Appendix J. Groundwater Impact Assessment (Tonkin, 2021)

Groundwater Impact Assessment

Buronga Landfill Expansion

Wentworth Shire Council

19 September 2021
Ref: 202597R03

Building exceptional outcomes together

Document History and Status

Rev	Description	Author	Reviewed	Approved	Date
A	DRAFT for Client comment	DAN (CEnvP SC)	MRS	MRS	22/04/2021
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Client: Wentworth Shire Council
Ref: 202597R03

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1 Introduction

Tonkin was commissioned by the Wentworth Shire Council (Council) to undertake a Groundwater Impact Assessment (GIA) to provide information for inclusion into an Environmental Impact Statement (EIS), which is required as part of the Development Application for the expansion of the Buronga Landfill. The location of the landfill site is presented following on Figure 1.

Wentworth Shire Council (Council) has identified that the predicted volume of waste requiring disposal at the Buronga Landfill is likely to increase beyond the current approved limit of 30,000 tonnes per annum. Council is therefore seeking approval to increase the waste disposal limit to 100,000 tonnes per annum to provide regulatory confidence in anticipation of future throughput and expand the landfill to areas north of the exiting footprint.

This assessment pertains to the potential groundwater impacts of the use of the site as a waste landfill consistent with the siting restrictions as outlined in Environmental Guidelines: *Solid Waste Landfills* (NSW EPA, 2016) and to address the NSW Planning & Environment Planning SEARs.

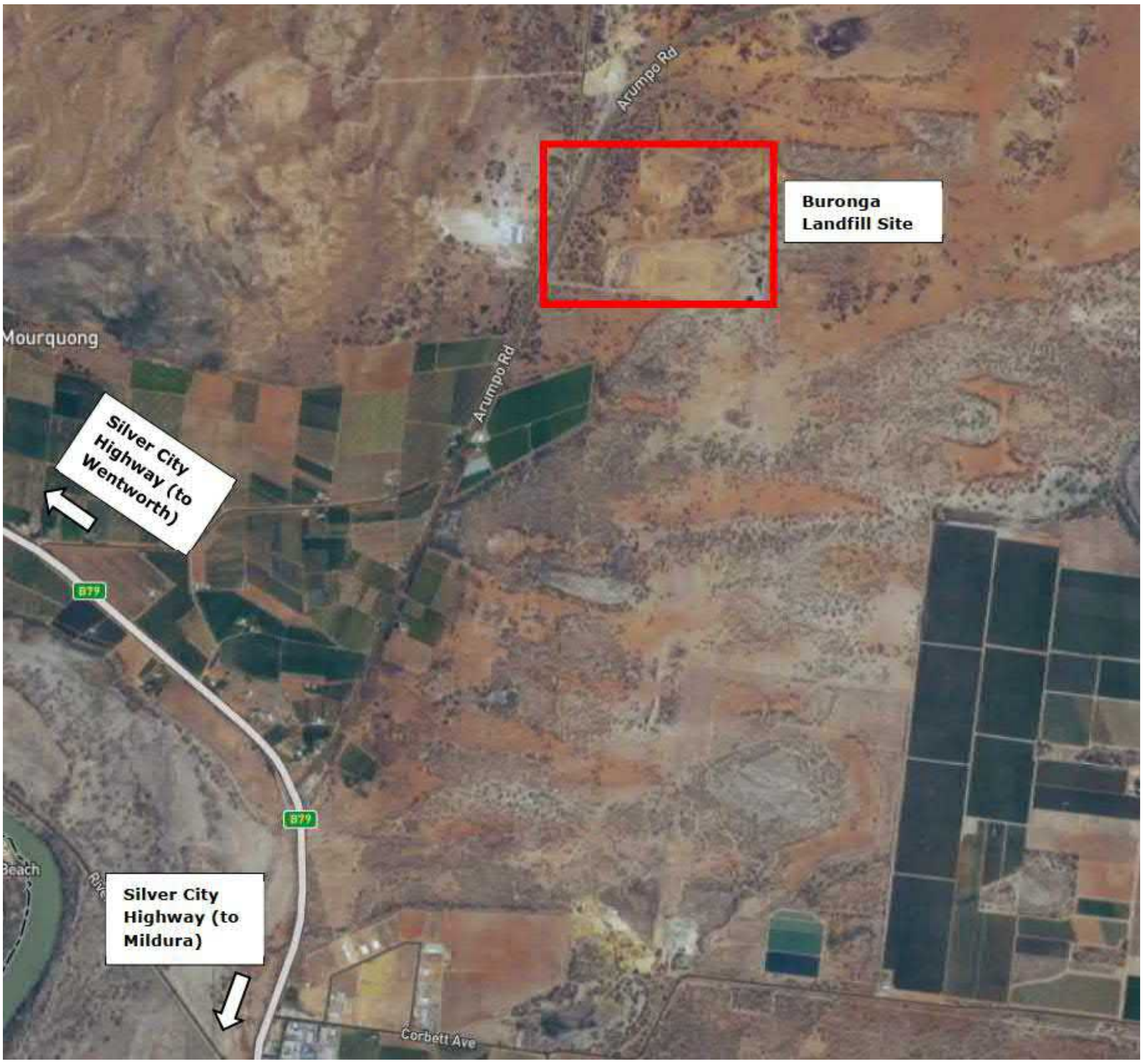

Figure 1 **Site Location Plan**

1.1 Site History and Operation

The site was first used for waste disposal in 1934. In 1967, the Local Government Gazettal notes Reserve No. 86496 (which contains the site) was trusted to the Wentworth Shire Council under the Public Trusts Act 1897 (NSW) for use in landfilling. Since 2015 the facility has been operated by the Wentworth Shire Council, from 2011-2015 the waste facility was operated by a private contractor. The site was operational for many years before the private contractor took over management of the site. The site is licenced by the NSW EPA under the Protection of the Environment Operations Act 1997, with Wentworth Shire Council holding Licence number 20209. The current licence was issued 5 April 2013 and was most recently varied on 24 November 2017. The site is operated under the conditions required by this licence, as well as by the Landfill Environmental Management Plan (LEMP) (WSC, 2015). The LEMP sets out operational procedures protecting human health and the environment from impact by the operations at the Buronga Landfill.

The first lined landfill cell was completed in 2017 and designed and constructed in accordance with the NSW EPA Environmental Guidelines for Solid Waste Landfills (NSW EPA, 2016) hereafter referred to as the NSW Landfill Guidelines. EPA approval of this cell was received in November 2017, following this approval landfilling commenced in the new lined cell. A community recycling centre (CRC) operates at the site, constructed in accordance with the NSW Environmental Trust Community Recycling Centre Grants Program.

