Buronga Landfill Expansion

Landfill Stage 1A Cell 1 Design Report

Wentworth Shire Council

21 September 2023
Ref: 202597R08Rev4

Building exceptional outcomes together

Document History and Status

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Appendices

1 Project Definition

1.1 Background

Wentworth Shire Council (WSC) owns and operates the Buronga Landfill, located at 258 Arumpo Road, Wentworth, NSW. The site is an existing landfill facility which WSC is proposing to expand to provide ongoing waste management and disposal capacity for Wentworth Shire.

Tonkin has been providing assistance to WSC with the approvals process for the proposed expansion of the facility and prepared a concept design for future landfill stages as a part of this process. Subsequently, Tonkin has been engaged by WSC to undertake the detailed design of a number of elements of the facility, including the detailed design of the first landfill cell referred to as Stage 1A Cell 1.

The design basis and assumptions have been set out in the basis of design document provided as Appendix A.

1.2 Objectives

The Stage 1A Cell 1 Landfill design shall be developed to comply with the requirements of:

- Site Licence: NSW EPA (2023). *Environment Protection Licence Number 20209*, Version Date 8 Mar 2023
- Landfill Guidelines: NSW EPA (2016). *Environmental Guidelines: Solid Waste Landfills,* Second Edition, April 2016, Ref: EPA 2016/0259
- Environmental Impact Statement: Tonkin (2022a). *Buronga Landfill Expansion, Environmental Impact Statement,* Revision 1, 25 January 2022, SSD-10096818, Ref: 202597R04Rev1
- Planning Submissions Report: Tonkin (2022b). *Buronga Landfill Expansion, Submission Report,* Revision 2, 1 December 2022, SSD-10096818, Ref: 202597R05Rev2
- Conditions of the development consent will be included once they become available, as the DA for the landfill expansion is yet to be finalised.

Additionally, the design will be developed to provide the following outcomes for WSC:

- Provide at least two to three years of landfill airspace per cell. Consumption rates can be selected based upon existing filling rates or projected future filling rates, to be advised by WSC.
- Minimise any relocation of waste required to construct the PBL
- Maximise airspace returns within Stage 1A by optimising baseliner grades in relation to the level of groundwater at the site

2 Key Design References

2.1 Reference Documentation

2.1.1 Project Brief

- Tonkin (2023). *Buronga Landfill Expansion, Tender for Design Works,* Revision 1, 31 January 2023, Ref: 202597P03

2.1.2 Stage 1A Concept Design

- Tonkin (2023). *Buronga Landfill Expansion, Landfill Stage 1A Basis of Design,* Revision 1, 5 June 2023, Ref: 202597R08Rev0
- Tonkin (2023). *Buronga Landfill Expansion Stage 1A Design Drawing Set,* Drawings 001 to 010 Revision A, 5 June 2023.

2.1.3 Landfill Expansion Planning Documentation

- Environmental Impact Statement: Tonkin (2022a). *Buronga Landfill Expansion, Environmental Impact Statement,* Revision 1, 25 January 2022, SSD-10096818, Ref: 202597R04Rev1
- Planning Submissions Report: Tonkin (2022b). *Buronga Landfill Expansion, Submission Report,* Revision 2, 1 December 2022, SSD-10096818, Ref: 202597R05Rev2
- Planning Amendment Report: Tonkin (2023). *Buronga Landfill Expansion, Amendment Report,* Revision 0, 8 February 2023, Ref: 202597R07Rev0
- Preliminary Scoping Report: Tonkin (2020a). *Buronga Landfill Proposed Expansion, Preliminary Scoping Report,* Revision 2, 8 October 2020, Ref: 20180746R001.
- Development consent for SSD-10096818, currently pending

2.1.4 Regulatory Requirements

- Site Licence: NSW EPA (2023). *Environment Protection Licence Number 20209*, Version Date 8 Mar 2023
- Landfill Guidelines: NSW EPA (2016). *Environmental Guidelines: Solid Waste Landfills,* Second Edition, April 2016, Ref: EPA 2016/0259

2.1.5 Site Management Documentation

- Wentworth Shire Council (2015). *Buronga Landfill, Landfill Environmental Management Plan,* Revision 0, December 2015

2.1.6 Geotechnical Information

- Tonkin (2021a). *Geotechnical Investigation Report, Buronga Landfill Expansion,* Revision A, 11 June 2021, Ref: 202597R02A
- 2023 Tonkin Geotechnical Investigation Report – in preparation at time of issue of this report.

2.1.7 Groundwater Information

- Tonkin (2021b). *Groundwater Impact Assessment, Buronga Landfill Expansion,* Revision 0, 19 September 2021, Ref: 202597R03Rev0
- Tonkin (2023). *Stage 2 Geotechnical Investigation Report,* Revision 0, 31 May 2023, Ref: 202597R09Rev0
- Groundwater information supplied by WSC for 2022

2.1.8 Previous Cell Design and Construction Documentation

- Tonkin (2016). *Buronga Landfill, Proposed Cell Technical Specification,* Revision S1B, 29 August 2016, Ref: 20155461S1B
- Tonkin (2017). *Buronga Landfill, New Landfill Cell – As Constructed Report,* Revision A, 20 October 2017, Ref: 20155461FR3

2.1.9 Volumetric Survey and Waste Acceptance Information

- Volumetric Surveys, Wentworth Shire Council, Dated 27/11/2019, 19/08/2022, 07/02/2023
- Waste Acceptance Data Dated: July 2021-April 2022, April 2022 – August 2022, August 2022 – Feb 2023.

2.1.10 Site Survey

- PriceMerrett Consulting (2021). *Buronga Landfill, Contour and Feature Plan,* 4 March 2021, Ref: F8648 Dwg 6257 Rev 0.
- Phil Maw Survey & Drafting (2023). *30322SM-TPS Buronga Landfill, Buronga, NSW-3D-Combined.dwg,* 22 March 2023.

2.1.11 Other Input Data

- Tonkin (2020b). *Leachate Pumping System Maintenance and Monitoring Schedule,* Revision 0, 24 November 2020, Ref: 202156R01

2.2 Existing Design Concept

A pre-concept design for the landfill expansion was prepared as a part of the planning process for the development application for the landfill expansion. Drawings and discussion of the basis of design and design process are provided in the Environmental Impact Statement (EIS).

The pre-concept design provides approximately 3,304,000 m^3 of airspace across four stages labelled Stage 1A to 1D, providing an expected 38 years of landfill life based upon future projected waste tonnages. Each stage is proposed to be divided into four landfill cells with baseliners grading in a sawtooth style arrangement, with the two central cells in the stage sharing a common sump. The pre-concept design also includes a design for the post-settlement final landform for the site. A drawing showing the layout is included as Appendix B.

The pre-concept for Stage 1 was progressed to a concept design for Stage 1A developed in early 2023. This concept design defined the baseliner and sideliner levels and the extent of each cell within Stage 1A. Subsequently, this concept design was used to inform the detailed design of Stage 1A Cell 1.

3 Site Conditions

3.1 Location and Profile of Adjacent Cell Liners

A portion of the existing landfill operation consists of a lined landfill cell which is currently operational. This landfill cell was designed by Tonkin in 2016 and includes a lined base and sideslopes. An interface will be made between Cell 1 and the existing cell to provide a continuous barrier beneath the landfill. The baseliner profile of the existing lined cell that will require interfacing with consists of the following profile from the top down:

- Separation Geotextile
- 300 mm leachate drainage aggregate containing perforated collection pipework
- Cushion geotextile
- 2.0 mm double sided textured HDPE Geomembrane
- 1.0 m compacted clay liner

And the sideliner profile consists of the following profile, from the top down:

- Separation Geotextile
- 300 mm leachate drainage aggregate
- Cushion geotextile
- 2.0 mm double sided textured HDPE Geomembrane
- Geosynthetic Clay Liner (GCL)
- 200 mm earthen layer (liner subgrade)

Details of the construction of this landfill cell including as constructed survey showing the extent of construction of the lining system are included within the as-constructed report for the landfill cell construction (Tonkin, 2017).

3.1.1 Adjacent Unlined Cells

Stage 1A Cell 1 is adjacent to the existing landfill operation. The existing landfill facility includes an unlined historical landfill area; however, Cell 1 is located adjacent to the existing lined landfill cell. The Cell 1 liner will interface with the liner of the existing lined landfill cell and no filling will occur above the existing unlined landfill during operation of Cell 1.

3.2 Post-Settlement Final Landform

A concept design for the post-settlement final landform was prepared as a part of the planning process for the landfill expansion project. This landform is shown in the drawing included as Appendix C. This concept post-settlement final landform has been used for the design of Cell 1A.

The landform was developed in accordance with the *Environmental Guidelines: Solid Waste Landfills* with side batter grades of up to 1V:5H and crest grades of 5% or greater. The landform includes surface water drains to shed water from the cap to drainage corridors along the eastern and western sides of the landform while maximising airspace.

3.3 Subsurface Geology and Materials Availability

Geotechnical investigations have been undertaken by Tonkin in 2021 and 2023 to inform the design of the landfill cells and inform materials availability for use in the construction of future infrastructure.

The 2021 investigation indicated that the site is generally underlain by the following units:

- 1: Fine to coarse grained SAND, to depths between 0.4 and 1.7 m in some areas, overlying
- 2: Fine to coarse grained SAND/Clayey SAND/Clayey Gravelly SAND, low plasticity fines to depths between 1.8 and 6.4 m in some areas, overlying
- 3A: Fine to coarse grained Clayey SAND, low plasticity fines, to depths between 0.05 and 4.6 m in some areas, overlying
- 3B: medium plasticity Sandy CLAY/CLAY, fine to coarse grained sands, to depths between 6.5 m and 10.0 m (extent of investigation) in some locations, underlain by
- 4: Fine to coarse grained SAND/Clayey SAND/Silty SAND to the extent of investigation.

Reference should be made to the 2021 geotechnical report for detailed information on soil strata including borehole logs and core photographs. Soil units encountered during the 2023 investigation were generally similar to those documented above.

The 2021 geotechnical report includes an assessment of the suitability of the material for reuse in construction. The report states that it is expected that the site materials other than those from unit 4 (Fine to coarse grained SAND/Clayey SAND/Silty SAND) would be suitable for reuse as general engineered fill for bulk earthworks. The report suggests that soils encountered in unit 3B (Sandy CLAY/CLAY) may be suitable for use in water retaining structures (i.e. compacted clay liners), but that no permeability testing was undertaken to confirm this. Due to the depths that these materials were encountered at (generally from approx. 4 to 8 mBGL, but shallower in some locations), it is considered unlikely that a sufficient volume of low permeability material will be won during bulk excavation for construction of a compacted clay liner in the future landfill cells, noting no comprehensive materials volume assessment has been undertaken. Due to this, a synthetic lining system will be used in Stage 1A. Additionally, based on further discussion with WSC it is not expected that the clay encountered is generally suitable for construction of a compacted clay liner.

The 2021 geotechnical investigation report also provides recommendations on excavation stability. The report suggests that permanent slopes should not exceed 1V:2.5H in the materials encountered and that excavations should remain a minimum of 2.0 m above the level of groundwater to avoid softening of the subgrade.

3.4 Groundwater

There are four existing groundwater wells at the site around the existing landfill operation. Three new groundwater wells to the north of the existing landfill operation were installed in 2023 to capture additional information regarding the groundwater within the Stage 1A footprint and to function as monitoring wells following construction of Stage 1A. Groundwater was encountered in most boreholes during the 2021 geotechnical investigation. During fieldwork in March 2023, all groundwater wells on site were gauged to gain an understanding of standing water level. Standing water levels have been converted to approximate elevations (in mAHD) using the site survey and GPS points of the monitoring locations to establish a groundwater surface reported in the 2023 Geotechnical Investigation Report.

Additional reporting regarding groundwater levels is also provided in the Groundwater Impact Assessment (Tonkin, 2021b) and the Preliminary Scoping Report (Tonkin, 2020a). These reports indicate that regional groundwater levels are generally between 30 and 32 mAHD, with on site wells gauged in 2010 and 2012 between 29.2 and 32.7 mAHD.

Based upon this information, we infer that site groundwater levels are generally between 30 and 34 mAHD. A groundwater surface has been triangulated based upon the groundwater levels encountered at monitoring wells during investigations to inform design of the Stage 1A baseliner. The landfill cells will be designed with a minimum 2m separation between the baseliner and groundwater in accordance with current best practice, noting that the *Environmental Guidelines: Solid Waste Landfills* does not contain a specific requirement for separation to groundwater. Development of a groundwater surface allows for the baseliner elevations to be optimised to maximise airspace while maintaining the minimum required separation between the liner and groundwater.

3.5 Target Cell Life

Information provided by WSC suggests that the existing landfill facility accepted approximately 28,500 t of waste in 2021/22 and will accept approximately 32,900 t of waste in 2022/23 (extrapolated from data available). Projections discussed in the EIS and amendment report adopted an annual tonnage of 64,000 tonnes per annum to account for future growth. Volumetric survey information was provided for periods of April 2022 to August 2022 and August 2022 to February 2023. Between April 2022 and August 2023, survey data provided indicates that approximately 13,700 m^3 of airspace was consumed, suggesting a landfilled waste density of 0.85 t/m^3 without correcting for cover soil usage. Between August 2022 and February 2023, survey data provided indicates that approximately 13,000 m^3 of airspace was consumed suggesting a landfilled waste density of approximately 1.2 t/m^3 in this period without correcting for cover soil usage. Due to the significant difference between these two densities in a short period of time, a conservative approach of adopting the lower waste density for the purposes of airspace consumption has been taken.

Based on the projected annual waste acceptance of 64,000 t of waste and a density of 0.85 t/m^3, annual airspace consumption is estimated to be 75,500 m^3 per annum.

The *Environmental Guidelines: Solid Waste Landfills* does not provide specific guidance for the design life of landfill cells. The design life of the cells needs to balance the practicalities of frequent construction of new cells with ensuring cells are not excessively large to cause issues with UV degradation of exposed liner materials or management of surface water. Cell sizes and staging will be developed based upon managing these factors however we consider that a landfill cell design life in the order of 3 years is appropriate. To achieve this, cell airspace would need to be in the order of 226,000 m^3. The Stage 1A Cell 1 extent was set during the Stage 1A concept design based upon this airspace target.

4 Design Criteria

4.1 Site Licence

The site licence (EPL 20209) includes the following conditions relevant to the development of the new landfill cells:

- O5.9: A leachate barrier and collection system must be installed and managed at the landfill as specified in Environmental Guidelines: Solid Waste Landfills or alternative of equal or better environmental performance
- O6.3: Surface drainage must be diverted away from any area where waste is being or has been landfilled

4.2 Planning Documentation

The EIS and submissions report include a significant detail on the expansion of the landfill facility as a whole including the development of Stage 1A Cell 1. This information is addressed in Section 2.2. The detailed design of Stage 1A Cell 1 has been developed in accordance with the concept design that was developed to form the basis of the development application as documented in the EIS and Amendment report. This design report has been developed to satisfy the requirements for the Landfill Cell Design report required by the development consent.

4.3 Environmental Guidelines: Solid Waste Landfills

The Environmental Guidelines: Solid Waste Landfills provide guidance to landfill operators regarding the environmental management of landfills in NSW by providing a series of minimum standards, including minimum standards for design of new landfill cells. Part B of these guidelines document these minimum standards which include:

- Requiring the base and walls of all solid waste landfill cells to be lined with durable materials of very low permeability.
- Requirements relating to the properties and quality of components of the lining system including compacted clay liners and geosynthetics
- Requirements for leachate collection, extraction, management, and disposal
- Requirements for the management of site stormwater
- Quality assurance requirements for construction of landfill cells, including conformance testing requirements for geosynthetics.

Specific minimum standards are discussed further in Section 6 including how these standards are addressed by the design of Stage 1A Cell 1.

5 General Controls

5.1 Groundwater Protection

5.1.1 General Description

A multi-component geocomposite basal liner barrier system and leachate collection and extraction system serve a critical part of a broader groundwater protection system. The system also incorporates a network of groundwater monitoring wells which are routinely monitored.

