WIN LAND CAPABILITY ASSESSMENT

Western Water

Property name: Parwan Pty Ltd

DECEMBER 2020

pinion ADVISORY

112 Wright Street, East Devonport, Tasmania 7310

Phone: 1300 746 466

Email: admin@pinionadvisory.com

www.pinionadvisory.com

Report author:	Jason Lynch & Sarah Jones
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1 Background

Western Water has developed the Western Irrigation Network (WIN) project to meet environmental compliance obligations for managing forecast recycled water volumed from the Bacchus Marsh, Sunbury and Melton recycled water plans until 2050.

The WIN project will connect the Bacchus Marsh, Melton and Sunbury recycled water plants to a new irrigation district in the Parwan-Balliang region to the west of Melbourne (Figure 1). The project involves construction of permanent infrastructure to supply class C recycled water to up to 4500ha of high quality irrigable land.

The Balliang East district is a traditional dryland cropping and pastoral production area which typically annually receives less than 500mm of rainfall. Agricultural productivity of the district is highly constrained due to the prevailing low rainfall conditions. The WIN irrigation development offers the opportunity for landowners to access a high reliability irrigation supply to support the production of various crops and pasture and hence underpin the ongoing viability of agricultural production systems in the district.

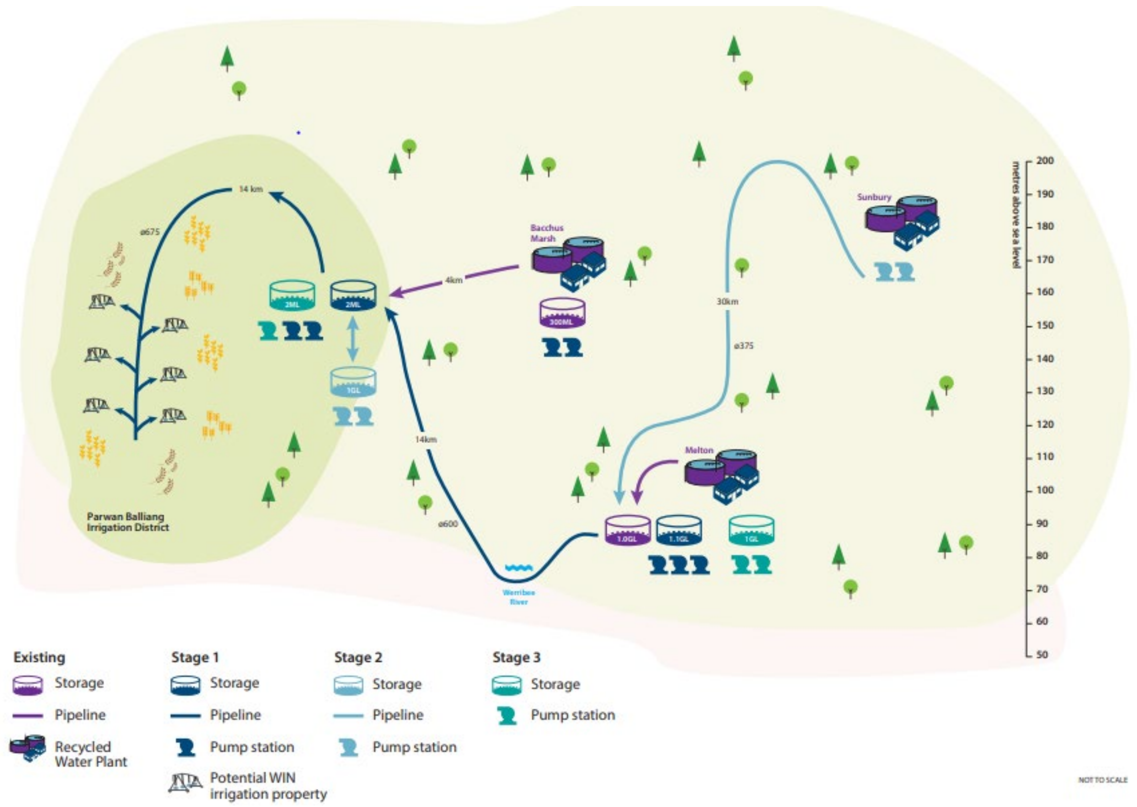

Figure 1 Schematic of the WIN network (supplied by Western Water)

Three foundation properties are central to the initial development of the WIN project (Table 1). Additional connections will be considered by Western Water as the project progresses.

Table 1 WIN stage 1 property details

Property name	Address	Proposed irrigation area (ha)	Recycled water allocation*
Griffiths	300 Agars Rd, Balliang East 3340	481ha	750-3500
Parwan Pty Ltd	3922-3684 Geelong-Bacchus Marsh Road, Parwan	307ha	500-2100
Sharkey	315 Sharkey Road, Balliang	397ha	1000-2700

*Approximate range from supply year one to supply year 20

Each property requires a land capability assessment (LCA) to ensure that recycled water irrigation is an appropriate and sustainable activity for the site. Before recycled water irrigation can commence a customer site management plan (CSMP), detailing irrigation protocols and specific recycled water risk management, will also be developed for Environment Protection Authority (EPA) Victoria approval.