1.2 Objectives

The primary objective of this report is to provide background information in support of the EIS. The focus of this document is to provide information on the existing environment and constraints for the proposed landfill expansion and provide an assessment of the likely impacts involved.

This report has been specifically prepared to provide a description of the existing groundwater environment, including:

- Bores within and surrounding the landfill Site;
- Springs and outflow zones;
- Groundwater dependent ecosystems;
- Aquifers underlying and in the vicinity of the project site; and
- Water quality in identified aquifers.

The objectives of the groundwater impact assessment include an assessment of the likely short term and long-term impacts of the proposed development on groundwater resources in the vicinity of the project site.

2 Scope of Works

The scope of works for this groundwater impact assessment includes the following:

- Summary of relevant legislation
- Detailed review of the site setting
- Review of offsite and onsite registered bores and construction details,
- Insight into groundwater availability and licensing within the investigation area
- Description of the existing subsurface and groundwater environment within the investigation area
- Identification of groundwater related environmental values (registered bore users and groundwater dependent ecosystems) with a two-kilometre buffer around the investigation area (hereafter, referred to as the ‘investigation buffer’) through a review of the following:
  - geological maps, Bureau of Meteorology’s (BoM) Groundwater Dependent Ecosystem (GDE) Atlas and National Groundwater Information System (NGIS) database search for registered bores
  - groundwater level and groundwater quality related to the investigation area and project buffer
  - climatic data (rainfall and evapotranspiration) from the nearest available source to the investigation area
- Identification of possible groundwater systems to be utilised as future resources

3 Regulatory Context

The following sections outline the Commonwealth and State legislation are relevant to the management of groundwater and water resources within the investigation area.

3.1 Commonwealth

Commonwealth guidelines relevant to the management of groundwater include:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (ANZECC/ ARMCANZ, 2000).
- Australian Drinking Water Guidelines (NHMRC, 2011).
- The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

3.2 State Based Legislation

There are two key parts of legislation for the management of groundwater in NSW:

- Water Act (1912); and
- Water Management Act 2000 (WMA 2000).

In addition to the above Acts, the relevant plans, policies and regulation are considered the main tools which assist in implementing and defining the provisions of the WMA:

- The Water Management (General) Regulation (2011);
- Water Sharing Plans (WSPs):
  - Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources (2012);
  - Water Sharing Plan for the Macquarie-Bogan Unregulated and Alluvial Water Sources (2012):
- The NSW State Groundwater Dependent Ecosystem Policy (2002);
- The NSW Aquifer Interference Policy 2012 (September 2012);
- The NSW Groundwater Policy Framework Document – General (1997);
- The NSW Groundwater Quality Protection Policy (1998);
- The NSW State Rivers and Estuaries Policy (1993); and
- The NSW Wetlands Policy (2010)

3.2.1 Water Management Act (2000)

Water resources are administered under the Water Act (1912) and the Water Management Act (2000) by the NSW Department of Industries – Water (DoI-W). The Water Management Act (2000) governs the issue of water access licences and approvals for those water sources (rivers, lakes, estuaries and groundwater) in New South Wales where Water Sharing Plans have commenced. Water sharing plans establish rules for sharing water between the environmental needs of the river or aquifer and water users, and also between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation. The Water Act (1912) governs the issue of water licences for water sources in other areas. There are Water Sharing Plans for regulated and unregulated river catchments and groundwater sources in water management areas.

The Water Management Act 2000 requires approvals for activities that impact the aquifer(s). The approval is for activities that intersect groundwater other than water supply bores and may be issued for up to ten years. Part 2 of the Water Management Act 2000 establishes access licences for the taking of water within a particular water management area.

Part 3 of the Water Management Act 2000 establishes three types of approvals that a proponent may be required to obtain. These are:

- water use approvals.
- water management work approvals (including water supply work approvals).
- activity approvals (including controlled activity approvals and aquifer interference approvals).

To construct a test or monitoring bore a 'Water Supply Work Approval' form, which can be downloaded from the DoI – W website, is required to be completed and submitted to the nearest DoI – W office. To construct a production bore the same form must be filled out together with a 'Water Use Approval' form.

3.2.2 Water Sharing Plans

Water Sharing Plans (WSPs)have been developed for rivers and groundwater systems across NSW following the introduction of the WMA. Water Sharing Plans made under the WMA are being prepared as Minister's plans under Section 50 of the Act. These plans protect the health of NSW rivers and groundwater while also providing water users with perpetual access licences, equitable conditions, and increased opportunities to trade water through separation of land and water.

WSPs provide a legislative basis for sharing water between the environment and consumptive purposes. Under the WMA, a plan for the sharing of water must protect each water source and its dependent ecosystems and must protect basic landholder rights.

The site sits within the Western Porous Rock water sharing plan which covers groundwater located within the sedimentary basins in the NSW portion of the Murray-Darling Basin. The plans also includes alluvial sediments that overly these basins that have not been separately mapped and incorporated into other WSPs as individual SDL resource units.

Whilst groundwater from these basins tends to be obtained from their porous rock layers, they also include sediment layers that do not have significant porosity. The SDL resource units include all groundwater from the entire geological basin sequence, including groundwater within these interbedded fractured rock sediments.

Twenty eight percent of these groundwater resource units are buried under other alluvial or fractured basalt groundwater WRP resources.

3.2.3 NSW State Groundwater Dependant Ecosystems Policy (2002)

The NSW Groundwater Dependent Ecosystems Policy is specifically designed to protect valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations. The policy defines GDEs as "communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater".

Five management principles establish a framework by which groundwater is managed in ways that ensure, whenever possible, that ecological processes in dependent ecosystems are maintained or restored. The principles are:

- GDEs can have important values. Threats should be identified, and action taken to protect them;
- Groundwater extractions should be managed within the sustainable yield of aquifers;

- Priority should be given to GDEs, such that sufficient groundwater is available at all times to meet their needs;
- Where scientific knowledge is lacking, the precautionary principle should be applied to protect GDEs; and
- Planning, approval and management of developments should aim to minimise adverse effects on groundwater by maintaining natural patterns, not polluting or causing changes to groundwater quality and rehabilitating degraded groundwater.

3.2.4 NSW Aquifer Interference Policy (2012)

The Aquifer Interference Policy forms the basis for assessment of aquifer interference activities under the EPA Act. It clarifies the need to hold water access licences or Water licences (as the case may be) under the WM Act and Water Act and establishes consideration in assessing whether 'minimal impact' occurs.

The WM Act defines an aquifer interference activity as that which involves any of the following:

- Penetration of an aquifer;
- Interference with water in an aquifer;
- Obstruction of the flow of water in an aquifer;
- Taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations; and
- Disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.

Examples of aquifer interference activities include mining, coal seam gas extraction, injection of water, and commercial, industrial, agricultural and residential activities that intercept the water table or interfere with aquifers.

