Fraser Earthmoving Construction Pty Ltd

ABN: 84 476 527 814

Part 7
Land Resources Assessment

for the

Howlong Sand and Gravel Expansion Project

State Significant Development 17_8804

Prepared by

Advanced Environmental Systems Pty Ltd

March 2020

This page has intentionally been left blank

HOWLONG SAND AND GRAVEL EXPANSION PROJECT

STATE SIGNIFICANT DEVELOPMENT

LAND RESOURCES ASSESSMENT

2020

ADVANCED ENVIRONMENTAL SYSTEMS
CREATING A SUSTAINABLE FUTURE

PHONE: (03) 5482 5882 EMAIL: info@ environmentalsystems.com.au

WEB: www.environmentalsystems.com.au

Client Details	
Project Name	Howlong Sand and Gravel Expansion Project
Address of site	4343 Riverina Highway, Howlong NSW 2643
Business owner, contact number and email	Mr Greg Fraser 0427 337 376 gregfraser@fraserearthmoving.com
Business owner postal address and ABN	Fraser Earthmoving Construction Pty Ltd 574 Kiewa Street, Albury NSW 2640 ABN: 84 476 527 814
Site manager, contact number and email	Andrew McKimmie 0417 883 576 andrewmckimmie@fraserearthmoving.com
Quarry Site Land Titles	Lot 173 DP753744 Lot 1 DP1039973 Lot 174 DP753744 Lot 1 DP798291 Lot 174A DP753744 Lot 3 DP113703 Lot 231 DP753744 Lot 4 DP113703 Lot 1 DP741037

Consultant/Assessor Details	
Name of investigating company	Advanced Environmental Systems Pty Ltd (AES)
Nominated individual/s	Mr Peter Clinnick (B. Ag. Sci. Hons. M. ASSSI.)
Date of assessment commencement	1-01-2018
Phone number	(03) 5482 5882 Mob: 0412 151 225
Email address	pc@environmentalsystems.com.au

Authors' Expertise: Peter Clinnick has a Degree in Agricultural Science with Honours from La Trobe University and is a recognized ecologist/soil scientist and member of the Soil Science Society of Australia. He has been engaged by CSIRO Forestry, industry, community groups and local government to work in extension, research and statutory planning throughout Australia. Peter is a NSW Biodiversity Assessment Method Accredited Assessor with over 30 years' experience in biodiversity, soils and geomorphology assessments for rural landholders, developers and utilities. Peter is currently Managing Director of the regionally based environmental consulting company Advanced Environmental Systems Pty Ltd.

Table of Contents

Figures

Tables

1. Introduction

Advanced Environmental Systems Pty Ltd (AES) has been commission by Fraser Earthmoving Construction Pty Ltd (the Applicant) to prepare this Soil and Land Capability Assessment to support the Environmental Impact Statement (EIS) to accompany an application for development consent for the continuation and expansion of extraction, processing and product transport operations at the Howlong Sand and Gravel Quarry (the Project).

This report identifies specific constraints and opportunities relating to land resources that could potentially affect the Project and its establishment, operation and post-operative rehabilitation. In conducting this assessment, AES has:

- conducted a review of the existing environmental context and land resource information;
- conducted a field survey of the landforms and soils;
- collected representative soil samples for laboratory testing;
- obtained relevant laboratory test results for specific soil characteristics; and
- analysed the laboratory data to provide recommended mitigation and management measures.

For the purposes of this document, the Project would be undertaken within an area referred to as “the Quarry Site” (**Figure 1**). The Quarry Site incorporates all operational areas and land traversed by the Quarry access road.

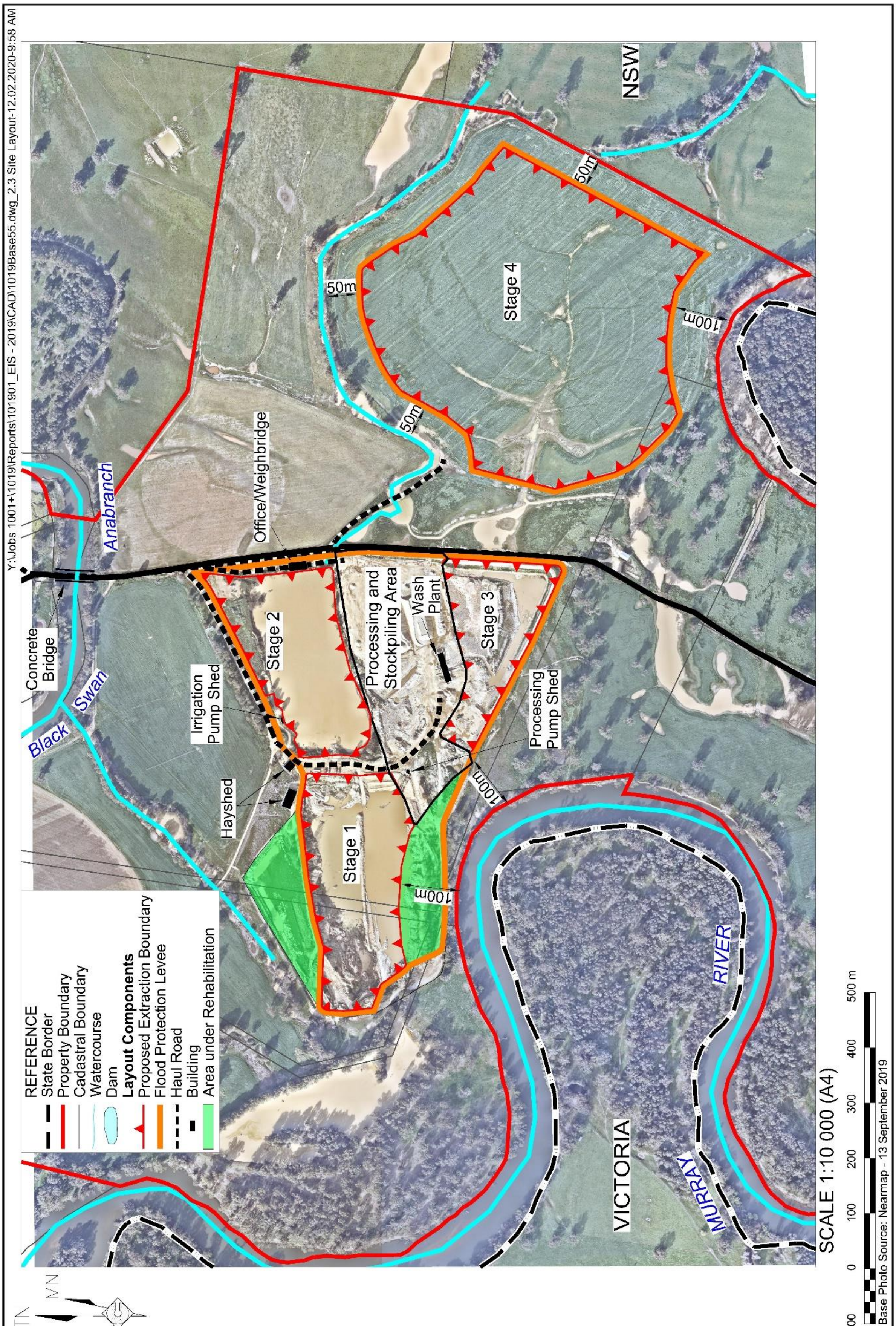


Figure 1 Proposed Quarry Site Layout

2. Description of the Project

The Project would continue to require the free-dig extraction of sand and gravel material, which would then be processed to meet client specifications, before despatch to a final destination. The following provides a summary of the key components of the Project for which development consent is being sought.

- Ongoing extraction of sand and gravel resource across four stages of development, commencing in the existing disturbed areas and progressively expanding to new areas in later stages.
- Production of no more than 300,000 tonnes per annum (tpa).
- Ongoing use of screening equipment and wash plant to process raw materials to meet client specifications. Occasional use of mobile crushing plant (once or twice per year) to provide primary shaping of the resource before screening.
- Ongoing transportation of material from the Quarry, via Howlong, to various destinations. Transportation would be limited to a maximum of 40 laden loads per day.
- Progressive emplacement of overburden or fine materials in completed pits and rehabilitation areas.
- Land previously disturbed within 100m of the Murray River would be regenerated.
- Progressive and final rehabilitation of the Quarry to develop a landform suitable for native vegetation conservation and as a wetland.
- Ongoing operation for a period of 30 years and associated employment of eight to ten personnel. Transportation operations would be contracted, or trucks and drivers would be supplied by clients.

3. Environmental Context

Location and Scope

The Quarry Site is located in the eastern Riverina, approximately 30 km west of Albury. The following section addresses aspects of land use, as well as land and soil capability.

Climate

Figure 2 presents the average annual rainfall and evaporation trends from Rutherglen Meteorological Station (No. 082032). Median annual rainfall in in the region is approximately 587 mm and the wet months are May to October, although rainfall has a tendency to be unreliable. Median annual evaporation is approximately 1,351 mm (BOM, 2019). Average daily minimum and maximum temperatures are 2.7 to 12.4°C in July and 13.9 to 30.8°C in January respectively. Wind data indicates that the strongest and most frequent winds during winter and spring are those from the north-west, west and south-west.