The basal liner barrier system prevents the migration of leachate to the groundwater system and the leachate collection and extraction system removes leachate from the landfill to prevent leachate head build up and ongoing risk of impact. The groundwater relief system prevents uplift pressure on the liner which can lead to damage of the liner.

5.1.2 Potential Environmental Impacts

An unlined landfill poses significant risk of negatively impacting the groundwater system as a result of leachate generation and infiltration to the groundwater system. The Cell 1 lining system serves to prevent leachate infiltration into groundwater.

The introduction of an appropriately designed and properly constructed lining (barrier) system significantly reduces the risk of groundwater impact. The use of geosynthetic barrier lining systems can reduce the risk of impact to the range of low to negligible.

5.1.3 Design Mitigation Controls

This design incorporates the following elements to prevent leachate migration to groundwater:

- Elevation of the baseliner engineered fill to a minimum of 2 m above the design groundwater level for the site, providing separation to accommodate any fluctuation in groundwater level and to promote the opportunity for attenuation via cation exchange if a leak was to occur;
- Graded base and batters covered with a geocomposite geosynthetic barrier system, being a HDPE geomembrane layer and a geosynthetic clay liner (GCL), underlain by an engineered subgrade to provide an attenuation layer should a leak occur;
- A leachate collection and extraction system consisting of a gravel drainage layer, collection pipework and a drainage geocomposite on the batter to control and remove leachate from the landfill cell, minimising head build up on the baseliner and preventing leachate migration to groundwater.

5.1.4 Assumptions

The adopted groundwater levels are based on the findings of the geotechnical and hydrogeological investigations undertaken during the EIS process as discussed in Section 2.1.7.

5.2 Leachate Control and Management

5.2.1 General Description

A leachate collection and extraction system within the base Cell 1 has been designed to continually control and direct leachate to the sump region for extraction, minimising head build up on the baseliner and preventing leachate migration to groundwater.

The leachate collection system consists of a drainage geocomposite on the Cell 1 batter and a gravel drainage layer placed over the composite barrier layers and on the cell base; to form a barrier to leachate migration from the cell. Perforated HDPE pipework will be placed along the cell inverts within the gravel layer to promote drainage within this layer to leachate extraction sumps. For Cell 1 this sump is located at the western extent of Cell 1. Leachate is directed through the gravel drainage layer by baseliner grades towards the sump. Grades will be provided at a minimum of 1% along the inverts of the cell and a minimum of 3% towards the invert in accordance with the landfill guideline.

5.2.1 Potential Environmental Impacts

Refer to Section 5.1.2.

5.2.2 Design Mitigation Controls

- Baseliner graded with cross fall towards the pipework and longitudinal grade along the inverts towards the collection sump;
- A gravel leachate collection and drainage layer containing perforated HDPE pipework. The gravel provides a stable, high permeability medium to allow the leachate to flow towards a sump and the pipework promotes the flow of leachate more directly to the sump. Pipes are spaced such that leachate head is minimised to less than 0.3 m over the liners;
- Drainage geocomposite to prevent leachate head accumulating over the Cell 1 batter;
- Separation geotextile layer overlying the gravel drainage layer to prevent the ingress of soil and fine particles into the collection system and prolong the effective functional life of the leachate collection system;
- Cushion geotextile layer overlying the HDPE geomembrane to prevent puncture of the barrier layers by the overlying gravel drainage layer or drainage geocomposite;
- Sumps with an active leachate extraction system to continually remove leachate and minimise head build up on the lining system connected to the broader site leachate management system.

5.2.3 Assumptions

The leachate generation rate has been based upon modelling conducted using the HELP[1] modelling package. The HELP model is a water balance model that has been developed for use in landfill design. Help modelling was undertaken for a number of scenarios during the life of the cell for both the base and the batters including:

- After placement of the initial waste lift;
- During operations; and
- After placement of interim cover.

HELP modelling considered 52 years of actual rainfall data sourced from the SILO database for the grid point closest to the site. The peak daily drainage from the above scenarios was used to design the leachate drainage system. The scenario of the cells under final capping was not modelled as the proposed final cap for the site is a phytocap; HELP is not a suitable modelling package for phytocaps. The phytocap will be designed to limit infiltration to a volume lower than the volume that the HELP modelling returned for the interim cover in accordance with the requirements of the *Environmental Guidelines: Solid Waste Landfills*. Based upon this, it has been assumed that the scenario of the cells under final capping is not the critical scenario for design of the leachate collection system.

The leachate generation rate modelled on the cell base was 27.7 mm/day, with a head of leachate in the leachate gravel of less than 100 mm during this peak event. The leachate generation rate modelled on the cell batters was 3.79 mm/hr, with a head of leachate in the drainage geocomposite of less than 2.1 mm during this peak event.

Giroud's equation for spacing of subsurface pipes, the leachate generation rate from HELP and an appropriate permeability reduction factor to account for chemical and biological clogging of the leachate drainage gravel was used to determine a maximum leachate pipe spacing on the cell base of 25 m. Based upon this design spacing, several pipes have been provided across the width of the cell.

5.3 Baseliner Level and Grades

The design has adopted a minimum 2 m groundwater separation from the top of highest recorded groundwater levels to the top of the engineered fill layer beneath the sump. The maximum groundwater surface was interpolated from standing water level data collected from the nearest site groundwater monitoring bores.

The proposed Cell has three inverts running east to west that all drain to a single edge sump. The inverts are spaced at 25 m to only require a single collection pipe along each invert except for the southern edge of the cell where a short extra pipe is required to achieve the 25 m spacing requirement. The pipework runs along cell inverts at 1.0% and the baseliner grades at 3.0% towards the drainage inverts.

5.4 Interim Waste Slopes and Waste Stability

The proposed liner for Cell 1 consists of a multi-component geosynthetic geocomposite liner system. As a result, several low friction interface layers are introduced into the design. Veneer stability analysis has been undertaken for the lined sloping surfaces to develop slopes which will be stable during construction and operation.

We have assumed the final capping profile for this cell and adjacent cells will be subject to slope stability analysis at the time of their design.

The operator must prevent any abnormal conditions developing. Specific operating restrictions should include:

- A maximum external (temporary) waste batter slope not exceeding 1V:3H to target post settlement slopes not exceeding 1V:4H.
- Prohibition of temporary stockpiling (waste and cover materials) or other loading which surcharges the outer edge of the waste mass / batter in any manner;
- Strict control of site drainage to prevent ponding and erosion and other factors (such as temporary excavation of batters) which may destabilise local areas;
- Management of the leachate drainage system to ensure effective operation at all times;
- Waste composition and homogeneity remains within the historic ranges and excludes monofilling of sludges, residues and other geotechnically weak materials;
- Development of an appropriate WHS and safe work procedures for batter construction to address stability during construction;
- Monitoring by WSC of the waste mass for signs of movement; and
- Any variation from these restrictions require an appropriate assessment of stability.

5.5 Post-Settlement Final Landform and Capping

The post-settlement final landform adopted for the design is that developed by Tonkin during concept phases of this project for the purposes of estimating cell volumes only. The design is such that variations to this landform can be accommodated should this be necessary in future. As the height of the landform was a key criteria in the EIS for approval of the expansion of the facility it is assumed that the height of the landform will not increase.

It is assumed, and recommended, that the final capping profile for these cells will be subject to global slope stability analysis at the time of the capping system design.

5.6 Construction Access and Mobility

It is considered that there is generally suitable access and open space for mobility which will be managed by the construction contractor and site operators in accordance with standard operating conditions. Consideration will need to be given to the construction site - operational site interface by the Contractor and Operator to ensure coordination of operations and construction activities, and management of conflicts at any operational interface.

5.7 Construction Methodology

Construction of the cell is assumed to progress in a single continuous construction campaign and the works will generally proceed as follows:

- Site establishment including works to establish the Contractor's compound, surface water runoff, erosion and sediment controls, access roads and systems including WHS, environmental and traffic management procedures and controls;
- Excavation of the floor and sidewall, including the access ramp;
- Subgrade filling and preparation works as required;
- Placement and compaction of engineered fill layer including intercell bunds and crest bunds;
- Anchor trench construction and surface preparation / maintenance prior to geosynthetics deployment;
- Deployment of the GCL, HDPE geomembrane and cushion geotextile layers;
- Deployment of drainage geocomposite and woven geotextile on the sideliners;
- Placement of pipework and gravel over the full extent of the cell baseliner; and
- Separation geotextile deployment over the full extent of the gravel.

5.8 Cell 1/Existing Cell Interface Design

An interface between Cell 1 and the Existing Cell is required as discussed in Section 3.1. The liner profile of this cell is discussed in that section. The connection between the existing cell liner and the new liner in Cell 1 is made on a bench that will be constructed to the north of the existing landfill cell. The existing geosynthetic materials will remain in the existing anchor trench with overlying new geosynthetics anchored by the construction of a bund on the bench.

6 Key Design Elements

6.1 Landfilling Extent

The Stage 1A Cell 1 landfilling extent is consistent with that shown in the concept design drawings and the pre-concept design provided at Appendix B. The extent of Cell 1 has been adjusted slightly based on the location of cell inverts and pipework. The footprint of the landfill operation is constrained by the existing landfill operation to the south, and the planning extents provided for the planning approval in the EIS to the east.

6.2 Liner Profiles

6.2.1 Design Compliance

Requirements of the *Environmental Guidelines: Solid Waste Landfills* are shown in the table below for barrier system design, with elements of the design implemented to comply with these requirements discussed following the table. This format is repeated for the respective sections addressing each component of the design.

Environmental Guidelines: Solid Waste Landfills Design Criteria **Leachate Barrier System Design**
The primary barrier system for a general solid waste landfill should include the following components, from bottom to top: • A compacted sub-base 200 millimetres thick to provide a firm, stable, smooth surface of high bearing strength on which to install the liner • A compacted clay liner at least 1000 millimetres thick, with an in situ hydraulic conductivity of less than 1×10^{-9} metres/second; for landfills receiving more than 20,000 tonnes of waste per year, the liner should include a geomembrane over the compacted clay; the base liner should have gradients of greater than 1% longitudinally and 3% in transverse directions. • A leachate collection layer comprising a 300 millimetres thick gravel drainage layer including collection pipework, which slopes to a sump or other extraction point from which leachate can be conveyed from the cell; the pipes should be at least 150 millimetres in internal diameter, be placed on the floor at intervals of not more than 25 metres (running the length of the cell) and be laid at gradients of at least 1% longitudinally into the sump and 3% in transverse directions. • As an alternative to compacted clay, a geosynthetic clay liner may be used, provided it is used in composite with an overlying geomembrane liner. • A protection or cushion geotextile should be used to protect geomembranes from damage by construction equipment and overlying materials. • A separation geotextile should be placed above the drainage layer to reduce the ingress of fines from the overlying waste. • A geonet drainage geocomposite may be used as an alternative to the gravel drainage layer for wall drainage and leak detection layers. • The elements of leachate barrier systems installed on slopes must have adequate slope stability. A slope stability analysis should demonstrate that there are adequate factors of safety for all potential failure mechanisms (e.g. veneer and global stability) at the proposed post-settlement final landform and at interim stages during construction. • The outer perimeter at any elevation of all new landfill cells should be set back at least 15 metres from the boundary of the premises. This is to ensure that land is available for the installation of monitoring wells and plume-abatement measures (e.g. construction of barriers) if liquid or gaseous pollutants are found to be escaping off-site.

6.2.2 Baseliner

The baseliner profile for Stage 1A Cell 1 has been developed to comply with the requirements of the *Environmental Guidelines: Solid Waste Landfills*. This guideline requires that the primary barrier system for general solid waste landfills should consist of a compacted clay liner at least 1,000 mm thick, overlain by a geomembrane for landfills which accept more than 20,000 tonnes of waste per year.

As discussed in Section 2.1.6, we do not expect that sufficient suitable material will be won during bulk excavation for construction of a compacted clay liner. Due to this, we propose to use a synthetic liner system for the base of the landfill, using a GCL as an alternative to a compacted clay liner. The use of a GCL as an alternative to a compacted clay is permitted by the *Environmental Guidelines: Solid Waste Landfills,* provided that it is used in composite with a geomembrane. The liner system for the base of the landfill consists of the following, from the top down:

- Separation Geotextile
- 300 mm leachate drainage gravel containing perforated leachate collection pipework
- Cushion geotextile
- 2.0 mm double sided textured High Density Polyethylene (HDPE) Geomembrane
- Geosynthetic Clay Liner
- 300 mm clayey engineered fill layer (liner subgrade), and
- Prepared subgrade

DN180 collection pipes perforated with four 12 mm diameter holes spaced every 100 mm have been provided. Pipes are placed along floor inverts spaced at 25 m maximum spacings. Design grades are consistent with the minimum grades required and a cell floor including multiple inverts has been adopted to maximise cell airspace.

The leachate collection system for the base of the landfill is discussed in greater detail in Section 5.2. Design compliance for each element of the baseliner system is discussed in greater detail in the respective sections in Section 6.

The baseliner has also been designed to contain landfill gas emissions and work with the future landfill cap in containing landfill gas within the cell.

6.2.3 Sideliner

The sideliner profile proposed for the cell batter slopes over a natural cut surface (i.e. not over waste) differs slightly from the proposed cell baseliner due to the need to manage slope stability and loads on the lining system acting in a down slope direction. The proposed liner system for the sideliner consists of the following, from the top down:

- Tensile Reinforcement Layer (Refer below)
- Drainage Geocomposite (Refer below)
- Cushion Geotextile
- 2.0 mm single sided textured HDPE Geomembrane, textured side down
- Geosynthetic Clay liner
- 300 mm clayey engineered fill layer (liner subgrade), and
- Prepared subgrade

Side batter grades have been nominated as a maximum of 1V:3H to facilitate safe construction while maximising airspace. The *Environmental Guidelines: Solid Waste Landfills* allows the use of a drainage geocomposite for side batter drainage as an alternative to the 300 mm leachate drainage gravel required for the base. This material is proposed on the side batters as the side batters have a reduced drainage requirement to the base, it provides favourable slope stability properties, and is lower cost than a 300 mm gravel layer for leachate drainage. This layer will also extend over the bench between Cell 1 and the existing cell and interface with the drainage gravel in the existing landfill cell.

Veneer slope stability calculations have been undertaken during detailed design to assess the stability of the sideliner system. Based upon these calculations, a geogrid has been specified as the tensile reinforcement layer. Details regarding the design of this layer are discussed in Section 6.13. Interface friction testing has been specified for the critical interfaces of the sideliner system to confirm assumptions made during design. This testing shall be undertaken prior to procurement of material, followed by confirmation testing using actual materials procured for use in cell construction.

The sideliner terminates at a bench to allow for anchoring of geosynthetic liner materials. Along the southern extent of the sideliner the bench has been located along the extent of the existing landfill cell according to the as-constructed survey from the construction of that cell.

The sideliner has also been designed to contain landfill gas emissions and work with the future landfill cap in containing landfill gas within the cell.

6.2.4 Potential Environmental Impacts

An unlined landfill poses significant risk of negatively impacting the groundwater system as a result of leachate generation and infiltration to the groundwater system.

The introduction of an appropriately designed and properly constructed lining (barrier) system significantly reduces the risk of groundwater impact. The baseliner has been designed in accordance with the Landfill Guidelines and industry best practices and together with good installation practice and CQA to limit the risks of impact.

6.2.5 Design Mitigation Controls

- Graded baseliner with fall towards the pipework and collection sump;
- A gravel leachate collection and drainage layer augmented with perforated HDPE pipework. The gravel provides a stable high permeability medium to allow the leachate to flow towards the sump and the pipework promotes the flow of leachate more directly to the sump. Pipes are spaced such that leachate head is minimised to less than 0.3 m over the liners;
- A drainage geocomposite on the sideliner to capture and drain leachate into the baseliner leachate collection system;
- Geotextile cushion layer to prevent puncture of the barrier layers overlain by gravel and another layer of geotextile on top of the gravel layer to prevent the ingress of soil and fine particles into the collection system. These both serve to prolong the effective functional life of the leachate collection system.