3.2.5 Groundwater Quality Protection Policy

The objectives of managing groundwater quantity in NSW are:

- To achieve the efficient, equitable and sustainable use of the State's groundwater;
- To prevent, halt and reverse degradation of the State's groundwater and their dependent ecosystems;
- To provide opportunities for development which generate the most cultural, social and economic benefits to the community, region, state and nation, within the context of environmental sustainability; and
- To involve the community in the management of groundwater resources.

4 Project Site Setting

Buronga Landfill is located on Arumpo Road Buronga approximately 4.5 km north northeast of the township of Buronga, NSW. Access to the Landfill is via Arumpo Road with most landfill operations occurring in an area of approximately 19 ha, with the landfill footprint covering approximately 5 Ha. The Landfill is zoned SP2 (Waste or Resource Management Facility) and is surrounded by agricultural activities and remnant vegetation. A summary of the site details is shown in Figure 3.1 and Table 3.1 following.

Table 4.1 Site Identification Details

Aspect	Detail
Site Name	Buronga Landfill
Site Location	258 Arumpo Road, Wentworth, NSW, 2739
Landfill Area (ha)	Approximately 19 ha operational of a total 124 ha licenced area
Site Owner	Wentworth Shire Council
Site Occupier	Wentworth Shire Council
Certificate of Title	Lot 197 & 212 DP756946 and Lot 1 DP1037845
Current Zoning	Site - SP2 (Waste or Resource Management Facility) Surrounding Areas – RU1 (Primary Production)
Current Use	Solid Waste Landfill / Resource Recovery Centre
EPA Licence	Environmental Protection Licence (EPL) No. 20209
Regional Setting	Rural, Industrial, Agricultural
Surrounding Land Uses	NORTH: Broadscale agriculture (grazing), Arumpo Road
	EAST: Remnant vegetation, irrigated agriculture to SE, Lake Gol Gol (1.8 km)
	SOUTH: Remnant vegetation, irrigated agriculture to SW (grapevines, orchards)
	WEST: Arumpo Road, Industry including bentonite and gypsum suppliers, Mourquong saltwater disposal basin

4.1 Climate

According to Climate Data.org[1] the Buronga area is elevated approximately 43m above sea level and the climate is considered to be a local steppe climate. Rainfall is generally low throughout the year whilst the climate is classified as "Bsh" by the Koppen-Geiger system. The average annual temperature is 18.2 degrees centigrade and the annual rainfall is 274mm. The driest month is March with an average of only 16 mm of rain, whilst in September the precipitation reaches its peak in September with an average rainfall of 28 mm.

[1] https://en.climate-data.org/oceania/australia/new-south-wales/buronga-764924/#climate-graph

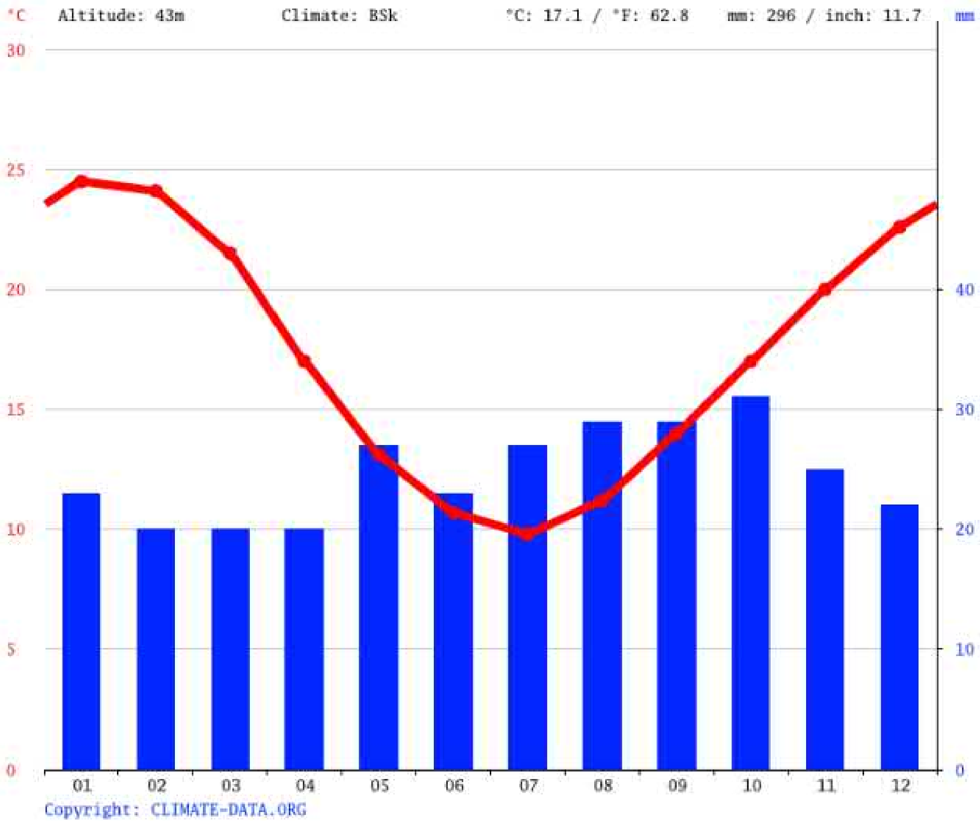

Figure 2 **Map of the Western Porous Rock © Commonwealth of Australia (Murray–Darling Basin Authority)**

4.2 Soil Profiles and Landscape

The site area lies on Tertiary and Quaternary sediments. These are subsequently overlain with the Woorinen Formation which are formed from windblown sands, silts, and calcareous clays from Quaternary deposits, and the Coonambidgal Formation which is comprised of alluvial deposits, and channel sands from the Holocene.

The soil regolith stability classification of the regional area is logged as "class R3" – relating to high coherence soils with high sediment delivery potential.

The likely soil types within the region range from vertosols (soil type in which there is a high content of expansive clay minerals) to Rudosols (Soils that have negligible pedologic organisation, the component soils vary widely in texture and depth).