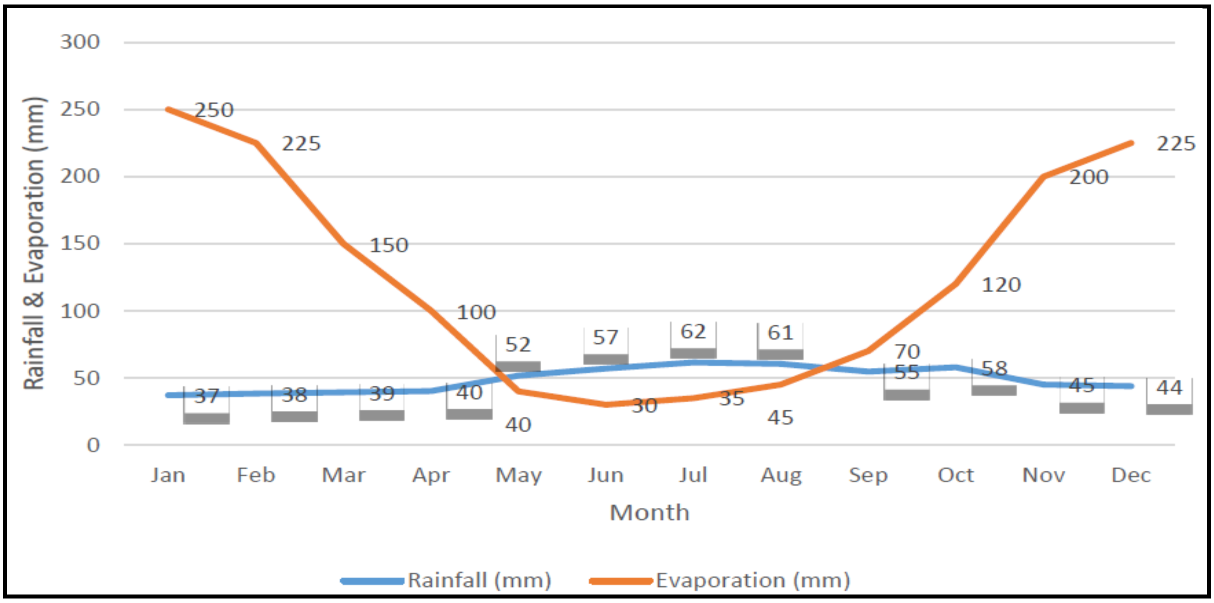


Figure 2 Average Rainfall and Evaporation Trend for Rutherglen Met Station No. 082032 (BOM, 2019)

Land Uses

Land within the Quarry Site was previously used for irrigated dairy production, but is now predominantly used for dryland agriculture. Gravel extraction has been conducted on the property for about 60 years. Cereal production is the dominant activity on farms surrounding the Quarry Site. Wheat, barley, and triticale are all grown extensively, whilst oat and cereal rye crops are also grown on a number of farms. The livestock industry is dominated by sheep, with a small number of growers stocking cattle.

Agriculture in the district has undergone changes in recent decades. Wheat, once the principal crop, has declined, giving way to a wider mix of cereals and a small but steady increase in legume crops.

The properties immediately adjacent to the Quarry Site are used for primary production activities including seed production, grazing and cropping. A small allotment near the Riverina Highway has accommodation facilities and is used by the Scouting Association of NSW. **Figure 3** displays grazing activities and irrigation infrastructure on properties surrounding the Quarry Site.

Figure 3 Grazing on Flood Plain Topography and Evidence of Previous Irrigated Pasture Production

Topography and Soils

The Quarry Site is situated on an island in the alluvial flood plain between the Black Swan Anabranch and the Murray River. Topography consists of flat land with occasional gentle slopes up to 5% on sub terrace interfaces. The elevation varies from 139.5 m to 140.0 m across the floodplain (**Figure 4**) and rises abruptly up to 150 m on the upper terrace at the Riverina Highway.

Soils across the floodplain are commonly grey black and yellow Vertosols (Cracking clays) and occasionally Brown Chromosols (Clays) and grey silty or fine sandy Kandosols (Grey earths) (OEH 2015). The Quarry Site and immediate surrounding areas are predominantly yellow Vertosols. There are also some small areas of subdued scroll bar topography on the eastern side of Quarry Site with sandy brown sodosols.

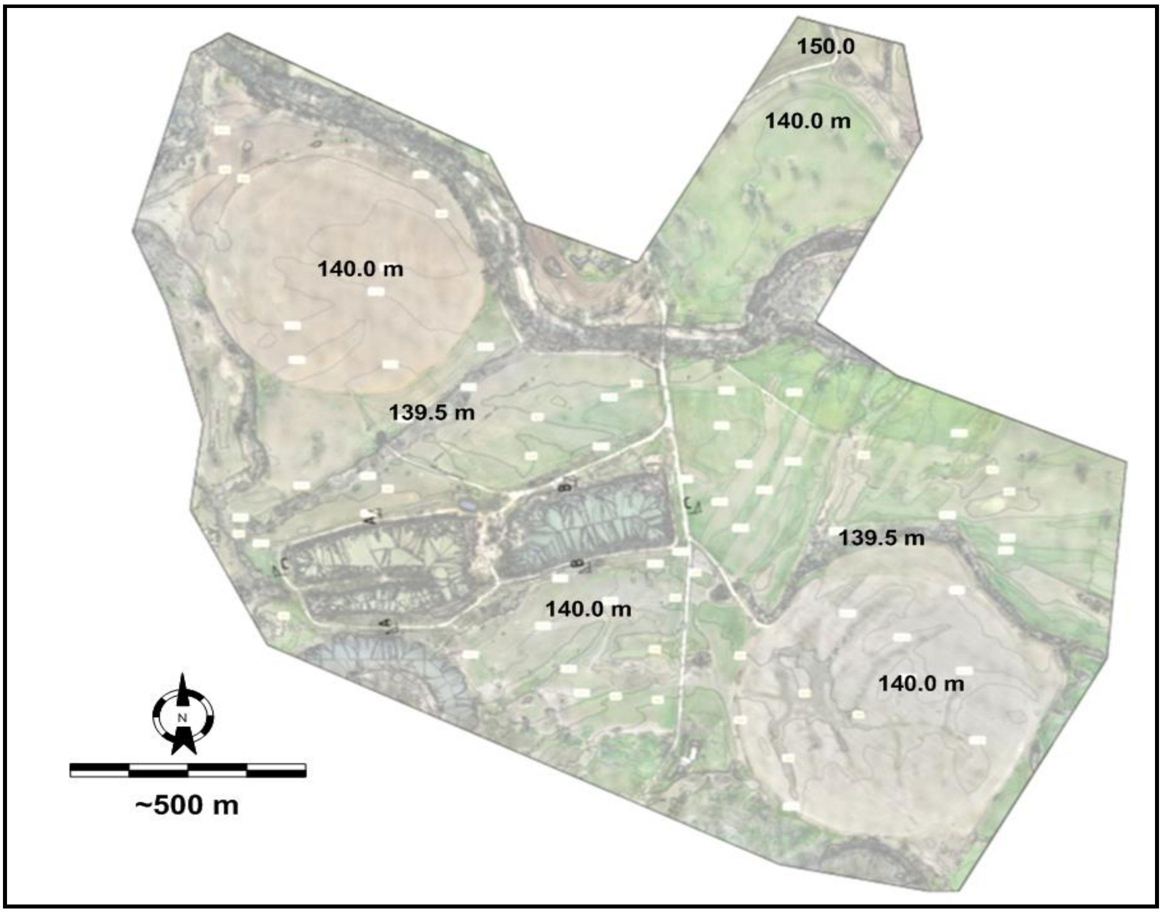


Figure 4 Indicative Quarry Site Levels (contour source CAF Consulting 2018)

4. Soil Investigations

Soil Assessment Methodology

The floods plain has been exposed within the existing extraction area and a representative sample site was chosen for soil assessment within the south western corner of Stage 1 extraction area.

Soil samples were collected from the various horizons in the profile at the sample site and were assessed for a range of chemical parameters by SWEP Laboratories Pty Ltd (SWEP). The full results are provided in **Appendix 1**. Field assessments were made for soil texture, slaking and dispersion characteristics. Colour was assessed using the standard Munsel Colour Chart.

Soil Landscape Units

The Quarry Site is located within the Murray Alluvium hydrogeological landscape (HGL) which is characterised by alluvial floodplains, terraces and levees. Soils within the HGL typically comprise unconsolidated Quaternary channel and flood plain sediments including sand, gravel and clay (OEH, 2015).

Soil Profiles

Most of the topsoil (A Horizon) at the sample site was measured to be approximately 25 cm deep. The topsoils have a propensity for cracking upon drying in summer. This shrink-swell attribute allows water to reach subsoil horizons in autumn-winter, but with the dry conditions of summer soils crack, shearing plant roots and allowing rapid air-drying of the profile. This is attributable to high proportions of minerals (e.g. kaolinite and illite) that impart shrinking and swelling characteristics. The subsoils are deep, predominantly brownish yellow, with the sample site subsoil extending to 350 cm below the surface. **Figure 5** presents the soil horizons identified at the representative sample site. **Table 1** presents a summary of the soil morphology at the sample site.