1.1 Scope of LCA

This land capability assessment report, specific to the Parwan Pty Ltd property, analyses and documents the following:

- Assessment of current and historic land use.
- Assessment of the landscape capability for use of recycled water.
- Calculation of the 10th, 50th and 90th percentile irrigation requirements and summarise total water demand of the proposed irrigation design.
- Assessment of the nutrient leaching risk associated with recycled water.
- Assessment of the salinity risk associated with the application of recycled water.

This LCA is informed by a site visit (28 August 2018), soil pit survey (5th November 2020), a water quality review (Stantec, undated) and landowner interview (undertaken by Pinion Advisory Senior Agronomist Jason Lynch, October 2020).

2 Land use review

The proposed recycled water irrigation site is located at 3922-3684 Geelong-Bacchus Marsh Road, Parwan. Western Water have been in discussion with the landowner regarding potential recycled water supply from thee WIN project for several years. As a result, a concept irrigation design is well developed and attached as appendix A.

The property already utilises recycled water, on irrigation areas identified as Pivot A1 and A2, supplied from the Bacchus March RWP. This water source will form part of the WIN network supply (Figure 1).

The land is currently used for pastoral purposes, predominantly finishing prime lambs and cattle.

The property represents an aggregation of small land titles which the current owners have been purchasing since 1995. Interview with the landowners indicates that there are no historical land practices, or contaminants of concern, that might impact the irrigation development area.

The property owners operate a well-managed and organised pastoral enterprise implementing appropriate pasture production and land management practices, including soil testing, agricultural chemical resistance management and weed control.

A single application of biosolids was made on the property in 2016, with 30 hectares of land treated with biosolids sourced from the Bacchus March RWP. These biosolids were applied in the vicinity of pivots B and F.

In order to effectively manage and match nutrient application with crop demand, it is recommended that the application of biosolids cease once the recycled water irrigation scheme commences operation. This has been discussed and agreed by the landowner.

3 Land capability assessment

The land capability assessment identifies the limitations associated with soil and landscape characteristics as relevant to the proposed irrigation development.

An initial site reconnaissance was undertaken on 28th August 2018 and soil pit survey was undertaken on November 5th 2020.

Further geotechnical studies have been undertaken on the property by CH2M Beca during September and October 2019 as part of the investigation on the Parwan Balliang Irrigation District scheme storage dam and pipeline network.

As a result of the site reconnaissance, discussion with the land owner, geotechnical studies, and uniformity of regional site conditions, only one soil pit was developed, analysed and sampled (Table 2). The location is shown on appendix B.

Table 2 Soil pit location

Soil pit ID	Easting	Northing
Parwan Pty Ltd	144.4610	37.7671

The location of the representative soil pit within the proposed irrigation development area was based on discussion with the property owner, local landscape considerations and review of available satellite imagery. The uniformity of local soil conditions has be confirmed by review of the Assessment of Agricultural Land Capability in Melbourne's Green Wedge and Peri-Urban Areas (Agriculture Victoria, 2018), land suitability analysis of the Shire of Moorabool (DPI Vic, 2006), ASRIS datasets (CSIRO), a broader Balliang East district soil reconnaissance project undertaken on behalf of Western Water in 2018 (Macquarie Franklin), and a geotechnical report commissioned by Western Water as part of the WIN project development (CH2M Beca, 2019).

The review of the various available land capability, land suitability, soils, geotechnical and geology indicates this property is consistent covered a single soil type, as per that which was identified in the soil pit. Full description of this soil pit is attached as appendix C, recorded information includes:

- Soil texture, pedality and morphology of the each of the horizons
- Soil colour
- Depth of effective root zone
- Depth and layer of any impeding layer
- Presence of stone and rock
- Soil profile pH and nutrient status
- Profile drainage status
- Presence of any concretions in the soil profile.

Landscape and soil properties were assigned a suitability class based on Table 3. The detailed results are attached as appendix D.

Table 3 Land capability assessment description

Suitability class*	General description	Growth reduction (%)
1	Very few limitations present and easily overcome. Crop growth is expected to be unimpeded with minimal intervention required.	0
2	Minor limitations affecting either productive land use and/or risk of degradation. Limitations overcome by careful management. Crop growth can be marginally impeded by limitations if no intervention is undertaken.	10
3	Moderate limitations significantly affecting productive land use and/or risk of degradation. Careful management and conservation measures required. Crop growth can be significantly impeded if no intervention is undertaken.	30
4	High degree of limitations not easily overcome by standard development techniques and/or resulting in high risk of degradation. Extensive conservation measures and careful ongoing management required. Crop growth is significantly impeded threatening crop survival.	60
5	Severe limitations. Use is usually prohibited in terms of development costs or the associated risk of degradation. Crop survival unlikely and management not feasible.	100

* Adapted from Van Gool D, Tille P & Moore G, 2005 & FAO Soil Bulletin 32 1976 by Stantec (2018).

3.1 Soil and landscape features

The landscape around the property where the proposed irrigation development would occur consists of flat and gently sloping land (0-5%). (appendix A).

The flat to gently sloping nature of the land suggests it is suitable for broadscale irrigation which utilises spray irrigation application technology (centre pivot infrastructure).

All land included within the irrigation development area has been under the current property ownership since 1995 and has been used for pastoral use thereafter.

