Buronga Landfill

Stage 1A Cell 1 Technical Specification

Wentworth Shire Council

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tonkin

Building exceptional
outcomes together

Document History and Status

Rev	Description	Author	Reviewed	Approved	Date
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Contents

Project: Buronga Landfill | Stage 1A Cell 1 Technical Specification
Client: Wentworth Shire Council
Ref: 202597S01RevB

Tables

Appendices

1 General

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. This technical specification details the materials, construction, and quality assurance requirements for the construction of Stage 1A Cell 1 (Cell 1) at the site.

1.2 Drawings

The design drawings (the Drawings) associated with the works are presented in Appendix A and are summarised in Table 1.1.

Table 1.1 List of Drawings

Sheet No	Title
L001	LOCALITY PLAN & DRAWING SCHEDULE
L002	EXISTING FEATURES - PLAN
L003	DESIGN SUBGRADE - PLAN
L004	DESIGN BASELINER - PLAN
L005	ISOPACHTYE - SURVEY TO SUBGRADE
L006	LONGITUDINAL SECTION - MCS0
L007	CROSS SECTIONS 1 OF 3
L008	CROSS SECTIONS 2 OF 3
L009	CROSS SECTIONS 3 OF 3
L010	DETAILS - SHEET 1 OF 5
L011	DETAILS - SHEET 2 OF 5
L012	DETAILS - SHEET 3 OF 5
L013	DETAILS - SHEET 4 OF 5
L014	DETAILS - SHEET 5 OF 5
L015	SAFETY IN DESIGN

1.3 Scope of Works

This technical specification including all drawings (the Specification) has been prepared for the Cell 1 works at the site.

The scope of works described in the Specification and shown on the Drawings, including any obvious items for the proper completion of the work associated with the Cell 1 works, comprises of, but is not limited to, the following activities.

- Clearing and grubbing of the cell area;
- Subgrade bulk excavation and preparation to design levels, including cell floor, side batters and leachate collection sump;
- Placement of an engineered fill layer on the cell base and side batters to achieve the minimum design thickness of 300 mm;
- Excavation of anchor trenches;
- Installation of a geosynthetic clay liner (GCL) across the cell base and side batters;
- Installation of a HDPE geomembrane layer across the cell base and side batters;
- Installation of a cushion geotextile layer across the cell base and side batters;
- Installation of a drainage geocomposite layer on cell side batters;
- Installation of a separation geotextile layer across the leachate drainage gravel;
- Installation of a tensile reinforcement layer on cell side batters;
- Backfilling of anchor trenches;
- Installation of leachate collection pipework, leachate flushing and extraction risers;
- Placement of the drainage gravel layer on cell floor;
- Construction of a concrete leachate extraction riser headwall and spill pad, and;
- Excavation of waste to expose the existing landfill cell liner along the proposed interface with Cell 1;
- Connection of the Cell 1 lining system to the existing landfill cell liner;
- Construction of temporary perimeter bunds for Cell 1;
- Construction of temporary liner terminations on the Cell 1 side batters.
- Installation of leachate pipework to transfer leachate from the extraction point at the leachate spill pad to the existing leachate basin. Council will be responsible for installation of the extraction pump and connection to the transfer pipework.
- Construction of supporting stormwater infrastructure as shown on the drawings.

1.4 Drawings and Specification

A copy of the Specification and Drawings shall be available on the site at all times during the construction of the works.

1.5 List of Definitions

1.5.1 Parties Involved

The following parties are referred to in the Specification:

Table 1.2 Parties Involved

Role	Party
Principal	Wentworth Shire Council (Council)
Superintendent	Appointed representative of Council

Designer	Tonkin Consulting
Contractor	Party engaged by the Principal to perform the construction works
Liner Installer	Specialist geosynthetic materials installation company
CQA Engineer	Independent Engineer experienced in landfill construction verification engaged by the Principal. Responsible for overseeing implementation of the quality assurance aspects of the works. Experienced in design and CQA inspection of geosynthetic reinforcing and lining systems. CQA inspection of all aspects of the geosynthetic lining system construction on a full-time basis. Compile the As-constructed Report and provide verification of the works against the requirements of the Technical Specification.
Geotechnical Testing Authority (GTA)	Independent testing authority engaged by the Principal to provide inspection and testing services for the subgrade layers.
Geotechnical Inspection and Testing Authority (GITA)	Independent testing and inspection authority engaged by the Principal to provide full time inspection and testing of engineered fill layer earthworks at Level 1 responsibility in accordance with AS 3798.
Surveyor	Licenced Surveyor engaged by the Contractor
Geomembrane Testing Authority (GMTA)	Experienced independent party engaged by the Principal to conduct geomembrane integrity survey

1.5.2 List of Acronyms

Table 1.3 List of Acronyms

Acronym	Definition
AHD	Australian Height Datum
AS	Australian Standard
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
CEMP	Construction Environment Management Plan
CQA	Construction Quality Assurance
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DN	Nominal Diameter (pipes)
EPA	Environment Protection Authority
GCL	Geosynthetic Clay Liner
GITA	Geotechnical Inspection and Testing Authority
GMTA	Geomembrane Testing Authority
GRI	Geosynthetics Research Institute
GTA	Geotechnical Testing Authority

HALS	Hindered Amine Light Stabilisers
HDPE	High Density Polyethylene
HP-OIT	High Pressure Oxidation Induction Time
ISO	International Organisation for Standardisation
ITP	Inspection and Test Plans
IQA	Independent quality assurance
LDPE	Low Density Polyethylene
LIS	Liner Integrity Survey
MARV	Minimum Average Roll Value
MC	Moisture Content
MD	Machine Direction
MGA	Map Grid of Australia
MQA	Manufacturer Quality Assurance
MQC	Manufacturer Quality Control
NATA	National Association of Testing Authorities
NCR	Non Conformance Report
NEPM	National Environment Protection Measures
NSW	New South Wales
OIT	Oxidation Induction Time
OMC	Optimum Moisture Content
PCR	Post Consumer Resin
PE	Polyethylene
PN	Nominal working pressure rating
PSD	Particle Size Distribution
QA/QC	Quality Assurance / Quality Control
QMP	Quality Management Plan
SDDR	Standard Dry Density Ratio
SEDMP	Sediment Erosion Drainage Management Plan
SiD	Safety in Design
SN	Stiffness (pipe)
SP-NCTL	Single Point – Notched, Constant Tensile Load
UV	Ultraviolet
VENM	Virgin Excavated Natural Material

WHS	Work Health & Safety
WMP	Wrinkle Management Plan
WMS	Work Method Statement
XMD	Cross Machine Direction

1.6 Work Health and Safety (WHS) Plan

A WHS Plan shall be developed for the works by the Contractor (including works by sub-contractors and site attendance by others) and with reference to the Designer Safety in Design (SiD) assessment presented in the final drawing sheet. The WHS Plan shall specifically address all risks associated with working on a construction site and an active landfill site. The WHS Plan shall include safe work instructions for high risk activities.

The WHS Plan shall be reviewed and updated ahead of each new work element or component of work and submitted to the Superintendent at least 10 days prior to commencing the works. The Superintendent will not approve the WHS plan as the responsibility for the plan lies with the Contractor. The Superintendent shall ensure the WHS plan has been submitted and periodically inspect compliance with the approved WHS Plan.

1.7 Quality Assurance

The Works will be subject to third party CQA inspection and auditing.

A CQA Engineer will be appointed by the Principal, independent of the Contractor, to review and verify the submittals, materials and Contractor CQA processes nominated in the Specification.

All CQA submittals and testing information required to be supplied to the Superintendent as part of the works shall be forwarded by the Principal to the CQA Engineer for review.

The CQA Engineer shall review all earthworks testing and reporting provided by the GTA and GITA and survey and undertake inspections necessary to monitor the works and for the Superintendent to release Hold Points.

The geosynthetic reinforcement and lining system CQA involvement will include review of materials manufacturer quality assurance (MQA) and independent quality assurance (IQA) information required by this Specification and liner system installation inspection and reporting on a full-time basis.

1.7.1 Quality Submittals

The Contractor shall develop a Quality Management Plan (QMP) for the project. The Contractor shall submit the QMP to the Superintendent (including Construction Checklists) for review by the Superintendent prior to the works commencing on-site. The QMP shall include any additional Inspection and Test Plans (ITP's) required in addition to those documented in the CQA Plan.

Subcontracted works and procured items and materials shall comply with the requirements of the Contract. The Contractor shall provide to the Superintendent evidence of a QMP and contractual compliance of subcontracted work and procured items and materials, including the Contractors verification of such compliance.

ITP's shall contain at least the following information for each significant activity identified:

- Element of work/activity description
- Specification reference & requirements/tolerances/acceptance criteria
- Test type/description
- Test/inspection frequency

- Inspection type/description
- Hold Points and Witness Points
- Person responsible for activity (title)
- Relevant activity checklists (title only)
- Identification of relevant procedure and quality records
- Work item or work lot identification

The method of releasing Hold Points and Witness Points shall be clearly stated in the QMP. The Superintendent may request the Contractor to include additional Hold Points and/or Witness Points into the ITP. Provisions shall be made on the Quality Checklists for the Contractor and Superintendent to sign off, as released, each Hold Point and each Witness Point. Alternatively, a stand-alone 'Inspection Certificate for Witness/Hold Point' may be used.

During construction, the Superintendent reserves the right to conduct audit inspections of any or all of the Works without prior notification to the Contractor.

Any non-conformances identified during the checking process are to be reported to the Superintendent on a Non Conformance Report (NCR) form.

The Contractor shall submit NCR's to the Superintendent within the time period noted in the Technical Specification for particular activities or, at minimum, within 24 hours of the Contractor becoming aware of the non-conformance. The proposed corrective action shall be subject to approval by the Superintendent.

Failure by the Contractor to submit NCR's within the nominated time frame shall constitute a substantial breach of Contract and, at the Superintendent's discretion, the Contractor maybe subject to a stop work order. In addition to the Contractor's responsibility to rectify non-conformances the Contractor shall be responsible for any costs and/or time delays arising from any stop work order.

1.7.2 Work Method Statements

Work Method Statements (WMS's) shall be submitted to the relevant parties for review and approval as nominated within the Specification.

1.7.3 Hold Points

Hold points are critical aspects of the works requiring assessment as nominated in this Specification.

Works shall not proceed to the next stage, or the works shall not be covered until the release of the hold point by the Superintendent. Such release shall not, in whole or in part, release responsibility for the quality of the work subject to the hold point.

The Superintendent shall be advised with sufficient notice (nominally 24 hours locally or excluding weekends and public holidays) when a hold point has been reached (or is anticipated to be reached) to enable inspections, as required.

Relevant testing, survey and other documentation associated with the hold point shall be submitted to the Superintendent.

If following the inspection and review of relevant documentation, the Superintendent does not release a hold point, the Superintendent shall advise as soon as practical in writing (or within 24 hours), the reasons why a hold point has not been released and any remedial works required to enable the release of the hold point.

The Superintendent or Principal shall not be liable for any cost (including standby costs) incurred as a result the Superintendent not releasing a hold point.

1.7.4 Testing Laboratories

Suitably qualified NATA accredited material testing laboratories shall carry out all field and laboratory testing, compliance testing etc. as required under the Contract. No separate payments will be made for this work.

1.7.5 As-Constructed Information Submission

The Contractor shall submit the following as-constructed information to the Superintendent:

- Surveyor certified amended design plans (the As-constructed Drawings) in AutoCAD format (including 3D format) detailing the as-constructed works as required by Clause 1.8.4 to demonstrate that the earthworks and material thicknesses comply with, and are within the tolerances defined in, this Technical Specification and to identify the geosynthetic liner system aspects.
- All NCR's generated
- 'Completion Report' for the Works which 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 engineered fill layer
  - All completed Quality Check Lists (including verified Hold 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

The as-constructed information shall be presented in a logically compiled document that includes a table of contents. All test results are to also be compiled in summary sheet format.

Granting of Practical Completion is subject to the Contractor submitting all As-constructed information, review of the as-constructed information by the Superintendent and CQA Engineer and confirmation by the Superintendent that the as-constructed works comply with all requirements of the Contract.

1.8 Survey

The contractor shall engage a suitably qualified independent surveyor to undertake all as constructed survey required by this Clause of the specification. The surveyor proposed for the works shall be endorsed by the Superintendent.

1.8.1 Existing Levels

Existing levels at the time of the most recent survey are supplied for reference only and are not intended to indicate every detail of the current existing surface profile at the time of construction.

1.8.2 Setting Out and Control Survey

The works are to be set out in accordance with the information provided on the Drawings, or as otherwise directed by the Superintendent. From this information and the Drawings associated with the Works, the whole of the Works shall be set out, and this will form the basis of reference for the alignment, levels and dimensions of all parts of the Works.

Survey reference benchmarks, temporary or permanent, which are relevant to the setting out of the Works, shall be supplied by the Superintendent. Where permanent survey marks are utilised in the Works, the appropriate sections of the Surveying and Spatial Information Act with regard to the care of survey marks shall apply.

Proper care shall be exercised during construction of the works to ensure preservation of all alignment, reference and level pegs or marks set out. If such pegs or marks are injured, lost or removed, they shall be reset by or on behalf of the Principal.

All dimensions shall be checked on site before proceeding with the work.

All survey control necessary for accurate completion and verification of the Works during construction shall be adopted.

1.8.3 Tolerances

The theoretical level of the upper surface of any material is defined as the level obtained by starting from the finished surface level and subtracting the total of the nominal specified thickness of the overlying layers.

All surfaces shall be smooth and regular and prepared to the satisfaction of the GITA or CQA Engineer and suitable for placement of the lining layer above. The approving party for the surface finish of each layer is documented in the respective sections of this Specification.

Construction Tolerances are as follows:

- Base of excavation for engineered fill layer (subgrade layer level) –100 mm, + 0 mm
- Surface of engineered fill layer: to achieve minimum layer thickness of 300 mm, –0 mm, + 50 mm
- Slopes of side batters: -100mm, +100mm, and will be practically plane and ± 5% of the gradient shown on the Drawings
- Bunds: -0mm, +100mm
- Trenches: depth -0 mm, +100 mm, width -0mm, +100mm
- Minimum longitudinal gradients along leachate drain lines: not less than 1% and cross fall towards drainage lines not less than 3%.
- Pipelines: Pipes and connections typically as indicated in the Drawings
- Surface of drainage gravel layer: to achieve minimum layer thickness, – 0mm +50 mm
- Concrete spill pad/leachate riser headwall: -25 mm, +25 mm
- Leachate drainage structures: -50mm, + 50 mm

1.8.4 As-Constructed Survey

1.8.4.1 Scope

The prepared subgrade and engineered fill layer shall be surveyed prior to construction of subsequent layers to confirm that the surface complies with the design requirements and the specified tolerances.

The extent of placed GCL and HDPE panels shall be surveyed to confirm construction and for future reference. Where covering of the GCL with HDPE panels is occurring progressively, the contractor shall arrange for the surveyor to be on site full time, or, for the surveyor to attend site at regular intervals to survey the edges of GCL panels.

The drainage gravel layer shall be surveyed to confirm that the surface complies with the design requirements and the specified tolerances.

The extent and alignment of the anchor trenches and all pipework shall be surveyed prior to covering.

General

All survey data shall be provided to the Superintendent in 3D electronic format as a DWG file and with a DXF file for review.

Minimum survey requirements for the cell construction will be as follows:

- The Contractor is to provide a qualified and licensed Surveyor for all survey required by the Specification
- Spot levels typically at 10 m grid spacing and 10 m intervals along string lines / break lines including changes of grade and top and bottom of batters, extent of works and other features.
- Surfaces to be to be surveyed:
  - Site at possession

- Top of subgrade (Plane 1)
- Top of engineered fill layer (Plane 2)
- GCL
- HDPE geomembrane
- Top of drainage gravel layer (Plane 3)

- Features to be surveyed as follows:
  - Leachate collection pipework
  - Alignment of anchor trenches (inner and outer top edges)
  - Indication of depth at 10m intervals
- Survey drawings to be provided as follows:
  - Plane 1 (50 mm contours or less)
  - Plane 2 (50 mm contours or less)
  - Plane 3 (50 mm contours or less)
  - Leachate pipework
  - Anchor trench on appropriate sheets or on a separate sheet
  - Cross sections perpendicular to drainage line at 20 m intervals showing Planes 1, 2 and 3
  - Long section along all HDPE pipes (drainage lines, side batters risers) in Plane 2 and 3
  - Isopachytes of design subgrade level and Plane 1 (50 mm contours or less)
  - Isopachytes of Planes 1 and 2 (50 mm contours or less)
  - Isopachytes of Planes 2 and 3 (50 mm contours or less)
  - GCL panel layout (including QC/QA information required by this Specification)
  - HDPE panel layout (including QC/QA information required by this Specification)
- Geosynthetic materials shall include, at least, the following information:
  - Location, as accurately as possible, of each GCL panel. GCL panel layout survey shall record panel corners and intermediate locations. Additional survey locations shall be recorded to reflect panels that are cut;
  - Location, as accurately as possible, of each HDPE geomembrane panel;
  - Location of all HDPE destructive test locations, patches and repairs;
  - Identification of all HDPE panels, seams, patches and repairs with appropriate numbers or identification codes (following the liner installers numbering/labelling codes).

Level survey shall be to GDA2020 and levels to Australian Height Datum (AHD).

Specific as-constructed survey requirements are detailed in the Quality Requirements section of each section of this Specification requiring survey.

Field survey, measurements and drafting, to produce 'as-constructed' drawings shall be provided.

In addition to design and 'as-constructed' details, any relevant additional information obtained during the course of construction of the works, such as the verification of location, size, type and level of existing services, or location of additional services not shown on the design Drawings, shall also be shown on the 'as-constructed' drawings.

The Superintendent retains the right to withhold the issue of Completion until satisfactory 'as-constructed' information is received and accepted by the Designers Representative.

1.9 Construction Environmental Management Plan (CEMP)

1.9.1 General

The Contractor will provide a Construction Environmental Management Plan (CEMP) to the Superintendent 10 days prior to commencing the works.

All measures and controls necessary to ensure minimum disturbance to the existing environment by the operations shall be implemented.

All environmental management rules, regulations and codes of practice shall be implemented and all notices and instructions issued by the Superintendent in relation to such Rules and Regulations shall be complied with.

Explosives shall not be used.

1.9.2 Environmental Control During Construction

All pollutants such as dust, sediment, litter and wash down water must not leave the site during construction of the works. All measures necessary shall be taken that ensure minimum disturbance to the existing environment by the operations.

Environmental management shall be undertaken in accordance the sites Environment Management Plan and comply as a minimum with the following clauses.

1.9.2.1 Erosion, Sediment and Runoff Control

Minimise or eliminate soil erosion, sedimentation and pollutant laden runoff caused in the execution of the work under the Contract and ensure active work areas are not impacted, and no offsite impacts are caused.

Carry out the work in such a way as to ensure that no heading up of floodwaters in new or existing drains or gutters occurs and ensure no damage to public or private property caused by the operations or which may arise from such operations. Should this clause not be complied with, the Superintendent may order work to cease until in his opinion, satisfactory arrangements for such drainage have been made.

Account for and handle all surface water flows during the construction period and make due allowance in the tender for all costs involved.

Where the potential exists for surface water flows from the work area to leave the site, surface water discharges shall comply with relevant discharge limits nominated in the Site Licence and comply with relevant environmental legislation (e.g. Protection of the Environment Operations Act 1997).

1.9.2.2 Sediment, Erosion and Drainage Management Plan

The Contractor is required to provide a Sediment, Erosion and Drainage Management Plan (SEDMP) to the Superintendent for review at least 10 days prior to commencing the Works. The SEDMP shall describe the range of measures proposed for managing sediment and erosion control and surface water drainage within their work area. The SEDMP shall consider flows entering the work area and potential impacts outside of their work areas.

The SEDMP must be reviewed and implemented prior to the commencement of all phases of the works to ensure protection to all phases as the site and operations change.

The SEDMP shall identify potential areas at risk of exposure and impact to surface water runoff, propose measures to be implemented to minimise the risk of impacts and propose monitoring and management of the SEDMP for the duration of the Works. The SEDMP shall be reviewed and updated as necessary prior to commencement of each new works element, or layer identified by each new section of this Specification.

1.9.2.3 Dust

Minimise environmental impact caused by dust emissions from activities undertaken in completing the Works. Comply with the site licence and any other relevant environmental legislation (e.g. Protection of the Environment Operations Act 1997).

1.9.2.4 Noise

Minimise environmental impact caused by excessive noise emissions from activities undertaken in completing the Works. Comply with the site licence and any other relevant environmental legislation (e.g. Protection of the Environment Operations Act 1997).