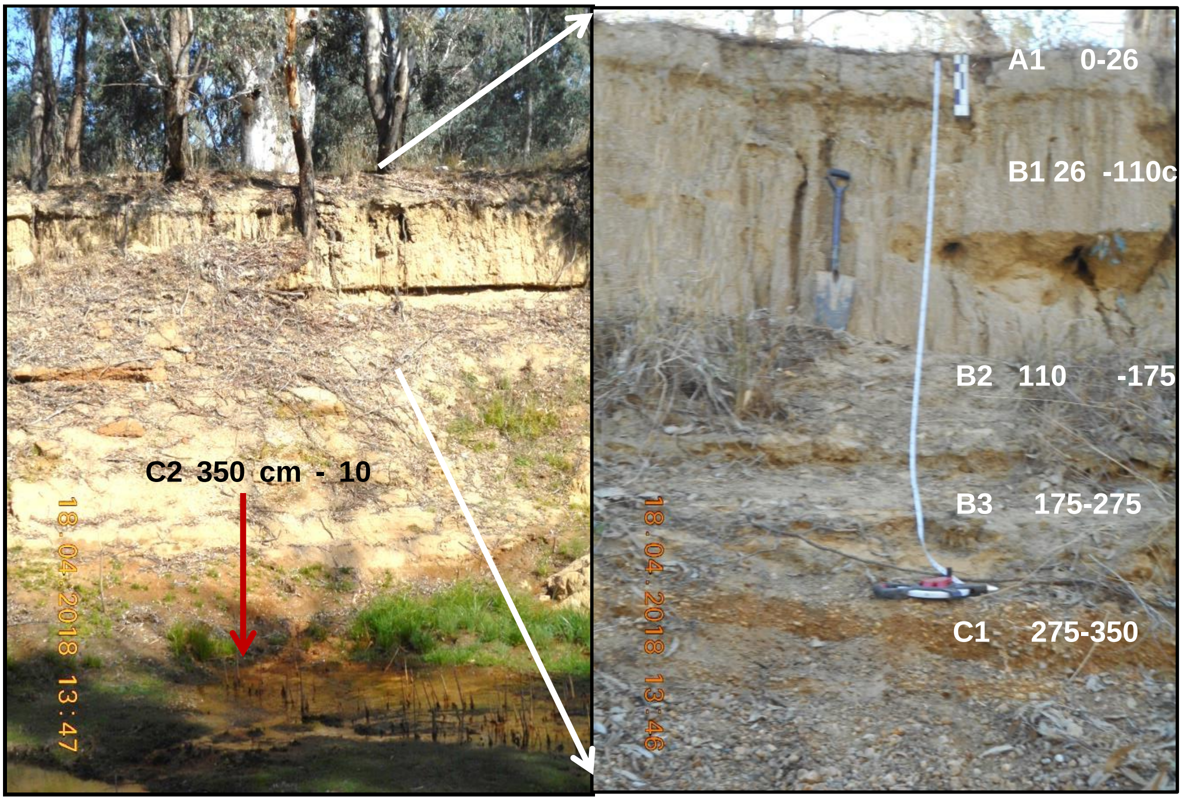


Figure 5 Soil Profile - Epipedal, Episodic Yellow Vertosol

Table 1 Soil Morphology Summary

Horizon and depth (cm)	Texture	Colour	Field dispersion Low – L Moderate – M High- H	Field slaking Low – L Moderate – M High- H	Notes
A1 0-26	Light clay	10 YR 5/6 Yellowish brown	L	L	Some orange mottles
B1 26-110	Silty clay	10 YR 6/4 Light Yellowish brown	M	M	Ironstone nodules 2-3 mm, Peds 4-5 cm
B2 110-175	Light clay	10 YR 6/6 Brownish yellow	L	H	10% orange mottles Peds 5-8 cm
B3 175-275	Medium clay	10 YR 5/4 Brownish yellow	M	L	More friable than B2, holding vegetation 5% orange-brown mottles
C1 275-350	Clayey Fine/ coarse sand	7.5 YR 5/6 Strong brown	L	M	Slightly moist Fine sands
C2 350 -10 m	Coarse sand/gravel	10 YR 5/6 Yellowish brown	L	M	Slightly moist Gravel 5-20 mm

Soil Chemical Testing

Soil samples from the different soil horizons at the sample site were sent to SWEP for testing in order to identify key chemical attributes. The full results of these analyses are included as **Appendix 1**. **Table 2** presents a summary of the key results of the chemical analyses.

Table 2 Chemistry summary

Horizon and depth (cm)	pH1:5 water	EC (uS/cm)	Cation exchange capacity (cmol/kg)	Exchangeable Sodium (%)	Calcium/ Magnesium ratio	Available phosphorus (ppm)	Available nitrogen (ppm)
A1 0-26	5.7	106	13.86	7.8	0.77	0.1	3.51
B1 26-110	8.2	380	15.57	27.94	0.28	0.33	24.7
B2 110-175	7.3	2,290	23.78	24.47	0.18	12.5	22.1
B3 175-275	7.3	142	15.97	12.52	0.36	1.39	3.2
C1 275-350	7.0	28	4.33	3.7	0.47	12.6	0.1
C2 350-10m	6.4	18	2.81	2.14	0.79	0.6	1.3
Desirable levels	5.5 – 7.5	<300	>10	<5.0	2 – 4:1	25	27

Soil pH

pH is the measure of alkalinity or acidity. pH is a logarithmic scale, so a shift of one unit from say 6 to 7 is a ten times factor and a shift of two units is a 100 times factor.

pH is an important determinant of plant nutrient availability. Phosphorus for example is only readily available in the pH range 6-7 (Glendinning 1999).

- Topsoil is slightly acidic (5.7) and will therefore have a lime requirement.
- Subsoil pH varies slightly from alkaline (8.2) to 7.0 deeper in the soil profile. Subsoils with pH higher than 8.5 are not likely to be encountered on this site.

EC (Electrical Conductivity)

EC is used a measure of soil salinity. Soils below 2,000 US/cm (2.0 dS/M) are classed as non-saline. Soils in the range 2,000- 4,000 US/cm are classed as slightly saline.

The topsoil and immediately underlying subsoil down to 110 cm is non-saline; while from 110 to 175 cm there is a horizon (B3) that exhibits slightly saline characteristics. At deeper levels the soil returns to being non-saline. Saline soils make it hard for plants to extract moisture from the spaces between soil particles.

Cation exchange capacity

Concentrations of cations are expressed in centimoles of positive charge per kilogram of soil (cmol(+)/kg) or, previously, me/100 g. Adding the concentrations of each cation (magnesium, potassium, sodium etc) gives you an estimate of the CEC figure. A figure above 10 cmol(+)/kg is preferred for plant production. Soils with high levels of swelling clay and organic matter can have a CEC of 30 cmol(+)/kg or more.

The topsoil and subsoils from the sample site have a moderate level of CEC which will aid plant performance.

Exchangeable sodium

Ideally, the Exchangeable sodium percentage (ESP) should be less than 5. The ESP is high in the topsoil and very high in the subsoils down to about 275 cm. Sodicity prevents good soil structural development and as can be seen in **Table 1** the slaking and dispersion characteristics mean that the B1 horizon as well as those below it, may be acting as a throttle to the vertical movement of water in wetter years.

Calcium /magnesium ratio

Both calcium and magnesium are important to plant growth and the ideal ratio is between 2 and 4 parts calcium to one magnesium. The results from the soil assed at the sample site indicate that calcium is in short supply which is also in part why pH is slightly acidic.

Available phosphorus and nitrogen

Available phosphorus (P) and nitrogen (N) are important nutrients in plant growth and performance. Both P and N are extremely low in the soil assessed at the sample site. Substantial addition of both nutrients would be required to bring the soil to a productive condition for agricultural pasture and crops.

Soil Drainage

Readily available water holding capacity was not assessed in detail as a part of this study. However, based on soil texture (Silty light clay) the water storage capacity can be substantial, but the amount of water actually available to plants from these soils (10- 20%), is limited by the very small pore size.

Similarly, plant nutrients can be locked up in clays, especially phosphorus in the case of red clays with high iron and aluminium content. The type of minerals present in the clay influence structure and the proportion of elements, such as calcium, magnesium and sodium (as well as organic matter) can affect structural stability under irrigation. Structural problems in these soils can be ameliorated to some degree with appropriate amounts of lime and gypsum.

The extent, duration and impact of waterlogging is determined by how quickly water enters and leaves the soil by deep percolation, lateral flow or evapotranspiration. The Vertosol soils may show signs of waterlogging or perched water tables for more than three months of the year.

Soil Contamination

Past land use has involved very low intensity grazing and some cropping, with minimal use of fertilizer. There are no records of pesticides or herbicides having been previously used. There is no evidence of contamination by oil or other hydrocarbon products on the Quarry Site or in surrounding excavations.

Potential future contaminants could include diesel fuel, oil and hydraulic fluid from cars using the access road. However, this risk to the environment exists irrespective of the whether the Project is approved.

Soil Erodibility

The moderate infiltration rates of the surface and associated hydraulic conductivities through the profile mean that runoff will occur in high intensity events, or during continuous lower intensity rainfall occurrences. Sediment production is possible, but gentle slopes and detention in grassed areas limit the spread of sediment (OEH 2006).

Flooding is a different scenario when the erosive force of water has greater potential to dislodge soil and suspended material will travel with overland flow. This suspension and movement of material will occur, not just in areas surrounding the pits, but across the wider landscape, wherever agricultural activities or natural events such as fire, allow soil exposure to occur.

5. Land Capability

It is important to assess the impacts of the Project on the agricultural potential of land within the Quarry Site and determine if the loss of agricultural land is going to be of social, economic or environmental importance for existing and future generations and weigh this against the gains from sand and gravel extraction. There should also be some consideration given to the potential for productive post resource extraction activities to generate productive outcomes in the future.

Land capability is determined by the physical capacity of the land to sustain a range of long-term land uses and management practices without causing degradation to soil, land, air and water resources. Land degradation and ecosystem decline results from a site being used or managed beyond its level of land capability.

The following land capability assessment for the Quarry Site is based on the methodology described in the *NSW Office of Environment and Heritage Land and Soil Capability (LSC)*

Assessment Scheme, *Second approximation (2012)*. The method includes the eight classes of the superseded rural capability system, but places additional emphasis on specific soil limitations and their management. The context and application of the LSC assessment scheme is largely for:

- regional assessment of land capability; and
- the assessment of land capability for broad-scale, dry-land agricultural land use.

Table 3 presents the LSC ratings for the various land and soil degradation hazards identified for the Quarry Site

Table 3 Land and Soil Capability (LSC) Site Assessment

Degradation Hazard	Land and soil capability class
Water erosion, including sheet, rill and gully erosion	2
Wind erosion	1
Soil structure decline	4
Soil acidification	3
Salinity	2
Waterlogging	4
Shallow soils and rockiness	1
Mass movement.	1
Land capability class (most limiting factor)	4

Class 4 Land capability means the land has moderate to severe limitations for some land uses that need to be consciously managed to prevent soil and land degradation. The limitations can be overcome by specialised management practices with high levels of knowledge, expertise, inputs, investment and technology (OEH 2012). The Quarry Site and its soils are not prime agricultural land.