The land has been significantly modified in terms of an extended history of soil cultivation, de-stoning and the application of fertiliser and soil ameliorants (lime, gypsum and in 2016 a one off application of biosolids).

The site inspection indicates the property is consistently covered by red sodosol soils, which features a silty clay A horizon over a clay B Horizon, with rock and stone fragments present in the soil profile overly decomposing basalt.

Sodosols are texture contrast soils (duplex) which have lighter textured surface A horizon (e.g. sandy loam or clay loam) overlying a clayey sodic subsoil B horizon, typically an acidic A horizon soil that becomes more alkaline at depth and frequently include calcium carbonate precipitates.

The nutrient status of the soils indicates they have a low level of fertility, with the highlights being:

- Low phosphorus levels in the A horizon (10 mg/kg) with very low levels in the B1 and B2 horizon (<5 mg/kg).
- Marginally low sulphur levels in the A horizon (9 mg/kg) with marginally low and ideal levels in the B1 and B2 horizon (6 and 12 mg/kg).
- Slightly acidic pH in the A horizon (6) and alkaline soil pH in the B1 and B2 horizon (8.5 and 8.7).
- Elevated exchangeable sodium percentage (but non sodic) in the A horizon (5.2%) and marginally high in the B1 and B2 horizon (13% and 10%).
- Low electrical conductivity in the A, B1 and B2 horizon (0.25, 0.19 and 0.47 dS/m).
- Low soil organic carbon levels in the A, B1 and B2 horizons (1.7, 0.7 and 0.9%).
- Low phosphorus buffer index (PBI) value in the A horizon (110) which increases to very high in the B1 horizon (590) and high in the B2 horizon (490).
- Low Aluminium levels in the A, B1 and B2 horizons (<0.1 mg/kg).
- Below threshold levels for all heavy metals with the exception of an elevated Chromium level in the B1 and B2 horizon (110 and 105 mg/kg).

Due to the lower nutrient levels present in the soil it would be anticipated that this would be negatively impacting pasture growth.

The chromium levels present in the A horizon are likely to be related to the geological parent material, and elevated levels (>100 mg/kg) have also been identified on similar red sodosol soils during a wider Balliang East 2018 soil survey.

The A horizon of these red sodosols are moderately well drained and the permeability of these soils is estimated to be approximately 15-20 mm/day (or 0.6-0.8mm/h). The clay nature of the B horizon would constrain the drainage capacity of the soil at depth.

The accumulation of sodium in the soil A horizon of the profile could result in impairment of the soil’s drainage capacity, and therefore the application of gypsum must be considered to mitigate the potential for soil sodicity.

Excessive, inappropriate irrigation and/or the application of recycled irrigation with an elevated sodium content could result in degradation of the soil’s drainage capacity and lead to soil water logging.

3.2 Outcome of land capability assessment

A single soil group was identified, being the red sodosol which can be characterised as moderately well drained.

The various characteristics and features of the landscape and red sodosol soil were assigned a rating and the property is assessed as having a suitability score of 2. The land capability assigned is therefore class 2 (appendix D) with generally minor limitations for recycled water irrigation.

It is noted that due to elevated sodium content of these soils sodicity must be carefully monitored. The application of gypsum will be required to positively manage the soil's permeability and overall drainage capacity.

4 Irrigation water balance

The assessment of irrigation application rates uses a water balance model which includes inputs from climate, crop water usage and elements of the land capability assessment. The outcome is an analysis of the variation in irrigation requirements based on variable annual rainfall.

4.1 Rainfall and evaporation

Rainfall and evaporation data (Table 4) has been generated by combining available rainfall records from Balliang East Bureau of Meteorology weather station #087008 (1970-2020) and evaporation modelling data generated using SILO modelling.

East Balliang receives a median annual rainfall of 464mm and has an expected annual pan evaporation of 1298mm. Median monthly rainfall does not exceed the pan evaporation rate at any time of year. The annual 10^{th}, 50^{th}, 90^{th} percentiles and minimum and maximum median rainfall, pan evaporation and evapotranspiration values are shown in Table 5.

Table 4 Annual rainfall, evaporation and evapotranspiration statistics

	Minimum	10^{th} percentile	50^{th} percentile	90^{th} percentile	Maximum
Rainfall (mm)	225	328	464	615	797
Pan evaporation (mm)	1062	1166	1298	1440	1540
Evapotranspiration (mm)	1062	979	1090	1210	1540

Table 5 Median rainfall, evaporation and evapotranspiration by month

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	32.4	40.1	33.9	37.7	36	32.4	33.7	36.8	44.7	48.8	44.5	43.1
Pan evaporation (mm)	196.8	165.5	133.4	85.3	52.8	38.1	44.8	60.1	83.9	119.6	143.4	179.1
Evapotranspiration (mm)	165.3	139.0	112.1	71.7	44.4	32.0	37.6	50.5	70.5	100.5	120.5	150.4

The crop demand, determined using crop coefficients and potential evapotranspiration, for lucerne and pasture are outlined in Table 6. Lucerne and wheat represent the highest and lowest irrigation demand of the likely crop options for the property.

