluent irrigation.

The site layout has been revised and provides a total irrigation area of 26.6 ha.

Effluent Reuse Scheme

The average annual volume irrigated is around 35 ML/year, which equates to a long term average application rate of 1.44 ML/ha/year (144 mm) on the main irrigation area and 0.98 ML/ha/year (98 mm) on the limited irrigation areas. The average across the site is 1.31 ML/ha/year (131 mm). These are low annual application rates.

Nutrient balances for a preferred cropping regime based on ryegrass pasture, with possible lucerne rotations, show that the nutrient load can be utilised or assimilated by the soil profile across the irrigation areas. Salinity can be managed largely through natural leaching and with managed responses based on monitoring. The effluent quality will not cause soil infiltration issues and will not impact on the natural soil sodicity at depth.

The proposed effluent irrigation scheme is based on a deficit irrigation approach and results in only a small average annual application of effluent. This will minimise the risk of water logging and hence surface runoff and deep drainage of effluent.

Management of the effluent reuse scheme will need to be adaptive in response to monitoring data. Monitoring will be used to identify at an early stage any departure from the plan and will be used as the basis to adjust aspects of the waste management plan if required.

The site assessment indicates that the land is suitable for managed effluent irrigation and there is adequate land to ensure hydraulic and nutrient loads can be managed on site. In the very unlikely event that issues arise, the following contingency measures could be undertaken:

- Supplying all or part of the treated effluent to off-site users nominated under authority approved contractual arrangements;
- Connection to the reticulated sewerage system for disposal of part of the effluent volume;
- Removing part or all of the effluent load from the site by road tanker; or
- Changes to effluent treatment process.

1.9.1.6 Domestic Effluent Management

Domestic wastewater will be treated in a packaged onsite aerated wastewater treatment system (AWTS) and reused through irrigation across a dedicated land application area.

The minimum land area required is 2,500 m^2 and there is adequate room on the site to accommodate this dedicated area.

1.9.2 PROVISIONAL OPINIONS

There are no provisional opinions relating to my report.

1.9.3 QUESTIONS OUTSIDE AREA OF EXPERTISE

I consider that the subject matter of the report is within my area of expertise and addresses the relevant issues required in the agreed scope of work. My report is complete and to the best of knowledge accurate.

1.10 DECLARATION

I have made all the enquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.

MARTIN DAVID HAEGE
Principal Environmental Engineer/Director, Geolyse Pty Ltd

12 June 2015

Introduction

2.1 BACKGROUND

RLX Investment Company Pty Ltd, as trustee for RLX Investment Trust (RLX IC), proposes to relocate the Central Victoria Livestock Exchange (CVLX) from its existing site in central Ballarat to the north-west outskirts of the city. This move will allow the development of a state-of-the-art facility that will provide livestock marketing and saleyard services for the Ballarat district and extending further into central Victoria.

The facility will provide:

- Covered livestock selling centres (cattle and sheep);
- Offices, agents facilities and associated car parking areas;
- Truck parking and truck wash facilities;
- Holding yards and paddocks; and
- Associated site infrastructure.

The proposal is being considered through a works approval under the *Environment Protection Act* 1970 and a proposed Planning Scheme Amendment under the *Planning and Environment Act* 1987.

2.2 SCOPE

A *Water Cycle Management Report* (Geolyse, 2014) (WCMR) was prepared to support the proposed development. Since the preparation of the 2014 WCMR, there have been some minor amendments to the proposed layout in response to the submissions of parties; specifically larger roof areas and reduced external yard areas. These amendments change the water cycle.

In addition, further data has been used to refine the estimated quantity and quality of the effluent for onsite reuse through irrigation, and additional soil and groundwater data obtained to confirm the site suitability for effluent reuse.

This report presents details of the changes and provides an updated water cycle management report for the proposed development. The general concepts of how the water cycle and effluent management system will be managed remain the same as presented in the 2014 WCMR.

2.3 SUZ15 DEVELOPMENT PLAN REQUIREMENTS

I have reviewed the requirements of Schedule 15 to the Special Use Zone.

In my opinion the requirement to prepare a Flood Investigation, Stormwater Management Plan and an Operations and Environmental Management Plan are appropriate and sufficient for the proposed development.

These investigations and plans will address the following areas which are covered in my report:

- Water cycle management;
- Surface water management including flooding;
- Liquid and solids waste management;
- Onsite effluent reuse through irrigation; and
- Management and monitoring.

Revised Development

3.1 SITE LAYOUT

The revised site layout is shown in **Figure 1**.

Amendments to the site layout include:

- Larger roof areas:
  - Cattle roof was 4,230 m^3 now 9,046 m^2
  - Sheep roof was 12,840 m^2 now 27,125 m^2
- Less uncovered yards:
  - External cattle yards was 6,900 m^2 now 4,082 m^2
  - External sheep yards was 19,800 m^2 now 13,081 m^2
- Removal of Holding Pond 1;
- Increased the rainwater pond from 5 ML to 7 ML;
- Relocation of the first flush pond;
- Relocation of the surface water wetland system;
- Inclusion of the western area for limited irrigation;
- Identification of a limited irrigation area in the eastern part of the site;
- Designation of a domestic effluent land application area; and
- Designation of a grassed overflow carpark area.

3.2 BENEFITS OF REVISED LAYOUT

Benefits of the revised layout are summarised below:

- Larger roof areas – increases the catchment area for rainwater harvesting increasing the volume of onsite supply. Reduces the area of uncovered external yards.
- Less uncovered yards – reduces the volume of first flush water entering the effluent management system. Reduces the volume of wash down water used for periodic cleaning.
- Removal of Holding Pond 1 – required holding pond volume provided in one storage. Increases land available for irrigation in the western part of the site. Simpler irrigation management.
- Larger rainwater pond – improves onsite water harvesting coupled with larger roof area.
- First flush pond – located to suit likely grades of the external yards.
- Surface water wetland – located to below the 100 year flood line as a fully in ground structure (so as not to impact on flooding patterns). Provides room to relocate the rainwater pond and increase the available irrigation area.
- Domestic effluent land application area – provides a designated land application area and demonstrates adequate land area is available.
- Overflow carpark – provides a designated overflow car park area and demonstrates adequate land area is available.

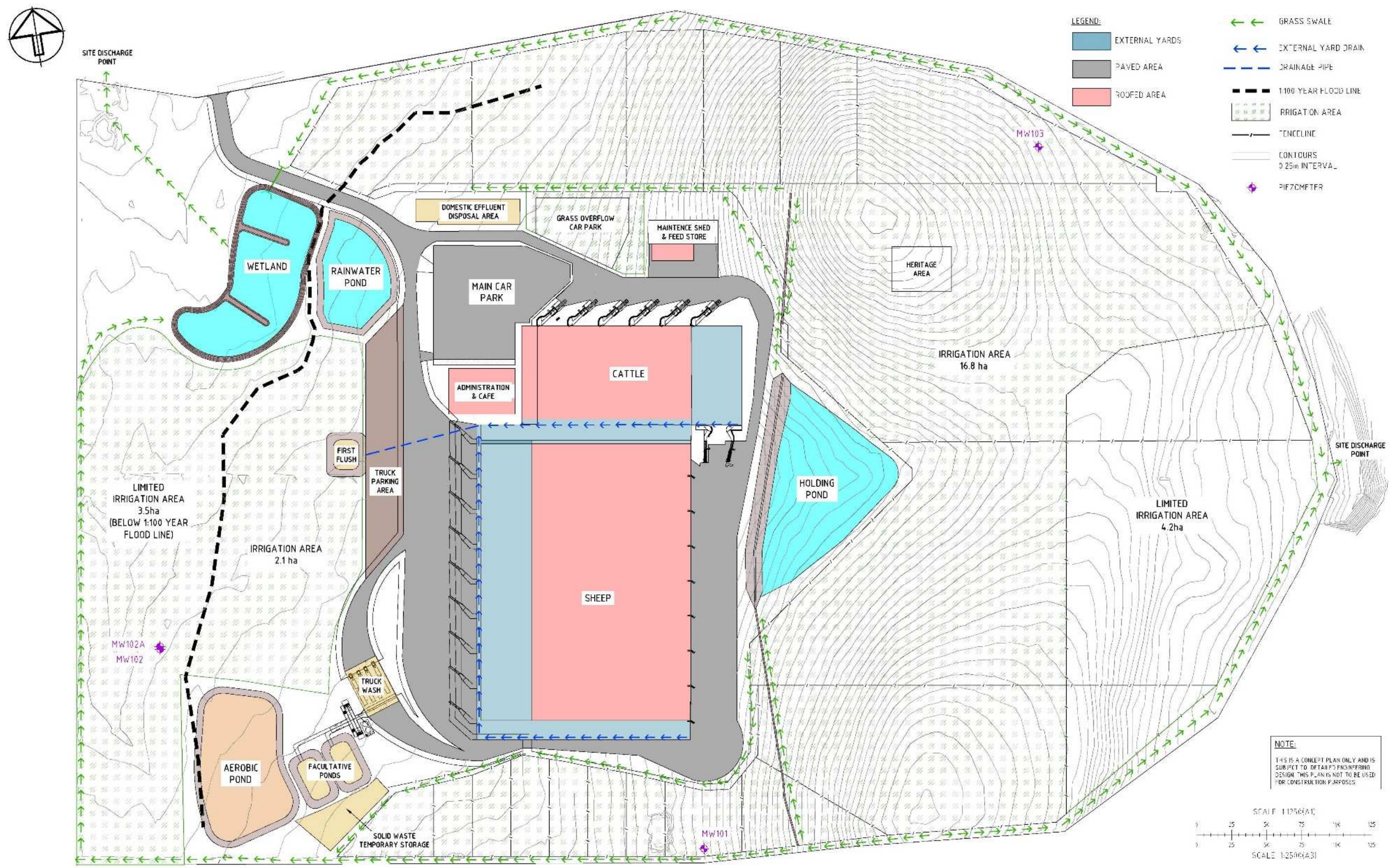


Figure 1: CVLX revised layout

Water Cycle Modelling

4.1 WATER DEMANDS

Water demands remain as presented in the 2014 WCMR apart from the following:

- Truck wash demand – refer to the discussion in **Section 4.3.1**
- Sheep yard wash down – refer to the discussion in **Section 4.3.3**

4.2 ROOFWATER HARVESTING

The larger roof areas increases the rainwater harvesting capacity.

Runoff from the roofs was calculated using an initial loss of 1 mm and runoff coefficient of 0.9. The rainwater pond has been increased from 5 ML to 7 ML to manage the additional roof runoff.

4.3 WASTEWATER GENERATION

The 2014 WCMR detailed wastewater volume generation. Some components have changed due to the revised site layout or through consideration of further data. These changes are noted for each wastewater source as required.

4.3.1 TRUCK WASH

The average annual truck wash wastewater volume presented in the 2014 WCMR was 27.8 ML/year. This was derived from the application of the 85th percentile sale numbers for each sale throughout the year and assumption that all B-doubles and semi-trailers delivering stock will use the truck wash facility.

Use of the 85th percentile sale data for every sale in the year was conservative as it exceeded the capacity of the facility over a year and over-estimated truck wash volumes and effluent generation. The derivation of the truck wash wastewater volume has therefore been revised using four years of sale data for the existing facility in Ballarat and design details for the proposed truck wash.

Sale data for the existing livestock selling facility in Ballarat was summed to obtained monthly totals for the period May 2010 to April 2015. Four complete years (2011 to 2014) of monthly data were extracted and used to derive a pattern of sales through a year. Typically there are higher sale numbers in summer months compared to winter months and there is no store cattle sale in January which results in larger store cattle sales in February.

The monthly distribution for each sale type and number of sales per month was then used to distribute the facility's capacity through the year (i.e. Store cattle 48,000; Prime cattle 22,000 and Sheep 1,600,000 pa). This assessment resulted in design sale sizes that varied through the year. The results are shown in **Figures 2**, **3** and **4**.

The figures also show the previously adopted 85th percentile sale size that were used in the 2014 WCMR (Geolyse, 2014). The revised analysis typically results in sales sizes larger than the 85th percentile sale in summer months, and lower in the winter months.

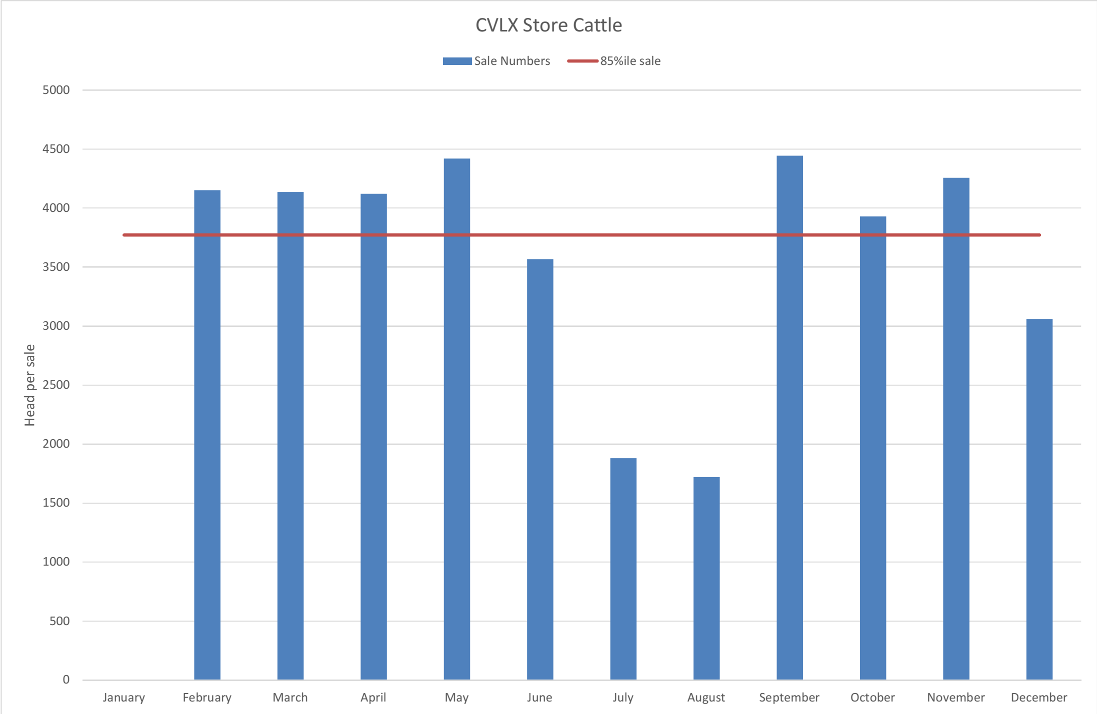


Figure 2: Design store cattle sales

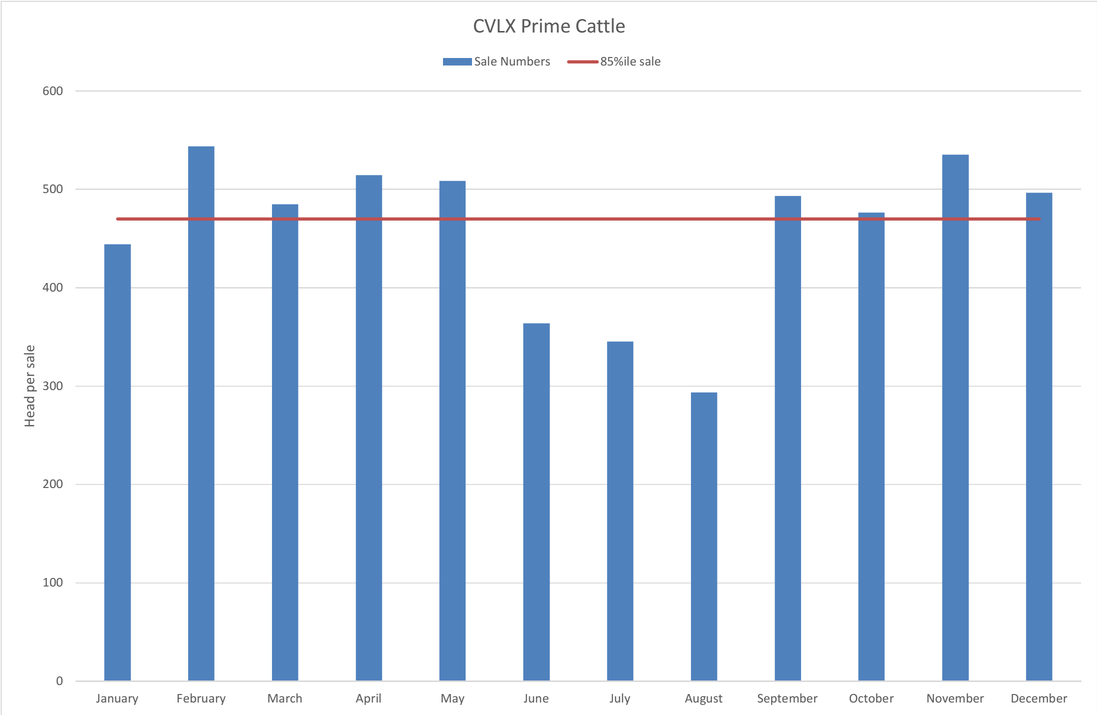


Figure 3: Design prime cattle sales

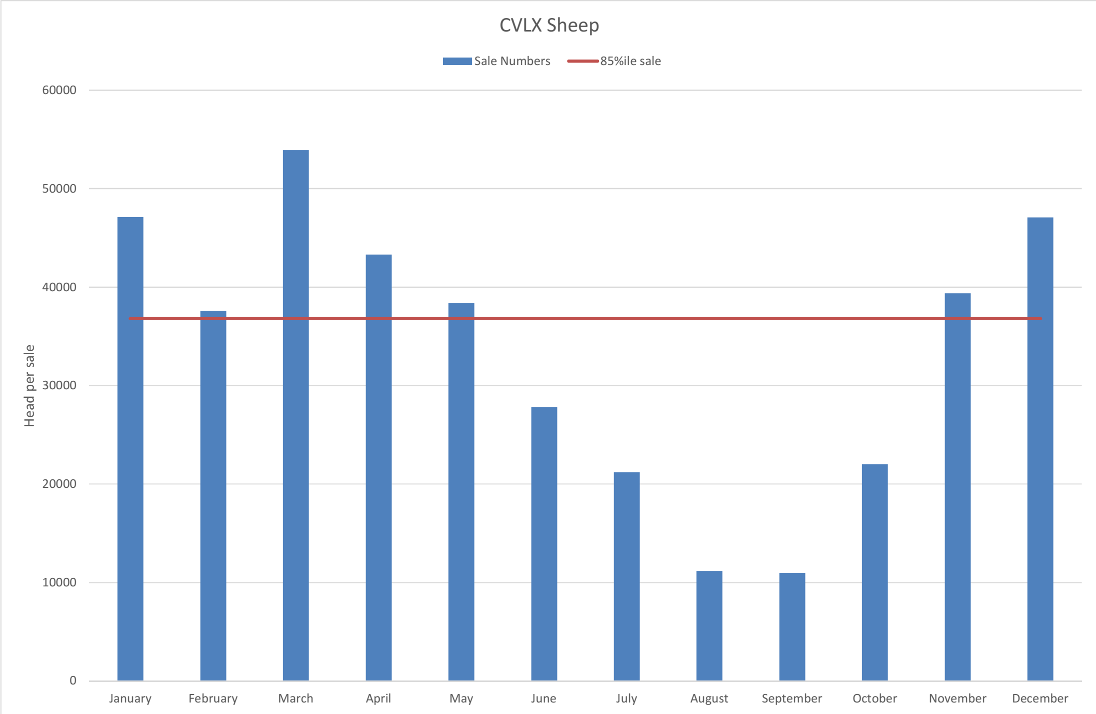


Figure 4: Design sheep sales

The traffic engineering assessment report (Traffix Group, 2014) identified the typical truck breakdown for trucks delivering stock for sale. This data and typical truck stock capacities were used to derive truck numbers for each sale based on the monthly sale data. It was then assumed that every B-double and semi-trailer and 30% of rigid trucks delivering stock will use the truck wash.