6.2.6 Assumptions

The leachate generation rate is based upon:

- Climate data for the site via the Queensland Government Department of Environment and Science SILO website[1];
- The outcome of HELP water balance modelling undertaken for the site; and
- Areas where infiltrating rainfall will contact waste and enter the leachate containment system as per the design drawings.

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[1] http://www.longpaddock.qld.gov.au/silo

6.3 Subgrade

6.3.1 Basis of Design

The subgrade will provide a competent foundation for the landfill and forms a critical component of the landfill leachate containment system by supporting the overlying soil and geosynthetic layers and the waste mass. Deformation of a subgrade beneath a lining system due to issues such as weak subsurface conditions or poor subgrade conditions could result in excessive stresses imposed on the geosynthetic barrier layer components (HDPE, GCL, geotextiles) which can lead to lining system failure.

The geotechnical investigations (Refer Section 3.3) undertaken in the footprints of proposed Cell 1 encountered material that is expected to be a suitable subgrade for the cell subject to construction controls as nominated in the specification.

6.4 Engineered Fill Layer

6.4.1 Basis of Design

The engineered fill layer when constructed will form the subgrade for the geosynthetic composite liner system which will be deployed directly onto the prepared engineered fill layer surface. This layer will form an attenuation layer between the underside of the composite geosynthetic liner and natural subgrade / groundwater.

The engineered fill layer shall be a minimum 0.3 m thick layer constructed of well graded reworked site soil material. The layer shall be placed and compacted to target the materials OMC with a tolerance of 0% to +3% OMC and achieve compaction of at least 98% SMDD uniformly across the entire working area.

The engineered fill layer shall be free of rubbish, organic soil, organic matter, or any other deleterious materials, finished with a smooth surface and be well graded soil with sufficient fines (clay) to not act as a free draining subgrade.

Based upon the geotechnical investigations undertaken (Section 3.3) we expect that most soil material encountered will be suitable for use in the Engineered Fill layer other than the Unit 4 SAND/Clayey SAND/Silty SAND encountered in some boreholes. The materials specification has been developed considering the site soils. Prequalification material testing has been specified to confirm suitability of materials proposed for use in construction.

6.4.2 Assumptions

The engineered fill layer will be constructed over a well compacted subgrade. Where uncontrolled fill materials or soft spots are encountered in the subgrade, they shall be removed and reinstated under controlled conditions and meeting the Specification.

6.5 Geosynthetic Clay Liner (GCL)

6.5.1 Design Compliance

Environmental Guidelines: Solid Waste Landfills Design Criteria **Geosynthetic Clay Liner (GCL)**
Geosynthetic clay liners used as alternatives to compacted clay should: • Consist of a thin layer of bentonite 'sandwiched' between layers of geotextiles with a hydraulic conductivity less than 5 x 10^{-11} metres/second

- Be reinforced (i.e. the geotextile layers are bonded by needle punching or stitching to enhance the internal shear strength of the geosynthetic clay liner compared with that of unreinforced products)
- Have adequate strength, flexibility and durability to maintain performance over the entire life of the landfill (including the operating and post-closure periods) relevant specifications published by the Geosynthetic Research Institute (Folsom, PA, USA) from time to time, or in equivalent recognised industry standard specifications; see GRI-GCL3[2] (Geosynthetic Research Institute, 010)
- Be made from bentonite that has been formulated for landfill applications; the bentonite should meet the specifications in Table 1 (Replicated in Table 1 below).

The nominated GCL is specified to meet or exceed the minimum requirements of GRI-GCL3 and the bentonite requirements documented in Table 1. A single carrier GCL (woven geotextile carrier only) has been specified for the base of the cell and a composite or double carrier (woven and non-woven composite carrier) GCL has been specified for the side batters of the cell as this provides increased tensile strength.

Table 1 Minimum bentonite specification (NSW EPA, 2015)

Property	Range or Value
Montmorillonite content	>70 wt%
Carbonate content	<1 to 2 wt%
Bentonite form	Natural Na-bentonite Or > 80 wt % sodium as activated bentonite
Particle size	Powdered (e.g. 80% passing 75-micron sieve) or Granulated (e.g. <1% passing 75-micron sieve)
Cation exchange capacity	≥0 meq/100 g (or cmol/kg)
Free swell index	≥24 cm^3/2 g

6.5.2 Basis of Design

The GCL shall be deployed into position directly over the engineered fill layer forming the lower layer of the geocomposite liner barrier layer. The barrier layer is designed as a composite where the GCL serves to seal defects that may develop in the geomembrane. The GCL is a very low permeability liner material selected for its combination of low permeability, mechanical properties and its resistance to chemical attack and breakdown as a result of exposure to leachate and the landfill leachate collection system environment.

The GCL shall be a proprietary product consisting of two geotextile outer layers with a uniform core of sodium bentonite clay powder. The GCL shall be needle punched throughout to provide increased shear strength and stability of the GCL and uniformity of the bentonite during manufacture, handling and installation. The geotextile layers shall be polypropylene non-woven on the upper layer (cover) of the GCL. The lower (carrier) layer on the base of the landfill shall be a woven geotextile, and woven / non-woven composite on the lower (carrier) layer on the sideliner.

[2] Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs), Geosynthetic Institute, Revision 5, 21 November 2019

GCL shall generally be deployed on a suitable prepared engineered fill layer as detailed in Section 6.4. GCL used in the works shall meet the minimum properties and manufacturer quality assurance (MQA) testing frequencies as shown in the Technical Specification.

6.5.3 Assumptions

The GCL Installation Contractor will be suitably prepared and experienced to install the GCL panels in accordance with the Specification.

The surface will be prepared in accordance with the Specification and fit for GCL deployment without risk of protrusions or deformations.

The GCL cannot get excessively wet or flooded prior to addition of a confining layer. The overlying HDPE, or a temporary plastic film may be used to prevent premature hydration but must be completely sealed on all sides and ends to ensure the GCL does not get wet.

GCL relies on drawing moisture through the subgrade to hydrate the bentonite. Typically, this will not result in excessive hydration of the GCL.

The GCL supplier will supply all GCL roll QA/QC certificates from the manufacturer to the Superintendent prior to deployment of the GCL.

6.6 Geomembrane Liners

6.6.1 Design Compliance

Environmental Guidelines: Solid Waste Landfills Design Criteria Geomembrane Liners
Geomembrane liners should: • Consist of a thin plastic film, minimum 2mm thick, manufactured from high density polyethylene or other material demonstrated to offer equivalent performance, strength and durability. • Be strong enough to ensure adequate tear resistance, puncture resistance, and resistance to installation damage • Be able to resist degradation caused by factors such as chemical attack, temperature, oxidation and stress cracking over the entire life of the landfill (including the operating and post-closure periods) • Meet or exceed the requirements for manufacture and performance contained in the relevant specifications published by the Geosynthetic Research Institute (Folsom, PA, USA) from time to time, or in equivalent recognised industry standard specifications; see GRI Test Method GM 13 and GRI Test Method GM 17 for, respectively, high density polyethylene geomembranes and linear low density geomembranes (Geosynthetic Research Institute, 2014a and 2014b).

To comply with the requirements shown above, A 2 mm HDPE Geomembrane liner has been specified for the lining system of Cell 1. To improve the stability of the lining system a double sided textured geomembrane has been specified for the floor as it provides higher strength interfaces above and below the geomembrane. A single sided textured geomembrane has been specified for the sideliner to be placed with the smooth side facing up to reduce strain mobilised in the geomembrane as a result of the tensile loading on the side batters of the cell.

6.6.2 Basis of Design

A HDPE geomembrane liner shall form the primary liner layer and be installed and welded into position directly over the GCL layer forming the top layer of the geocomposite baseliner barrier system. The barrier layer is designed to be the primary protection liner and prevent migration of leachate to the landfill subsurface and groundwater. The geomembrane is a very low permeability liner material selected for its combination of low permeability, mechanical properties and its resistance to chemical attack and breakdown as a result of exposure to leachate and the landfill LCS environment.

The geomembrane shall have a formulated thickness generally of nominally 2.0mm and a sheet density of typically 0.940 g/ml, or higher. A firm specification reflecting a high quality product with properties promoting longevity in this application is proposed. Formulation of the HDPE shall reflect performance with respect to OIT testing against benchmarks accepted as best practice for this application.

The geomembrane shall be textured both sides on the bell floor and single sided textured on the sidewalls to provide increased interface strength. Geomembrane shall be deployed over and completely covering the GCL on a suitably prepared subgrade over the cell floor terminating within an anchor trench.

6.6.3 Assumptions

The specialist HDPE Installation Contractor will liaise with the GCL installation Contractor (or be the same party), if not the same Contractor; to ensure the GCL is not hydrated prior to the installation and full coverage of the geomembrane.

The HDPE Installation Contractor will be fully qualified and suitably experienced in the deployment, welding, testing and CQA documentation processes.

CQA shall include liner integrity testing as assurance of a low frequency or absence of defects after placement to ensure a high probability of performance as required.

The geomembrane supplier will supply all roll QA/QC certificates from the manufacturer to the Superintendent prior to deployment of the geomembrane.

6.7 Cushion Geotextile

6.7.1 Design Compliance

Environmental Guidelines: Solid Waste Landfills Design Criteria **Cushion Geotextile**
The cushion (protection) geotextile should: • Be a non-woven, needle-punched geotextile, typically made of polyester or polypropylene (with the exception of inhibitors and/or carbon black added for UV resistance), formulated to meet landfill conditions and not containing recycled materials • Be of sufficient mass, strength and thickness to protect the underlying geomembrane from puncture and from excess stresses and strains due to indentations from overlying gravel particles or from the ribbing, edges and joints of drainage geocomposites. • Meet or exceed the requirements GRI Test Method GT12(a) and GRI Test Method GT12(b) (Geosynthetic Research Institute, 2012a and 2012b). • The grade (mass, strength, thickness) of the protection geotextile should be justified by the results of site-specific liner testing.

The cushion geotextile specified is:

- A non-woven needle punched continuous filament polyester or polypropylene geotextiles due to its ability to provide long-term durability and provide the mechanical characteristics required under the assumed conditions.
- Specified to protect the underlying geomembrane from puncture and from excess stresses and strains.
- To be demonstrated as satisfactory through appropriate compression testing prior to use in the works.

6.7.2 Basis of Design

The geotextile cushion layer shall provide a long lasting durable protective layer over the HDPE geomembrane liner to prevent puncturing of the HDPE geomembrane by the gravel drainage layer as a result of stresses acting on the overlying gravel drainage layer both during construction and in service.

The design specification shall require the Contractor to supply a cushion geotextile that can be demonstrated to limit strain on the geomembrane liner to <4% under the conditions experienced in Cell 1. Testing on the geotextile to demonstrate the required performance shall be undertaken in accordance with ASTM D5514 and using samples of the leachate drainage gravel, HDPE membrane and GCL proposed to be used in the works. Testing parameters are nominated in the technical specification.

6.7.3 Assumptions

Specification of the cushion geotextile for this design is based on the following assumptions:

- Utilising a non-woven needle punched continuous filament polyester or polypropylene geotextile due to its ability to provide long-term durability and provide the mechanical characteristics required under the assumed conditions.
- Gravel typically 19-37.5 mm but with a maximum particle size of 37.5 mm will be placed above the cushion geotextile.
- Waste depth ranging across the cell between 0–23.5 m with a final capping thickness of 1.6 m of soil.
- The Contractor shall undertake a Geomembrane Protection Efficiency Test to find a suitable geotextile that will limit strain on the liners to 4% at a pressure of 470 kPa when tested for a minimum 24 hour period.
- The post closure use will be passive open space.
- No vehicles will directly traverse the uncovered geotextile.
- Gravel will be placed with low ground pressure equipment and only traversing the covered surface over 0.3 m of placed gravel.
- A gravel placement work method statement and field trial validating the WMS shall be undertaken by the Contractor.

6.8 Gravel Drainage Layer

6.8.1 Design Compliance

Environmental Guidelines: Solid Waste Landfills Design Criteria **Gravel Drainage Layer**
The gravel drainage material should: • Consist of hard, strong, durable and clean gravel that will maintain the required performance under the maximum loads likely to be imposed on it in service • Have a saturated hydraulic conductivity greater than 1 x 10^{-3} m/sec when tested in accordance with Australian Standard AS 1289.6.7.1 Determination of the Permeability of a Soil (constant head method) • Be relatively uniform in particle size, with a nominal particle size greater than 20mm and a maximum particle size of 40mm, and with not more than 10% of particles smaller than 20mm in diameter and not more than 3% smaller than 0.075mm • Be non-reactive in mildly acidic conditions and chemically resistant to the leachate in the landfill, with a calcium carbonate content of less than 8.5% by mass

- Not have a shape and angularity that will damage the underlying geomembrane liner (the best type of gravel is rounded and smooth-surfaced)
- Be installed in a continuous layer at least 300mm thick across the entire base of the landfill cell, sloped with at least a 1% longitudinal gradient and 3% transverse gradient.
- Source material should be tested to show that the gravel drainage material meets these requirements.

The leachate collection system includes a gravel drainage layer with a minimum depth of 300 mm placed across the cell floor. This layer provides a high permeability drainage pathway for leachate.

The gravel drainage layer nominated is a clean, hard, durable, sound gravel and is specified to meet the following criteria:

- Be free of organic matter, clay or other deleterious material and not subject to physical or chemical degradation by leachate.
- Be free of fine material with no more than 3% (by weight) of material passing the 0.075 mm sieve and 10% by weight passing the 20 mm sieve.
- Consist typically of 19 mm – 37.5 mm stone.
- Have a coefficient of uniformity less than 2.
- Have an as-placed permeability of 1 x 10-3 m/s or greater.
- Containing no limestone or other calcareous material that would be subject to chemical attack and be less than 8.5% calcium carbonate by mass.
- Have an acid solubility of <5%
- Undergo prequalification testing prior to delivery to site.

6.8.2 Basis of Design

The gravel drainage layer shall provide adequate leachate flow capacity to transmit the maximum leachate flow produced at the site.

In accordance with the Landfill Guidelines the drainage layer extends across the entire landfill floor, comprises at least 0.3 m of coarse aggregate (Nominally >20 mm in grain size) and shall have a hydraulic conductivity greater than $1x10^{-3}$ m/s. The gravel drainage layer will work in combination with the leachate collection pipework discussed in Section 6.9.

6.9 Leachate Collection Pipework

6.9.1 Design Compliance

Environmental Guidelines: Solid Waste Landfills Design Criteria

Leachate Collection Pipework

The leachate collector pipes should:

- Be flexible pipes (typically high density polyethylene) at least 150 millimetres in internal diameter (water balance and pipe flow calculations should confirm the pipe size needed to convey peak leachate flow rates)
- Be perforated such that the size, frequency and layout of the perforations are sufficient to facilitate leachate inflow and extraction without clogging, prevent entry of drainage gravel, and maintain adequate pipe strength
- Be strong enough to maintain performance under the maximum loads likely to be imposed in service, complying with the requirements of Australian Standard AS 2566.1-1998 Buried flexible pipelines – Structural design (Standards Australia, various dates)

- Be joined by using techniques and materials recommended by the pipe manufacturer.

Perforated pipework is placed within the leachate drainage gravel layer to convey leachate to a sump from which leachate can be pumped to the site leachate management system. The leachate collector pipes specified are:

- HDPE due to being durable and inert to landfill baseliner environment.
- D180 mm collection pipes perforated with two pairs of 12 mm dia holes spaced every 100 mm sized and spaced to cope with potential leachate generation flow rates.
- Spaced to maintaining a maximum leachate head less than 0.3 m above the baseliner.
- Resistant to clogging as a result of biological or chemical attack.
- Flexible and structurally sound and able to resist excessive deflection which can lead to buckling or collapse accommodating the design loads.
- The specified pipework shall conform in every respect with AS/NZS 4130 Polyethylene (PE) Pipes for Pressure Applications.
- Leachate collection pipework shall continue up the cell sidewalls to facilitate flushing with specialised pipe cleaning equipment to maintain flow capacity as required. Flushing risers shall be unperforated above the level of the leachate gravel.