Table 6 Lucerne and grass pasture crop coefficients

Monthly crop coefficient												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lucerne	1.14	1.08	1.02	0.96	0.84	0.66	0.66	0.78	0.9	1.02	1.14	1.2
Grass Pasture	1.1	1	0.9	0.8	0.7	0.6	0.6	0.7	0.8	0.8	1	1.1

The water balance indicates that in a median rainfall year a lucerne pasture would require 7.8 ML/ha of irrigation, whilst a grass pasture would require 7.0 ML/ha of irrigation. The complete irrigation requirements for lucerne and grass pasture are summarised in Table 7.

Table 7 Total annual irrigation requirements for lucerne and winter wheat

	Minimum rainfall	10th %ile rainfall	50th %ile rainfall	90th %ile rainfall	Maximum rainfall
Lucerne	11.1	10	7.8	7	2.2
Grass pasture	9.9	9.2	7.0	6.2	1.7

5 Irrigation concept design and demand

The irrigation concept design is attached as appendix A. The detail of the proposed irrigation plan is outlined in Table 8 which summarises potential water use of each pivot area.

Two of the pivot sites on this property (A1 and A2) are already in operation as recycled water irrigation. Currently this recycled water is supplied from the Bacchus Marsh RWP and under the proposed WIN project the Bacchus Marsh RWP will continue to be used as a source of recycled irrigation for the scheme.

Table 8 Irrigation areas and estimated water demand (Lucerne or grass pasture) under various climate scenarios

Centre pivot	Area (ha)	Crop	Total irrigation demand (ML)		
			10th percentile	50th percentile	90th percentile
Pivot A1	29	Lucerne	290	226	203
		Grass pasture	267	203	180
Pivot A2	30.1	Lucerne	301	235	211
		Grass pasture	277	211	187
Pivot B	38.4	Lucerne	384	299	269
		Grass pasture	353	269	238

Pivot C	28.2	Lucerne	282	220	197
		Grass pasture	249	197	175
Pivot D	18.8	Lucerne	188	146	131
		Grass pasture	173	131	116
Pivot E	16.2	Lucerne	162	126	113
		Grass pasture	149	113	100
Pivot F	38.4	Lucerne	384	299	269
		Grass pasture	353	269	238
Pivot G	40.2	Lucerne	402	313	281
		Grass pasture	370	281	249
Pivot H	34	Lucerne	340	265	238
		Grass pasture	312	238	210
Pivot I	28	Lucerne	280	218	196
		Grass pasture	257	196	173

5.1 Buffer zones and offsite risk management

Buffer zones and irrigation controls are necessary to ensure that recycled water remains on the identified property and that sensitive receptors are protected from unintentional irrigation spray drift.

The key risk areas on and adjacent to the property include:

- Two residential dwellings and a church.
- Geelong-Bacchus Marsh Road, Springhill Road, Nerowie Rd

In line with the *Guidelines for Environmental Management: Use of Reclaimed Water (EPA Victoria, 2003*) buffer zones, as identified in appendix A, are summarised in 9.

Table 9 Recycled water irrigation buffer requirements

Receptor	Distance
On farm dwellings	100m
External boundaries	50m

In addition to buffer zones, it is recommended that the following practices be implemented to minimise the risk of off-site movement of recycled water:

- Adopt deficit irrigation practices where water is to be applied to crops and pasture such that it will be immediately used by the plants. This limits potential for soil water logging and surface water runoff.

- Implement appropriate irrigation scheduling, such that it is consistent with the soil's permeability, and therefore the selection of the centre pivot nozzle pack is important
- Include anemometer controllers to shut down the centre pivot under a combination of excessive wind speed and specific directions.
- Monitor the soil nutrient levels to minimise the potential excessive sodium accumulation which can impact permeability.

Centre pivots irrigators will be used to apply recycled water. In comparison to other irrigation options, pivot irrigation has low labour requirements, allows high level of control over the volumes and distribution of water, providing ability to closely match irrigation to crop/pasture requirements and soil permeability characteristics. No end guns will be fitted to the centre pivots due to the high risk of irrigation water spray drift and associated unwanted off-site movement of recycled irrigation water.

The principle of operation will be to include Variable Rate Irrigation control (VRI) on area which requirement specific nozzles to be switched off to protect buffer zones in specific areas (current design shows this on Pivot areas A1, G E and H). VRI is setup by a GIS map within the irrigator control system, such that it doesn't require manual intervention.

The current buffer zone between the existing recycled water pivot area A1 and Nerowie Road is insufficient. It is proposed that this will be adjusted (via VRI) as part of the irrigation redevelopment.

6 Surface water risk management

No water courses impact the Parwan Pty Ltd and therefore risk to surface water is very low.

The following measures are recommended to prevent off-site surface water movement:

- Utilisation of centre pivot irrigation equipment which allows maximum control of irrigation direction and application rates.
- Deficit irrigation planning, such that the amount of recycled irrigation water applied is relative to the crop water usage and weather conditions and the potential for soil waterlogging conditions occurring is minimised.
- The centre pivot is to be designed to apply recycled irrigation water at 15mm per application which is commensurate with the soil's permeability.
- Ongoing monitoring of soil sodicity to ensure that the permeability of the soil is not compromised. The requirement for treatment with gypsum will need ongoing review.
- Adherence to buffer zones (Appendix A).