Truck wash data from the Tamworth Regional Livestock Exchange shows that the average wash time for a B-double is 58 minutes. This was rounded to 60 minutes and used to estimate a wash time of 50 minutes for semi-trailers and 30 minutes for rigid trucks.

The proposed truck wash at the CVLX will use hoses with a flow rate of 1.6 L/s. The above data therefore results in the following water consumption per truck wash:

- B-doubles 5.76 kL per wash
- Semi-trailers 4.8 kL per wash
- Rigid trucks 2.88 kL per wash

The annual truck wash water consumption from this analysis is 25.8 ML/year.

Data from the existing truck wash in Ballarat shows an average annual water consumption over the past five years of 21.5 ML/year. This facility uses hoses with a flow rate of 2 L/s. If the flow rate was reduced to 1.6 L/s the average annual water consumption would be 17.2 ML/year. Therefore the average annual truck wash water consumption derived for the proposed CVLX is greater than the recorded consumption at the existing site. It is considered that this provides a conservative basis for the long term assessment of the effluent treatment and reuse scheme.

Effluent from the truck wash passes through a solids separation system and a portion of the water is removed in the solids. Further, some water used in the truck wash is removed on the truck. These losses are estimated as 2% of the water consumption which equates to 0.5 ML/year.

Therefore the truck wash wastewater volume used for the design and assessment of the treatment system and reuse scheme is estimated to be 25.3 ML/year.

4.3.2 TROUGH WASH

Stock water troughs throughout the facility will be cleaned every fortnight to remove a build-up of dust. The total capacity of the troughs is around 45,000 litres. The model includes an allowance to completely fill and wash out stock troughs every two weeks which generates about 1.2 ML/year of wastewater.

4.3.3 SHEEP YARD WASH DOWN

The revised concept layout for the proposed CVLX has a larger roofs for the cattle and sheep yards. The larger roof areas means the area of external yards is reduced (see discussion below) and less sheep yard wash down is required.

The majority of the sheep yards will be dry cleaned following sales. Some critical areas will be washed on a fortnightly basis. This activity will take about 4 hours using three hoses each with a flow rate of 1.6 L/s and consume 69.12 kL of water per fortnight.

It has been assumed that 90% of the water used for wash down will end up in the wastewater system, therefore generating 1.6 ML/year of wastewater.

4.3.4 CATTLE SCALE WASH DOWN

The scales are cleaned after each cattle sale. This is done using a high pressure cleaner with a flow rate of about 0.3 L/s and takes around 25 to 30 minutes. The model includes 500 litres per week from this activity.

4.3.5 EXTERNAL YARD FIRST FLUSH

The revised concept layout for the proposed CVLX has a larger roofs for the cattle and sheep yards. Therefore the area of external yards has reduced as follows:

- External cattle yards: was 0.69 ha ; revised 0.41 ha
- External sheep yards was 1.98 ha; revised 1.31 ha

Rainfall runoff from the external yards will be directed to a first flush basin that is sized to capture the first 50 mm of runoff. The first flush pond acts as a surge tank capturing runoff and allowing a controlled discharge to the effluent treatment system via a small pump or gravity pipe (depending on final design levels).

Runoff modelling assumed an initial loss of 3 mm and runoff coefficient of 70% from the external yards. This generates an average volume of 4.75 ML/year.

4.4 IRRIGATION MODEL

The entire site water cycle was modelled using an integrated daily water balance model, as presented in the 2014 WCMR. The model is based on SILO generated daily climate (rainfall and evaporation) data covering the period 1 January 1889 to 31 December 2013 (i.e. 125 years). SILO generated data was used to obtain at least 100 years of daily climate data.

The water cycle model includes an irrigation reuse component that is based on a soil moisture balance to calculate irrigation demand and a storage balance to calculate the wet weather holding pond requirements.

The soil moisture calculations are based on the following equation:

Change in Soil Storage = Precipitation + Irrigation - Evapotranspiration - Runoff - Drainage

The above equation is used to track soil moisture using a daily time step as described by the following equation:

$$SM_d = SM_{d-1} + P_d + I_d - ET_d - R_o - D_d$$

Where SM_d = soil moisture at the end of the current day

SM_{d-1} = soil moisture at the end of the previous day

P_d = rainfall for the current day

I_d = irrigation for the current day

ET_d = crop evapotranspiration for the current day

R_o = runoff

D_d = drainage below the root zone for the current day

Runoff from the irrigation area is calculated in accordance with the method outlined in *Guidelines for Irrigation Publication 168* (EPA, 1991). The model assumes one soil horizon and deep drainage is calculated if the soil moisture content increases above field capacity. The model assumes that the input and output of water occurs in a set order each day as follows:

- Precipitation added;
- Runoff removed;
- Evapotranspiration removed;
- Irrigation added; then
- Drainage calculated.

Daily evapotranspiration is determined using crop factors applied to the average daily potential evaporation. Crop factors for lucerne and ryegrass were used for the modelling consistent with the crop factors outlined in Table 7 of *Guidelines for Irrigation Publication 168* (EPA, 1991).

The soil moisture store is used to represent the readily available water (RAW = field capacity – wilting point) in the soil profile. The following relationships apply to the soil moisture:

- Soil moisture can be reduced by evapotranspiration until it reaches zero (i.e. wilting point) after which no further evapotranspiration can occur (i.e. no water removed from the soil profile below wilting point).
- Deep drainage (potential groundwater recharge) would occur if the soil moisture increases to field capacity.

The irrigation regime modelled was based on a deficit irrigation approach that applies 5 mm once the soil moisture fell to 15 mm below field capacity. Only applying 5 mm provides a 10 mm soil moisture buffer to accommodate some rainfall if it was to occur immediately following irrigation. It also ensures the soil profile does not become saturated through irrigation.

A storage balance is used to track the behaviour of the holding pond. Calculations are based on the following equation:

$$S_d = S_{d-1} + IN_d + P_d - EV_d - I_d - SP_d - SL_d$$

Where S_d = storage volume at the end of the current day

S_{d-1} = storage volume at the end of the previous day

IN_d = inflow for current day

P_d = gain in storage volume due to rainfall on current day

EV_d = loss in storage volume due to evaporation

I_d = irrigation for current day

SP_d = spill from storage in current day

SL_d = seepage losses – nil as the ponds will be lined (clay or HDPE)

Inflow to the holding pond is determined from the water cycle model based on flow through the effluent treatment system. The holding pond will receive runoff from a small upstream catchment which was calculated assuming initial losses of 5 mm and a runoff coefficient of 20%.

Direct rainfall will add to the pond volume and evaporation will extract water. Evaporation losses from the holding pond are determined using the average daily evaporation figures and a pan factor of 0.7 to convert pan evaporation to storage surface evaporation. The area available for evaporation varies depending on the pond storage volume, based on a stage/surface area relationship. Direct rainfall is added to the pond storage using the area at top of bank.

Spill is determined if the storage from the previous day plus inflows minus outflows exceeds the maximum storage capacity of the pond.

Irrigation water is drawn from the pond when the soil moisture conditions are below the irrigation trigger value. A maximum of 200 kL (5 mm over 4 ha) is irrigated when conditions permit.

The daily water cycle model used for the CVLX is the same model as used for the design and assessment of the Northern Victoria Livestock Exchange (NVLX). The model is made site specific given the proposed facility layout and local climate data. Results from the NVLX assessment, including a comparison with the EPA's monthly water balance model, were reviewed and accepted by the EPA.

4.5 REVISED WATER CYCLE ASSESSMENT

The revised water cycle results are shown on **Figure 5**.

Key changes from the 2014 WCMR are:

- The estimated annual potable water demand has reduced from 25.4 ML/year to 11.6 ML/year as follows:
  - 4.5 ML/year less to supply the truck wash top up
  - 2.5 ML/year less for sheep yard wash down
  - 6.8 ML/year less for rainwater pond top up due to increased roof water harvesting
- The estimated annual irrigation volume has reduced from 41.8 ML/year to 34.7 ML/year due to less first flush runoff and less truck wash and sheep yard wash down effluent.
- A reduction in the holding pond volume required from 38.2 ML to approximately 31 ML. This is due to the lower annual effluent production and the change in truck wash generation through the year (there is less truck wash effluent generated in the winter months due to lower sale numbers). There is no spill from the holding pond.
- An increase in the estimated annual site runoff from the western catchment to 29.5 ML/year.

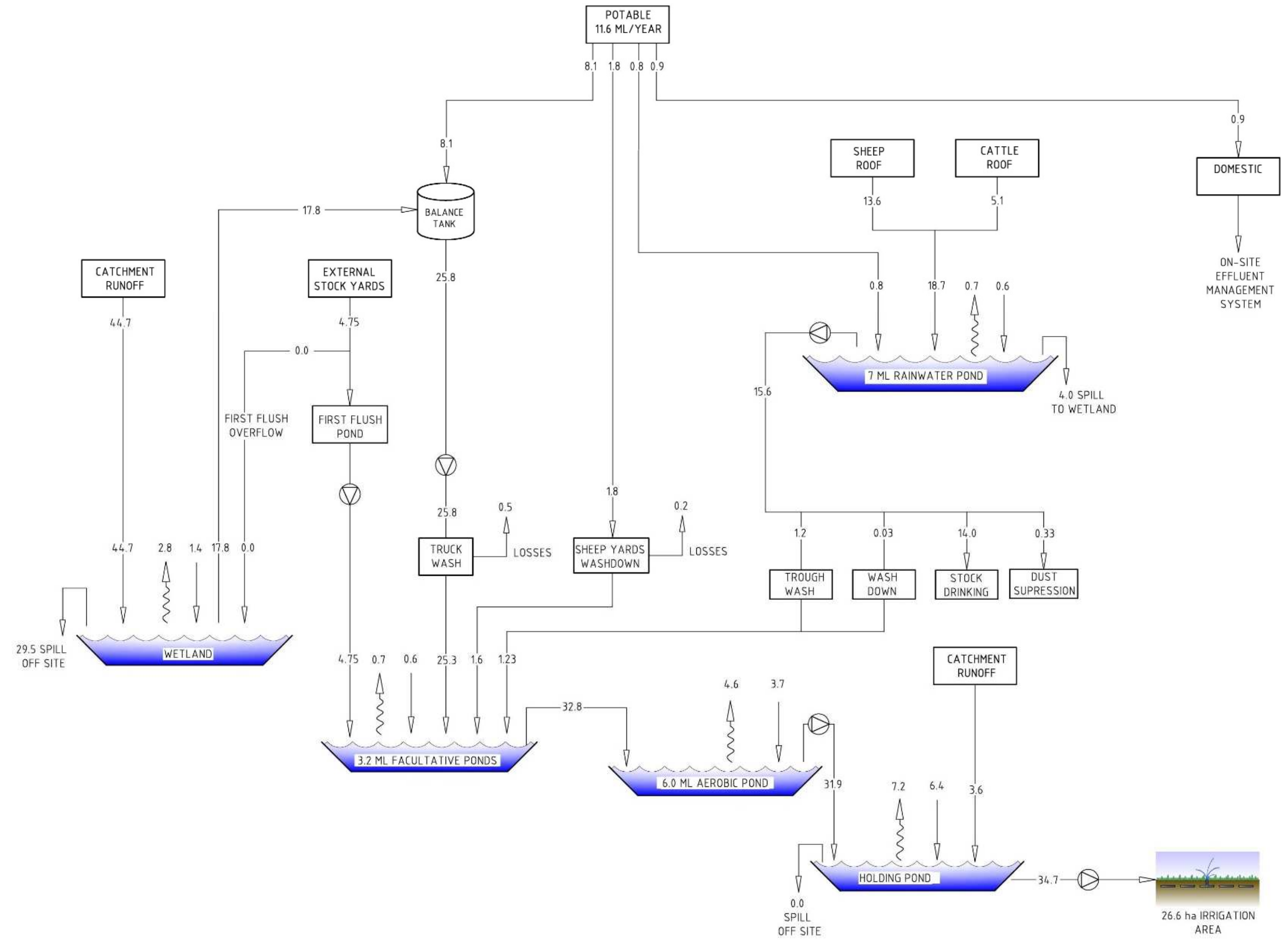


Figure 5: Water cycle schematic (ML/year)

Surface Water Management

5.1 MANAGEMENT PHILOSOPHY

5.1.1 CATCHMENT DEFINITION

The proposed surface water management system will separate the development into three catchments and treat runoff according to the level of potential contamination present. The three catchment types are: clean water; contaminated water and minor contaminants. Drains, diversion banks/bunds and ground shaping will be used to define and separate the catchments.

Table 5.1 provides a summary of the catchment types, the pollutants likely to be present and the fate of the surface water emanating from each catchment type.

Table 5.1 – Surface water catchments

Catchment type	Elements of the Proposed Development Contained with the Catchment	Likely Pollutants	Fate of Catchment Runoff
Clean	• Pavilion roofs • Roof of Central Facilities Building	• Suspended solids • Metals • Minor microbial content from birds and dust	Roof water will be collected in the rainwater pond and used as the principle supply of water for stock drinking, wash down and dust suppression. The water cycle modelling demonstrates that the proposed 7 ML pond coupled with the roof catchment supplies 95% of the average annual non-potable water demand.
Contaminated	• Yard wash down • Trough wash • Scale wash down • Truck wash • First flush system (external yards)	• Suspended solids • Nutrients • Salt • Hormones (possibly) from stock waste • Metals (from truck wash) • Oil and grease and hydrocarbons (from truck wash) • Microbial content	Fully contained catchment in which water and wastewater (runoff or water generated from process activities) is collected and treated through the effluent management system. Treated effluent will be reused across the irrigation area.
Minor Contaminants	• Car/truck parking areas • Trafficable areas/roadways • Central facilities building • Irrigation areas • Holding paddocks • Grassed areas • Landscaped areas	• Suspended solids • Minor nutrients and salts from stock wastes that may discharge from heavy vehicles • Minor microbial content • Very minor oil and grease, hydrocarbons and metals from trafficable areas • Minor nutrients from paddock runoff	All runoff from the western catchment will be directed to the surface water wetland system for treatment prior to discharge offsite. All runoff from the eastern catchment will be collected in grass swales which will provide treatment prior to discharge offsite.

A significant proportion of the water generated from the clean catchment (roofs) will be used in the development. Any spill from the rainwater pond will be collected and treated in the surface water wetland system before discharging off-site. Some of the wetland water is also reused on site. Therefore the majority of pollutants contained within the runoff from the clean catchment will be retained onsite.

The contaminated catchment is a fully contained system that will treat and reuse effluent for irrigation. The irrigation reuse scheme is designed to exceed the requirements of the EPA publication *Guidelines for Environmental Management Use of Reclaimed Water* (EPA, 2003). It has been designed as a full reuse scheme that will balance the hydraulic load so that there is no discharge to surface water. Site soils are suitable and the area available will result in a hydraulic and nutrient deficit irrigation program that will ensure excess nutrients will not be available to leach from the site.

