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BEVERIDGE CENTRAL PRECINCT

Preliminary Salinity Assessment

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REPORT

Golder Associates

Table of Contents

TABLES

PLATES

FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 Background

Golder Associates Pty Ltd (Golder Associates) has undertaken a preliminary salinity assessment (PSA) for the Beveridge Central Precinct, Beveridge, Victoria (Study Area), in accordance with our proposal P1539872, dated 8 September 2015.

The precinct takes in approximately 290 hectares (around 720 acres) of land, either side of the Hume Freeway at Beveridge. The precinct is bounded by Cameron's Lane, the Hume Freeway, Spring Street, Kelly Street, Stewart Street, Rankin Street and Patterson Road (See Figure 1). Once developed, the precinct may accommodate over 7,000 people in around 2,500 households (GAA, 2013). The Beveridge Central Precinct is in preliminary planning stage in which several technical reports have been conducted in support of a future Precinct Structure Plan (PSP). A Salinity Management planning Overlay (SMO) applies to the western part of the precinct (See Figure 1).

Your attention is drawn to the document titled - "Important Information Relating to this Report", which is included in Appendix B of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.

1.2 Objectives

The objective of the preliminary investigation is to assess the potential presence of salinity within the Study Area in regard to potential salinity-related risks to the proposed precinct development and identify the types of management actions that should be considered, if required.

1.3 Scope of work

The preliminary salinity assessment included the following:

- A high level review of available historic data about the risk and presence of potential salinity, including maps, reports, borehole data and historic aerial photos.
- A limited field inspection including identification and mapping of general landforms, areas of existing or potential salinity (if any).
- In situ soil salinity measurements at up to 10 sample locations.
- Preparation of this report.

The field inspection was primarily conducted from publicly accessible areas, with limited access to private property, so does not constitute a detailed inspection of all parts of the Study Area.

2.0 CONCEPTUAL MODEL FOR SALINITY

Dryland salinity is caused when saline water tables intersect the ground surface and manifest in early stage impact such as appearance of salt tolerant vegetation progressing to later stage impact and bare unproductive ground (Dahlhaus et al, 2004). Within urban areas salinity can cause damage and instability to foundations and infrastructure (DEDJTR, 2015a).

The groundwater processes which contribute to salinity, notably whether salinity problems might be severe or localised or more regional in nature, depend on a combination of effective rainfall, hydro-geological and topographic factors. The influence of these environmental factors on salinity risk within the Study Area and surrounds forms the basis of the assessment below.

The following conceptual model is summarised from DEDJTR (2015b). Dryland salinity (as opposed to irrigation salinity) occurs in situations where saline groundwater is close to or discharging at the ground surface. Evaporation concentrates salts from the groundwater, which can lead to changes in vegetation and soil structure. This may affect land use: in agricultural land, crops and pasture may not grow; in urban areas the salts in soil or groundwater may be corrosive to steel or concrete structures in contact with the ground (on the surface or underground). Salinity may be a natural phenomenon or may be induced by land uses which raise the elevation of the water table. Clearing of deep-rooted vegetation can result in a rise in the water table as the replacement vegetation (such as grass) extracts less groundwater. This change typically occurs over several years to decades after the clearing of vegetation. Changes to surface water drainage such as construction of dams and barriers to surface flow can also result in a rise in groundwater level.

Evaporation of groundwater occurs at groundwater discharge zones and from above the water table, if this is shallow. Water will rise by capillary action through the soil, to different extents depending on the soil type. Up to one metre of capillary rise above the groundwater table may be expected in fine grained, clayey soils, whereas less than 0.3 m capillary rise may occur in coarser sandy soils.

Physical indicators of dryland salinity include groundwater discharge (free surface water or dampness during the summer), mid-slope seepage, bare soil, surface soil salt stains or crystals and soil blackening (organic matter staining). Plant species have different tolerances to soil and water salinity levels, so indicator plant species are commonly employed in combination with physical indicators to assist in dryland salinity assessment. Soil salt concentrations on a site vary depending on the season of the year and most saline sites are variable in terms of salt distribution across their surfaces. Slightly elevated areas may have a lower salt level than slightly depressed areas. Sandier surfaces may allow more rapid leaching of salt than clay surfaces. As a consequence of this variation, it is not uncommon to find a mosaic of plant species of varying salt-tolerance across a site.

3.0 BACKGROUND INFORMATION REVIEW

3.1 Information sources

The following sources of information have been reviewed for this assessment:

- Dryland salinity and salinity risk mapping (DEPI, 2013).
- Port Phillip and Western Port Salinity Report (PPWPCMA, 2010).
- Land systems (Mitchell Shire) and geological information (Jones *et al,* 1996).
- Victorian Groundwater Database for information about point source depth and groundwater quality information (DEPI, 2011).
- Visualising Victoria's Groundwater (VVG) for spatial and three dimensional models about groundwater information, local depth and quality (FedUni, 2015).
- Atlas of Groundwater Dependent Ecosystems (BoM, 2015).
- Lane-Piper, 2011. Phase 1 Environmental Site Assessment, Beveridge PSP, Victoria.
- Geological Survey of Victoria, 1991. Kilmore 1:50 000 Geological Map.
- Port Phillip and Western Port Groundwater Atlas (SRW, 2014).
- Air photo and historical imagery from Google Earth and NearMap.

3.2 Geology

The surface geology of the Study Area (Figure 2) comprises Quaternary volcanics derived from the volcanic vent at Mt Fraser (approximately 425 m above sea level (ASL)). Mt Fraser is a scoria cone, surrounded by basalt with minor stoney rises and hillocks (GSV, 1991).

Available geology logs from registered bores in the area show soil and clay over variably weathered basalt rock. The soil and clay are typically less than one metre thick, but are recorded to be up to three metres thick at some locations. The basalt overlies Silurian to Devonian basement rocks, variably described as sandstone, siltstone or mudstone. On the plains, the top of the basement rock is typically around 10 m to 15 m below the ground surface, but up to 60 m deep under scoria and basalt in elevated areas towards Mt Fraser.

Silurian/Devonian rock outcrops to the south and west of the Study Area.

3.3 Landforms

The Study Area ranges in elevation from approximately 280 m AHD in the north-east to 260 m AHD in the south-west. A drainage channel runs from east to west through the centre of the area, along Whiteside Street, and another drain runs along part of the southern boundary, along Rankin Street (see Figure 3). There are a number of small dams across the Study Area, generally isolated from drainage channels.

