STATEMENT OF EXPERT EVIDENCE

Amendment C185 Ballarat Planning Scheme

And EPA Works Approval Application

Desktop Soil and Wastewater Irrigation Assessment for Sustainable Irrigation of Wastewater at the Proposed Location of the New Ballarat Saleyards

Central Victorian Livestock Exchange (CVLX)

For RLX Investment Company Ptd Ltd

By Glenn Marriott *B.Ag.Sc*.

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(June 2015)

Central Victorian Livestock Exchange

Desktop Soil and Wastewater Irrigation Assessment for Sustainable Irrigation of Wastewater at the Proposed Location of the New Ballarat Saleyards

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1. Name & Address:

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2. Qualifications & Experience:

Bachelor of Agricultural Science (Honours) graduated 2003

Certified Professional Soil Scientist (CPSS) Level 2

Employment:

2005 – 2007 : EPA Victoria – Field Investigations and Dairy Officer

2007 – Current : Ag-Challenge Consulting – Agricultural and Environmental Consultant

I am a Director of Ag-Challenge Consulting Pty Ltd and Land Safe. My professional focus is on soil and wastewater irrigation management. I provide consultancy services to a broad range of clients including Water Authorities, Dairy Companies, Shire Councils and Dairy Farmer clients, including facilitation roles in multiple dairy discussion groups in Gippsland.

On completion of my Honours Degree in Agricultural Science I worked with EPA Victoria from March 2006 to June 2007 as a field officer based in Warrnambool. I specialised in dairy effluent management, auditing over 400 dairy farms for compliance with the SEPP Waters of Victoria. While with Ag-Challenge Consulting I have been involved in a number of soil and wastewater projects including the Land Capability Assessment of Tarago Reservoir and the site selection and development of wastewater irrigation schemes for the townships of St Arnaud and Cowes on Phillip Island. In the *"Land Safe"* partnership with van de Graaff & Associates, I have completed more than 200 Land Capability Assessments for domestic wastewater land application in a range of Shires across Victoria. Since joining Ag-Challenge Consulting in 2007 I have been an integral part of the Werribee Irrigation District soil monitoring team, with contributions made to soil sampling, data collation and interpretation and writing of the annual soil monitoring report for Southern Rural Water as part of Regional Environment Improvement Plan.

I became a Certified Professional Soil Scientist Level 1 (CPSS-1) in 2007 and I am now a CPSS Level 2 specialising in the classification of land for irrigation with recycled water and biosolids application. I have undertaken significant projects including Environmental Management Plans for Yarra Valley Water Class A household recycled water use and Township Scale Land Capability Assessments for South Gippsland, Baw Baw and Surf Coast Shire Councils.

I recently facilitated two Fert$mart soil fertility courses on behalf of Dairy Australia, which involved soil sampling and development of 25 fertiliser and whole farm nutrient management plans and the delivery of 4 workshops on the interpretation of soil test results and nutrient balances. In July 2014, I completed a four day National Centre for Dairy Education Australia (NCDEA) course on Design Livestock Effluent Systems and I am now an accredited livestock effluent system designer.

Ag-Challenge Consulting holds a number of long-term soil monitoring contracts with a range of recycled water irrigation users, from Water Authorities to Milk Processing plants across the state of Victoria, south of the divide. As part of my rule at Ag-Challenge Consulting it has been my role to write between 12 and 25 annual soil monitoring reports for sustainable recycled water use each year for the past 8 years.

Project Involvement:

2009-10 : Assist in the creation of the EPA Victoria On-site Wastewater Code of Practice Guidelines for Environmental Management – Short-term Secondment with EPA Victoria

2010 : Land Capability Assessment and Environmental Management Plan (EMP) for recycled water use in the Mitchell Growth Corridor – Yarra Valley Water

2012 : Township scale Land Capability Assessment for domestic wastewater management in the Prom Views Estate, Walkerville – South Gippsland Shire Council

2007 – 2013 : Land Capability Assessments including soil hydraulic conductivity testing for domestic wastewater dispersal in the following Shires:

Baw Baw	East Gippsland	Golden Plains	LaTrobe
Manningham	Mornington	Murrindindi	Nillumbik
Pyrenees	Shepparton	South Gippsland	Strathbogie
Wellington	Whittlesea	Wyndham	

Completion of Land Capability Assessments for onsite wastewater management including all facets of each project including:

- Desktop Feasibility Studies using Victorian Resources and Geovic online interactive maps
- On-site field investigations including soil textural classification, soil permeability measurement, landscape assessment and environmental constraints
- Collation of field results and report writing

2008-2013 : Bannockburn, Portarlington, Winchelsea & Aireys Inlet Recycled Water Irrigation Sites Annual Soil Monitoring – Barwon Water

2003-14 : Annual Soils Monitoring of Recycled Water Irrigation Sites – Wannon Water

2007-15 : Wastewater Reuse Soil Monitoring Report (Cobden) – Fonterra

2007-15 : Recycled Water Werribee South Irrigation District Field Component & Co-Author of the Annual Soil Monitoring Report – Southern Rural Water

2009 : Environmental Management Plan (EMP) for Dairy Processing Plant Sludge – Burra Foods

2010 : Soil Compaction Assessment including fieldwork and report writing Carlton Gardens Birrarung Marr & Alexandra Gardens - Melbourne City Council

2012 : Cowes Wastewater Irrigation Scheme Development – Westernport Water

2010-12 : Annual Soils Monitoring of Biosolids Land Application Sites – Wannon Water

2010 : Environmental Management Plan (EMP) for recycled water use in Aurora & Highlands Estate and Brushy Creek catchment – Yarra Valley Water

20013-15 : Annual Soils Monitoring of Recycled Water Irrigation Sites – East Gippsland Water

20013-15 : Annual Soils Monitoring of Recycled Water Irrigation – Warrnambool Cheese and Butter

Area of Expertise:

I specialise in the classification and reporting of soil and land for irrigation of recycled water and biosolids. Much of the work I have undertaken in this field has related to Land Capability Assessments for on-site wastewater management for individual households, restaurants, school camps, whole Townships and catchments. The following is a list of my particular expertise:

- Skilled Soil Scientist – particularly in the field of classification and mapping of soils and land for recycled water irrigation
- Soil chemical data interpretation for agricultural/horticultural production and environmental considerations, including recommendations pertaining to fertiliser rates of application and remedial measures
- Potentially Contaminated Land – Preliminary Investigations including development and implementation of soil sampling protocols and interpretation of laboratory data in accordance with Australian Standards
- Soil compaction assessments of Parks and Gardens
- Soil moisture monitoring data interpretation for stormwater management
- Accredited Livestock Effluent Management system designer including water and nutrient balance, storage and irrigation system specifications
- Accomplished user of Adobe Illustrator for the creation of detailed overlays on aerial photography for farm plans and soil mapping.

3. Instructions Received:

This statement has been prepared on the instruction of Greg Tobin of Harwood Andrews. I was instructed to:

1. Review the exhibited material and submissions

2. Review the proposed SUZ15 and advise if any changes are considered necessary to the development plan requirement as they relate to my discipline;

3. Prepare a desktop review of the exhibited materials as they relate to my discipline

4. Provide any further relevant information and

5. Prepare a written report and appear at a planning panel proposed for the week beginning 22 June 2015.

My discipline is soils and wastewater irrigation for sustainable agricultural and environmental outcomes.

4. Information Used and Relied Upon

I acknowledge receipt of full copies of the exhibited material and submissions, including the Revised Concept Layout Plan (Revision M), which is attached as Figure 1 to this statement.

In responding to my instructions, I have examined in most detail the following documents:

- Douglas Partners (21 August 2014) *Report on On-site Effluent Disposal Assessment* Central Victorian Livestock Exchange Western Hwy & Sunraysia Hwy Interchange Ballarat Prepared for Regional Livestock Exchange (RLX) Investment Company Pty Ltd. Project: 79187.00

- Douglas Partners (5 June 2015) *Additional Soil Investigation and Testing* - Central Victorian Livestock Exchange Western Hwy & Sunraysia Hwy Interchange Ballarat Prepared for Regional Livestock Exchange (RLX) Investment Company Pty Ltd. Project: 79187.01

- Geolyse (December 2014) – *Water Cycle Management Report* - Central Victorian Livestock Exchange Prepared for RLX Investment Company Pty Ltd

- Geolyse (3 June) *Central Victorian Livestock Exchange – Response to Central highlands Water*

- *Spiire (June 2015) Central Victorian Livestock Exchange (CVLX) – Contingency Effluent Disposal Report*

From within each of the Douglas Partner reports I have assumed all soil chemical data to be factual and representative of the soils on the property. From within the Geolyse reports I have assumed the quality and quantity of the wastewater available for irrigation as being indicative of an average year. While the Geolyse wastewater quality data has been used to form the basis of my nutrient loading calculations, these data may have limitations and may not truly represent the quality of wastewater generated.

Other Reference documents taken into account include:

Australian Standards AS1547-2012 Disposal Systems for effluent from domestic premises.