Modelling of the scheme indicates no discharge from the holding pond occurred in the 125 years modelled, which exceeds the EPA design criteria which permits discharge on average once every ten years. Any discharge of pollutants from the contaminated catchment is highly unlikely.

Runoff from the balance of the development area that may contain minor contaminants would be similar to urban/agricultural land runoff. The major pollutants identified for this catchment are suspended solids, nutrients and microbial content. There is the potential for very minor oil and grease, hydrocarbon and metal loads from trafficable areas. Therefore an integrated surface water management system comprising of grass swales and a constructed wetland system is proposed to manage pollutants from this catchment.

5.1.2 SURFACE WATER MOVEMENT PATHWAYS

Spill from the rainwater pond will be collected and treated in the surface water wetland system before discharging offsite.

The contaminated catchment (effluent management system) is a fully contained system that will treat and reuse effluent for irrigation. Modelling of this system exceeds the EPA design criteria as there is no modelled spill over 125 years. If there was spill from the system it would be treated effluent from the holding pond which would then be conveyed by the surface water system to the constructed wetland before discharging offsite.

Therefore the potential pathways for water moving from the site are:

- The outlet from the constructed wetland; and
- The outlet from the grass swales drains on the eastern boundary.

These are shown on **Figure 1**.

5.2 WATER QUALITY ASSESSMENT

5.2.1 INDEPENDENT REVIEW

An independent review of the site surface water modelling (water quality and quantity) presented in the 2014 WCMR has been undertaken (Neil M Craigie Pty Ltd, 2015).

In terms of the water quality modelling, this review recommended the following changes to the MUSIC[1] model:

- Use of 10 years of 6 minute rainfall data (1986 to 1995 six minute rainfall data for Ballarat Aerodrome);
- An annual potential evapotranspiration (PET) of 1,031 mm/year varied using the monthly areal record for Ballarat;
- Different soil parameters to model runoff from pervious areas including lower field capacity in the developed case to model the potential for increased runoff from irrigated areas as follows:
  - soil storage capacity 120 mm, field capacity 50 mm for non-irrigated pervious areas; and
  - soil storage capacity 120 mm, field capacity 40 mm for irrigated pervious areas; and
- Changes to the modelling of the surface water wetland system.

The above recommendations have been adopted for the MUSIC modelling of the revised site layout described in the following sections.

[1] MUSIC – Model for Urban Stormwater Improvement Conceptualisation

5.2.2 MUSIC MODELLING

5.2.2.1 Catchments

Catchment areas for each case modelled are summarised in **Table 5.2**.

Table 5.2 – MUSIC catchment areas

Model	Western Catchment		Eastern Catchment	
	Area (ha)	% impervious	Area (ha)	% impervious
Existing	34.84	0	9.1	0
Catchment not reaching wetland	9.98	Na	Na	Na
Developed – roof	3.74	100	Na	Na
Developed – sealed	4.69	100	Na	Na
Irrigated paddocks	12.33	0	9.1	0
Balance	4.10	0	Na	Na

5.2.2.2 Surface Water Wetland

Preliminary sizing of the wetland indicated a volume of approximately 7 ML and a surface area of approximately 0.4 ha would be required for water quality control. Further, a volume of about 4,000 m^3 above the normal water level would be required to retard peak stormwater discharge in the critical 100 year ARI event. These are conceptual sizes and are subject to detailed design; however they form the basis for modelling of the proposed surface water wetland system.

The wetland system will provide a source of water for the truck wash facility. The water cycle modelling shows that an average of about 69% of the annual truck wash demand can be supplied from the wetland.

The wetland will include three zones:

- sedimentation basin – a deeper area at the inlet (approximately 2 ML);
- macrophyte zone – a shallow area supporting aquatic macrophytes (approximately 60% of the surface area holding around 1 ML); and
- open water zone – a deeper zone at the outlet (approximately 3-4 ML);

The water supply from the truck wash will be drawn from the open water zone and internal bunds will contain water in the macrophyte zone when the pond is drawn down. The water cycle model allowed reuse from the wetland whenever the storage was greater than 5 ML.

The surface water wetland system is modelled in MUSIC using a wetland (sedimentation basin and macrophyte zone) and pond (open water zone with reuse). The following modelling assumptions were adopted for the wetland system in MUSIC.

Wetland:

- Inlet pond volume 2,000 m^3
- Macrophyte surface area 2,500 m^2
- Extended detention depth 0.5 m
- Permanent pool volume 1,000 m^3
- Initial volume 1,000 m^3 (i.e. starts full)
- Exfiltration rate nil
- Evaporative loss 15% of PET
- Equivalent pipe diameter 70 mm

• Overflow weir		10 m
• k	TSS	1500 m/yr
	TP	1000 m/yr
	TN	150 m/yr
• C*	TSS	12 mg/L
	TP	0.09 mg/L
	TN	1.0 mg/L

Pond:

• Surface area		1,500 m^2
• Extended detention depth		0.5 m
• Permanent pool volume		4,000 m^3
• Initial volume		4,000 m^3 (i.e. starts full)
• Exfiltration rate		nil
• Evaporative loss		25% of PET
• Equivalent pipe diameter		100 mm
• Overflow weir		10 m
• k	TSS	400 m/yr
	TP	300 m/yr
	TN	40 m/yr
• C*	TSS	12 mg/L
	TP	0.09 mg/L
	TN	1.0 mg/L
• Reuse		17,756 kL/year distributed using the monthly pattern determined from the water cycle modelling

Grass Swales (eastern catchment)

The proposed grass swales will run around the perimeter of the site in the eastern catchment to collect all site runoff and direct it to a discharge point (existing low point) on the eastern boundary. The total swale length will be around 790 m along the north-eastern and south-eastern boundaries.

For the MUSIC assessment, the eastern catchment was split into two subcatchments draining to the swales. The following model parameters were used for the swales.

North-east swale:

• Length	300 m (note: total length is about 390 m)
• Average bed slope	0.5%
• Base width	2 m
• Top width	5 m
• Depth	0.5 m
• Vegetation height	0.20 m
• Exfiltration	0.4 mm/hr

South-east swale:

• Length	300 m (note: total length is about 400 m)
• Average bed slope	1.5%
• Base width	2 m

- Top width 5 m
- Depth 0.5 m
- Vegetation height 0.20 m
- Exfiltration 0.4 mm/hr

Only 75% of the total swale length available was assumed to provide treatment. The exfiltration rate used in the modelling (0.4 mm/hour) would represent heavy to medium clay. The silty loam topsoil at the site (which will be used to line the swales to provide a medium for vegetation) would be expected to have an infiltration capacity of 10 to 80 mm/hour (EPA, 1991).

It is noted that all surface water components are subject to detailed design. The final detailed design will be consistent with the conceptual design presented in this report.

5.2.3 WATER QUALITY RESULTS

Results of the MUSIC modelling for the revised site layout are summarised in **Table 5.3** and **Table 5.4** for the western and eastern catchments respectively.

Table 5.3 - Water quality modelling results western catchment – average annual loads

Parameter	Units	Existing	Wetland		
			Inflow	Outflow	% Reduction through Wetland
Flow	ML/year	34.4	48.1	29.9	38%
Total Suspended Solids	kg/year	951	9870	461	95%
Total Phosphorous	kg/year	7.84	19.8	2.95	85%
Total Nitrogen	kg/year	43.3	91.1	33.2	64%

Table 5.4 - Water quality modelling results eastern catchment – average annual loads

Parameter	Units	Existing	Outflow from grass swale system
Flow	ML/year	8.99	7.9
Total Suspended Solids	kg/year	238	111
Total Phosphorous	kg/year	2.04	1.03
Total Nitrogen	kg/year	11.2	11.2

The MUSIC modelling shows that the average annual pollutant loads from the developed site are less than the existing loads. In the western catchment, this results from a combination of water recycling and the treatment provided by the surface water management system. The wetland significantly reduces the average annual pollutant loads as about 40% of the average inflow is recycled back to the facility which removes pollutants from the surface water system.

It is also noted that surface water in the western catchment will be conveyed to the wetland system by grass swales. The water quality benefit of the grass swales was not included in the water quality modelling.

Discharge from the eastern catchment is managed by the grass swale system which effectively reduces pollutant loads from this catchment. The volume of site discharge is expected to reduce slightly due to retention and evapotranspiration in the grass swale system.

The water quality modelling demonstrates that the downstream receiving environment will receive water with improved quality.

The results of the MUSIC modelling for the revised site layout are consistent with the findings from the independent review (Neil M Craigie Pty Ltd, 2015).

5.3 WATER QUANTITY ASSESSMENT

5.3.1 INDEPENDENT REVIEW

An independent review of the site surface water modelling (water quality and quantity) presented in the 2014 WCMR has been undertaken (Neil M Craigie Pty Ltd, 2015).

In terms of peak flow checks, the XP-RAFTS results presented in the 2014 WCMR were compared to results developed from the Rational Method and the RORB hydrologic model.

The RORB hydrologic model results were more conservative for the 10 and 100 year Average Recurrence Interval (ARI) storms for the existing catchment and were considered to be the appropriate targets for design.

5.3.2 STORMWATER DISCHARGE

The revised site layout was modelled using XP-RATFS. Model parameters were adjusted to obtain peak flows for the existing catchment that were more consistent with the results obtained using RORB (Neil M Craigie Pty Ltd, 2015).

Results are summarised in **Table 5.5**.

Table 5.5 – XP-RAFTS modelling results (western catchment)

ARI (years)	Pre development peak discharge @ north-west corner m^3/s	Post development			
		Peak discharge m^3/s	Peak basin level m	Depth over spillway m	Peak discharge @ north-west corner m^3/s
1	0.03	0.01	0.28	0	0.014
10	0.92	0.57	0.57	0.07	0.63
100	2.47	1.72	0.69	0.19	1.91

The XP-RAFTS modelling demonstrates that the proposed surface water wetland system effectively limits peak discharge from the developed site to less than existing levels. The post development peak discharge at the north-west catchment outlet is less than pre-development peak discharge for all modelled storms.

This is consistent with the findings from the independent review (Neil M Craigie Pty Ltd, 2015).

5.3.3 SITE YIELD

The water cycle and MUSIC models estimate existing average site yield from the western catchment to be about 34.4 ML/year. The proposed facility, including water harvesting and reuse, is estimated to discharge an average of about 29.9 ML/year.

Therefore the volume of water discharged from the site will be reduced.

The proposed facility sits in the Burrumbeet Creek catchment. Mapping provided by the Glenelg Hopkins CMA shows that the creek system has a catchment area of 7,642 ha upstream of the point of discharge. Modelling of this catchment indicates an average annual discharge of 7,550 ML/year. Therefore the existing site discharge makes up about 0.4% of the total catchment discharge, and the reduction in site yield is 0.07% of the total catchment discharge.

The reduction in site yield is therefore very unlikely to impact on water users downstream of the proposed facility.

5.4 SURFACE WATER ASSESSMENT

5.4.1 SURFACE WATER MANAGEMENT

The assessment and discussion above indicates that the surface water management system for the proposed developed will control and manage runoff within the development site. Each surface water catchment has management measures commensurate with the level of contamination likely to be present. The surface water management system will:

- limit post-development peak discharge to less than existing site peak discharge;
- ensure that future stormwater pollutant loads (total suspended solids, total phosphorous and total nitrogen) will be much lower than under existing conditions;
- ensure stormwater runoff volumes are less than existing; and
- supply a portion of the site water demand through roof and surface water harvesting.

Runoff from the western catchment, which is managed by the surface water wetland, will discharge to an ephemeral drainage line which heads in a north-westerly direction and joins with Burrumbeet Creek about 800 m downstream. This drainage line has a catchment area of about 280 ha upstream of the Sunraysia Highway. This drainage line will not impact on the Miners Rest residential areas.

Runoff from the eastern catchment of the development will be collected by the grass swales and directed to a discharge point on the eastern end of the development site. Runoff will discharge to an existing drainage line that passes beneath the Sunraysia Highway. This drainage line conveys water from a 720 ha catchment and heads in a northerly direction to the western edge of Miners Rest where it joins with Burrumbeet Creek.

The eastern catchment will include the stock holding paddocks and a portion of the irrigation area. There are no storages or other infrastructure proposed in the eastern catchment. The stocking density is generally low and short lived and will be typical of grazing activities in the area. The effluent reuse scheme will be based on a deficit irrigation approach that will prevent effluent runoff from the irrigation area and ensure there is soil moisture capacity to accept runoff should rainfall occur shortly following irrigation.

The grass swales in the eastern catchment will be designed to contain runoff for storms up to the 1 in 100 year ARI event (1% AEP). Water quality modelling demonstrates that the grass swales will manage the runoff quality.

Therefore:

- the potential for contaminated runoff from the eastern catchment is very low; and
- there will be no uncontrolled runoff for events up to the 1 in 100 year ARI (1% AEP). There may be some breaches of the swales system for events larger than this (e.g. the 0.5% AEP (1 in 200 year ARI)) however this is a rare event and if it was to occur there would be a substantial flow in the drainage line to the east of the development from the upstream 720 ha catchment.

The surface water management measures proposed for the development are:

- Managing surface water in defined catchments with management measures commensurate with the level of contamination likely to be present;

- Retaining as much surface water onsite for beneficial reuse to reduce the demand on potable water supplies;
- Maintaining grass/vegetative cover through stocking rotation and irrigation;
- Managing the effluent reuse scheme on a deficit irrigation approach that will prevent effluent runoff from the irrigation area and ensure there is soil moisture capacity to accept runoff should rainfall occur shortly following irrigation; and
- An integrated surface water management system comprising of grass swales and a surface water wetland system to manage flows and surface water quality.

Some surface water will continue to be discharged from the site. This discharge will occur in the same locations as it currently does. The volume, peak flow and velocity of the discharge will be less than existing conditions and the water will be better quality.

5.4.2 FLOODING

Flooding data provided by Glenelg Hopkins Catchment Management Authority (GHCMA) is included as **Appendix A**. This data shows modelled flood extents for events ranging from the 20% Annual Exceedance Probability (AEP) (5 year ARI) through to the 0.5% AEP (200 year ARI).

There are existing drainage lines on the eastern and western boundaries of the site. The eastern drainage line conveys runoff from a 720 ha catchment. It passes beneath the Western Freeway, runs around the eastern end of the site and then beneath the Sunraysia Highway. It then heads in a northerly direction to the western edge of Miners Rest where it joins with Burrumbeet Creek. Flood events up to the 5% AEP are contained to the drainage line with increasing amounts of ponding around the eastern end of the site. In larger events (> 5% AEP) some flood flow moves from the eastern end of the site along the southern side of the Sunraysia Highway to the western drainage line. 1% AEP flood levels at the eastern end of the site are between 418 to 418.4 mAHD.

There is no infrastructure proposed in the eastern part of the site that will alter peak site runoff. Therefore, there will be no change to flooding patterns in the eastern drainage line, and no flooding impacts on the western edge of Miners Rest as a result of the development.

The western drainage line conveys runoff from a 280 ha catchment. This drainage line passes beneath Western Freeway, follows the western boundary of the site and then passes beneath the Sunraysia Highway via a culvert. It continues in a north westerly direction and joins with Burrumbeet Creek about 800 m downstream.

Flooding data provided by GHCMA shows there is only a very small difference in flood levels and extents for floods ranging from the 20% AEP (5 year ARI) to the 0.5% AEP (200 year ARI) in the western drainage line. For example, at the southern end of the western drainage line (adjacent to where the proposed wastewater treatment ponds will be) the 20% AEP flood level is 411.8 m AHD (refer to Sheet 01 of 06 in **Appendix A**). At the same location the 0.5% AEP flood level is 412.0 m AHD which is only 0.2 m deeper (refer to Sheet 06 of 06 in **Appendix A**).

This is because flooding in the upper end of the western drainage line is controlled by the culvert beneath the Western Freeway. Flood levels and extents on the southern side of the Western Freeway increase with the larger flood events; however the flood water passing the proposed site remains relatively consistent. Downstream of the freeway the flood slope is steep with the flood profile generally following the longitudinal slope of the drainage line.

The main drainage outfall for the CVLX is to the western drainage line. The proposed surface water management system will limit peak discharge to less than existing. This can only help improve flooding albeit in a very minor sense given the relative size of the contributing catchments.

The western drainage line discharges to Burrumbeet Creek well downstream of Miners Rest. The 1% AEP flood levels at the north western corner of the CVLX site are approximately 410.80 mAHD compared with flood levels of about >414 mAHD at the western edge of Miners Rest. It is not possible for discharge from the CVLX site to change flooding patterns in Miners Rest.

5.4.3 EFFLUENT PONDS

The proposed wastewater treatment ponds are logically located in the lower part of the development. They are in close proximity to, but outside of, the defined 1% AEP flood extent.

The relevant consideration with regards to the risk of flood water entry to the wastewater treatment ponds is the height of the pond embankment above the flood level, not the proximity to the horizontal extent of flooding.

All wastewater treatment ponds (and the rainwater pond) will include embankments that are a minimum of 600 mm above the 1% AEP flood level (as per GHCMA advice). The existing ground levels are outside of the defined 1% AEP flood extent, so the pond embankments will be well above the 1% AEP flood level and even the 0.5% AEP flood level, given there is little difference in the flood level for these two events. This will provide adequate protection to prevent the entry of flood water to the wastewater treatment ponds.

The proposed wastewater treatment ponds are subject to detailed design. However given that the ponds will have embankments that are a minimum of 600 mm above the existing surface levels, and each pond will have a minimum of 900 mm freeboard to the normal operating level, the level of stored wastewater in the ponds against constructed embankments will be at most 300 mm. This means there will minimal risk of embankment failure and wastewater loss from the ponds.