6.9.2 Basis of Design

The leachate collection pipework is designed to promote the transfer of leachate collected within the leachate drainage layer towards the sump.

Design of the pipework system within the gravel layer is such that the maximum liquid head that may build up on the geocomposite baseliner is no greater than 0.3 m. This will be achieved by spacing the pipework at a maximum of 25m centres.

Drainage is via gravity flow facilitated by baseliner grades and along defined flow lines created by the baseliner profile.

Pipework is designed to be:

- Made of HDPE due to being durable and inert to landfill baseliner environment.
- Sized to cope with potential leachate generation flow rates.
- Spaced to maintaining a maximum leachate head less than 0.3 m above the baseliner.
- Resistant to clogging as a result of biological or chemical attack.
- Flexible and structurally sound and able to resist excessive deflection which can lead to buckling or collapse as per AS 2566.1.

Leachate collection branch pipes shall conform to the following properties:

- Nominal 180 mm diameter (DN 180).
- Perforated with two pairs of 12 mm diameter holes spaced every 100 mm.
- Minimum grade: 1%.
- Maximum Pipe Spacing: 25 m.

In order to be able to inspect and maintain the leachate collection pipe network permanently accessible leachate flushing risers have been designed into the pipework network. The flushing riser connects into the leachate collection system pipework to allow down hole inspection of the pipework via CCTV inspection camera and flushing by high pressure rotary jet pipe cleaning equipment. Flushing pipework has been sized and spaced where feasible to accommodate typically available equipment and reach.

6.9.3 Assumptions

Specification of the pipework for this design is based on the following assumptions:

- Giroud's equation was used to design the liner slope and pipe spacing to ensure the maximum design leachate head of 0.3m is not exceeded.
- Base grades of 3.0% toward the drainage line and 1.0% along the drainage lines
- Cell catchment areas as shown on the design drawings.
- Waste mass (incl cover) of between 0 – 23.5 m in height and varying across the Cell.
- A conservative waste density of 1.20 t/m^3, drainage gravel density of 1.70 t/m^3, and landfill cap density of 1.90 t/m^3.
- Capping thickness of 1.6 m in accordance with the NSW EPA Guideline.
- Maximum reach of high-pressure pipe cleaning equipment is up to 250m (though this may not be locally available).

6.10 Leachate Extraction and Level Control System

6.10.1 Design Compliance

Environmental Guidelines: Solid Waste Landfills Design Criteria Leachate Extraction and Level Control System
The leachate extraction and level-control system should: • Include a collection sump and leachate riser(s) to facilitate extraction of leachate from the cell. The riser should be stable under the load of the surrounding waste mass and should be able to withstand stresses due to settling of the surrounding waste. The pipes should comply with the requirements of applicable Australian Standards for the pipe material, for example Australian Standard AS 4058:2007 Precast Concrete Pipes (pressure and non-pressure) (Standards Australia, 2007b). • Be installed in all cells, be able to control leachate levels within each cell, and be able to convey collected leachate out of the cell to surface storage or other infrastructure • Be able to keep the leachate level no greater than 300 millimetres above the upper surface of the base liner, or below some other level that is justified by the design, site conditions and leachate management measures (note: the flow of leachate through the liner is greater when leachate is allowed to accumulate within the cell, and higher leachate levels can also interfere with landfill gas controls) • Be able to continue to function effectively until the landfill is considered stable.

The sump in Cell 1 is a depression formed at the low point of the cell to collect leachate and facilitate pumping out via a leachate extraction riser. A leachate edge riser has been provided for Cell 1. The riser has been nominated to be suitable to house an Airwell style submersible leachate pump for removal of leachate. The sump system consists of the following components:

- HDPE large diameter extraction riser that will facilitate pumping access to the base of the sump. The riser consists of a HDPE pipe perforated with 12 mm holes around the circumference of the pipe within the gravel drainage layer. The riser shall be unperforated above the level of the gravel drainage layer The specified pipework shall conform in every respect with AS/NZS 4130 Polyethylene (PE) Pipes for Pressure Applications.
- A flushing riser extends from the sump which will be a non-perforated extension of the main leachate drainage pipe that shall daylight on the lower containment bund to permit future hydro-jet cleaning of the main leachate collection pipework.
- The leachate extraction pump and level control system will be specified by others and consist of an airwell style submersible sump pump or similar. The edge riser has been designed to accommodate such a pumping system.
- Leachate will be pumped to the existing leachate pond at the site for disposal.

6.10.2 Basis of Design

The leachate sump has been designed to:

- Provide a low point for leachate to collect and be extracted.
- Provide a stable base for the leachate extraction riser.
- Be of minimal depth to maximise airspace in the cell while maintaining a head of leachate for the pump.

The leachate riser is designed to be:

- Made of HDPE due to being durable and inert to landfill baseliner environment.
- Sized to facilitate installation of an Airwell type submersible leachate pump or similar.
- Flexible and structurally sound and able to resist excessive deflection which can lead to buckling or collapse as per AS 2566.1.

The leachate extraction riser shall conform to the following properties:

- Nominal 630 mm diameter (DN 630).
- Perforated with three pairs of 12 mm diameter holes spaced every 150 mm, offset as shown on the design drawings.
- Unperforated above the level of the leachate gravel.
- Finished with a flange and bolt on blank cap that can be modified as required to facilitate pumping and landfill gas infrastructure designed by others.

Design of the leachate pump and level control system is by others and is assumed to consist of a proprietary system e.g. Airwell type pump or similar.

6.10.3 Assumptions

Specification of the pipework for this design is based on the following assumptions:

- Waste mass (incl cover) of between 0 – 23.5 m in height and varying across the Cell.
- A conservative waste density of 1.20 t/m^3, drainage gravel density of 1.70 t/m^3, and landfill cap density of 1.90 t/m^3.
- Capping thickness of 1.6 m in accordance with the NSW EPA Guideline.

6.11 Separation Geotextile

6.11.1 Design Compliance

Environmental Guidelines: Solid Waste Landfills Design Criteria **Separation Geotextile**
The separation geotextile should: • Be a non-woven, needle-punched geotextile, typically made of polyester or polypropylene (with the exception of inhibitors and/or carbon black added for UV resistance), formulated to meet landfill conditions and not containing recycled materials • Have appropriate filtration characteristics to limit the effects of clogging, while at the same time limiting excessive migration of soil fines into the underlying drainage layer • Allow flow of leachate into the underlying drainage layer without significant flow impedance • Have sufficient strength to resist installation damage • Have appropriate UV resistance properties based on the estimated exposure of the material before covering

- Have appropriate chemical resistance to the site's leachate
- Meet or exceed the requirements for manufacture and performance contained in the relevant specifications published by the Geosynthetic Research Institute (Folsom, PA, USA) from time to time, or in equivalent recognised industry standard specifications. See GRI Test Method GT13(a) and GRI Test Method GT13(b) (Geosynthetic Research Institute, 2012c and 2012d).

The separation geotextile specified is:

- A non-woven needle punched continuous filament polyester or polypropylene geotextiles due to its ability to provide long-term durability and provide the mechanical characteristics required under the assumed conditions.
- Specified to balance the filtration needs of the cell as well as the strength and fines retention requirements.

6.11.2 Basis of Design

This geotextile layer provides two key functions:

- Separation between waste and gravel drainage layer to prevent waste and fines intrusion into the gravel layer.
- Filtration function to retain soil and other particles whilst maintaining free movement of leachate between the waste mass and the LCS.

The separation / filtration geotextile properties have been specified to provide the following attributes:

- Durability and long term survivability.
- Mechanical properties (tensile strength, puncture resistance, elongation resistance etc) to survive the construction, waste filling and ultimate loading stresses.
- Sufficient pore opening size to retain fines but promote free drainage through specifying a geotextile with the largest opening size meeting retention criteria.
- Non-woven needle punched continuous filament polyester or polypropylene geotextiles has been selected due to its ability to provide long-term durability, provide the mechanical characteristics required whilst functioning as an effective filter medium.

6.11.3 Assumptions

The following assumptions will be made during detailed design of the separation / filtration geotextile layer:

- Minimum first waste layer thickness of 1.5m.
- Waste depth ranging between 0–23.5 m with a final capping thickness of 1.6 m of soil.
- A gravel particle size of typically between 19 – 37.5mm.
- Design reduction factors consistent with typical MSW landfills for soil, chemical and biological clogging, creep reduction, void space intrusion.
- No vehicles directly traversing the geotextile until minimum of 1.5m waste layer has been placed.
- Typically, the soil particle sizes to retain are associated with the soil cover soils typically used at the site.

6.12 Drainage Geocomposite

6.12.1 Design Compliance

Environmental Guidelines: Solid Waste Landfills Design Criteria **Drainage Geocomposite**
The geonet drainage geocomposite should: • Have an internal geonet drainage core manufactured from high-density polyethylene (plus anti-oxidants) and consisting of layers of parallel ribs creating drainage channels through which liquid can flow • Have a geotextile fabric bonded to the upper surface of the geonet to prevent fines from entering the drainage channels, and a geotextile fabric bonded to the lower surface to prevent damage to adjacent geosynthetic layers from the ribbing, edges and ties of the geonet • Be able to resist degradation cause by factors such as chemical attack, temperature, oxidation and stress cracking over the entire life of the landfill (this includes chemical resistance of the geotextile fabric polymers to the site's leachate) • Have adequate internal shear strength and interface friction with adjacent layers • Have adequate long-term flow capacity for the calculated leachate flow rate at the site. • Be protected by an overlying padding or protection layer.

The drainage geocomposite shall be placed on the cell batters. The drainage geocomposite is:

- A composite material consisting of a HDPE internal core with layers of ribs creating drainage channels covered by a bonded, non-woven geotextile fabric to prevent ingress of fines to the drainage channel.
- Specified to prevent damage to the underlying lining layers.
- Specified to have adequate tensile and compressive strength to resist applied loads from the landfill contents.
- Specified to have adequate flow rate to convey leachate to the leachate collection system on the base of the cell.
- Demonstrated satisfactory through appropriate testing prior to use in the works.
- The geocomposite shall be protected by cover soil placed ahead of waste.

6.12.2 Basis of Design

The drainage geocomposite provides an adequate leachate flow rate to transmit the maximum leachate flow produced at the site to the leachate collection system.

In accordance with the Landfill Guidelines the drainage geocomposite extends across the batters and has been sized with allowance for factors reducing the thickness and capacity of the drainage core under long term field conditions, including elastic deformation, long-term creep deformation and chemical and biological clogging caused by the leachate.

The drainage geocomposite will form the primary drainage layer and consists of a biplanar or triplanar HDPE drainage core material, bonded to an upper non-woven geotextile layer. This internal drainage core provides a netlike configuration of parallel sets of interconnected ribs.

The non-woven geotextile layer serves to prevent fine particles entering into and clogging the internal drainage core over the lifespan of the capping system, thereby preserving the flow capacity of the drainage geocomposite.

6.12.3 Assumptions

The drainage geocomposite shall meet the following criteria:

- Have an internal biplanar or triplanar drainage geonet manufactured from HDPE and resistant to degradation from factors such as chemical attack from leachate, temperature, stress cracking and oxidation over the life of the landfill.
- Have a non-woven geotextile bonded to the upper surface of the internal drainage geonet. This geotextile shall be suitable to prevent ingress of fine particles to the internal drainage core and be resistant to chemical attack over the life of the landfill.
- The drainage geocomposite will be placed over cushion geotextile to prevent damage to underlying layers.

Specification of the geocomposite for this design is based on the following assumptions:

- Side batters of the sideliner are 1V:3H (33%) maximum.
- Maximum waste height of 23.5 m above the geocomposite.
- Reduction factors of 2.0 for elastic deformation, creep and chemical and biological clogging, taken as upper limits from literature.
- Provision of a tensile reinforcement layer overlying the drainage geocomposite to limit strain in the geonet to manage long term performance.

6.13 Tensile Reinforcement Layer

6.13.1 Design Compliance

The *Environmental Guidelines: Solid Waste Landfills* does not include specific design compliance criteria for tensile reinforcement layers. A tensile reinforcement layer is required based upon the veneer stability analysis undertaken to inform the design of the sideliner. Based upon the veneer stability analysis a geogrid has been specified to provide tensile reinforcement for the sideliner.

6.13.2 Basis of Design

The tensile reinforcement layer specified shall be:

- Placed over the drainage geocomposite on the landfill sidewalls.
- A geogrid manufactured from woven high modulus polyester yarns to ensure long term strength at low strain and be resistant to attack by landfill leachate.
- Specified to provide adequate long term strength to maintain the slope stability of the sidewall.
- Be securely anchored in the anchor trench or below a bund at the crest of slopes.

The performance of the geogrid is critical to maintaining stability of the sideliner system and therefore interface shear testing has been specified to confirm design assumptions made in the slope stability assessment prior to construction of the cell.

6.13.3 Assumptions

The following assumptions have been made in the design of the tensile reinforcement layer:

- Friction between the geogrid and soil is 30 degrees with a friction of 8 degrees between the geogrid and underlying drainage geocomposite.
- Cover soil on the bund and in the anchor trench with a density of 21 kN/m^3.
- Placement of cover soil by plant with a mass and ground pressure not exceeding that of a CAT D3K dozer.
- Several operational controls shall be implemented to promote stability of the sideliner in combination with the provision of the tensile reinforcement layer:
    - Cover soil shall be placed to a minimum depth of 300 mm above the sideliner

- Cover soil shall be placed a maximum of 5 m vertically ahead of waste filling to manage the loading on the sideliner.

- The sideliner shall be covered by a sacrificial geosynthetic material to protect the tensile reinforcement layer and underlying drainage geocomposite from UV exposure until cover soil is placed as detailed in the technical specification.

6.14 Surface Water Management

6.14.1 Basis of Design

The location and size of surface water cut-off drains has been nominated on the drawings. The cut-off drains consist of drains located around the edges of the cut subgrade batter slopes to exclude any surface water flows from entering the landfill cell and leachate collection system.

A bund has been provided around the edge of the Cell 1 baseliner to exclude surface water flows from entering the leachate collection system. Around the edge of the Cell 1 baseliner a 5 m wide alignment has been provided between the baseliner and subgrade batter to allow for water collection. Two low points have been provided to facilitate pumping out of stormwater from this area, one to the north of Cell 1 and one to the east of Cell 1. This allows for stormwater pumping to continue from the undeveloped side of the cell following construction of the subsequent landfill cell.

For the cell construction phase, surface water controls shall be identified and implemented by the Contractor through development of a sediment, erosion and drainage management plan (SEDMP) as nominated in the Specification. The SEDMP shall address:

- Controlling run-on from the areas surrounding Cell 1, particularly the undeveloped areas to the north and east of the cell, to prevent runoff from entering the construction space via cut-off drains or bunds
- Controlling run-on from the southern waste batter slope to the extent practicable to prevent surface water from entering the construction space.
- Ensuring that run-off is directed away from the construction area.
- Managing water that accumulates in the work zone during construction.

6.15 Construction Quality Assurance

6.15.1 Design Compliance

Environmental Guidelines: Solid Waste Landfills Design Criteria

Construction Quality Assurance

Before the construction of all major features of the landfill, the occupier must prepare a CQA Plan. This applies to construction of the leachate barrier, final capping, leachate storage dams, stormwater basins, landfill gas controls and monitoring installations.

<u>General requirements of the CQA Plan</u>

The CQA Plan should address the following requirements:

- The Plan should set out the proposed testing, inspection and verification procedures to demonstrate that materials and constructed features at the landfill comply with the approved designs and specifications.
- In relation to materials testing, the Plan should specify the sampling locations, frequency of testing, test methods, laboratories, accreditations, applicable specifications and quality standards, data evaluation, acceptance and rejection criteria and contingency measures in the event of failure.
- The Plan should describe the roles, responsibilities and qualifications/experience of the parties involved in delivering CQA. All parties should have qualifications and experience appropriate for their roles in the project.