It should be noted that OEH in their assessment of hydrogeological landscapes for the Eastern Murray catchment – Murray Alluvium (**Appendix 2**) indicated that land capability was rated as Class 3 in a generalised context.

6. Mitigation and Management Measures

Water Erosion and Sediment Production

The moderate infiltration rates of the soil and associated hydraulic conductivities mean that runoff will occur in high intensity events, or in continuous lower intensity rainfall occurrences. Sediment production is possible, but gentle slopes and detention in grassed areas limit the spread of sediment (OEH 2006). It is noted that the extraction areas are surrounded by a levee and would be internally draining, thus, minimising the risk of soil dispersion beyond the proposed area of disturbance.

Flooding is a different scenario when the erosive force of water has greater potential to dislodge soil and suspended material will travel in the water column. This will not only occur within the Quarry Site, but across the wider landscape wherever agricultural activities or natural events, such as fire, allow soil exposure.

Wind Erosion

Wind could cause saltation of soil particles and elevation of finer material into the atmosphere, particularly in areas where soil is exposed. Wind erosion could potentially impact on sand stockpiles and exposed areas in late spring, summer and autumn, but is not generally considered to be a hazard for the areas surrounding the extraction and processing and stockpiling areas because of the extent of ground cover throughout the year.

It is recommended that water carts or sprinklers are engaged to suppress dust from excavators, trucks and stockpiles during periods when wind speeds exceed 10m/s or if dust is evident. Air quality monitoring should also be conducted on a regular basis across the site. It is noted that dust suppression on roads should be ongoing and not dependent on wind speed.

The level of preventative management on the Quarry Site will mean that wind erosion is not an issue. The subdued elevation of the extraction areas below the existing surface and wet sands/ gravels will also ensure that the impacts of wind erosion are minimal.

Soil Structure Decline

From a management perspective, there is a need to distinguish between sodic soils and saline sodic soils. The soil samples assessed are sodic, but predominantly non-saline, or only slightly saline at depth. The effects of exchangeable sodium on the physical behaviour of the soil is influenced by such factors as electrolyte concentration (salinity), pH, mineralogy, organic matter, aggregate stability and biopolymers.

In the case of the Quarry Site, soil problems associated with sodicity may include:

- surface crusting;
- low infiltration and permeability; and
- very hard, dense subsoil.

As previously mentioned, the topsoils, and more so the subsoils, are sodic (Exchangeable sodium >4.0%) between 0 - 275 cm depth.

The implications are that there will be a high gypsum (>7 t/ha) and lime requirement (>3 t/ha) for areas that are to be revegetated, especially if direct seeding is used. Operationally it will be important to ensure that mobile equipment and traffic movements are controlled and limited to defined areas following rehabilitation.

Acid Sulphate Soils

Soil sampling and chemical analysis indicate that the surface soil is slightly acidic and has a moderate buffering capacity resulting in a moderate rating of LSC 3. While there are some acid sulphate soils in the area (associated with waterlogged drainage lines), there are no soils that are of concern within proposed area of disturbance. If discovered, acid sulphate soils would likely require the application of lime. Tolerant native species of plants would also be required for revegetation.

Salinity

The heavier texture (medium clay) and lower hydraulic conductivity of the mid-level subsoil (B2) horizon indicates that it is accumulating some salt leached from horizons above. Since the salinity is only just above 2,000 US/cm and is deep in the profile it is a not an influence on plant performance, hence the land capability hazard is low rating of LSC 2. No specific management or mitigation measures are required.

Waterlogging

The soils at the site have the potential to be waterlogged for a few months of the year in wetter years because of the clayey B3 horizon limiting water flow through the profile (LSC rating 4). This may potentially reduce plant performance for a few months in some years. No specific management or mitigation measures are suggested.

Other land capability factors

Other factors in the land and soil capability assessment are soil depth and rockiness as well as mass movement. These are not considered to be hazard or threats to agricultural production within the Quarry Site and are therefore given a low rating of LSC 1. No specific management or mitigation measures are required.

Soil Removal and Handling

It is recommended that the following management and mitigation measures are implemented throughout the life of the Project to minimise the potential for unacceptable soil and land capability-related impacts.

- Clearly mark areas for stripping and stockpiling.
- Strip soil from all areas of disturbance and store in stockpiles no more than 2m high for future rehabilitation activities or transfer soil directly to areas to be revegetated.
- As far as practicable, refrain from stripping or placing soil during wet conditions.
- Implement erosion control measures (e.g. silt-stop fencing) at downslope locations if clearing during wet periods is unavoidable.

- Ensure that the soil stockpile surfaces have a surface that is as ‘rough’ as possible, in a micro-scale, to assist in surface water runoff control and seed retention and germination.
- Spread seed of a suitable cover crop on all soil stockpiles to facilitate revegetation.
- Signpost the soil stockpile and limit operation of machinery on the stockpile to minimise compaction and further degradation of soil structure.
- Rip or scarify all areas to be respread with topsoil to allow the respread material to be keyed into the underlying material.

Progressive Revegetation and Rehabilitation

An indicative protocol for revegetation activities and final rehabilitation is presented as **Appendix 3**. In summary, soil testing may be necessary to determine the requirement for treatment with either gypsum for sodic soils or with lime for acidic characteristics. Other factors such as site preparation, plant selection and the need for guards on tubestock would be progressively tested through progressive revegetation activities.

Soil management requirements for ongoing revegetation and final rehabilitation should be described in a Biodiversity and Rehabilitation Management Plan so that they are readily accessible to Quarry personnel.

7. Conclusion

Adherence to the recommended soil and growth medium stripping, handling, stockpiling procedures and other management practices, together with appropriate rehabilitation practices would result in a minimal impact to soils and land capability within the Site. Assuming successful management of soil resources within the Quarry Site, ongoing revegetation activities and final rehabilitation are not likely to be significantly constrained. The Project would not impact adversely on the agricultural potential of the land given the existing land uses and the prevalence of moderate capability soils within the Quarry Site.

8. References

OEH - Office of Environment and Heritage (2006) Erosion and sediment Control - Guide for Local Councils. https://www.environment.nsw.gov.au/resources/stormwater/erosionsediment0642.pdf

OEH - Office of Environment and Heritage (2012). The land and soil capability assessment scheme. Second approximation.

OEH - Office of Environment and Heritage (2015). Hydrogeological landscapes for the Eastern Murray catchment – Murray Alluvium.

Appendix 1: Soil Analyses (A 1, B1 and C1 Horizons)

A1 Horizon

SWEP PTY. LTD. ANALYTICAL LABORATORIES

Tel: (03) 9701 6007
Fax: (03) 9701 5712

ASPAC
A member of the Australasian Soil and Plant Analysis Council

REPORT ON SAMPLE OF SOIL

FILE NO : 1804134634 **DATE ISSUED :** 3/05/2018

ADVANCED ENVIRONMENTAL SYSTEMS P/L - AES
2/75 HUME STREET
ECHUCA, VIC 3564

CLIENT ID : AES001
PHONE : 03 5482 5882
FAX : 03 5480 2982

E-mail: pc@environmentalsystems.com.au

REFERENCE :
REFERENCE PHONE :
DATE RECEIVED : 30/04/2018
ANALYSIS REQUIRED : Full (ST-1)

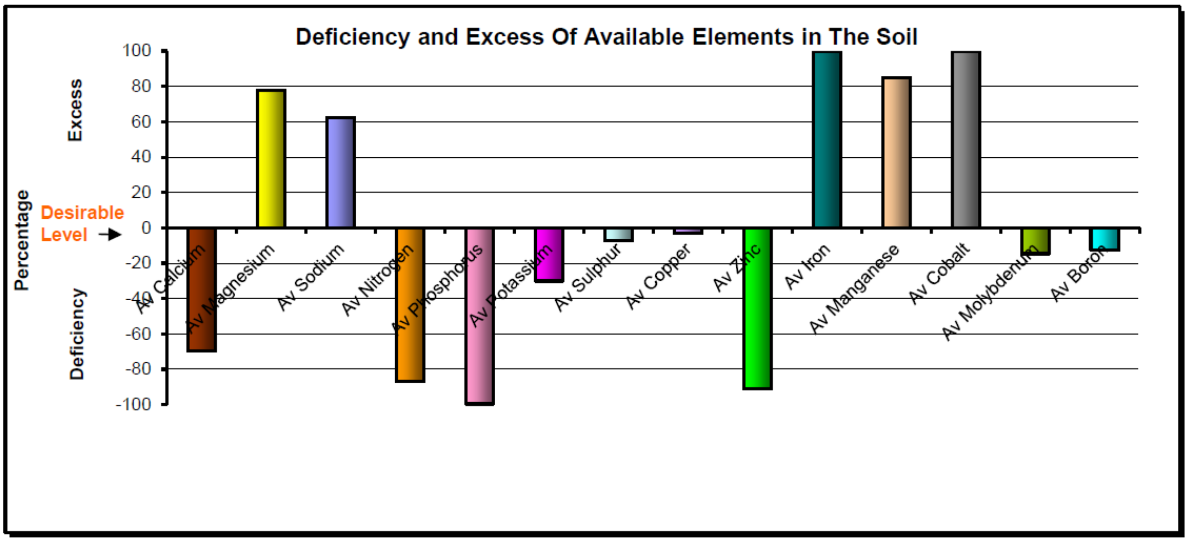
SAMPLE ID : A1 0-26 CM
DEPTH OF SAMPLE (cm): 0 to 26
LAND USE : PASTURE