Therefore, there will be minimal risk of wastewater loss from the ponds through embankment failure and an extremely low (to nil) risk of flood water entry to the wastewater ponds.

5.4.4 SURFACE WATER WETLAND

Following revision to the site layout and discussion with GHCMA, the proposed surface water wetland system is now located within the 1% AEP flood extent. To facilitate this, the wetland system will be constructed fully below ground with no embankments. Swale drains discharging water to the wetland system will also be constructed below ground so as not to change flooding patterns. A below ground tail out channel will be used to control the level in the wetland system to ensure air space is retained for peak stormwater control, consistent with the concepts described in this report.

The independent review (Neil M Craigie Pty Ltd, 2015) identified a preference for a low bank to be constructed along the western edge of the proposed wetland system. This bank would allow greater flexibility for hydraulic control in the wetland and would prevent the ingress of flood water.

I have considered the proposed low bank and I am satisfied that it would be preferred for the above reasons and that it could be incorporated into the design without detrimentally impacting on flooding patterns in the location.

Effluent Reuse Scheme

6.1 LAND CAPABILITY

Further soil and groundwater investigations have been completed across the site comprising:

- Excavation of six additional test pits to a target depth of 2.5 m – 15 soil test pits now completed across the site;
- Drilling three boreholes to 25 m and completing these as monitoring piezometers;
- Installation of a shallow monitoring piezometer in the south west of the site (paired with a deep monitoring piezometer); and
- Excavation of 17 shallow test pits in the south eastern portion of the site to map the extent of an underlying basalt flow.

The extent of these investigations is shown on **Figure 6**.

Data from the additional site investigations, coupled with an understanding of the proposed development, have been used to assess the land capability for the onsite reuse of treated wastewater through irrigation.

6.1.1 LANDFORM

The proposed area for effluent reuse through irrigation is shown on the revised site layout (**Figure 1**). It contains no rock outcrops and generally slopes less than 1% to the west, with the exception of hillocks in the east of the site which slope at gradients ranging from 1% to 5%. The site landform is classed as level to undulating (EPA, 1991).

A small farm dam is located in the north-west corner with another on the southern boundary. A shallow ephemeral drainage line runs along the western site boundary.

Sites with slopes of less than 10% are preferred for irrigation (EPA, 2003) and recommended water application rates for slopes of 1% to 5% are within the infiltration rate of the top 0.4 m of the soil profile (Table 12 of EPA, 1991).

There are no landform constraints to onsite effluent irrigation.

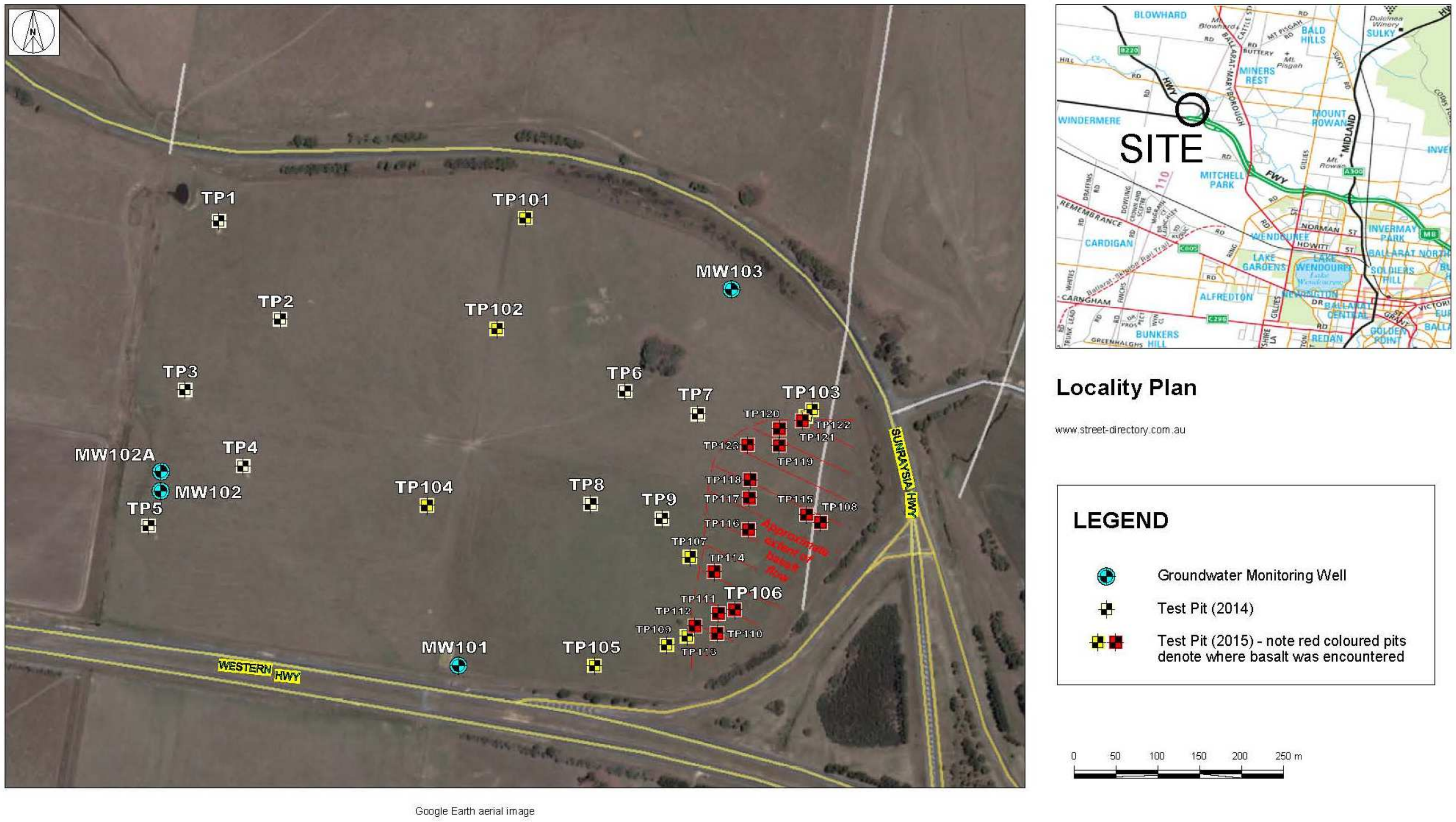
6.1.2 SOIL PROFILE

The level to undulating landform is relatively uniform across the site. The site is not a complex land system that indicates the presence of different soil systems. Vegetation across the site is uniform and consistent and does not indicate any significant changes in soil fertility.

Fifteen soil test pits have been excavated across the site to a target depth of 2.5 m. Nine were excavated in 2014 and a further six in 2015. A further 17 test pits were excavated in the 2015 investigation to map the extent of a basalt flow. These pits provide adequate coverage of the site which, as discussed below and as indicated by the site visual features, has little soil variation across the landscape. A summary of the soil profile encountered in the test pits is provided in **Table 6.4**.

The 32 test pits were excavated to depths of between 0.8 m and 2.9 m and no groundwater was observed in any of the test pits prior to backfilling.

Topsoil analysis was undertaken from two locations during the 2014 investigations. Subsoil analysis was undertaken at four locations during the 2015 investigations. The following sections provide a discussion of the findings from these two investigations.



Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: RLX Investment Company Pty Ltd	Monitoring Well and Test Pit Location Plan Livestock Exchange Miners Rest	PROJECT No: 79187.01
	OFFICE: Melbourne		DRAWING No: 1
	DATE: May 2015		REVISION: -

Figure 6: Monitoring well and test pit location (Douglas Partners, 2015)

Table 6.1 – Soil test pit profile summary

Test pit	Sandy/clayey silt topsoil thickness m	Silty clay subsoil thickness m	Depth to rock m
1	0.45	>2.25	>2.7
2	0.3	>2.5	>2.9
2	0.3	>2.55	>2.9
4	0.25	>2.65	>2.9
5	0.25	>1.25	>1.5
6	0.2	>1.3	>1.5
7	0.2	>1.3	>1.5
8	0.7	>1.6	>2.0
9	0.1	1.6	>2.0
101	0.4	>2.1	>2.5
102	0.4	>2.1	>2.5
103	0.4	>2.1	>2.5
104	0.4	>2.1	>2.5
105	0.3	0.7	>2.5
106	0.2	0.8	1.0
107	0.4	0.9	1.3
108	0.3	1.2	1.5
109	0.4	1.1	1.5
110	0.3	0.6	0.9
111	0.3	0.9	1.2
112	0.3	1.0	1.3
113	0.4	1.1	1.5
114	0.3	1.1	1.4
115	0.3	0.7	1.1
116	0.3	1.7	2.0
117	0.35	1.05	1.4
118	0.3	1.0	1.3
119	0.3	0.5	0.8
120	0.3	0.7	1.0
121	0.2	0.9	1.1
122	0.4	2.0	>2.7
123	0.3	0.6	0.9

Source: Douglas Partners, 2015

The soil test pits show minimal variation in the soil profile across the site. The soil profile generally comprises a surface layer of sandy/clayey silt, typically about 0.2 m to 0.4 m thick beneath a grass root mat surface. This is underlain by a typically hard, orange brown/grey silty clay, typically of high plasticity and 'crumbly' when disturbed (i.e. 'moderate' structure). The thickness of the high plasticity silty clay subsoil ranged from 0.5 m to >2.65 m. Drilling indicated the silty clay subsoil is 1.5 m thick at MW101, 3.5 to 4.0 in MW102 and MW102A respectively and 7.0 m thick at MW103.

A basalt flow was located in the south-eastern portion of the site. As with the remainder of the site, the topsoil in this area is sandy/clayey silt, typically about 0.2 m to 0.4 m thick beneath a grass root mat surface. The underlying silty clay subsoils range in thickness from 0.5 m to 1.7 m before reaching the basalt which is located at depths of between 0.8 m to 2.0 m.

Seventeen additional test pits were used to map the extent of the basalt flow (refer to **Figure 6**).

6.1.3 INFILTRATION

The sandy/clayey silt topsoil would be expected to have an infiltration capacity similar to clay loam which has an indicative infiltration rate of 2 to 15 mm/hour (EPA, 1991). The proposed irrigation application rate ranges from 2.5 to 5.0 mm/day, so the topsoil infiltration capacity is not limiting.

Infiltration testing of the subsoil was conducted in the 2014 and 2015 investigations. Results are summarised in **Table 6.2**. Whilst there is some variability in the results, the range is reasonably consistent with the indicative infiltration rate range of 0.1 to 8 mm/hour for clay as reported in *EPA Publication 168* (EPA, 1991).

The results indicate that the subsoil has relatively low permeability. The topsoil has a moderate infiltration rate which is not limiting and there is typically 0.2 to 0.4 m of the topsoil overlying the clay subsoil. The low subsoil permeability can be managed by appropriate irrigation scheduling including light applications and irrigating to match a soil moisture balance. The clay subsoils will be good for retaining moisture to support crop growth, retaining nutrients particularly phosphorous and for preventing excessive downward movement of irrigation water.

Table 6.2 – Insitu soil permeability test results

Test	Depth	Result mm/hour
IT1 (2014)	0.25 – 0.50m	17
IT2 (2014)	0.25 – 0.50m	0
IT3 (2014)	0.25 – 0.50m	4
TP101 (2015)	0.50 – 0.80m	7
TP102 (2015)	0.45 – 0.60m	0
TP104 (2015)	0.45 – 0.72m	0
TP105 (2015)	0.45 – 0.85m	0.8

6.1.4 SOIL CHEMISTRY

A summary of the soil chemistry analysis is provided in **Appendix B**.

pH

Soil pH values ranged from 4.6 (very strongly acid) to 7.4 (mildly alkaline). Soil pH was noted to vary across the site and with depth (the lowest pH obtained at a depth of 1.4 m). The preferred crops for the site are lucerne and ryegrass. Optimum soil pH range for these crops is 5.6 to 8.5 (EPA, 1991) with ryegrass tolerating more acidic conditions compared to lucerne. The soil pH is considered suitable for these crops.

Other crops that may be considered for rotation include winter cereals (wheat/oats) which have an optimum pH range of 5.5 to 7 (Hazelton and Murphy, 2007). Again the soil pH is considered suitable for these crops.

Salinity

The topsoil is rated as non-saline with electrical conductivity (saturated extract) (EC_e) ranging from 0.02 dS/m and 0.04 dS/m. The soil salinity then appears to increase with depth through the soil profile as follows:

- Depth 0.4 – 0.5 m (TP103): EC_e = 0.8 dS/m (non-saline)
- Depth 0.9 – 1.0 m (TP102): EC_e = 2.0 dS/m (slightly saline)
- Depth 1.4 – 1.5 m (TP104): EC_e = 4.7 dS/m (moderately saline)
- Depth 1.4 – 1.5 m (TP105): EC_e = 4.4 dS/m (moderately saline)

Lucerne is moderately salt tolerant with no yield reduction expected in soil with an EC_e < 2.8 dS/m (Hazelton and Murphy, 2007). The higher soil salinity at depth may restrict lucerne growth if roots extend to this depth.

Ryegrass and wheat are more salt tolerant with no yield reduction expected in soil with an EC_e < 5.6 dS/m and 6.0 dS/m respectively (Hazelton and Murphy, 2007).

Therefore the soil salinity will not be limiting to suitable crop production.

Sodicity

Sodicity is a measure of exchangeable sodium (Na) in relation to other exchangeable soil and is usually expressed as the Exchangeable Sodium Percentage (ESP) of the soil. The measured ESP values indicate the topsoil is non-sodic. The subsoil is rated as being marginally to strongly sodic which is also indicated by the low permeability of the subsoil.

The non-sodic topsoil indicates that surface crusting is unlikely to occur and the infiltration capacity of the topsoil should be maintained. The soils are also not susceptible to erosion. Based on the expected reuse water quality (moderate salinity and low SAR) no risk of increased soil sodicity is indicated (refer to later discussion).

Cation Exchange Capacity

The cation exchange capacity (CEC) of the topsoil ranges from 1.8 to 6.0 cmol+/kg, which is considered to be very low (Hazelton and Murphy, 2007) and consistent with a soil type having low soil organic matter. The organic content and CEC of the soil will improve over time with the addition of treated effluent. The CEC increases to moderate in the subsoil (Hazelton and Murphy, 2007) indicating the subsoil has a good ability to hold nutrients.

Nutrients

Total nitrogen ranges from 200 to 1,000 mg/kg through the soil profile which is rated as being low to very low. Almost all of the total nitrogen is organic with insignificant amounts of the mineralised forms of nitrogen present. The addition of nitrogen in the treated effluent will help meet crop nutrient requirements.

Available phosphorous, as measured by the Colwell test, ranges from 8.9 mg/kg to 16.4 mg/kg in the topsoil and 5 mg/kg to 20 mg/kg in the subsoil. These are rated as low, with values of 20 mg/kg on the boundary of low to moderate (Department of Environment and Primary Industries, 2015).

Phosphorous Sorption Capacity

The phosphorous sorption capacity averages 380 mg/kg in the topsoil. The phosphorous sorption capacity in the subsoil is higher averaging 905 mg/kg and ranging from 680 mg/kg to 1,000 mg/kg. This result is consistent with the higher clay content in the subsoil and indicates that the soil profile has a good capacity to retain phosphorous.

6.1.5 GROUNDWATER

A desktop groundwater review was completed by Douglas Partners prior to site investigations. This report is included in **Appendix C**.

Four groundwater wells were installed at the site (refer to **Figure 1** and **Figure 6**), intercepting groundwater attributed to shallow and deeper aquifers underlying the site. Three deep boreholes (MW101, MW102 and MW103) were progressed to depths ranging from 23.5 to 25.2 m below ground level (mBGL), and one shallow borehole (MW102A) was progressed to 8.0 mBGL. No groundwater infiltration was recorded as being encountered at depths shallower than 5.5 mBGL and beyond this depth observations of infiltration were obscured by drilling fluid.

The standing water level (SWL) prior to purging of groundwater was recorded as ranging from 2.44 mBGL to 8.62 mBGL. Corrected groundwater levels based on survey datum was calculated to range from 406.32 m Australian Height Datum (AHD) at MW102A to 413.50 mAHD at MW101. The observed groundwater levels are consistent with the regional depth to water table and the groundwater flow potential across the site is in a north westerly direction.

It is noted that the corrected SWL in the deep groundwater well MW102 is 2.5 m higher than the SWL in the adjacent shallow well MW102A. This is indicative of the deeper aquifer being pressurised to a degree, causing the hydraulic head to be elevated. This indicates the basalt layer forms an aquitard separating the shallow and deep systems.

Groundwater quality is summarised in **Table 6.3**. Groundwater salinity is moderate to high which makes it poor quality. The observed salinity is broadly consistent with the mapped regional salinity. The deeper monitoring well MW102 has lower salinity compared to the adjacent MW102A. This is further evidence that the basalt is separating the two aquifer systems.

Low levels of nutrient are present in the groundwater.