The Study Area is currently developed with a mix of low density residential and agricultural land use. The township of Beveridge is located to the north-east, with a golf course and residential development in progress immediately to the west.

A land systems survey within the Mitchell Shire has previously been conducted (Jones et al, 1996) which includes terrain and soils mapping for the purpose of land use planning and land management. Within this survey, the Study Area is included within the Quaternary Volcanic land system (Qvf) which is characterised by gentle volcanic slopes within the undulating volcanic plain or at the base of volcanic cones. Salting risk within this land system has been ascribed a “very low” rating based on slope type and depth to water table (Appendix A Land Systems Description (Qvf)).

According to historical information included in Lane-Piper (2011), the area has been used for grazing since the 1840s or 1850s.

3.4 Hydrogeology

3.4.1 Groundwater occurrence and depth

The Study Area falls within an area characterized as Volcanic Plains Groundwater Flow Systems (unit GFS 18 of Dahlhaus et al, 2004). While characterization of salinity risk and groundwater flow within this land unit covers a range of topographic and terrain types, the landscape of the Study Area represents the lower slopes of a volcanic cone (Mount Fraser) and the mid-upper reaches of the Port Phillip catchment. Groundwater flow is expected to conform to a conceptual model of regional and intermediate flow systems. Intermediate groundwater flow systems are described as having recharge and discharge flow systems which are not confined to small sub-catchments.

A critical factor of salinity risk within the Volcanic Plains Groundwater Flow systems is water table depth. Within the Study Area and surrounds the water table depth is expected to be from less than 5 up to 20 metres (FedUni, 2015) (Plate 1).

A perennial spring-fed swamp (Beveridge Spring) is present approximately 250 m to the east of the eastern edge of the Study Area (MCMC, 2010) (Figure 3), which indicates that groundwater discharge occurs at this location. Depth to groundwater is likely to be shallow in the surrounding area.

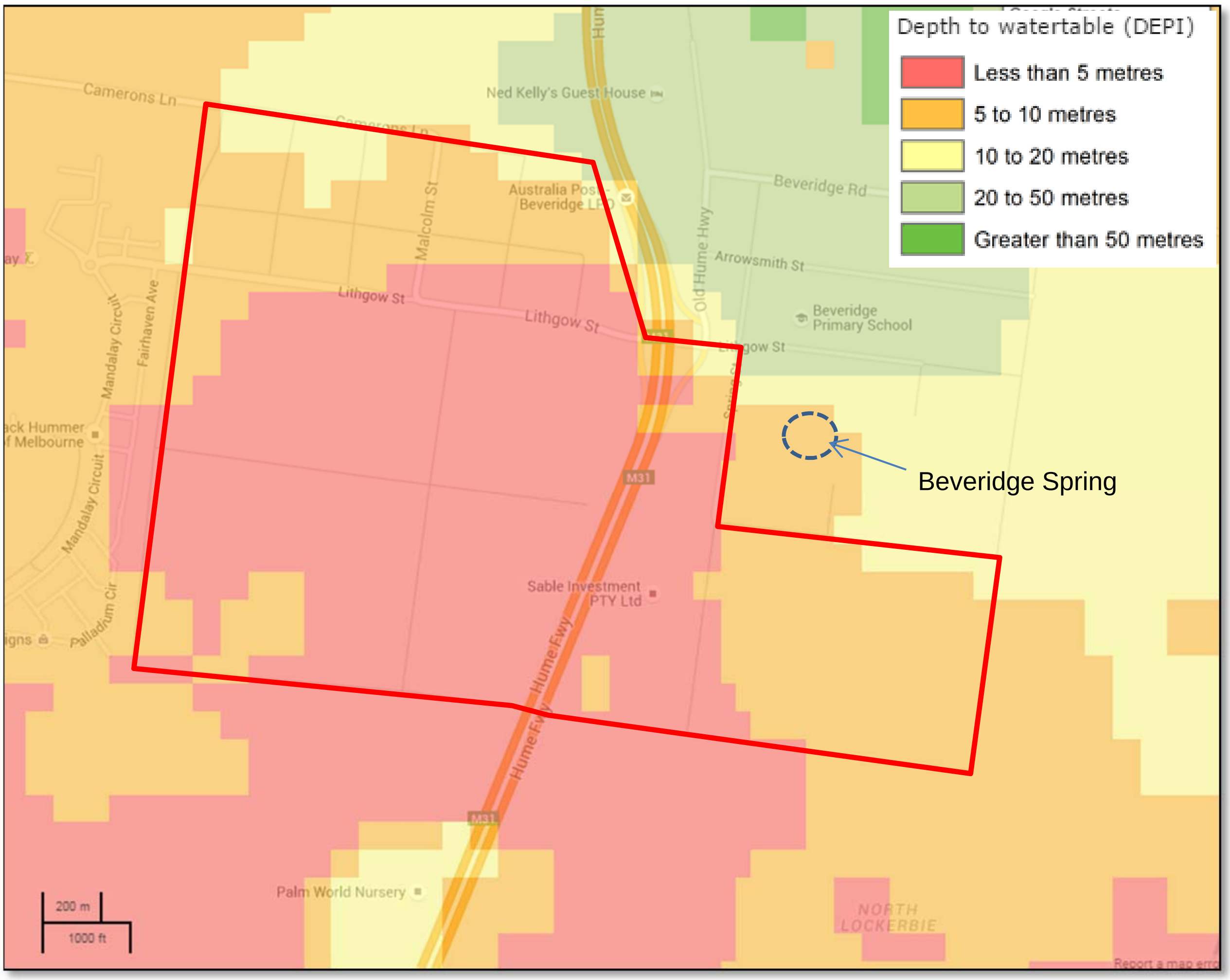

Plate 1: Inferred depth to groundwater (FedUni, 2015)

While there are many registered groundwater wells in the area, none within 5 km of the Study Area have publicly available water level information.

Air photo interpretation of Google and Nearmap imagery between 2005 and 2012 shows some dams within the Study Area are dry at some times, while others remain wet. This is true of dams both along and away from drainage channels. Dams remaining wet during dry periods may be an indication of groundwater discharge. This is not conclusive, however, as other factors such as the rate of use of water from the dam, the depth of the dam and the permeability of the dam base and walls can influence the rate of water loss.