1.9.2.5 Air Emissions

Minimise environmental impact caused by fugitive air emissions resulting from activities undertaken in completing the Works. Comply with the site licence and any other relevant environmental legislation (e.g. Protection of the Environment Operations Act 1997).

1.9.2.6 Storage and Use of Hazardous Materials

Avoid storage and use of hazardous materials in the Works wherever possible. Where unavoidable ensure compliance with any relevant hazardous materials storage conditions of the site Licence, Protection of the Environment Operations Act 1997, and Australian Standard AS 1940-2004: The storage and handling of flammable and combustible liquids.

1.10 Access Road

An access road to the work site will be provided by the Principal at the commencement of the project. The location and alignment of this road may change during the construction activities to suit the operational requirements of the site. Any changes shall not result in extra costs, variations or extensions of time to the Contract. The Contractor shall maintain the operable condition of the access road for the duration of the Contract works.

1.11 Protection of Existing Improvements

The areas of operation of plant and equipment shall be restricted to a minimum consistent with the specified extent of the Works and shall provide all protective measures required to ensure minimum disruption and damage to existing improvements in the vicinity of the site.

The existing roads and other infrastructure shall be protected against deliberate and accidental damage and all reasonable instructions issued by the Superintendent in this regard shall be complied with. At locations where the existing roads adjacent to the site are traversed by construction plant carrying out the specified works, adequate protective measures shall be employed to minimise damage to the existing road pavements and kerbs and gutters.

Any damage to the existing improvements resulting from the operations shall be repaired and the existing works made good to the satisfaction of the Superintendent.

1.12 Matching in and Making Good

In addition to the requirements specified above, any damage caused or any temporary relocation necessary to existing leachate drainage pipework, monitoring wells, stormwater drains, sign posts, barrier posts, or other similar items shall be made good to a standard which is at least equal to the existing construction and operation.

Unless otherwise specified, where the specified works adjoin or abut an existing roadway or other existing construction, the existing pavement shall be removed within the limits shown on the Drawings so that the new pavement matches to give a smooth riding surface and satisfactory drainage properties.

Any damage which occurs to adjacent existing works as a result of the construction operations shall be made good.

1.13 Cleaning Up

During the progress, and on completion of the work, the site shall be maintained and left in a clean and tidy condition.

1.14 Standard of Workmanship and Codes of Practice

All materials and workmanship shall be the best of their respective kinds and shall conform to all relevant Australian Standards.

Where standards or codes of practice are referred to in this Specification, the code shall be the latest relevant addition, including amendments, current on the date of closing of tender, and shall be read in conjunction with the Specification.

1.15 Silence of Specification

The apparent silence of the Specification or Drawings as to any details or the apparent omission from them of a detailed description concerning any point shall be regarded as meaning only the best general practice or the best quality are to be used following the approval of the Superintendent.

All interpretations of this Specification shall be made on the basis of the above.

1.16 Obvious Work

Where the Specification and Drawings do not contain any mention of minor parts or work, which in the opinion of the Superintendent, are reasonably and obviously necessary for the satisfactory completion of the contract works, such parts shall be supplied and installed without any extra charge.

1.17 Departure from the Specification and Drawings

The Contractor shall Provide a supporting proposal to the Superintendent where any departure from the Specification such as substitution, non-conformance or design change is proposed. The Superintendent shall consult with the Designer regarding the proposed change. Confirmation in writing from the Superintendent must be obtained prior to incorporation into the works. Departure from Specification shall not entitle any claim to an extension of time or variation to the contract sum.

All departures from the Specification shall be noted in the final as-constructed reporting including description of the change and include certification by the Superintendent that the competed works confirm to the original design, performance and serviceability intent.

2 Civil Works

The internal civil works at the site including access roads and stormwater ponds will be included in this technical specification, however, these sections have been excluded from this issue of the technical specification as these elements of the design are unrelated to the quality requirements of the construction of Cell 1. They will be included in future issues of the specification as Council intend to undertake construction in one campaign however these elements are not required to comply with the *Environmental Guidelines: Solid Waste Landfills.*

3 Interface Shear Strength Testing

3.1 General

The geosynthetic interfaces used in the construction of Cell 1 shall be tested to confirm interface shear strength. Shear strength testing shall be conducted prior to procurement of material to allow assumptions used to in the design development to be confirmed.

The results of the interface shear strength testing shall be provided to the Designer for review and comparison against the assumptions documented in the cell design report. Where interface shear strengths are below those assumed in the design, the designer shall evaluate the impacts on the design and advise if any changes are required to the material specification, design or operational procedures to account for these changes.

3.2 Standards

Interface shear strength testing shall comply with the requirements of the following standards:

ASTM D5321 Standard test method for determining the shear strength of soil-geosynthetic and geosynthetic-geosynthetic interfaces by direct shear.

3.3 Sampling and Interfaces to be Tested

The following interfaces shall be subject to direct shear testing:

- Cushion geotextile vs Smooth HDPE;
- Tensile Reinforcement Layer to cover geotextile of drainage geocomposite;
- Drainage geocomposite (bare geonet side) to cushion geotextile; and
- Tensile Reinforcement Layer to protective cover soil

One set of tests shall be carried out for each interface. Samples of the geosynthetics and soil from the project shall be used for the testing. The contractor shall supply soil and geosynthetic samples for testing at no cost to the Principal. Collection of geosynthetic samples shall be undertaken under supervision of the CQA Engineer and collection of soil samples shall be undertaken under supervision of the GITA.

3.4 Laboratory Testing

Interface shear testing shall be undertaken by a NATA accredited geosynthetics testing laboratory. The direct shear testing shall be conducted in accordance with ASTM D5321 for all interfaces. Each interface shall be tested at confining pressures of 50, 100, and 300 kPa.

3.5 Evaluation

The results of the interface shear strength testing shall be forwarded to the Designer for assessment against the assumptions documented in the Design Report. The Designer shall provide a written assessment of the results confirming design assumptions are met or confirming design or operational changes that are required on the basis of the testing results.

4 Site Preparation and Subgrade

4.1 General

This clause of the Specification details the requirements for subgrade earthworks including selection of materials, clearing, grubbing, excavation and filling for the Cell 1 works prior to construction of the engineered fill layer.

Clause 3 shall be read in conjunction with the Drawings.

4.1.1 Standards

This Specification shall be read in conjunction with the following Standards and references, which are deemed to form a part of this Specification.

AS 1289 Methods of Testing Soils for Engineering Purposes

AS 3798 Guidelines on Earthworks for Commercial and Residential Developments

4.2 Materials

4.2.1 General

Site preparation and earthworks materials are to be as specified herein or as otherwise approved.

4.2.2 Suitable Materials

Subgrade fill materials shall be any cohesive soils or cohesive soil-gravel mixtures of low to medium plasticity, well graded and capable of compaction in layers to form a dense, stable fill suitable for subsequent construction of the layers above. The material shall not be susceptible to excessive softening, erosion or instability when exposed to water and have the following properties:

- 100% passing 100 mm
- >10% passing 0.075 mm
- Liquid Limit > 20%
- Plasticity index > 5%
- Organic fraction <1%
- (or Trial Specification).

Large particles must be broken down or capable of being broken down during the filling works to a maximum particle size of 100 mm.

They shall be free from debris, weeds, roots, organic material or other foreign matter and meeting the criteria described in Sections 4.2.3 and 4.2.4.

Material shall be pre-qualified to comply with the specification requirements, including testing necessary to support its classification as set out in Table 4.2, and be approved for use by the CQA Engineer prior to being imported to site.

If non-complying alternative materials are proposed to be used for the subgrade layer, then they shall be assessed for suitability by the Designer prior to being imported to site.

4.2.3 All Imported Fill Materials

All imported fill shall be selectively sourced Virgin Excavated Natural Material (VENM) or a quarry product meeting the specification requirements.

Material that is to be imported to the site and is not a quarry product, shall be assessed and recommended as being suitable for use on the site by an approved Environmental Consultant with experience in rehabilitation, and the recommendation must be supported by the Superintendent.

No fill material may be brought into site without written approval from the Superintendent or the Principal and appropriate accompanied documentation. Material imported to site that is deemed to be unsuitable by the Environmental Consultant shall be removed from site or managed as directed by the Principal.

4.2.4 Unsuitable Materials

Unsuitable materials shall be materials unable to be compacted for the construction of subgrade or deemed to include the following:

- Site won materials unable to be compacted to meet this Specification; or
- Material deemed to include the following:
  - Organic soil (topsoil)
  - Fill contaminated through past site usage which contain toxic substances or soluble compounds
  - Imported soil from any Lot, site or property that is listed on the Environment Management Register or the Contaminated Land Register or has been used historically for a Notifiable Activity as defined by the Protection of the Environment Operations Act 1997, or from an area that has the potential to contain acid sulphate soils unless approved in writing by the Superintendent
  - Fill containing deleterious materials including, metal, wood, rubbish, vegetation
  - Other materials deemed unsuitable by the Superintendent

Any unsuitable soils brought onto the site shall be removed from the site at no cost to the Principal.

Should any suitable materials being used in the Works become unsuitable through activities undertaken, or not undertaken, the material shall be removed and replaced with suitable materials at no cost to the Principal.

4.2.5 Prequalification Testing

Materials to be used in the subgrade layer shall be stockpiled for prequalification testing prior to use in the Works. Stockpiles shall be clearly identified for testing and reporting purposes.

Samples of materials proposed for use shall be tested in a NATA registered laboratory. Results of the materials testing shall be provided to the Superintendent and CQA Engineer for approval prior to use. All materials to be incorporated into the Works shall be tested for compliance with the material requirements in this Specification.

4.3 Construction and Workmanship

4.3.1 Site Clearance

The site shall be cleared only in those parts on which the specified construction works are to be carried out, or as otherwise shown on the Drawings.

All materials resulting from the site preparation shall be removed from the area of construction and either stockpiled or disposed of as directed by the Superintendent.

Existing surface vegetation to be removed shall be stockpiled onsite at a location nominated by the Superintendent.

Stockpiles shall have adequate drainage and erosion protection and be protected from contamination by other excavated material, weeds and building debris.

All materials stockpiled shall remain the property of the Principal and shall be left in a neat stockpile in the position or positions on the site as directed by the Superintendent.

4.3.2 Excavation

4.3.2.1 General

Overcut shall be made good to the satisfaction of the Superintendent.

In the event that soft spots, voids or piping erosion are revealed in the subgrade, the Superintendent shall be notified immediately who may deem it necessary to inform the Designer for further direction. If the Superintendent deems it necessary, remedial measures shall be carried out as directed, and the excavation backfilled with material selected by the Superintendent.

Where evidence of internal erosion, voids or the potential for differential settlements in the subgrade are encountered during subgrade preparations, the Designer should be alerted. The Designer shall consider the appropriate remedial action(s) to be taken such as, for example, the removal and reinstatement of the affected area or placement of a geogrid tensile reinforcing layer.

All areas disturbed by the excavation and all loose surface material shall be compacted by watering, if necessary, and rolling with approved compaction equipment to the density specified for filling. The floors and sides of excavations shall be trimmed to the lines, levels, grades and batters shown on the Drawings, and within the tolerances specified.

Where the subgrade layer is unable to support construction equipment, or it is not possible to compact the overlying material because of a high subgrade layer moisture content, perched groundwater or other reasons for subsurface water infiltration, one or both of the following shall be performed:

- Allow the subgrade layer to dry until it will support equipment and allow compaction; and/or
- Excavate the wet material, remove to spoil as directed, and replace with and compact suitable select fill material.

4.3.2.2 Protection of excavations

All work necessary to protect excavations and prevent damage to adjoining structures, services and property shall be undertaken as required. This responsibility includes installation and maintenance of timbering, shoring, strutting, bracing, sheeting, piling, etc.

The stability of the ground to be excavated shall be confirmed prior to construction commencing.

The provisions of the Regulations under the Work Health and Safety Act shall also apply.

All work methods shall be carried out to the satisfaction of the Superintendent. The Superintendent may order work to cease until such time as equipment is provided and methods adopted which are to the satisfaction of the Superintendent.

4.3.2.3 De-watering of excavations

Excavations are to be maintained in a thoroughly drained condition at all times. If, during the course of excavation, the natural ground water is encountered, de-watering shall be carried out in a safe and efficient manner and in accordance with the site's licence requirements and SEDMP.

Groundwater pumped from excavations shall be disposed of in a manner which satisfies the requirements of the site's licence conditions.

4.3.2.4 Disposal of surplus excavated material

All clean surplus excavated material (other than topsoil) arising from the specified works shall be stockpiled on site at the location nominated by the Superintendent prior to reuse in the works.

If, in the opinion of the Superintendent, the material is unsuitable for filling, stockpiles shall be clearly separated so as not to contaminate stockpiles suitable for reuse. Stockpiles shall have an identifying measure in place indicating the stockpiles as being unsuitable for use. The stockpiles shall have

adequate drainage and erosion protection and be protected from contamination by other excavated material, weeds and building debris.

4.3.3 Fill Construction

Filling construction includes all operations associated with the preparation of foundation areas where fill is to be placed, and the placing and compaction of approved suitable material.

Filling shall commence only after the surface upon which fill material is to be placed has been inspected and approved by the GTA.

4.3.3.1 Fill Foundation and Proof Rolling

Prior to placement of fill material the surface shall be inspected by the GTA (as applicable to meet the requirements of AS 3798) and the fill foundation shall be proof rolled in accordance with a method to the satisfaction of the Superintendent.

If the GTA considers the surface is suitable, filling shall commence as described below. If the GTA considers that the surface is unsuitable, additional excavation or other measures shall be carried out as directed by the GTA.

4.3.3.2 Subgrade Layers Affected by Moisture

Where the subgrade layer is unable to support construction equipment or it is not possible to compact the overlying material because of a high subgrade layer moisture content as a result of an ineffective surface water management, the Contractor shall be deemed to have caused the conditions and shall perform one or more of the following:

- allow the subgrade layer to dry until it will support equipment and allow compaction; and/or
- scarify the subgrade layer to a depth of 150 mm, work as necessary to accelerate drying, and re-compact when the moisture content approximates the optimum; and/or
- excavate the wet material, remove to spoil as directed, and replace with and compact suitable select fill material.

4.3.3.3 Placing Fill

The method of excavation, transportation, depositing and spreading of the fill shall be determined to ensure the fill is placed in a uniform mixture and the placed material meets the requirements of the Specification.

Fill materials shall be placed in horizontal layers of uniform thickness, deposited systematically across the fill area, so that the surface is always self-draining. Large particles shall be broken down and evenly distributed through the fill material. The maximum size of rock particles throughout the fill material shall not exceed the grading requirement.

The layers shall be uniformly compacted from a loose depth targeting 300 mm (maximum) unless approved by the GTA.

Prior to placing subsequent fill layers, ensure that previously accepted layers still conform to requirements.

Care shall be taken to use equipment and construction techniques to minimise surface heaving or other damage to the lower layers including damage by over working or construction traffic.

A method specification may be adopted in accordance with AS 3798 for achieving the compaction and material requirements as intended by the base liner design for the subgrade layers.

The method specification and method statements shall be provided to the Superintendent and GTA for approval at least 14 days prior to construction commencing. The proposed method shall consider the compaction and surface preparation. The method specification may include the completion and testing of a trial pad.

The construction and condition of the placed fill layers shall be verified by testing (where applicable) by the GTA.

4.3.3.4 Compacting Fill

All fill layers shall be systematically compacted with appropriate compaction equipment to ensure compaction to the full depth and width of each layer. Embankment slope faces shall either compact separately or overfill and cut back to the tolerances required.

Filling, and areas disturbed by excavation, shall be compacted to a minimum dry density ratio of 95% relative to standard compaction, in accordance with AS 1289.5.1.1 and AS 1289 5.4.1. Bond between layers is to be ensured, if necessary, by wetting or scarifying.

Rock fill or cohesion less soils shall have no visible deflection of surface under 10 tonne rollers after 6 - 8 passes.

For the compaction and construction requirement of anchor trenches, refer to Clause 6.

4.3.3.5 Moisture Control

The moisture content of the fill material shall be adjusted as required to achieve the specified density or moisture content prior to compaction, to the satisfaction of the GTA.

Completed fill layers shall be graded and rolled with a smooth drum roller, or similar, to the satisfaction of the GTA to prevent ponding.

4.3.3.6 Filling Adjacent to Structures

Equipment and construction techniques shall be employed to ensure protection of adjacent structures and landfill infrastructure from damage due to filling operations.

4.3.4 Surface Water and Base Flows

The site may be subject to surface water in the form of base flows or flood flows during the construction period. All flows, base and flood, during the construction period, shall be managed by the Contractor to ensure protection of the works.

4.4 Quality Requirements

4.4.1 Geotechnical Testing Authority (GTA)

A suitably qualified independent (Level 2) Geotechnical Testing Authority (GTA) shall be appointed by the Principal. The GTA will undertake testing in accordance with AS 3798 – Guidelines on Earthworks for Commercial and Residential Developments where required by this Specification.

The compaction of subgrade layer filling shall be tested by the nominated GTA. The testing shall be carried out by a NATA accredited laboratory, in accordance with AS 1289 - Methods of Testing Soils for Engineering Purposes.

Copies of the test results shall be made available to the Superintendent for his approval prior to the commencement of construction of any subsequent layer. The Contractor shall programme the Works accordingly and no claims for delays will be considered due to delays in the availability of such test results to the Superintendent.

On completion of the earthworks, the GTA shall provide test reports for all sampling and testing it has carried out including the locations and results thereof prior to issue of Completion.

4.4.2 Materials

Suitable materials as nominated in Clause 4.2.2 shall be produced into identifiable lots and tested in accordance this Specification and AS 3798 – Guidelines on Earthworks for Commercial and Residential Developments.

4.4.3 Quality Testing

4.4.3.1 Proof Rolling

Proof rolling in accordance with the requirements of AS 3798 shall be undertaken in the presence of the GTA to confirm competence of the subgrade layer when:

- subgrade layer design level is achieved within excavated areas of cut; or
- undocumented fill material is present or removed to expose the natural subgrade layer and prior to filling works.

4.4.3.2 Subgrade Fill Construction Materials Test Methods and Frequency

All subgrade materials to be incorporated into the work shall be tested for compliance prior to use in the construction works in accordance with Table 4.1 and Table 4.2.

Table 4.1 Subgrade Fill Materials and Construction Test Methods

Abbreviation	Test	Test Method
PSD	Particle Size Distribution	AS 1289 - 3.6.1
Atterbergs	Atterberg Limits	AS 1289 - 3.1.1, AS 1289 - 3.2.1, AS 1289 - 3.3.1 & AS 1289 - 3.4.1
MC	Moisture Content	AS 1289 - 2.1.1
OMC	Optimum Moisture Content (standard compactive effort)	AS 1289 - 5.1.1
SDDR	Standard Dry Density Ratio	AS 1289 - 5.1.1, AS 1289 - 5.8.1, AS 1289 - 5.4.1

Testing of subgrade fill construction shall be in accordance with the frequency and requirements as set out in Table 4.2 and Table 4.3. Detailed records of the Works shall be kept.

Table 4.2 Subgrade Fill Materials Prequalification Test Frequency

Test	Frequency	Stage	Criteria
Visual Inspection	At least daily	Prior to placement	Visual Inspection Free from debris, weeds, roots, organic material or other foreign matter. Meeting the requirements of Clause 4.2.3 and 4.2.4
PSD and Atterbergs	1 test per 500 m^3 compacted material	Prior to placement (Prequalification)	100% passing 100 mm >10% passing 0.075 mm Liquid Limit > 20% Plasticity index > 5% (or Trial Specification)

Table 4.3 Subgrade Layer Fill Construction Compaction Test Frequency

Test	Frequency	Stage	Criteria
SDDR	1 test per 2,500 m^2 per layer under Level 2 engagement	After placement and compaction	≥95%
MC and variation from OMC			Target OMC with tolerance range: 2% dry (-2%) to 3% wet (+3%) of OMC (or Trial Specification)

Testing for the grading of the subgrade layer fill material to ensure the material has maximum particle size of 100 mm, shall be performed and periodically inspected by the GTA.

Where testing is required, the following test procedures shall be used:

- Dry Density Ratio shall be calculated to the nearest 0.5%.
- Density measurements shall be made to the nearest 0.01 tonne/m^3.
- Test location co-ordinates shall be measured to the nearest 100 mm.

4.4.3.3 Material Variation from the Specification

Where in the opinion of the GTA, the material being used in the works differs from the specified material, the GTA may order a sample to be taken and retested. If the material does not comply with the Specification, the cost of sampling and testing shall be at no cost to the Principal and, in addition, the work which incorporates the material shall be liable to be rejected at the Superintendent's discretion.