ITEMS			RESULTS	DESIRABLE LEVEL
pH(1:5 Water)'			5.7	5.5-7.5
pH(1:5 0.01M $CaCl_2$)'			5.13	
Electrical Conductivity'	EC	µS/cm	106	< 300
TOTAL SOLUBLE SALT	TSS	ppm	349.8	< 990
AVAILABLE CALCIUM'	Ca	ppm	546	1807
AVAILABLE MAGNESIUM'	Mg	ppm	424.8	239
AVAILABLE SODIUM'	Na	ppm	248.4	< 153
AVAILABLE NITROGEN	N	ppm	3.51	27
AVAILABLE PHOSPHORUS'	P	ppm	0.1	25
AVAILABLE POTASSIUM'	K	ppm	169.26	242
AVAILABLE SULPHUR'	S	ppm	10.2	11 - 15
AVAILABLE COPPER'	Cu	ppm	1.94	2
AVAILABLE ZINC'	Zn	ppm	0.46	5 - 7
AVAILABLE IRON'	Fe	ppm	113	> 30
AVAILABLE MANGANESE'	Mn	ppm	37	> 20
AVAILABLE COBALT	Co	ppm	2.43	0.7-0.8
AVAILABLE MOLYBDENUM	Mo	ppm	0.26	0.3-0.4
AVAILABLE BORON'	B	ppm	0.52	0.6-0.7
TOTAL ORGANIC MATTER'	OM	%	2.4	4 - 6
TOTAL ORGANIC CARBON'	OC	%	1.2	2 - 3
TOTAL PHOSPHORUS'	TP	ppm	not required	
EXTRACTABLE ALUMINIUM'	Al	ppm	not required	
TOTAL NITROGEN'	N	%	not required	
TOTAL CALCIUM	Ca	ppm	not required	
TOTAL MAGNESIUM	Mg	ppm	not required	
CHLORIDE	Cl	ppm	not required	
AVAILABLE SILICA	Si	ppm	not required	

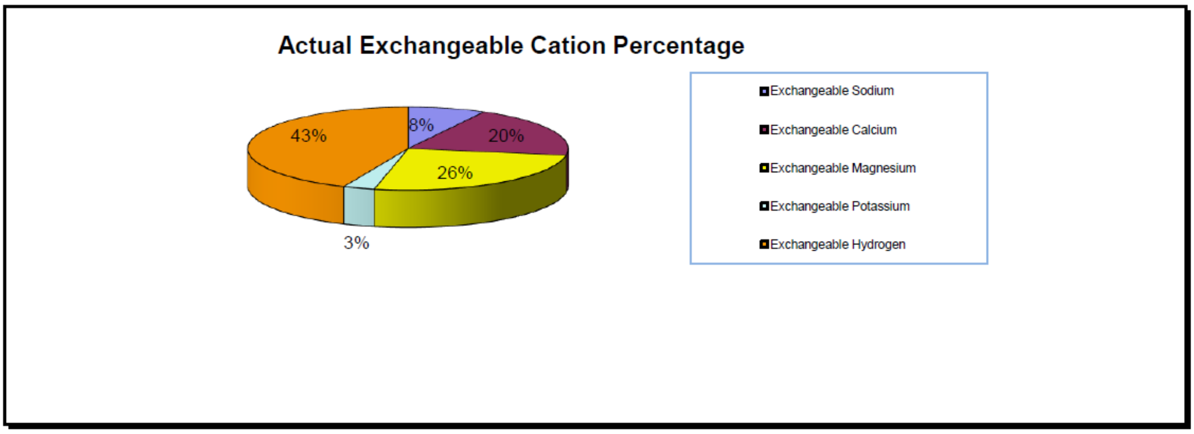
†This laboratory has been awarded a Certificate of Proficiency for specific soil and plant tissue analyses by the Australiasian Soil and Plant Analysis Council (ASPAC). Test for which proficiency has been demonstrated are highlighted in this report.

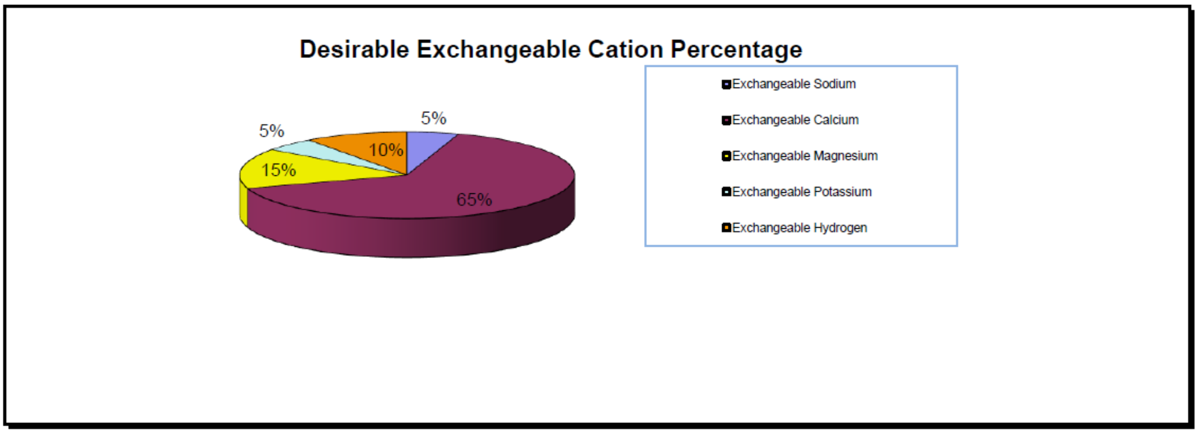
ITEMS			RESULTS	DESIRABLE LEVEL
EXCHANGEABLE CALCIUM	Ca	meq/100g of soil	2.51	8.23
EXCHANGEABLE MAGNESIUM	Mg	meq/100g of soil	3.26	1.90
EXCHANGEABLE SODIUM	Na	meq/100g of soil	0.99	< 0.63
EXCHANGEABLE POTASSIUM	K	meq/100g of soil	0.4	0.63
EXCHANGEABLE HYDROGEN	H	meq/100g of soil	6.7	
ADJ. EXCHANG. HYDROGEN	H	meq/100g of soil	5.5	< 1.90
CATION EXCHANGE CAPACITY	CEC		13.86	
ADJUSTED CEC	Adj.CEC		12.66	
EXCH. SODIUM PERCENTAGE	ESP		7.14	< 5
CALCIUM / MAGNESIUM RATIO	Ca/Mg		0.77	2 - 4
BASE SATURATION PERCENTAGE	BSP		54	

ITEMS		PERCENTAGE OF ADJUSTED CEC	DESIRABLE LEVEL
EXCHANGEABLE CALCIUM	Ca	19.8	65-70%
EXCHANGEABLE MAGNESIUM	Mg	25.8	12-15%
EXCHANGEABLE SODIUM	Na	7.8	0.5-5%
EXCHANGEABLE POTASSIUM	K	3.2	3-5%
EXCHANGEABLE HYDROGEN	H	43.4	<20%



- Phosphorus fixation effects if Iron is more than 300 ppm
- Manganese will be at toxicity level if it reaches 500 ppm





2974 kg of Calcium is needed to raise the Available Calcium to 68% and/or Exchangeable Calcium to 65%

GYPSUM REQUIREMENT	7.14 t/ha			
LIME REQUIREMENT	3.33 t/ha			
DOLOMITE REQUIREMENT	0 t/ha			
MAGNESIUM SULPHATE	0 kg/ha	or	MAGNESIUM OXIDE	0 kg/ha

TOTAL FERTILISER REQUIREMENT (kg/ha)	N	P	K	S
	23	30	73	0

with Trace Elements:

COPPER	1.5	kg/ha
ZINC	3.75	kg/ha
COBALT	0	kg/ha
MOLYBDENUM	0.025	kg/ha
IRON	0	kg/ha
MANGANESE	0	kg/ha
BORON	0.75	kg/ha

B1

Horizon

SAMPLE ID : B1 26-110 CM
DEPTH OF SAMPLE (cm): 26 to 110

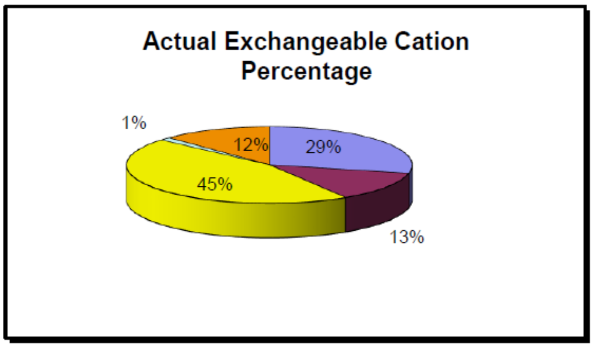
REFERENCE PHONE :
DATE RECEIVED : 30/04/2018
ANALYSIS REQUIRED : Full (ST-1)
No recommendations

ITEMS			RESULTS
pH(1:5 Water)*			8.2
pH(1:5 0.01M CaCl2)*			7.79
Electrical Conductivity*	EC	µS/cm	380
TOTAL SOLUBLE SALT	TSS	ppm	1254
AVAILABLE CALCIUM*	Ca	ppm	490
AVAILABLE MAGNESIUM*	Mg	ppm	1058.4
AVAILABLE SODIUM*	Na	ppm	1278.8
AVAILABLE NITROGEN	N	ppm	24.7
AVAILABLE PHOSPHORUS*	P	ppm	0.33
AVAILABLE POTASSIUM*	K	ppm	95.94
AVAILABLE SULPHUR*	S	ppm	32.8
AVAILABLE COPPER*	Cu	ppm	1.93
AVAILABLE ZINC*	Zn	ppm	1.15
AVAILABLE IRON	Fe	ppm	12
AVAILABLE MANGANESE*	Mn	ppm	15
AVAILABLE COBALT	Co	ppm	5.75
AVAILABLE MOLYBDENUM	Mo	ppm	0.45
AVAILABLE BORON*	B	ppm	0.37
TOTAL ORGANIC MATTER*	OM	%	0.6
TOTAL ORGANIC CARBON*	OC	%	0.3
TOTAL PHOSPHORUS*	TP	ppm	not required
EXTRACTABLE ALUMINIUM*	Al	ppm	not required
TOTAL NITROGEN*	N	%	not required
TOTAL CALCIUM	Ca	ppm	not required
TOTAL MAGNESIUM	Mg	ppm	not required
CHLORIDE	Cl	ppm	not required
AVAILABLE SILICA	Si	ppm	not required

*This laboratory has been awarded a Certificate of Proficiency for specific soil and plant tissue analyses by the Australiasian Soil and Plant Analysis Council (ASPAC). Test for which proficiency has been demonstrated are highlighted in this report.