3.4.2 Groundwater quality

When assessing groundwater quality in the context of salinity, quality is measured as total dissolved solids concentration (TDS). Electrical conductivity (EC) of the water is proportional to TDS. Various categorisations are available taking into consideration the potential uses of water of different salinity, or the effect of saline water on structures or vegetation. A classification based on EC is given in Rhoades et al. (1992), shown in Table 1.

Table 1: Classification of saline waters (Rhoades et al., 1992)

Water class	Type of water	EC (µS/cm)
Non-saline	Drinking water and irrigation	<700
Slightly saline	Irrigation water	700 – 2,000
Moderately saline	Primary drainage water and groundwater	2,000 – 10,000
Highly saline	Secondary drainage water and groundwater	>10,000

The State Environment Protection Policy (Groundwaters of Victoria) (SEPP (GoV), 1997) classifies groundwater into five segments on the basis of background TDS concentrations, and each segment has defined beneficial uses for protection. The range of beneficial uses to be protected for each segment are summarised in Table 2.

Table 2: Protected beneficial uses of groundwater

Beneficial Uses	Segment A1 (0 - 500 mg/L TDS)	Segment A2 (501 -1,000 mg/L TDS)	Segment B (1001 – 3,500 mg/L TDS)	Segment C (3501 – 13,000 mg/L TDS)	Segment D (greater than 13,000 mg/L TDS)
Maintenance of Ecosystems	✓	✓	✓	✓	✓
Potable Water Supply (desirable)	✓	-	-	-	-
Potable Water Supply (acceptable)	-	✓	-	-	-
Potable Mineral Water Supply	✓	✓	✓	-	-
Agriculture, Parks and Gardens (irrigation)	✓	✓	✓	-	-
Stock Watering	✓	✓	✓	✓	-
Industrial Water Use	✓	✓	✓	✓	✓
Primary Contact Recreation (e.g. bathing and swimming)	✓	✓	✓	✓	-
Buildings and Structures	✓	✓	✓	✓	✓

Groundwater is a commonly utilised resource in the Beveridge area. There are 19 registered groundwater wells within the Study Area, all registered as domestic and/or stock wells. There are a further 48 registered wells within 1 km of the site boundary. Of these, 38 are domestic and/or stock wells, one is registered for commercial/industrial use, one is an investigation well and the remaining eight have no purpose listed (DELWP, 2015). These registered wells are shown on Figure 2.

Twenty-five wells within 1 km of the Study Area have available groundwater salinity data (DELWP, 2015). Table 3 provides a summary of available groundwater salinity data from these wells by aquifer. This indicates that groundwater from the water table aquifer (Newer Volcanics) is slightly to moderately saline (i.e. EC between 1,000 µS/cm and 5,000 µS/cm) and potentially suitable for stock watering and irrigation (<3,500 mg/L TDS: Segment A or B) in the Study Area.

Table 3: Groundwater salinity data

Aquifer	Number of boreholes with salinity data[1]	Electrical Conductivity range (µS/cm)	Estimated salinity range (mg/L TDS)	Estimated median salinity (mg/L TDS)	Salinity Class	Segment
Newer Volcanics (basalt/scoria)	18	1,210 – 3,450	810 – 2,311	1,173	Slightly to moderately saline	A2 to B
Silurian (mudstone/siltstone /sandstone)	5	1,300 – 4,900	871 – 3,283	1,541	Slightly to moderately saline	A2 to B
Unknown (no geology information)	3	220 – 3,150	147 – 2,111	362	Non-saline to moderately saline	A1 to B

FedUni (2015) also provides an inferred state-wide groundwater quality map. Groundwater quality in the Study Area is mapped to be between 1,000 mg/L and 3,500 mg/L (i.e. Segment B), which is suitable for crop and stock use – though limited for human consumption. The reasonable quality of local groundwater is demonstrated by the number of domestic wells which utilise this resource within the area.

3.5 Salinity mapping and air photo interpretation

A small area of salinity was identified within the Study Area when regional mapping was conducted in 1991 (DEPI, 2013), located near the intersection of Lewis Street and Lithgow Street. The present record of mapped salinity within the Study Area is shown in Figure 1.

The presence of groundwater dependent ecosystems (GDEs) may also be indicator of potential groundwater discharge areas or shallow water tables, with associated higher salinity risk. High level mapping of groundwater dependent ecosystems (GDEs) has been undertaken by the Bureau of Meteorology (BoM, 2015). It should be noted that these areas were identified by automated processing of remote sensing data, with no field verification. This mapping shows an area of plains grassy woodland to the south of Lithgow Street, adjacent to the mapped area of salinity, which has a high potential for groundwater interaction (Figure 1). Other smaller areas of plains grassy woodland with low to moderate potential for groundwater interaction are mapped to the west of the Hume Freeway, along Spring Street and Kelly Street (Figure 1).

The upper reaches of Merri Creek, north of Craigieburn, have been mapped as drought refuges (SRW, 2014). These areas were seen to have water following extended drought, and are likely to receive groundwater baseflow. Merri Creek is located approximately 3 km to the east of the site area. Kalkallo Creek, located approximately 2 km to the west of the site, was not mapped as a drought refuge.

Air photo interpretation of Google and Nearmap imagery between 2005 and 2014 does not show significant areas of apparent salinity within the Study Area or surrounds during this period.

[1] One well was inferred to be screened across basalt and siltstone, so is counted twice here.

3.6 Conclusions from desktop assessment

Based on the information reviewed and summarised in this section, the following areas were identified as having higher potential for dryland salinity:

- An area of previously mapped salinity.
- Previously mapped GDEs.
- Geological contact between scoria and basalt in the north of the site area which may be a focus for groundwater discharge.
- Water courses/drains where the depth to groundwater may be shallow.
- Dams where restrictions on water flow may produce locally higher groundwater tables.

A preliminary inspection was undertaken of accessible areas as part of the field visit.

4.0 FIELD INSPECTION

4.1 Site inspection observations

A field inspection was carried out across the Study Area by a Golder Hydrogeologist on 9 December 2015. The purpose of the inspection was to observe and map potential saline discharge, to assess the general topography of the Study Area and to note general soil type and hydrology. Areas within the precinct highlighted as having higher likelihood for salinity were targeted for inspection, with other areas viewed from accessible roads. Field observations are summarised in this section.