4.4.4 Inspections and Acceptance Criteria

Hold points are stages of work beyond which work shall not proceed without mandatory inspection / verification and written approval before subsequent works can be initiated.

The following inspection and hold points are required during the site preparation and earthworks:

H-SE1 Superintendent review of WHS Plan and SEDMP

H-SE2 GTA's approval of subgrade fill materials proposed to be used in the works

H-SE3 Proof rolling by GTA to confirm subgrade bearing capacity

H-SE4 CQA Engineer's review and approval of as-constructed information

Where test results show that the level of compaction of filling material that has been achieved is below the level specified, the areas or volumes represented by the tests (as determined by the Superintendent) may be rejected. Defective material shall be replaced and re-worked or further compacted and re-submitted for further testing until the specified requirements are achieved and the Superintendent's approval received. All remedial works and re-testing shall be at no cost to the Principal.

The Superintendent and Contractor may also utilise proof rolling, final subgrade survey, supervision or other methods as part of the assessment of the acceptability of completed layers. Prior to the placement of engineered fill layer material, the Contractor shall approve that the subgrade is suitable for subsequent construction.

4.4.5 As-Constructed Reporting

Once compaction and grading of the final surface profile are complete, a level survey shall be undertaken by the Surveyor. Information and data as nominated for the relevant phases in Clause 1.8.4 and 1.7.5 shall be provided to the CQA Engineer for approval, prior to placement of subsequent layers.

Within 14 days of Completion of the works, all daily logs, materials and construction test reports and final surface survey shall be provided to the Superintendent prior to placement of subsequent layers.

The Superintendent and GTA shall take photographs of the progress of the Works when onsite, and detailed record on completion of the Works.

The CQA Engineer shall include all these documents and drawings in the final as-constructed reporting including comment on construction and if in accordance with the approved Specification.

5 Engineered Fill Layer

5.1 General

This clause of the specification covers the construction of the 0.3m thick engineered fill layer for the cell baseliner and side batters.

5.1.1 Standards

This Specification shall be read in conjunction with the Drawings and the following Standards and references, which are deemed to form a part of this Specification.

AS 1289 Methods of Testing Soils for Engineering Purposes

AS 3798 Guidelines on Earthworks for Commercial and Residential Developments

5.2 Materials

5.2.1 Suitable Materials

5.2.1.1 Engineered Fill

Suitable engineered fill materials shall be any cohesive soils or cohesive soil-gravel mixtures of low to medium plasticity, well graded and capable of compaction in layers to form a dense, stable fill suitable for subsequent construction of the layers above. The material shall not be susceptible to excessive softening, erosion or instability when exposed to water and have the following properties:

- 100% passing 100 mm sieve;
- >25% passing 0.075 mm sieve;
- Liquid Limit ≤50%;
- Plasticity Index 8 - 35%; and
- Emerson class >3.

Large particles must be broken down or capable of being broken down during the filling works to a maximum particle size of 100 mm.

The engineered fill material shall be free from debris, weeds, roots, organic material or other foreign matter and meeting the criteria described in Clauses 4.2.3 and 4.2.4.

Material shall be prequalified to comply with the above properties and be approved for use by the Superintendent or GITA prior to being imported to site.

5.2.1.2 Select Fill

Suitable select fill shall meet the criteria of engineered fill but shall be primarily fine grained material containing no particles greater than 13.2 mm and free from debris, weeds, roots and organic material or other foreign matter and meeting the criteria described in Clause 4.2.3 and 4.2.4. The material shall be capable of being finished to a smooth and flat surface and free of protrusions.

This material shall be approved by the Superintendent or GITA prior to use in the works.

5.2.2 Prequalification Testing

Materials to be used in the engineered fill layer shall be stockpiled for prequalification testing prior to use in the works. Stockpiles shall be clearly identified for testing and reporting purposes.

Samples of materials proposed for use shall be tested in a NATA registered laboratory. Results of the materials testing shall be provided to the Superintendent for approval prior to use. All materials to be incorporated into the works shall be tested for compliance with the material Specification in Table 5.2.

5.2.3 Materials Being Used in the Works

No material shall be used for construction of the engineered fill layer, without approval of the GITA in accordance with Clause 5 and receipt of satisfactory test results of the material, in accordance with Table 5.2.

Each compacted layer is to be free of lenses or pockets of materials that differ substantially in composition, texture, moisture content or density. If variations in the materials are detected, the Superintendent shall be advised, and the GITA will be required to assess the materials suitability.

Any material deemed substantially different by the GITA to that already approved or incorporated into the works and proposed for use in the engineered fill layer shall be trialled to ensure familiarity with the material prior to construction in the engineered fill layer.

All materials deemed suitable for use as engineered fill layer material, but differing from other suitable materials, shall be separately stockpiled and identified to allow for ready recognition.

5.2.4 Excavation and Winning of Engineered Fill Material

The engineered fill layer shall be selectively sourced wherever possible using on-site materials. Approval of the suitability of the materials shall be the responsibility of the GITA.

If an alternative source of material than site won materials is proposed to be used for the engineered fill layer, then all prequalification testing results shall be submitted to the GITA for approval prior to incorporation in the works. The results shall conform to the material specification requirements for imported materials as nominated below or to the GITA's approval.

5.3 Construction and Workmanship

5.3.1 General Construction

The engineered fill layer across the cell base shall be trimmed to the profile and grades detailed in the Drawings. The cell side batters shall be constructed to the alignment and dimensions as nominated in the Drawings.

The upper 100 mm (minimum) of the engineered fill layer contacting with geosynthetic lining materials shall be select fill material free of particles greater than 13.2 mm, unless the Contractor can demonstrate during lower engineered fill layer construction that a satisfactory surface, free of protrusions or the risk of development of protrusions, can be prepared with the engineered fill material. The surface shall be free of loose particles capable of protruding into the GCL and finished so as to provide a suitable surface for GCL placement and complying with Clause 5.3.6.

Prior to placement of the engineered fill layer material, the subgrade surface shall be inspected and approved by the GITA (as applicable to meet the requirements of AS 3798) and the subgrade layer shall be proof rolled in accordance with a method to be determined by the GITA.

If the GITA considers the surface is suitable, engineered fill layer filling shall commence as described below. If the GITA considers that the surface is unsuitable, additional excavation or other measures shall be carried out as directed by the GITA.

The engineered fill layer works shall commence only after the subgrade surface has been inspected and approved by the GITA.

5.3.2 Moisture Conditioning

The engineered fill layer material shall be placed and compacted to target the materials OMC with a tolerance range of 0% to 3% wet (+3%) of OMC. The wet end of the range has been nominated since surface moisture is required to hydrate the GCL once placed.

Moisture content tests shall be conducted on placed and compacted material at the rate nominated in Table 5.3 to ensure the correct moisture content is achieved and maintained. Placed material not conforming to the specified moisture content is liable to rejection, to be removed and replaced at no cost to the Principal.

Material shall be tilled, broken down, and allowed to dry or have water added and mixed thoroughly to ensure consistent moisture throughout prior to compacting as required.

During wetting or drying, the material shall be thoroughly mixed (e.g. with tilling equipment) and given time for moisture levels to reach equilibrium, prior to re-testing moisture content and subsequent compaction.

The moisture condition of any stockpiled material shall be maintained in accordance with Clause 5.3.5.

5.3.3 Compaction

The Contractor shall compact the engineered fill material with approved compaction equipment, suitable for the material being compacted in layers not exceeding a nominal 300 mm compacted thickness. Construction of subsequent layers shall not commence until satisfactory test results for compaction and moisture content are achieved.

Each layer shall be inspected and approved by the GITA prior to subsequent layers being constructed. The surface of each layer must be suitably prepared for subsequent layers. The lower layer must present a satisfactory surface to enable subsequent lifts to be placed without interfaces between layers occurring. This shall be done by either:

- The lower layer presenting a kneaded surface from compaction by suitable equipment that will allow the subsequent layer to blend in with the lower layer. Satisfactory compaction must still be achieved;
- Scarifying the surface to a nominal depth of 50 mm prior to placement of subsequent layers to allow layers to blend together.

Subsequent layers shall be placed to ensure that vertical construction joints are staggered between successive layers. Construction joints between lots of work shall be constructed with a minimum 1.0 m stagger of abutting joints in overlying or underlying layers between layers being constructed as part of the same construction activity, or to the satisfaction of the GITA.

5.3.4 Protection of Layers

Unless layers are to be immediately covered by subsequent layers, the surface of each layer shall be finished with a smooth drum roller to minimise areas of ponding of water due to rainfall. Traffic movement across the completed areas shall be limited to the maximum extent practical.

Finished surfaces shall be monitored for excessive desiccation cracking on a daily basis whilst on site, but possibly more often depending on weather conditions. Surfaces shall be lightly sprinkled on a regular basis as required to maintain moisture within the engineered fill layer.

If weather and fill material conditions are such that significant cracking or excessive moisture loss from the engineered fill is likely, the surface shall be sprinkled on a regular basis as required to maintain moisture near the surface of the layer. If deemed appropriate by the GITA, the surface shall be sprinkled and then covered by a protective layer (e.g. plastic film or sand).

Prior to subsequent layers being placed, the protective layer (if any) shall be removed, the surface inspected and conditioned as required.

If excess drying of liner material occurs, then all dried liner material shall be stripped off and replaced, or alternatively scarified and conditioned to correct moisture tolerances before placing the next layer. The layer shall be scarified, and re-moisture conditioned to the full depth of any drying and re-compacted. If the drying is greater than 150 mm, it shall be corrected by stripping off the upper liner material layer, treating the underlying material layer and replacing the stripped material.

5.3.5 Maintaining Moisture Condition

All material that is either stockpiled or not placed immediately as engineered fill material shall be monitored to ensure the correct moisture condition is maintained.

The GITA shall be satisfied that stockpiled material is of the correct moisture condition and suitable for placement. Prior to placing, stockpiled material, especially surface layers shall be reworked to ensure even moisture condition. Correct moisture condition shall be maintained by conducting MC tests at the rate as nominated in the Schedule or as otherwise approved by the GITA. Complying MC tests may be rejected if not promptly forwarded to the GITA or if adverse weather conditions occur.

Moisture content of both stockpiled and placed material shall be monitored and maintained. The appearance of significant cracking of any placed layer is indicative of excessive drying. Any section showing significant cracking may be deemed too dry and therefore subject to remediation or removal and replacement.

5.3.6 Surface Finish

The finished surfaces to be lined shall be firm, smooth and unyielding, free of any protruding debris, vegetation, roots, sticks, sharp rocks, or other deleterious or loose materials. Any particles that protrude from the surface by more than 10 mm shall be removed. Any voids left by removing material shall be filled with suitable material and rolled to reinstate a flat surface.

The surface should be free of any voids or large cracks and free of standing water.

The surface should not be disturbed or rutted by the equipment or other traffic and finished with a smooth drum roller to ensure a smooth and flat finish.

The surface must be maintained in this condition until the GCL is placed. Inspection of the surface shall be undertaken by the CQA Engineer as described prior to the GCL roll deployment.

5.3.7 Level Control

The GITA shall be satisfied that the engineered fill layer is constructed within the specified thickness, either by sufficient level control pegs or other approved method. Layers exceeding the specified thickness shall be subject to rejection by the GITA and removed. Approval shall be obtained from the GITA that each layer placed is within the specified layer thickness requirement, or otherwise, prior to construction of subsequent layers, and the GITA shall make note of passing layers in daily logs.

5.4 Quality Requirements

5.4.1 Geotechnical Inspection and Testing Authority (GITA)

A suitably qualified independent Level 1 Geotechnical Inspection and Testing Authority (GITA) shall be appointed and approved by the Superintendent for the construction of the engineered fill layer.

Construction of the engineered fill layer shall be undertaken under 'Level 1' geotechnical overview as defined in AS 3798. The engineered fill layer shall be constructed in accordance with this Specification and QA records maintained for construction of the works throughout. The work area shall be divided into manageable areas.

The GITA is responsible for ensuring that the adequate inspection and testing of the engineered fill layer in accordance with this Specification and AS 3798. The GITA shall have competent personnel on site at all times to inspect the earthwork. As a minimum the GITA shall inspect the following earthworks operations:

- Prequalification testing of the liner material in the stockpile
- Placing and compaction of engineered fill material including adding/removal of moisture
- Geotechnical Testing

On completion of the earthworks, the GITA shall provide a report setting out the inspections, sampling and testing it has carried out, and the locations and results thereof and shall express an opinion as to whether the works comply with the Specification and Drawings.

5.4.2 Engineered Fill Layer Materials Approval Testing

All materials to be incorporated into the engineered fill layer works, whether site won or imported shall be tested in accordance with this Clause of the Specification.

The Testing Authority will be a NATA accredited organisation, approved for engagement by the Superintendent.

Table 5.1 Engineered Fill Layer Materials and Construction Test Methods

Abbreviation	Test	Test Method
PSD	Particle Distribution	AS 1289 - 3.6.1
Atterbergs	Atterberg Limits	AS 1289 - 3.1.1, AS 1289 - 3.2.1, AS 1289 - 3.3.1 & AS 1289 - 3.4.1
MC	Moisture Content	AS 1289 - 2.1.1
OMC	Optimum Moisture Content (standard compactive effort)	AS 1289 - 5.1.1
SDDR	Standard Dry Density Ratio	AS 1289 - 5.1.1, AS 1289 - 5.8.1, AS 1289 - 5.4.1
Emerson Class	Emerson Class Number	AS 1289 – 3.8.1

5.4.2.1 Engineered Fill Layer Materials and Construction Test Methods and Frequency

Any site won materials to be reused in the works shall be prepared and stockpiled. The stockpiled material shall be regularly (at least daily) visually inspected and approved by the Superintendent or GITA prior to use in the works.

Table 5.2 Engineered Fill Layer Materials Testing Criteria

Test	Frequency	Stage	Criteria
Engineered Fill			
Visual Inspection	At least daily	Prior to placement (Prequalification)	Well graded. Free from debris, weeds, roots, organic material or other foreign matter Meeting the criteria described in Clause 4.2.3 and 4.2.4
Atterbergs	Greater of: 1 test per 500 m^3 of compacted material or 3 per source	Prior to placement (prequalification)	Liquid Limit < 50% Plasticity index 8 - 35% (or Trial Specification)
PSD	Greater of: 1 test per 500 m^3 of compacted material or 3 per source	Prior to placement (prequalification)	100% passing 100 mm sieve >25% passing 0.075 mm sieve

Emerson Class	Greater of: 1 test per 500 m^3 of compacted material or 3 per source	Prior to placement (prequalification)	>3
Select Fill (Top 100 mm) – Engineered Fill Criteria with the exception of the following			
PSD	1 test per 2,500 m^2 per layer	Prior to placement (Prequalification)	13.2 mm max particle size

All fill material placed on the top surface of the engineered fill layer and coming into direct contact with the geosynthetic liner materials shall meet the select fill criteria.

Testing for the grading of the engineered fill material to ensure the material has maximum particle size of 100 mm, shall be performed and periodically inspected by the Superintendent.

Where testing is required, the following test procedures shall be used:

- Dry Density Ratio shall be calculated to the nearest 0.5%.
- Density measurements shall be made to the nearest 0.01 tonne/m^3.
- Test location co-ordinates shall be measured to the nearest 100 mm.

5.4.2.2 Material Variation from the Specification

Where in the opinion of the Superintendent or GITA the material being used in the works differs from the specified material, the Superintendent or GITA may order a sample to be taken and retested. If the material does not comply with the Specification the cost of sampling and testing shall be at no cost to the Principal, in addition, the work which incorporates the material shall be liable to be rejected at the Superintendent's discretion.

5.4.3 Engineered Fill Layer Construction Approval Testing

Construction of the engineered fill layer works shall be tested in accordance with Table 5.3.

Table 5.3 Engineered Fill Layer Construction Compaction Test Frequency

Test	Frequency	Stage	Criteria
All Engineered Fill Layer Testing			
SDDR	1 test per 2,500 m^2 per layer under Level 1 engagement	After placement and compaction	≥98%
MC and variation from OMC			Target OMC with tolerance range: 0% to 3% wet (+3%) of OMC (or Trial Specification)

5.4.4 Inspection and Acceptance Criteria

Hold points are stages of work beyond which work shall not proceed without mandatory inspection / verification and written approval before subsequent works can be initiated.

The following inspection and hold points are required during the engineered fill layer construction:

H-EL1 GITA's approval of engineered fill layer materials proposed to be used in the works

H-EL2 GITA's inspection and approval of subgrade surface prior to engineered fill layer construction

H-EL3 CQA Engineer's review and approval of as-constructed information

Where test results show that the level of compaction of filling material that has been achieved is below the level specified, the areas or volumes represented by the tests (as determined by the GITA) may be rejected. Defective material shall be replaced and re-worked or further compacted and re-submitted for further testing until the specified requirements are achieved and the GITA's approval received. All remedial works and re-testing shall be at no cost to the Principal.

The GITA may also utilise proof rolling, supervision or other methods as part of the assessment of the acceptability of completed layers.

5.4.5 As-Constructed Reporting

Once compaction and grading of the final surface profile are complete, a level survey shall be undertaken by the Surveyor. Information and data as nominated for the relevant phases in Clause 1.8.4 and 1.7.5 shall be provided to the CQA Engineer for approval prior to placement of subsequent layers.

The Superintendent shall be provided with the GITA's report including all daily logs, materials and construction test reports and final surface survey within 14 days of completion of the Works, prior to placement of subsequent layers.

The Superintendent and GITA shall take photographs of the progress of the Works when onsite, and detailed record on completion of the Works.

The CQA Engineer shall include all these documents and drawings in the final as-constructed reporting including the certification that the works have been completed in conformance with the approved Specification.

6 Anchor Trenches

6.1 General

The anchor trenches for the geosynthetic liner components (GCL, HDPE geomembrane, cushion geotextile, drainage geocomposite and tensile reinforcement layer) shall be constructed in the locations and dimensions as shown in the Drawings.

The CQA Engineer will approve material for use to backfill the trenches, inspect the trenches prior to installation of the liner materials, inspect the trenches once backfilled and include a summary of the works in the CQA reporting.

6.2 Materials

The material to be placed into the anchor trenches shall be in accordance with the respective material, quality, construction and workmanship requirements of this Specification.

The anchor trench backfill material shall meet the Specification for select fill material as nominated in Clause 5.2.1.2.

The anchor trench backfill material shall be approved by the CQA Engineer prior to placement.

6.3 Construction and Workmanship

The CQA Engineer shall be provided with the proposed methodology for construction of the anchor trench for approval prior to construction of the anchor trench.

The anchor trench shall be constructed in accordance with the alignment and dimensions shown on the Drawings and the location and alignment of the anchor trench shall be excavated to ensure the minimum set back from the crest of the batter is achieved.

The inside of the upper edge of the anchor trench shall be chamfered or rounded off to ensure protection of the geosynthetic materials to be run over the inside edge of the trench.

The surface of the anchor trench and crest shall be inspected and approved prior to placement of the geosynthetic layer and backfill. The inside surface of the anchor trench shall be even and regular and not contain sharp protrusions or depressions. The trench shall not contain ponded or free water prior to backfilling.

Backfill shall be completed using suitable material compliant with Clause 6.2, placed in a minimum of two even layers and moisture conditioned to ensure compaction and adequate contact with material to be anchored. Compaction shall be to the satisfaction of the GITA.

The finished surface of the anchor trench shall be consistent with surrounding surface and design cross falls and shall not allow capture or ponding of water behind the trench.

The CQA Engineer shall visually assess placement of the backfill and report on sections of completed trench.

6.4 Quality Requirements

6.4.1 Anchor Trench Construction Approval Testing

Construction works shall be tested in accordance with Table 6.1.

Table 6.1 Anchor Trench Fill Layer Construction Test Frequency

Test	Frequency	Stage	Criteria
SDDR	1 test per 50 m per layer	After placement and compaction	≥98%
MC and variation from OMC			Target OMC with tolerance range: 0% to 3% wet (+3%) of OMC (or Trial Specification)

6.4.2 Inspections

Hold points are stages of work beyond which work shall not proceed without mandatory inspection / verification and written approval before subsequent works can be initiated.

The following inspection and hold points are required during the anchor trench construction and backfilling:

H-AT1	CQA Engineer's approval of backfill materials proposed to be used in the works
H-AT2	CQA Engineer's approval proposed construction methodology
H-AT3	CQA Engineer's inspection of the full extent of the anchor trenches prior to geosynthetic liner placement
H-AT4	GITA's approval of anchor trench backfill compaction
H-AT5	CQA Engineer's inspection of backfilled trenches
H-AT6	CQA Engineer's review and acceptance of as-constructed information

6.4.3 Acceptance Criteria

Inspection of the trench prior to the installation of the geosynthetic materials shall be conducted jointly with the CQA Engineer and the Superintendent.