7 Nutrient leaching and groundwater risk management

7.1 Nutrient management

The intial WIN development will connect Bacchus Marsh and Melton recycled water plants, with Sunbury to be collected in year three of the project (2025). For the purposes of this nutrient budget, supply from Sunbury (which contains comparatively low nutrients and will therefore reduce the WIN nutrient supply once it comes online) has been excluded. The longer term result is that assessment is very conservative.

Average nitrogen of 17.6 mg/L and average total phosphorus of 8.2 mg/L have been adopted to inform the nutrient budget (Stantec, undated) summarised in Table 10.

Table 10 Recycled water nutrient budget summary

	10th percentile irrigation				90th percentile irrigation			
	Lucerne		Grass pasture		Lucerne		Grass pasture	
	N	P	N	P	N	P	N	P
Irrigation applied (ML)	7	7	6.2	6.2	10	10	9.2	9.2
Nutrient concentration (mg/ML)	17.6	8.2	17.6	8.2	17.6	8.2	17.6	8.2
Nutrient applied (kg/ha)	123	57	109	51	176	82	162	75
Yield (t DM/ha)	16	16	12	12	16	16	12	12
Nutrient content (kg T DM)	30	3	25	3	30	3	25	3
Nutrient removed (kg/ha)	480	48	300	36	480	48	300	36
Soil factor P sorption rate (kg P/ha)		14.5		14.5		14.5		14.5
Net balance (kg/ha)	-357	-5	-191	0.5	-304	20	-138	24.5

The nutrient budget (Table 10) indicates that the application of recycled irrigation water will contribute only a small portion of nitrogen and phosphorus removed during the wheat cropping and lucerne production enterprise. This applies in a 10th percentile rainfall year where recycled water application will be at its highest.

The soil's phosphorus sorption capacity varies from low/moderate in the A horizon to very high in the B1 and B2 horizon. PBI values range from 110 in the A horizon and 590 and 490 in the B1 and B2 horizon which further positively influence the soil's ability to retain phosphorus (Corangamite Catchment Management Authority, 2013).

It is reasonable to consider that the land manager will be required to apply additional nitrogen and phosphorus to the soil to optimise lucerne and grass pasture production. This should be informed by ongoing soil monitoring in irrigated areas.

The nutrient budget in conjunction with the soil phosphorus sorption capacity indicates the proposed application of recycled irrigation water would not be expected to result in nitrogen or phosphorus leaching into the local groundwater.

7.2 Groundwater

The property lies within the Western Port Philip groundwater catchment, defined as an upper basalt aquifer that flows in a southerly direction towards Port Philip Bay. The depth of the upper aquifer at the Parwan Pty Ltd property is expected to be 5-10m, and the ground water salinity (TDS) ranges from 2000-10000 mg/L (Visualising Victoria's Groundwater, 2020).

A number of bores are present on the property in question and nearby land, range in depth from 21 to 178m, although none are monitored. Bore locations are marked on appendix B and data is summarised in appendix E.

The majorty of these bores have been drilled to assist with the identification and potential utilisation of the brown coal deposit which extends throughout the Balliang East district.

The landowner has advised that no bores are activietly used on the property and there is no groundwater monitoring in place.

The risk of nutrient leaching into the ground water from recycled water irrigaiton is considered to be low. This is due to the following:

1. Irrigation planning is designed as deficit irrigation. This practice ensures that the opportunity for soil waterlogging is minimised.
2. The nutrient budget (Table 10) indictes that the nutrient load to be applied from recycled water is low relative to the nutrient removal of lucerne and grass pasture pasture.
3. The clay nature of the red sodosols soils are not considered susceptible to leaching. Soil PBIs range from low/moderate to very high.
4. The basalt geology of the district forms a relatively impermeable layer, protecting groundwater from surface activity.

8 Soil salinity and sodicity risk management

8.1 Salinity risk assessment

The development of saline soil conditions would negatively impact the production of lucerne pastures and crops.

Western Water have advised that the target salinity of the WIN class C recycled water supply is an electrical conductivity of <750µ/cm. Landowners are to be notified if electrical conductivity exceeds 1000µS/cm.

Salinity tolerances of lucerne and grass pasture (ryegrass dominant) (DPI, 2016) are summarised in Table 11.

Table 11 Salinity tolerances of lucerne and grass pasture (ryegrass dominant)

	Irrigation Water Salinity (dS/m)		
Crop performance	No reduction	10% reduction	20% reduction
Lucerne	1.3	2.2	3.6
Grass pasture – ryegrass dominant	3.7	4.6	5.9

Based on these salinity tolerances (Table 11) it is possible to determine the minimum leaching requirement (MLR) in order to maintain target crop performance.

$$MLR = ECWA \div [(7.5 \times ECWY\ \%) - ECWA]$$

Where: MLR is the minimum leaching requirement
ECWA is the EC of the available irrigation water (dS/m)
ECWY % is the salinity level of the irrigation water that results in a specified percentage yield loss.