4.1.1 Previously mapped salinity

The area on Lithgow Street previously mapped as having soil salinity was observed to be a low-lying area. The ground was dry, but the clayey soil was deeply fissured, suggesting it had previously been wet and had shrunk on drying. The vegetation consisted of long grass with clumps of spiny rush (Plate 2, Plate 3). To the south of Lithgow Street, the grass had been cut; leaving isolated clumps of spiny rush (Plate 4).

Small areas of bare ground, generally associated with mud cracks, were seen (Plate 5). Isolated individual salt-tolerant species were present amongst pasture grasses (Plate 6, Plate 7). Examples of Buck's Horn Plantain leaves were green in colour, without the pink colour typical of plants growing in saline soil. No salt crystallisation was observed.

The area having similar characteristics was observed to be larger than that previously mapped as saline, extending further to the north and east, north of Lithgow Street and also to the east of the stony rise south of Lithgow Street (see Figure 3).

Soil samples S2, S4 and S5 were collected from within this area. Field tests indicated that these samples were not saline (see Section 4.2). Based on these observations and sampling results, this area would be classified as non-saline to slightly saline.

Plate 2: View north-east from Lithgow St

Plate 4: View south-west from Lithgow St

Plate 3: View north-east from stony rise south of Lithgow St

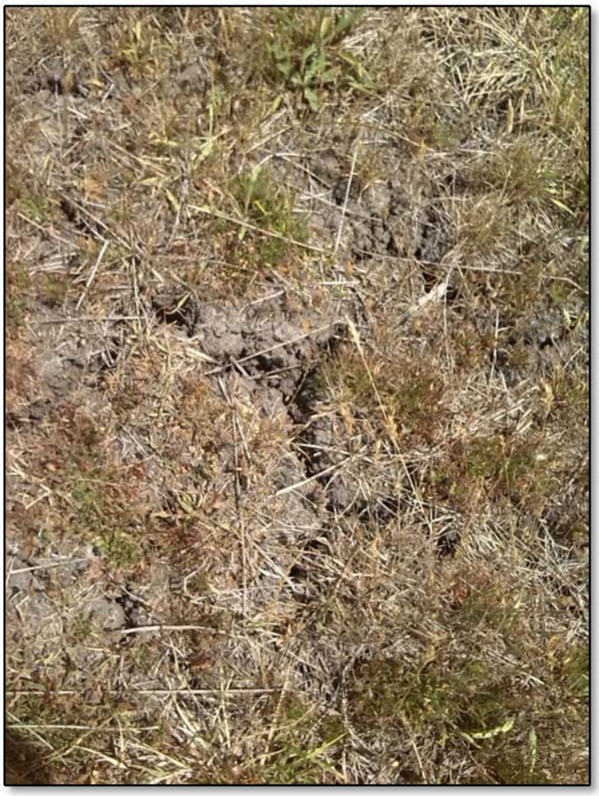

Plate 5: Mud cracks and salt tolerant species (S2 sample location)

Plate 6: Buck's Horn Plantain in grasses (S4 sample location)

Plate 7: Annual Celery in grasses (S5 sample location)

4.1.2 Groundwater Dependent Ecosystems

Potential GDEs in the Study Area identified previously from remote sensing data (BOM, 2015) were inspected in the field. The mapped area of plains grassy woodland to the south of Lithgow Street was seen to consist of gorse, with some acacia, growing on a stony rise (foreground of Plate 3). Another mapped potential GDE to the west of the Hume Freeway in the south of the study area is similarly gorse growing on a stony rise. Given the elevated landscape position, these areas are not expected to be actual GDEs or groundwater discharge zones, so are not likely to be vulnerable to groundwater related salinity. Sample S3 was taken from this area, and showed the soil to be non-saline (see Section 4.2).

Small areas of plains grassy woodland mapped along Kelly Street, west of the Hume Freeway were seen to consist of domestic gardens and pine windbreaks. These are not considered likely to be actual GDEs and so not vulnerable to groundwater related salinity.

A mapped potential area of GDE on Spring Street was seen to be marshland with tall reeds. As this vegetation is related to the Beveridge Spring, it is likely to be an actual GDE. The roadway is built up, with a concrete culvert under allowing water to flow to a channel west of Spring Street (Plate 9). This has a partial damming effect, with more extensive marshy areas to the east of Spring Street. West of Spring Street, wet ground and marsh vegetation is confined to the drainage channel (Plate 8). Water was flowing through the culvert at the time of the site visit, at a low flow rate (audible trickle). The extent of the groundwater discharge area of the Beveridge Spring is not known, but groundwater levels are likely to be close to the ground surface in the surrounding area. No salt-affected land or salt crystallisation was observed along Spring Street. Beardsell (1997) observed increased Spiny Rush and Streaked Arrow Grass as indications of salinity in the Beveridge Spring marsh area.

Soil sample S6 was taken from marshy ground to the east of Spring Street (Plate 10). This was indicated to be moderately saline (see Section 4.2).

Plate 8: View to west from Spring St

Plate 9: Culvert under Spring St

Plate 10: Marshy ground east of Spring St (S6 sample location)

4.1.3 Geological contacts

The area in the north of the Study Area, in the vicinity of the geological contact between scoria and basalt, was inspected for indications of groundwater discharge. An area of longer greener grass was noted in the north-eastern corner of the Study Area (see Figure 3). No indications of soil salinity such as bare patches, salt-tolerant species or salt crystallisation were observed in this area. Additional areas of greener grass were observed on the western side of the embankment of the Hume Freeway in this area. These areas are also seen to be green on historical aerial photographs (e.g. 2010). These areas may be localised areas of groundwater discharge, but given the elevated position, groundwater is likely to be from recent local recharge, and not of high salinity.

The Beveridge Spring, located to the east of the Study Area, may represent a groundwater discharge zone associated with the geological contact and break of slope at the foot of Mt Fraser. The groundwater discharge area is not thought to extend into the Study Area, but groundwater levels may be shallow near the northern part of Spring Street.