The location, depth and width of the anchor trench shall be inspected by the CQA Engineer, with spot measurements taken to confirm it conforms to the design.

Prior to backfilling of the anchor trench, the as-constructed location of the anchor trench shall be surveyed by a licensed Surveyor. The backfill material shall be a clayey material meeting the requirements of Clause 6.2 and approved by the CQA Engineer.

The CQA Engineer shall visually assess placement of the backfill and report on sections of completed trench.

6.4.4 As-Constructed Reporting

The inside edge of the anchor trench shall be measured by survey and located on the as-constructed drawings for the project in accordance with Clause 1.8.4 and 1.7.5. Survey shall be carried out by the Surveyor and submitted to the CQA Engineer for review and acceptance within 14 days of completion of the works.

The Superintendent and CQA Engineer shall take photographs of the progress of the works when onsite, and detailed record on completion of the works.

The CQA Engineer shall include all information and drawings in the final as-constructed reporting including comment on construction, and if in accordance with the approved Specification.

7 Geosynthetic Clay Liner

7.1 General

This clause of the Specification is applicable to the supply and construction of the Geosynthetic Clay Liner (GCL) barrier layer to be constructed after completion of the engineered fill layer and prior to placement of the overlying HDPE geomembrane.

The GCL shall be constructed in accordance with this Specification and the Drawings, and the Contractor shall maintain QA records for construction throughout. The work areas shall be divided into manageable areas by the Contractor.

The GCL is to be placed across the full extent of the cell floor and walls and shall terminate as shown on the drawings.

7.1.1 Standards

This Specification shall be read in conjunction with the Drawings and the following Standards and references, which are deemed to form a part of this Specification:

AS 3706	Geotextiles – Methods of testing
ASTM D5887	Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using Flexible Wall Permeameter
ASTM D5888	Standard Guide for Storage and Handling of GCLs.
ASTM D5890	Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
ASTM D5891	Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
ASTM D5993	Test Method for Measuring the Mass Per Unit Area of Geosynthetic Clay Liners
ASTM D6102	Standard Guide for Installation of GCL
ASTM D6496	Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners
ASTM D6768	Test Method for Tensile Strength of Geosynthetic Clay Liners
GRI-GCL3	Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)

7.2 Materials

7.2.1 Manufacture

The GCL shall be manufactured under strict quality control. The manufacturer shall be certified to the current version of ISO 9001. The components and the final GCL shall undergo regular and frequent testing in the manufacturer's laboratories according to the quality management standard ISO 9001. The component supplier shall guarantee consistent quality through careful selection, processing and handling at all times. The manufacturer shall provide its own in-house test documents (Manufacturer Quality Control) covering each roll of GCL delivered to site.

7.2.2 Labelling

GCL shall be supplied in rolls wrapped in moisture tight protective covers and marked or tagged on the wrapping and within the core with the following information:

- Manufacturer’s name
- Product identification

- Lot number
- Roll number
- Roll dimensions

7.2.3 Properties

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 and thermal locked throughout to provide increased shear strength and stability of the GCL and uniformity of the bentonite during manufacture, handling and installation.

The GCL shall be free of flaws that may have an adverse effect on the physical and mechanical properties of the GCL.

For the GCL used on the cell base the geotextile layers shall be polypropylene non-woven on the upper layer (cover) and polypropylene woven on the lower (carrier) layer. For the GCL used on the side batters the geotextile layers shall be polypropylene non-woven on the upper layer (cover) and polypropylene woven / non-woven composite on the lower (carrier) layer. The geotextiles shall be rot proof, chemically inert and compatible with leachate and gas generated in putrescible waste landfills.

The GCL to be used shall meet the material properties and MQA testing frequencies as shown in the following table and be reviewed and approved by the CQA Engineer:

Table 7.1 GCL Material Properties and MQA Test Frequencies

Property	Test	Units	Values – Cell Base	Values – Side Batters	MQA Minimum Frequency of Testing
GCL Total Mass	ASTM D5993	g/m^2	>4,300	>4,200	4,000 m^2
Cover Geotextile Mass (Non-woven)	AS3706.1	g/m^2	>200	>200	20,000 m^2
Carrier Geotextile Mass	AS3706.1	g/m^2	>100 (Woven)	>320 (Woven/Non-woven composite)	20,000 m^2
Tensile Strength (MD)	ASTM D6768	kN/m	>8	>12	20,000 m^2
Peel Strength	ASTM D6496	N/m	>360	>360	4,000 m^2
CBR Burst Strength	AS 3706.4	N	>1,600	>3,700	20,000 m^2
Hydraulic Conductivity	ASTM D5887	m/s	≤3 x 10^{-11}	≤3 x 10^{-11}	25,000 m^2
Bentonite					
- Mass (@0% moisture content)	ASTM D5993	g/m^2	≥4,000	≥3,700	4,000 m^2
- Moisture content	ASTM D5993	%	≤ 15	≤ 15	4,000 m^2
- Fluid Loss	ASTM D5891	mL	≤ 18	≤ 18	50 tonnes

- Free Swell	ASTM D5890	$cm^3/2g$	≥ 24	≥ 24	50 tonnes
- Cation Exchange Capacity	Methylene Blue Method	C mol/kg or meq/100g	≥ 70	≥ 70	50 tonnes
- Montmorillonite content, and - carbonate content	CSIRO x-ray diffraction	%	≥ 70 ≤ 2	≥ 70 ≤ 2	50 tonnes
Needle punch reinforcing			Yes	Yes	
Bentonite impregnation (lap area)			Yes	Yes	
300 mm lap marker			Yes	Yes	

The values listed in the table are to be interpreted according to the designated test method. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).

7.2.4 Plastic Membrane

If required to prevent premature unconfined hydration, a plastic membrane will be used to protect the GCL. The membrane shall be a 200-300 micron flexible plastic membrane, either Polyethylene (PE) or Low Density Polyethylene (LDPE) (UV stable). The material shall be removed from the GCL surface prior to geomembrane liner installation.

7.3 Construction and Workmanship

7.3.1 General

The GCL shall be installed in accordance with the manufacturer's requirements, this Specification and general principles set out in ASTM D6102 – Standard Guide for Installation of GCLs.

7.3.2 GCL Deployment Work Method Statement

No GCL shall be deployed until the CQA Engineer has approved the proposed work method statement detailing panel layout and proposed placement, hydration and protection methodology. The method statement shall be provided to the CQA Engineer at least 10 working days prior to scheduled deployment.

7.3.3 GCL Transportation, Handling and Storage

The GCL shall be transported, handled and stored in accordance with the manufacturer's requirements, this Specification and the principles set out in ASTM D5888 - Standard Guide for Storage and Handling of GCLs.

The GCL rolls shall be transported, handled and stored in moisture tight plastic wrapping and be protected from rain, chemicals, standing water, excessive heat and ultraviolet radiation, mud, dust, puncture, cutting, vandalism or other damage which may impact the GCLs performance.

GCL rolls shall be unloaded and handled using a spreader bar through the centre of the roll. The spreader bar may be a carpet prong from a loader (greater than 3.5 tonne), or other suitable equipment inserted at least 75% into length of roll and capable of supporting the full weight without bending.

Alternatively, use two slings located at third points along the roll length provided no significant bending occurs.

Under no circumstances shall the GCL rolls be dragged, lifted by one end only, dropped or handled in a manner that may impact the performance of the GCL.

All GCL rolls shall be inspected by the Superintendent upon delivery to site. Any damaged rolls shall be rejected, transported off-site and replaced at no cost to the Principal.

The GCL rolls shall be stored in a location on site approved by the CQA Engineer and such that transportation and handling requirements are facilitated. GCL rolls shall be stored on a flat, hard, dry, stable and free draining location, ensuring the rolls lay flat and are continually supported and protected from the passage of vehicles. It is recommended the GCL rolls be placed on blocks and pallets of sufficient quantity to have approximately 50% of each rolls length evenly supported. GCL rolls shall not be stored at a safe height and not be stored any greater than 3 rolls high.

7.3.4 GCL Base Preparation

The surface shall be prepared in accordance with Clause 5.3.6.

The engineered fill layer surface shall be lightly sprinkled with water to promote hydration of the GCL once placed. However, there should be no ponding on the surface at time of GCL deployment.

The engineered fill layer surface shall be inspected with the CQA Engineer and approval given prior to deployment of GCL.

7.3.5 GCL Deployment

The GCL shall be installed in accordance with the manufacturer's requirements, this Specification and general principles set out in ASTM D6102 – Standard Guide for Installation of GCLs.

Installation of the GCL shall be undertaken using a crane, tele-handlers or by side casting the GCL roll with an excavator or loader. All options nominated must utilise a spreader bar and ensuring there is no traffic allowed to traverse over the prepared engineered fill layer or placed GCL. Any other method of GCL deployment must be approved prior to installation by the CQA Engineer.

GCL panels should be placed with the carrier side down and without folds. Overlaps shall be a minimum of 300 mm on side laps and 500 mm on end laps. All panel overlaps shall be free from loose and foreign matter to provide intimate contact of the GCL to the contacting surfaces. Side laps shall be bentonite pre-treated. End laps shall be pre-treated with at least 700 g/m^2 added bentonite included in the outer 300 mm (min.) strip of the roll. Alternatively, a low viscosity hydrated bentonite paste shall be applied to a minimum of 200 mm of the lap between panels and protruding 50 mm past the end of the upper GCL.

Once placed, the GCL should be well secured by sand bags or other measures due to the potential for deployed panels to be affected by wind prior to soil coverage. The GCL shall be covered with the specified HDPE geomembrane as soon as possible to ensure premature hydration does not occur. The placed GCL must not be trafficked by any plant or vehicles.

Only those GCL panels, which can be anchored and covered to prevent unconfined hydration in the same day, shall be unpacked and installed. If exposed GCL cannot be permanently covered before the end of a working day, it shall be temporarily covered with plastic such as a plastic membrane or other water-proof material to prevent unconfined premature hydration. No GCL shall be left exposed overnight. Exposed edges of the GCL shall be covered by temporary water-resistant sheeting until work commences again. All plastic sheeting used to prevent premature hydration shall be removed prior to placement of cover materials.

7.3.6 GCL Overlays and Repairs

If the GCL has been damaged during installation, cover the damaged area with a panel cut to cover the damaged area and extend with a minimum 0.5 m overlap in all directions and paste as described above.

7.3.7 GCL Hydration

The Contractor must confirm with the Superintendent or Geomembrane Testing Authority (GMTA) the test method that will be adopted and the GCL hydration requirements prior to installation of the GCL.

7.4 Quality Requirements

7.4.1 CQA Engineer

The Principal shall arrange for a suitably qualified and experienced CQA Engineer to monitor the GCL installation works on a full-time basis. All monitoring and audit activities as described in this Specification shall be accommodated. The role of the CQA Engineer will include verification of materials and installation methods, organisation of independent testing, inspection of laps and repairs, evaluation of testing results and CQA reporting.

7.4.2 Quality Testing

7.4.2.1 Manufacturer Quality Assurance (MQA)

Manufacturer's material property data sheets are required for each grade of GCL to be used in the works. The manufacturer's quality control testing data for the batches relating to all rolls to be supplied to the project, are to be submitted to the CQA Engineer for approval prior to the delivery of the materials to site. GCL property reports shall include all properties at the testing rates as nominated in Table 7.1.

7.4.2.2 Independent Quality Assurance (IQA)

The Contractor shall provide the CQA Engineer (at no cost to the Principal) with suitable size and number of samples for independent off site laboratory testing of properties (laboratory and tests to be determined by the CQA Engineer). Sampling shall occur under supervision of the CQA Engineer. The Contractor must provide 2 weeks' notice of sampling to provide opportunity for a representative to be present. Testing shall include the first and last rolls based on production order with minimum of 2 tests per grade of GCL.

The Principal will be responsible for the cost of testing once the samples arrive at the nominated laboratory. A representative sample of GCL shall be cut from each sampled roll but not within the first roll wrap. Samples shall be tested at the frequency nominated in Table 7.2 and meet the property test values presented in Table 7.1. The Contractor's program shall allow for the completion of all IQA testing and in any event no less than 4 weeks.

Table 7.2 GCL Material Properties IQA Testing

Property	Test	Units	IQA Minimum Frequency of Testing
Peel Strength	ASTM D6496	N/m	1,250 m^2
Bentonite Mass (@0% moisture content)	ASTM D5993	g/m^2	1,250 m^2
Hydraulic Conductivity	ASTM D5887 Or ASTM D6766	m/s	10,000 m^2

GCL mass per unit area	ASTM D5993	g/m^2	2,500 m^2
Tensile Strength (MD)	ASTM D6768	kN/m	5,000 m^2
CBR Burst Strength	AS 3706.4	N	5,000 m^2
Fluid Loss	ASTM 5891	mL	1,250 m^2
Swell Index	ASTM D5890	cm^3/2g	2,500 m^2
Montmorillonite Content and Carbonate Content	CSIRO x-ray diffraction	% by weight	10,000 m^2
Cation Exchange Capacity	Methylene Blue Method	cmol kg-1	2,500 m^2

Note: Cell floor and side batter grades of GCL are treated as separate products for the purposes of testing frequencies.

7.4.3 Inspection and Acceptance Criteria

Hold points nominated are stages of work beyond which work shall not proceed without mandatory inspection / verification and written approval before subsequent works can be initiated.

The following inspection and hold points are required during GCL installation:

H-GCL1 CQA Engineer's approval of WMS and panel layout plan

H-GCL2 CQA Engineer's approval of GCL materials proposed to be used in the works

H-GCL3 CQA Engineer's approval of GCL material independent test results

H-GCL4 CQA Engineer's inspection and approval of engineered fill layer surface prior to GCL installation

H-GCL5 CQA Engineer to confirm GCL deployment, overlaps, repairs and pasting

Where materials, installation or lapping distance do not meet the CQA Engineer's approval, the identified issue shall be rectified to the satisfaction of the CQA Engineer at no cost to the Principal.

7.4.4 GCL As-Constructed Reporting

The Contractor shall provide the deployed GCL panel survey to the CQA Engineer with the following information within 14 days of the completion of GCL placement:

- Survey information as nominated in Clause 1.8.4 and 1.7.5;
- Photographs showing the progression of works; and
- Certification of construction being in accordance with the approved Specification.

The CQA Engineer shall undertake full-time inspection during the works and confirm that the materials and installation procedures comply with this Specification.

The CQA Engineer shall take photographs of the progress of the works when onsite, and detailed record on completion of the works.

The CQA Engineer shall include all documents including MQA certificates and IQA test data in the final as-constructed reporting including comments on construction, and if in accordance with the approved Specification.

8 HDPE Geomembrane

8.1 General

This Clause of the Specification is applicable to the supply and installation of the white or black 2.0mm HDPE (double sided textured for the cell floor and single sided textured for the side batters) geomembrane layer overlying the GCL layer.

The HDPE geomembrane layer shall be constructed in accordance with this Specification and the Drawings and CQA records for construction maintained throughout. The work areas shall be divided into manageable areas.

This Specification is based on the Geosynthetic Research Institute (GRI) Test Method GM13 'Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes', Rev 17, dated 17 July 2023.

8.1.1 CQA Engineer

The Superintendent shall arrange for a suitably qualified and experienced CQA Engineer to monitor the geomembrane installation works on a full-time basis. All monitoring and audit activities as described in this Specification shall be accommodated. The role of the CQA Engineer will include verification of materials and installation methods, organisation of independent testing, evaluation of testing results and CQA reporting.

8.1.2 Standards

This Specification shall be read in conjunction with the following Standards and references, which are deemed to form a part of this Specification.

ASTM D792	Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D1004	Test Method for Initial Tear Resistance of Plastics Film and Sheeting
ASTM D1238	Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D1505	Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D1603	Test Method for Carbon Black in Olefin Plastics
ASTM D4218	Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
ASTM D4833	Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
ASTM D5199	Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
ASTM D5397	Procedure to Perform a Single Point Notched Constant Tensile Load – (SP-NCTL) Test: Appendix
ASTM D5596	Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
ASTM D5721	Practice for Air Oven Aging of Polyolefin Geomembranes
ASTM D5885	Test method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
ASTM D5994	Test Method for Measuring the Core Thickness of Textured Geomembranes
ASTM D6370	Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)

ASTM D6693	Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
ASTM D6747	Standard Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes
ASTM D7238	Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
ASTM D7466	Test Method for Measuring the Asperity Height of Textured Geomembranes
ASTM D7953	Standard Practices for Electrical Leak Location on Exposed Geomembranes Using the Arc Testing Method
ASTM D8117	Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by Differential Scanning Calorimetry
GRI GM10	Specification for the Stress Crack Resistance of Geomembrane Sheet
GRI GM13	Standard Specification for Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
GRI GM19a	Seam Strength and Related Properties of Thermally Bonded Homogeneous Polyolefin Geomembranes/Barriers
U. S. EPA	Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

8.2 Material Properties

8.2.1 Packaging

The geomembrane shall be rolled onto a substantial core or core segments and held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of installation.

8.2.2 Storage and Handling

Protection and security of the material shall be provided before, during and after installation including for delivery of materials to the site, unloading, transport within the site, deployment of the materials, Protection shall also include protection from fire and wind damage.

All geomembrane rolls shall be inspected by the Superintendent upon delivery to site. Any damaged rolls shall be rejected, transported off-site and replaced at no cost to the Principal.

Materials shall be stored off the ground in such a manner that no surface irregularities or other influences apply point loads, cause abrasions, cuts, distortions or any other form of damage to the material. Rolls may be stacked upon each other; however, the height of any stack shall not exceed two roll diameters. Adjustments to the method of roll storage may be directed by the CQA Engineer if any evidence of damage is observed.

The location for storage of HDPE rolls is to be approved by the CQA Engineer.

8.2.3 Certification and Warranty

Geomembrane materials quality and manufacturer quality assurance (MQA) test certificates, data, statements and reports for all rolls to be supplied shall be provided to the CQA Engineer 14 days prior to supply and installation. The manufacturer's geomembrane MQA certification shall demonstrate that the material was manufactured and tested in accordance with this Specification and satisfies all material properties.

The manufacturers certified test data with each batch of welding granulate shall also be provided to the CQA Engineer with the MQA documentation.

8.2.4 Properties

Geomembrane rolls shall be virgin, first quality seamless HDPE manufactured specifically for intended use as a landfill lining material. If rework is used, it shall be limited to 10% and must be an identical HDPE as the parent material. No post consumer resin (PCR) of any type shall be added to the formulation.

The geomembrane shall be free of holes, pinholes, bubbles, blisters, gels, nicks, cuts on liner edges, contamination by any foreign matter or any other defects.

Geomembrane shall be supplied in rolls. Folding shall not be permitted under any circumstances. All additives shall be thoroughly dispersed throughout the geomembrane.

Where textured geomembrane is produced by co-extrusion and secondary attachment:

- Textured material shall be attached to a base sheet.
- The coextruded secondary attachment sheet shall remain intact and shall be resistant to separation from the base sheet as a result of abrasion and contact with chemicals encountered in solid waste applications.
- Secondary attachment shall be performed by the manufacturer of the base sheet.

The geomembrane shall conform to the test property requirements described in Table 8.1.

The properties of the geomembrane shall be tested at the minimum frequencies shown in the Table 8.1. If the manufacturer's quality control guide is more stringent, this supersedes the specified requirements and must be followed.

The extruded granulate for surface extrusion welding shall be manufactured from the same resin type used in the manufacture of the membrane. All physical properties shall be identical to those possessed by the membrane raw material. All granulate supplied shall be packed to prevent the ingress of moisture and other contaminants.