If the most salt sensitive crop is considered (lucerne) it is calculated that 5.6% additional fresh water (in addition to the irrigation water requirements) is required during the irrigation season (September to April) in order to prevent a reduction in growth. This equates to between 0.4 to 0.56 ML/ha (10^{th} to 90^{th} percentile irrigation seasons) or 43-56mm/ha of rainfall. It should be noted that during the lucerne irrigation season the East Balliang area receives 325mm in median rainfall year. This significantly exceeds the freshwater leaching requirement.

Based on this calculation, and local rainfall data, it is unlikely that the salinity of the WIN recycled water supply would result in a reduction in lucerne pasture yield.

8.2 Sodicity risk assessment

The soils currently have a marginally elevated level of sodicity (as measured by exchangeable sodium percentage, ESP) although it is not considered sodic in the A horizon (ESP 5.2 %) and it would be appropriate to apply gypsum at 1 T/ha prior to the application of the recycled irrigation water.

The potential for increasing sodicity of the soil, and associated impairment in soil permeability and drainage capacity, is a function of the sodium content of the recycled irrigation water, measured as sodium absorption ration (SAR).

The annual average SAR of the WIN recycled water supply is anticipated to be less than 4.6 (Stantec, undated). Irrigation water with an SAR <3 is considered low risk but where the SAR is >6 the risk of soil impact significantly increases (DPI NSW, 2016).

Based on the forecast recycled water salinity and SAR value there is a moderate risk of increasing the sodicity levels of the soil, and it would be appropriate to apply 2.5 T/ha gypsum to irrigation areas if the ESP of the soils exceeds 10%.

In order to manage the risk of rising soil sodicity, and maintain soil permeability and drainage characteristics, it is recommended that annual soil analysis be undertaken and ESP data be used to inform an ongoing gypsum application program.

8.3 Soil monitoring

Prior to commencement of irrigation, representative soil sampling transects are to be established across each of the proposed irrigation areas. Baseline sampling and analysis (prior to commencement of irrigation) is essential. Ongoing monitoring of topsoil (0-10cm) and subsoil (10-30cm) for nutrient status, pH, salinity and sodicity levels will be required.

Standard soil testing analytes are included in appendix C.

A nutrient budget reconciliation should form part of the annual soil monitoring program, and this must be based on a review of the nutrient inputs (fertiliser and recycled water) and removal (pasture and crop yields and phosphorus sorption impact) and determine the potential for unnecessary soil nutrient accumulation.

9 Conclusions and recommendations

The land capability assessment has identified the land associated with the proposed recycled water irrigation development can be considered suitable for the intended use.

- The property has been under the same ownership since the 1995 and since this time has only used for pastural use. As a consequence, the land has undergone significant modification in terms of cultivation, soil fertility, destoning and vegetation cover.
- Since 2016 recycled water from Bacchus Marsh STP has been utilised for irrigation of pasture, initially on the land north of Nerowie Road. In 2018 additional land, under pivot areas A1 and A2 was made available for recycled water irrigaiton. The property owners have been able to successfully manage recycled water and it has become a valuable part of their livestock production system.
- The landscape and soils have a class 2 suitability rating.
- Red sodosol soils uniformly cover the property, and these are considered to have a minor restriction to the application of recycled water irrigation.
- Prior to irrigation commencing, soil sampling transects are to be established and soil sampling is to then occur on an annual basis to ensure the soil nutrient, salinity and sodicity levels remain appropriate.
- While soil conditions are not prohibitive to irrigation it is recommended that gypsum applied to irrigation areas at 1 T/ha prior to the application of the recycled water. This action will proactively manage the potential for rising soil sodium levels and soil exchangeable sodium percentage. Annual monitoring of soil ESP will inform an ongoing gypsum application program.
- The 50th percentile annual application for Lucerne pasture is anticipated to be 7.8 ML/ha, and for a grass pasture is anticipated to be 7 ML/ha.
- The 10th percentile annual application for Lucerne pasture is anticipated to be 10 ML/ha, and for a grass pasture is anticipated to be 9.2 ML/ha.
- Risks associated with soil salinity and nutrient leaching are considered low.
- The proposed recycled water irrigation development covers 302 hectares. Buffer zones to the key risk areas on and adjacent to the property include two residential dwellings and a church, Geelong-Bacchus Marsh Road, Springhill Road, Nerowie Rd have been included in the concept design. These must be adhered to as the development progresses.
- Centre pivot irrigators equipped with VRI technology and low drift sprinkler are the preferred irrigation infrastructure for the site.
- The property is well suited to the proposed recycled water irrigation development.