Table 6.3 – Groundwater quality

Parameter	MW101	MW102	MW102A	MW103
Electrical conductivity, µS/cm	2,700	860	5,900	2,000
Total dissolved solids, mg/L	1,800	390	3,900	1,100
Total phosphorous, mg/L	0.1	<0.05	0.2	<0.05
Aluminium, mg/L	<10	<10	<10	<10
Sodium, mg/L	390	100	840	300
Potassium, mg/L	3.8	2.6	2.0	4.0
Calcium, mg/L	59	23	96	32
Magnesium, mg/L	120	31	210	53
Total nitrogen, mg/L	0.82	1.9	1.7	1.7
Phosphate, mg/L	0.043	<0.005	0.006	<0.005
Ammonia as N, mg/L	0.005	0.15	0.007	0.15
Nitrite as N, mg/L	<0.005	0.006	0.006	0.14
Nitrate as N, mg/L	0.017	0.032	0.097	0.22
Total Kjeldahl nitrogen, mg/L	0.8	1.9	1.6	1.3
Oxidised nitrogen as N, mg/L	0.017	0.038	0.1	0.35

Source: Douglas Partners, 2015

The four groundwater monitoring piezometers will form the basis of a monitoring network for the irrigation scheme. **Section 6.3.6** outlines the proposed groundwater monitoring program which will be included in the site EMP.

6.1.6 LAND CAPABILITY SUMMARY

The site investigations and laboratory testing identifies that the land is suitable for managed effluent irrigation. The area chosen for irrigation contains no rock outcrops, has slopes of less than 10% and does not exhibit any signs of erosions.

The soil profile is generally classified as sandy/clayey silt overlying silty clay. Soil pH is suitable for the proposed crops and the existing soil salinity (which increase at depth) will not be limiting to suitable crop production. Current soil fertility is low and crops will respond to the application of nutrients in the treated effluent.

Drilling onsite indicated no groundwater infiltration was recorded as being encountered at depths shallower than 5.5 m below ground level. The standing water level in the aquifers beneath the site ranges from 2.5 to 8.5 m below ground level. The groundwater gradient is towards the north and west.

Groundwater salinity is moderate to high which makes it poor quality. Low levels of nutrient are present in the groundwater.

Infiltration testing indicates that the subsoil profile has relatively low permeability. The topsoil has a moderate infiltration rate which is not limiting for the proposed irrigation scheme. The low subsoil permeability can be managed by appropriate irrigation scheduling. The water balance for the irrigation system is based on applying 2.5 mm/day to 5 mm/day when the soil moisture store is at least 15 mm less than field capacity. This is a low application that would match the low permeability of the subsoil. The 300 to 400 mm of topsoil would buffer water movement through to the subsoil. Appropriate irrigation scheduling will be used to ensure the soil profile does not become saturated through irrigation.

The clay subsoils will be good for retaining moisture to support crop growth and for retaining nutrients. The low permeability will also help prevent excessive downward movement of irrigation water.

The proposed irrigation areas are shown on the site layout in **Figure 1**. The site layout has been revised and provides a total irrigation area of 26.6 ha as follows:

- Main irrigation area 18.9 ha
- Limited irrigation area (eastern portion) 4.2 ha
- Limited irrigation area (western portion) 3.5 ha

The main irrigation area will be used on a rotational basis and irrigated as soil conditions allow. These areas are characterised as having a deep soil profile.

The limited irrigation areas are located in the eastern and western part of the site. The limited irrigation area in the eastern part of the site correlates with the area of the mapped basalt flow. The soil profile in this part of the site is not as deep. Therefore irrigation rates in the eastern portion will be lower (around 2.5 mm per irrigation) to match site conditions. Irrigation of the western portion will generally be restricted to summer months and will not occur when there is surface water present.

The proposed effluent irrigation scheme is based on a deficit irrigation approach and results in only a small average annual application of effluent. This results from the need to spread the effluent across the entire irrigation area to ensure a nitrogen deficit or balance is achieved. The operation of the irrigation scheme on a moisture deficit basis will minimise the risk of water logging and hence surface runoff and deep drainage of effluent. The low average annual application rates coupled with the available soil profile will minimise deep drainage to the underlying groundwater.

6.2 EFFLUENT TREATMENT SYSTEM

6.2.1 EFFLUENT QUANTITY

The design flow for the effluent management system is 90 kL/day, which has been derived from the revised water cycle modelling.

6.2.2 DESCRIPTION

The effluent management system will include:

- Primary solids removal in a trafficable solids trap.
- Treatment in a 3.2 ML mechanically aerated facultative pond system (two parallel 1.6 ML facultative ponds) which will reduce the organic (BOD) and suspended solids content. These ponds will provide 36 days hydraulic residence time (HRT). The aeration system creates a facultative pond with an oxygenated upper layer which reduces odour and a deeper anaerobic layer. The system delivers a cost effective means of achieving breakdown of organic material, biological sludge removal and odour control. The facultative system will use two ponds that will operate in parallel. The use of two ponds will allow one to be taken offline for short periods for maintenance and cleaning as required.
- A 6.4 ML aerobic pond that will provide a further 71 days HRT. This pond has a design depth of 1.2 m to provide aerobic treatment of the effluent stream. This pond has been designed for passive aeration. The calculations presented in the following section indicate that adequate biological breakdown should occur in this pond with passive aeration alone. Additional aeration could be added to this pond if ongoing operational monitoring indicates that it is required.
- A 37 ML holding pond located on the eastern side of the facility. This pond would be used to balance irrigation.

All ponds (apart from the holding pond) will be constructed as turkey nest dams with minimum embankment height of 0.6 m above the surrounding ground levels. As such they will not receive any surface runoff. Only direct rainfall will add to the pond volume and evaporation and reuse will extract water.

The holding pond will receive runoff from a small catchment which has been included in the analysis.

All ponds are subject to final detailed engineering design.

6.2.3 SYSTEM MANAGEMENT

The proposed treatment system is a robust, stable biological system that requires very little intervention once fully commissioned. Normal plant management processes will include weekly inspection that will target the following areas:

- Aerator operation
- Pond condition – colour, odour, surface layers, volume
- Transfer pipe condition
- Embankment condition

Any mechanical items (i.e. aerators and transfer pumps) will be subject to routine maintenance in accordance with manufacturer's recommendations and/or repaired as required. Routine monitoring will be used throughout the commissioning period, and on a reduced frequency on an ongoing basis, to ensure the system is functioning as expected. These measures will be detailed in a site Environmental Management Plan (EMP).

6.2.4 CLASS C EFFLUENT

The proposed wastewater management system has been designed to ultimately achieve Class C effluent as defined by the *EPA Publication 464: Guidelines for Environmental Management, Use of Reclaimed Water* (The Reuse Guidelines, EPA (2003)). Class C effluent is suitable for irrigation on pasture/crops for grazing or fodder production.

In accordance with Table 1 of the Reuse Guidelines the following treated effluent targets apply:

- pH 6 – 9
- Biochemical Oxygen Demand < 20 mg/L
- Suspended solids < 30 mg/L
- E. coli < 1,000 cfu/100mL

These targets are median values to be determined over a 12 month period.

No targets are provided for nutrients as these are considered on a loading basis (refer to **Section 6.2.5**).

As detailed in the 2014 WCMR it will take 12 to 18 months for the effluent management system to be fully commissioned. The commissioning period is required to allow the necessary biological systems to establish and to obtain data to demonstrate that the reclaimed water is fit for purpose. During this time, Class C effluent may not be achieved. A range of management measures are proposed for this period which include:

- Applying minimum buffer distances of 50 m to the irrigation area to minimise the possibility of spray drift into adjoining properties;
- Using a low pressure travelling irrigator to minimise spray drift;
- Irrigating under suitable wind conditions;
- Adopting deficit irrigation scheduling to ensure the irrigation area does not become saturated due to irrigation; and
- Withholding stock from the reuse area until such time that the scheme monitoring demonstrates that grazing will be possible (i.e. when Class C achieved).

If, for some reason, the effluent was not meeting Class C, the above management actions will be employed. Investigations for effluent improvement would also be undertaken.

In terms of the targets for Class C effluent, none of the quality parameters are fatal to the proposed reuse scheme. Periods outside of these target values could be easily managed.

6.2.5 EFFLUENT QUALITY FOR IRRIGATION

Data from operating livestock exchanges were used to inform the design effluent quality used in the modelling for the proposed CVLX. The site characteristics and data for these operating facilities are summarised in **Table 6.4**.

The difference in the wastewater quality between the two operating sites is related to the pollutant sources. The Central Tablelands Livestock Exchange (CTLX) effluent system receives input from the truck wash and scale wash down only. This facility is fully covered and there is no input from yard runoff.

The Inverell Regional Livestock Exchange (IRLX) is an uncovered facility and the effluent system receives runoff and wash down from the yard surface and discharge from the truck wash.

Both facilities have facultative treatment followed by aerobic holding ponds.

Table 6.4 – Effluent data

Parameter	CTLX	IRLX	Adopted for CVLX
Effluent source	Truck wash, scale wash down	Trucks wash and uncovered cattle and sheep yards with concrete and dirt floors	Truck wash, scale wash down, some external yard runoff, holding pond catchment
pH	Average: 7.9 Range: 6.8 – 8.86 (n = 29)	Average: 7.9 Range: 7.7 – 8.01 (n = 7)	6.5 – 8.5
Total Kjeldahl Nitrogen, mgN/L	Average: 48.2 Range: 18.2 – 91.1 (n = 29)	Average: 194 Range: 140 – 398 (n = 7)	148
Ammonia, mgN/L	Average: 25.2 Range: 1 – 55.9 (n = 29)	Average: 117 Range: 95.2 – 146 (n = 7)	73
Nitrite, mgN/L	Average: 1.4 Range: <0.1 – 4.77 (n = 23)	Average: <0.1 Range: (n = 7)	2
Nitrate, mgN/L	Average: 0.8 Range: <0.1 – 2.75 (n = 23)	Average: 0.04 Range: <0.1 – 0.04 (n = 7)	
Total nitrogen, mg/L	Average: 50 Range: 18.3 – 91.1 (n = 29)	Average: 194 Range: 140 – 398 (n = 7)	150
Total phosphorous, mg/L	Average: 18.6 Range: 2.25 – 29 (n = 29)	Average: 47.2 Range: 32.2 – 113 (n = 7)	30
Potassium, mg/L	Average: 211 Range: 34 – 319 (n = 29)	Average: 389 Range: 280 – 596 (n = 7)	250
Electrical conductivity, µS/cm	Average: 1,550 Range: 349 – 2,340 (n = 28)	Average: 3,301 Range: 2,830 – 4,330 (n = 7)	1,900
Sodium absorption ratio (SAR)	Average: 2 Range: 0.9 – 3 (n = 29)	Average: 3.7 Range: 3.0 – 5.4 (n = 7)	2.5

The source of nutrients in the wastewater system at the proposed CVLX is from the truck wash, scale wash down, external yard runoff, periodic sheep yard wash down (after dry cleaning) and runoff to the holding pond. The following factors were considered when estimating the final effluent quality for CVLX:

- The CVLX effluent system will receive external yard runoff and washdown (after dry cleaning). Therefore the effluent is expected to have higher nutrient concentration compared to the CTLX facility. However, the effluent is very unlikely to be similar to the IRLX facility as the majority of the yards will be roofed.
- The IRLX monitoring data has one outlier result. Without this result the average total nitrogen concentration would be 160 mg/L and total phosphorous 36 mg/L.
- The electrical conductivity (salinity) of the effluent at IRLX is higher compared to CTLX as bore water is used as part of the water supply. The bore water has an electrical conductivity of 600 to 800 µS/cm. This would also affect the SAR.

The monitoring data from the operating sites shows that the nitrogen in the wastewater is almost entirely organic with 50% or more being ammonia. There is very little oxidised nitrogen and the proposed treatment process will not generate significant amounts of nitrate.

6.3 EFFLUENT REUSE SCHEME

6.3.1 WATER BALANCE AND IRRIGATION AREAS

The irrigation scheme water balance has been revised based on the re-evaluation of wastewater generation as detailed in **Section 4.3**. The site layout has been revised and provides a total irrigation area of 26.6 ha as follows (refer to **Figure 1**):

- Main irrigation area 18.9 ha
- Limited irrigation area (eastern portion) 4.2 ha
- Limited irrigation area (western portion) 3.5 ha

The main irrigation area will be used on a rotational basis and irrigated as soil conditions allow.

The limited irrigation areas are located in the eastern and western part of the site. Irrigation rates in the eastern portion will be lower (around 2.5 mm per irrigation) to match site conditions. Irrigation of the western portion will generally be restricted to summer months and will not occur when there is surface water present. It has been assumed that these areas will receive about 25% less irrigation compared to the main irrigation area.

Water balance modelling was undertaken assuming either lucerne or ryegrass was established across the irrigation areas.

The average annual volume irrigated is around 35 ML/year, which equates to a long term average application rate of 1.44 ML/ha/year (144 mm) on the main irrigation area and 0.98 ML/ha/year (98 mm) on the limited irrigation areas. The average across the site is 1.31 ML/ha/year (131 mm). These are low annual application rates.

The average irrigation rates for both crops remains about the same; the pattern of water use through the year is slightly different (**Figure 7**). This is because it is the effluent availability that dictates the annual application rate, not the crop water demand. That is, there is not sufficient treated effluent volume to meet the crop water demands. This will be reflected in reduced crop yields, which has been factored into the nutrient balances.

The average irrigation depth applied in each month is shown in **Figure 7**. Typically the values in January to May are around 10 to 17 mm per month as the effluent application is limited by the wastewater production (i.e. the holding pond is empty). Larger monthly values occur in October to December to empty the holding pond which has stored treated wastewater over winter (minimal irrigation in June to September). The largest average monthly application is just over 20 mm in November for ryegrass.

Average application through the winter period is very low:

- Lucerne: total of 15 mm is applied over June, July, August and September; and
- Ryegrass: total of 7 mm is applied over June, July, August and September.

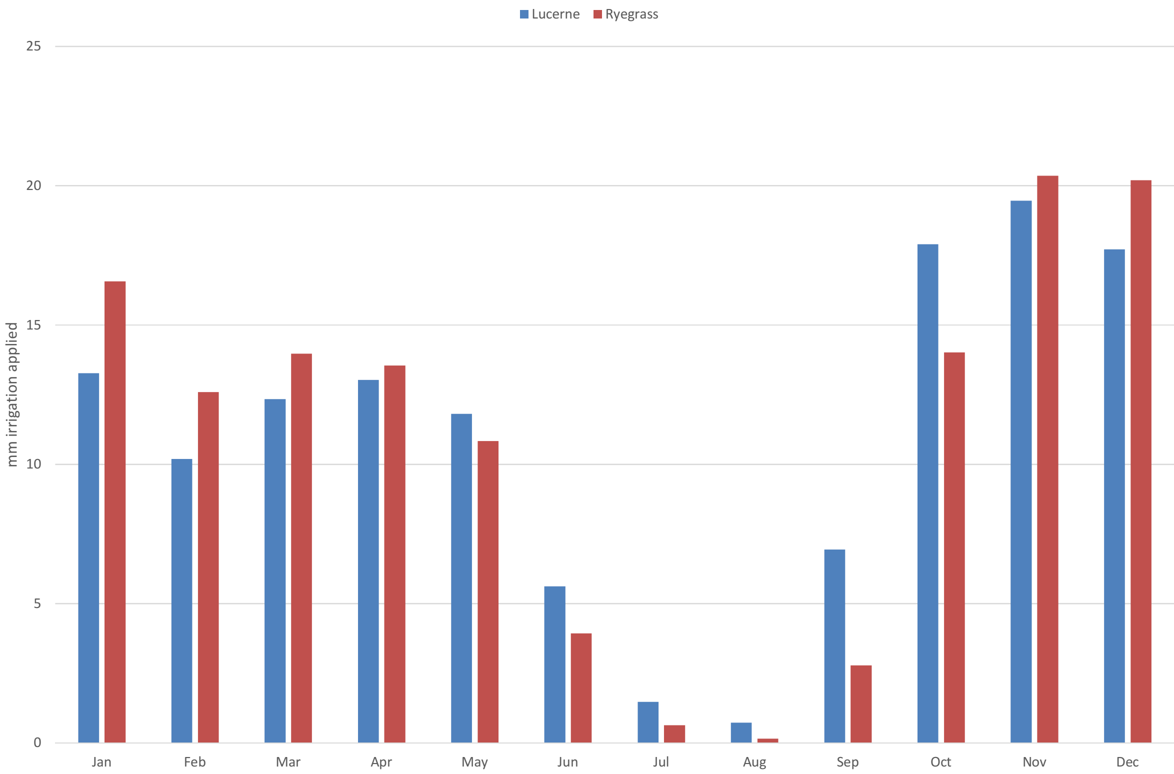


Figure 7: Average monthly irrigation depth (mm)

SEPP (Waters of Victoria) requires that effluent reuse schemes should be designed and constructed to contain all wastes in at least the 90th percentile wet year. The daily water cycle modelling of the reuse scheme determined the following winter storage (holding pond) requirements over the 125 years modelled:

Lucerne

- 90th percentile storage = 20.7 ML
- Maximum storage = 27.4 ML

Ryegrass

- 90th percentile storage = 24 ML
- Maximum storage = 31 ML

The holding pond shown on the revised site layout (**Figure 1**) provides a storage of 37 ML. It can therefore balance the hydraulic load for either lucerne or ryegrass.

The holding pond exceeds the 90th percentile design criteria and there is no spill from the system over the 125 years modelled.

6.3.2 NUTRIENT BALANCES

Revised nutrient balances have been calculated based on the following:

- Nutrient content of final wastewater:
  - TN = 150 mg/L (Organic N 75 mg/L; NH_3 73 mg/L; NO_x 2 mg/L)
  - TP = 30 mg/L
  - K = 250 mg/L
- 15% volatilisation loss of NH_3 portion in the wastewater.