Table 8.1 Geomembrane Properties and MQA Requirements

Property	Test Method	Test Value (Textured)	Minimum Frequency of MQA Testing
Polymer Resin			
Density (g/cc) (min.)	ASTM D792 / D1505	>0.932	Per production batch
Melt Index (g/10min)	ASTM D1238	<1	Per production batch
Geomembrane Sheet			
Thickness (mm) -Minimum Average -Lowest individual value of 8 out of 10 values -lowest individual of 10 values	ASTM D5994 (textured)	 1.9 1.8 1.7	Per roll
Asperity height (mm) (min. ave)	ASTM D7466	0.4	Every 2nd roll (1)

Density (g/cc) (min.)	ASTM D792 / D1505	>0.940	Per production batch
Tensile Properties (min. ave.) (2)	ASTM D6693 Type IV		9,000 kg
-yield strength (kN/m)		29	
-break strength (kN/m)		21	
-yield elongation (%)		12	
-break elongation (%)		100	
Tear Resistance (N) (min. ave.)	ASTM D1004	249	20,000 kg
Puncture Resistance (N) (min. ave.)	ASTM D4833	534	20,000 kg
Stress Crack Resistance (3)	ASTM D 5397 (App.)	500 hr	per GRI GM-10
Carbon Black Content (%)	ASTM D4218 (4)	2.0 – 3.0	9,000 kg
Carbon Black Dispersion	ASTM D5596	Note (5)	20,000 kg
Oxidative Induction Time (OIT) (mins) (min. ave.) (6)			90,000 kg
Standard OIT	ASTM D8117	100	
and			
High Pressure OIT	ASTM D5885	400	
Oven Aging at 85°C (%) (6) (7)	ASTM D5721		Per each formulation
(a) Standard OIT (min. ave.) - % retained after 90 days	ASTM D8117	55	
or			
(b) High Pressure OIT (min. ave.) – % retained after 90 days	ASTM D5885	80	
UV Resistance (8)	ASTM D 7238	N.R. (9)	Per each formulation
(a) Standard OIT (min. ave.)	ASTM D8117		
or			
(b) High Pressure OIT (min. ave.) – % retained after 1600 hrs (10)	ASTM D5885	50%	

Notes:

1. Alternate the measurement side for double sided textured sheet
2. Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction:
   - Yield elongation is calculated using a gauge length of 33 mm
   - Break elongation is calculated using a gauge length of 50 mm

3. The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials. The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
4. Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established. Particle size must be ~20 nm.
5. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
   - 9 in Categories 1 or 2 and 1 in Category 3
6. At least 0.5% antioxidants and HALS stabilisers.
7. Results at 30 and 60 days shall be provided to compare with the 90-day response.
8. The condition of the test should be 20 hr. UV cycle at 750C followed by 4 hr. condensation at 600C.
9. Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
10. UV resistance is based on percent retained value regardless of the original HP-OIT value.

The values listed in the table are to be interpreted according to the designated test method. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).

If the results of any test do not conform to the requirements of this Specification, retesting to determine conformance or rejection may be undertaken at the discretion of the CQA Engineer.

Single sided textured and double-sided textured geomembranes will be treated as different materials for the purposes of assessing material testing frequencies.

8.2.4.1 Textured Geomembrane Weld Edges

Where textured geomembrane with a smooth weld edge is proposed for use in the works, the weld edge of the textured geomembrane must meet the thickness requirements as shown in Table 8.2.

Table 8.2 Textured Geomembrane Weld Edge Thickness Requirements

Property	Test Method	Test Value	Minimum Frequency of MQA Testing
Thickness (mm)			
-Minimum Average	ASTM D5199	2.0	Per roll
-lowest individual of 10 values		1.8	

8.2.5 Appearance

All HDPE geomembrane shall have good appearance and be free from surface blemishes. It shall be free from any defects that would affect the specified properties of the geomembrane. All HDPE geomembrane shall be free from holes, blisters, folds, undispersed raw materials, and any sign of contamination by foreign matter.

All membrane material shall be provided in rolls of a minimum width of 7 m, unless otherwise approved by the CQA Engineer. Each roll shall be labelled to provide the following identifying data:

- Name of manufacturer and type
- Material thickness
- Roll number
- Roll length
- Roll weight

- Roll width
- Reference numbers to raw material batch and laboratory certified reports
- The manufacturer's approved QA stamp and the technician's signature.

The CQA Engineer shall check geomembrane rolls for damage and defects and approve of all materials prior to geomembrane placement.

8.3 Construction and Workmanship

8.3.1 HDPE Deployment Work Method Statement

No HDPE shall be deployed until the CQA Engineer has approved the proposed work method statement detailing panel layout and proposed placement and protection methodology. The method statement shall be provided to the CQA Engineer at least 10 working days prior to scheduled deployment.

The work method statement shall detail the proposed work methods and confirm construction timing/schedule and quality control measures including addressing wrinkle management. The work method statement shall include detailed drawings of the proposed panel layout, all primary welds, secondary welds, corner arrangements, penetrations, weld crossovers, anchor trench alignment, offsets and base to embankment weld locations for approval. After acceptance by the CQA Engineer, any changes, deviations, tests and repairs shall only be made with the written approval of the CQA Engineer.

Deployment and installation allowances necessary to accommodate variations in temperature and operational conditions and minimising wrinkle development must be made. The liner shall be installed in such a way as to ensure that changes in the operating environment do not lead to an increase in stress in the liner or to the liner changing shape and that wrinkle development does not affect placement, weld quality and liner integrity post construction.

8.3.2 Geosynthetics Installation Qualifications

The installation, including all works, testing and quality control procedures in this Specification and the Drawings, shall be undertaken by experienced geomembrane installation personnel approved by the CQA Engineer.

Evidence of the liner installation staff experience and accreditations shall be provided to the CQA Engineer prior to the liner deployment and welding and shall demonstrate:

- Welding technicians hold current third-party certification for seaming to a recognised industry standard
- Installation field staff foreman has a minimum of 200,000m^2 welding and supervisory experience with the same type of welding equipment and materials being used in this project
- All field staff performing welding have a minimum of 200,000m^2 welding experience with the same type of welding equipment and materials being used in this project and are directly supervised by the foreman.

All deployment, weld preparation, welding and testing shall be undertaken in the presence of the foreman.

8.3.3 Monitoring Installation

The CQA Engineer shall monitor the geomembrane installation works on a full-time basis. All monitoring and audit activities as described in this Specification shall be accommodated.

Where any areas of the Works, construction methods or test results show non-conformances with the Specification, then work shall cease until the non-conformance is resolved by repair or rectification works, re-sampling or testing or another activity as nominated in this Specification or otherwise approved by the CQA Engineer.

8.3.4 Certification of Prepared Surface

The GCL surface shall be inspected and approved during inspection with the CQA Engineer and prior to geomembrane placement.

The earthworks construction must also be deemed suitable for the installation of the liner and confirmed by written advice of acceptance of the earthworks.

The surface of the subgrade shall be managed to conform to the requirements of the Specification until deployment and placement of geomembrane. This shall include the following:

- Maintaining appropriate moisture condition with no excessive moisture or soft areas, drying out or cracking
- Ensuring the surface is consistent and smooth with no foreign matter, lumps, indentations or abrupt changes of grade.

8.3.5 Geomembrane Placement

The geomembrane panels shall be inspected for damage or defects during placement and prior to welding.

The CQA Engineer is to witness placement of geomembrane panels.

Any defects or damage detected shall be repaired to standards required by this Specification and acceptable to the CQA Engineer or the damaged material shall be totally replaced at no cost to the Principal.

The HDPE membrane shall be placed in accordance with the accepted plan or Drawings. The membrane sheets shall be lapped a minimum of 100 mm. The edge of the HDPE liner shall be extended as shown on the Drawings.

Connecting seams between the geomembrane panels on the slope and floor shall be located a minimum of 1.5 m from the toe of the slope.

Single sided textured geomembrane shall be used on all on side batters and placed smooth surface up.

Once placed, the HDPE shall be well secured by sand bags or other measures due to the potential for deployed panels to be affected by wind prior to coverage.

Geomembrane joining and welding shall be undertaken in accordance with an approved wrinkle management plan (WMP) and not be undertaken if:

- the ambient temperature is below 10°C or above 35°C
- in the presence of rain or standing water
- in periods of high winds or excessive dust, or
- if the CQA Engineer determines that weather conditions are causing excessive movement, shrinkage, folding or wrinkling of the geomembrane so as to affect the quality of the installed liner.

A handheld temperature measuring device shall be used to confirm both panels of geomembrane to be welded (all seams and tie-in seams) have been allowed to equilibrate to the same temperature before the welding works commences.

8.3.6 Welding

Suitable experience of welding personnel shall be demonstrated to the CQA Engineer prior to placement. Welding personnel shall have the minimum welding experience supported by evidence of this experience as nominated in Clause 8.3.2.

Regular checking, calibrating and recording the following items shall be undertaken:

- preheat air flow and temperature at the nozzle,
- extrudate flow and temperature at the barrel outlet, and

- split copper wedge temperature on both contact points.

All primary welds shall utilise the Split Hot-Wedge Fusion welding method. The welding equipment shall be a fully automated device consisting of a heated copper wedge, pressure rollers and electronic controls. The fusion welder shall create two contact fusion areas void between each of the separate parallel weld zones. This void shall be created over the entire seam length to allow for field weld pressure testing.

All secondary welds shall utilise surface extrusion hand welders. The minimum width of the surface extruded bead shall be 30 mm. The surface extrusion welder shall be semi-automated and equipped with electronic controls which constantly monitor outputs for both preheat and HDPE extrudate. The unit shall be capable of pre-heating the sheet just prior to the casting of HDPE extrudate.

Extrusion welding shall be used where fusion welding is not possible such as patches, repairs and short (less than a roll width) run of seams.

The granulate for surface extrusion welding supplied shall be packed to prevent the ingress of moisture and other contaminants. If necessary, the granulate shall be dried to ensure weld quality.

Prior to any primary or secondary welding all weld zones must be clean, free from moisture, dust and any other foreign matter. All weld zone surfaces shall be either cleaned or abraded immediately prior to welding.

The CQA Engineer is to witness the welding of all geomembrane panels, patches and caps.

8.3.7 HDPE Liner Testing of Field Welds

8.3.7.1 General

All welds shall be subjected to both destructive and non-destructive testing.

All T seams shall be patched with a minimum distance of 0.5 m and all patches over T seams shall be tested in accordance with this Specification.

The CQA Engineer is to witness all destructive and non-destructive testing.

Any material or welds rejected on site by the CQA Engineer shall be jointly inspected. If required, the material or weld shall be tested and if unable to meet the Specification, it shall be replaced at no cost to the Principal.

All field destructive and non-destructive test locations shall be numbered and marked on the HDPE adjacent each test location and recorded in the appropriate quality control record sheets. Other information to be recorded includes date, time, panel numbers, welding machine and welding operator.

In the event of a failure, all prior welds shall be tested back to the last test which passed. All seams must be repaired and made good to the satisfaction of the CQA Engineer.

8.3.7.2 Independent Testing

Laboratory destructive testing of all destructive weld samples for the project passing the field testing shall be carried out at an independent off site geosynthetic testing laboratory (to be nominated by the CQA Engineer). The minimum number required will be nominated by the CQA Engineer. Tests shall be performed on 10 specimens obtained from the field sample with 5 to be tested in shear and 5 to be tested in peel.

A sufficient quantity of samples must be provided in a timely manner so as to allow the Superintendent to freight samples, and receive test results from the laboratory prior to the completion of the work lot represented by the tested samples. Independent testing results can take 48 hours to be provided, following receipt of samples. The Contractor shall make allowance for this in the schedule.

8.3.7.3 Split Hot-Wedge Fusion Weld – Destructive Testing

Trial Welds

Prior to actual field welding, trial welds shall be run on fragment pieces of membrane for destructive testing. Such trial welds shall be made:

- at the beginning of each welding period for each operator.
- after significant changes in weather conditions.
- following shutdown or replacement of the welding apparatus.
- after every 5 hours of the operation of the welding apparatus.

The trial weld sample shall be a minimum 1.5 m long by 0.3 m wide with the weld centred lengthways. Four 25 mm wide specimens shall be cut from the trial weld sample using a calibrated die cutter and tested in shear (two specimens) and peel (two specimens) using a calibrated tensiometer (calibrated within the previous 12-month period) to determine whether the trial welds have passed or failed.

Welding technicians or welding apparatus that have not produced a passing trial weld will not be permitted to perform actual field welding.

All trial welds shall be performed under the same conditions as the actual field welding.

Once qualified by a passing trial weld, welding technicians shall not change the welding parameters (speed, temperature, wheel adjustment) without performing another trial weld, unless approved by the CQA Engineer.

Destructive Weld Tests

Destructive weld tests shall also be performed at random locations selected by the CQA Engineer during installation at a minimum frequency of one sample every 150 m. Weld strength testing shall be completed as welding work progresses. The purpose of these tests shall be to confirm and evaluate seam strength and continuity during the field seaming.

The spacing may be varied between destructive weld tests to avoid conducting a destructive test within the cell footprint, if considered representative by the CQA Engineer i.e. the spacing may be varied so the test coupon is cut from the anchor trench and/or outside the cell footprint.

Each sample shall be cut using a calibrated die cutter into four 25 mm wide pieces and shall be tested in shear (two specimens) and peel (two specimens) for preliminary field testing. If any of the four specimens fails in the field testing, the entire destructive test is considered as failure, and additional destruction test samples shall be taken.

All destructive weld test samples passing the preliminary field testing shall be sent off site for independent laboratory destructive testing. The destructive weld testing sample obtained in the field shall be of suitable size (as agreed with the CQA Engineer) to allow on site field testing and off site laboratory testing.

In addition to the normal testing rate of 1 test per 150 m interval, any cap seams exceeding 50 m in length or if the weld is of questionable quality as determined by the CQA Engineers, shall also be destructively tested.

Failed Destructive Sample Procedure

The deficient weld is required to be reconstructed once its extent has been determined. All welds that are reconstructed shall be bound by passing destructive tests. Additional destructive tests shall be taken from both directions along the deficient weld from the failure location until the portions which pass laboratory destructive testing are located. If any of these destructive testing samples fails the laboratory testing, the tracing procedure shall be repeated in the failed direction until the passing laboratory results are obtained.

When a portion of a seam fails destructive testing, the Contractor may elect to remove the entire seam (including seams with relevant welding conditions, if no passing destructive test result is achieved) to the extent of conforming destructive tests and reweld or cap the full length of the weld, subject to the CQA Engineer's approval.

The CQA Engineer shall document all actions taken in conjunction with destructive test failures.

Hot Fusion Weld Test Evaluation Criteria

The evaluation of destructive and non-destructive tests shall be undertaken in accordance with GRI Test Method GRI-GM19a, Revision 10, dated 18 March 2021, plus the following criteria which take precedence:

Table 8.3 Hot Wedge Fusion Weld Test Criteria

Property	Test Value (Note 3)	
	Metric	Imperial
Shear Strength[1,3], N/25 mm | N/inch	>701	>711
Shear Elongation at Break[2], %	>50	
Peel Strength[1,3], N/25 mm | N/inch	>530	>538
Peel Separation, %	≤25	

Notes:

11. Value listed for shear and peel strengths are for 5 out of 5 test specimens for laboratory destructive tests.
12. Elongation measurements should be omitted from field testing.
13. Values listed are for the use on site of either a metric (25mm) sample cutter or an imperial sized (1 inch) cutter.

The field tensiometer test speed should be set at 50mm/min.

Both tracks of the fusion weld are to be tested in shear and peel.

The rated yield strength of the geomembrane shall be that listed on the material property certificate or that determined from testing of the parent material using a calibrated tensiometer. The method for determining the rated yield tensile strength of the geomembrane sheet shall be agreed with the CQA Engineer prior to commencement of testing.

Alternative methods of evaluation of weld tests may be considered. Alternative methods shall be submitted to the CQA Engineer in writing for approval 7 days prior to the commencement of welding.

8.3.7.4 Split Hot-Wedge Fusion Weld Non-Destructive Testing

All wedge welds will be non-destructive tested. The air pressure channel testing unit required shall be a manometer apparatus consisting of a hollow needle attached to a pressure gauge and air fitting. Air pressure can be provided by manual or mechanical pumps. The testing unit shall be capable of withstanding and maintaining pressures between 175 to 275 kPa.

The following procedure for air channel testing shall be adopted:

- Seal both ends of the seam to be tested.
- Connect manometer into the tunnel created by the wedge welder.
- Connect air pump and pressurise the tunnel to a minimum of 175 kPa, cease air input. Observe and maintain the pressure for 5 minutes.
- If loss of pressure exceeds 15 kPa or does not stabilise, locate faulty area, repair with surface extrusion weld and retest seam.

- Unseal far end of weld from location of the manometer and observe air pressure leaving the tunnel.
- Remove the manometer and seal with extrusion surface weld.

If pressure is not observed leaving the tunnel when unsealing the far end of the weld (i.e the full tunnel is not pressurised) the test shall be repeated until the entire weld has been air tested.

8.3.7.5 Surface Extrusion Welding Destructive Testing

Trial Welds

Prior to actual field welding, trial welds shall be run on fragment pieces of membrane for destructive testing. Such trial welds shall be made:

- at the beginning of each welding period for each operator.
- after significant changes in weather conditions.
- following shutdown or replacement of the welding apparatus.
- after every 5 hours of the operation of the welding apparatus.

The trial weld sample shall be at a minimum 1.5 m long by 0.3 m wide with the weld centred lengthways. Four 25 mm wide specimens shall be cut from the trial weld sample and tested in shear (two specimens) and peel (two specimens) using a calibrated tensiometer (calibrated within the previous 12-month period) to determine whether the test welds have passed or failed.

Welding technicians or welding apparatus that have not produced a passing trial weld will not be permitted to perform actual field welding.

All trial welds shall be performed under the same conditions as the actual field welding.

Once qualified by a passing trial weld, welding technicians shall not change the welding parameters (temperatures) without performing another trial weld, unless approved by the CQA Engineer.

Destructive Weld Tests

Destructive weld tests shall also be performed at random locations during the installation selected by the CQA Engineer, at a minimum rate of one sample every 120 m. The purpose of these tests shall be to confirm and evaluate seam strength and continuity during the field seaming.

The spacing may be varied between destructive weld tests to avoid conducting a destructive test within the cell footprint, if considered representative by the CQA Engineer i.e. the spacing may be varied so the test coupon is cut from the anchor trench and outside the cell footprint.

Each sample shall be cut into four 25 mm wide pieces and shall be tested in shear (two specimens) and peel (two specimens) for preliminary field testing. If any of the four specimens fails in the field testing, the entire destructive test is considered as failure, and additional destruction test samples shall be taken.

All destructive weld test samples passing the preliminary field testing shall be carried out off site independent laboratory destructive testing. When a laboratory destructive test shall be completed on a field sample, the sample shall be of suitable size (as agreed with the CQA Engineer) to allow on site field testing and off site laboratory testing.

Failed Destructive Sample Procedure

Additional destructive tests shall be taken from both directions along the deficient weld from the failure location until the portions which pass laboratory destructive testing are located. If any of these destructive testing samples fails the laboratory testing, the tracing procedure shall be repeated in the failed direction until the passing laboratory results are obtained.

The CQA Engineer shall document all actions taken in conjunction with destructive test failures.

Extrusion Weld Test Evaluation Criteria

The evaluation of destructive and non-destructive tests shall be undertaken in accordance with GRI Test Method GM19a, Revision 10, dated 18 March 2021, plus the following criteria which take precedence:

Table 8.4 Extrusion Weld Test Criteria

Property	Test Value (Note 3)	
	Metric	Imperial
Shear Strength[1,3], N/25 mm | N/inch	>701	>711
Shear Elongation at Break[2], %	>50	
Peel Strength[1,3], N/25 mm | N/inch	>455	>462
Peel Separation, %	≤25	

Notes:

1. Value listed for shear and peel strengths are for 5 out of 5 test specimens for laboratory destructive tests.
2. Elongation measurements should be omitted from field testing.
3. Values listed are for the use on site of either a metric (25mm) sample cutter or an imperial sized (1 inch) cutter.

The field tensiometer test speed should be set at 50mm/min.

The rated yield strength of the geomembrane shall be that listed on the material property certificate or that determined from testing of the parent material using a calibrated tensiometer. The method for determining the rated yield tensile strength of the geomembrane sheet shall be agreed with the CQA Engineer prior to commencement of testing.

Alternative methods of evaluation of weld tests may be considered. Alternative methods shall be submitted to the CQA Engineer in writing for approval 7 days prior to the commencement of welding.

The requirement for laboratory destructive testing at an offsite geosynthetic testing laboratory will be assessed by the CQA Engineer based on the results of field testing and observed installation procedures on site.

8.3.7.6 Surface Extrusion Welding Non-Destructive Testing

All surface extrusion welds will be tested by method of vacuum testing or other method approved by the CQA Engineer.

The vacuum box assembly unit required for testing shall consist of a rigid housing, a transparent viewing window, a soft gasket attached to the bottom of the rigid housing, a valve assembly and a gauge to indicate chamber vacuum. This unit shall be designed for the sole purpose of vacuum testing and shall be a complete unit incorporating a pump assembly equipped with a pressure controller, pipe connections and a vacuum hose with fittings and connections.

The following procedures for vacuum testing shall be followed:

- Energise the vacuum pump.
- Prepare the test area with water based foaming agent.
- Place the vacuum box over the wetted area and open vacuum valve.
- Ensure that a leak tight seal is created.
- Obtain a vacuum to a minimum pressure of 40 kPa for a minimum period of 15 seconds, examine the seam through the viewing window for the presence of bubbles.
- If no bubbles appear after the 15 second period, close the vacuum valve and open the vent to relieve the vacuum pressure and move the box over the next adjoining area with a minimum of 25 mm overlap and repeat the process.