EPA Guidelines for Environmental Management – Onsite Wastewater Management Code of Practice December 2008 – Publication 891.2

EPA Document 168 EPA Victoria (1991) Guidelines for Wastewater Irrigation

MAV – Model Land Capability Assessment Report. February 2006

Bureau of Meteorology for rainfall and evaporation data

Incitec Pivot – Technical Bulletin

Victorian Resources Online – Soil and Land Survey Director

Maher JM, Martin JJ (1987) 'Soil and landforms of south-western Victoria, Part 1. Inventory of soils and their associated landscapes' (State Chemistry Laboratory).

I have read the submissions received by Council. A summary of the key issues relating to my discipline of soils and wastewater irrigation for sustainable agricultural and environmental outcomes is provided in Section 5.

Central Victorian Livestock Exchange

Desktop Soil and Wastewater Irrigation Assessment for Sustainable Irrigation of Wastewater at the Proposed Location of the New Ballarat Saleyards

5. Executive Summary

- Long-term success of this proposed wastewater irrigation system can be achieved with appropriate monitoring and management. The farm operator will need to possess appropriate wastewater irrigation management and farm operation skills to ensure effective use of the nutrient rich wastewater for productive crop output in excess of 7.5 t/ha per year. An appropriate monitoring regime will assist the farm operator to make farm management changes in a timely manner as required.

- The proposed irrigation system is expected to apply only a low volume (1.5 ML/ha) of moderately saline wastewater each year over a total area of 26.6 ha. This is low volume of water with respect to the plant evapotranspiration requirements in this climate, but should enable yields of 7.5 tDM/ha of pasture to be obtained as part of a cut and carry operation.

- The anticipated SAR of the wastewater is quite low at 2.5 such that the wastewater is unlikely to have a negative impact on soil structure, despite the existing sodic to strongly sodic nature of the subsoil. Long-term irrigation with wastewater of this quality is unlikely to negatively impact on soil permeability.

- The wastewater is expected to contain an appreciable concentration of salt, but given the low hydraulic loading rate, the mass salt load of 1.7 t/ha is considered manageable, given the leaching winter rains, despite the low subsoil permeability.

- The wastewater contains significant quantities of nutrient in the form of nitrogen, phosphorus and potassium. It is the nutrient loading on this site which presents the most significant constraint to sustainable irrigation of wastewater. A list of analytes to be included in the on-going monitoring program for soil and wastewater have been included in Appendix 1 and 2, along with a suggested soil sampling procedure.

- Irrigation volumes with each application should also be monitored such that the total hydraulic loading per hectare can be calculated, and the mass loading of salt and nutrients can be calculated annually.

- Based upon the anticipated quantity of N, P, K nutrient to be applied in the wastewater no inorganic nitrogen, phosphorus or potassium need be imported or applied to land within the proposed irrigation to meet plant nutrient requirements.

- The effective implementation of the recommended ongoing monitoring program for crop, wastewater and soil is also seen as a necessary component of sustainable irrigation on this property as these three components of monitoring and how they feedback into changes in wastewater irrigation and farm management can have a large bearing on the success or failure of wastewater irrigation systems.

6. Introduction

At the request of Greg Tobin of Harwood Andrews, Ag-Challenge Consulting has been instructed to complete a desktop soil and wastewater irrigation assessment for the proposed relocation of the Ballarat Saleyards to Lot 1 and Lot 2 TP840697. At this stage the proponents (Regional Livestock Exchange (RLX) investment Company Pty Ltd) are seeking a Planning Scheme Amendment C185. This assessment will include:

- A review of the available soil and wastewater data prepared to date by Douglas Partners.
- Consideration of the Geolyse Water Cycle Management Report
- A response to some of the issues raised by Central Highlands Water.

This assessment aims to assess whether the proposal to treat and apply wastewater to land onsite is sustainable from an environmental and agricultural perspective given the soil chemical and physical analytical results described by Douglas Partners and the anticipated wastewater chemical characteristics as modelled by Geolyse.

The sustainable application to land of wastewater is mostly dependent upon the inherent soil properties and specific wastewater characteristics which impact on the soil ability to cope with the wastewater being applied. How the soil and wastewater interact is however also very much dependent upon ongoing management and with this in mind, this desktop assessment will:

- Describe the soils in terms of their existing chemical status and interpret their suitability for wastewater application and how this impacts on the development of irrigated crops/pasture on the property
- Document the general details of the proposed site from an agricultural perspective
- Assess water quantity, quality and nutrient balances for sustainable irrigation, agronomic capability and environmental compliance
- Describe and define on-going monitoring procedures to ensure sustainable wastewater irrigation management. This will include soil and wastewater sampling frequency, irrigation scheduling, soil sampling depths and analytes required for on-going soils monitoring of the property.

The areas of specific interest for the soils investigation are those parts of the property that are intended for wastewater application to land – essentially the farming land of the property that surrounds the proposed stockyards. This land has been referred to as *the irrigation area*, as shown in Figure 1.

These reports by Douglas Partners and Geolyse describe the onsite soil conditions and the proposed irrigation of lucerne with low pressure sprinklers to utilise the wastewater volumes generated on the property irrigation. This assessment will use the information from these previous studies together with Ag-Challenge Consulting data on climate, soils, agriculture and prior knowledge of sustainable wastewater irrigation practices to plan the future use, development and on-going monitoring and management of the property.

This is a desktop assessment only. No onsite inspection of the property has been undertaken by Ag-Challenge Consulting.

7. The RLX proposal summary

It is understood that the proposed irrigation system is to consist of the following key parameters

Total irrigation area = 26.6 ha

Total volume of irrigation water = 34.8 ML (on average)

Anticipated hydraulic loading rate = 1.31 ML/ha per year or 131 mm = 131 L/m^2

Total salt load = 1150 kg/ML or 1642 kg/ha

Sodium Absorption Ratio (SAR) = 2.5

Phosphorus application rate = 30 kg/ha

Nitrogen application rate = 200 kg/ha

8. Climate and Water Balance

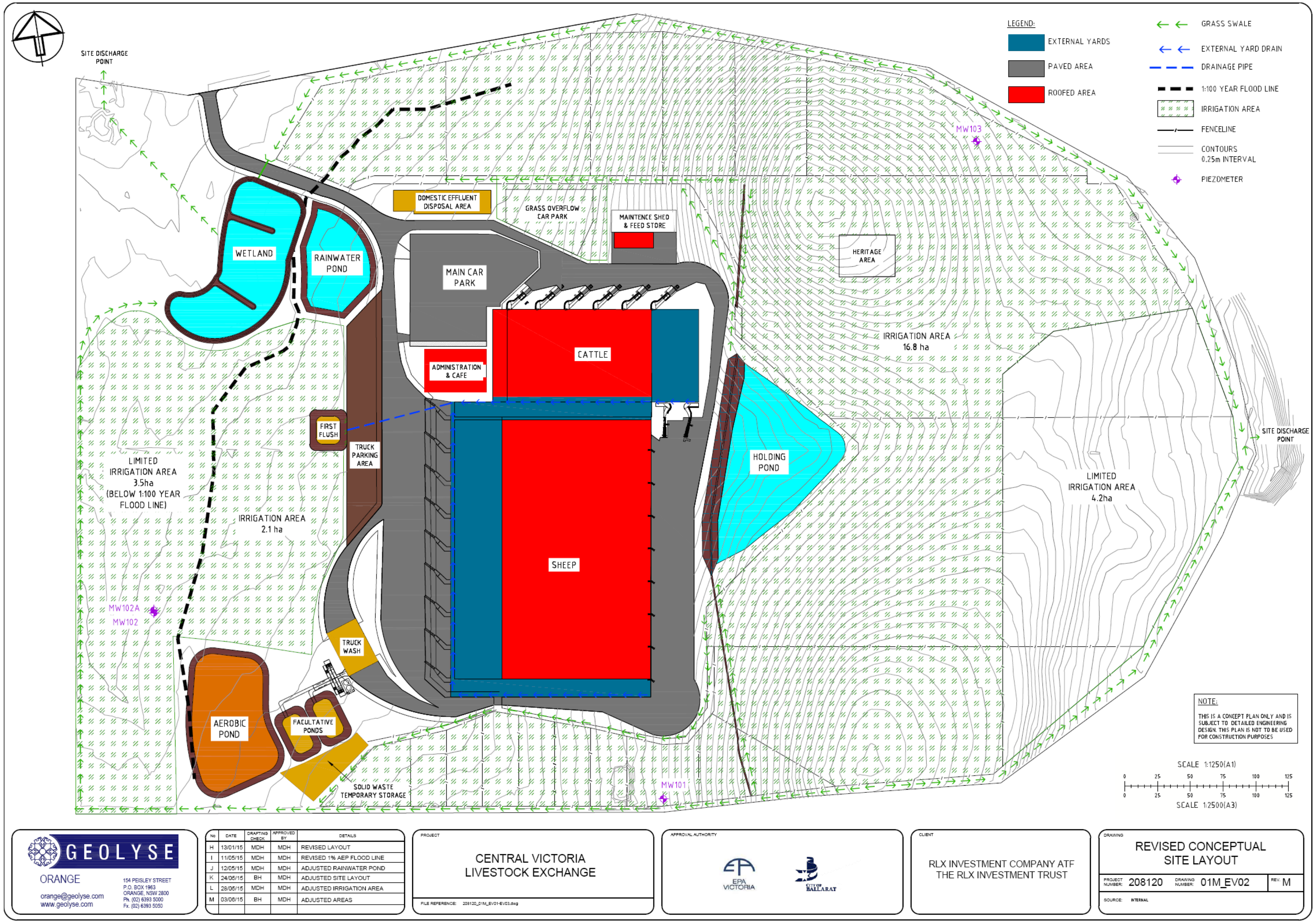
Average climate data for the site north west of Ballarat is shown in Table 1. The data shows that there is a significant disparity between mean annual rainfall of 668 mm and the mean annual evaporation of 1168 mm. This is a relatively dry climate with an annual plant evapotranspiration deficit of 353 mm or 3.5 ML/ha in an average season. The proposal to irrigate 150 mm or 1.5 ML/ha is insufficient to fully meet plant evaporation needs. The data in Table 1 shows an average of 120 mm of excess winter rainfall, which presents a leaching fraction of 18%. This is considered to be adequate to achieve the required leaching for the annual removal of salts applied in the wastewater. Leaching will normally occur in the months of June, July and August.