- Organic mineralisation rates of:
  - Year 1 60%
  - Year 2 30%
  - Year 3 10%
- Total available nitrogen after year 3 = 139 mg/L.
- No nitrogen loss through denitrification in the soil.
- Crop yield and uptake as summarised in **Table 6.5**.
- Phosphorous sorption capacity based on a soil depth of 0.75 m for ryegrass and 1.5 m for lucerne, phosphorous sorption capacity of 680 mg/kg (lowest of the subsoil values across the site) and 33% threshold before some P loss. Lucerne = 5,720 kgP/ha; ryegrass = 2,860 kgP/ha.

Table 6.5 – Crop uptake

Crop/location	Nitrogen	Phosphorous	Potassium
Lucerne – main irrigation			
Crop yield, t(dm)/ha/year	7.5	7.5	7.5
Content of cut portion	3.3%	0.3%	2.3%
Nutrient removal, kg/ha/year	248	23	173
Lucerne – limited irrigation			
Crop yield, t(dm)/ha/year	5	5	5
Content of cut portion	3.3%	0.3%	2.3%
Nutrient removal, kg/ha/year	165	15	115
Lucerne published range[1]	*220-540*	*20-30*	*170-220*
Ryegrass – main irrigation			
Crop yield, t(dm)/ha/year	6	6	6
Content of cut portion	3.4%	0.3%	2.0%
Nutrient removal, kg/ha/year	204	18	120
Ryegrass – limited irrigation			
Crop yield, t(dm)/ha/year	4	4	4
Content of cut portion	3.4%	0.3%	2.0%
Nutrient removal, kg/ha/year	136	29	243
Ryegrass published range[1]	*200-280*	*60-80*	*270-330*

Source: (1) Table 6 EPA (1991)

Nutrient balances are presented in Table x for lucerne and Table x for ryegrass and discussed below.

Lucerne

The nutrient balances show a nitrogen deficit and slight phosphorous excess across the irrigation areas. The phosphorous excess can be assimilated by the soil profile. The potassium balance indicates an excess of about 130 to 187 kg/ha/year. It is considered that this excess will not detrimentally impact on the soil profile due to the existing low soil salinity levels and the soil's ability to immobilise and retain potassium (The Inter-Departmental Committee on Intensive Animal Industries, 1997).

Table 6.6 - Nutrient balances – lucerne

Component	Units	Nitrogen	Phosphorous	Potassium
Main Irrigation Area (18.9 ha)				
Effluent applied	ML/ha/year	1.44	1.44	1.44
Nutrients in effluent	mg/L	139	30	250
Nutrients applied in effluent	kg/ha/year	200	43	360
Total nutrient uptake in 7.5 t(dm)/ha/yr	kg/ha/year	248	23	173
Average net balance	kg/ha/year	- 48	21	187
Years before phosphorous threshold	years	-	274	-
Limited irrigation areas (7.7 ha)				
Effluent applied	ML/ha/year	0.98	0.98	0.98
Nutrients in effluent	mg/L	139	30	250
Nutrients applied in effluent	kg/ha/year	136	29	245
Total nutrient uptake in 5 t(dm)/ha/yr	kg/ha/year	165	15	115
Average net balance	kg/ha/year	- 29	14	130
Years before phosphorous threshold	years	-	394	-

Table 6.7 - Nutrient balances – ryegrass

Component	Units	Nitrogen	Phosphorous	Potassium
Main Irrigation Area (18.9 ha)				
Effluent applied	ML/ha/year	1.43	1.43	1.43
Nutrients in effluent	mg/L	139	30	250
Nutrients applied in effluent	kg/ha/year	199	43	357
Total nutrient uptake in 6 t(dm)/ha/yr	kg/ha/year	204	18	120
Average net balance	kg/ha/year	- 5	25	237
Years before phosphorous threshold	years	-	114	-
Limited irrigation areas (7.7 ha)				
Effluent applied	ML/ha/year	0.97	0.97	0.97
Nutrients in effluent	mg/L	139	30	250
Nutrients applied in effluent	kg/ha/year	135	29	243
Total nutrient uptake in 4 t(dm)/ha/yr	kg/ha/year	136	12	80
Average net balance	kg/ha/year	- 1	17	163
Years before phosphorous threshold	years	-	165	-

Ryegrass

The nutrient balance shows an approximate nitrogen balance in both irrigation areas and a phosphorous excess across the irrigation areas. The phosphorous excess can be assimilated by the soil profile with an expected capacity exceeding 100 years. The potassium balance indicates an excess of about 160 to 240 kg/ha/year. Again, it is considered that this excess will not detrimentally impact on the soil profile due to the existing low soil salinity levels and the soil's ability to immobilise and retain potassium (The Inter-Departmental Committee on Intensive Animal Industries, 1997).

It is noted that the phosphorous and potassium uptake range stated in EPA Publication 168 is significantly higher than used in the ryegrass nutrient balances. If the lower end of these published ranges were adopted, there would be a phosphorous deficit and potassium excess of around 90 kg/ha/year.

Summary

The nutrient balances indicate a cropping program based on either lucerne or ryegrass will ensure nutrient utilisation. Based on the existing natural soil salinity, ryegrass is the preferred crop. And the two crops could be used in rotation with the deeper rooted lucerne being used to dewater the soil profile after a period of ryegrass production.

Another option would be to use winter cereal crops (e.g. wheat or oats) for crop rotation and nutrient utilisation through the winter period.

The nutrient balances demonstrate that a cropping program based on lucerne or ryegrass with possible rotations of winter cereal crops could be used to manage nutrients across the site. It is expected that the irrigation area can therefore be managed to prevent excessive nutrient build up and leaching.

6.3.3 ORGANIC LOAD

Biochemical Oxygen Demand (BOD) is the amount of oxygen required for microbial breakdown of organic compounds in wastewater. Excessive application of effluent with a high BOD can create anaerobic conditions in the soil which, if prolonged, will reduce the capability of soil micro-organisms to break down the organic matter in the effluent. This will ultimately lead to increased odour generation and pollution of water resources. Sufficient time must be allowed between irrigations for the soil to return to an aerobic state.

The time over which the soil is in an anaerobic state must be minimised in order to minimise odour release and avoid soil degradation problems.

The ability of soils to assimilate effluent with high BOD varies according to soil texture and structure. Sandy loams and loamy soils are able to utilise high BOD effluents better than sands, silt loams or clay loams.

The guideline BOD application rates for various soil types are (PIRSA, 2003):

- Sandy soils 10,000 kg/ha/year;
- Sandy loam and loam soils 15,000 kg/ha/year; and
- Silt loams and clay loams 10,000 kg/ha/year.

The soils across the site are generally sandy/clayey silt topsoils overlying silty clay subsoils. On this basis a sustainable organic loading rate of 10,000 kg/ha/year would be applicable.

The organic content of the treated effluent is expected to be <20 mg/L. Based on the average application of 131 mm, the organic loading will be 26 kg/ha/year which is well below the guideline values.

6.3.4 SALINITY AND SODICITY MANAGEMENT

The treated effluent is expected to a have an electrical conductivity (EC) of approximately 1,900 µS/cm; salinity Class 3 in accordance with *EPA Publication 168* (EPA, 1991). Management will be required to control salinity levels in the soil profile.

The site has a deep soil profile with the soil salinity increasing with depth. The salt load applied in the effluent will need to be managed to avoid increasing the soil salt levels to the point where crop yield is impacted.

In a mass balance sense, the ability of the soil profile to assimilate salt can be determined by calculating the amount by which the soil profile salinity can increase before crop yield would be affected. For this example, it is assumed that ryegrass is established and the soil across the effluent irrigation area is a minimum of 0.8 m deep (rooting depth for pasture). Laboratory analysis of the soil indicates an average soil salinity of about 1.4 dS/m EC_e through the top 0.8 m.

Ryegrass will experience yield reductions once soil salinity levels increase above 5.6 dS/m EC_e (Hazelton and Murphy, 2007). Therefore there is the potential to increase salinity in the soil profile by 4.2 dS/m EC_e before yield reductions in ryegrass could be expected.

A salt balance for the main irrigation area assuming a soil bulk density of 1,700 kg/m^3 and an average soil depth of 0.8 m is shown in **Table 6.8**.

Table 6.8 – Salt balance

Component	Unit	Value
Effluent applied	ML/ha/year	1.43
Salt in effluent (TDS)	mg/L	1,220
Salt load	kg/ha/year	1,745
Total soil store	kg/ha	21,500
Soil threshold	Years	~ 12

The salt balance shows it would take approximately 12 years before the soil salinity in the effluent irrigation area could reach a level that would start affecting ryegrass yields. It should be noted that the approach adopted for this analysis is very conservative as it assumes no loss of salt through leaching of salt beyond the assumed soil depth of 0.8 m. This inevitably occurs, and can be done on a managed basis, to control salinity through the soil profile. What the salt balance does indicate is that there is time to make informed management decisions based on monitoring.

A leaching fraction would be the key management tool to control soil salinity. The required leaching fraction can be calculated using equation 5-5 from EPA Publication 168 as follows:

Leaching required = $100 \times EC_{iw}/EC_{dw}$

Where EC_{iw} = electrical conductivity of the irrigation water = 1.9 dS/m
EC_{dw} = electrical conductivity of the drainage water at which the relative crop yield is 50% = 12.2 dS/m (Table 13 EPA Publication 168)

Therefore the leaching required is 16%, or 21 mm.

Modelling shows that with irrigation, the average annual deep soil drainage increases by 19 mm. Therefore 90% of the required leaching fraction is achieve without special leaching events. The requirement for leaching will be based on profile monitoring.

The soil investigation shows that the soil sodicity increases with depth. The topsoil is non-sodic while the subsoils are marginally to strongly sodic. The non-sodic topsoil indicates that surface crusting is unlikely to occur and the infiltration capacity of the topsoils should be maintained. The soils are also not susceptible to erosion.

Consideration of the irrigation water Sodium Absorption Ratio (SAR) and Electrical Conductivity (EC) can indicate if infiltration issues are likely to arise.

EPA Publication 168 (EPA, 1991) provides a method to assess the permeability hazard of irrigation waters when used on susceptible soils. This method uses an adjusted Sodium Absorption Ratio (SAR) and can be calculated from the following effluent quality data derived from other operating sites:

Na^{+} 4.35 meq/L

Ca^{++} 3.50 meq/L

Mg^{++} 3.33 meq/L

HCO_3^-	8.36 meq/L
Ca_x	1.2 meq/L
$adjR_{Na}$	2.9
Irrigation water EC	1.9 dS/m

Using Figure 3 in *EPA Publication 168* (EPA, 1991) and the above values for $adjR_{Na}$ and irrigation water salinity shows minimal risk of soil permeability loss.

Soil monitoring will be used to identify any adverse changes that may trigger the need for remedial actions which may include:

- Undertaking an irrigation leaching event to improve the soil salinity;
- Adding soil ameliorants such as gypsum;
- Cropping rotation;
- Cultivation; or
- Resting a particular irrigation area.

6.3.5 MANAGEMENT APPROACH

It is not practicable to irrigate the entire irrigation area in one day. Therefore irrigation will be undertaken a smaller section on a day to day basis as soil conditions permit. The management aim will be to spread the annual effluent volume across the irrigation area to spread the nutrient load.

The normal irrigation season will start in September/October and end in March/April, depending on weather and soil conditions at the time. The operators will commence irrigation as soon as soil moisture conditions allow in spring to plan for optimum utilisation of recycled water.

The operating objectives for the holding pond will be to achieve optimum draw down of the storage lagoon by the end of the irrigation season to design minimum capacity (maintaining adequate water cover above the lagoon clay liner) enabling reserve capacity for the non-irrigation season.

The basis of irrigation scheduling will be a water balance. This determines the daily, seasonal and annual hydraulic loading to be applied over the irrigation area. Soil moisture observations, weather records and irrigator experience will be used to check how much water can be applied on a day-to-day basis. In determining when to irrigate the operators will consider the prevailing and forecast weather conditions. Irrigation will not occur if heavy rain is forecast within the next 24 to 48 hours.

The frequency of irrigation will depend on climatic factors and plant water use. It is expected that early in the irrigation season irrigation will occur infrequently. In mid-summer when evaporation and plant water requirements peak, irrigation may occur every few days. The frequency is likely to reduce again in autumn.

The irrigation scheme will use a moisture deficit irrigation approach that will prevent effluent runoff from the irrigation area. The irrigation area will be inspected during and after irrigation to ensure ponding and runoff are not occurring.

With the exception of storm water runoff due to heavy rainfall events there should be no recycled water run-off from the irrigation areas.

The site assessment indicates that the land is suitable for managed effluent irrigation and there is adequate land to ensure hydraulic and nutrient loads can be managed on site. In the very unlikely event that issues arise, the following contingency measures could be undertaken:

- Supplying all or part of the treated effluent to off-site users nominated under authority approved contractual arrangements;
- Connection to the reticulated sewerage system for disposal of part of the effluent volume;

- Removing part or all of the effluent load from the site by road tanker; or
- Changes to effluent treatment process.

6.3.6 MONITORING

The assessment demonstrates that the hydraulic and nutrient load in the effluent can be managed on site without significant environmental risk.

However, management of the effluent reuse scheme will need to be adaptive in response to monitoring data. While the assessment indicates the system is capable of handling the expected hydraulic and nutrient load, monitoring will be used to identify at an early stage any departure from the plan and will be used as the basis to adjust aspects of the waste management plan if required.

Monitoring will include:

- Daily weather observations and irrigation records;
- Effluent monitoring;
- Soils;
- Crop monitoring;
- Surface water; and
- Groundwater.

An outline of the proposed monitoring plan is provided in the following sections. A comprehensive monitoring plan will be included in the EMP

6.3.6.1 Liquid Waste Monitoring

Samples will be collected from the anaerobic treatment pond (inflow and outflow) and outflow from the aerobic pond every three months for the first year to determine the effectiveness of the treatment process. Samples will be analysed for:

- BOD or COD;
- suspended solids;
- total nitrogen;
- total phosphorus;
- pH; and
- electrical conductivity.

Effluent reused across the irrigation area will also be monitored for both quantity and quality. Effluent quantity will be recorded using a flow or pump meter on the main irrigation line. Readings will be recorded daily during irrigation.

Effluent quality from the holding pond will be sampled every three months for the first year of operation and then reduced to biannually. The following parameters will be analysed:

- pH;
- Electrical conductivity;
- Kjeldahl nitrogen;
- Ammonia;
- Nitrite/Nitrate;
- Total nitrogen;
- Orthophosphate;
- Total phosphorus;

- Potassium, sodium, calcium and magnesium;
- SAR;
- Total suspended solids;
- Biochemical oxygen demand; and
- Coliforms.

6.3.6.2 Soils

Soils in the effluent irrigation area will be sampled to monitor changes in nutrients and salinity and to maximise crop production. Surface soil samples from the effluent irrigation area will be obtained on an annual basis, and be analysed for pH; Salinity; Exchangeable Cations; Nitrate; TKN; Available Phosphorus; Total Phosphorus and Organic carbon. Subsoil samples in the effluent irrigation areas will be collected every three years and analysed for the same parameters as the surface soils with the addition of phosphorus sorption capacity.

The soil sampling program will be based on establishing representative soil reference points for topsoil and subsoil analysis.

6.3.6.3 Crops

Crop yield will be measured and recorded at each harvest.

Representative crop samples will be analysis for moisture content, nitrogen, phosphorous and potassium.

6.3.6.4 Surface Water

A rising stage sampler will be installed on the outlet of the surface water wetland system that will collect discharge from the wetland in the event of overflow.

A minimum of four samples will be collected in the first year of operations. This will then reduce to two samples per year (winter and summer periods).

The surface water analysis suite will include:

- Conductivity;
- pH;
- Total suspended solids;
- Total nitrogen;
- Nitrate;
- Ammonia; and
- Total Phosphorus.

6.3.6.5 Groundwater

Despite the low risk to groundwater, a monitoring program will be implemented. The groundwater monitoring network will include the four monitoring piezometers.

Groundwater levels will be recorded every three months for the first two years of operation, after which it will reduce to every six months.

Groundwater quality will be monitored every three months for the first two years and then every six months. An indicator suite will be analysed to monitor key groundwater quality parameters. This will include:

- pH;
- electrical conductivity;
- total dissolved solids;
- nitrate;
- total phosphorus; and
- phosphate.

If this monitoring indicated some change in groundwater quality, a more comprehensive suite will be undertaken. This will add cations and a full nitrogen suite.

Domestic Effluent Management

7.1 DOMESTIC EFFLUENT GENERATION

The water cycle modelling indicates that the hydraulic load from the central facilities building averages 2,500 L/day and ranges from 900 L/day to 5,800 L/day on peak sales days. The system will be designed to ensure it can manage increased loads during sale days.

The 75th percentile flow is 3,125 L/day.

7.2 ON-SITE DOMESTIC EFFLUENT MANAGEMENT

The onsite effluent management system will be sized and constructed in accordance with *AS/NZS 1547:2012 On-site domestic wastewater management* and *EPA Publication 891.3 Code of practice onsite wastewater management* (EPA, 2013). This latter reference applies to systems which treat up to a maximum peak daily flow of 5,000 L/day. However as noted above, the peak flow will only occur on peak sale days with the average flow significantly less than 5,000 L/day.

7.2.1 TREATMENT

The domestic wastewater will be treated using an aerated wastewater treatment system (AWTS). The system will be design to manage the varying loads and provide secondary treated effluent for reuse through onsite surface irrigation.

7.2.2 IRRIGATION

7.2.2.1 Design Irrigation Rate

The silty clay subsoil at the site will be limiting for onsite domestic effluent disposal by irrigation.