- All areas where bubbles appear shall be marked, repaired and retested.

8.3.8 Defects and Repairs

8.3.8.1 Identification

All seams and non-seam areas of the lining system shall be examined for identification of defects in the seam or sheet.

Identification of the defect may be made by marking on the sheet/seam with paint or other marks. The following procedure shall be followed:

- For any defect in the seam or sheet that is an actual breach (hole) larger than 6 mm in the liner and cover system, the installer personnel shall circle the defect and mark the letter "P" inside the circle. The letter "P" indicates a patch is required.
- For any defect in the seam or sheet that is less than a 6 mm hole, the installer personnel shall only circle the defect indicating that the repair method may be only an extruded bead and a patch is not necessary.

A detailed walk over with the CQA Engineer shall be conducted to visually check all seams and non-seam areas of the liner and check for defects, holes, blisters and signs of damage during installation.

All other personnel shall at all times be on the look-out for any damaged areas. Damaged areas shall be marked and repaired.

The Contractor shall be responsible for making repairs to the exposed section of the existing lined cell HDPE geomembrane along the interface between Cell 1 and the existing landfill cell to the satisfaction of the CQA Engineer.

8.3.8.2 Evaluation

Each suspect area that is identified as needing repair shall be repaired in accordance with this Clause and non-destructively tested.

After work is complete a final walk-through of the area shall be conducted to confirm that all repairs have been appropriately performed, all test results are positive and the area has all scrap, trash and debris removed. Only after careful evaluation by the Contractor and acceptance by the CQA Engineer should any material be placed upon the liner.

8.3.8.3 Repair Procedures

Any portion of the lining system exhibiting a defect which has been marked for repair shall be repaired with one or combination of the following procedures:

- Patching – used to repair holes, tears, and undispersed raw materials in the sheet.
- Grind and re-weld – used to repair small sections of extruded seams.
- Grind and extrusion welding – used to repair needle holes from air pressure testing.
- Spot welding – used to repair small, minor localised flaws.
- Flap welding – used to extrusion weld the flap of a fusion weld in lieu of a full cap, where fusion welding is not possible and the seam length is less than 5 metres.
- Capping – used to repair failed seams.
- Topping – application of extrudate bead directly to existing seams.

The following conditions shall apply to all the above methods:

- Surfaces of the liner which are to be repaired shall be abraded.
- All surfaces must be clean and dry at the time of repair.
- All seaming equipment used in repairing procedures shall be qualified.
- All patches and caps shall extend at least 100 mm beyond the edge of the defect and all patches shall have rounded corners.

- Repairs for failing seams that exceed 5 m length shall be repaired by capping.
- The repair methodology shall be approved by the CQA Engineer.

8.3.8.4 Verification of Repairs

Every repair shall be non-destructively tested, in accordance with the methods detailed in this Specification. If passed, a marking shall be placed on the repair, indicating the test is complete and has passed the test.

If the defects remain, the appropriate markings shall be made to cause additional repairs.

Repairs which pass the non-destructive test shall be deemed adequate. Repair test results shall be logged on a testing reporting form, to be forwarded to the CQA Engineer. The repair location shall be recorded on the 'As Built' drawings.

8.3.8.5 Large Wrinkles

Large wrinkles that remain in the sheet as a result of temperature expansion may need removal in consideration of applied dead loads on the wrinkle. Should the wrinkle need removing and in the case of wrinkles greater than 300 mm in height, the lower down slope edge of the wrinkle shall be cut, overlapped and repaired in accordance with this Specification. Both ends of the wrinkle repair shall be patched. Where overlap is not sufficient the wrinkle shall be cut and patched or capped as detailed in this Specification. Whenever it is not possible to manage wrinkles to less than specified, wrinkles shall be combined through accumulation to minimise the number of repairs being made. Caution must be taken in removing any wrinkles. Wrinkles are needed to allow for contraction of the liner in cold weather and provision to displace trapped air may be required.

8.3.9 Anchor Trench

The anchor trench shall be constructed in accordance with the alignment and dimensions shown on the Drawings and Clause 6 of this Specification.

8.3.10 Miscellaneous

Traffic over the geomembrane

Traffic over the geomembrane shall be limited to personnel foot traffic using approved, clean footwear only. The movement of equipment (e.g. generators) over the geomembrane shall be subject to the approval of the CQA Engineer. No vehicle traffic shall be allowed.

Cutting of the geomembrane

All cuts (e.g. destructive test sampling, defect removal, installation preparation for penetrations and geometry) made on the HDPE geomembrane shall be made with rounded corners to prevent tear propagation in the geomembrane.

8.4 Quality requirements

8.4.1 Quality Testing

8.4.1.1 Manufacturer Quality Assurance (MQA)

Material property data sheets for the HDPE to be used in the works with the manufacturer's quality control testing data for the batches relating to all rolls to be supplied to the project are to be submitted to the CQA Engineer for approval prior to the delivery of the materials to site. MQA property reports shall include all properties as nominated in Table 8.1. MQA testing frequencies shall be as nominated in Table 8.1.

8.4.1.2 Independent Quality Assurance (IQA)

The supplier shall provide the CQA Engineer (at no cost to the Principal) with suitable size and number of samples to the Superintendent for off-site laboratory IQA testing of properties (laboratory and tests to be determined by the CQA Engineer). Sampling shall occur under supervision of the CQA Engineer. The Contractor must provide 2 weeks' notice of sampling to provide opportunity for a representative to be present. Testing shall include the first and last rolls based on production order.

The Principal will be responsible for the cost of testing once the samples arrive at the nominated laboratory. A representative 0.5m wide sample shall be cut from the sampled roll but not within the first roll wrap. Samples shall be tested at the frequency nominated in Table 8.5. The Contractors program shall allow for the completion of all IQA testing and in any event no less than 6 weeks since some testing has to be undertaken in the United States.

Table 8.5 HDPE Material Properties IQA Test Frequencies

Property	Test	Units	IQA Minimum Frequency of Testing
Thickness (mm)	ASTM D5994	mm	5,000 m^2
Density	ASTM D792 / D1505	g/cc	5,000 m^2
Tensile Properties	ASTM D6693	kN/m, %	5,000 m^2
Puncture Resistance	ASTM D4833	N	5,000 m^2
Tear Resistance	ASTM D1004	N	5,000 m^2
Carbon Black Content	ASTM D4218 / D1603	%	5,000 m^2
Carbon Black Dispersion	ASTM D5596		5,000 m^2
Stress Crack Resistance	ASTM D5397	hr	10,000 m^2
Standard OIT	ASTM D8117	min	10,000 m^2
High Pressure OIT	ASTM D5885	min	10,000 m^2

Note: Single sided textured and double-sided textured geomembranes will be treated as different materials for the purposes of assessing material testing frequencies.

8.4.1.3 Textured Geomembrane Weld Edges

Where textured geomembrane with a smooth weld edge is proposed for use in the works, additional IQA testing is required for the weld edge as nominated in Table 8.6.

Table 8.6 Textured Geomembrane Weld Edge IQA Test Frequencies

Property	Test	Units	IQA Minimum Frequency of Testing
Thickness (mm)	ASTM D5199	mm	5,000 m^2

Note: Testing frequency refers to the area of textured geomembrane and not area of weld edge. Single sided textured and double-sided textured geomembranes will be treated as different materials for the purposes of assessing material testing frequencies.

8.4.1.4 Installation

Destructive and non destructive tests are to be carried out as specified in Clause 8.3.7.

Laboratory destructive testing of field welds shall be carried out at an independent off site geosynthetic testing laboratory in accordance with Clause 8.3.7.

8.4.2 Liner Integrity Survey (Completed Geomembrane Surface)

An independent Geomembrane Testing Authority (GMTA) engaged by the Principal shall be appointed to conduct a liner integrity survey in accordance with ASTM D6747 - Standard Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes and ASTM D7953 – Standard Practices for Electrical Leak Location on Exposed Geomembranes Using the Arc Testing Method if liner and weather conditions allow effective testing by this method. The test method must be approved by the Designer after the installation of the HDPE geomembrane. The survey shall cover the full area of exposed geomembrane including the exposed section of the existing lined cell HDPE geomembrane along the interface between Cell 1 and the existing landfill cell.

The GMTA shall have experience in conducting liner integrity surveys of the proposed method(s) including having tested a minimum of 200,000m^2 on at least three projects.

The Contractor will be responsible for:

- Preparing the site for survey.
- Coordination of attendance of the GMTA.
- All preparatory and necessary works required by the GMTA.
- All rectification works (including allowance for up to two holes created by the Principal for blind method validation purposes).
- Re-survey of areas subject to rectification where these are required as a result of installation damage (tears, multiple holes or other damage) inclusive of areas over which machinery has tracked in undertaking rectification works.

This will entail but not necessarily be limited to the following:

- Providing the GMTA with as-constructed drawings that show:
  - Design drawings including amendment to show any modifications or variations from the design.
  - Plan of the survey area.
  - Details of connection to adjacent lining systems.
  - Structures and obstructions above the liner.
  - Electrical equipment or installation above the geomembrane.
- Consult and agree with the GMTA on their requirements and the requirements of the liner installation schedule prior to commencing installation, and inclusion of these in the works program.
- Electrically isolate the works including any anchor or cover soil layers from the surrounding ground or adjacent fill (i.e. by open trenching or installation of a non-conductive insulator of liner material.
- Installation of any necessary electrodes during construction as required by the GMTA.
- Meet the requirements of the GMTA including to ensure that there is adequate moisture for the dipole leak detection testing. If necessary, supplement with additional water to the satisfaction of the GMTA during construction and prior to testing. A water truck must be available at all times as it may be necessary to wet the surface just in advance of the survey, as deemed necessary by the GMTA.
- The GMTA shall report the general results of the survey to the Superintendent, Contractor and appointed person during the daily progress of the field work.
- Prior to the demobilisation of the survey personnel from the site, the leak detection consultant shall submit a list of locations of the leaks detected to the Superintendent, Contractor and appointed person unless an alternative arrangement is agreed in advance.
- Completion of placement of any anchor or cover layers in accordance with the Specification following approval of the GMTA to do so.

8.4.3 Inspections and Approvals

Hold points are stages of work beyond which work shall not proceed without mandatory inspection / verification and written approval from the CQA Engineer before subsequent works can be initiated.

The following inspection and hold points are required during geomembrane installation:

H-GM1 CQA Engineer's approval of WMS, panel layout plan and approval of geomembrane materials proposed to be used in the works

H-GM2 CQA Engineer's inspection and approval of GCL surface prior to geomembrane installation

Where materials, installation or reporting does not meet the CQA Engineers approval, the identified issue shall be rectified to the satisfaction of the CQA Engineer.

8.4.4 As-constructed Reporting

Provide the CQA Engineer with the following listed test certificates and records prior, during and at the completion of the Works as each report and record is required:

- Certification and test results of raw materials from raw material supplier
- Certification and test results of raw materials from membrane manufacturer
- Certification and test results of raw materials from the extrudate manufacturer
- Roll test data reports at the frequencies specified
- Proposed panel/seam layout drawing
- Certificates of calibration for all welding and testing equipment
- Daily installation reports for each welder and technician:
  - trial test weld record
  - wedge weld records
  - surface extrusion weld records
  - weld peel and tensile test records
  - wedge air tunnel pressure test records
  - vacuum box test records
  - repair records.
- Certification the Works have been completed in accordance with the Specifications and Drawings
- Completed as-built drawing, including roll numbers, panel layout, seam locations and repair locations within 14 days of Completion and prior to placement of subsequent layers.
- Survey information as nominated in Clause 1.7.5 and 1.8.4.
- Provide the CQA Engineer with the following plans and manuals prior to the commencement of works and at least 14 days prior to supply of materials:
  - Quality Control Procedures Manual
  - Wrinkle Management Plan, and
  - Stormwater Management and Erosion Protection plan
- Maintain all site records and quality forms and provide documents within one days' notice if requested.

The CQA Engineer shall undertake inspections during the Works and confirm that the materials and installation procedures comply with this Specification.

The CQA Engineer shall take photographs of the progress of the Works when onsite and detailed record on completion of the Works.

The CQA Engineer shall include all these documents in the final as-constructed reporting including MQA documentation and IQA test reports and the certification that the Works have been completed in conformance with the approved Specification.

9 Cushion Geotextile

9.1 General

This Clause of the Specification is applicable to the supply and installation of the cushion geotextile which is required to be placed over the HDPE geomembrane to provide a separation and protection layer under the leachate drainage gravel on the baseliner system and under the drainage geocomposite on the side batters.

The cushion geotextile shall be constructed by an experienced specialist liner installer engaged by the Contractor in accordance with this Specification and the Drawings and CQA records for construction maintained throughout.

The extent of the cushion geotextile is shown on the Drawings.

9.1.1 Standards

This specification shall be read in conjunction with the following Standards and references, which are deemed to form a part of this specification:

AS 3706	Geotextiles – Methods of testing
ASTM D5514	Standard Test Method for Large-Scale Hydrostatic Puncture Testing of Geosynthetics
ASTM D7238	Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent Condensation Apparatus Materials

9.2 Materials

9.2.1 Manufacture

The cushion geotextile shall be manufactured under strict quality control. The manufacturer shall be certified to ISO 9001. The cushion geotextile shall undergo regular and frequent testing in the manufacturer's laboratories according to the quality management standard ISO 9001. The manufacturer shall guarantee consistent quality through careful selection, processing and handling at all times. The manufacturer shall provide its own in-house MQA test documents covering each roll of cushion geotextile delivered to site.

9.2.2 Packaging

The geotextile shall be rolled onto a substantial core, or core segments, and wrapped in a protective wrapper. Rolls should be held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of installation.

9.2.3 Transportation, Handling and Storage

During transportation, handling and storage geotextiles shall be protected from ultraviolet light exposure, rain or inundation, mud, dust, puncture, cutting or other damaging deleterious conditions.

All geotextile rolls shall be inspected by the Superintendent upon delivery to site. Any damaged rolls shall be rejected, transported off-site and replaced at no cost to the Principal.

Geotextiles shall be stored in accordance with the manufacturer’s guidelines and off the ground in a location on site such that transportation and handling are facilitated. Storage space(s) shall be flat and protected from the passage of vehicles.

9.2.4 Labelling

Geotextiles shall be supplied in rolls wrapped in protective covers and marked or tagged on the wrapping and within the core with the following information:

- Manufacturer's name
- Product identification
- Lot number
- Roll number
- Roll dimensions

9.2.5 Properties

Geotextiles shall be proprietary products manufactured from polypropylene or polyester materials. The geotextile filaments shall be rot proof, chemically stable and shall have low water absorbency, they shall resist delamination and maintain their relative position in the geotextile.

Geotextiles shall be non-woven with filaments bonded by needle punching processes.

The geotextiles shall be approved by the CQA Engineer and conform to the test property requirements specified in the table below, unless otherwise authorised by the CQA Engineer.

Geotextiles shall be free of flaws that may have an adverse effect on the physical and mechanical properties of the geotextiles.

The cushion geotextiles shall be 'needle free' and not contain any contaminants or deleterious material which may affect the performance of the cushion geotextile over the HDPE liner. The cushion geotextile shall be scanned by the supplier prior to delivery to site and certified as 'needle free' by the supplier.

Geotextiles shall be stabilised against ultraviolet (UV) radiation to the degree that 500 hours exposure of the geotextile to UV light should not reduce its strength to less than 70% of the specified values.

Products shall be chemically inert and compatible with typical leachate generated in putrescible waste landfills.

The proposed HDPE liner will be subject to significant load during its design life due to proposed waste and fill heights following filling and closure of the cell. A number of assumptions have been made in determining the cushion geotextile requirements:

- Drainage gravel of maximum particle size of 37.5 mm
- The maximum filling height is 23.5 m
- The post closure use will be passive open space.

A guide to the cushion geotextile property values is provided in Table 9.1 below; however, the Contractor shall conduct a Geomembrane Protection Efficiency Test on the cushion geotextile in accordance with test method ASTM D5514-06 (Mod) – Large Scale Hydrostatic Puncture Testing of Geosynthetics – Procedure C to demonstrate the suitability of the geotextile.

Strain in the geomembrane as a result of the Geomembrane Protection Efficiency Test should not exceed 4% at a pressure of 470 kPa when tested for a minimum 24 hour period. Samples of the textured geomembrane (or smooth geomembrane with a resin density within 0.002g/cc of the textured geomembrane density) and gravel material proposed to be used in the works shall be tested. Where the strain limit of 4% is exceeded, a heavier duty geotextile shall be tested. The Contractor shall supply a cushion geotextile that can produce strain values in the geomembrane of less than 4%.

The Contractor shall provide the results of the Geomembrane Protection Efficiency Test to the Superintendent and the Designer for review and confirmation of the preliminary cushion geotextile minimum properties nominated in Table 9.1 below prior to procurement and installation of the cushion geotextile.

The cushion geotextile should not be ordered until the results of this test have been undertaken with the proposed materials, and approval has been provided by the CQA Engineer.

The cushion geotextile suggested properties are specified in Table 9.1. The values presented may be varied by the designer based on the outcomes of the Geomembrane Protection Efficiency Test.

Table 9.1 Cushion Geotextile Minimum Properties and MQA Test Frequencies

Property	Test	Units	Minimum value
Minimum mass	AS 3706.1	g/m^2	1,200
Grab Tensile Strength	AS 3706.2-	N	4,000
Trapezoidal Shear Strength	AS 3706.3	N	1,200
CBR Burst	AS 3706.4	N	9,000
MQA Test Frequency	**As above**	**m^2**	**10,000***

* UV stability MQA frequency per formulation only

9.3 Construction and Workmanship

9.3.1 General

The proposed cushion geotextile panel layout and work method statement shall be provided to the CQA Engineer at least 10 working days prior to scheduled deployment, for approval prior to commencing the works. The statement shall include details of handling, placement and preservation of the layer once installed.

The HDPE surface shall be inspected with the CQA Engineer and prior to geotextile placement. The CQA Engineer shall provide written advice of acceptance of the geotextile deployment to proceed.

Geotextiles shall be installed in accordance with the manufacturer's requirements and the additional requirements of this Specification.

The geotextile shall be handled in such a manner to ensure that the geotextile is not damaged in any way.

Geotextiles shall be deployed down slope in such a manner as to keep the geotextile tensioned to preclude folds and wrinkles and shall not be allowed to bridge changes of grade, voids or low areas.

Care shall be taken not to entrap stones, excessive dust or moisture that could damage the geotextile or generate clogging.

Geotextile overlaps shall be heat bonded or glued with a construction adhesive compatible with the type of geotextile used. The geotextiles shall be adequately secured and weighed down during construction to ensure that the sheets remain in place prior to installation of the next layer and shall be covered as soon as practical.

9.3.2 Overlays and Repairs

Geotextiles shall be lapped a minimum of 300 mm, including end laps and stitched or heat bonded or alternative method approved by the Superintendent such as by using construction adhesive compatible with the type of geotextile used.

Any holes or tears shall be repaired by placing a patch of the same geotextile over the hole or tear with a minimum 500 mm overlap in all directions. Care shall be taken when removing any soil or other materials that may have penetrated the geotextile. Repairs shall be heat bonded or stuck down using construction adhesive compatible with the type of geotextile used.

9.4 Quality Requirements

9.4.1 CQA Engineer

The Principal shall arrange for a suitably qualified and experienced CQA Engineer to monitor the cushion geotextile installation works on a full time basis. All monitoring and audit activities as described in this Specification shall be accommodated. The role of the CQA Engineer will include verification of materials and installation methods, organisation of independent testing, evaluation of testing results and CQA reporting.

9.4.2 Quality Testing

9.4.2.1 Manufacturer Quality Assurance (MQA)

Prior to delivery of the material to site the Contractor shall provide material property data sheets and MQA test certificates to confirm the geotextile supplied complies with the material properties using relevant test methods as nominated in Table 9.1. Test certificates shall be supplied for all supplied corresponding roll numbers to be supplied to the project. Testing frequencies shall be as nominated in Table 9.1.

9.4.2.2 Independent Quality Assurance (IQA)

The Contractor shall provide the CQA Engineer (at no cost to the Principal) with suitable size and number of samples for IQA off-site laboratory testing of properties (laboratory and tests to be determined by the CQA Engineer). The Principal will be responsible for the cost of testing once the samples arrive at the nominated laboratory.

The CQA Engineer will carry out independent verification testing of samples of material supplied to site, to confirm the materials are compliant with the roll data provided and this Specification. A representative sample of approximately 1 m width of geotextile shall be cut from each sampled roll but not within the first roll wrap. Testing shall include the first and last rolls based on production order. Samples shall be tested at the frequency nominated in Table 9.2 and meet the property test values presented in Table 9.1.