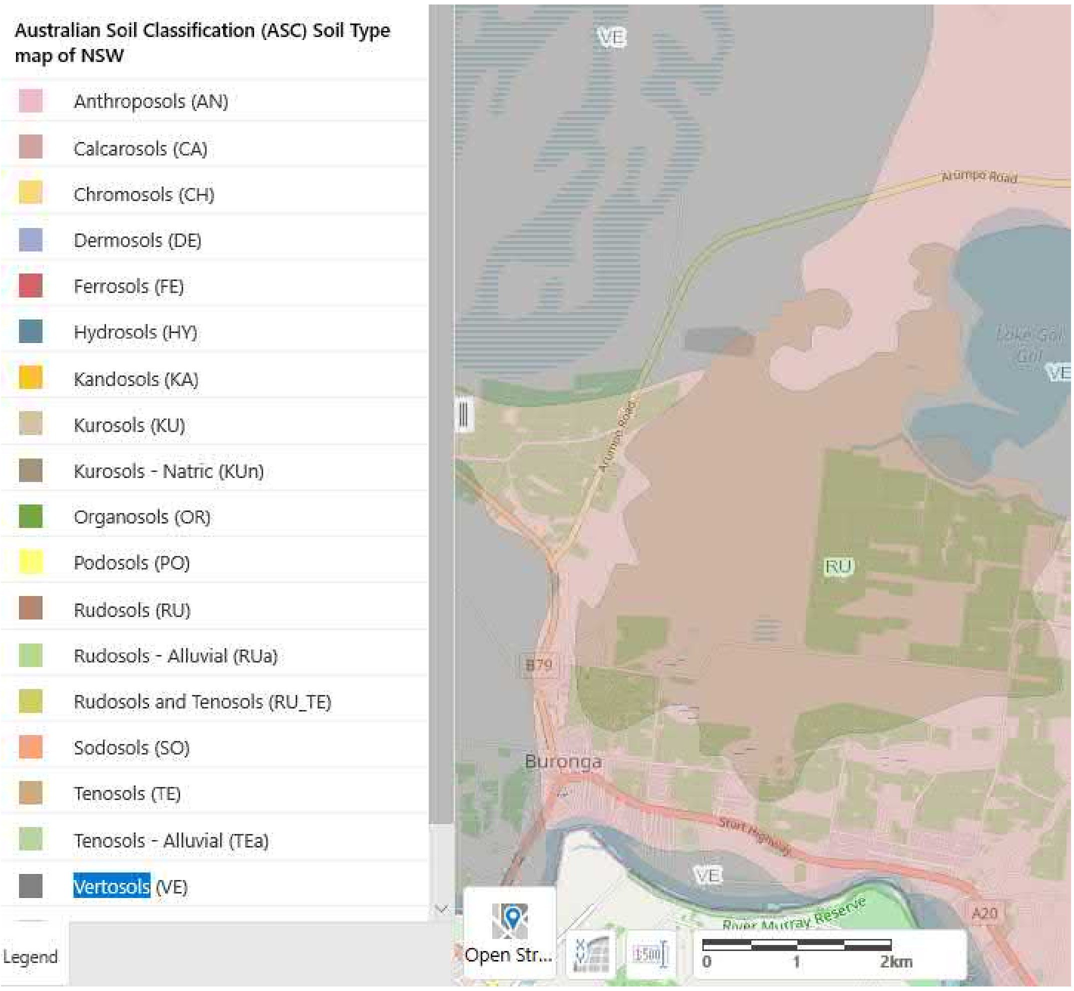

Figure 3 **Map of Western NSW Soils (from SEED Map[2])**

The site is situated within the Huntingfield land system which predominantly consists of sandplains and dune fields sustaining predominant Belah and Bluebush vegetation. Geomorphologically the regional landform consists of a series of playas and basins.

[2] Walker P.J, 1991, Land System of Western NSW, Technical Report No. 25, Soil Conservation Service of NSW, Sydney

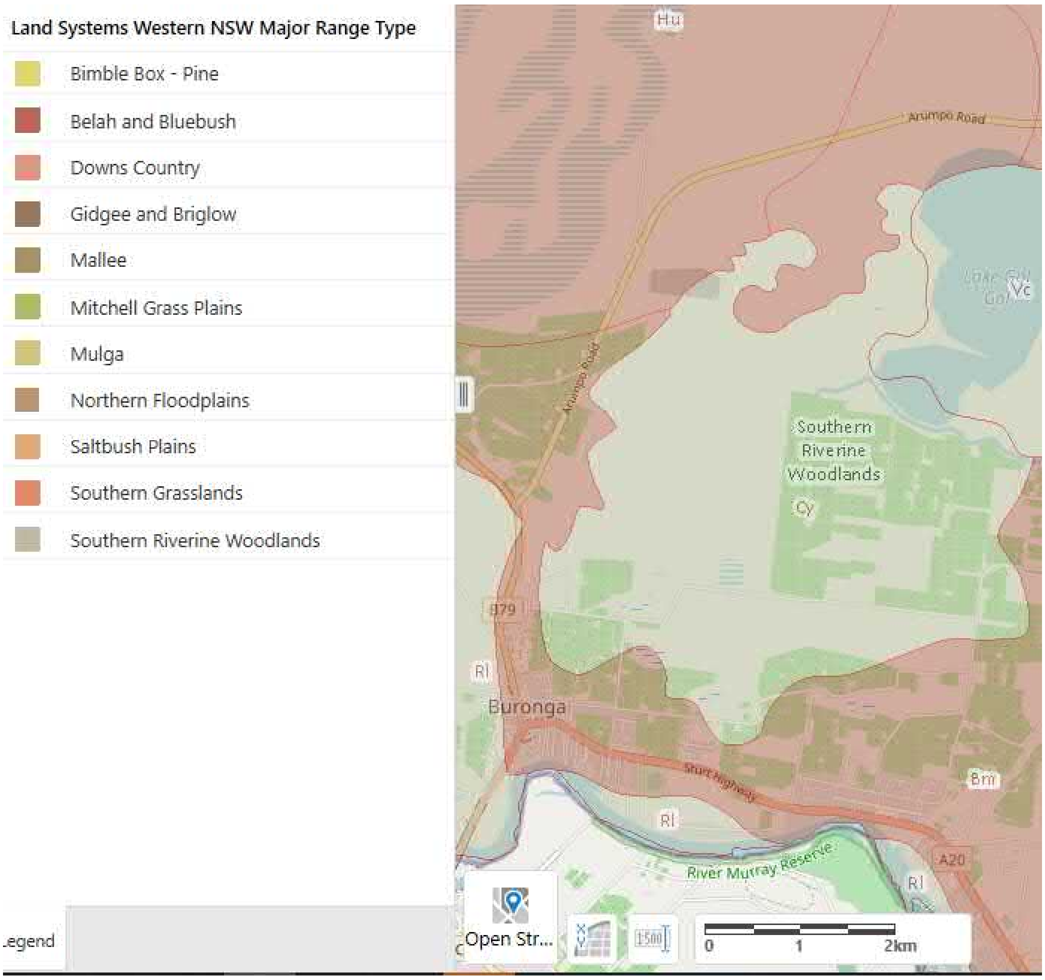

Figure 4 Map of Western NSW Landforms (from SEED Map)

4.3 Regional Hydrogeological and Geological Setting

The site is situated within the southern part of the Western Porous Rock resource unit. The Western Porous Rock SDL resource unit is located in the semi-arid zone of south-western NSW. It extends approximately between the South Australian border in the west, the River Murray in the south, Wilcannia and Broken Hill in the north and Balranald in the east, covering a total area of approximately 73,000 km^2. The location and extent of the Western Porous Rock SDL resource unit is shown following in Figure 5, whilst a cross sectional view is presented following in Figure 6.