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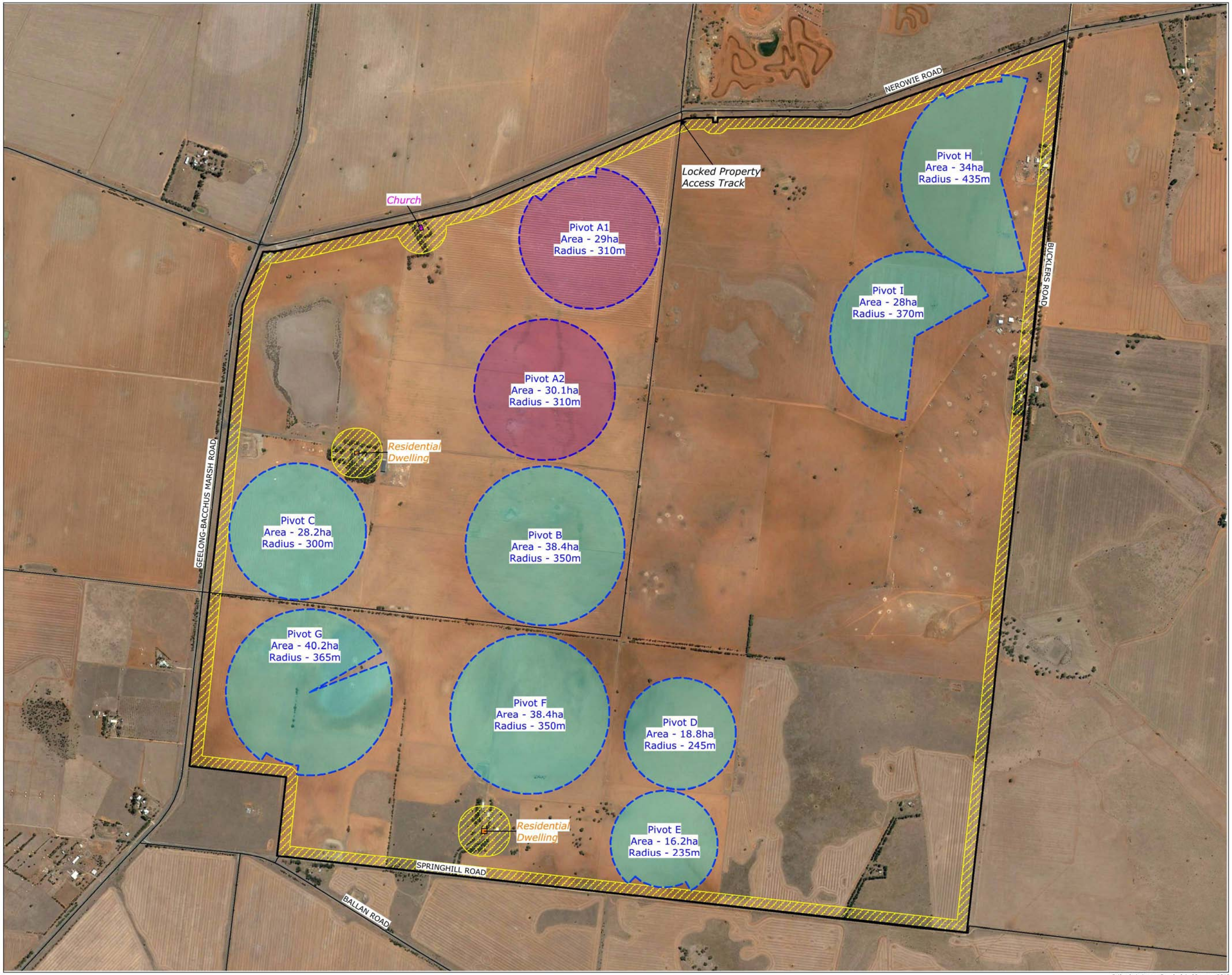
11 Appendices

Appendix A: Irrigation concept design map



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Irrigation Management Plan

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1 : 15,000 @ A3

Print Date: 23rd October 2020

Datum: GDA94 (Zone 55)

Created by: Mick Lehman
Reference: WesterW

GDA

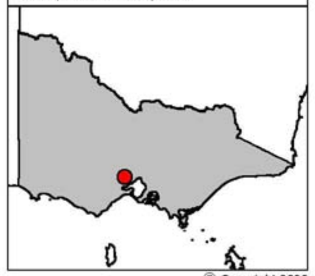
LEGEND

- Property Boundary
- Residential Dwelling
- Church
- Proposed Centre Pivot Irrigator
- Recycled Water Irrigation Area (242 ha)
- Existing Recycled Water Irrigation (59 ha)
- Road

Recycled Water Buffer

- 50m - External boundary
- 100m - Residential dwelling, Church

Pinion Advisory Pty Ltd
112 Wright Street
East Devonport Tas 7310
Ph : 0419 671 000
www.pinionadvisory.com



Appendix B: Soil map with groundwater bore identification

Orthophoto image Google dated January 2019

pinion
ADVISORY

Soil Management Plan

Failli

Western Water WIN

N

0 150 300
metres

1 : 15,000 @ A3

Print Date: 11th December 2020

Datum: GDA94 (Zone 55)

Created by: Mick Lehman
Reference: WesterW

GDA

LEGEND

- Property Boundary
- Existing Bore
- Bore - Currently in use
- Soil Pit
- Soil Type - Red Sodosol
- Major Watercourse
- Road

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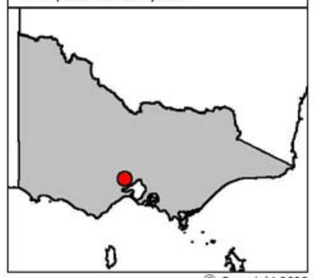

Appendix C: Soil profile assessment

Table 12: Parwan test pit soil profile (Oct 2020)