Table 9 in EPA Publication 891.3 (EPA, 2013) recommends a maximum design irrigation rate (DIR) of 2 L/m^2/day (2 mm/day) for medium to heavy clays with an indicative permeability of <0.06 – 0.5 m/day.

The land application area (LAA) required using a DIR of 2 mm/day is:

- Average flow: 2,500 L/day – LAA required = 1,250 m^2
- 75th percentile flow: 3,125 L/day – LAA required = 1,565 m^2

7.2.2.2 Nutrient and Hydraulic Balances

Nutrient and hydraulic balances for the LAA are included as **Appendix D** and are based on the assumption that ryegrass is established across the irrigation area. Water requirements (crop factors) and nutrient uptake rates are as described in this report for a ryegrass yield of 6 t/ha/year.

The balances show the following minimum area requirements:

- Nitrogen balance 1,340 m^2
- Phosphorous balance 2,445 m^2
- Hydraulic balance 2,070 m^2

The limiting design parameter is the phosphorous loading which requires a LAA of around 2,500 m^2.

7.2.2.3 Proposed LAA

The proposed LAA is shown on **Figure 1**. There is adequate space in this location to provide a LAA of 2,500 m^2.

References

AS/NZS *On-site domestic wastewater management*.

Department of Environment and Primary Industries (2015) *Soil fertility monitoring tools.* http://www.depi.vic.gov.au/agriculture-and-food/farm-management/business-management/ems-in-victorian-agriculture/environmental-monitoring-tools/soil-fertility.

Douglas Partners (2105) *Additional soil investigation and testing – Central Victorian Livestock Exchange Western Hwy & Sunraysia Hwy Interchange, Ballarat.*

EPA Victoria (1991) *Guidelines for wastewater irrigation Publication 168*. EPA Victoria.

EPA Victoria (2003) *Guidelines for environmental management use of reclaimed water Publication 464.2*. EPA Victoria.

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Geolyse Pty Ltd (2014) *Water cycle management report – Central Victorian Livestock Exchange*.

Hazelton P and Murphy B (2007) *Interpreting soil results: What do all the numbers mean?* CSIRO Publishing.

Neil M Craigie Pty Ltd (2015) *Central Victorian Livestock Exchange surface water management issues.* Statement of Evidence Amendment C185 Ballarat Planning Scheme and EPA Works Approval Application.

The Interdepartmental Committee on Intensive Animal Industries (Feedlot Section) (1997) *The New South Wales Feedlot Manual.*

PIRSA (2003) *Manual for spreading nutrient-rich wastes on agricultural land.* Primary Industries and Resources South Australia.

Traffix Group (2014) *Traffic engineering assessment Western Highway & Sunraysia Highway, Miners Rest, Proposed Saleyard – Livestock Exchange*.

Appendix A

GHCMA Flood Mapping

Glenelg Hopkins CMA

Date: 5 May 2014
Document No: 1

Spiire
Attn: Nicolas Green
Po Box 4032
Geelong, Victoria 3220

nicholas.green@spiire.com.au

Dear Nicolas,

Application Number (CMA Ref):	**F-2014-0107**
Property Address:	**Sunraysia Highway Ballarat, Victoria 3350**
Cadastral:	**Lot 1, TP840697, Parish of DOWLING FOREST**
Zone(s):	**Farming Zone (FZ)**
Overlay(s):	**Nil**

Thank you for your application which we received on 29 April 2014.

Flood Information Summary

Item	Best Available Information
20% AEP flood Level	409.9 up to 412.0m AHD
10% AEP flood Level	410.3m up to 412.0 AHD
5% AEP flood Level	410.5m up to 412.1m AHD
2% AEP flood Level	410.6 up to 412.1m AHD
1% AEP flood level	410.7 up to 418.3 m AHD
0.5% AEP flood Level	410.8 up to 418.5 m AHD
Minimum depth of flooding on site 1%AEP	0.0m
Maximum depth of flooding on site 1%AEP	1.2m
Property Hazard category	Low to High
Maximum depth of flooding on access 1%AEP	Flood free
Access Hazard category	Low

This property is identified as flood-prone, indicated by the green shading and flood level contours provided on sheets 1 through 6 below.

The floodplain land within this property represents important overland flow paths for water originating south of the Western Highway during floods ranging in magnitude from the 20% AEP (5yr ARI) and larger. Flow paths on the western and northern boundary are most significant and are subject to high velocity flow during large floods.

Flooding of the north-south running tributary on the western boundary is flashy in nature with flood peaks likely to be experienced within 7 hours after commencement of a 1%AEP rainfall event.

Flooding on the northern boundary directly caused by Burrumbeet Creek will persist for longer with the flood peak estimated to occur in the order of 14hrs after commencement of a 1%AEP rainfall event.

Given the importance of the floodplain land within the property for conveying floodwater it is proposed to apply the Floodway Overlay in the Ballarat City Council Planning Scheme via a planning scheme amendment.

The CMA would not object to development of the site as sale-yards facility subject to development plans that demonstrate recognition of the flood-prone nature of part of the site. There should be no impacts on floodwater storage and conveyance across the site as a result of development and potential impacts on the health of Burrumbeet Creek must be accounted for.

The CMA is likely to recommend permit conditions similar but not limited to the following:

1. There is to be no introduction of fill onto the identified floodplain land. If manipulation of ground levels is required on floodplain land then this must be done on a balanced cut and fill basis as per the CMAs Guidelines for Floodplain Cut & Fill (attached).
2. No buildings should be constructed on land within the floodplain unless they are open sided.
3. No hay sheds should be constructed within the floodplain given the potential for disruption of floodwater conveyance by stored bales.
4. Any fences constructed on floodplain land should be open style – eg. post and wire – as per the CMAs Guidelines for Floodplain Fencing (attached).
5. Effluent ponds should not be located on floodplain land.
6. Yards for intensive impoundment of stock should not be located on floodplain land to avoid nutrient laden sediment transport into Burrumbeet Creek and risks to stock welfare during flash flood events.
7. Any runoff from hard surfaced areas within the site should be retarded to pre development volumes.

Contact **Graeme Jeffery** on 03 5571 2526 should you have any queries. Please quote **F-2014-0107** to assist the CMA in handling in your enquiry.

Yours sincerely,

for
Brad Henderson
Statutory Water Program Manager
Cc: Jessie Keating – Strategic Planner - Ballarat City Council

The information contained in this correspondence is subject to the disclaimers and definitions below.

Glenelg Hopkins Catchment Management Authority
Statutory Water Group

A: PO Box 502, Hamilton Vic 3300 **T:** 03 5571 2526 **F:** 03 5571 2935 **E:** planning@ghcma.vic.gov.au **W:** www.ghcma.vic.gov.au

Definitions and Disclaimers

1. The area referred to in this letter as the 'property' is the land parcel(s) that, according to the CMA's assessment, most closely represent(s) the location identified by the applicant. The identification of the 'property' on the CMA's GIS has been done in good faith and in accordance with the information given to the CMA by the applicant(s) and/or relevant local government authority.
2. While every endeavour has been made by the CMA to identify the proposed development location on its GIS using VicMap Parcel and Address data, the CMA accepts no responsibility for or makes no warranty with regard to the accuracy or naming of this proposed development location according to its official land title description.
3. No warranty is made as to the accuracy or liability of any studies, estimates, calculations, opinions, conclusions, recommendations (which may change without notice) or other information contained in this letter and, to the maximum extent permitted by law, the CMA disclaims all liability and responsibility for any direct or indirect loss or damage which may be suffered by any recipient or other person through relying on anything contained in or omitted from this letter.
4. This letter has been prepared for the sole use by the party to whom it is addressed and no responsibility is accepted by the CMA with regard to any third party use of the whole or of any part of its contents. Neither the whole nor any part of this letter or any reference thereto may be included in any document, circular or statement without the CMA's written approval of the form and context in which it would appear.
5. The flood information provided represents the best estimates based on currently available information. This information is subject to change as new information becomes available and as further studies are carried out.
6. **1%AEP Flood –** A flood of this magnitude has a 1% chance of occurring in any given year. It is also known as the 100 year Average Recurrence Interval (ARI) flood. However a flood of this magnitude (or greater) may occur more frequently than once in any year. The 1% AEP flood extent is the minimum standard for land use and development planning decisions in Victoria (the planned for flood level). There is always a possibility that floods larger in height and extent than the 1% AEP flood may occur in the future. The 1% AEP flood is not the probable maximum flood (PMF).
7. **AEP** as Annual Exceedance Probability – is expressed as a percentage (%) risk. It is the reciprocal of ARI (Average Recurrence Interval).
8. **ARI** as Average Recurrence Interval - is the likelihood of occurrence, expressed in terms of the long-term average number of years, between flood events as large as or larger than the design flood event. For example, floods with a discharge as large as or larger than the 100 year ARI flood will occur <u>on average</u> once every 100 years.
9. **PMF** as Probable Maximum Flood – is the largest conceivable flood for a location
10. **AHD** as Australian Height Datum – is the adopted national height datum that generally relates to height above mean sea level. Elevation is in metres.
11. **Freeboard** is a height allowance above a flood level. In the context of planning for development of flood-prone land, freeboard is applied to ensure floors are finished at a level above the estimated flood level. This lowers the risk of over-floor flooding due to floods bigger than the 1%AEP event and due to uncertainties in estimation of the planned for flood level. Uncertainties include factors such as the effect of waves caused by wind or the effect of vehicles moving through a flooded area, or the impact of rising mean sea level.
12. **Nominal Flood Protection Level (NFPL)** is the 1%AEP flood level plus a freeboard (height) allowance to provide increased protection against flooding. It is generally the minimum floor level for habitable spaces and the level below which no electrical outlets or sewer openings are permitted.

Disclaimer:
Glenelg Hopkins Catchment Management Authority do not warrant that this map is definitive nor free of error and does not accept liability for any loss caused or arising from reliance upon information provided herein. This map has been prepared using the best available data and mapping techniques. The accuracy of this map is not absolute and reflects only the accuracy of the data and techniques used. This information is subject to change where new information is found or determined from future work.

N

MAP SCALE
0 134.0
metres

LEGEND
Parcel (Title)
Property Boundary
Flood level contour m AHD

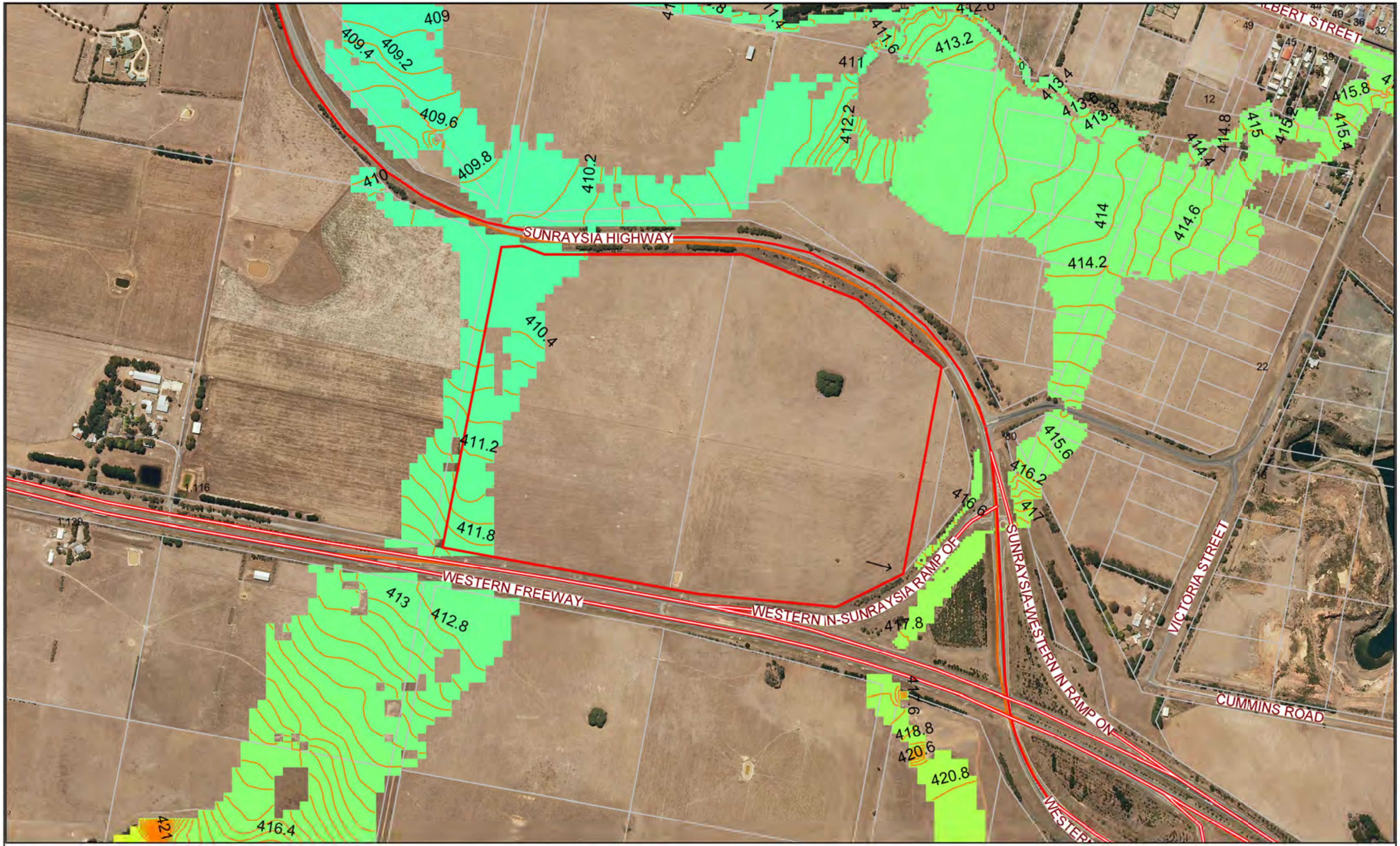
20%AEP flood extent - Lots 1 & 2 TP 840697

2013 Burrumbeet Creek Flood Investigations

DRAWN BY: Graeme Jeffery

SHEET: 01 of 06

Glenelg Hopkins
CMA



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N

MAP SCALE

0 134.0

metres

LEGEND

Parcel (Title)

Property Boundary

Flood level contour m AHD

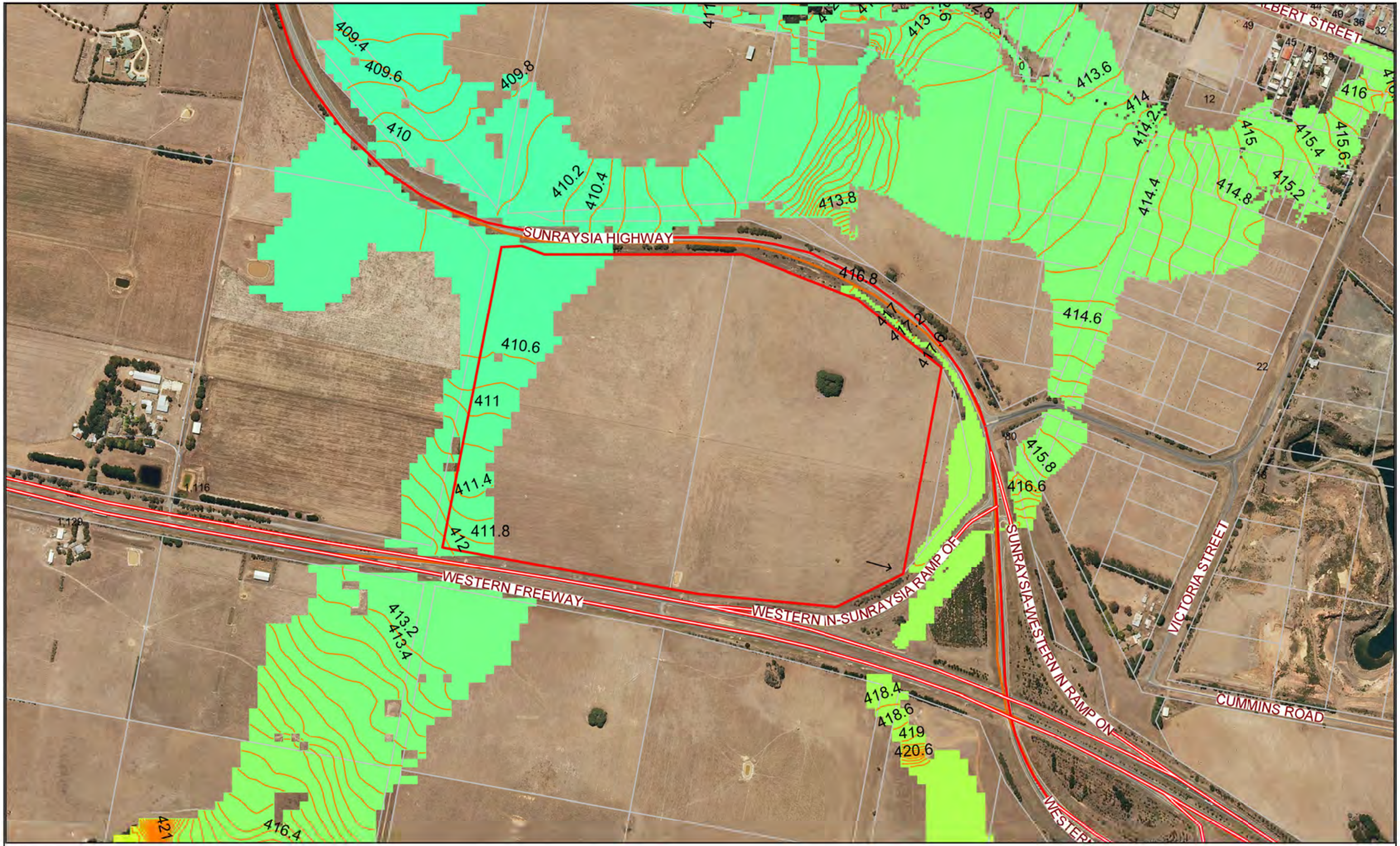
10%AEP flood extent - Lots 1 & 2 TP 840697