The resource unit incorporates all groundwater within sediments of Tertiary and Quaternary age and all alluvial sediments within the outcropped area. The two major aquifers of the resource unit are the Renmark Group Aquifer and the Pliocene Sands Aquifer, the sands of which are weakly cemented and thus defined as porous rock (NSW Office of Water 2013)[3].

The Renmark Group Aquifer forms the major confined aquifer covering most of the water source. It is an accumulation of riverine sediments deposited approximately 30 to 50 million years ago (NSW Office of Water 2013). It is comprised of intercalations of lignite, peat, carbonaceous clay and medium to coarse grained quartz sand (NSW Office of Water 2013). Salinity in the Renmark Group ranges from

[3] NSW Office of Water (2013) Western Murray Porous Rock and Lower Darling Alluvium Groundwater Sources, Groundwater Status Report 2011, January 2013

2,000 to 36,000 mg/L TDS with the freshest water located in the northern margins and salinity increasing down the hydraulic gradient. Vertical stratification is commonly observed in the areas to the north and east.

The Pliocene Sands Aquifer forms the major shallow unconfined/semiconfined aquifer covering most of the water source. It is comprised of layers of sand and gravel deposited approximately 2 to 6 million years ago. The aquifer is predominantly sands of marine origin comprised of the Loxton-Parilla Sand, while to the east lies a small area of sands of riverine origin comprised of the Calivil Formation (NSW Office of Water 2013). The Loxton-Parilla Sands contain significant deposits of heavy mineral sands (rutile, zircon and ilmenite), whilst overlying younger deposits contain bentonite and gypsum. The Pliocene Sands Aquifer contains highly saline groundwater ranging from 1,000 to 82,000 mg/L TDS and very locally up to 160,000 mg/L TDS near salt lakes.

Areas of Murray Group Limestone are also located in the south-west of the groundwater source overlying the Renmark Group. The Murray Group Limestone is comprised of marine sediments of calcarenite, limestone and marl about 12 to 32 million years old (NSW Office of Water 2013). This unit is not a target of groundwater extraction due to its higher salinity and lower hydraulic conductivity, and hence has not been included in any groundwater resource planning.

Management of the Western Porous Rock SDL resource unit is governed by the *Water Sharing Plan for the NSW Murray-Darling Basin Porous Rock Groundwater Sources* (NSW Office of Water 2011).

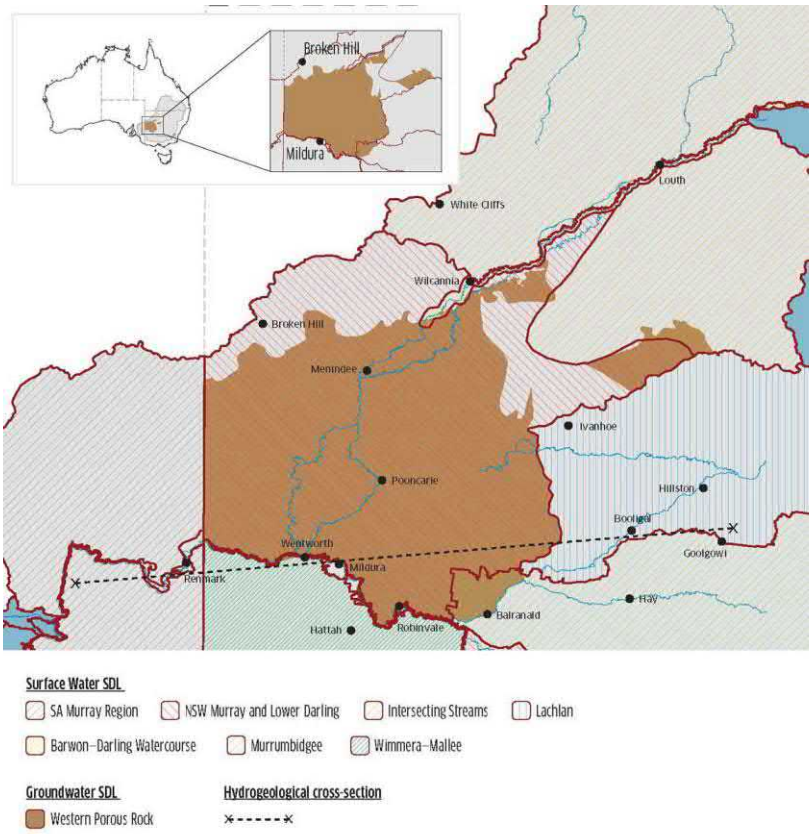

Figure 5 **Map of the Western Porous Rock © Commonwealth of Australia (Murray–Darling Basin Authority)**