Site	Soil description	Image
Soil type: - red sodosol Landscape: - gently sloping ground with minimal stone and/or rock fragments (<30mm) on the surface. Effective rooting depth: - 400mm. Drainage: - Moderate in the A horizon to poorly drained in the B horizon.	A1: red silty clay loam to 30cm, moderate crumb structure 3-5mm, moderately abundant fine roots, basalt gravels and rock fragments (<20mm) present throughout with a clear boundary to: B1: red clay to 45cm, compact blocky structure, occasional fine roots, occasional basalt gravels and fragment (<30mm) present, diffuse boundary to: B2: reddish brown clay to 55cm, blocky structure, occasional fine roots (maximum depth to 50cm), frequent large fragments (50+mm), diffuse boundary to: C: orange/light brown clay to 75cm, decomposing basalt overly basalt floaters at the base, limit of excavation	

Table 13 Parwan Pty Ltd test pit soil nutrient status

Analyte	Limit Ranges		Unit	Horizon		
	Lower	Upper		A (0-30cm)	B1 (30-60cm)	B2 (60-120cm)
Sample ID (Nutrient Advantage)						
pH (1:5 water)	6	9		6	8.5	8.7
Electrical conductivity (1:5 SE)		4	dS/m	0.25	0.19	0.47
Chloride		100	mg/kg	190	56	69
Nitrate nitrogen	2		mg/kg	35	7.6	6.3
Ammonia nitrogen			mg/kg	16	0.9	1.5
Total nitrogen (kjeldahl)			mg/kg	0.2	0.12	0.1
Phosphorus (Colwell)	40		mg/kg	10	<5	<5
Phosphorus buffer index				110	590	490
Exchangeable sodium percentage	6	15	%	5.2	13	10
Aluminium saturation		1	%	<1.0	<1.0	<1.0
Copper DPTA	0.5	2	mg/kg	1.1	2	1.9
Iron DPTA	4.5		mg/kg	45	17	18
Manganese DPTA	15	30	mg/kg	53	2.8	2.4
Zinc DPTA	0.7	20	mg/kg	1.8	0.09	0.07
Sulphur (KCl40)	10		mg/kg	9	6	12
Organic carbon (Walkley & Black)	1.74	2.62	%	1.7	0.7	0.9
Aluminium (KCl)			mg/kg	<0.1	<0.1	<0.1
Calcium (Ammonium acetate)	60	80	%	42	23	42
Magnesium (Ammonium acetate)	15	30	%	38	59	45
Potassium (Ammonium acetate)	5	10	%	14	5.1	3.6
Phosphorus environmental risk index				0.09	0.01	0.01
Grass tetany risk index				0.18	0.06	0.04
Sample ID (ALS)	**Metals trigger levels**			**EM2019920-001**	**EM2019920-002**	**EM2019920-003**
	HIL	**EIL**				
Arsenic	100	40	mg/kg	3.8	4.1	4.2
Cadmium	20		mg/kg	<0.2	<0.2	<0.2
Chromium	100	130	mg/kg	84.4	110	105
Cobalt	100		mg/kg	23.3	20.1	20.6
Copper	6000	49	mg/kg	16.3	37.1	35.9
Lead	300	470	mg/kg	10.1	7.9	8.6
Manganese	3800		mg/kg	465	401	358
Nickel	400	37.5	mg/kg	57	154	133
Zinc	7400	66	mg/kg	41.3	30.8	31.1
Mercury	40		mg/kg	<0.1	0.1	<0.1

Above desired level	Below desired level	Potentially a problem/toxic	Condition problematic/toxic

Appendix D: Land capability score

Table 14 LCA scoring method

	Capability rating				
Score	1	2	3	4	5
Level of restriction to recycled water irrigation	Nil	Minor	Moderate	Major	Severe

Adapted from Van Gool D, Tille P & Moore G, 2005 & FAO Soil Bulletin 32, 1976 by Stantec (2018).

Table 15 Soil and landscape suitability score for the Failli property

Landscape properties	Capability Rating
Slope (%)	1
Surface rock (%)	1
Inundation/flooding	1
Depth to regional water table	2
Soil properties	
Surface texture (%clay)	2
Surface ESP (0-40cm) (%)	2
Subsoil ESP (40-100cm) (%)	3
Surface salinity (ECe (0-70cm) (dS/m)	1
Subsoil salinity (ECe (70-100cm) (dS/m)	1
Effective rooting depth (cm)	1
Solum depth (cm)	1
Surface infiltration (mm/h)	1
Profile drainage status	3
AWC within ERZ (mm)	2
Surface pH (field)	1
CEC (40-100cm) (meq/100g)	2
Overall suitability rating	2 (Class 2)
Potential development area (ha)	303

Appendix E: Local groundwater bore identification

Data has been retrieved from www.vvg.org.au (28 November 2020). Locations are identified on appendix B. No bores are active on the Parwan Pty Ldt property.

Table 16 Bore identification on and nearby to the Parwan Pty Ltd property recycled irrigation development site

Bore Identificiation number	Year Constructed	Depth	Use (where known)	Monitoring
81976	1926	61.5	-	No
320293	1981	118	Coal	No
325983	1926	147.8	Coal	No
325986	1927	154	Coal	No
325987	1930	156.7	Coal	No
326073	1981	116	Coal	No
326080	1984	21	Coal	No
326081	1984	178	-	No
WRK971209	0	60	-	No