Table 1. Water balance for Ballarat[1]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean Rainfall	**49**	**50**	**48**	**58**	**58**	**50**	**50**	**55**	**60**	**67**	**66**	**62**	**668**
Mean Evaporation	**183**	**160**	**124**	**75**	**47**	**30**	**31**	**47**	**69**	**102**	**129**	**167**	**1168**
Crop Factor	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	
Evapotran-spiration	146	128	99	53	33	21	22	33	48	82	103	134	901
Water Deficit	98	78	52							15	38	72	353
Water Excess				5	25	29	28	22	12				120

[1] Based on mean Rainfall at Ballarat Park (met station No. 089002) and mean Evaporation at White Swan Reservoir (met station No. 089048)

Figure 1. Site Plan



9. Soil type

According to soil and landform investigations undertaken by Maher & Martin (1987)[2], the soils described by Douglas Partners on the site are considered most likely to be located in the Mapping unit 8. The soils in this gently undulating rise landform are described by Maher & Martin (1987) as '*Hard pedal mottled-yellow duplex*' and may or may not be prone to severe seasonal waterlogging.

10.Recycled Water Quality

The use of recycled water for sustainable irrigation is very much dependent upon the inherent soil properties, but also the quality of recycled water available for irrigation. The way in which recycled water is managed for irrigation can also be a strong determinant in the longevity of a site used for irrigation. Laboratory analysis of the wastewater at two other livestock exchange sites has been provided by Geolyse[3] to assess the suitability of the wastewater for its sustainable irrigation to land. The mean of these data are included in Table 2 along with anticipated mass loading rates at an indicative mean hydraulic loading rate of 1.5 ML/ha for pasture as anticipated by Geolyse[4]. This rate is in fact intended to vary over the irrigation area in an average year. A conservative value of 1.5 ML/ha has been assumed over the whole irrigation area available of 26.6 ha

Table 2. Anticipated Recycled water quality[5] & mass inflow at a hydraulic loading rate of 1.5 ML/ha.

Parameter	Units	Concentration	Mass Inflow at 1.5 ML/ha (kg/ha)
Total nitrogen	mg/L	**150**	28.6
Total phosphorus	mg/L	**30**	45
Electrical Conductivity	µS/cm	**1900**	
pH		**6.5 – 8.5**	
Total Dissolved Solids	mg/L	**1140**	1710
Potassium	mg/L	**250**	375
SAR		**2.5**	

Overall the recycled water is of reasonable quality for irrigation.

- Salinity is moderate at a TDS of 1140 mg/L and classified as Class 3 water according to EPA Victoria document 168. At a theoretical hydraulic loading rate of 1.5 ML/ha, a total of 1710 kg/ha or 1.7 t/ha of salt would be applied in the recycled water. While significant, this is not an excessively high quantity of salt which must be mobilised through the soil profile, especially given the anticipated leaching winter rainfall of 18%. Annual monitoring of soils irrigated with this recycled water is recommended to ensure salts applied in the recycled water are being leached through the soil without accumulation in the soil profile. Monthly monitoring of the wastewater electrical conductivity during the irrigation period will also

[2] M Maher JM, Martin JJ (1987) 'Soil and landforms of south-western Victoria, Part 1. Inventory of soils and their associated landscapes' (State Chemistry Laboratory).
[3] Geolyse (3 June) *Central Victorian Livestock Exchange – Response to Central highlands Water*
[4] IBID
[5] IBID

provide data on the total salt load applied in the wastewater each year and can be used to adjust irrigation application rates to achieve desired leaching fractions.

- There is minimal risk of soil structure loss with irrigation of this recycled water given the low sodium absorption ratio (SAR) value of 2.5 in combination with the Electrical Conductivity value of 1900 µS/cm (see Figure 3 Page 29 EPA Victoria doc No. 168). Where SAR values are high relative to EC, there is a risk that irrigation will result in soil structure loss and a decline in soil permeability. It is essential that soils irrigated with recycled water remain sufficiently permeable to allow salt applied in the recycled water to leach through the soil profile. Annual monitoring of soil Exchangeable Sodium Percentage (ESP) in the A1, A2 and B1 soil horizons will provide an indication of whether sodium is being retained in the soil and whether remedial measures such as gypsum need be applied. Monthly monitoring of the SAR in the wastewater during the irrigation period will also provide an indication of the risk of soil permeability loss with irrigation of the wastewater.

- The pH of the wastewater is expected to vary between 6.5 – 8.5 which is slightly acid to moderately alkaline. The application of wastewater with this pH is expected to increase soil pH. How much the soil pH increases will depend on the inherent pH buffering capacity of the soil. This wastewater pH is within the acceptable range according to EPA document 168 – page 38.

- The recycled water contains significant levels of nitrogen and phosphorus, 150 and 30 mg/L respectively. While beneficial to plant growth both of these nutrients can have negative effects on surface and groundwater if applied in excess and allowed to mobilise off-site. At a hydraulic loading rate of 1.5 ML/ha, nitrogen and phosphorus will be applied at 225 and 45 kg/ha which is within the expected uptake range of these nutrients by rye-grass pasture[6]. This is discussed in more detail in Section 11.3.1.

- The wastewater contains a significant amount of potassium, which is another essential plant nutrient. While potassium does not present a direct risk to the environment from off-site discharge it is a single valency cation and as such when applied in excess has the potential to cause soil permeability loss. The proposed cut and carry of hay or silage from the property should ensure adequate removal of this nutrient. However all soil monitoring activity should include analysis of Colwell potassium and potassium should also be included in analysis of the wastewater during the irrigation season.

Overview of Wastewater and the Proposal

The proposed irrigation system is expected to apply only a low volume (1.5 ML/ha) of moderately saline wastewater each year. The SAR of the wastewater is quite low such that the wastewater is unlikely to have a negative impact on soil structure and as such long-term irrigation with wastewater of this quality is unlikely to negatively impact on soil permeability. The wastewater does however contain appreciable quantities of nutrient in the form of nitrogen, phosphorus and potassium. While both N and P are essential plant nutrients, each has the potential for negative environmental impact on surface and groundwater should they be allowed to discharge off-site. Therefore overall it is the nutrient loading on this site which presents the most significant constraint to sustainable irrigation of wastewater on this site. Based upon the anticipated quantity of N, P, K nutrient to be applied in

[6] EPA Victoria (1991) Guidelines for Wastewater Irrigation – Table 6 - Page 35:Rye-grass 200 to 280 kg/ha for Nitrogen and 60-80 kg/ha for phosphorus.

the wastewater no inorganic nitrogen, phosphorus or potassium need be imported or applied to land within the proposed irrigation to meet plant nutrient requirements. A list of analytes to be included in the on-going monitoring program for soil and wastewater have been included in Appendix 2. Irrigation volumes with each application should also be monitored such that the total hydraulic loading per hectare can be calculated, and the mass loading of salt and nutrients can be calculated annually.

11. Land and Soil Properties and How They Relate to the Proposed Wastewater Irrigation System

11.1 Land and soil

Based upon the soil profile descriptions by Douglas Partners[7], soils on the site would be described in an agricultural perspective as mostly consisting of duplex silty clay loams (A horizon) over poorly structured silty clays (B Horizon). There is believed to be soil of volcanic basalt influence on the eastern side of the property, which are likely to be heavier textured and with a shallower soil profile depth of basalt. The transition between the A and B horizons is not described, but is expected to have been clear or abrupt given the gravely buckshot which was encountered at the transition between the A and B soil horizons. Buckshot gravel is typically a good indication of soils which are poorly drained and are likely to be intermittently saturated above the B soil horizon during the year when in wet conditions. Intermittent saturated or waterlogged soils are common throughout Victoria and this does not preclude the property as being suitable for wastewater irrigation. However it does mean that wastewater application rates need to be relatively low to prevent saturated soil conditions from occurring, or else wastewater be only applied during times of significant soil water deficient.

Irrigation of wastewater in the area within the 1 in 100 flood zone is not considered an issue provided the irrigation occur at a suitable rate and weather forecasts including rainfall events are taken into consideration in the irrigation schedule. The construction of the wetland ensures wastewater applied to this area is captured in the event run-off does occur. A similar approach to irrigation scheduling is recommended over the whole irrigation area to reduce the risk of substantial rainfall events occurring after irrigation.