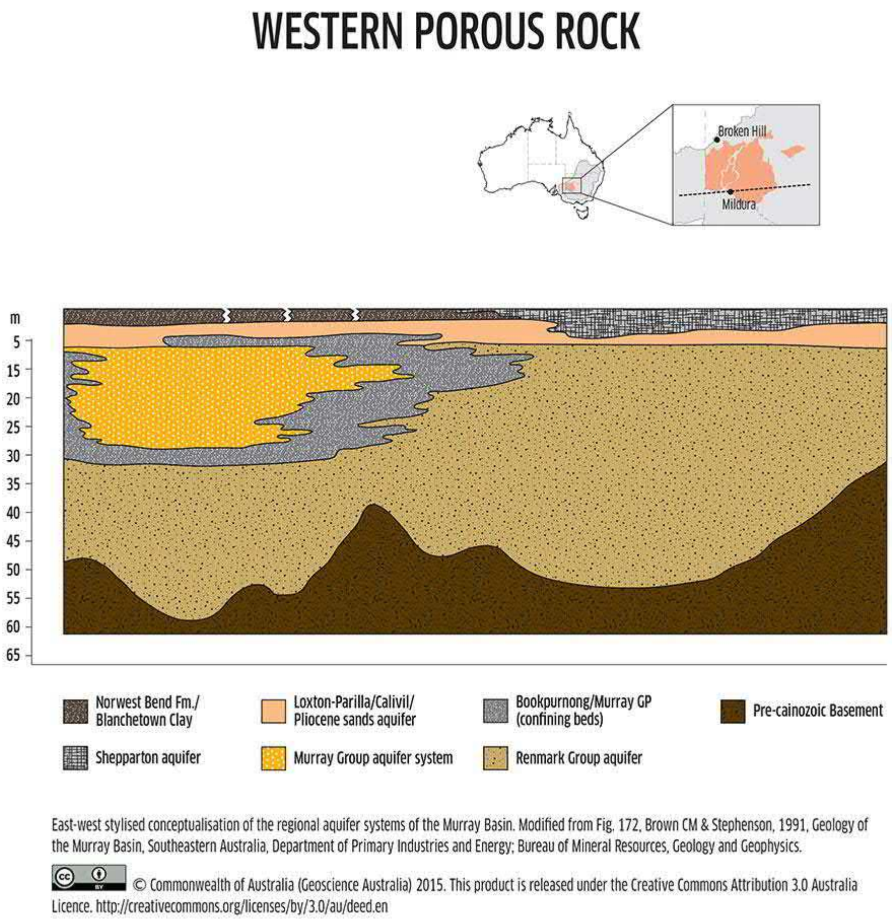

Figure 6 **Cross Section of the Western Porous Rock © Commonwealth of Australia (Murray–Darling Basin Authority)**

According to GHD (2012)[4], the NSW Government online groundwater data base has indicated that there are 20 bores situated within a 2km radius of the proposed construction site. Of the 20 bores five are situated within 1km of the site, of which a total of nine purpose constructed groundwater monitoring boreholes were considered. The boreholes vary in depth from between 10.5 to 61m depth, with measured groundwater levels between 1.5 to 7.37 mgl.

4.4 Salt Interception Schemes

Although the township of Buronga was only declared in 1937, settlement in the area commenced in the 1920s. Early settlement focussed on cropping and horticultural activities and thus irrigation has been undertaken in the area for many years.

The salinity problem observed today are caused by the construction of the Mildura Weir and Lock and the groundwater mounding under the nearby irrigation areas (Mildura-Merbein, Buronga and Coomealla). These activities have increased the pressures in the Parilla Sands aquifer system, resulting in the displacement of saline groundwater from that aquifer to the Murray River on the downstream side of the weir, over a reach of approximately 3.5km.

[4] GHD (2012) Buronga Landfill Geotechnical Investigation Report, Wentworth Shire Council (21/21400/181848)

A series of eight groundwater bores with submersible pumps have been installed along the banks of the River Murray between Mildura west (Lock 11) and Mourquong where the saline water is believed to be entering the river. The submersible pumps are located in the deeper Parilla Sands aquifer. Saline water is pumped from this aquifer to lower the pressure that is driving the saline water into the river. By lowering the pressure in the aquifer, the gradient is reversed away from the river. The intercepted saline water is pumped approximately 7km to the Mourquong disposal complex.

The Buronga scheme is part of the Murray-Darling Basin Authority's Basin Salinity Management Strategy developed to manage the problems of river salinity, waterlogging and land salinisation in the Basin.

The Buronga scheme will intercept the deeper Parrilla Sands aquifer and prevent approximately 17,500 tonnes of salt from entering the Murray River annually. This scheme together with the companion Mildura-Merbein scheme located in Victora, contribute approximately 14 EC benefit to the river at Morgan, South Australia. The scheme has been designed as an efficient and effective component of a regional 'no borders' approach to salinity management in the Sunraysia Region[5].

The scheme also provides a major socio-economic benefit to the region, by providing the raw material (saline groundwater) necessary for the successful salt harvesting operation located at the Morquong basin. The location of the salt interception scheme and evaporation basin are presented following on Figure 7.

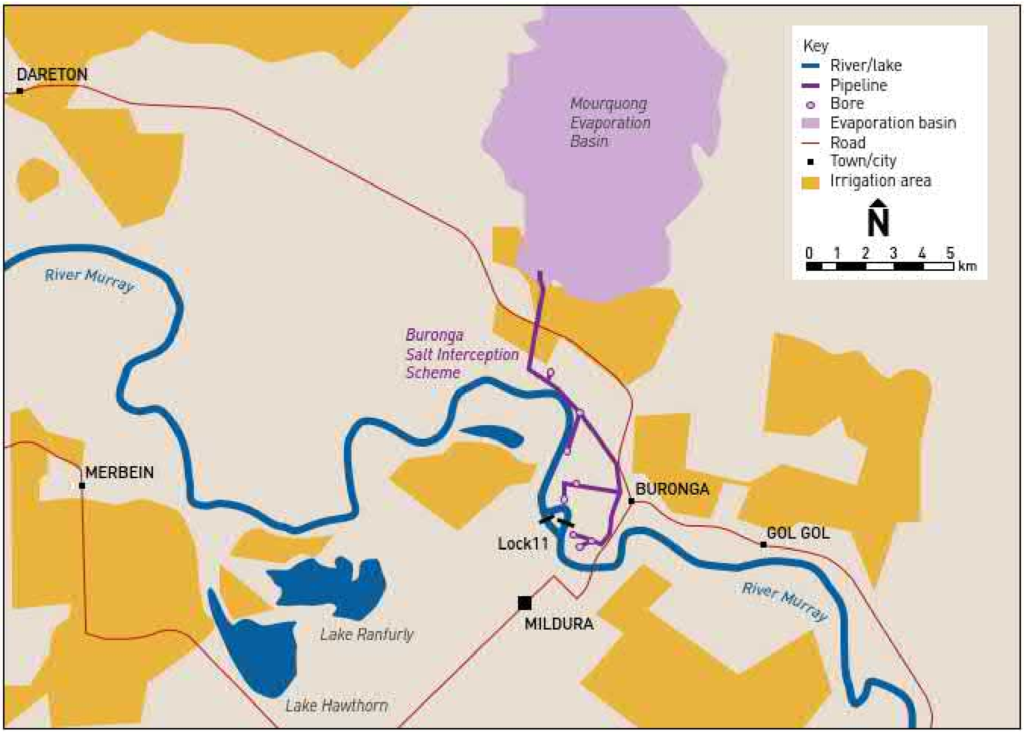

Figure 7 **Buronga Salt Intersection Scheme (from Murray Darling Basin Authority[6])**

[5] https://www.industry.nsw.gov.au/water/science/groundwater/interception-schemes/buronga

[6] NSW Government Office of Water, Murray Darling Basin Authority Buronga Salt Interception Scheme www.mdba.gov.au

4.5 Groundwater Dependant Ecosystems

DPI Water defines ecosystems that depend on groundwater as those 'ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services' (Richardson et al. 2011[7]).