- The licensee should engage a Construction Quality Assurance engineer to verify and report on all CQA matters. The engineer should be independent of the construction contractor and should be either an independent consultant engaged by the Principal (the licensee) or by the construction Superintendent (if there is one). The engineer should be a civil or geotechnical engineer with professional qualifications acceptable to Engineers Australia (or equivalent), should have at least 5 years of experience in landfill design and construction, and should be currently practising competently in this field.
- Sub-contractors who install geosynthetic materials should have qualifications, experience, and competence in the installation, seaming and/or joining of such materials. Drilling sub-contractors installing sub-surface monitoring devices should hold appropriate licences to do this work.
- The Plan should specify the hold points and inspection points for the project. These points are typically the start or finish of key stages of the work that cannot later be rectified because they will no longer be accessible. Upon reaching each hold point, the CQA engineer should review all test results for the materials proposed to be used; proposed work methods and quality control procedures; proposed panel layouts for any geosynthetic elements; and each sub-contractor's credentials. When each stage has been completed, the engineer should review a work-as-executed survey of the completed work. At all of these points, work should stop and should not restart until the engineer has reviewed the documentation and given approval for the project to continue. The CQA engineer should do on-site inspections of the work at all of these points and should be present when all samples are taken for the testing of construction materials. At a minimum, hold and inspection points should be established at the start and finish of the following stages during construction of the leachate barriers and final capping: trial pad activities, sub-base, bearing layers, each lift of clay liner or sealing layer, the finished top surface of the clay liner or sealing layer, drainage layers, all geosynthetic layers, protection layers, pipework, landfill gas controls, penetrations of liners by leachate and gas collection infrastructure, and monitoring installations. These are minimum requirements for hold points and inspections to facilitate a CQA program. Ideally, a CQA engineer should be present at the site full-time during the construction of major features such as the leachate barrier system and the final capping of completed cells.
- Response actions are required if there are variations to the approved designs and specifications and the CQAP. If a major variation arises, work should stop on the affected element and the licensee should notify the EPA in writing, seeking a licence variation. For minor variations, notification is not required; it is sufficient for the CQA engineer to note the variation in the final CQA Report and to confirm that the variation did not compromise achievement of the minimum standards in these guidelines. The engineer should use his or her judgment to determine whether a variation is a major one in terms of the requirements of these guidelines.
- If staged construction is proposed, this should be noted in the CQAP. The most common example of this is where the walls of a new cell will be constructed progressively as the waste height rises. The licensee should submit an addendum to the CQA Report upon completion of each new portion of the cell wall. In addition to these general requirements, the following sub-sections contain guidance on some key issues for quality assurance of the particular types of construction materials used at landfills. (*Designers note: Staged construction is not proposed for Stage 1A Cell 1)*

Refer to the Landfill Guidelines for further detail of CQA requirements specific to:

- Clay liners and subgrade
- Gravel drainage layers
- Geosynthetic materials

<u>CQA Report</u>

- Following construction of key works at the landfill, a CQA Report must be prepared. It must give details of the works' construction and the QA measures that were followed.

The Technical Specification for Cell 1 includes the quality assurance requirements for the construction of Cell 1. The CQA Plan for Cell 1 incorporates CQA control requirements for materials, construction, hold points etc and includes inspection and test plans (ITP's) and construction checklists to be prepared by the Contractor and approved by the Superintendent prior to the commencement of works to ensure all CQA requirements for cell construction are identified and met.

The CQA Plan outlines all necessary CQA testing, inspection and reporting meeting the criteria of the *Environmental Guidelines: Solid Waste Landfills*. The CQA Plan includes the requirements for a CQA

Consultant to monitor and verify the works, including preparation of the CQA report detailing the construction. The CQA reports shall include, but not be limited to, the following information:

- As-constructed geosynthetic panel layout plans, panel referenced test results and panel referenced test failure records.
- GITA reporting of the testing, inspection and certification of the subgrade and compacted clay layer.
- All completed Quality Check Lists (including verified Hold Point and Witness Point releases by the Superintendent).
- All Inspection and check records.
- All Non-conformance Reports (including acceptable actions as signed-off by the Superintendent).
- All Daily Project Reports (including, but not limited to - manning levels, machines and plant onsite, weather records).
- All Work Method Statements.
- Verification surveys.
- Materials prequalification, MQA and IQA certificates.

6.16 Rehabilitation

Rehabilitation of Stage 1A Cell 1 will commence as soon as is practicable after completion of filling within the cell. A detailed design of a landfill cap for the Buronga Landfill has not been completed, however possible capping options are discussed in the EIS. Capping contours are expected to be in accordance with the post-settlement final landform developed as a part of the EIS and shown in Appendix C.

The type of capping proposed for use has not been finalised, however, Council is exploring the possibility of using a phytocap at the site. The design of Stage 1ACell 1 facilitates rehabilitation in accordance with the *Environmental Guidelines: Solid Waste Landfills.* Considerations made to facilitate construction of the final cap include:

- Termination of the sideliner on a bench at the crest of the slope to facilitate an interface between the cell liner and a future final cap. The termination allows for an interface with a phytocap to be made, or if a composite cap was used, a connection to be made between geosynthetic barrier layers.
- Design of the lining and leachate collection system to provide long-term protection of the environment following rehabilitation of the cell. This includes specifying durable materials that are known to function long-term in a landfill baseliner environment and implementing reduction factors in the specification of materials considering environmental degradation of the lining and leachate collection system exposed to leachate within the landfill.
- Consideration of loading on the lining components from waste filling and capping of the cell.
- The leachate collection system includes a large diameter side riser and leachate flushing risers to provide ongoing leachate collection following rehabilitation of the cell.

Rehabilitation timing will be discussed in further detail in the LEMP.

7 Safety in Design

A Safety in Design review has been undertaken by Tonkin as a part of the detailed design for Cell 1. The draft register is attached to this document (Appendix D) and a workshop will be held with WSC following the design submission to discuss the outcomes of this process, required controls and responsibilities for these controls. The safety in design register is also included on the design drawings. The Safety in Design process serves to satisfy the requirements of WHS legislation and serves to:

- Identify potential risks from construction & operation of Cell 1;
- Assess risk in terms of impact / consequence and probability / frequency;
- Develop management and mitigation strategies where required;
- Identify risks with medium or higher residual risks; and
- Include risk assessment and residual risk implications in technical specification.

A Safety in design register was developed for the concept design of Stage 1A and is contained within the basis of design report.

Following the draft risk assessment process, the following residual risks were identified as medium or higher:

- During Construction:
  - Failure of stability of slopes resulting in injury or environmental damage due to liner failure was rated as Medium. Controls include the designer limiting maximum side batter angles and assessing slope stability of proposed design, and creation of a stable base, lining and leachate collection system to provide a safe foundation for activities. The Contractor will ensure that appropriate precautions are made for earthworks. WSC will ensure operator / contractor comply with precautionary measures. The superintendent will monitor works and undertake CQA.
  - Failure of waste faces of adjacent landfill cells causing injury or damage was rated as Medium. Controls include the Contractor ensuring that an appropriate WHS plan is made for earthworks and the Contractor is satisfied with slope conditions. The Contractor will be required to remove waste from earthworks areas prior to construction including the interface with the existing landfill cell. The Contractor will cut waste slopes back to a maximum grade of 1:3 where slopes exceed 1:3, or flatter if conditions dictate. The Contractor is to develop an appropriate and specific WHS plan for exposure and relocation of waste if waste relocation is required. The Contractor will liaise with the Principal regarding implementation of exclusion areas for landfill operations and the extent of waste slopes requiring modification.
  - Exposure to landfill gas during construction during connection with the existing cell interface was rated as Medium. The Contractor will address risks associated with venting landfill gas and develop controls to prevent impacts upon workers, ensure no confined spaces are created where LFG could accumulate and ensure no ignition sources/smoking in vicinity of landfill.
  - Dangers of excavation and encountering waste and leachate while constructing the interface between the existing Cell and Cell 1 was rated as medium. Controls include the designer accommodating construction of the interface with safe excavation and waste removal by minimising difference in level between the liners. The Contractor will address the interface specifically in the WHS plan and implement controls, Contractor's staff will utilise appropriate PPE and not handle waste or contaminated soils. The Contractor will ensure no work is undertaken over placed waste and avoid/limit manual work along the interface. The Principal will review the Contractor's WHS plan and undertake inspections during construction to observe implementation of the plan. The Contractor will ensure that waste is removed from the interface area and that the waste batter slopes are stable and cut to a maximum grade of 1:3, or flatter if conditions dictate.

- During Operation:
  - Injury or damage during leachate extraction was rated as medium. To control this risk the Principal will establish an operations management plan and WHS Plan addressing risks associated with a hazardous working area (explosive and hazardous atmosphere). The Principal will require a safe and competent surface for access, testing and operation adjacent ot the sump riser at all times. Staff will be trained in operation of the leachate management system.
  - Injury or damage during waste tipping, traffic movements, cover soil placement, stormwater management was rated as medium. To control this risk, the Designer will specifiy maximum waste slopes and the Principal will ensure the operator establishes an Operations Plan addressing waste management, traffic management, tipping and disposal, use of cover soils, waste batter slopes, soil management, stormwater management etc. All staff will correctly utilise appropriate PPE (e.g. high visibility clothing).

The Safety in Design register will be updated as the design process continues.

Appendix A – Basis of Design

Buronga Landfill Expansion

Landfill Stage 1A Basis of Design

Wentworth Shire Council

5 June 2023
Ref: 202597R08Rev1

Building exceptional outcomes together

Document History and Status

Rev	Description	Author	Reviewed	Approved	Date
0	For Client Review First issue pre-concept design	IPN	JV	MRS	12/04/2023
1	Concept Design Issue	IPN	JV	JV	05/06/2023

Contents

Project: Buronga Landfill Expansion | Landfill Stage 1A Basis of Design
Client: Wentworth Shire Council
Ref: 202597R08Rev1

Appendices

1 Project Definition

1.1 Background

Wentworth Shire Council (WSC) owns and operates the Buronga Landfill, located at 258 Arumpo Road, Wentworth, NSW. The site is an existing landfill facility which WSC is proposing to expand to provide ongoing waste management and disposal capacity for Wentworth Shire.

Tonkin has been providing assistance to WSC with the approvals process for the proposed expansion of the facility and prepared a concept design for future landfill stages as a part of this process. Subsequently, Tonkin has been engaged by WSC to undertake the detailed design of a number of elements of the facility, including the first new stage of landfill cells (Stage 1A) and supporting leachate management infrastructure. This report documents the basis of design for Stage 1A and the supporting leachate infrastructure.

1.2 Objectives

The Stage 1A Landfill design shall be developed to comply with the requirements of:

- Site Licence: NSW EPA (2023). *Environment Protection Licence Number 20209*, Version Date 8 Mar 2023
- Landfill Guidelines: NSW EPA (2016). *Environmental Guidelines: Solid Waste Landfills,* Second Edition, April 2016, Ref: EPA 2016/0259
- Environmental Impact Statement: Tonkin (2022a). *Buronga Landfill Expansion, Environmental Impact Statement,* Revision 1, 25 January 2022, SSD-10096818, Ref: 202597R04Rev1
- Planning Submissions Report: Tonkin (2022b). *Buronga Landfill Expansion, Submission Report,* Revision 2, 1 December 2022, SSD-10096818, Ref: 202597R05Rev2
- Conditions of the development consent will be included once they become available, as the DA for the landfill expansion is yet to be finalised.

Additionally, the design will be developed to provide the following outcomes for WSC:

- Provide at least two to three years of landfill airspace per cell. Consumption rates can be selected based upon existing filling rates or projected future filling rates, to be advised by WSC.
- Minimise any relocation of waste required to construct the PBL
- Maximise airspace returns within Stage 1A by optimising baseliner grades in relation to the level of groundwater at the site

2 Key Design References

2.1 Reference Documentation

2.1.1 Project Brief

- Tonkin (2023). *Buronga Landfill Expansion, Tender for Design Works,* Revision 1, 31 January 2023, Ref: 202597P03

2.1.2 Landfill Expansion Planning Documentation

- Environmental Impact Statement: Tonkin (2022a). *Buronga Landfill Expansion, Environmental Impact Statement,* Revision 1, 25 January 2022, SSD-10096818, Ref: 202597R04Rev1
- Planning Submissions Report: Tonkin (2022b). *Buronga Landfill Expansion, Submission Report,* Revision 2, 1 December 2022, SSD-10096818, Ref: 202597R05Rev2
- Planning Amendment Report: Tonkin (2023). *Buronga Landfill Expansion, Amendment Report,* Revision 0, 8 February 2023, Ref: 202597R07Rev0
- Preliminary Scoping Report: Tonkin (2020a). *Buronga Landfill Proposed Expansion, Preliminary Scoping Report,* Revision 2, 8 October 2020, Ref: 20180746R001.
- Development consent for SSD-10096818, currently pending

2.1.3 Regulatory Requirements

- Site Licence: NSW EPA (2023). *Environment Protection Licence Number 20209*, Version Date 8 Mar 2023
- Landfill Guidelines: NSW EPA (2016). *Environmental Guidelines: Solid Waste Landfills,* Second Edition, April 2016, Ref: EPA 2016/0259

2.1.4 Site Management Documentation

- Wentworth Shire Council (2015). *Buronga Landfill, Landfill Environmental Management Plan,* Revision 0, December 2015

2.1.5 Geotechnical Information

- Tonkin (2021a). *Geotechnical Investigation Report, Buronga Landfill Expansion,* Revision A, 11 June 2021, Ref: 202597R02A
- 2023 Tonkin Geotechnical Investigation Report – in preparation at time of issue of this report.

2.1.6 Groundwater Information

- Tonkin (2021b). *Groundwater Impact Assessment, Buronga Landfill Expansion,* Revision 0, 19 September 2021, Ref: 202597R03Rev0
- Tonkin (2023). *Stage 2 Geotechnical Investigation Report,* Revision 0, 31 May 2023, Ref: 202597R09Rev0
- Groundwater information supplied by WSC for 2022

2.1.7 Previous Cell Design and Construction Documentation

- Tonkin (2016). *Buronga Landfill, Proposed Cell Technical Specification,* Revision S1B, 29 August 2016, Ref: 20155461S1B

- Tonkin (2017). *Buronga Landfill, New Landfill Cell – As Constructed Report,* Revision A, 20 October 2017, Ref: 20155461FR3

2.1.8 Volumetric Survey and Waste Acceptance Information

- Volumetric Surveys, Wentworth Shire Council, Dated 27/11/2019, 19/08/2022, 07/02/2023
- Waste Acceptance Data Dated: July 2021-April 2022, April 2022 – August 2022, August 2022 – Feb 2023.

2.1.9 Site Survey

- PriceMerrett Consulting (2021). *Buronga Landfill, Contour and Feature Plan,* 4 March 2021, Ref: F8648 Dwg 6257 Rev 0.
- Phil Maw Survey & Drafting (2023). *30322SM-TPS Buronga Landfill, Buronga, NSW-3D-Combined.dwg,* 22 March 2023.

2.1.10 Other Input Data

- Tonkin (2020b). *Leachate Pumping System Maintenance and Monitoring Schedule,* Revision 0, 24 November 2020, Ref: 202156R01

2.2 Existing Design Concept

A concept design for the landfill expansion was prepared as a part of the planning process for the development application for the landfill expansion. Drawings and discussion of the basis of design and design process are provided in the Environmental Impact Statement (EIS).

The design concept provides approximately 3,304,000 m^3 of airspace across four stages labelled Stage 1A to 1D, providing an expected 38 years of landfill life based upon future projected waste tonnages. Each stage is proposed to be divided into four landfill cells with baseliners grading in a sawtooth style arrangement, with the two central cells in the stage sharing a common sump. The concept design also includes a concept design for the final landform for the site. A drawing showing the layout is included as Appendix A.

The concept design also includes additional leachate management infrastructure including a ring main to collect leachate from sump pumps and an area allowed for a new leachate pond/ponds.