Table 9.2 Cushion Geotextile Material Properties IQA Testing

Property	Test	Units	CQA Minimum Frequency of Testing
Minimum mass	AS 3706.1	g/m^2	2,500 m^2
Grab Tensile Strength	AS 3706.2b	N	5,000 m^2
Trapezoidal Shear Strength	AS 3706.3	N	5,000 m^2
CBR Burst	AS 3706.4	N	5,000 m^2

9.4.3 Inspections and Acceptance Criteria

Hold points nominated are stages of work beyond which work shall not proceed without mandatory inspection / verification and written approval.

The following inspection and hold points are required during cushion geotextile installation:

H-CG1 CQA Engineer's approval of WMS and panel layout plan

H-CG2 CQA Engineer's approval of geotextile materials proposed to be used in the works

H-CG3 CQA Engineer's inspection and approval of HDPE geomembrane surface prior to cushion geotextile installation

H-CG4 CQA Engineer to confirm deployment, overlaps and repairs lap width and bonding

A final walk-over examination of the installed geotextiles over the entire surface shall be conducted with the CQA Engineer upon completion of each portion of work (or at completion if undertaken in a single episode), and prior to covering with pipework or gravel to ensure that the installation complies with the Specification and Drawings.

Where materials, installation or lapping distance do not meet the CQA Engineer's approval, the identified issue shall be rectified to the satisfaction of the CQA Engineer at no cost to the Principal.

9.4.4 Geotextiles As-Constructed Reporting

Drawings (scaled hand marked acceptable) of the cushion geotextile deployment shall be provided and include the following information on the drawings within 14 days of completion of the cushion geotextile layer:

- Geotextile panel arrangement and date of panel placement;
- Corresponding roll numbers for each placed geotextile panel;
- Location and description of patches or repairs
- Certification of completion in accordance with the Specification.

The CQA Engineer shall undertake inspections during the works and confirm that the materials and installation procedures comply with this Specification.

The CQA Engineer shall take photographs of the progress of the works when onsite and detailed record on completion of the works.

The CQA Engineer shall include all documents and drawings including all MQA documentation and IQA test data in the final as-constructed reporting including construction certification and if in accordance with the approved Specification.

10 Leachate Collection System

10.1 General

This clause of the specification applies to all leachate collection pipework comprising collection pipes, jointing, structures, inspection points and valves.

10.1.1 Standards

This specification shall be read in conjunction with the following Standards and references, which are deemed to form a part of this specification.

AS 1012	Methods of testing concrete
AS 1646	Elastomeric Seals for Waterworks Purposes
AS 1379	Specification and supply of concrete
AS 2566	Buried flexible pipelines
AS 2033	Installation of polyethylene pipe systems
AS 3600	Concrete Structures
AS 3610	Formwork for Concrete
AS 4130	Polyethylene (PE) pipes for pressure applications
AS 4129	Fitting for polyethylene (PE) pipes for pressure applications
AS 4671	Steel Reinforcing Materials

10.2 Materials

10.2.1 General

Quality assurance documentation for the pipework shall be submitted to the CQA Engineer confirming the products supplied comply with the material Specifications prior to delivery to site.

10.2.2 Pipe and Fittings

The HDPE leachate drainage pipework shall comply with AS 4130 and as indicated on the Drawings:

- Leachate collection and flushing riser pipes: 180 mm nominal diameter (DN 180) SDR 11, PN 16, (PE100); and
- Leachate extraction sump and riser pipes: 630 mm nominal diameter (DN 630) SDR 11, PN 16 (PE100).

Pipes requiring perforations shall be drilled by the manufacturer or contractor on or prior to delivery to site, to the dimensions and spacing as detailed on the Drawings and in the Clause below. Drill waste generated during perforation and any other materials inside the pipes shall be cleaned out from the pipes prior to pipework placement.

Fittings shall be manufactured and tested in accordance with AS 4129.

All pipework and fittings associated with the leachate transfer, pumping and storage system shall be as nominated on the drawings.

10.2.3 Leachate Collection Pipe Perforations

The following pipe perforation requirements shall apply for lengths of leachate collection pipe nominated to be perforated on the Drawings:

- The pipe shall have 4 x 12 mm diameter holes drilled at equal spaces around the circumference of the pipe at 100 mm centres along the pipe as shown in the Drawings.
- Perforations shall be terminated:
  - within 150 mm of any joint; and
  - 300 mm from the toe of side batter slopes or bunds;
- The pipe shall be perforated in such a manner that the leachate drainage layer gravel does not enter the pipe perforations; and
- There shall be not less than four rows of perforations along the entire length of the pipe.

10.2.4 Edge Riser and Sump

The extraction riser shall be a 630 mm HDPE pipe in accordance with AS 4130 Class PN 16 butt welded to a horizontal 630 mm HDPE perforated pipe as shown on the Drawings. The horizontal perforated section shall be perforated with rows of 12 mm diameter holes spaced at approximately 150 mm sections as per the drawings.

The Contractor shall construct leachate risers and sumps to the alignments, levels, grades and dimensions indicated on the Drawings.

10.2.5 Concrete Extraction Riser Spill Pad

Concrete, formwork and steel shall be as detailed in the Drawings and shall comply with AS 1379 – Specification and supply of concrete. Installation of concrete shall be as per AS 3600 – Concrete Structures. Formwork shall comply with AS 3610 – Formwork for Concrete. The concrete shall be so designed and produced that the following performance requirements are met:

Table 10.1 Concrete Requirements for Spill Pads

Item	f'c at 28 days	Slump
Headwalls	32 MPa	80 mm

Unless otherwise specified all concrete shall have drying shrinkage test results to AS 1012 showing a maximum (including tolerance) of 650 µm up to and including grade N32.

All concrete is to be ready mixed and delivered in agitating trucks in accordance with AS 1379 by the batch production process, unless approved otherwise by the Designer.

10.2.5.1 Reinforcement

Reinforcement for drainage structures shall be manufactured and supplied in AS4671 – Steel Reinforcing Materials class N and installed in accordance with AS3600 – Concrete Structures and the Drawings.

10.3 Construction and Workmanship

10.3.1 Pipe Installation

Documentation confirming evidence of the HDPE pipe welders experience and that weld procedures have been undertaken in accordance with AS 2566 shall be provided to the Superintendent.

All pipes shall be stored, handled, transported and installed in accordance with AS 2033.

Pipes shall not be subject to rough handling, particularly during loading and unloading operations. Pipes shall be suitably protected from scouring from lifting equipment. Pipes shall be suitably supported during lifting to prevent distortion or buckling.

Pipes shall be delivered from the fabricator directly to the work area and "strung out" along the top of the liner or stockpiled on site at a location approved by the Superintendent. The stockpile location shall be protected to prevent dust, mud and debris contaminating the pipes. Pipes shall be evenly supported and clear of sharp sections bearing against the pipe.

Pipes shall be lifted gently into position so as to avoid damage to the pipe and liner materials. The pipes shall not be dragged or dropped. Any damage sustained or suspected shall be thoroughly examined and rectified to the satisfaction of the Superintendent.

Stages of work shall be such that for operating cells, work is to proceed from the lowest point to the highest point in each system, to maintain minimum grades and ensure a connected flow path for leachate.

All grading shall be carried out to the lines, levels and grades as shown on the Drawings and shall be as even as practical consistent with good pipe laying techniques.

Each pipe shall be accurately laid and aligned in terms of grade, position on the cell floor and perforation orientation. The pipe shall be firmly and continuously supported on the liner floor.

Butt welding shall be undertaken in accordance with Manufacturer's requirements using electrofusion sockets or butt welding by a certified or suitably experienced PE pressure pipe welder using an approved procedure. Evidence shall be provided that the pipe laying and welding has been undertaken in accordance with AS 2566.

Pipes shall not be laid in hot weather conditions, unless precautions are taken against damage due to contraction. During hot weather conditions, laying and backfilling operations shall be carried out in cool early morning conditions. Should the weather conditions be such that any of the above procedures are required, the prior approval of the CQA Engineer shall be obtained.

Any soil or other material entering the pipes during the construction of the drain shall be progressively removed as pipe laying proceeds so that the drain provides an unobstructed waterway of the specified diameter upon completion.

Once pipes are in their final resting position survey shall be undertaken by the Surveyor and the pipes inspected by the CQA Engineer prior to coverage.

10.4 Quality Requirements

10.4.1 Inspection and Acceptance Criteria

Hold points are stages of work beyond which work shall not proceed without mandatory inspection / verification and written approval.

The following inspection and hold points are required during leachate collection pipe installation:

H-LCS1	CQA Engineer's inspection of pipe materials and perforations prior to installation
H-LCS2	CQA Engineer's inspection and approval of cushion geotextile surface prior to pipework installation
H-LCS3	CQA Engineer to confirm pipework placement, condition, jointing/welding and perforation orientation

All pipes shall be inspected by the CQA Engineer and no pipes, fittings or other work shall be covered with leachate drainage gravel until approved by the CQA Engineer. For survey requirements refer to Clause 1.8.4.

Where materials, placement or jointing or installation of plant, equipment and tanks does not meet the CQA Engineer's approval, the identified issue shall be rectified to the satisfaction of the CQA Engineer at no cost to the Principal.

10.4.2 As-Constructed Reporting

Quality assurance documentation, documentation confirming evidence of the welder's experience and that weld procedures have been undertaken in accordance with AS 2566.

Certification that works have been completed in accordance with the Specification shall form part of the as-constructed information to be submitted to the CQA Engineer within 14 days.

Top of pipe survey shall be provided to the CQA Engineer in accordance with Clause 1.8.4 and 1.7.5 for approval prior to placement of subsequent layers.

The CQA Engineer shall take photographs of the progress of the works when onsite and detailed record on completion of the works.

The CQA Engineer shall include all these documents in the final as-constructed reporting including certification that the works have been completed in conformance with the approved Specification.

11 Drainage Gravel Layer

11.1 General

This clause of the Specification is applicable to the supply and construction of the drainage gravel layer to be constructed after completion of the cushion geotextile layer placement and leachate collection pipework installation.

The drainage gravel layer shall be constructed in accordance with this Specification and the Drawings, and QA records maintained throughout construction. The work areas shall be divided into manageable areas.

Conformance with the Specification for the gravel materials supplied shall be tested from stockpiles. Non-complying material shall be rejected.

Conformance with the Specification for the gravel materials placed shall be tested in-situ from the cell floor.

11.1.1 Standards

This specification shall be read in conjunction with the following Standards and references, which are deemed to form a part of this specification:

AS 1141	Methods for sampling and testing aggregates
AS 1289	Methods of testing soils for engineering purposes
ASTM D6747	Standard Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes
ASTM D7007	Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials
AWWA B100.96	Standard for Filtering Material

11.2 Materials

11.2.1 General

Material for the drainage gravel layer shall be a clean, hard, durable, sound gravel and shall meet the following criteria:

- Be free of organic matter, clay or other deleterious material, and not subject to physical or chemical degradation by leachate.
- Consist typically of a nominal 19 mm – 37.5 mm stone with 100% passing the 37.5 mm sieve.
- Be free of fine material with no more than:
  - 10% (by weight) of material passing the 19 mm sieve
  - 1% (by weight) of material passing the 0.075 mm sieve.
- Have a coefficient of uniformity of less than 2.0
- 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.
- Be non-soluble in acid (<5% Acid Solubility)
- Have a Los Angeles Abrasion Value equal to or less than 35.

The material source shall be of known quality and consistency to the CQA Engineer and/or the Superintendent, supported by documented evidence of having previously provided suitable rock or gravel for the purpose of a landfill leachate drainage layer or similar projects. The material source shall

be prequalified and approved by the CQA Engineer prior to commencement of delivery and placement of material within the cell.

Geomembrane Protection Efficiency Testing of the aggregate over cushion geotextile and HDPE shall be undertaken to verify suitability of the material prior to acceptance in accordance with Clause 9.2.5. The Contractor's program shall allow a period of 4 weeks to complete this testing.

11.2.2 Material Properties – Prequalification Testing

Screening prequalification testing shall be carried out at the candidate quarry(ies) prior to selecting a suitable gravel supplier. Testing shall be carried out at a frequency that satisfies the CQA Engineer that the potential material source has been satisfactorily characterised.

The Supplier of the material nominated to be used in the works shall ensure stockpiled drainage gravel layer material shall be sampled and tested to monitor the quality of the materials being supplied. Testing shall be undertaken by an independent GTA appointed by the Supplier in accordance with the parameters listed in Clause 11.2.1. Samples shall be recovered from stockpiles, tested and confirmed as complying with this Specification prior to delivery and placement on the cell floor using the method and frequency nominated in Table 11.1.

The gravel supplier shall take all steps they determine as necessary to ensure materials supplied meet the requirements at their own cost. Non-conforming materials are liable for rejection at no cost to the Principal. Where non-conforming product is detected within a stockpile, further testing shall be carried out to determine the extent of the non-conforming materials so it can be removed from the stockpile to the satisfaction of the CQA Engineer.

The results of this testing, and a sample of the proposed material, should be forwarded to the CQA Engineer for approval at least 10 working days prior to using the materials in the works.

The CQA Engineer may wish to conduct independent prequalification testing at no cost to the Contractor prior to delivery of gravel material to site.

Table 11.1 Drainage Gravel Layer Materials Prequalification Testing Requirements

Test	Method	Frequency
Particle size distribution (PSD)	AS 1289 3.6.1, or AS 1141.11.1 (by washing)	1 per 1,000 m^3
Acid Solubility	AWWA B100.96	1 per 1,000 m^3 per material source
Calcium Carbonate Content (by mass)	By rapid titration as specified in 'Soil and Plant Analysis' by CS Piper or Rayment and Higginson 19A1-1992	1 per 1,000 m^3 per material source
Organic Content	AS 1289 4.1.1	1 per 1,000 m^3 per material source
Los Angeles Abrasion	AS 1141.23	1 per 1,000 m^3 per material source
Permeability	AS 1289 6.7.1	1 per 1,000 m^3 per material source

11.2.3 Gravel Drainage Materials Post Delivery Processing and Testing

Testing shall be undertaken following delivery of the gravel to site and prior to placement of the gravel to confirm that the delivered material complies with the material property requirements. Any material

that passes prequalification testing prior to delivery to site but is non-conforming following delivery shall be rejected at no cost to the Principal.

Non-confirming material shall either be removed from site and replaced with complying material, or the Contractor may undertake additional screening on site to produce complying material. Removal and replacement and/or additional processing shall be undertaken at the Contractors expense.

Where non-conforming product is detected on site, further testing shall be carried out to determine the extent of the non-conforming materials so it can be removed from the stockpile to the satisfaction of the CQA Engineer.

Testing shall be undertaken by the GTA in accordance with Table 11.2. The GTA shall visually inspect all material immediately following delivery to site, and shall undertake any additional testing that they deem is required to confirm compliance of the material with this specification. If further processing is carried out on site, testing shall be undertaken following processing at the same frequency shown in Table 11.2.

Table 11.2 Gravel drainage materials post-delivery testing

Test	Method	Frequency
Particle size distribution (PSD)	AS 1289 3.6.1, or AS1141.11.1 (by washing)	1 per 2,500 m^3

11.3 Construction and Workmanship

11.3.1 Gravel Placement Work Method Statement and Field Trial

A gravel placement method statement shall be prepared and submitted to the CQA Engineer for approval 10 working days prior to scheduled commencement of the work. The statement shall cover materials movement and handling from the point of pick up to completion and compliance testing of the gravel. Gravel placement works shall not commence without written approval from the CQA Engineer for the works to proceed.

The work method statement and construction methodology for the drainage aggregate shall be developed in accordance with the guidance provided below:

- The drainage aggregate shall be placed with a uniform particle size distribution to prevent concentration of fines. This can be achieved through conditioning of the material prior to placement.
- Aggregate shall be placed directly on the underlying geosynthetic rather than pushing in place to avoid the formation of excessive wrinkles or 'waves'.
- Drainage aggregate shall be placed in a manner which does not result in excessive particle breakdown or crushing.
- Drainage aggregate shall be placed carefully around any pipe to ensure the pipe has sufficient and uniform support.

A field trial shall be undertaken by the contractor to verify the contractor's work method statement for placement of drainage gravel. The contractor shall adjust the placement method as necessary based on the results of the field trial. The field trial shall be supervised by the Contractor, Liner Installer, Superintendent and CQA Engineer. The field trial shall measure approximately 10m by 20m and be located within the proposed drainage gravel layer area unless otherwise approved by the Superintendent. Should the Superintendent approve construction of the field trial outside of the proposed drainage gravel layer area, the Contractor shall construct the field trial on an area consistent with those represented on the Drawings, and the areas of drainage gravel shall be constructed using the methods, materials and equipment to be used during construction of the permanent drainage gravel layer.

The complete underlying material profile shall be installed for the field trial to provide meaningful and complete results. The underlying materials for the field trial shall be installed as per the methods used to install the permanent underlying materials.

The drainage gravel shall be placed as per the work method statement. The field trial shall mimic the actual placement method and real-world conditions. Any variations from this work method statement shall result in a non-conforming field trial unless approved by the Superintendent.

Prior to removal of the drainage gravel, the layer thickness shall be recorded in order to compare the degree of damage to the thickness of the drainage gravel. Following completion of the field trial, the underlying geomembrane shall be exposed.

Most of the material may be removed using an excavator; however, care shall be taken to avoid causing any damage to the underlying geosynthetics during material removal. Within 100 mm of the geomembrane, the material shall be removed by hand excavation to avoid damage to the geomembrane.

Once the material has been removed, the geomembrane shall be inspected for damage. The geomembrane shall be inspected over the length of the field trial test area.

Damage to the geomembrane shall include any holes, creases, indentations or scratches. Undamaged geomembrane shall be unblemished.

The location of the damage shall be recorded and compared to the drainage gravel thickness at that point.

Where it is clear that there is no damage to any layers of the underlying geosynthetics as agreed with the Superintendent, the thickness of the drainage gravel and associated plant and equipment used at that point shall be recorded.

The Contractor shall submit a report to the Superintendent outlining the major findings from the field trial. The Contractor shall update the proposed placement method to reflect the findings of the field trial.

The Superintendent shall review and approve the updated placement method prior to placement of the permanent drainage gravel layer. The report and updated placement method shall be provided to the Superintendent 10 working days prior to placement of the drainage aggregate.

11.3.2 HDPE Geomembrane Wrinkle Management

A wrinkle management plan (WMP) shall be submitted for the approval of the CQA Engineer at least 10 working days prior to scheduled installation. As a minimum the WMP shall ensure that, throughout works, to cover the geomembrane with drainage gravel:

- Less than 5% of the area is subject to wrinkles;
- Total wrinkle length must be less than 500 m/ha; and
- Removal of large wrinkles in accordance with Clause 8.3.8.5 of the Specification where these are formed during the works.

If the work procedures cannot achieve these performance requirements, the CQA Engineer will instruct cessation of installation until satisfactory work procedures are agreed to ensure the above performance requirements can be achieved. The cessation of work will be at no cost to the Principal and will not entitle an extension of time.

Appropriate measures for achieving the above requirements shall include:

- Limiting installation time to ensure HDPE coverage does not occur between 10am and 3pm. The working time restriction may be modified based on observed behaviour of the geomembrane during weather conditions (in particular cloud cover, not temperatures) similar to those forecast for placement times. Such modification will only be made based on written permission from the CQA Engineer and require monitoring and a provision to cease works if conditions vary.

- Restraining (using ballast bags or similar) the perimeter of the working area to reduce the interconnection of wrinkles.

11.3.3 Gravel Placement

The drainage gravel layer shall be constructed under the full time Supervision of the GITA or CQA Engineer. No gravel shall be placed without the presence of this appointed person.

Prior to gravel placement the cushion geotextile surface shall be inspected with the appointed person to ensure cushion geotextile layer remains intact and in good condition, pipework is resting in correct position and that no potentially harmful foreign or protruding objects or rubbish are present.

The appointed person shall inspect and report on all placement of gravel to ensure compliance with the work method statement, SEDMP and wrinkle management plan and the Drawings and this Specification.

Drainage gravel material shall be placed surrounding the pipes to secure the position of the pipes. Immediately adjacent the pipe, the drainage gravel layer shall be thickened as shown on the Drawings. Care shall be taken to ensure that no voids are created between the drainage gravel layer material and sides of the pipe.

The gravel shall be placed and spread evenly so as not to allow concentration, segregation and accumulation of similar particle sizes, in particular, concentrations of fines.

The cell floor drainage material shall be placed to the dimensions shown on the Drawings as a minimum. It is essential that this placement operation be carried out such that the stability and integrity of the liner and drainage components beneath the gravel layer are maintained. In particular, the placement methods shall take into account loads imposed by haulage vehicles and placement machines.