Groundwater dependent ecosystems (GDEs) require groundwater to maintain their composition and functioning. The removal or change in groundwater availability or quality will influence the composition, structure and function of these ecosystems (Eamus et al. 2006[8]). Groundwater dependent vegetation does not rely on the surface expression of water to maintain ecosystem function. Instead, the vegetation depends on the sub-surface presence of groundwater, often accessed via the capillary fringe or vadose zone (i.e. the subsurface water just above the water table that is not completely saturated). Plant species within a community may exhibit differing degrees of groundwater dependency (and can range from obligate (total/entire) to facultative (partial and infrequent (i.e. seasonal/episodic).

Wetlands identified by Eamus et al (2006) as being groundwater dependent can be either ephemeral or permanent systems that have a continuous or seasonal connection with groundwater. Wetlands are considered dependent on groundwater if the presence of groundwater is essential to the biota and ecological processes of that wetland.

4.5.1 Types of Local and Regional GDEs identified – Literature Review

A literature review of DPI (2016)[9], (Howe et al. 2007)[10] and Eamus et al (2006) and has revealed the following likely GDEs are significant both directly to the project site and within the broader regional area:

- Phreatophytes - terrestrial vegetation that are dependent on the sub-surface presence of groundwater and is often accessed via the capillary fringe or vadose zone. (i.e. the sub-surface water just above the water table that is not completely saturated)
- Wetlands - Wetlands identified as being groundwater dependent can be either ephemeral or permanent systems that have a continuous or seasonal connection with groundwater. Wetlands are considered dependent on groundwater if the presence of groundwater is essential to the biota of that wetland and their ecological processes.
- Terrestrial vegetation - trees mostly take up groundwater from the capillary fringe as oxygen is required for plant respiration. The direct uptake from the water table is difficult for roots to grow and function under saturated conditions. Soil water is an important source of water for plants as less energy is required to draw on water from the vadose zone than from the water table. Trees and shrubs mostly access soil moisture water from the upper unsaturated soil profile.

4.6 Regional Beneficial Use Assessment

4.6.1 Aboriginal values and uses

According to DPI (2016) there is a significant relationship between groundwater and the traditional owners of these lands. Water and specifically groundwater is written into their Lore, their traditional stories and their dreaming. Creation beings live in these stories with cultural knowledge being passed

[7] Richardson, S, Irvine, E, Froend, R, Boon, P, Barber, S & Bonneville, B 2011, 'Australian groundwater-dependent ecosystem toolbox part 1: assessment framework', Waterlines report, National Water Commission, Canberra.

[8] Eamus, D, Hatton, T, Cook, P & Colvin, C 2006b, 'Ecohydrology: Vegetation function, water and resource management', CSIRO publishing, Victoria.

[9] Department of Primary Industries – Water, Methods for the Identification of High Probability Groundwater Dependent Vegetation Ecosystems, 2016

[10] Howe, P, O'Grady, A, Cook, PG, Knapton, A, Duguid, A & Fass, T 2007, 'A framework for assessing the environmental water requirements of groundwater dependent ecosystems', Land and Water Australia, Adelaide.

down through the stories. Song and dance demonstrate the significance of this connection to water, and the people's relationship to land.

Groundwater has provided the life support for generations of traditional owners. Water provided for the trees, the medicinal plants and the animals that sustained the lives of the local communities. Aboriginal people place a high level of value on water as the uses are significant and many, in relation to the survival of Aboriginal people and their culture. DPI Water supports involvement of Aboriginal people in the water resource planning process and supports Aboriginal people to document and share their social, spiritual and cultural information, including identifying specific values and uses associated with water. It is important to better understand Aboriginal values and uses in order to manage risks to them.

Water Dependant Aboriginal cultural asset types and their values are summarised following:

- Waterholes/soaks/ billabongs
- Wetlands
- Lagoons/Wetland bowls
- Transit stops – ephemeral flows
- Occupation sites and campgrounds
- Spiritual sites areas

4.6.2 Irrigated Agriculture

There is only minor development of groundwater resources for irrigated agriculture across the SDL resource units within the WRP areas. This is primarily due to the low groundwater yields and variable salinity levels.

4.6.3 Water for Towns and Essential Human Needs

Groundwater is relied upon within the area for town water supply and stock and domestic purposes, as well as to support local commerce. Town water supply and stock and domestic users have a higher priority for access than other groundwater licences. WSPs recognise this priority by ensuring that a full share of water is allocated for annual town water supplies except where exceptional drought conditions prevent this. The annual water available is specified on the town's licence.

According to the DPI (2017) document, across the WRP areas town water supply (local water utility) access licences have a total share component of 870 ML/year. This is made up of 480 ML/year in the Gunnedah-Oxley Basin (for an SDL of 205,640 ML) and 390 ML/year in the Western Porous Rock (for an SDL of 530,486 ML).

The *Water Management Act* 2000 also requires WSPs to protect water for basic landholder rights, which are made up of domestic and stock rights, harvestable rights and native title rights. Water taken under a domestic and stock right may be used for normal household purposes around the house and garden and/or for drinking water for stock.

5 Conceptual Hydrogeological Model

The local and site-specific geological and hydrogeological settings influence the fate and transport of any potential site contaminants, the movement of groundwater offsite and the fluctuation of groundwater levels in the vicinity of and at the subject site.

The distributions of any contaminants across a site are influenced by the local geology and natural or manmade/altered drainage features in the area or at the site. Their distribution within the sub-surface is influenced by geological structures, variations in the permeability of soil and rock (which may result in perched or 'seasonal' water tables), geochemical, biological and mineralogical variations and the presence of preferential pathways such as loose fill around services.

Certain sites may be located in areas that are naturally enriched with mineral resources and can appear to contain elevated levels of metals and metalloids in soil, surface water or groundwater.

Consequently, it is essential to have an understanding of the background quality of these media and to evaluate potential contamination of this type in terms of the beneficial uses of the groundwater beneath the site.

5.1 Soil Investigation

Drilling works were undertaken by Tonkin across the proposed construction area between 16 and 18 February 2021 an are described in detail in the Geotechnical Investigation Report[11]. Works undertaken included the advancement of 12 boreholes to depths of between 8.1 and 11.0m below ground level (bgl). The borehole locations are identified following on Figure 8 following.

5.1.1 Site Specific Geology

The proposed construction area is situated predominantly within sediments of the Middle Pleistocene – Holocene age Woorinen Formation[12]. The Woorinen Formation is described as being unconsolidated red-brown medium to fine silty sand, red calcareous silty clay, sandy clay, clay pellet aggregates which forms extensive dune fields with subdued crests and flakes separated by swales and sand plains.

The southern and eastern most portion of the site is situated within proximity to the boundaries of the Woorinen Formation and the Late Pleistocene – Holocene aged Yamba Formation. The Yamba Formation consists of friable pale grey gypsite, gypsiferous clay, grey pelletal gypsum-quartz aggregates, black sulphide-rich mud, and ephemeral salt crusts of gypsum, halite, bischofite, thenardite, mirabilite.