4.1.4 Drains

The drain from the Beveridge Spring continues under the Hume Freeway, adjacent to the western side of the Freeway, then along the north side of Whiteside Street. Marshy reeds are present in the drain channel until it reaches Whiteside Street. Where it is located adjacent to Whiteside Street, the drain has coarse rock ballast within the floor of the channel, so no flowing water was observed. Greener grass was observed along both sides of the drain (Plate 11). It could not be determined whether this is due to water carried along the drain from the Spring or rainfall, or to groundwater discharge along the channel. No indications of salinity were observed along this drain. The drain channel terminates at the western end of Whiteside Street at a grated pit with underground piping continuing further to the west beneath the Mandalay development.

Sections of drainage channel along Lewis Street showed bare ground in the base of the channel with greener grass along the sides (Plate 12). Small areas of bare ground on the bank of the channel were seen near the intersection of Lewis Street and Whiteside Street. Fine white salt crystals were seen on the surface of the soil here (Plate 13). A soil sample from this location (S7) indicated moderate salinity (see Section 4.2).

A mapped drainage channel along the southern boundary of the Study Area, west of the Hume Freeway, was seen to be dry, with no indications of salinity or groundwater discharge noted.

Plate 11: Drain along Whiteside St, looking east

Plate 13: Eastern bank of Lewis St drain showing bare soil and salt crystallisation (S7 sample location)

Plate 12: Drain along Lewis St, looking south

4.1.5 Dams

There are a number of small dams within the Study Area. Apart from dams in the north-east of the Study Area, most dams are on flat land and appear to have limited run-off catchment. Some dams were seen to have channels connecting to the Whiteside Street drain, which may allow filling from or overflow to this channel. Some dams may have been excavated to intersect groundwater. At the time of the site visit, some dams held water while others were dry, without a discernible pattern. As noted in Section 3.4.1, a number of factors may influence water levels in dams, so the water level in dams is not necessarily an indication of the depth to groundwater.

Potential indications of salinity were noted at two dams. A dam to the north-east of the intersection of Lewis Street and Whiteside Street (adjacent to soil sample location S7 – see Figure 3) showed white material on the soil above the water line (Plate 14). This may be salt crystallisation, although this was not confirmed by sampling. Algae were also noted on the water in this dam. Exposed basalt rocks in a dry dam to the south of Whiteside St (Plate 15) were seen to have a white surface coating, which may have been salt, but could have been lichen or other discoloration. Dams were viewed from the roadside, and properties were not accessed for closer inspection.

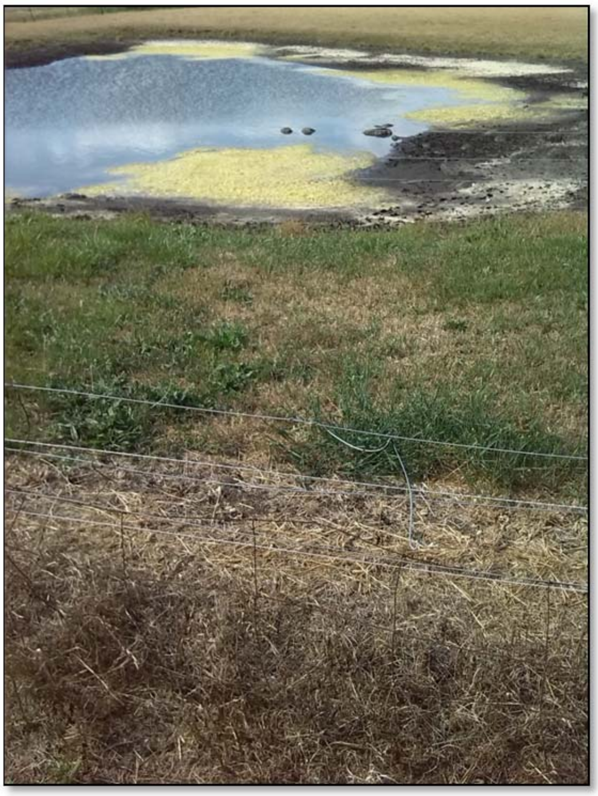

Plate 14: Dam with possible salt crystallisation

Plate 15: Dry dam with exposed rocks

4.1.6 Other areas

From the limited field inspection undertaken for this preliminary assessment, the other parts of the Study Area did not show obvious signs of soil salinity. Reference soil samples from the north-west (S1) and centre (S8) of the area indicated non-saline conditions (see Section 4.2).

Spreading of imported fill was noted to be underway at a site to the north-east of the corner of Spring Street and Rankin Street, in the south of the Study Area. Waterlogging of low-lying ground may require the addition of fill prior to development, but the purpose of the fill in this instance was not confirmed.

4.2 Soil sampling

The field inspection included a limited program of soil sampling focused around and potential areas of soil salinity within the Study Area. Soil sample locations are shown on Figure 3.

4.2.1 Method - soil salinity (1:5 extract)

Soil was sampled in the field using a hand trowel from the surface to approximately 0.1 m below the surface. No deeper soil samples were collected as part of this preliminary investigation. Soil Electrical Conductivity (EC) was measured by mixing one part soil to five parts de-ionised water (by volume) (20 g:100 mL), shaken for 1 minute and allowed to settle before testing for EC using a water quality meter.

4.2.2 Adopted investigation levels

As an indication of soil salinity levels which may affect vegetation, EC ranges are given by the Victorian Department of Environment and Primary Industries (DEPI), for different soil types, as shown in Table 4.

Table 4: Soil salinity classes

Soil Salinity Class[2]	EC 1:5 Sandy loams (µS/cm)	EC 1:5 Clay loams to light clays (µS/cm)	EC 1:5 Medium to heavy clays (µS/cm)
Non Saline	< 200	< 200	< 300
Slightly Saline	200 - 300	200 - 400	300 - 600
Moderately Saline	400 - 700	500 - 900	700 – 1,300
Highly Saline	800 – 1,500	1,000 – 1,800	1,400 – 2,700
Extremely Saline	> 1,500	> 1,800	> 2,700

4.2.3 Results

Soil electrical conductivity results from the Study Area are shown in Table 5.