2013 Burrumbeet Creek Flood Investigations

DRAWN BY: Graeme Jeffery

SHEET: 02 of 06

Glenelg Hopkins CMA



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N	MAP SCALE 0 – 134.0 metres	LEGEND		
		Parcel (Title)		5%AEP flood extent - Lots 1 & 2 TP 840697
		Property Boundary	Flood level contour m AHD	2013 Burrumbeet Creek Flood Investigations
				DRAWN BY: Graeme Jeffery — SHEET: 03 of 06

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N

MAP SCALE

0 134.0

metres

LEGEND

Parcel (Title)

Property Boundary

Flood level contour m AHD

2%AEP flood extent - Lots 1 & 2 TP 840697

2013 Burrumbeet Creek Flood Investigations

DRAWN BY: Graeme Jeffery

SHEET: 04 of 06

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N	MAP SCALE 0 – 134.0 metres	LEGEND Parcel (Title) Property Boundary	Flood level contour m AHD	1%AEP flood extent - Lots 1 & 2 TP 840697 2013 Burrumbeet Creek Flood Investigations DRAWN BY: Graeme Jeffery — SHEET: 05 of 06

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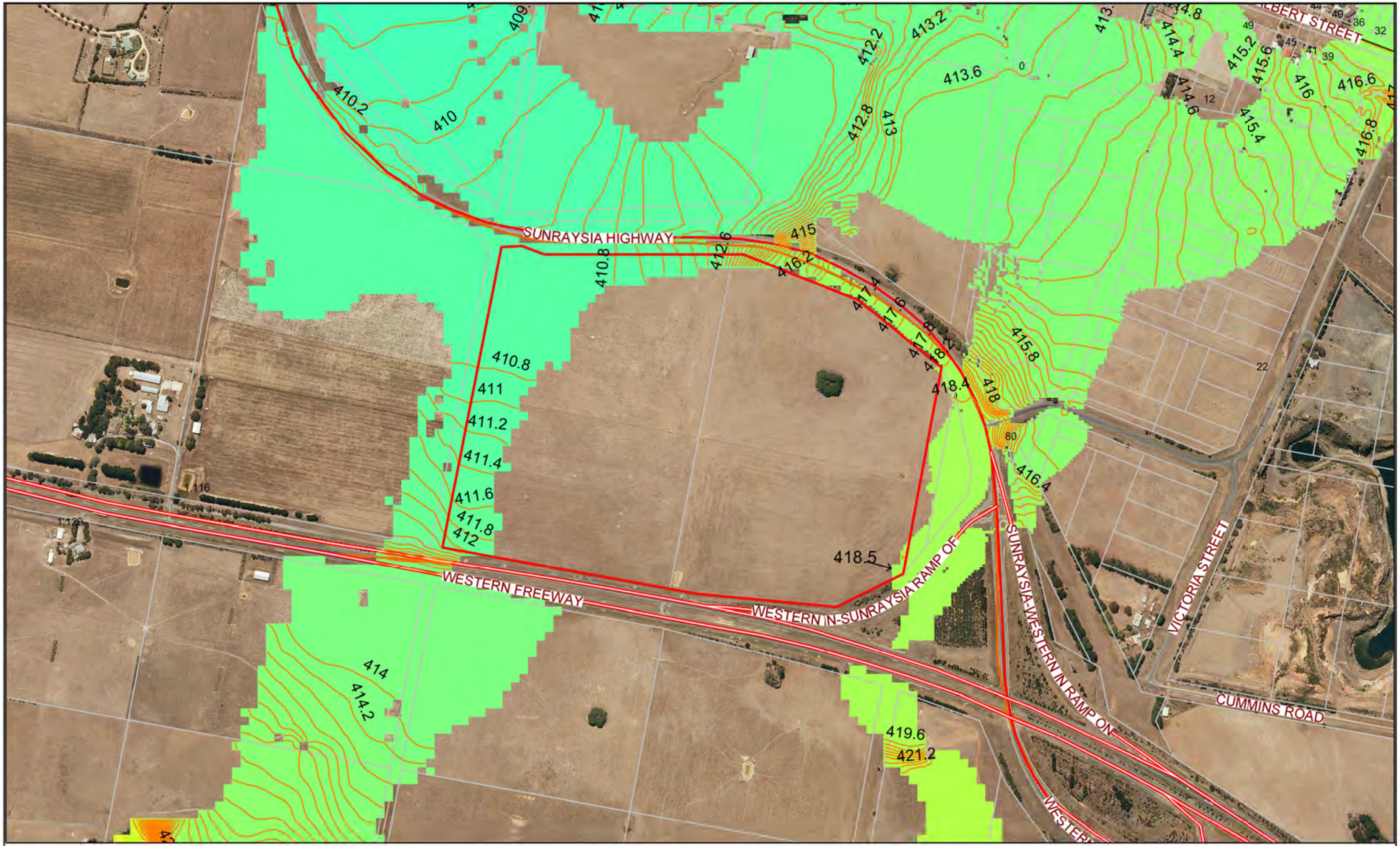

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N

MAP SCALE

0 134.0

metres

LEGEND

Parcel (Title)

Property Boundary

Flood level contour m AHD

0.5%AEP flood extent - Lots 1 & 2 TP 840697

2013 Burrumbeet Creek Flood Investigations

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N	MAP SCALE 0 — 134.0 metres	LEGEND Parcel (Title) Property Boundary	Lans subjecto to inundation overlay Floodway overlay	Proposed planning controls - Lots 1 & 2 TP 840697 2013 Burrumbeet Creek Flood Investigations DRAWN BY: Graeme Jeffery — SHEET: 01 of 01

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Appendix B

Soil Chemistry Summary

CVLX: SOIL CHEMISTRY ANALYSIS SUMMARY

Sample ID	Lab ID	Interval (mm)	Soil Description	Textural Class	pH		Salinity		Total Nitrogen		Available Phosphorous		PSC	CEC		Sodicity	
					Value	Rating[1]	EC_e dS/m	Rating[1]	mg/kg	Rating[1]	mg/kg	Rating[2]	mg/kg	meq%	Limitation[1]	ESP	Rating[1]
TP3-1	1	100-200	Sandy Gravelly Silt	Silty Loam	6.1	Slightly Acid	0.015	Non-Saline	370	Very Low	8.9	Low	327	1.8	Very low	5.2	Non-sodic
TP9-1	2	100-200	Silty Gravel	Silty Loam	7.3	Neutral	0.042	Non-Saline	1000	Low	16.4	Low	433	6.0	Low	1.6	Non-sodic
TP102-2	3	900-1000	Silty Clay	Medium Clay	6.6	Neutral	2.0	Slightly Saline	270.1	Very Low	20	Low	960	21.0	Moderate	22.4	Strongly sodic
TP103-1	4	400-500	Silty Clay	Medium Clay	6.6	Neutral	0.8	Non-Saline	840.3	Low	10	Low	1000	22.0	Moderate	12.4	Marginally sodic
TP104-3	5	1400-1500	Silty Clay	Medium Clay	4.6	Very Strongly Acid	4.7	Moderately Saline	200	Very Low	8	Low	980	13.0	Moderate	7.9	Marginally sodic
TP105-3	6	1400-1500	Silty Clay / Siltstone	Silty Clay Loam	7.4	Mildly Alkaline	4.4	Moderately Saline	330.1	Very Low	5	Low	680	15.0	Moderate	21.9	Strongly sodic

Notes:

1: Hazelton and Murphy (2007)

2: Department of Environment and Primary Industries (2015)

Appendix C

GROUNDWATER DESKTOP STUDY

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
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Project: 79187.01
5 June 2015
RL : 002
DAW / PM : ae

Regional Livestock Exchange (RLX) Investment Company Pty Ltd
PO Box R1313
Royal Exchange NSW 1225

Attention: Mr Paul Brown

Email: paul.brown@palisadepartners.com.au
Cc: John Hannagan (jhannagan@harwoodandrews.com.au)
Martin Haege (mhaege@geolyse.com)

Dear Sirs,

Groundwater Desktop Study
Central Victorian Livestock Exchange
Western Hwy & Sunraysia Hwy Interchange, Ballarat

1. Introduction

This letter report presents the findings of a groundwater desktop study undertaken by Douglas Partners Pty Ltd (DP) for the proposed Central Victorian Livestock Exchange, northwest of Ballarat.

The purpose of the current phase of work was to provide comment on the following:

- A summary of the hydrogeology setting including a discussion of the geology;
- A discussion of the depth to groundwater in the various aquifers beneath the site;
- The location of bores on the groundwater database within 1 km of the site;
- The registered uses for bores within the search area;
- A calculation of the distance of each registered bore from the boundary of the site. Particular mention will be made of the registered Central Highlands Water (CHW) supply bores;
- A discussion of the regional groundwater flow direction; and
- Discussion of likely groundwater quality with reference to the presence of landfills, petrol stations and industrial land.

The work was carried out for Regional Livestock Exchange (RLX) Investment Company Pty Ltd, with Harwood Andrews Pty Ltd acting as the project managers and Geolyse Pty Ltd as part of the design team.

2. Hydrogeological Setting and Depth to Groundwater

The Geological Survey of Victoria's 1:50,000 scale *Creswick* map indicates that Quaternary age alluvium, swamp and flood plain deposits are present beneath the western half of the site, with Ordovician age sandy silt or clay outcropping beneath the eastern half of the site. The *Murray Basin Hydrogeological Map Series – Ballarat* published by the Australian Geological Survey Organisation (AGSO 1994) indicates that the site is underlain directly by the bedrock aquifer, but a groundwater divide is present immediately east and south of the site, where Newer Volcanics basaltic flows are present. The basalt is generally present in two flows and can be up to 200 m thick.

The bedrock aquifer is characteristic of a fractured rock system with highly variable hydraulic conductivity parameters. The salinity is likely to be 1,500-3,000 mg/L and the yield is likely to be low <0.5 L/sec. Flow in the bedrock aquifer is expected to be generally towards the south west. The basalt aquifer typically has a higher yield and lower salinity, but the depth to water is similarly expected to be 5-15 m below ground surface.

3. Location of Nearby Groundwater Bores and Groundwater Flow Direction

The locations of registered groundwater wells within a 1 km radius of the site are summarised in Table 1. Data was sourced from the *Visualising Victoria's Groundwater* website. Additional data pertaining to the Ballarat West Borefield (Cardigan Borefield) was also sourced from various reports published by Central Highlands Water.

Table 1: Summary of Groundwater Bores within 1 km of the Site

Bore licence number	Distance from site	Direction	Depth	Use	Year	Geology
WRK041080	300	East	10	N/A	1970	N/A
WRK007998	500	East	Unknown	Industrial	N/A	N/A
60759	400	North	46	Domestic/ stock	1991	Rock from 6 m
60740	680	North west	39	Domestic/ stock	1980	Rock from 5 m
'Windmill'	~400	South	N/A	Domestic/ stock	N/A	Basalt
Supply bores	6.5 km	South	150	Municipal supply	2007	Lower

Notes: N/A – not available

'Windmill' bore is not registered on the database and information presented is anecdotal based on information from farmer

Data available from Central Highlands water indicates that the Ballarat west borefield was used to supplement the City of Ballarat's water supply between July 2007 and October 2010. The borefield is situated just west of Lake Wendouree and observation wells indicate that the groundwater table was drawn-down by up to 5 m during the period of pumping. This reversed the regional flow direction from generally westerly to generally south-easterly. Maps indicate that the extent of influence from the pumping did not extend as far north as the subject site, and this is consistent with the change in geology and the presence of a 'groundwater divide' separating the two geological units indicated for the site.

4. EPA Database Search

A review of EPA databases indicates that there were no previous Environmental Audits conducted within 1 km of the site. Also, no Priority sites were recorded within 1 km of the site as of May 2015.

The surrounding land uses appear to be generally grazing with an overall low potential for contamination. Due to the generally shallow depth to water of around 5 m, it is possible that contamination from any shallow sources,, including septic tanks, could reach the groundwater with a low potential for attenuation.

5. References

- The *Murray Basin Hydrogeological Map Series – Ballarat* published by the Australian Geological Survey Organisation (AGSO 1994)
- State Government Victoria, 2015 "Visualising Victoria's Groundwater", viewed 15 January 2015, http://www.vvg.org.au/
- EPA Victoria, 2015 "Certificates and statements of environmental audit and 53V audit reports", viewed 20 May 2015, http://www.epa.vic.gov.au/our-work/environmental-auditing/53v-reports-certificates-statements-of-environmental-audit

6. Limitations

Douglas Partners (DP) has prepared this report for this project at Western Highway and Sunraysia Highway Interchange, Ballarat in accordance with DPs proposal ref GGG150016 (Rev 2) dated 11 May 2015 and acceptance received from Greg Tobin of Harwood Andrews Pty Ltd dated 13 May 2015. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Regional Livestock Exchange (RLX) Investment Company Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Please contact either of the undersigned for clarification of the above as necessary.

Yours faithfully,
Douglas Partners Pty Ltd

Dean Woods
Senior Associate

Reviewed by

Paul Moritz
Principal

Attachments Notes About This Report

Drawing 1 - Registered Bore Location Plan

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Image and data sourced from Visualising Victoria's Groundwater Website

Douglas Partners — Geotechnics / Environment / Groundwater	CLIENT: RLX Investment Company	**Registered Bore Location Plan**	PROJECT No:	79187.01
	OFFICE: Melbourne	**Livestock Exchange**	DWG No:	1
	DATE: 1 Jun 2015	**Miners Rest**	REVISION:	A

Appendix D

DOMESTIC EFFLUENT SYSTEM BALANCES

ON-SITE DOMESTIC SEWAGE MANAGEMENT

Client:	RIPL
Job No.:	208120
Location:	CVLX
Effluent Treatment:	AWTS
Disposal:	Surface irrigation
Hydraulic Loading:	2500 litres per day

1. NUTRIENT LOADING

Nitrogen	TN concentration in effluent	30	mg/L
	Critical loading rate	56	$mg/m^2/d$
	Irrigation area required	**1339**	$\mathbf{m^2}$
Phosphorus	TP concentration in effluent	10	mg/L
Soil uptake:	P sorption	224.4	mg/kg
	Bulk density	1700	kg/m^3
	P sorption capacity (1 m deep)	3814.8	kg/ha
	soil depth	0.75	m
	P sorption capacity	2861	kg/ha
		0.28611	kg/m^2
Vegetation:	Vegetation uptake	5	$mg/m^2/d$
	Vegetation uptake over 50 years	91250	mg/m^2
		0.091	kg/m^2
	P generation over 50 years	456	kg
	Irrigation area required	**2445**	$\mathbf{m^2}$

Limiting nutrient loading is ***Phosphorus*** which requires a minimum disposal area of **2445** $\mathbf{m^2}$

2. HYDRAULIC LOADING

Minimum Area Method

Daily Effluent	Q	2500 litres/day
Design percolation rate	R	5 mm/wk

Parameter	**Symbol**	**Formula**	**Units**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Days in month	D		days	31	28	31	30	31	30	31	31	30	31	30	31	365
Precipitation	P		mm/month	31.8	32.8	30.3	44.2	59.0	60.4	64.2	73.6	64.3	66.7	53.0	42.0	622.3
Evaporation	E		mm/month	207	173	134	78	45	28	31	46	67	106	137	179	1231.789
Crop factor	C		-	0.7	0.7	0.7	0.6	0.5	0.45	0.4	0.45	0.55	0.65	0.7	0.7	-
Outputs																
Evapotranspiration	ET	ExC	mm/month	144.8	121.4	94.0	46.6	22.3	12.6	12.4	20.7	36.7	69.2	96.0	125.6	802.4
Percolation	B	(R/7)xD	mm/month	22.1	20.0	22.1	21.4	22.1	21.4	22.1	22.1	21.4	22.1	21.4	22.1	260.7
Outputs		ET+B	mm/month	167.0	141.4	116.1	68.1	44.5	34.0	34.5	42.8	58.2	91.3	117.4	147.8	1063.1
Inputs																
Precipitation	P	-	mm/month	31.8	32.8	30.3	44.2	59.0	60.4	64.2	73.6	64.3	66.7	53.0	42.0	622.3
Possible Effluent irrigation	W	(ET+B)-P	mm/month	135.2	108.6	85.8	23.9	-14.5	-26.4	-29.7	-30.8	-6.1	24.6	64.4	105.8	440.8
Actual Effluent Production	I	H/12	mm/month	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	440.8
Inputs		P+I	mm/month	68.5	69.5	67.0	80.9	95.7	97.1	100.9	110.3	101.0	103.4	89.7	78.7	1063.1
Storage	S	(P+I) - (ET+B)	mm/month	-98.4	-71.8	-49.1	12.9	51.2	63.1	66.4	67.5	42.9	12.1	-27.7	-69.0	-
Cumulative storage	M	-	mm	0.0	0.0	0.0	12.9	64.1	127.2	193.6	261.1	304.0	316.1	0.0	0.0	-

Irrigation Area	L	365 x Q/H	m^2	**2070**