The bore logs for the drilling works (refer Appendix A) indicate the observed geology onsite is generally consistent with the published information, however some localised variance in sand content within clays was observed.

Fill was only encountered in borehole H3 to a depth of 0.2m below the surface. Topsoil was mostly non-existent apart from a sandy surface layer observed in most boreholes. Generally, sand and clayey sand materials were observed in the upper layer, underlain by clays and sandy clays of low to medium plasticity, further underlain by silty clayey sand and sand often containing groundwater. The upper sands and clayey sand layers were more predominant in the western boreholes (H1 to H6, H11 and H12), with the eastern boreholes (H7 to H9) encountering clays near the surface.

[11] Tonkin. 2021. *Geotechnical Investigation Report Buronga Landfill Expansion*. Ref 202597R02 Rev0 Dated 28/09/21

[12] Raymond, O.L., Liu, S., Gallagher, R., Zhang, W., Highet, L.M., 2012, Surface Geology of Australia 1:1 million scale dataset 2012 edition: Commonwealth of Australia (Geoscience Australia). 5 / 697310

A generalised summary of the encountered geology is included following, whilst a borehole location plan is presented following as Figure 8:

- FILL: Clayey Sand, identified at surface
- Unit 1: SAND, fine to coarse grained, red brown and pale brown
- Unit 2A: Clayey Gravelly SAND/Clayey SAND, fine to coarse grained, pale orange/brown, pale brown and white, fine to coarse gravel, low plasticity fines
- Unit 2B: SAND/Clayey SAND, fine to coarse grained, pale brown, orange/brown and orange, low plasticity fines.
- Unit 3A: Clayey SAND, fine to coarse grained, grey/brown, low plasticity fines.
- Unit 3B: Sandy CLAY/CLAY, medium to high plasticity, grey, grey/brown, yellow brown, red, fine to coarse sand
- Unit 4A: Clayey SAND/Silty SAND, fine to coarse grained, yellow brown, grey, low plasticity fines
- Unit 4B: SAND, fine to coarse grained, grey

A review of the data shows that the groundwater intersections during push tube drilling occurred predominantly within the sandy CLAY and clayey SAND/ clayey silty SAND materials. Given piezometers were not installed as a part of the works, actual groundwater standing water levels (SWLs) are not able to be calculated and hence actual groundwater levels are likely to differ from the water intersection levels reported herein.

Where boreholes were left open overnight, groundwater levels were found to rise approximately 1m above the original intersected level. This was observed within two boreholes, H7 and H9. At both these locations groundwater intersection was measured as being within, or on the boundary of the high plasticity clays. This may be indicative of the both the lower aquifer transmissivity within the high plasticity clay material and or that the clay layers partially confine the groundwater onsite. Given hole collapse in several boreholes it is currently unknown however if the same water level rises would be observed within the other observed materials.

Based on the obtained groundwater intersection data:

- The northern W-E sections provided groundwater levels varying from 8.1 m (H12) to 7.8 m (H9), the predominant groundwater bearing unit was clayey SAND
- The central W-E sections provided groundwater levels varying from 9 m (H5) to 7.2 m (H8), the predominant groundwater bearing unit was clayey SAND
- The southern W-E sections provided groundwater levels varying from 9.5 m (H2) to 8 m (H4), the groundwater bearing unit included clayey SAND, CLAY and Sandy CLAY

Given the potential partially confined nature of the aquifer, it is probable that true groundwater levels beneath the site are within the order of 5.9 and 7.5 mbgl, conforming with groundwater depths obtained from surrounding water bores within a 2km radius of the site. It is likely that water levels ultimately are controlled by regional and local recharge and prolonged heavy rainfall periods could see further groundwater level rises.

Calculation of an accurate groundwater flow direction, groundwater gradient and hydraulic conductivities are unable to be determined given the absence of established piezometers onsite. However, based on the obtained information and published information, it is estimated that:

- Groundwater flow is potentially towards the east, in the direction of Lake Gol Gol and the associated wetlands.
- Groundwater gradients are likely to be quite flat given the topography, with hydraulic conductivities variable, ranging from 0.01 to 0.21 m/day.

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Wentworth Shire Council

Buronga Landfill Expansion
Hydrogeological Investigations
Borehole Location Plan

Figure 2

6 Conclusions and Recommendations

Tonkin was commissioned by the Wentworth Shire Council (Council) to undertake a Groundwater Impact Assessment (GIA) to provide information for inclusion into an Environmental Impact Statement (EIS), which is required as part of the Development Application for the expansion of the Buronga Landfill.

The investigation has included a desk top study of regional and site specific information pertaining to groundwater occurrence and usage within the region and also within immediate proximity to the proposed construction area.

The investigation has determined that:

- The site is situated within the Huntingfield land system which predominantly consists of sandplains and dune fields. Geomorphologically the regional landform consists of a series of playas and basins. The climate is described as steppe (semi-arid), so rainfall occurrence is low, and vegetation is restricted to smaller shallow rooted species such as Belah and Bluebush vegetation. Given the low rainfall, regional groundwater recharge is low.
- The presence of surrounding groundwater bores within a 2km radius of the site suggests shallow groundwater of variable salinity and quality, typically with salinity increasing further south.
- The geology encountered onsite is indicative of the regional setting and consists of a succession of sands and clays. Clays range from highly plastic with low transmissivity to low plastic sandy clays with moderate transmissivity. Water occurrence beneath the site appears to be predominantly within the clayey SAND and Sandy CLAY materials which are partially confined in places by higher plasticity clays.
- Literature research shows that there are definite GDEs within proximity to the site, particularly wetlands and terrestrial vegetation. There are also potential beneficial uses of the groundwater including irrigation and potential (non-potable) domestic use.

The study has shown that although groundwater movement from site is likely to be relatively slow, groundwater levels are shallow and variable between unconfined and partially confined, based on the interbedded sequences of clay (partial confining layer) and the sandy clay/ clayey sand materials. Therefor in theory groundwater levels are able to rise exponentially, if recharge permits.

However, given the semi-arid climate and the review of regional and site-specific data it is perceived that level rises above 5.9m below ground level are unlikely and the variance between high and low groundwater points lower. Additionally, with groundwater essentially within the clay bearing units which are of a lower conductivity than sand, groundwater flow rates are likely to be lower should the water table be intersected through excavation works.

It is therefore concluded that overall risk to groundwater onsite of the construction is low, however it is recommended that groundwater monitoring wells are installed up and down hydraulic gradient of the site to enable temporal groundwater data and water quality data to be monitored prior to construction and during operation of the site. These monitoring wells should additionally be located as such to provide sufficient coverage for the upgradient and down gradient monitoring of potential groundwater contamination emanating from the landfill activities on-site.