ITEMS			RESULTS
EXCHANGEABLE CALCIUM	Ca	meq/100g of soil	1.92
EXCHANGEABLE MAGNESIUM	Mg	meq/100g of soil	6.91
EXCHANGEABLE SODIUM	Na	meq/100g of soil	4.35
EXCHANGEABLE POTASSIUM	K	meq/100g of soil	0.19
EXCHANGEABLE HYDROGEN	H	meq/100g of soil	2.2
ADJ. EXCHANG. HYDROGEN	H	meq/100g of soil	1.9
CATION EXCHANGE CAPACITY	CEC		15.57
ADJUSTED CEC	Adj.CEC		15.27
EXCH. SODIUM PERCENTAGE	ESP		27.94
CALCIUM / MAGNESIUM RATIO	Ca/Mg		0.28
BASE SATURATION PERCENTAGE	BSP		89

ITEMS		PERCENTAGE OF ADJUSTED CEC
EXCHANGEABLE CALCIUM	Ca	12.6
EXCHANGEABLE MAGNESIUM	Mg	45.3
EXCHANGEABLE SODIUM	Na	28.5
EXCHANGEABLE POTASSIUM	K	1.2
EXCHANGEABLE HYDROGEN	H	12.4



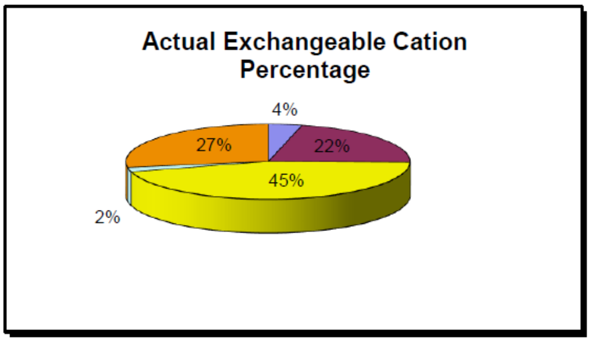
C1 Horizon

SAMPLE ID :	C1 275-350 CM	REFERENCE :	
		REFERENCE PHONE :	
DEPTH OF SAMPLE (cm):	275 to 350	DATE RECEIVED :	30/04/2018
		ANALYSIS REQUIRED :	Full (ST-1)
			No recommendations

ITEMS			RESULTS
pH(1:5 Water)*			7
pH(1:5 0.01M CaCl2)*			6.37
Electrical Conductivity*	EC	µS/cm	27.7
TOTAL SOLUBLE SALT	TSS	ppm	91.41
AVAILABLE CALCIUM*	Ca	ppm	192.4
AVAILABLE MAGNESIUM*	Mg	ppm	243.6
AVAILABLE SODIUM*	Na	ppm	40.02
AVAILABLE NITROGEN	N	ppm	0.856
AVAILABLE PHOSPHORUS*	P	ppm	12.6
AVAILABLE POTASSIUM*	K	ppm	33.345
AVAILABLE SULPHUR*	S	ppm	0.414
AVAILABLE COPPER*	Cu	ppm	0.72
AVAILABLE ZINC*	Zn	ppm	0.67
AVAILABLE IRON	Fe	ppm	51
AVAILABLE MANGANESE*	Mn	ppm	10
AVAILABLE COBALT	Co	ppm	2.76
AVAILABLE MOLYBDENUM	Mo	ppm	0.13
AVAILABLE BORON*	B	ppm	0.28
TOTAL ORGANIC MATTER*	OM	%	0.3
TOTAL ORGANIC CARBON*	OC	%	0.15
TOTAL PHOSPHORUS*	TP	ppm	not required
EXTRACTABLE ALUMINIUM*	Al	ppm	not required
TOTAL NITROGEN*	N	%	not required
TOTAL CALCIUM	Ca	ppm	not required
TOTAL MAGNESIUM	Mg	ppm	not required
CHLORIDE	Cl	ppm	not required
AVAILABLE SILICA	Si	ppm	not required

ITEMS			RESULTS
EXCHANGEABLE CALCIUM	Ca	meq/100g of soil	0.9
EXCHANGEABLE MAGNESIUM	Mg	meq/100g of soil	1.89
EXCHANGEABLE SODIUM	Na	meq/100g of soil	0.16
EXCHANGEABLE POTASSIUM	K	meq/100g of soil	0.08
EXCHANGEABLE HYDROGEN	H	meq/100g of soil	1.3
ADJ. EXCHANG. HYDROGEN	H	meq/100g of soil	1.15
CATION EXCHANGE CAPACITY	CEC		4.33
ADJUSTED CEC	Adj.CEC		4.18
EXCH. SODIUM PERCENTAGE	ESP		3.7
CALCIUM / MAGNESIUM RATIO	Ca/Mg		0.47
BASE SATURATION PERCENTAGE	BSP		71

ITEMS		PERCENTAGE OF ADJUSTED CEC
EXCHANGEABLE CALCIUM	Ca	21.5
EXCHANGEABLE MAGNESIUM	Mg	45.2
EXCHANGEABLE SODIUM	Na	3.8
EXCHANGEABLE POTASSIUM	K	1.9
EXCHANGEABLE HYDROGEN	H	27.5



Appendix 2: Murray Alluvium Hydrogeological Landscape (OEH 2015)

4. Murray Alluvium Hydrogeological Landscape

LOCALITIES	**South Albury, Cooks Lagoon, Lesters Lagoon**
MAP SHEET	**Jerilderie 1:250 000** **Wangaratta 1:250 000**
CONFIDENCE LEVEL	**Low**

OVERVIEW

The Murray Alluvium Hydrogeological Landscape (HGL) extends along the Murray River from Lake Hume to the edge of the study area at Walbundrie (Figure 1). The HGL covers an area of 95 km^2 and receives 550 to 700 mm of rain per annum. This is a regulated river system.

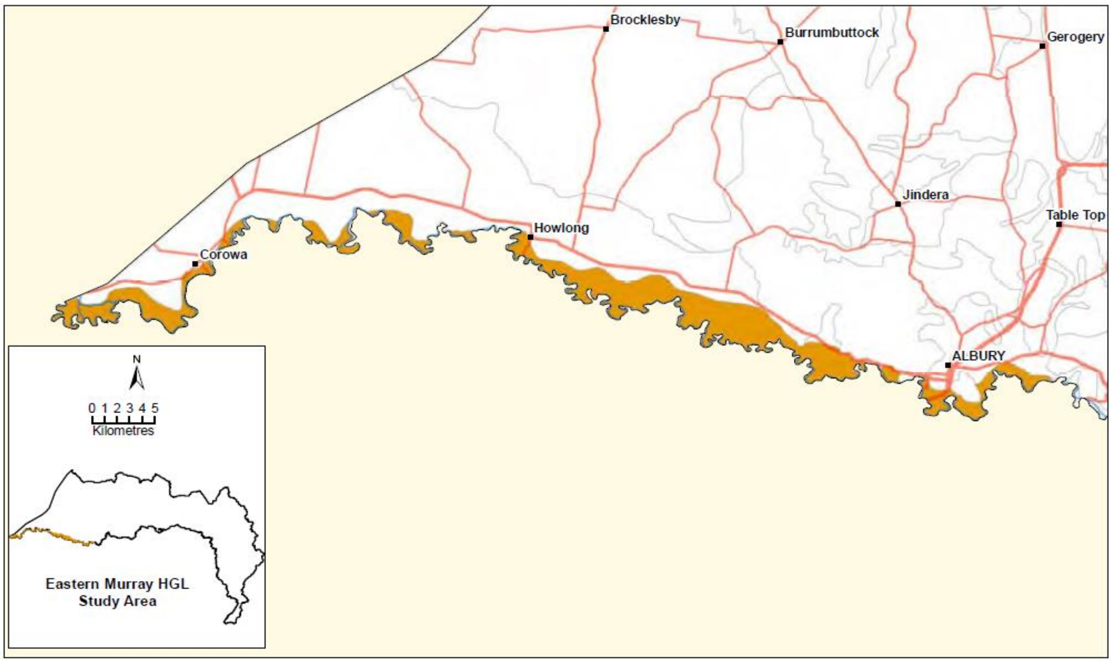


Figure 1: Murray Alluvium HGL distribution map.

The Murray Alluvium HGL is a depositional environment characterised by alluvial floodplains with flood-runners, ox-bows and levees (Figure 2). This HGL comprises unconsolidated Quaternary channel and flood plain sediments. Typically these are sands, gravels and clays. Small patches of windblown sand occur locally as sandy rises. Topsoils in logged and cleared areas are generally thinner and have less organic carbon than undisturbed areas. Stream-bank erosion and compaction due to vehicular traffic are the most common land degradation issues in this HGL.