WSC is proceeding with detailed design of Stage 1A which is the first of the four new landfill stages. Stage 1A is located adjacent to the existing landfill, of which only the newest landfill cell , the western cell, is lined. As such, Stage 1A will include a piggyback liner over existing unlined waste disposal cells to provide a continuous barrier to leachate beneath all new surfaces of waste placement.

The staging of construction of the landfill cells and approximate size of the cells will be determined as a part of the design process for Stage 1A.

3 Site Conditions

3.1 Adjacent Unlined Cells

Stage 1A is adjacent to the existing landfill operation. The existing landfill facility includes an unlined historical landfill area. To provide a continuous final landform, filling will occur above the unlined area of the existing landfill. The *Environmental Guidelines: Solid Waste Landfills* requires all surfaces to be used for waste disposal to be lined and due to this it is expected that a piggyback liner will need to be constructed over the existing unlined landfill.

A risk-based approach will be used to inform the requirement and design of the piggyback liner system considering the site specific conditions. The piggyback liner system extends over landfilled areas and will be a different profile to the liner within other parts of Stage 1A to account for loads on the piggyback liner caused by differential settlement of the waste mass beneath it. The specific liner profile will be developed during detailed design. Advice from WSC is that the newest waste in the unlined areas requiring piggyback lining was filled in 2017, this is supported by volumetric surveys provided by Council. Based upon this, it is expected that the waste placed still has some settlement and landfill gas generation potential.

The grades of the existing waste surface are variable and will require reshaping to achieve acceptable grades for construction of the piggyback liner, expected to be 1V:3H or flatter. Some relocation of waste may be required as a part of these earthworks, but this will be minimised to the greatest extent possible.

3.2 Location and Profile of Adjacent Cell Liners

A portion of the existing landfill operation consists of a lined landfill cell which is currently operational. This landfill cell was designed by Tonkin in 2016 and includes a lined base and sideslopes. An interface will be made between the new cells in Stage 1A and the existing cell to provide a continuous barrier beneath the landfill and avoid the need to construct a piggyback liner over waste filled in the existing lined cell. The baseliner profile of the existing lined cell that will require interfacing with consists of the following profile from the top down:

- Separation Geotextile
- 300 mm leachate drainage aggregate containing perforated collection pipework
- Cushion geotextile
- 2.0 mm double sided textured HDPE Geomembrane
- 1.0 m compacted clay liner

And the sideliner profile consists of the following profile, from the top down:

- Separation Geotextile
- 300 mm leachate drainage aggregate
- Cushion geotextile
- 2.0 mm double sided textured HDPE Geomembrane
- Geosynthetic Clay Liner (GCL)
- 200 mm earthen layer (liner subgrade)

Details of the construction of this landfill cell including as constructed survey showing the extent of construction of the lining system are included within the as-constructed report for the landfill cell construction (Tonkin, 2017).

3.3 Final Landform

A concept design for the post-settlement final landform was prepared as a part of the planning process for the landfill expansion project. This landform is shown in the drawing included as Appendix B. This concept final landform will be used for the design of Stage 1A.

The landform was developed in accordance with the *Environmental Guidelines: Solid Waste Landfills* with side slope grades of up to 1V:5H and crest grades of 5% or greater. The landform includes surface water drains to shed water from the cap to drainage corridors along the eastern and western sides of the landform while maximising airspace.

3.4 Subsurface Geology and Materials Availability

Geotechnical investigations have been undertaken by Tonkin in 2021 and 2023 to inform the design of the landfill cells and inform materials availability for use in the construction of future infrastructure.

The 2021 investigation indicated that the site is generally underlain by the following units:

- 1: Fine to coarse grained SAND, to depths between 0.4 and 1.7 m in some areas, overlying
- 2: Fine to coarse grained SAND/Clayey SAND/Clayey Gravelly SAND, low plasticity fines to depths between 1.8 and 6.4 m in some areas, overlying
- 3A: Fine to coarse grained Clayey SAND, low plasticity fines, to depths between 0.05 and 4.6 m in some areas, overlying
- 3B: medium plasticity Sandy CLAY/CLAY, fine to coarse grained sands, to depths between 6.5 m and 10.0 m (extent of investigation) in some locations, underlain by
- 4: Fine to coarse grained SAND/Clayey SAND/Silty SAND to the extent of investigation.

Reference should be made to the 2021 geotechnical report for detailed information on soil strata including borehole logs and core photographs. Soil units encountered during the 2023 investigation were generally similar to those documented above.

The 2021 geotechnical report includes an assessment of the suitability of the material for reuse in construction. The report states that it is expected that the site materials other than those from unit 4 (Fine to coarse grained SAND/Clayey SAND/Silty SAND) would be suitable for reuse as general engineered fill for bulk earthworks. The report suggests that soils encountered in unit 3B (Sandy CLAY/CLAY) may be suitable for use in water retaining structures (i.e. compacted clay liners), but that no permeability testing was undertaken to confirm this. Due to the depths that these materials were encountered at (generally from approx. 4 to 8 mBGL, but shallower in some locations), it is considered unlikely that a sufficient volume of low permeability material will be won during bulk excavation for construction of a compacted clay liner in the future landfill cells, noting no comprehensive materials volume assessment has been undertaken. Due to this, it is expected that a synthetic lining system will be used in Stage 1A. Additionally, based on further discussion with WSC it is not expected that the clay encountered is generally suitable for construction of a compacted clay liner.

The 2021 geotechnical investigation report also provides recommendations on excavation stability. The report suggests that permanent slopes should not exceed 1V:2.5H in the materials encountered and that excavations should remain a minimum of 2.0 m above the level of groundwater to avoid softening of the subgrade.

3.5 Groundwater

There are four existing groundwater wells at the site around the existing landfill operation. Three new groundwater wells to the north of the existing landfill operation were installed in 2023 to capture additional information regarding the groundwater within the Stage 1A footprint and to function as monitoring wells following construction of Stage 1A. Groundwater was encountered in most boreholes during the 2021 geotechnical investigation. During fieldwork in March 2023, all groundwater wells on site were gauged to gain an understanding of standing water level. Standing water levels have been converted to approximate elevations (in mAHD) using the site survey and GPS points of the monitoring locations to establish a groundwater surface reported in the 2023 Geotechnical Investigation Report.

Additional reporting regarding groundwater levels is also provided in the Groundwater Impact Assessment (Tonkin, 2021b) and the Preliminary Scoping Report (Tonkin, 2020a). These reports indicate that regional groundwater levels are generally between 30 and 32 mAHD, with on site wells gauged in 2010 and 2012 between 29.2 and 32.7 mAHD.

Based upon this information, we infer that site groundwater levels are generally between 30 and 34 mAHD. A groundwater surface has been triangulated based upon the groundwater levels encountered at monitoring wells during investigations to inform design of the Stage 1A baseliner. The landfill cells will be designed with a minimum 2m separation between the baseliner and groundwater in accordance with current best practice, noting that the *Environmental Guidelines: Solid Waste Landfills* does not contain a specific requirement for separation to groundwater. Development of a groundwater surface allows for the baseliner elevations to be optimised to maximise airspace while maintaining the minimum required separation between the liner and groundwater.

3.6 Target Cell Life

Information provided by WSC suggests that the existing landfill facility accepted approximately 28,500 t of waste in 2021/22 and will accept approximately 32,900 t of waste in 2022/23 (extrapolated from data available). Projections discussed in the EIS and amendment report adopted an annual tonnage of 64,000 tonnes per annum to account for future growth. Volumetric survey information was provided for periods of April 2022 to August 2022 and August 2022 to February 2023. Between April 2022 and August 2023, survey data provided indicates that approximately 13,700 m^3 of airspace was consumed, suggesting a landfilled waste density of 0.85 t/m^3 without correcting for cover soil usage. Between August 2022 and February 2023, survey data provided indicates that approximately 13,000 m^3 of airspace was consumed suggesting a landfilled waste density of approximately 1.2 t/m^3 in this period without correcting for cover soil usage. Due to the significant difference between these two densities in a short period of time, a conservative approach of adopting the lower waste density for the purposes of airspace consumption has been taken.

Based on the projected annual waste acceptance of 64,000 t of waste and a density of 0.85 t/m^3, annual airspace consumption is estimated to be 75,500 m^3 per annum.

The *Environmental Guidelines: Solid Waste Landfills* does not provide specific guidance for the design life of landfill cells. The design life of the cells needs to balance the practicalities of frequent construction of new cells with ensuring cells are not excessively large to cause issues with UV degradation of exposed liner materials or management of surface water. Cell sizes and staging will be developed based upon managing these factors however we consider that a landfill cell design life in the order of 3 years is appropriate. To achieve this, cell airspace would need to be in the order of 226,000 m^{3}at current filling rates

During detailed design of Stage 1A, an options assessment will be undertaken to establish appropriate cell staging to achieve this life in the first landfill cell (Cell 1A1). If necessary, landfill cells may be broken into sub-cells to achieve acceptable design life.

4 Design Criteria

4.1 Site Licence

The site licence (EPL 20209) includes the following conditions relevant to the development of the new landfill cells:

- O5.9: A leachate barrier and collection system must be installed and managed at the landfill as specified in Environmental Guidelines: Solid Waste Landfills or alternative of equal or better environmental performance
- O6.3: Surface drainage must be diverted away from any area where waste is being or has been landfilled

4.2 Planning Documentation

The EIS and submissions report include a significant detail on the expansion of the landfill facility as a whole including the development of Stage 1A. This information is addressed in Section 2.2. The detailed design of Stage 1A will be in accordance with the concept design that was developed to form the basis of the development application as documented in the EIS and Amendment report. The development consent conditions will be relevant to the design of Stage 1A, however these are pending at the time of issue of this report.

4.3 Environmental Guidelines: Solid Waste Landfills

The Environmental Guidelines: Solid Waste Landfills provide guidance to landfill operators regarding the environmental management of landfills in NSW by providing a series of minimum standards, including minimum standards for design of new landfill cells. Part B of these guidelines document these minimum standards which include:

- Requiring the base and walls of all solid waste landfill cells to be lined with durable materials of very low permeability.
- Requirements relating to the properties and quality of components of the lining system including compacted clay liners and geosynthetics
- Requirements for leachate collection, extraction, management, and disposal
- Requirements for the management of site stormwater
- Quality assurance requirements for construction of landfill cells, including conformance testing requirements for geosynthetics.

Specific minimum standards are discussed further in Section 5 including how these standards will be addressed by the design of Stage 1A.

5 Key Design Elements

5.1 Landfilling Extent

The Stage 1A landfilling extent is consistent with that shown in the pre-concept design drawings provided at Appendix A, with specific cell sizes to be confirmed during detailed design.

The footprint of the landfill operation is constrained by the existing landfill operation to the south, and the extents provided for planning approval in the EIS. The boundary between Stage 1A and 1B may be adjusted during detailed design, however the extent of the stage to the east and west is limited by the planning approvals.

5.2 Liner Profiles

5.2.1 Baseliner

The concept baseliner profile for Stage 1A has been developed to comply with the requirements of the *Environmental Guidelines: Solid Waste Landfills*. This guideline requires that the primary barrier system for general solid waste landfills should consist of a compacted clay liner at least 1,000 mm thick, overlain by a geomembrane for landfills which accept more than 20,000 tonnes of waste per year.

As discussed above, we do not expect that sufficient suitable material will be won during bulk excavation for construction of a compacted clay liner. Due to this, we propose to use a synthetic liner system for the base of the landfill, using a GCL as an alternative to a compacted clay liner. The use of a GCL as an alternative to a compacted clay is permitted by the *Environmental Guidelines: Solid Waste Landfills,* provided that it is used in composite with a geomembrane. The proposed liner system for the base of the landfill consists of the following, from the top down:

- Separation Geotextile
- 300 mm leachate drainage gravel containing perforated leachate collection pipework
- Cushion geotextile
- 2.0 mm double sided textured High Density Polyethylene (HDPE) Geomembrane
- Geosynthetic Clay Liner
- 300 mm clayey engineered fill layer (liner subgrade), and
- Prepared subgrade

5.2.2 Sideliner

The sideliner profile proposed for the cell batter slopes over a natural cut surface (i.e. not over waste) differs slightly from the proposed cell baseliner due to the need to manage slope stability and loads on the lining system acting in a down slope direction. The proposed liner system for the sideliner consists of the following, from the top down:

- Tensile Reinforcement Layer (Refer below)
- Drainage Geocomposite (Refer below)
- Cushion Geotextile
- 2.0 mm single sided textured HDPE Geomembrane, textured side down
- Geosynthetic Clay liner
- 300 mm clayey engineered fill layer (liner subgrade), and

- Prepared subgrade

Side slope grades have been nominated as a maximum of 1V:3H to facilitate safe construction while maximising airspace. The *Environmental Guidelines: Solid Waste Landfills* allows the use of a drainage geocomposite for side slope drainage as an alternative to the 300 mm leachate drainage gravel required for the base. This material is proposed on the side slopes as the side slopes have a reduced drainage requirement to the base, it provides favourable slope stability properties, and is lower cost than a 300 mm gravel layer for leachate drainage.

Veneer slope stability calculations will be undertaken during detailed design to assess the stability of the sideliner system. These calculations will inform the requirements for the tensile reinforcement layer which may consist of a high tensile strength woven geotextile or geogrid. Interface friction testing will be specified for the critical interfaces of the sideliner system to confirm assumptions made during design. This testing will be specified to be undertaken prior to procurement of material, followed by confirmation testing using actual materials procured for use in cell construction.

The sideliner will terminate at a bench to allow for anchoring of geosynthetic liner materials. Along the southern extent of the sideliner the bench has been located along the anticipated extent of waste line in the existing landfill which has been based upon a series of test pits dug as a part of the 2023 geotechnical investigation, historical aerial imagery and the volumetric surveys supplied. During detailed design of the respective cells, this extent of waste should be confirmed via additional test pitting.

5.2.3 Piggyback Liner

As identified above, a piggyback liner is expected to be required over the unlined areas of the exiting landfill. Due to the strains that can be induced due to differential settlement over existing landfilled waste, a different profile to that of the sideliner is proposed. The design of the piggyback liner will be developed using a risk-based approach during detailed design of the respective landfill cells and may not need to be as high a standard as the base and sideliner of the landfill. It is expected that the first landfill cell constructed in Stage 1A will not require a piggyback liner as it will interface with the existing lined landfill cell.

For the purpose of the concept design, a piggyback liner profile with a depth of 500 mm above the existing interim cover over the landfill surface has been adopted. Based upon past experience this is a typical depth for a piggyback liner using a geosynthetic lining system over a soil bridging layer. The final piggyback liner profile will be developed during detailed design of the respective landfill cells.

5.3 Surface Grades

The *Environmental Guidelines: Solid Waste Landfills* provides minimum grades for the base of the landfill. The minimum grades required are 1% along drainage lines (i.e. along the cell invert) and 3% towards the invert. Design grades are consistent with these minimum grades to maximise cell airspace.

Sideliner and piggyback liner grades will be specified as a maximum of 1V:3H to facilitate construction and long term stability of these slopes.

5.4 Leachate Collection, Extraction and Flushing

The leachate collection system includes the gravel drainage layer on the floor and drainage geocomposite on sidewalls and the piggyback liner. These layers provide a high permeability drainage pathway for leachate. Perforated pipework is placed within the leachate drainage gravel layer to convey leachate to a sump from which leachate can be pumped to the site leachate management system. Pipework will be placed along the invert and at maximum 25 metre spacings as per the requirements of the *Environmental Guidelines: Solid Waste Landfills.* The concept cell design for the floor includes a single central invert for each cell which will require placement of pipework in a herringbone arrangement to satisfy the 25 metre spacing requirement. There is the possibility to refine the floor arrangement to reduce the amount of pipework required, this has been raised with Council.

Leachate edge risers will be provided for the outer cells of Stage 1, with a central leachate riser provided between the two central cells. The risers will be suitable to house an airwell style submersible leachate pump for removal of leachate. Leachate edge risers will consist of a solid, large diameter polyethylene pipe. The horizontal section of leachate edge risers will be perforated within the sump. The central leachate riser will consist of a prefabricated large diameter concrete shaft which can be progressively extended as filling occurs in the adjacent cell. The central riser will include a concrete footing with a perforated interval to assist leachate to flow from the collection pipework and gravel layer into the riser for pumping.