Table 5: Soil salinity results

Sample No.	Location Description	Soil type	EC 1:5 µS/cm	Soil Salinity Class
S1	Grassed area between road (Camerons Ln) and fence	Medium clay	28	Non-saline
S2	Low lying area in paddock to south of Lithgow St	Medium clay	79	Non-saline
S3	Stony rise in paddock to south of Lithgow St	Clay loam	24	Non-saline
S4	Paddock to north of Lithgow St	Medium clay	82	Non-saline
S5	Paddock to north of Lithgow St	Medium clay	106	Non-saline
S6	Marshy ground to east of Spring St	Clay loam	582	Moderately saline
S7	Shallow drain east of Lewis St	Medium clay	741	Moderately saline
S8	Grassed area between road (Whiteside St) and fence	Medium clay	60	Non-saline

[2] From http://vro.depi.vic.gov.au/dpi/vro/vrosite.nsf/pages/water_spotting_soil_salting

5.0 POTENTIAL INFLUENCE OF SALINITY ON DEVELOPMENT

5.1 Summary of Findings

We understand that any pre-existing native vegetation was cleared for grazing around the 1840s to 1850s (i.e. over 150 years ago) (Lane-Piper, 2011), therefore, salinity due to water table rise would be expected to have become evident by this time. Seasonal variations and longer-term climatic variation are likely to vary the level of the water table, but significant changes due to lag effects of vegetation clearing are not expected.

The typically thin soil cover over the basalt would limit capillary rise of groundwater, if the water table is located within the basalt material (i.e. below the soil horizon).

Existing dams and open drainage channels are expected to be removed as part of the development. Although the planned stormwater management approach for the future development is not known, improved drainage, along with the introduction of impermeable surfaces of roads and roofing, may have the effect of lowering the groundwater table. This would reduce the risk of salinity expression at the surface.

Although the depth to groundwater in the Study Area has not been confirmed, available groundwater chemistry information suggests the groundwater in the uppermost (basalt) aquifer to be of low salinity.

Limited areas of moderately saline soil were identified within:

- *The Study Area* - around dams and drains in the centre of the Study Area, near Lewis Street and Spring Street.
- *Adjacent to the Study Area* - associated with the Beveridge Spring marshland at the eastern boundary of the Study Area.

A previously mapped area of soil salinity in the north of the Study Area was found to have non-saline soils, based on limited sampling, and indications of only slight salinity.

5.2 Further Salinity Assessment

The preliminary salinity assessment has concluded the potential salinity risks to the development are low. It is recommended a further assessment of salinity be undertaken to confirm the findings of preliminary study prior to a detailed development design. We recommend that the further assessment should include:

- A systematic inspection of the landscape for salinity indicators and to collect appropriate surface samples for field and laboratory testing (pH, sulphate (as SO_4) and chloride (as Cl)).
- Targeted placement of shallow piezometers in the area surrounding the groundwater discharge areas/drainage channel to confirm water table depths and further define the extent of potentially saline soil.
- Soil salinity testing through the soil profile at each of the piezometer locations and targeted discharge areas.

The findings from the further assessment should be reviewed in the context of the proposed development layout and drainage strategy by a person experienced in soil and groundwater salinity.

6.0 CONCLUSIONS

Golder has undertaken a preliminary salinity assessment for the 290 hectare Beveridge Central Precinct (the precinct), Beveridge, Victoria. The purpose of the investigation was to undertaken a preliminary assessment of the potential presence of salinity at the site in regard to potential salinity-related risks to the proposed precinct development and identify the types of management actions that should be considered, if required.

The Study Area is located within the Quaternary Volcanic land system (Qvf) which is characterised by gentle volcanic slopes within the undulating volcanic plain or at the base of volcanic cones. Salting risk within this land system has been assigned a “very low” rating based on slope type and depth to water table (Appendix A). Areas of shallow groundwater are more vulnerable to dryland salinity such as discharge points around drains, dams and springs. No piezometers have been installed to verify groundwater quality and depths, however surface observations were made and some preliminary sampling of soils was undertaken of the more vulnerable areas with the landscape. The preliminary field observations and surface sampling confirmed some localised moderately saline soils around some drains and dams onsite, with no evidence of broad based salinity with the Study Area. The area has a high density of groundwater wells used for domestic and stock watering uses (19 registered wells within the Study Area), consistent with the available groundwater quality data which indicates that groundwater is of sufficiently low salinity to be potentially suitable for stock watering, or irrigation without harm to vegetation.

In conclusion, the risks to the development from groundwater, in particular from groundwater-related salinity, are considered to be generally low.

It is Golder’s opinion that the SMO could be removed from this PSP area on the basis that a further salinity assessment (See Section 5.2) is undertaken which confirms the preliminary findings of this report, that the risk of groundwater-related salinity is acceptably low.

7.0 REFERENCES

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Report Signature Page

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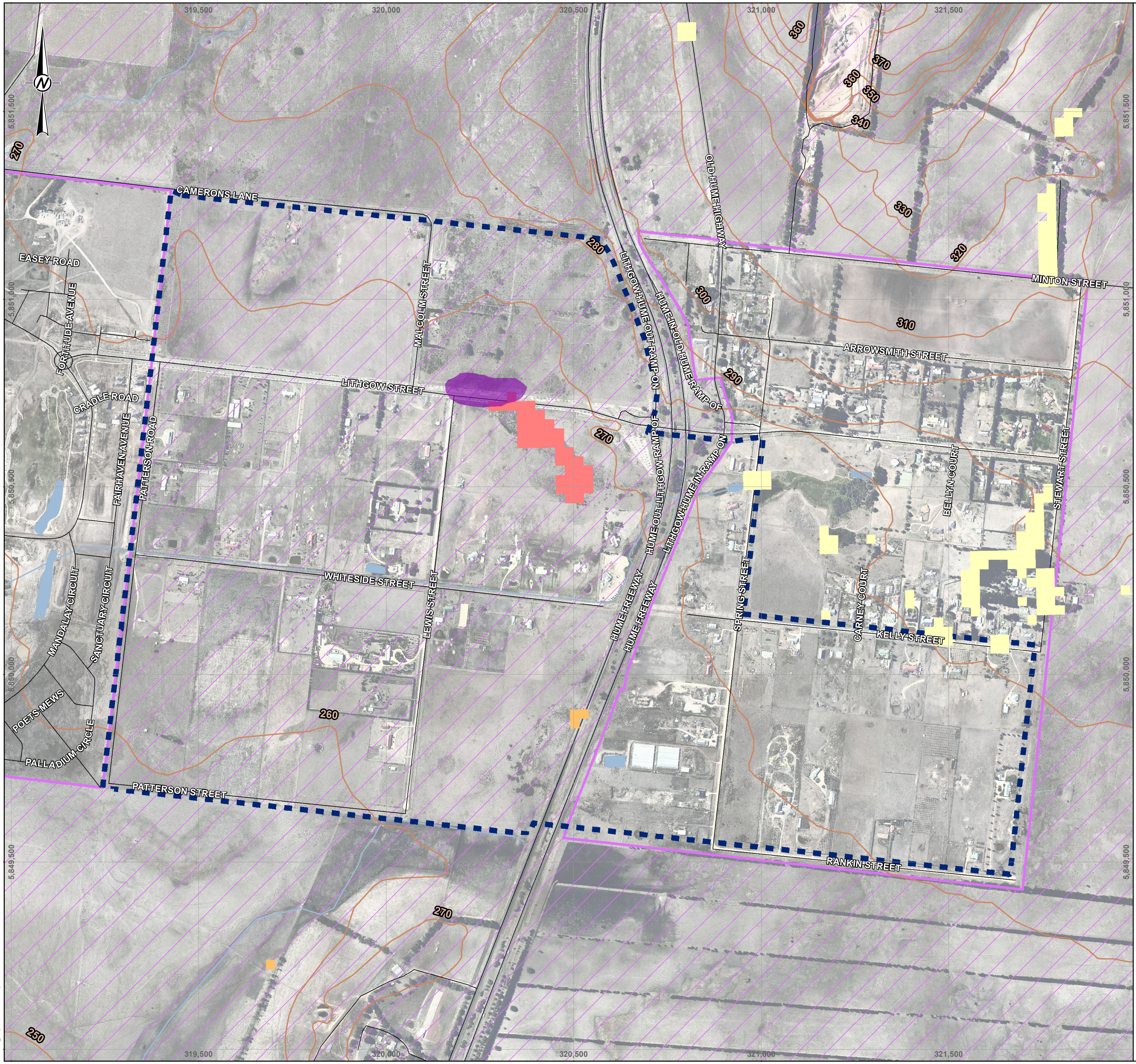
FIGURES