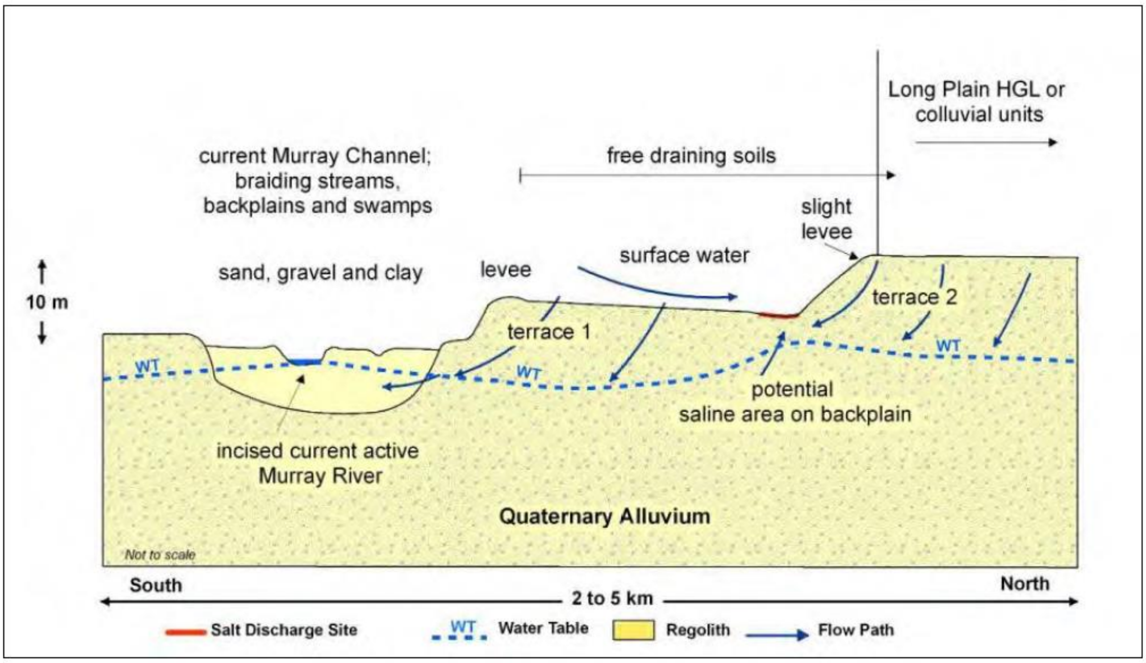


Figure 2: Conceptual cross-section for Murray Alluvium HGL showing the distribution of regolith and landforms, salt sites if present, and flow paths of water infiltrating the system.

Land salinity is occasionally observed on the back plain adjacent to the Long Plain HGL. Impacts from salt load and EC are low (Table 1).

Table 1: Murray Alluvium HGL salinity expression.

SALINITY EXPRESSION	
Land Salinity (Occurrence)	Low – land salinity is occasionally observed on the back plain adjacent to the Long Plain HGL
Salt Load (Export)	Low – main Murray River flow is fresh; little local load impact
EC (Water Quality)	Low – dominated by Murray River / Lake Hume influences

Salt stored within the Murray Alluvium HGL has moderate mobility. There is a moderate salt store that has moderate availability (Table 2).

Table 2: Murray Alluvium HGL salt store and availability.

SALT MOBILITY			
	Low availability	**Moderate** availability	**High** availability
High salt store			
Moderate salt store		**Murray Alluvium**	
Low salt store			

The overall salinity hazard in the Murray Alluvium HGL is very low. This is due to the low likelihood that salinity issues will occur that have potentially limited impacts (Table 3).

Table 3: Likelihood of salinity occurrence, potential impact and overall hazard of salinity for the Murray Alluvium HGL.

OVERALL SALINITY HAZARD			
	Limited potential impact	**Significant** potential impact	**Severe** potential impact
High likelihood of occurrence			
Moderate likelihood of occurrence			
Low likelihood of occurrence	**Murray Alluvium**		

LANDSCAPE FEATURES

The following photographs illustrate landscapes and specific features observed in this HGL. Information used to define the HGL is summarised in Table 4.

Photo 1: Distinct river terraces are a characteristic feature of the Murray Alluvium landscape at Howlong (Photo: OEH/A Nicholson).

Photo 2: The Murray Alluvium HGL has a floodplain adjacent to the Murray River (far background) that is broad in places and has small streams adjacent to terrace elements (Photo: OEH/A Nicholson).

Photo 3:The flat flood plain above an area of stream-bank erosion is common in the Murray Alluvium HGL (Photo: OEH/A Nicholson).

Photo 4:At Wirlinga, upstream of Albury, the alluvial floodplain of the Murray Alluvium HGL is broad and cleared, and is primarily used for grazing (Photo: OEH/R Muller).

Photo 5: The broad floodplain adjacent to the Murray River at Wirlinga is characteristic of the wider sections of the Murray Alluvium HGL (Photo: OEH/R Muller).

Table 4: Summary of information used to define the Murray Alluvium HGL.

Lithology *(Raymond et al. 2007; Geoscience Australia 2011)*	This HGL comprises unconsolidated Quaternary channel and flood plain sediments: • alluvium – gravel, sand, silt and clay.
Annual Rainfall	550–700 mm
Regolith and Landforms	The Murray Alluvium HGL is variably weathered and is characterised by broad level alluvial plains of Quaternary sediments deposited by the Murray River system, downstream of Lake Hume. The river is inset 3–5 m below adjacent alluvial plains, and was subject to seasonal flooding prior to river regulation. Slopes are typically 0–5%, but up to 50% on banks, local relief is <10m and this HGL is between 60–160 m elevation. The HGL features stream channels and banks, flood-runners, ox-bows, levees, and floodplains. Regolith materials are unconsolidated interbedded clay, silt, sand and gravel, Quaternary to Recent riverine deposits of the Murray River. Due to the dynamic nature of alluvial deposition and reworking, the distribution of materials is highly variable and challenging to predict.

Soil Landscapes *(DECCW 2010)*	This HGL corresponds closely to Wakool River soil landscape. Small patches of the Wait-a-While soil landscape occur on areas of stagnant alluvial plain. Soils are typically: Epipedal and Crusty Grey and Black Vertosols (Cracking Grey Clays) and Eutrophic Brown Chromosols (Brown Clays) occurring along floodplains. Silty/fine sandy Grey Kandosols (Grey Earths/Alluvial Soils) occur locally along channels where pedogenesis has yet to alter materials. Small patches of windblown sand also occur locally as sandy rises, commonly overlying sodic clays at depth – sandy Brown Sodosols and Arenic Rudosols (NSG). Red and Brown Sub-plastic Chromosols and Sodosols (Red-brown Earths/transitional Red-brown Earths) are found at the upper margins of the HGL, well away from the active river course. Topsoils in logged or cleared areas are generally thinner and have less organic carbon than undisturbed areas. Salt is often associated with particular stratigraphic soil layers.
Land and Soil Capability *(OEH 2012)*	Class 3
Land Use	Cropping and grazing, with large areas wetlands and areas of urban development around Albury and towns along the Murray River
Key Land Degradation Issues	• stream-bank erosion on outside meander bends • some soil compaction due to vehicle access.
Native Vegetation *(Stelling 1998; Keith 2004)*	Vegetation within Murray Alluvium HGL is typically river red gum woodland which has characteristically developed on the riverine deposits of clay, silt, sand and gravel surrounding the Murray River, forming alluvial loams and clay soils. Tree species can include *E. camaldulensis* (river red gum) along with *E. bridgesiana* (apple box) where the soils are moderately fertile and well drained, *E. blakelyi* (Blakely's red gum), *E. bridgesiana* (apple box) and *Acacia dealbata* (silver wattle), and *Callitris glaucophylla* (white cypress pine) and *E. melliodora* (yellow box) on lighter soils. Understorey species may include *Acacia acinacea* (gold-dust wattle), *A. paradoxa* (kangaroo thorn), *Callistemon sieberi* (river bottlebrush), *Exocarpos strictus* (dwarf cherry) and *Bursaria spinosa* (sweet bursaria).

HYDROGEOLOGY

Aquifers within this landscape are unconfined with groundwater flow occurring primarily through unconsolidated alluvial sediments. Hydraulic conductivity and transmissivity are moderate to high. Groundwater recharge rates are estimated to be high.

Groundwater systems are typically local with short flow lengths, and are loosely defined by topographic catchments. Water quality within these systems is fresh to marginal. Watertable depths are shallow to intermediate. Localised perching of watertables occurs above clay lenses during wetter periods.

Short to medium residence times are typical. These landscapes have a medium to fast response time to changes in land management.

Typical values for the hydrogeological parameters of this HGL are summarised in Table 5.

Table 5: Summary of values for typical hydrogeological parameters of the Murray Alluvuim HGL.

Aquifer Type	Unconfined in unconsolidated alluvial sediments Vertical and lateral flow components Local perching above clay-rich layers (seasonal)
Hydraulic Conductivity	Moderate to high Range: 10^{-2}–>10 m/day
Aquifer Transmissivity	Moderate to high Range: 2–>100 m^2/day
Specific Yield	Moderate to high Range: 5–>15%
Hydraulic Gradient	Gentle Range: <10%
Groundwater Salinity	Fresh to marginal Range: <1600 µS/cm
Depth to Watertable	Shallow to intermediate (localised perching) Range: <8 m
Typical Sub-Catchment Size	Small (<100 ha)
Scale (Flow Length)	Local Flow length: <5 km (short)
Recharge Estimate	High
Residence Time	Short to medium (months to years)
Responsiveness to Change	Fast to medium (months to years)

MANAGEMENT OPTIONS

Overarching salinity management strategies have specific biophysical outcomes. These are achieved by implementing a series of targeted land management actions that take into account the opportunities and constraints of the particular HGL. The actions recognise the need for diffuse and specific activities within the landscape to impact on salinity. Further explanation of land management functions, strategies and actions can be found in Wooldridge *et al.* (2015).

Salinity is driven by interactions between water-use capacity of vegetation, physical soil properties and hydrogeological processes within the HGL.