Leachate collection pipework located on the cell floor will continue to the cell perimeter and up the cell side slope as a flushing riser (unperforated) to allow flushing and inspection of the leachate collection pipe with equipment typically available to specialist sewer inspection and cleaning contractors. Flushing riser pipework will terminate adjacent to the edge risers within concrete headwalls for anchorage. Additional flushing risers if required will be terminated with suitable anchorage blocks at the edges of the cell.

Leachate will be pumped from the leachate sumps and risers to a lined leachate pond for storage and disposal via evaporation. An existing lined leachate pond is present adjacent to the lined landfill cell. An assessment undertaken during preparation of the EIS indicates that this pond has some capacity to dispose of additional leachate volumes from new landfill cells. Preliminary modelling indicates that a new leachate pond is not required for the increase leachate expected following the construction of Cell 1A1, however this capacity would not be sufficient for disposal of leachate volumes expected from the full extent of Stage 1A. Allowance has been made for the construction of new leachate ponds to the east of the existing landfill operation to increase disposal capacity.

The staging of the construction of the new leachate ponds will be informed by leachate balance modelling, which is to be undertaken as a future component of this project. Following this modelling, the basis of design for new leachate ponds including geometry, lining requirements, sizing and staging will be developed.

5.5 Surface Water Management

The location and size of surface water cut-off drains will be developed during detailed design. It is expected that these will include cut-off drains around the edges of the cut batter slopes down into the cell floor to exclude any surface water flows from entering the landfill cell and leachate collection system. A cut-off bund may be required along the crest of the proposed piggyback liner to exclude any runoff from the existing landfill surface. Sizing and alignment of these controls will be determined during detailed design.

The need for sub-cell stormwater management controls within Stage 1A will be identified during detailed design. Depending on the staging of landfill cells, areas may need to grade towards the constructed landfill cells. In this instance, controls such as 'rain flaps' or temporary cut-off bunds will be constructed to separate stormwater and leachate to minimise the volume of leachate generated at the site.

Temporary stormwater controls will be required along the northern boundary of Stage 1A as the floor of the cell will be below the surrounding ground level. Stormwater will be excluded from flowing into the stage by bunding at the crest of batter slopes, however there will be a catchment on the batter from the surface to subgrade level where stormwater cannot be directed away from the below grade areas. Stormwater run-on will be excluded by a bund along the edge of the active cell but will require a sump where stormwater can be promptly pumped to the surface water management system during or immediately following rain events.

5.6 Construction Quality Assurance

The *Environmental Guidelines: Solid Waste Landfills* includes requirements for construction quality assurance (CQA) including requirements for testing and supervision of geosynthetics installation and supervision of earthworks construction. CQA requirements for Stage 1A will be documented in the Technical Specification as well as the CQA Plan required by the *Environmental Guidelines: Solid Waste Landfills.* The CQA Plan will document all CQA requirements including roles and responsibilities in a format that is conducive to use on site by the CQA Engineer including inspection and test plans (ITP's) for progressive sign off during the construction of new landfill cells. Specific requirements for CQA of different elements of construction will be documented in the Technical Specification and CQA Plan.

6 Safety in Design

A Safety in Design review has been undertaken by Tonkin as a part of the detailed design for Stage 1A. The draft register is attached to this document (Appendix C) and a workshop will be held with WSC following the concept design submission to discuss the outcomes of this process, required controls and responsibilities for these controls. The Safety in Design process serves to satisfy the requirements of WHS legislation and serves to:

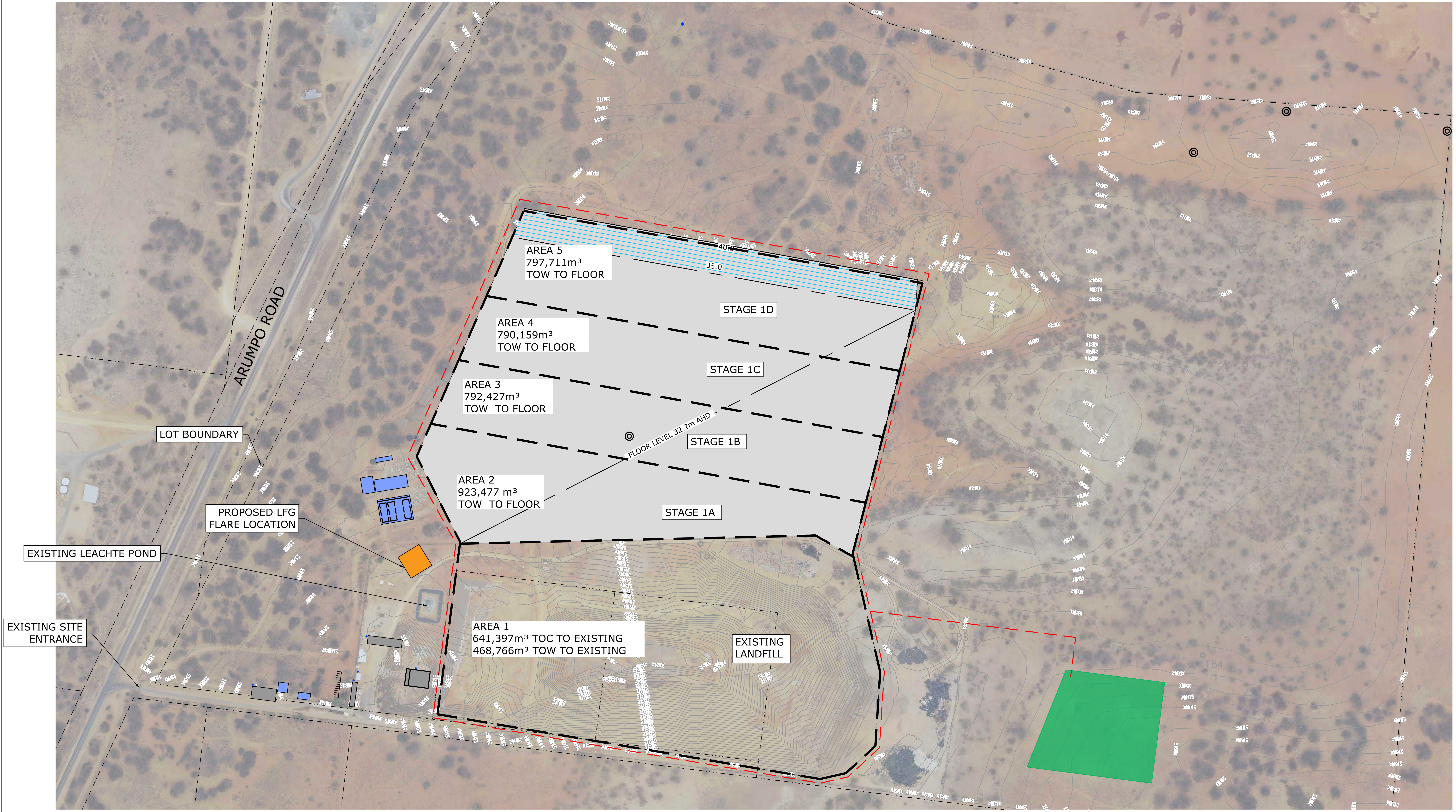
- Identify potential risks from construction & operation of Stage 1A;
- Assess risk in terms of impact / consequence and probability / frequency;
- Develop management and mitigation strategies where required;
- Identify risks with medium or higher residual risks; and
- Include risk assessment and residual risk implications in technical specification.

Following the draft risk assessment process, the following residual risks were identified as medium or higher:

- During Construction:
  - Failure of stability of slopes resulting in injury or environmental damage due to liner failure was rated as Medium. Controls include the designer limiting maximum side slope angles and assessing slope stability of proposed design, and creation of a stable base, lining and leachate collection system to provide a safe foundation for activities. The Contractor will ensure that appropriate precautions are made for earthworks. WSC will ensure operator / contractor comply with precautionary measures. The superintendent will monitor works and undertake CQA.
  - Failure of waste faces of adjacent landfill cells causing injury or damage was rated as Medium. Controls include the Contractor ensuring that an appropriate WHS plan is made for earthworks and the Contractor is satisfied with slope conditions. The Principal will remove waste from earthworks areas prior to construction. The Principal will cut waste slopes back to a maximum grade of 1:3 where slopes exceed 1:3. Principal to develop appropriate WHS plan for exposure and relocation of waste if waste relocation is required.
  - Exposure to landfill gas during construction during connection with the existing cell interface was rated as Medium. The Contractor will address risks associated with venting landfill gas and develop controls to prevent impacts upon workers, ensure no confined spaces are created where LFG could accumulate and ensure no ignition sources/smoking in vicinity of landfill.
- During Operation:
  - Injury or damage during waste tipping, traffic movements, cover soil placement, stormwater management was rated as medium. To control this risk, the Designer will specifiy maximum waste slopes and the Principal will ensure the operator establishes an Operations Plan addressing waste management, traffic management, tipping and disposal, use of cover soils, waste batter slopes, soil management, SW mgt etc. All staff will correctly utilise appropriate PPE (e.g. high visibility clothing).

The Safety in Design register will be updated as the design process continues.

Appendix B - Stage 1 Drawing



LEGEND

40.0	EXISTING CONTOUR (0.5m INTERVAL)
	PROPOSED STAGE BOUNDARY
	PROPOSED CELL BOUNDARY
	PROPOSED STAGE 1 SERVICE ALIGNMENT
	PROPOSED STAGE 2 SERVICE ALIGNMENT
33.0	PROPOSED FLOOR CONTOURS
	PROPOSED LEACHATE POND
	ABORIGINAL ARTIFACT SITE
	PROPOSED BUILDING OR SHED
	PROPOSED HARDSTAND AREA
	PROPOSED LFG AREA (FUTURE)

THIS DRAWING IS TO BE VIEWED IN COLOUR AS SOME FEATURES / SYMBOLS ARE DIFFERENTIATED BY COLOUR. DRAWING NOT TO BE RELIED ON IF PRINTED IN GREYSCALE.

NOT FOR CONSTRUCTION

0 25 50 100 150
1:2500 (A1); 1:5000 (A3)
100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE
A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	FOR INFORMATION		IN	JDT
B	ISSUED FOR INFORMATION	10.8.22	IN	JDT
A	FOR INFORMATION	14.09.21		

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: 1:2500
SURVEYED: PRICEMERRET
SURVEY DATE: 03.03.21
APPROVED / PROJECT LEADER
MEL SALT

PUBLIC UTILITIES:
THE SERVICES SHOWN ARE DERIVED FROM PLANS OBTAINED FROM THE RELEVANT SERVICE AUTHORITIES. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO ARRANGE WITH THE RELEVANT SERVICE AUTHORITIES FOR CONFIRMATION OF SERVICES AND THEIR LOCATION BEFORE EXCAVATION WORK COMMENCES.

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WENTWORTH SHIRE COUNCIL

BURONGA LANDFILL EXPANSION
FIGURE 7
PROPOSED CELL LAYOUT

FILENAME: 202597 CONCEPT DESIGN.DWG

PROJECT NUMBER	DRAWING NUMBER	REVISION
202597	011	C

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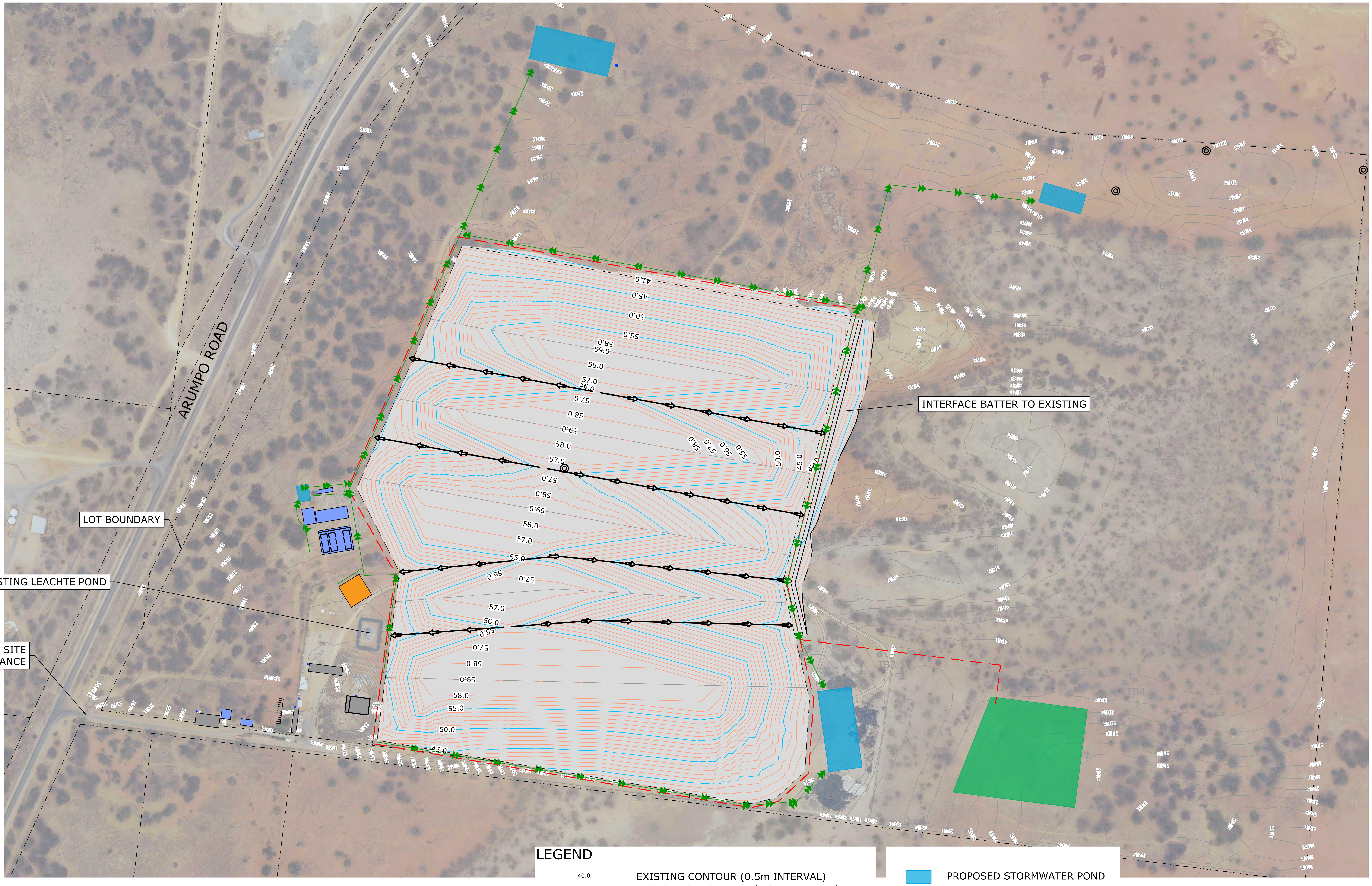
Appendix C – Final Landform Drawing



LEGEND

40.0	EXISTING CONTOUR (0.5m INTERVAL)
51.0	DESIGN CONTOUR MAJ (5.0m INTERVAL)
50.1	DESIGN CONTOUR MIN (1.0m INTERVAL)
	PROPOSED STAGE BOUNDARY
	PROPOSED CAP CROWN
	PROPOSED CAP DRAIN
	PROPOSED STORMWATER DRAIN
	PROPOSED STAGE 1 SERVICE ALIGNMENT
	PROPOSED STORMWATER POND
	PROPOSED LEACHATE POND
	ABORIGINAL ARTIFACT SITE
	PROPOSED BUILDING OR SHED
	PROPOSED HARDSTAND AREA
	PROPOSED LFG AREA (FUTURE)

THIS DRAWING IS TO BE VIEWED IN COLOUR AS SOME FEATURES / SYMBOLS ARE DIFFERENTIATED BY COLOUR. DRAWING NOT TO BE RELIED ON IF PRINTED IN GREYSCALE.