LOCATION MAP

LEGEND

- Salinity Mapping (DEPI, 2013)

Groundwater Dependent Ecosystem reliant on subsurface groundwater (BOM atlas)

- High potential for GW interaction
- Moderate potential for GW interaction
- Low potential for GW interaction
- Salinity Management Planning Overlay
- Beveridge Central Precinct
- Surface elevation contour (m AHD)
- Watercourse
- Area of surface water

NOTES

1. Dryland salinity and salinity risk mapping, sourced from Department of Environment and Primary Industries, 2013.
2. Groundwater Dependent Ecosystem information sourced from the Bureau of Meteorology (BoM), 2015. Atlas of Groundwater Dependent Ecosystems.
3. Road and property information, sourced from VicMap, 30/03/2015.
4. Imagery dated 26/02/2010, sourced from nearmap.com.
5. Location map sourced from Esri online basemaps.

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0 200 400 600 800 METRES

REFERENCE SCALE: 1:10,000 (at A3)

PROJECTION: GDA 1994 MGA Zone 55

CLIENT
LAUDERS RIVIERA GROUP

PROJECT
BEVERIDGE CENTRAL PRECINCT
PRELIMINARY SALINITY ASSESSMENT

TITLE
PRECINCT TOPOGRAPHY AND SALINITY OVERLAY

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-02-05
PREPARED	EC / SLM
DESIGNED	-
REVIEWED	CJW
APPROVED	CJW

PROJECT NO.	CONTROL	REV.	FIGURE
1539872	001-R	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: A3

25mm

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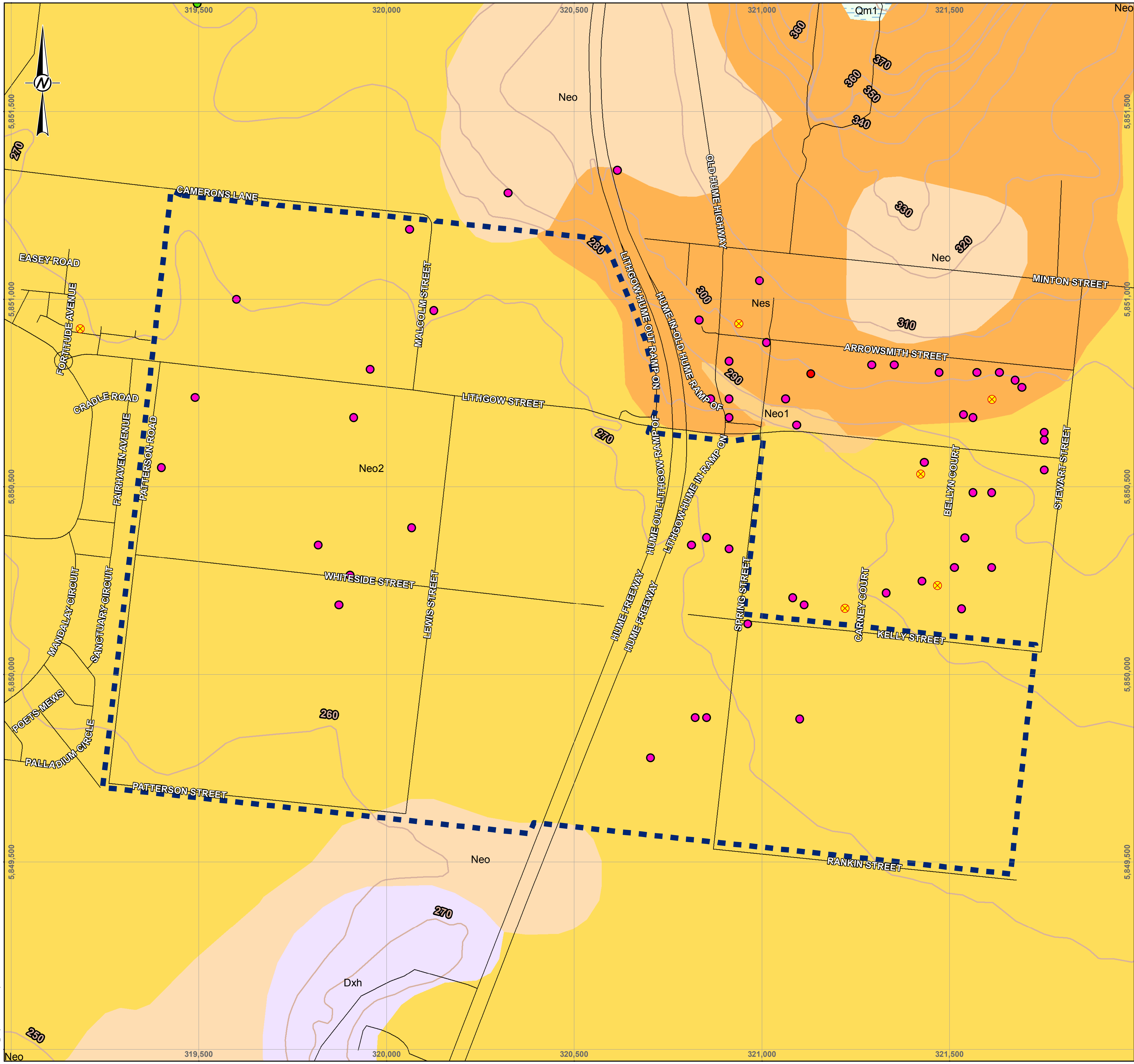