11.2 Subsoil permeability

The most fundamental requirement of any wastewater irrigation scheme is that of drainage. As such it is necessary to establish that the most limiting soil horizon (in this instance the clay B soil horizon) has adequate permeability to allow the additional water applied as irrigation to drain through to the underlying soil and eventually to groundwater.

[7] Douglas Partners (21 August 2014) *Report on On-site Effluent Disposal Assessment* Central Victorian Livestock Exchange Western Hwy & Sunraysia Hwy Interchange Ballarat Prepared for Regional Livestock Exchange (RLX) Investment Company Pty Ltd. Project: 79187.00
Douglas Partners (5 June 2015) *Additional Soil Investigation and Testing* - Central Victorian Livestock Exchange Western Hwy & Sunraysia Hwy Interchange Ballarat Prepared for Regional Livestock Exchange (RLX) Investment Company Pty Ltd. Project: 79187.01

A total of seven in-situ constant head subsoil permeability tests have been undertaken at various locations across the site by Douglas Partners[1]. Of the seven tests only 5 are considered representative of the clay subsoil. The geomean soil permeability of these 5 data sets is 0.01 m/day, which is very low and indicative of a poorly drained heavy clay soil and would be categorised as a either a 5c or 6b soil according to AS/NZS1547:2012[8]. In reality this means that no more than 10 mm of water can be applied in a single day without some accumulation in the A2 soil horizon. It does not mean that more than 10 mm/day cannot be applied. It just means that should more than 10 mm be applied in any one day then the soil water storage capacity of the A horizon would begin to fill at a greater rate than is moving through the B soil horizon. Assuming a porosity of 30 % and an average depth of the A2 of 300 mm, then the A2 soil horizon has a soil water storage capacity of 100 mm before the A horizon becomes fully saturated.

Based upon a subsoil permeability of 0.01 m/day or 10 mm/day, the proposed mean hydraulic loading rate of 1.31 ML/ha or 131 mm/day can be applied as 13 applications of 10 mm per application without any water accumulation in the A soil horizon above the limiting clay B soil horizon.

While the subsoils on this property have relatively low permeability, the proposed wastewater application rate is sufficiently low that the low subsoil permeability does not present a significant constraint.

11.3 Nutrient Loading

The rate at which the wastewater can be sustainably applied is very much dependant not only upon the wastewater quality but on the soils ability to bind and the plants ability to uptake those nutrients.

11.3.1 Nitrogen

As identified in Section 2, one of the most significant constraints to sustainable wastewater management in this proposal is that of nitrogen and phosphorus loading rates. Appropriate nitrogen and phosphorus application rates are required to ensure these nutrients are assimilated in the crop and the soils, and do not accumulate to such an extent that they pose a risk to the environment. Both of these nutrients can cause significant harm to waterways and groundwater, and are the key drivers for toxic algal blooms. In potable water, nitrate can cause severe health problems.

To determine an appropriate nitrogen application rate, the rate at which nitrogen is applied must be balanced with crop requirements, or more specifically, crop removal rates. The limiting application rate is determined by matching the amount of nitrogen in the wastewater, against the ability of the crop to utilize the nitrogen. The data in Table 3 is based upon the anticipated range of indicative nitrogen uptake rates for lucerne and pasture[9]. Table 3 shows that lucerne would be expected to use considerably more nitrogen than pasture and that at an application rate of 1.5 ML/ha/year, the amount of nitrogen applied in the wastewater would be very close to the amount expected to be removed in the crop as hay. Note both of these rates of nitrogen removal in Table 3 assume the fodder crops are cut and carried from the property, not fed out to stock on the property.

[8] Australian Standards (2012) Onsite wastewater management ANZ1547:2012
[9] EPA Victoria (1991) Guidelines for Wastewater Irrigation – Table 6 - Page 35

Table 3. Nitrogen Balance for Lucerne and Pasture Hay based on EPA Victoria data[10].

Nutrient	Crop	Nitrogen Uptake range (kg/ha/year)	Wastewater Nitrogen concentration (kg/ML)	Nitrogen applied at 1.5 (ML/ha)
Nitrogen -	Lucerne	220-540 kg	150 kg/ML	225 kg
Nitrogen -	Pasture	200-280 kg	150 kg/ML	225 kg

Based on the result in Table 3 alone, lucerne would be recommended as the crop of choice on this property because of its greater nitrogen utilisation rate. Lucerne however is not well suited for use on this site given its requirement for free draining soil of higher soil pH. The soils on this property are not free draining nor do they have a high soil pH. Because the rate of nitrogen application in Table 3 is so close to that expected to be used and removed by plants, Table 4 has been included to explore nitrogen removal rates in more detail and how they would be expected to vary with crop yield. Because there is inadequate wastewater available to fully meet plant evapotranspiration rates over the summer months, crop yields are expected to vary with rainfall and as such there is expected to be considerable variation in crop yield from one year to the next. How these expected fluctuations in yield impact on nitrogen removal rates are explored in Table 4.

Table 4. The impact of crop yield on nitrogen removal rate.

		Amount of Nitrogen in crop at varying yields (kg/ha)		
	N% DM	**at 5 t/ha**	**at 7.5 t/ha**	**at 10 t/ha**
Lucerne	3.40%	171	257	342
Pasture	2.62%	131	197	262

From Table 4 alone, if lucerne yields of at least 7.5 tDM/ha per year were obtained, the 225 kg/ha of nitrogen applied in the wastewater at a hydraulic loading rate of 1.5 ML/ha, would not be in excess of plant requirements. Rye-grass pastures are recommended in preference to lucerne. Table 4 also demonstrates that with rye-grass, crop yields would need to be around 8.5 tDM/ha before the anticipated rate of nitrogen removal would equate to that applied in the wastewater. Therefore based on these data, irrigation and crop harvest would need to be well managed to ensure the required crop yields area achieved. That is, achieving the desired rate of crop production is heavily dependent upon the skill and capability of the farm manager. With inadequate management and low crop yields there is a risk of nitrogen being mobilised beyond the plant root zone and a risk of nitrate being mobilised to groundwater.

To minimise the potential for excess nitrogen input, it is recommended that the wastewater be used instead of inorganic fertiliser and that no additional nitrogen fertiliser be applied. To maximise plant nitrogen uptake the wastewater could be applied at the fringes of the season, ie towards the end of Spring and at the Autumn Break. This would ensure wastewater is applied to actively growing plants at a time when plant nitrogen uptake is high, as opposed to applying the wastewater in summer

[10] EPA Victoria (1991) Guidelines for Wastewater Irrigation – Table 6 - Page 35

when the soil is very dry and plants are potentially beyond wilting point and not actively growing or taking up nitrogen.

The data in Table 3 and Table 4 provide slightly more conservative outcomes than those demonstrated by Geolyse[11], because we have assumed that all of the nitrogen in the wastewater is readily plant available. In reality some nitrogen will be in the organic form and could take approximately 1 year before it is converted into nitrate and made available for plant uptake. It is recommended that a conservative approach be taken in the design phase with regard to nutrient loading. The actual wastewater quality data is at this stage an estimate of only two other livestock exchange sites. Only once the wastewater system is operational will the actual wastewater nitrogen concentration be known and this may vary considerably from that used in these calculations.

When assessing nitrogen application rates it is worth considering how they compare with typical agricultural practice. For example in this instance it should be remembered that nitrogen is commonly applied to pasture and crops as a fertiliser to improve pasture and crop growth rates and overall yields. In dairying it is common place for nitrogen to be applied in the form of urea at rates of 75-100 kg/ha (35-46 kg/ha of N), every 30 days throughout the growing season. Rapidly growing rye-grass is expected to utilise between 1 and 1.5 kg/ha of nitrogen per day. Based on mean Ballarat climate data (Table 1) the growing is likely to extend from May to November and as such it is not unrealistic to expect 6 applications of nitrogen as urea to actively growing pastures during this time. Six applications of urea at 75 kg/ha, equates to 207 kg/ha, or 276 kg/ha as six applications at 100 kg/ha. Within the potato growing areas around Ballarat similar rates of nitrogen use would be expected, particularly the longer growing varieties such as Russet Burbank which are grown for McCains and other chipping processing operations. It can therefore be said that the anticipated rate of nitrogen application at the proposed CVLX site may be indicative of that being applied on intensive dairy farm operations and potato growers as normal agricultural practice around Ballarat.

To ensure the amount of nitrogen being removed in crops cut and carried from the site, is proportional to that being applied in the wastewater, there are a number of monitoring procedures which should be implemented to ensure this is the case, or else if changes need to be implemented:

- Firstly the wastewater in the storage lagoon should be sampled and monitored for total nitrogen at the point of pumping on a monthly basis throughout the irrigation period. (The complete list of recommended analytes is shown in Append 1).

- Secondly the lucerne/pasture crop should be tested for nitrogen and phosphorus as it is being removed from the site, such that complete nutrient budgets can be accurately undertaken.