Actions that influence the way water is used by vegetation or stored in the soil profile will have impacts on recharge. The influence of both continual and episodic recharge and the impacts of extreme weather events need to be considered when deciding on appropriate management actions. Short and long-term climate cycles also need to be considered as they have a bearing on salinity processes, particularly salt load and land salinity.

Landscape Salinity Functions – Murray Alluvium HGL

Functions this landscape provides within a catchment scale salinity context:

- **A**. The landscape provides fresh water runoff as an important water source
- **B.** The landscape provides fresh water runoff as an important dilution flow source
- **C.** The landscape provides important base flows to local streams
- **E.** The landscape receives and stores salt load through irrigation or surface flow.

Management Strategy Objectives – Murray Alluvium HGL

Appropriate overall strategies pertinent to this landscape:

- **Maintain or maximise runoff (10):** This unit conducts large water flows which are mostly influenced by large storages and the runoff from other landscapes.
- **Discharge rehabilitation and management (4):** Salt sites are not common and generally exhibit minor salinity symptoms. The sites are frequently waterlogged. Discharge management will improve on-site and off-site salinity outcomes.

Key Management Focus – Murray Alluvium HGL

Management should be closely linked to river and flow management. This HGL will not have large impacts on the salinity outcome within the Murray River. It is the transition zone for water derived from other landscapes.

Specific Land Management Opportunities

Specific opportunities for this HGL:

- There are wetland management opportunities in this HGL.

Specific Land Management Constraints

Constraints for land management in this HGL include:

- Areas with in this HGL are impacted by flow regimes and flooding.

Specific Targeted Actions

Management areas for this HGL are illustrated in Figure 3. The specific management actions for these areas are described in Table 6.

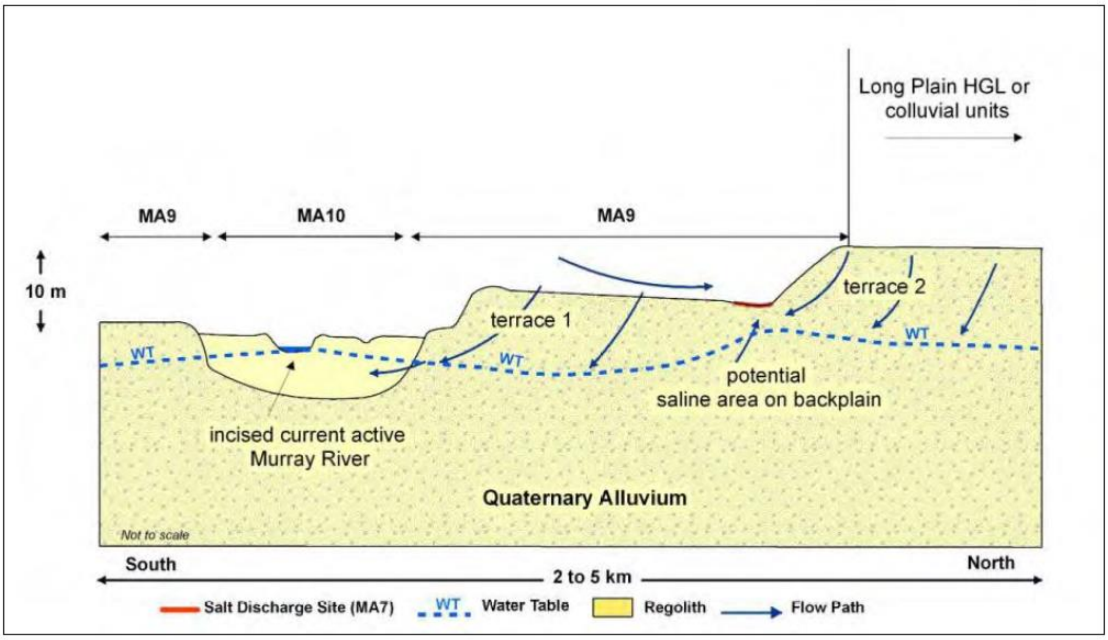


Figure 3: Management cross-section for Murray Alluvium HGL showing defined management areas.

Table 6: Specific management actions for management areas within the Murray Alluvium HGL.

Management Area (MA)	Action
MA9 (ALLUVIAL PLAIN)	**Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3).** Maintain and improve riparian native vegetation to reduce discharge to streams **(VE4).** **Vegetation for production** Improve grazing management of existing perennial pastures to manage recharge (**VP1).**
MA10 (ALLUVIAL CHANNEL)	**Vegetation for ecosystem function** Maintain and improve existing native woody vegetation to reduce discharge **(VE3).** Maintain and improve riparian native vegetation to reduce discharge to streams **(VE4).**

High Hazard Land Use

There are some management actions that should be discouraged in this HGL as they will have negative impacts on salinity (Table 7).

Table 7: Management actions having negative salinity impacts in the Long Plain HGL.

At Risk Management Areas	Action
MA9/10 (ALLUVIAL PLAIN)	Locating infrastructure on discharge areas **(DLU7).** Irrigation using inefficient on-farm water delivery practices **(DLU13).**

REFERENCES

DECCW, 2010, *Reconnaissance soil and land resources of the Murray CMA*, NSW Department of Environment, Climate Change and Water, Sydney

Geoscience Australia, 2011, *Australian stratigraphic units database*, Canberra, Australia, [Accessed: 10 November 2014] http://dbforms.ga.gov.au/www/geodx.strat_units.int

Keith, D. A. 2004, *Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT*, Hurstville, NSW Department of Environment and Conservation

OEH, 2012, *The land and soil capability assessment scheme second approximation, a general rural land evaluation system for New South Wales*, OEH Sydney, [Accessed: 10 November 2014] www.environment.nsw.gov.au/resources/soils/20120394lsc2s.pdf

Raymond, O.L., Lui, S., Kilgour, P., Retter, A.J., Stewart, A.J. and Stewart, G. 2007, *Surface geology of Australia 1:1,000,000 scale, New South Wales – 2nd edition*, Geoscience Australia, Canberra, Australia

Stelling, F. 1998, *South west slopes revegetation guide (south of the Murrumbidgee River)*, Murray Catchment Management Committee / NSW Department of Land and Water Conservation, Albury

Wooldridge, A., Nicholson, A., Muller R., Jenkins, B. R., Wilford, J. and Winkler, M. 2015, *Guidelines for managing salinity in rural areas*, NSW Office of Environment and Heritage, Sydney, NSW

Appendix 3: Revegetation Planting Guide - Specifications for revegetation

Revegetation can occur using several methods including planting seedlings, direct seeding and precluding stock to allow natural regeneration.

The most certain method to achieve success with revegetation works is to plant seedlings. The following plant and establishment specifications apply to planted trees and understory species. Natural regeneration from the planted trees will start to occur after about 10 to 15 years, depending on the seasonal conditions. Some natural regeneration will also occur in the vicinity of remnant trees if grazing pressure is removed.

Native grasses should also be included in the revegetation planning. This is best scheduled six to twelve months after trees and shrub species have become established.

Soil assessment,

Soils in areas to be revegetated should be assessed in the laboratory for pH and sodicity. Alkaline soils (less than pH 9) will not generally inhibit the growth of indigenous native floodplain species. If soils are more alkaline than pH 9 it is generally due to high sodicity which can be remediated with gypsum. These soils should have been already identified in the overburden removal process and placed at depths of more than 3 m in the rehabilitation process. If soils display an Exchangeable Sodium Percentage greater than 5% then the rate of gypsum application will need to be determined by laboratory analysis.

Acidic soils (if less than pH 5.5) should have lime applied at a rate which will need to be determined by laboratory analysis.

Lime and gypsum applications, where required can be distributed (1 m width) along the planting line, rather than broadcast across the whole revegetation area.

Site preparation

Ripping – Tree rows, generally 4 m to 5 m apart, will need to be deep ripped to a depth of 60 cm. A winged ripper should be used so as not to disrupt topsoil integrity.

Topsoil cultivation - Topsoil will need to be cultivated to a good tilth to a depth of 10-15 cm.

Plants

Trees are to be supplied as large seedlings or tubes with a top height of 10-15 cm. (Plants must be checked in the nursery for “J” rooting. Direct seeded seedlings should not suffer from the “J” rooting problem, but tube stock can often be sub-standard in this regard. This stock quality check needs to be conducted at the point of supply, well in advance of planting stock delivery.

Planting

Planting should commence following autumn rainfall sufficient to sustain the plants. The top of the soil plug should be covered by 2-5 cm of topsoil to reduce evaporation. Follow-up watering may need to be considered in contracts.

Guards

Milk carton guards and two bamboo stakes could be applied to each tree. Alternatively a baiting program and contract spotlighting should be conducted. A handful of blood and bone fertilizer can be used as a deterrent for hares and rabbits. Generally it is cheaper to replace trees that have been browsed. Close monitoring is required.

Pest control

The impact of pests, such as insects, will need specific assessment as to their economic impact and recommendations on control will depend on the type and stage of development of insects.

Weed control

Weed control will be required following plant establishment. Without chemical weed control or mulch, survival is reduced and growth severely depressed. Simazine (6kg/ha) could be applied in a 2 m strip over the trees prior to weed emergence. Alternatively a knockdown organic herbicide, such as ‘Slasher’ could be used around the trees after weeds and grasses have germinated. Early control is required and a follow-up application may be necessary to get effective results.

Watering

Plants should be watered in at the time of planting, unless soil moisture conditions and seasonal conditions are such that survival is ensured.

Timing

Planting can occur following autumn and spring rains up until the end of September.

Survival

95 % survival should be achieved within six months of planting.

Indigenous revegetation - Spacing

Low –medium trees and shrubs - 2.5 m between plants.

Tall growing species - 4 m between plants.

Between rows spacing: 4 m.

Distance from fences 2.5 m.

On-going management

Following establishment regular inspections should be conducted to ensure that optimum growth conditions and plantation and revegetation performance. Various aspects such as, watering programs and weed management will require further planning and implementation.

This page has intentionally been left blank