LOCATION MAP

LEGEND

Registered groundwater wells

- LICENCED USE
- DOMESTIC / STOCK
- MONITORING / OBSERVATION
- OTHER
- Surface elevation contour (m AHD)
- Beveridge Central Precinct

Geological Unit

- Swamp and lake deposits (Qm1)
- Newer Volcanic Group - basalt (Neo)
- Newer Volcanic Group - valley-filling basalt (Neo1)
- Newer Volcanic Group - stony rises basalt (Neo2)
- Newer Volcanic Group - scoria deposits (Nes)
- Humevale Siltstone (Dxh)

NOTES

1. Bored data sourced from the Department of Environment Land, Water & Planning, 'Water Measurement Information System, 2015.
1. Road, property & geology information, sourced from VicMap, 30/03/2015.
2. Imagery dated 26/02/2010, sourced from nearmap.com.
3. Location map sourced from Esri online basemaps.

0 200 400 600 800 METRES

REFERENCE SCALE: 1:10,000 (at A3)

PROJECTION: GDA 1994 MGA Zone 55

CLIENT
LAUDERS RIVIERA GROUP

PROJECT
BEVERIDGE CENTRAL PRECINCT
PRELIMINARY SALINITY ASSESSMENT

TITLE
SURFACE GEOLOGY AND REGISTERED WELLS

CONSULTANT: Golder Associates

YYYY-MM-DD	2016-02-05
PREPARED	EC / SLM
DESIGNED	-
REVIEWED	CJW
APPROVED	CJW

PROJECT NO.	CONTROL	REV.	FIGURE
1539872	001-R	0	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM A3

25mm

LOCATION MAP

LEGEND

- Soil sample location: Moderately saline
- Soil sample location: Non-saline
- Field observation
- Beveridge Central Precinct
- Surface elevation contour (m AHD)
- Watercourse

NOTES

1. Road, property & geology information, sourced from VicMap, 30/03/2015.
2. Imagery dated 26/02/2010, sourced from nearmap.com.
3. Location map sourced from Esri online basemaps.

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0 200 400 600 800
METRES

REFERENCE SCALE: 1:10,000 (at A3)

PROJECTION: GDA 1994 MGA Zone 55

CLIENT
LAUDERS RIVIERA GROUP

PROJECT
BEVERIDGE CENTRAL PRECINCT
PRELIMINARY SALINITY ASSESSMENT

TITLE
SITE OBSERVATIONS AND SAMPLE LOCATIONS

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-02-05
PREPARED	EC / SLM
DESIGNED	-
REVIEWED	CJW
APPROVED	CJW

PROJECT NO.	CONTROL	REV.	FIGURE
1539872	001-R	0	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM A3

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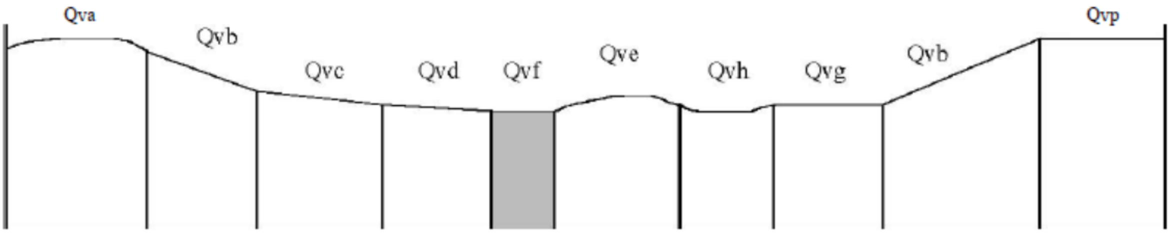
APPENDIX A

Land systems description

Land systems classification of the study area (Qvg)(Shire of Mitchell Land Capability Report).

MAP UNIT SYMBOL: **Qvf**	MAP UNIT: **Quaternary volcanic, gentle slope**



A. GENERAL DESCRIPTION

Gentle volcanic slopes occur within the undulating volcanic plain or at the base of volcanic cones. The soils are similar to map units previously described, red gradational with dark reddish brown clay loam topsoils and dark reddish brown light to medium clay subsoils, although in this map unit a dark brown gradational soil is also common. There are minor occurrences of cracking clays. Coarse fragments are present throughout the profile and some mottling occurs in the subsoils. Rock outcrop is variable, and is absent in some areas. This unit is susceptible to sheet erosion.

SITE CHARACTERISTICS

Parent Material Age:	Quaternary	**Depth to Seas. Watertable:**	> 1.0 m
Parent Material Lithology:	Olivine basalt	**Flooding Risk:**	Nil
Landform Pattern:	Gently undulating rises/low hills	**Drainage:**	Well drained
Landform Element:	Mid-slope	**Rock Outcrop:**	Nil
Slope a) common:	9%	**Depth to Hard Rock:**	0.5-1.0 m
Slope b) range:	4-10%		

Potential Recharge to Groundwater:	Low-moderate
Major Native Vegetation Species:	River Red Gum, Blackwood
Present Land Use:	Grazing
Length of Growing Season	April - October

LAND DEGRADATION

Degradation Processes	**Water Erosion sheet/rill**	**gully**	**Wind Erosion**	**Mass Movement**	**Salting**	**Acidification**
Susceptibility	High	Low	Moderate	Low	Very low	Moderate
Incidence	Low	Low	Low	Low	Very low	Not available

APPENDIX B

Important information about this report

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