- Thirdly a soil monitoring program should be implemented. This will involve the establishment of at least two defined soil monitoring transects within the wastewater irrigation area. These monitoring transects should be established prior to the commencement of irrigation with wastewater such that baseline data can be obtained against which all future monitoring can be compared. An appropriate soil monitoring procedure and list of soil analytes to be included within the annual soil monitoring program

[11] Geolyse (3 June) *Central Victorian Livestock Exchange – Response to Central highlands Water*

have been included in Appendix 2. Soil monitoring depths shall be selected to represent the A1, A2 and B1 soil horizons and would expected to be located at approximate depths of 0-10 cm, 20-30 and 50-60 cm respectively. At least two defined soil monitoring transect should be established within the irrigation area and monitored on an annual basis. Analysing the soil for total nitrogen, total carbon and soil nitrate, at these depths will provide a good indication whether nitrogen is being applied in excess of plant nutrient requirements and whether nitrogen or nitrate is at risk of moving beyond the surface soil, into the subsoil and potentially leaching to groundwater.

- Fourthly groundwater monitoring would ultimately provided data whether nitrate has leached to the groundwater, but at nitrate is not known to be readily broken down in the groundwater, groundwater monitoring does not offer an effective ongoing preventative management strategy in preventing nitrate leaching the same way the soil monitoring will.

The proposed rates of nitrogen application in the wastewater are likely to be closely matched with the rates of nitrogen removal in crop to be cut and carried from the site, provided the property, crops and irrigation is well managed. Given the limited amount of wastewater available (1.5 ML/ha on average) it is recommended that to maximise crop yield and plant nitrogen uptake, wastewater be applied to actively growing plants in early autumn and late spring. Appling nutrient rich wastewater at this time will maximise the potential for nitrogen uptake and extend the growing season. Applying wastewater at these times will ensure plant nitrogen requirements are met without the need for inorganic nitrogen fertiliser to be applied and to ensure the wastewater is applied to actively growing plants which will readily take up the nitrogen applied. Ongoing soil and crop monitoring would be required to ensure adequate rates of nitrogen removal or else if management procedures require adjustment.

11.3.2 Phosphorus

To determine the appropriate phosphorus application rate requires a different approach to that of nitrogen. Crops only require a small proportion of the phosphorus applied in fertiliser to fully satisfy their phosphorus needs. Excessive levels of phosphorus are supplied as part of normal agricultural practice because soils will fix most of the free phosphate ions present in applied fertiliser onto the surface of colloidal clays as insoluble and unavailable phosphate. This fixation of phosphate is a widely recognized feature of Australian soils, and these soils have been assessed as having considerable phosphate fixing capability[12].

From Table 5 contains the anticipated range of indicative phosphorus uptake rates for lucerne and pasture according to EPA document 168[13].

From Table 5 the likelihood of there being excess phosphorus will depend upon the whether lucerne or rye-grass is grown as rye-grass would be expected to use considerably more phosphorus than

[12] Douglas Partners (5 June 2015) *Additional Soil Investigation and Testing* - Central Victorian Livestock Exchange Western Hwy & Sunraysia Hwy Interchange Ballarat Prepared for Regional Livestock Exchange (RLX) Investment Company Pty Ltd. Project: 79187.01
[13] EPA Victoria (1991) Guidelines for Wastewater Irrigation – Table 6 - Page 35

lucerne. At an application rate of 1.5 ML/ha/year, the amount of phosphorus applied in the wastewater is greater than that expected to be used by lucerne, but less and that expected to be used by rye-grass. Note both of these rates of phosphorus removal in Table 5 assume the fodder crops are cut and carried from the property, not fed out to stock on the property.

Table 5. Phosphorus Balance Lucerne and Pasture Hay based on EPA Victoria data[14]

Nutrient	Crop	Phosphorus Uptake range (kg/ha/year)	Wastewater Phosphorus concentration (kg/ML)	Phosphorus applied at 1.5 ML/ha (kg/ha)	Phosphorus excess/deficit (kg/ha)
Phosphorus -	Lucerne	20 - 30 kg	30 kg/ML	45 kg	+15 to +25 kg
Phosphorus -	Rye-grass	60 - 80 kg	30 kg/ML	45 kg	-15 to -65 kg

From Table 5 the rate of phosphorus application in the wastewater is close to that expected to be used and removed by plants, so Table 6 has been included to explore how phosphorus removal rates may vary with crop yield. Because there is inadequate wastewater available to fully meet plant evapotranspiration rates over the summer months, crop yields are expected to vary with rainfall and as such there is expected to be considerable variation in crop yield from one year to the next. How these expected fluctuations in yield impact on phosphorus removal rates are explored in Table 6.

Table 6. The impact of crop yield on phosphorus removal rate.

		Amount of Phosphorus in crop at varying yields (kg/ha)		
	P% DM	at 5 t/ha	at 7.5 t/ha	at 10 t/ha
Lucerne Hay	0.4%	18	27	36
Rye-grass	0.3%	16	24	32

From Table 6, a lucerne yield of 7.5 tDM/ha per year, will remove 27 kg/ha of phosphorus, such that with 45 kg P/ha having been applied in the wastewater at a hydraulic loading rate of 1.5 ML/ha, there will be an excess of 18 kg/ha of phosphorus above plant requirements. Therefore provided no additional phosphorus fertiliser is applied, it is expected that 18 kg of P per year will need to be sorbed by the soil to prevent phosphorus from being mobilised beyond the plant root zone. While data in Table 6 for lucerne is similar to that in Table 5 for lucerne, there is quite a disparity with regard to rye-grass and as such the values in Table 5 from the EPA are considered to overstate the actual P removal expected from rye-grass and the values in Table 6 are considered more realistic. This means that regardless of the selected crop by lucerne or rye-grass, there is expected to be an excess of ~15-20 kg/ha of phosphorus applied in the wastewater above plant requirements that will need to be sorbed by the soil.

The expected rate of phosphate fixation has been calculated from the soil Phosphorus Sorption Index (PSI), and this soil test has been undertaken to more precisely determine the phosphorus sorption potential. The PSI on these subsoils at 0.4 – 0.5 m depth has been calculated at 1000 mg/kg. When extrapolated out to include a soil profile of 1.5 m, this equates to:

[14] EPA Victoria (1991) Guidelines for Wastewater Irrigation – Table 6 - Page 35

1000 mg/kg = 1000 kg/t
1.3 t/m^3 x 1.5 m x 10,000 m^2 = 19,500 t x 1000 = 19,500,000 kg
19,500,000 kg x 1000 mg/kg = 19,500,000,000 mg
19,500,000,000 mg ÷ 1000 ÷ 1000 = 19,500 kg of phosphorus

This means that the soil has the potential to bind and retain a total of 19,500 kg of phosphorus. Therefore at an excess application rate of 18 kg/ha above plant removal rates, it would take 1080 years before the entire soil profile to a depth of 1.5 m is completely saturated with phosphorus. This is purely theoretical and given the unpredictability of phosphorus migration once it moves beyond the plant root zone, it would be preferable if a more conservative approach were adopted. Based on a phosphorus PBI value of 81[15] at a depth of 0-10 cm this would mean an application rate of 7 kg/ha of elemental phosphorus is required to raise the soil test Olsen P value by 1 mg/kg (see Appendix 3). The existing soil Olsen P (plant available phosphorus) is currently unknown, but is expected to be in the order of 10 to 15 mg/kg. Based on the low phosphorus binding capacity of the A soil horizon, once the Olsen P exceeded 35 mg/kg, phosphorus binding sites within the A1 horizon (0 - 10 cm) would be expected to become saturated and phosphorus may then begin to move vertically downward through the soil profile into the soil horizons below. Assuming a current Olsen P value of 15 mg/kg and a surplus of 18 kg/ha of phosphorus per year, the Olsen P would be expected to increase by approximately 2.6 mg/kg per year and reach the threshold of 35 mg/kg in around 7-8 years.

It is should not however be forgotten that phosphorus is an essential plant nutrient and is also typically applied in fertiliser in the form of single super phosphate or as blends with muriate of potash such as “3 & 1” or “2 & 1”. The application of 2 & 1 typically occurs in the autumn on dairy farms at a rate of 350 kg/ha, which would apply 20.7 kg/ha of phosphorus. The proposal to apply wastewater containing phosphorus at 30 kg/ha in 1.5 ML/ha is therefore above that which would be considered normal practice on dairy farms around Ballarat. However on potato crops grown around Ballarat it is typical for phosphorus to be applied at rates of 150 kg/ha, which is well in excess of the 45 kg/ha being proposed on this site, albeit on a different soil type to that on which potatoes are typically grown.

Compared to nitrogen, phosphorus is tightly bound to the soil and does not leach readily to groundwater. The greatest risk of phosphorus loss from the site is as run-off. If a heavy rainfall event occurred immediately after a pass of irrigation, or soil erosion occurred, phosphorus movement into waterways may also occur. To prevent phosphorus loss in run-off in rainfall events, irrigation scheduling needs to take weather forecasts including rainfall events into consideration. This is of particular relevance to irrigation within the 1 in 100 flood zone and the eastern end of the irrigation area which does not drain into the wetland.

Overall with regard to phosphorus, the amount applied in the wastewater is expected to be in excess of plant requirements regardless of the crop grown. Based on the soil phosphorus sorption capacity it is expected to take around 6-7 years before the surface soils (0-10 cm) are saturated with

[15] Douglas Partners (21 August 2014) *Report on On-site Effluent Disposal Assessment* Central Victorian Livestock Exchange Western Hwy & Sunraysia Hwy Interchange Ballarat Prepared for Regional Livestock Exchange (RLX) Investment Company Pty Ltd. Project: 79187.00

phosphorus, but in the order of hundreds of years before the entire soil profile is saturated. These are purely theoretical values, and the actual time before the soils become saturated will depend on:

- The soils actual not theoretical ability to bind and retain phosphorus.
- Crop yields
- Phosphorus concentration of the wastewater
- Wastewater irrigation rates

MAV Nutrient Balance model

The MAV nutrient balance spreadsheet has been included in Appendix 4 indicates that there is adequate area available for the sustainable application to land of nitrogen and phosphorus. This is the EPA Victoria model used to design domestic on-site wastewater management systems.