NOT FOR CONSTRUCTION

0 25 50 100 150
1:2500 (A1); 1:5000 (A3)
100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE
A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	FOR INFORMATION		IN	JDT
B	ISSUED FOR INFORMATION	10.8.22	IN	JDT
A	FOR INFORMATION	14.09.21		

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: 1:2500
SURVEYED: PRICEMERRET
SURVEY DATE: 03.03.21
APPROVED / PROJECT LEADER
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WENTWORTH SHIRE COUNCIL

BURONGA LANDFILL EXPANSION
FIGURE 8
STORMWATER MANAGEMENT STAGE 1

FILENAME: 202597 CONCEPT DESIGN.DWG
PROJECT NUMBER: 202597
DRAWING NUMBER: 013
REVISION: C

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Appendix D – Safety in Design

SAFE DESIGN RISK REGISTER

	Location Address:	Buronga Landfill, Wentworth, NSW
PROJECT OR DESIGN ELEMENT:	Client	Project Number/Location Code:
Landfill Stage 1A Cell 1	Wentworth Shire Council	202597
	Revision	Date
	Issued for Approval (RevB)	18/09/2023
Brief Description Of Design Element:	Brief Description of any specific Safety Focus or Requirements:	
Proposed Cell Construction and Cell Operations - Final SiD	Construction of subgrade, engineered fill, GCL, HDPE, geotextiles, drainage geocomposite, leachate pipework & extraction riser and drainage gravel placement. Operation and Maintenance of the Cell.	

Workshop Organiser or Chair

Responsible Officer:	Project Role:	Organisation:
Isaac Nicholls	Project Engineer	Tonkin

RISK ASSESSMENT

Activity or Task	Hazards or Environmental Impacts	Perceived Risk: Consequence	Perceived Risk: Likelihood	Perceived Risk: Risk Rating	Control Measures (Eliminate, Substitute, Isolate/Engineering Controls, Administrative Controls, PPE)	Residual Risk: Consequence	Residual Risk: Likelihood	Residual Risk: Risk Rating	Person responsible for Controls	Status
Cell Construction										
Placing or Spreading Fill	Vehicle rollover due to uneven surfaces and steep slopes	5	3	H	Principal Principal to provide safe access to the Cell. Contractor Contractor work method statement to address safety and construction of access tracks to the cell floor if required.	4	1	L	Contractor	Identified
Loading or Carting	Vehicle rollover on dedicated haul road	5	3	H	Contractor Contractor to address vehicle safety at the site and use dedicated access tracks.	4	1	L	Contractor / Principal	Identified
Working on slopes	Trips, slips and falls or machinery rollover due to working on steep waste or natural slopes. Hazards from working in deep excavations along cell interfaces.	5	3	H	Designer: Minimise the need for work on steep slopes and in deep excavations. Contractor: Contractor to address hazards assosciated with steep slopes in WH&S Plan. Contractor to make safe waste slopes where required and discuss requirements with the Principal Principal: Enforce exclusion zones for landfill operations above construction zone.	4	1	L	Designer / Contractor / Principal	Identified
Traffic Movement	Traffic conflicts / accidents, including with landfill operations machinery	4	2	M	Principal Principal to provide speeds limits, enough space for vehicle interactions, contractor compound and stockpiling throughout site and to ensure that normal waste filling operations do not impact on construction safety. All vehicles to have a UHF radio to communicate vehicle movements. Induction for technicians / inspectors / surveyors etc. Contractor Dedicated haul roads and general site controls. Use flashing light on vehicles. Wear high visibility clothing Schedule work to avoid working near/below operational tipping face Contractor to establish safe work instructions for hazardous activities	4	1	L	Contractor / Principal	Identified
Waste and Soil Placement Stability	Sliding failure of placed waste or soil (e.g sideslope construction)	2	3	M	Designer Limit lined sideslopes to 1:3 Limit placed waste slopes to 1:3 Contractor/Principal Placement and spreading of material from the bottom of slopes up.	2	1	L	Designer / Principal / Contractor	Identified
Inspecting Baseliner / Sideslopes	Trips, slips & falls from steep and uneven surfaces	2	3	M	Designer Limit lined sideslopes to 1:3. Contractor Contractor to adopt to general site procedure systems. Induction for technicians / inspectors /surveyors visiting site. First aid available. Postpone works in wet weather Staff to use appropriate PPE and take care when walking on uneven surfaces and clay.	2	2	L	Designer / Contractor	Identified
Groundwater Management	Damage to the baseliner due to groundwater levels rising to the baseliner level or perched groundwater	2	3	M	Designer Ensure large separation distance between recorded site groundwater levels and the baseliner Contractor Contractor to monitor for any perched groundwater/leachate during construction and advise Superintendent if encountered.	1	3	L	Designer / Contractor	Identified
Temporary Surface Water Management	Flooding, erosion and sediment loss during and following baseliner construction	2	3	M	Principal Build cell during drier months. Designer Include controls such as temporary drainage swales, pumping locations, soil bunds etc outside of cell. Contractor Establish SEDMP addressing SW management	2	2	L	Principal / Designer / Contractor	Identified
Baseliner Construction	Impact to air due to dust generation	3	2	M	Designer Minimise construction footprint disturbance Contractor Use water cart to reduce dust generation.	2	2	L	Designer / Contractor	Identified

SAFE DESIGN RISK REGISTER

	Location Address:	Buronga Landfill, Wentworth, NSW	
PROJECT OR DESIGN ELEMENT:		Client	Project Number/Location Code:
		Wentworth Shire Council	202597

Baseliner Construction	Environmental exposure – resulting in injury or harm associated with working in the elements (heat, sunburn etc)	3	3	H	Contractor Avoid exposed manual work during the hottest part of the day in summer where possible. All staff correctly utilising appropriate PPE (e.g. hat, sun cream, long sleeve shirt etc.).	2	2	L	Contractor	Identified
Stockpile Management	Dangers of manual sorting of materials, unsafe stockpiling causing injury or harm	2	3	M	Contractor No manual handling. Machine sorting only. Materials to be stockpiled in accordance with Licence as directed by the Principal.	1	1	L	Contractor	Identified
Geosynthetics Installation	Injury during HDPE welding and testing, handling and placement of geosynthetics	3	3	H	Designer Limit to max practical extent joining and welding required. Subcontractor Follow a safe work instruction for HDPE welding. Establish a WH&S Plan and safe work instruction for geosynthetic handling. All staff correctly utilising appropriate PPE.	2	2	L	Designer / Subcontractor	Identified
Geosynthetics Installation	Injury due to manual handling of heavy geosynthetic materials	3	3	H	Designer Limit to max practical extent joining and welding required. Subcontractor Follow a safe work instruction for geosynthetics deployment. Establish a WH&S Plan and safe work instruction for geosynthetic handling. Use mechanical lifting aids where possible All staff correctly utilising appropriate PPE.	2	2	L	Designer / Subcontractor	Identified
Geosynthetics Installation	Injury due to bentonite dust during GCL installation	3	3	H	Subcontractor Follow a safe work instruction for GCL deployment Establish a WH&S Plan and safe work instruction for GCL handling in accordance with manufacturers instructions. All staff correctly utilising appropriate PPE.	2	2	L	Designer / Subcontractor	Identified
Base/side liner slope stability	Failures of stability in the slopes resulting in injury or environmental damage due to liner failure	3	5	H	Designer Limit maximum side slope angle and assess slope stability under proposed design Creation of a stable base, lining and leachate collection system to provide safe foundation for activities Contractor Ensure that appropriate precautions are made for earthworks Principal Ensure operator / contractor comply with precautionary measures. Superintendent to monitor works and undertake CQA	4	2	M	Designer / Contractor / Principal	Identified
Waste Slope Stability	Failure of waste faces of adjacent landfill cells causing injury or damage.	4	3	H	Contractor Ensure that appropriate WHS plan is made for earthworks and the contractor is satisfied with slope conditions Contractor to remove waste from earthworks areas prior to construction. Contractor to cut waste slopes back to a maximum grade of 1:3 (or flatter if conditions require) where slopes exceed 1:3 Principal: Principal to implement and enforce exclusion zones for landfill operations above construction zone	4	2	M	Contractor / Principal	Identified
Air Quality Exposure	Exposure to LFG resulting in injury or harm (e.g explosion, asphyxiation)	5	3	H	Designer Minimise manual works adjacent to existing cells No confined work processes Contractor Contractor to address in WHS Plan Avoid creating confined spaces and areas of strong LFG odour No smoking or lighting fires on site All staff correctly utilising PPE Principal Principal to maintain integrity of cover over waste	4	1	L	Designer / Contractor / Principal	Identified
Air quality exposure at cell interfaces	Exposure to LFG venting when adjacent cells leachate collection gravel layers uncovered, leading to damage to health, asphyxiation or fire/explosion	5	3	H	Contractor: Address risks associated with venting landfill gas and develop controls to prevent impacts upon workers. Ensure no confined spaces are created where LFG could accumulate No ignition sources/smoking in vicinity of landfill	4	2	M	Contractor	Identified
Manual work	Climate	4	2	M	Contractor Heat stroke policy enforced First Aid, Sunscreen and insect repellent available PPE and water available Shade and adequate breaks	2	1	L	Principal/ Contractor	Identified

SAFE DESIGN RISK REGISTER

	Location Address:	Buronga Landfill, Wentworth, NSW	
PROJECT OR DESIGN ELEMENT:		Client	Project Number/Location Code:
		Wentworth Shire Council	202597

Baseliner inter-connection alignment and levels along Stage 1 Cell 1 and Existing Lined Cell Interface	**Dangers of excavation and encountering waste and leachate.**	**3**	**3**	**H**	**Designer** **Design to accommodate construction of interface with safe excavation and waste removal (minimise difference in level between liners)** **Contractor** **Contractor to address & implement in WHS plan. Staff to utilise appropriate PPE.** **Do not handle waste or waste contaminated soils without PPE.** **No work to be undertaken over placed waste. Manual work along interface should be limited** **Contractor to ensure that waste is removed from the construction area prior to construction and that waste slopes are stable and cut to a maximum grade of 1:3, or flatter if conditions require** **Principal** **Princial to review contractor WHS plan and undertake regular inspections to observe implentation.**	**3**	**2**	**M**	**Designer / Contractor / Principal**	**Identified**
Operation and Maintenance										
Waste Filling	**Impact to Land and Surface Waters Due to Leachate Impact**	**3**	**3**	**H**	**Designer** **Facilitate the separation of "clean" SW runoff and leachate through provision of bunding and SW drainage elements**	**2**	**2**	**L**	**Designer**	**Identified**
Waste Filling	**Groundwater Impact due to leachate migration**	**4**	**4**	**E**	**Designer** **Design a lining system to prevent migration of leachate to groundwater. Ensure materials fit for purpose, configuration effective and practical. Design a leachate collection and removal system to limit potential for leachate to migrate through the lining system to groundwater. Interface detail with the existing Cells to ensure the liner is keyed into existing Cells forming a continuous barrier layer. Ensure CQA procedures provided in the specification to promote effectiveness and durability of the lining system.**	**2**	**2**	**L**	**Designer**	**Identified**
Leachate Sump and Riser Failure or Displacement	**Sump failure prevents leachate removal**	**3**	**4**	**H**	**Designer** **Riser design to consider possible modes of failure, required service life and factor of safety to provide robust sump that is tolerant of landfilling and leachate environment.** **Provide anchorage for extraction and flushing risers** **Principal** **Regular extraction of leachate and flushing of leachate collection pipes from the sumps to prevent flooding and keep dry as possible** **Routine inspection of the system in accordance with the site management plan.**	**2**	**2**	**L**	**Principal**	**Identified**
Leachate Management	**Injury or damage during leachate extraction**	**3**	**4**	**H**	**Principal** **Establish an Operations Mgt Plan and WHS Plan addressing risks associated with hazardous working area (explosive and hazardous atmosphere)** **Require safe and competent surface for access, testing and operation adjacent to the sump riser at all times. Staff to be trained in operation of the leachate management system.**	**2**	**3**	**M**	**Principal**	**Identified**
Cell Operation and Maintenance	**Injury or damage during waste tipping, traffic movements, cover soil placement, stormwater management**	**3**	**4**	**H**	**Designer** **Specify maximum waste slopes.** **Principal** **Operator to establish Operations Plan addressing waste management, traffic management, tipping and disposal, use of cover soils, waste batter slopes, soil management, SW mgt etc.** **All staff correctly utilising appropriate PPE (Eg high vis).**	**2**	**3**	**M**	**Designer / Principal**	**Identified**
Cell Rehabilitation and Capping	**Injury, damage to infrastructure or the environment associated with construction of landfill cap**	**3**	**4**	**H**	**Cell Designer** **Consider interfacing of cap with cell edges.** **Cap Designer (Future)** **Consider ongoing functionality of cell leachate collection and extraction system** **Undertake Safety in Design assessment for proposed rehabilitation strategy.** **Principal** **Enact identified risk controls allocated to the principal from Cap Safety in Design (Future) and ensure contractor implements suitable environmental and WHS controls.**	**2**	**2**	**L**	**Cell Designer / Cap Designer (Future) / Principal**	**Identified**
Demolition / Decommissioning										
Demolition or Future Landfill Mining	**Future demolition would generally occur in reverse order to construction and as such the same environmental and WHS risks are expected to apply. Additional risks assosciated with accessing waste apply.**	**3**	**3**	**H**	**Principal** **All activities would generally be in the reverse order of construction and filling processes and therefore deconstruction would need to consider the same environmental and WHS risks associated with cell construction. A risk assessment process to identify additional risks must be undertaken.**	**2**	**2**	**L**	**Principal**	**Identified**

Workshop Attendees

Name of Attendee	Name of Employer	Project Role	Relevant Qualifications	Date	Time	Signature to acknowledge

SAFE DESIGN RISK REGISTER

	Location Address:	Buronga Landfill, Wentworth, NSW	
PROJECT OR DESIGN ELEMENT:		Client	Project Number/Location Code:
		Wentworth Shire Council	202597

RISK ASSESSMENT GUIDE

SAFETY AND ENVIRONMENTAL HAZARD IDENTIFICATION/RISK ASSESSMENT

LIKELIHOOD

5	**Event will occur**	The event is a common occurrence on all projects
4	**Event almost certain to occur**	The event will probably / is likely to occur at least once during most projects
3	**Event may occur**	The event is possible to / might occur during some projects
2	**Event not likely to occur**	The event is unlikely to occur (though it could occur during similar work activities)
1	**Event rarely occurs**	The event could occur, but it is rare / only in exceptional circumstances

PROJECT (Level 1) RISK RATINGS

1-4	Low	*Broadly acceptable - managed by routine procedures*
5-8	Medium	*Tolerable - managed with general controls*
9-15	High	*Undesirable - managed with specific controls*
16-25	Extreme	*Intolerable- design to be changed or do not start activity*

	DESCRIPTOR	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
5	Event will occur	5 MEDIUM	10 HIGH	15 HIGH	20 EXTREME	25 EXTREME
4	Event almost certain to occur	4 LOW	8 MEDIUM	12 HIGH	16 EXTREME	20 EXTREME
3	Event may occur	3 LOW	6 MEDIUM	9 HIGH	12 HIGH	15 HIGH
2	Event not likely to occur	2 LOW	4 LOW	6 MEDIUM	8 MEDIUM	10 HIGH
1	Event rarely occurs	1 LOW	2 LOW	3 LOW	4 LOW	5 MEDIUM

Lowest Level of Control ⟷ **Highest Level of Control**

PPE | Administration | Isolation/Engineering | Substitution | Elimination

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Level	Descriptor	CONSEQUENCE / SEVERITY / IMPACT
5	Catastrophic	*Loss of human life, complete design failure, loss of security and safety or extensive financial or social loss*
4	Major	*Major and permanent injury, hospitalisation, partial design failure, major system damage or major financial or social loss*
3	Moderate	*Moderate injury or illness, medical treatment required, degradation of design,or moderate financial or social loss*
2	Minor	*Minor injury or illness, First Aid required, minor impact on design performance or operator inconvenience*
1	Insignificant	*No injury, inconvenience caused by event, virtually no impact*