Only with ongoing soil monitoring of defined transects at specific depths (as detailed in Appendix 2) will the soils actually ability to bind and immobilise phosphorus be known. In the event soil phosphorus is detected in the deep subsoil (eg 50-60 cm), options for additional wastewater treatment will need to be investigated that will reduce the phosphorus concentration in the wastewater, additional land for irrigation may need to be sought for irrigation, or else the property connected to sewer. The monitoring program recommended for nitrogen, which covers crop, wastewater and soil assessment is similarly recommended for phosphorus such that changes in management can be implemented in a timely manner to as to prevent phosphorus loss off-site.

11.4 Soil Salinity

The two most common limitations to irrigation with recycled water are induced salinity and sodicity of the soil. This section aims to assess how the soils are likely to respond to the irrigation with moderately saline wastewater and to make an assessment as to whether development of the property for wastewater irrigation presents any hazards with regard to salinity.

Soil salinity is commonly measured as the electrical conductivity of a 1:5 soil water suspension and the conductivity gives a direct measurement of the concentration of free salts in the soil. The measurement covers all salts in the soil, not just sodium chloride. EC values in the surface soil (0-10 cm) of less than 0.3 dS/m indicate low and harmless salt content. EC values in the surface soil (0-10 cm) above 0.3 dS/m up to around 0.6 dS/m indicate a mild level of salinity. Values above 0.6 dS/m in the surface soil indicate that toxic levels of salt may be present and it becomes necessary to know what sort of salts are present and what type of plants are to be grown. In the subsoil greater levels of salinity are tolerable, such that only once the EC exceeds 1.0 dS/m is the considered need for concern.

From Douglas Partners[16] the existing level of salinity in the surface soil (0.1-0.2 m) is low at between 0.015 and 0.04 dS/m. Soil salinity was measured at 0.4 to 0.5 m below the surface at 0.1 dS/m, which is a low and harmless level of salinity. The soil are more saline at depth with a value of 0.62 dS/m recorded at 1.4 m below the surface, but again this is not of concern given the depth at which it

[16] Douglas Partners (5 June 2015) *Additional Soil Investigation and Testing* - Central Victorian Livestock Exchange Western Hwy & Sunraysia Hwy Interchange Ballarat Prepared for Regional Livestock Exchange (RLX) Investment Company Pty Ltd. Project: 79187.01

occurs. The two most significant aspects when determining the risk of soil salinity is the existing level of soil salinity and whether the soil has sufficient permeability to mobilise the salts applied in the wastewater. The anticipated quality of the wastewater is such that at a hydraulic loading rate of 1.5 ML/ha only 1.7 t/ha of salt is anticipated to be applied (Table 2). While this is not insignificant, it is considered a manageable quantity of salt which much be leached through the soil profile each year to avoid accumulation. Drainage is the most fundamental requirement of any wastewater irrigation scheme. In this instance it has been established in the water balance that there is an excess of 120 mm year of winter rainfall which is considered more than adequate to flush the 1.7 t/ha of salts applied in the wastewater through the soil profile, given the measured subsoil permeability of 0.01 m/day.

The best method to ensure adequate leaching is being generated is through an annual soil monitoring program as per Appendix 2, in conjunction with analysis of the salt content of the wastewater and accurate record keeping of wastewater volumes applied. With these data the actual amount mass salt load can calculated and with annual ongoing soil monitoring of the same transects and depths a good indication of whether salts are accumulating or else passing through the soil profile can be obtained. Such soil monitoring transects need to be established by suitably qualified soil scientists with experience in the field of classification and recycled water soil irrigation management. It is not uncommon for the salinity profile of a soil exposed to a new regime of irrigation with mildly saline water to increase quite markedly and then settle down to a new equilibrium of salt movement in and out of the soil profile. Only with ongoing monitoring of these soils will a determination of changes and trends able to be accurately detected. Where accumulations of salt are occurring, the soil monitoring program will act a feedback loop to the irrigation manager to ensure that irrigation management practices can be adjusted in a timely manner. Where excess salt is identified there are a number of management practices which can be implemented.

Overall soil salinity is considered to present a low to moderate risk to sustainable wastewater application on this property, based on the moderate salt load to be applied each year and the low level of existing soil salinity within the plant rooting depth. It would however be beneficial to obtain data on the existing level of soil salinity such that a more informed judgement could be made. The limited data on the surface soil salinity indicates that caution will be required for managing these soils when irrigated with recycled water, but that such irrigation should be sustainable with appropriate management and soil monitoring. This statement is preliminary and subject to review with further soil monitoring.

11.5 Sodicity

Soil sodicity is measured by the percentage of exchangeable sodium compared to the total of exchangeable cations in the soil, and the percentage is abbreviated to the acronym ESP. A soil is considered to be sodic if the ESP value is above 6 (more than 6% of the exchangeable cations are sodium ions) and strongly sodic if the ESP is greater than 15. As soils become more sodic, they lose some of the important physical properties that influence productivity. In particular, sodic soils are less permeable, less well aerated, prone to surface sealing, and have a narrower range of suitable moisture content for cultivation. Maintaining the soil at a moderate to low level of sodicity is an integral part of protecting recycled irrigation farm for long term use.

The data in Table 7 shows that soils on this property vary from non-sodic in the surface soil (0.1-0.2 m) to strongly sodic in all subsoil depths. As such only the subsoils would be expected to be prone to dispersion. Based upon the wastewater having an anticipated SAR of 2.5, long-term application of this wastewater would in fact be expected to reduce the soil ESP. Therefore despite the subsoils on this property being naturally sodic, the expected irrigation wastewater quality is such that there is minimal risk of soil permeability loss through reduced soil structure. Some intervention to reverse the current highly sodic nature of this soil may only be warranted as means of improving subsoil drainage so as to improve the natural vertical movement of water through these soils, but only in the event salts began to accumulate in the soil and permeability is being compromised by the high sodium level.

Table 7. Soil Sodicity at 4 sites and at depths varying between 0.1 m and 1.5 m[17].

Soil parameter	Units	Site No.	Depth	Value
Exchangeable Cations	meq/100g	113118-14	0.1 to 0.2 m	1.8
	meq/100g	113118-15	0.1 to 0.2 m	6.0
	meq/100g	128438-5	0.9 to 1.0 m	21
	meq/100g	128438-7	0.4 to 0.5 m	22
	meq/100g	128438-12	1.4 to 1.5 m	13
	meq/100g	128438-15	1.4 to 1.5 m	15
Exchangeable sodium	meq/100g	113118-14	0.1 to 0.2 m	<0.1
	meq/100g	113118-15	0.1 to 0.2 m	<0.1
	meq/100g	128438-5	0.9 to 1.0 m	4.8
	meq/100g	128438-7	0.4 to 0.5 m	2.6
	meq/100g	128438-12	1.4 to 1.5 m	1.0
	meq/100g	128438-15	1.4 to 1.5 m	3.3
Exchangeable Sodium Percent (ESP)	%	113118-14	0.1 to 0.2 m	**<5.6%**
	%	113118-15	0.1 to 0.2 m	**<1.7%**
	%	128438-5	0.9 to 1.0 m	**23%**
	%	128438-7	0.4 to 0.5 m	**12%**
	%	128438-12	1.4 to 1.5 m	**7.7%**
	%	128438-15	1.4 to 1.5 m	**22%**

While the subsoils are sodic the anticipated water quality is such that it poses minimal risk of causing dispersion and soil permeability loss. As a precautionary measure it is recommended that the on-going subsoil monitoring include assessment of ESP (as per Appendix 2), to ensure ESP does not deteriorate, and to ensure that remedial measures such the application of gypsum or else deep ripping can occur in a timely manner.

12. Soil properties with respect to farming land use

12.1 Soil pH

[17] Douglas Partners (5 June 2015) *Additional Soil Investigation and Testing* - Central Victorian Livestock Exchange Western Hwy & Sunraysia Hwy Interchange Ballarat Prepared for Regional Livestock Exchange (RLX) Investment Company Pty Ltd. Project: 79187.01

Soil pH ranges from 6.1 to 7.3 at a depth of 0.1 to 0.2 m below the surface and from 4.6 at 1.4 m to 7.4 at a similar depth of 1.4 m. All measured values fell within this range. This indicates that the subsoils vary from circum neutral to strongly acidic and as such are considered suitable for the growth of rye-grass but not for the growth of lucerne which prefers a higher soil pH. The pH of the surface soil is acceptable for maintaining good availability of plant nutrients and effective use of gypsum. The pH of the irrigated wastewater is expected to vary between 6.5 and 8.5, such that increases in soil pH are expected with irrigation of this wastewater. An increase in soil pH would not negatively impact pasture growth provided soil pH remained within an acceptable range. A minor increase in soil pH, may actually improve nutrient availability, and would effectively act in a similar manner to the application of lime ($CaCO_3$) which is applied as standard agricultural practice. How much the soil pH will increase is difficult to predict as it will depend on the inherent pH buffering capacity of the soil. This wastewater pH is within the acceptable range for irrigation according to EPA document 168 – page 38, but on-going soil and wastewater monitoring should include pH, such that changes in management can be implemented in a timely fashion.

12.2 Available Phosphorus

There is no data available for surface soil available phosphorus (Olsen P or Colwell P) and as such it is difficult to assess the current soil fertility and crop yield potential. It is however known that the wastewater contains significant quantities of phosphorus and that no additional phosphate fertiliser need be applied from the outset of irrigation to increase crop yields.

12.3 Available Potassium

Plant available potassium (Colwell K) is low at less than 39 mg/kg in each of the soil samples collected at depth of 0.1 to 0.2 m. Initially crop yield potential is likely to be limited by potassium. It is however known that the wastewater contains significant quantities of potassium and it is unlikely that additional potassium fertiliser will need be applied to increase crop yields once irrigation with wastewater commences. Potassium fertilisers are unlikely to be required.

13. Farming Operations on the site

The effective operation of this property as a sustainable wastewater irrigation site is heavily dependent upon the effective growth and removal of fodder and the associated rate of nutrient removal it is expected to achieve. As discussed early based on this desktop assessment the soil drainage characteristics and soil pH are unsuitable for the effective growth and persistence of lucerne. Rye-grass pastures are therefore the preferred crop of choice and all pasture grown will need to be cut and removed from the property in one form or another.

To achieve the required yields and fodder removal rate, it is envisaged that the property will need to be managed as a cut and carry operation for the whole year. This will involve "locking" up pastures in late Winter, such that the first silage cut can occur in Spring. The property could then be irrigated during dry periods of October and November such that a second cut as hay could then be baled and removed off-site. To ensure the required rates of fodder removal are achieved irrigation could then occur again at the Autumn break and a third "cut and carry" of green fodder would need to be removed off-site and potentially made available to local dairy farmers at stock feed in May-June.

Applying wastewater to land twice a year during the active plant growth periods of late Spring and Autumn is considered the best method of achieving maximising utilisation of the nutrient content within the wastewater. This practice should improve crop yield without the need to import or spread inorganic fertiliser, which would add to the nutrient load. Ensuring the water storage lagoon is empty prior to winter and recommencing irrigation prior to the onset of summer reduces the potential for wastewater storage capacity to be exceeded.

14. Potential design constraints

One of the most significant constraints is that of the reliability of the data currently being relied upon as being indicative of the wastewater to be generated at the proposed Saleyards. The data provided comes from two sources, both of which are noted as being very different in the way they are managed and different in terms of the sources of wastewater collected. Ideally additional investigations would be undertaken on more existing saleyard operations, such that the likely wastewater quality to be generated on this site can be predicted with a greater degree of accuracy. It is understood however that there is limited wastewater quality data available from roofed livestock saleyards in Australia that would predict with a high degree of accuracy the quality of wastewater to be generated at this proposed facility. It will be necessary to establish the actual wastewater quality available for irrigation once this saleyard and wastewater system is operational, prior to the commencement of irrigation.

15.Summary and Conclusions

- Long-term success of this proposed wastewater irrigation system can be achieved with appropriate monitoring and management. The farm operator will need to possess appropriate wastewater irrigation management and farm operation skills to ensure effective use of the nutrient rich wastewater for productive crop output in excess of 7.5 tDM/ha per year. An appropriate monitoring regime will assist the farm operator to make farm management changes in a timely manner as required.

- The proposed irrigation system is expected to apply only a low volume (1.5 ML/ha) of moderately saline wastewater each year over a total area of 26.6 ha. This is low volume of water with respect to the plant evapotranspiration requirements in this climate, but should enable yields of 7.5 tDM/ha to be obtained.

- The anticipated SAR of the wastewater is quite low at 2.5 such that the wastewater is unlikely to have a negative impact on soil structure, despite the existing sodic to strongly sodic nature of the subsoil. Long-term irrigation with wastewater of this quality is unlikely to negatively impact on soil permeability.

- The wastewater is expected to contain an appreciable concentration of salt, but given the low hydraulic loading rate, the mass salt load of 1.7 t/ha is considered manageable, given the leaching winter rains, despite the low subsoil permeability.

- The wastewater contains significant quantities of nutrient in the form of nitrogen, phosphorus and potassium. It is the nutrient loading on this site which presents the most significant constraint to sustainable irrigation of wastewater. A list of analytes to be included in the on-going monitoring program for soil and wastewater have been included in Appendix 1 and 2, along with a suggested soil sampling procedure.

- Irrigation volumes with each application should also be monitored such that the total hydraulic loading per hectare can be calculated, and the mass loading of salt and nutrients can be calculated annually.

- Based upon the anticipated quantity of N, P, K nutrient to be applied in the wastewater no inorganic nitrogen, phosphorus or potassium need be imported or applied to land within the proposed irrigation area to meet plant nutrient requirements.

- The effective implementation of the recommended ongoing monitoring program for crop, wastewater and soil is also seen as a necessary component of sustainable irrigation on this property as these three components of monitoring and how they feedback into changes in wastewater irrigation and farm management can have a large bearing on the success or failure of wastewater irrigation systems.

16. The Submissions to Amendment C185

This statement responses to issues relating Land Capability and Ground water contamination which have been raised in the submission to Amendment C185 that have been supplied to me.

The issues raised in the submissions in my discipline can be summarised as:

- The lack of detail pertaining to the land capability of the site to sustainably cope with the proposed irrigation of wastewater

- The potential for groundwater contamination from the over application of nutrients nitrogen and phosphorus in the wastewater.

17. Responses

Based on the analysis of the available material the proposed wastewater irrigation system will work effectively and the risks can be managed and therefore reduced with an appropriate monitoring regime.

Based upon the anticipated quality and quantity of the wastewater to be applied and the existing physical and chemical parameters of the land and soil, sustainable irrigation of the proposed volume of wastewater is sustainable, provided it is adequately managed to achieve maximum crop yield.

An ongoing monitoring program which includes annual assessment of the soil and monthly analysis of the wastewater quality is considered necessary to adequately monitor the progress of the site under irrigation. The implementation of such a monitoring program will provide the necessary feedback such that changes in irrigation management, water quality or irrigated area required can be implemented in a timely manner so as to preclude environmental degradation.

18. Declaration

In making this statement 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.

G D Marriott B Ag Sc (Hons)

11 June 2015

Appendix 1. Monitoring Parameters – Wastewater for irrigation

It is recommended that wastewater quality be monitored on a monthly basis during times of irrigation from the pumping point of the wastewater storage lagoon.

It is recommended that water samples be analysed for the following parameters:

Parameter	**Units**
Total nitrogen	mg/L
Total phosphorus	mg/L
Electrical conductivity	µS/cm
pH	
Carbonate	mg/L
Total Dissolved Solids	mg/L
Chloride	mg/L
Sulphate	mg/L
Calcium	mg/L
Magnesium	mg/L
Sodium	mg/L
Potassium	mg/L
SAR	

Appendix 2 – Monitoring Parameters and Procedure – Soil

The purpose of soil monitoring is to use the chemical changes that occur within the soil profile as an indicator of change in soil physical or chemical condition, or any potential environmental impacts that may be occurring as a consequence of irrigation with wastewater. Soil sampling is to be undertaken initially every year for the first three years of operation of the reuse site. At the end of the first three years the frequency of further monitoring will be reviewed.

1. Soil samples are to be collected in late Autumn early Winter, preferably in the month of May or early June. Irrigation of wastewater should have been completed by this time.

2. Samples will be collected from the nominated sampling routes. It is recommended that two transects be established, one within each soil type and irrigation management zone. Both routes need to be entirely within the irrigation area.

3. The soil sampling transect will be defined by GPS coordinates and the route shown on Figure, such that it can be easily replicated each year.

4. Soil samples other than the surface soil cores are collected via augering by hand to a depth of at least 60 cm, preferably with an Alderman soil auger . At least five samples are collected and bulked together along the sampling route for the two depths of ~20 to 30 cm (A2 soil horizon) and ~50 to 60 cm (B1 soil horizon).

5. Surface cores (A1 soil horizon: 0-10 cm) are collected with a foot auger. A minimum of 20 surface cores are to be collected along the sampling transect.

6. The depth of the soil B1 horizon may be variable. The sampling depth of 20 to 30 cm is to represent the A2 soil horizon, and the 50-60 cm depth is the first 10 cm below the point where the operator is confident that the B horizon has been encountered, or the first 10 cm below 70 cm depth, whichever is the lower.

7. The cores are bulked together as collected. Soils from within the 0 to 10 cm depth are bulked together to provide the surface soil sample. Soils from the 20 to 30 cm depth range are bulked together to provide the A2 sample. Soils from the 50 to 60 cm depth range are bulked together to provide the B1 horizon sample.

8. A subsample of approximately 0.7 kg from each bulked sample is then selected after thorough mixing and transferred to a plastic bag for forwarding to a soil testing laboratory.

Soil samples are to be analysed in a certified ASPAC laboratory for the following parameters:

pH in water	available phosphorus (Olsen method)
pH in calcium chloride	available potassium (Colwell method)
electrical conductivity	available sulphur
exchangeable cations	total nitrogen
chloride	total organic carbon
ammonium nitrogen	Phosphorus Buffering Index
nitrate nitrogen	

Appendix 3 - Phosphorus Sorption Index

TECHNICAL BULLETIN

The Phosphorus Buffer Index (PBI)

What is the PBI?

The phosphorus Buffering Index (PBI) is a new single phosphorus test developed by the Dept Agriculture in Victoria.

The PBI measures the phosphorus sorptivity of a soil, which indicates how much of the applied fertiliser phosphorus will be tied up in the soil into forms unavailable for plant uptake. The PBI test also indicates how tightly the absorbed phosphorus will be held be the soil. These two factors influence the amount of phosphorus available for plant uptake.

The higher the PBI value the more phosphorus will be absorbed by the soil and the tighter it will be held by the soil; soil prone to locking up available phosphorus. Conversely, the lower the PBI value the less phosphorus will be absorbed by the soil and the less tightly it will be held; soils may be prone to leaching of phosphorus.

What can the PBI be used for?

- Identify soils prone to phosphorus tie-up.
- Identify soils at risk of phosphorus leaching
- Adjustment of fertiliser application rates taking into account the soil tie up or leaching potential.
- More accurate determination of fertiliser requirement to build soil phosphorus reserves.

PBI interpretation table

PBI Class	PBI Value	Kg P/Unit Colwell P	Kg P/Unit Olsen P	P Leaching Potential	P Tie-up Potential
Very Low	< 50	2	5	*****	*
Low	50 – 100	2	7	****	*
Moderate	100 – 200	3	9	***	**
High	200 – 300	3	11	**	***
Very High	300 – 600	4	13	*	****
Extremely High	>600	4	15	*	*****

*	Very Low	****	High
**	Low	*****	Very High
***	Moderate		

For further information on the PBI test contact your local Incitec Pivot Agronomist, or Pivotest on (03) 99744100.

INCITEC PIVOT LIMITED A.C.N. 004 080 264 70 Southbank Boulevard, Southbank Vic 3006
Tel: 1800 333 197 or (03) 8695 4400 www.pivot.com.au

PIVOT

Appendix 4 – Nutrient Balance – Nitrogen & Phosphorus

Nutrient Balance - New Development

Site Address: **Ballarat CVLX**

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = **208800 m^2**

20.88 ha

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake				
Hydraulic Load	95,342	L/Day	Crop N Uptake	200	kg/ha/yr	which equals	55 mg/m^2/day
Effluent N Concentration	150	mg/L	Crop P Uptake	23	kg/ha/yr	which equals	6 mg/m^2/day
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	**Phosphorus Sorption**				
Total N Loss to Soil	2,860,274	mg/day	P-sorption result	500	mg/kg	which equals	11250 kg/ha
Remaining N Load after soil loss	11,441,096	mg/day	Bulk Density	1.5	g/cm^2		
Effluent P Concentration	30	mg/L	Depth of Soil	1.5	m		
Design Life of System	150	yrs	% of Predicted P-sorp. [2]	0.75	Decimal		

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer			Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)			
Nitrogen	208,800	m^2	Nominated LAA Size	224,000	m^2	22.40 ha
Phosphorus	131,735	m^2	Predicted N Export from LAA	-304	kg/year	
			Predicted P Export from LAA	-731	kg/year	
			Phosphorus Longevity for LAA	357	Years	
			Minimum Buffer Required for excess nutrient	0	m^2	

PHOSPHORUS BALANCE
STEP 1: Using the nominated LAA Size

Nominated LAA Size	224,000	m^2				
Daily P Load	2.860	kg/day	Phosphorus generated over life of system		156600	kg
Daily Uptake	1.412	kg/day	Phosphorus vegetative uptake for life of system		0.345	kg/m^2
Measured p-sorption capacity	1.125	kg/m^2				
Assumed p-sorption capacity	0.844	kg/m^2	Phosphorus adsorbed in 50 years		0.844	kg/m^2
Site P-sorption capacity	189000	kg	Desired Annual P Application Rate		1775.200	kg/year
				which equals	4.86356	kg/day
P-load to be sorbed	529	kg/year				

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guideline*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Appendix 5 Curriculum Vitae

Glenn Marriott

47 Clifford St
Warragul 3820
glenn@landsafe.com.au
www.landsafe.com.au

Mobile: 0447 613 594
Phone: 0356 234 372

On completion of an Honours Degree in Agricultural Science Glenn Marriott worked with EPA Victoria from March 2005 to June 2006 as a field officer based in Warrnambool. Glenn specialised in dairy effluent management, auditing over 400 dairy farms for compliance with the SEPP Waters of Victoria. While with Ag-Challenge Consulting Glenn has been involved in a number of soils and wastewater projects including the Land Capability Assessment of Tarago Reservoir and the site selection and development of a wastewater irrigation scheme in St Arnaud. In the *"Land Safe"* partnership with van de Graaff & Associates, Glenn has completed more than 200 Land Capability Assessments for domestic wastewater land application in a range of Shires particularly across southern Victoria. Glenn became a Certified Professional Soil Scientist (CPSS) in 2008 and is now a Level 2 CPSS. Glenn's professional focus is on soil and wastewater management. Since joining Ag-Challenge in 2006 Glenn has been an integral part of the Werribee Irrigation District soil monitoring team, with contributions made to soil sampling, soil chemical data interpretation, report writing and technical review of the annual soil monitoring report for Southern Rural Water.

Education

2003 Bachelor of Agricultural Science (Honours) from La Trobe University

2014 Design Livestock Effluent System – NCDEA TAFE course

Academic Awards & Qualifications:

2002 : Australia Institute of Agricultural Science Prize for the best Honours Thesis

2000 : GW Leeper Memorial Prize for best results in second year Soil Science

1999: National Farmers Federation Prize for best 1st year results in Agricultural Science subjects

2008 - Current : Certified Professional Soil Scientist (CPSS) Level 2

Experience

2007 - Current | Agricultural and Environmental Scientist

Ag-Challenge Consulting | 28B Albert St, Warragul 3820
Completion of Land Capability Assessments for onsite wastewater management including all facets of each project including:

- Desktop Feasibility Studies using Victorian Resources and Geovic online interactive maps

- On-site field investigations including soil permeability measurement, landscape assessment and environmental constraints

- Collation of field results and report writing including water and nutrient balances for sizing wastewater land application systems

Skills

- Skilled Soil Scientist – particularly in the field of soil chemical data interpretation, and also classification and mapping of soils and land to determine suitability for recycled water irrigation
- Proficient in the use of Micro-Soft Office programs including Word and particularly Excel
- Accomplished user of Adobe Illustrator for the creation of detailed overlays on aerial photography for farm plans and soil mapping.

Project involvement

2012-15: Annual Soils Monitoring of Recycled Water Irrigation Sites – Westernport Water

2003-14: Annual Soils Monitoring of Recycled Water Irrigation Sites – Wannon Water

2012-15: Annual Soils Monitoring of Recycled Water Irrigation Sites – East Gippsland Water

2008-2013: Bannockburn Recycled Water Irrigation Site Soil Monitoring – Barwon Water

2007-15: Wastewater Reuse and Treatment Facility Soil Monitoring Report – Fonterra

2012-15: Wastewater Reuse and Treatment Facility Soil Monitoring Report – Warrnambool Cheese and Butter Factory

2007-15: Recycled Water Werribee South Irrigation District Field Component & Technical Review of Annual Soil Monitoring Report – SRW

2009: Soils Monitoring Report for Class A Recycled Water Use at Werribee Golf Course, National Equestrian Centre and Werribee Park Mansion – Southern Rural Water

2009: Environmental Management Plan (EMP) for Dairy Processing Plant Sludge – Burra Foods

2010: Soil Compaction Assessment including fieldwork and report writing Carlton Gardens Birrarung Marr & Alexandra Gardens - Melbourne City Council

2010: Environmental Management Plan (EMP) for Class A recycled water use in Aurora & Highlands Estate and Brushy Creek catchment – Yarra Valley Water

2002: Land Capability Assessment – Tarago Reservoir Catchment

2002: St Arnaud Wastewater Irrigation Scheme Development – GWMWater

2010-2014: Annual Soils Monitoring of Biosolids Land Application Sites – Wannon Water

2014-15 : Fert$mart Facilitator – Soil Fertility Workshop Presenter – Dairy Australia

2007-15: Land Capability Assessments including soil hydraulic conductivity testing for domestic wastewater dispersal in the following Shires:

East Gippsland	Wyndham	Strathbogie	Nillumbik	La Trobe
Wellington	Whittlesea	Mornington	Baw Baw	Pyrenees
Golden Plains	Murrindindi	South Gippsland	Manningham	

Professional Memberships

- 2007 – 2015 Australian Soil Science Society Inc. (ASSSI)
- 2007 – 2015 Australian Waster Association (AWA)

Referees

Meg Humphries	Robert van de Graaff	Gillian Hayman
Recycled Resources Officer	Principal Consultant	NRM technical specialist
Treatment Services	Van de Graaff & Associates	Dairy Australia
Westernport Water	03 9872 4677	0428 345 493
03 5956 4117		