The drainage material shall be spread with a tracked bobcat or excavator (or similar approved machine) with a maximum ground contact pressure of 40 kPa. The machine shall operate over at least 300 mm thickness of drainage material at all times. The equipment used shall not take large cuts into heaped material. Equipment shall not slew or break suddenly unless over a designated temporary haul road or tipping area where the drainage material is maintained at a minimum thickness of 800 mm as measured from the surface of the engineered fill layer.

Rubber tyred haulage vehicles may traffic on completed liner surface while delivering the drainage gravel material, provided that a minimum thickness of 800 mm cover is provided over the underlying liner components. Where it is proposed to remove the gravel haul road on completion of the drainage layer, a geotextile, equivalent to the separation geotextile specified in Clause 13 shall be placed over the initial drainage layer (at 300 mm) and removed at completion of the haul road removal, taking all precautions necessary to ensure deposited fines are not allowed to fall into the drainage gravel layer.

Any damage to the liner materials or pipework sustained or suspected during placement shall be examined and rectified to the satisfaction of the Superintendent, including removal of any excessive fines caused by hauling and placement activities.

11.4 Quality Requirements

11.4.1 General

Following confirmation by prequalification testing that stockpiled gravel meets the materials properties nominated in Clause 11.2, it must be demonstrated the gravel material is in compliance with the Specification once placed by in-situ testing following placement. To this end work methods must be adopted that prevents inclusion or generation of excessive fines (such as breakdown during construction) as a result of work methods.

The point of compliance for gravel layer acceptance is the in-situ testing. Compliance testing may be undertaken progressively to actively monitor performance.

11.4.2 Material Properties - Compliance Testing on the Cell Floor

Following placement and levelling of gravel, the placed material shall be sampled and tested by a GTA and NATA accredited testing authority in accordance with the frequencies and methods set out in Table 11.3.

Table 11.3 Drainage Gravel Layer Materials In-situ Compliance Testing Requirements

Test	Method	Frequency
Particle Size Distribution (PSD) of the placed drainage gravel layer.	AS 1289 1.1 or AS 1141.11.1 (by washing)	1 per 500 m^3 or 1 per 2500 tonnes whichever results in the most tests, And, A minimum of three tests.

Where test results show that the gravel PSD as tested in-situ is below the level specified, the areas or volumes represented by the tests (as determined by the appointed person) may be rejected. Any defective material is to be removed and replaced followed by further testing until the specified requirements are achieved and the appointed person's approval received. All remedial works and re-testing shall be undertaken at no cost to the Principal.

11.4.3 Liner Integrity Survey (Completed Gravel Layer)

An independent Geomembrane Testing Authority (GMTA) approved by the Principal shall be appointed to conduct a LIS in accordance with ASTM D6747 - Standard Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes and ASTM D7007 – Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials after the placement of the leachate drainage gravel layer within the newly completed landfill cell, and prior to installation of separation geotextile.

The GMTA shall have experience in conducting liner integrity surveys utilising the proposed method(s) including having tested a minimum of 200,000m^2 on at least three projects.

The Contractor will be responsible for:

- Preparing the site for survey.
- Coordination of attendance of the GMTA.
- All preparatory and necessary works required by the GMTA.
- All rectification works (including allowance for up to two holes created by the Principal for blind method validation purposes).
- Re-survey of areas subject to rectification where these are required as a result of installation damage (tears, multiple holes or other damage) inclusive of areas over which machinery has tracked in undertaking rectification works.

This will entail, but not necessarily be limited to, the following:

- Providing the GMTA with as-constructed drawings that show:
  - Design drawings including amendment to show any modifications or variations from the design
  - Plan of the survey area
  - Details of connection to adjacent lining systems
  - Structures and obstructions above the liner
  - Electrical equipment or installation above the geomembrane
- Consult and agree with the GMTA on their requirements and the requirements of the liner installation schedule prior to commencing installation, and inclusion of these in the works program.
- Electrically isolate the works including the drainage gravel layer and any anchor or cover soil layers from the surrounding ground or adjacent fill (i.e. by open trenching or installation of a non-conductive insulator of liner material.
- Temporary installation of any necessary electrodes during construction as required by the GMTA.

- Meet the requirements of the GMTA including to ensure that there is adequate moisture in the material(s) covering the geomembrane for the dipole leak detection testing. If necessary, supplement with additional water to the satisfaction of the GMTA during construction and prior to testing. A water truck must be available at all times as it may be necessary to wet the surface just in advance of the survey, as deemed necessary by the GMTA.
- Provide a hand labour (machinery not likely to be acceptable), as appropriate, to excavate the drainage gravel layer down to the geomembrane as required by the GMTA for calibration purposes, where anomalies are detected and as otherwise required to support the GMTA in conducting this work during both survey and verification of rectification works.
- Uncover and expose any leaks detected for repair by the HDPE installer in accordance with the Specifications.
- After the identification and excavation of a leak, the gravel around the leak location shall be cleaned and inspected for adjacent leaks. Where machinery is used on the gravel surface, the areas tracked by the machine shall also be surveyed.
- The GMTA shall report the general results of the survey to the Superintendent, Contractor and appointed person during the daily progress of the field work.
- Prior to the demobilisation of the survey personnel from the site, the leak detection consultant shall submit a list of locations of the leaks detected to the Superintendent, Contractor and appointed person unless an alternative arrangement is agreed in advance.
- Completion of placement of the drainage gravel layer and any anchor or cover layers in accordance with the Specification following approval of the GMTA to do so.

11.4.4 Inspections and Acceptance Criteria

Hold points nominated are stages of work beyond which work shall not proceed without mandatory inspection / verification and written approval before subsequent works can be initiated.

The following inspection and hold points are required during drainage gravel layer placement:

H-DG1	CQA Engineer's approval of WMP and WMS
H-DG2	CQA Engineer's approval of drainage gravel materials proposed to be used in the works
H-DG3	CQA Engineer's review and approval of as-constructed information

11.4.5 As-Constructed Reporting

The appointed person shall be provided with all daily logs, materials and construction test reports, final surface survey and certification the gravel layer has been constructed in accordance with the Specification, within 14 days of practical completion of the gravel placement works.

Once placement and levelling of the drainage gravel layer is complete, a level survey shall be undertaken by the Surveyor. Information and data as nominated for the relevant phases in Clause 1.8.4 and 1.7.5 and shall be provided to the appointed person for approval prior to placement of subsequent layers.

The CQA Engineer shall undertake inspections during the works and confirm that the materials and installation procedures comply with this Specification.

The CQA Engineer shall take photographs of the progress of the works when onsite, and detailed record on completion of the works.

The CQA Engineer shall provide all these documents and drawings for inclusion in the final as-constructed reporting including certification that the works have been completed in conformance with the approved Specification.

12 Drainage Geocomposite

12.1 General

This Clause of the Specification is applicable to the supply and installation of the drainage geocomposite layer which will be installed as a primary subsurface infiltration drainage layer for the side batter as shown in the Drawings. The drainage geocomposite shall be installed across the full extent of the cell except where the drainage gravel is present on the baseliner.

12.1.1 Standards

This Specification shall be read in conjunction with the following Standards and references, which are deemed to form a part of this Specification:

AS 3706	Geotextiles – Methods of testing
ASTM D792	Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D1505	Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D1621	Standard Test Method for Compressive Properties of Rigid Cellular Plastics
ASTM D4716	Standard Test Method for Determining The (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity Of A Geosynthetic Using A Constant Head
ASTM D6767	Standard Test Method for Pore Size Characteristics Of Geotextiles By Capillary Flow Test

12.2 Materials

12.2.1 General

The drainage geocomposite layer shall consist of a biplanar or triplanar virgin HDPE drainage core material bonded to an upper non-woven geotextile layer.

The drainage geocomposite material shall be a netlike configuration of parallel sets of homogeneously interconnected ribs.

12.2.2 Packaging

The rolls packaging must be adequate for safe transportation to the point of installation. Packaging must be capable of preventing creasing or folding of the drainage geocomposite material core and should not be removed until immediately prior to installation.

12.2.3 Transportation, Handling and Storage

The Contractor shall be responsible for all damage to the drainage geocomposite material incurred prior to and during transportation to the site.

During transportation, handling and storage the drainage geocomposite material shall be protected from ultraviolet light exposure, rain or inundation, mud, dust, puncture, cutting or other damaging deleterious conditions.

All drainage geocomposite rolls shall be inspected by the Superintendent or the CQA Engineer upon delivery to site. Any damaged rolls shall be rejected, transported off-site and replaced at no cost to the Principal.

The Contractor shall store the drainage geocomposite material off the ground in a location on site such that transportation and handling are facilitated. The Contractor shall ensure that the storage space(s) are flat and protected from the passage of vehicles.

The drainage geocomposite material rolls shall not be dragged on the ground and should be lifted or rolled.

12.2.4 Labelling

The drainage geocomposite material shall be supplied in rolls wrapped in protective covers and marked or labelled with the following information:

- Manufacturer's name
- Product identification
- Lot number and roll number
- Dimensions

12.2.5 Properties

12.2.5.1 Geonet Core

The drainage geocomposite material geonet core shall have the minimum properties listed in Table 12.1.

12.2.5.2 Non-Woven Geotextile

The non-woven geotextile layer bonded to the geonet core shall be a proprietary product manufactured from polypropylene, polyester, polyethylene and polyamide materials, either singularly or in combination. The geotextile filaments shall be rot proof, chemically stable and shall have low water absorbency. They shall resist delamination and maintain their relative position in the geotextile.

The geotextile shall be non-woven with filaments bonded by needle punching, heat or chemical bonding processes. The bond strength (Ply Adhesion) of the non-woven geotextile to the geonet shall meet or exceed 180 g/cm.

The geotextile shall conform to the test property requirements specified in Table 12.1 below, unless otherwise authorised by the Superintendent.

The geotextile shall be free of flaws that may have an adverse effect on the physical and mechanical properties of the geotextiles.

The geotextile shall be stabilised against ultraviolet radiation to the degree that 6 months exposure of the geotextile to sunlight should not reduce its strength to less than 70% of the specified values.

The geotextile shall be chemically inert and compatible with typical leachate generated in putrescible waste landfills.

Table 12.1 Drainage Geocomposite Material Core Properties

Property	Units	Value	Test Method
Geonet HDPE core			
HDPE polymer density	g/cc	>0.94	ASTM D1505/D792
Thickness (min)	mm	>6.3	AS 3706.1
Compressive Strength @ inclination of 18 degrees	kPa	>840	ASTM D1621
Geotextile			
Mass	g/m^2	>150	AS 3706.1
CBR Burst Strength	N	>1500	AS 3706.4

Pore size	µm	>75, <250	ASTM D6767
Permittivity	s^{-1}	>1.2	AS 3706.7
Geocomposite			
Peak tensile strength (MD)	kN/m	>11	AS 3706.2a
Flow rate (planar) @ 310 kPa, 0.1 gradient and 100 hrs	L/s/m	0.05	ASTM D4716

12.3 Construction and Workmanship

12.3.1 General

Drainage geocomposite material shall be installed in accordance with the Manufacturer's requirements and the additional requirements of this Specification. Once installed, the drainage geocomposite material shall be covered within 14 days.

The Contractor shall handle and install the drainage geocomposite material in such a manner to ensure that it is not damaged, creased or folded in any way. Care shall be taken not to entrap stones, excessive dust or moisture that could damage the drainage geocomposite material core or the geotextile.

The drainage geocomposite material shall be deployed down slope in such a manner as to keep the product tensioned to preclude folds and wrinkles. Side laps should therefore be perpendicular to the slope. Side laps shall be a minimum of 100 mm.

End joints are not permitted on slopes with a grade greater than 10% and should be avoided where possible. Where end joints are permitted, they must be a minimum 800mm or in accordance with the manufacturers requirements. Continuity between the top geotextile shall be maintained an all joints to ensure effective filtration.

The drainage geocomposite material core overlaps shall be secured by tying. The core ribs of the overlapping panel shall be oriented in the same direction as the ribs on the receiving panel.

Tying shall be achieved by plastic or nylon fasteners a minimum of every 2.0 m along all laps. Plastic/nylon fasteners shall be a different colour to the drainage core material to assist with identification of tying locations. Fasteners shall be positioned such that any hard edges are finished within the geonet core to avoid damage to underlying or overlying layers.

The drainage geocomposite material shall be adequately weighed down with sandbags, especially along laps, to ensure that they remain in place. Therefore, sandbags shall remain in place following completion and removed only immediately prior to subsequent layer placement.

12.3.2 Drainage Geocomposite Placement Work Method Statement

The Contractor shall provide a proposed drainage geocomposite panel layout and work method statement to the CQA Engineer at least 10 working days prior to scheduled deployment for approval prior to commencing the works. The statement shall include details of handling, placement and preservation of the layer once installed.

12.3.3 Defects and Repairs

Any rolls demonstrating a discontinuity of the core ribs or folds or creases arising from manufacture process shall be rejected and replaced.

Any holes or tears, not a result of the manufacturing process shall be repaired by overlaying a piece of drainage geocomposite over the damaged area that extends a minimum of 0.3 m in all directions of the damage. The overlay shall be tied to ensure secure attachment of the new piece. The damaged area

may require removal for successful intimate contact and alignment of the repair piece. The ribs of the core must be aligned and the geotextile must be reinstated and heat welded (or alternative method approved by the Superintendent) to ensure it is fully secured prior to placement of subsequent layers.

12.4 Quality Requirements

12.4.1 CQA Engineer

The Principal shall arrange for a suitably qualified and experienced CQA Engineer to monitor the drainage geocomposite layer installation works. All monitoring and audit activities as described in this Specification shall be accommodated. The role of the CQA Engineer will include verification of materials and installation methods, organisation of IQA testing, evaluation of testing results and CQA reporting. The CQA Engineer shall keep a daily log including construction activities, weather conditions and conformance of the works to the Specification.

12.4.2 Quality Testing

12.4.2.1 Manufacturer Quality Assurance (MQA)

The Contractor shall provide MQA test certificates confirming the geotextile and geonet core complies with the material properties using relevant test methods as set out in Table 12.1, for the corresponding roll numbers to be supplied to the project. Testing frequencies shall be one per production lot or minimum one per 4,000 m^2 of drainage geocomposite material, whichever results in the most tests.

12.4.2.2 Independent Quality Assurance (IQA)

The Contractor shall provide the CQA Engineer (at no cost to the Principal) with suitable size and number of samples to the CQA Engineer for off site IQA laboratory testing of properties (laboratory and tests to be determined by the CQA Engineer). The Principal will be responsible for the cost of testing once the samples arrive at the nominated laboratory.

The CQA Engineer will carry out independent verification testing of samples of material supplied to site, to confirm the materials are compliant with the roll data provided and this Specification. A representative sample of approximately 1m width of drainage geocomposite shall be cut from each sampled roll but not within the first roll wrap. Samples shall be tested at the frequency nominated in Table 12.2 and meet the property test values presented in Table 12.1.

Testing shall include the first and last rolls based on production order with minimum of two tests.

Table 12.2 Drainage Geocomposite Material Properties IQA Test Frequencies

Property	Test	Units	Minimum IQA Frequency of Testing
Geonet			
Thickness	AS 3706.1	mm	One sample per 1,250 m^2, including the first and last rolls (based on production order): minimum of two tests
Compressive Strength	ASTM D1621	kPa	
Geotextile			
Pore Size	ASTM D6767	µm	One sample per 10,000 m^2, including the first and last rolls (based on production order): minimum of two tests
Permittivity	AS 3706.9	s^{-1}	
Drainage Geocomposite			

Peak tensile strength	AS 3706.2a	kPa	One sample per 5,000 m^2, including the first and last rolls (based on production order): minimum of two tests
Flow rate (planar) @ 310 kPa and 0.1 gradient	ASTM D4716	L/s/m	One sample per 1,250 m^2, including the first and last rolls (based on production order): minimum of two tests

12.4.3 Inspections and Acceptance Criteria

Hold points nominated are stages of work beyond which work shall not proceed without mandatory inspection / verification and written approval from the Superintendent before subsequent works can be initiated.

The following inspection and hold points are required during drainage geocomposite installation:

H-DGC1 CQA Engineer's approval of WMS, panel layout plan and drainage geocomposite materials proposed to be used in the works

H-DGC2 CQA Engineer's inspection and approval of cushion geotextile deployment and surface prior to drainage geocomposite installation

H-DGC3 Drainage geocomposite material rolls inspected and approved by the CQA engineer prior to joining of geotextile laps

H-DGC4 CQA Engineer's review and approval of as-constructed information

The CQA Engineer and the Contractor are to inspect all drainage geocomposite material rolls throughout deployment of rolls for defects.

Prior to placement of drainage geocomposite layer the geomembrane layer surface shall be inspected by the CQA Engineer. If the CQA Engineer considers the surface is suitable, drainage geocomposite material placement shall commence as described above. If the CQA Engineer considers that the surface is unsuitable, measures shall be carried out as directed by the CQA Engineer.

The CQA Engineer and the Contractor are to inspect all drainage geocomposite material rolls throughout deployment of rolls for defects.

The CQA Engineer is to witness placement, lapping and bonding of all drainage geocomposite material panels.

A final walk-over examination of the installed drainage geocomposite material over the entire surface shall be conducted by the CQA Engineer and the Contractor upon completion of each portion of work to confirm the installation complies with the Specification and Drawings.

12.4.4 As-constructed Reporting

The Contractor shall provide the CQA Engineer with the following listed records at the completion of the works and within 14 days of completion of the drainage geocomposite layer;

- Roll test data reports provided by the Contractor (to be provided prior to installation);
- Daily installation reports and photos, and;
- Completed as-built drawing/sketches, including roll numbers, panel layout and repair locations and details.

13 Separation Geotextile

13.1 General

This Clause of the Specification is applicable to the supply and installation of the separation geotextile. The separation geotextile is required to be placed to provide separation between the leachate drainage gravel and overlying waste, forming part of the baseliner system. The extent of the geotextile is shown on the Drawings.

13.2 Materials

13.2.1 Manufacture

The separation geotextile shall be manufactured under strict quality control. The manufacturer shall be certified to ISO 9001. The geotextile shall undergo regular and frequent testing in the manufacturer's laboratories according to the quality management standard ISO 9001. The manufacturer shall guarantee consistent quality through careful selection, processing and handling at all times. The manufacturer shall provide its own in-house test documents (Manufacturer Quality Assurance MQA) covering each roll of geotextile delivered to site.

13.2.2 Packaging

The geotextiles shall be rolled onto a substantial core or core segments and wrapped in a protective covering. Rolls should be held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of installation.

13.2.3 Transportation, Handling and Storage

During transportation, handling and storage geotextiles shall be protected from ultraviolet light exposure, rain or inundation, mud, dust, puncture, cutting or other damaging deleterious conditions.

Geotextiles shall be stored off the ground in a location on site such that transportation and handling are facilitated. Storage space(s) shall be flat and protected from the passage of vehicles.

13.2.4 Labelling

Geotextiles shall be supplied in rolls wrapped in protective covers and marked or tagged on the wrapping, and within the core, with the following information:

- Manufacturer’s name
- Product identification
- Lot number
- Roll number
- Roll dimensions

13.2.5 Properties

Geotextiles shall be proprietary products manufactured from polypropylene or polyester materials. The geotextile filaments shall be rot proof, chemically stable and shall have low water absorbency, they shall resist delamination and maintain their relative position in the geotextile.

Geotextiles shall be non-woven with filaments bonded by needle punching, heat or chemical bonding processes.

The geotextiles shall be approved by the Superintendent as conforming to the test property requirements specified in Table 13.1, unless otherwise authorised by the CQA Engineer.

Geotextiles shall be free of flaws that may have an adverse effect on the physical and mechanical properties of the geotextiles.

Geotextiles shall be stabilised against ultraviolet (UV) radiation to the degree that 500 hours exposure of the geotextile to UV light should not reduce its strength to less than 70% of the specified values.

Products shall be chemically inert, and compatible with typical leachate generated in putrescible waste landfills.

The separation geotextile shall meet the requirements of Table 13.1.

Table 13.1 Separation Geotextile Minimum Material Properties and MQA Test Frequencies

Property	Test	Units	Value
Grab Tensile Strength	AS 3706.2b	N	>1,100
Trapezoidal Tear Strength	AS 3706.3	N	>380
CBR Burst Strength	AS 3706.4	N	>3,150
Permittivity	AS 3706.9	sec^{-1}	>0.5
Pore size	ASTM D6767	um	>75, <210
UV Resistance (550 hrs)	ASTM D4355	%	>70
MQA Test Frequency	**As above**	**m^2**	**15,000**

13.3 Construction and Workmanship

13.3.1 General

The proposed geotextile panel layout and work method statement shall be provided to the CQA Engineer at least 10 working days prior to scheduled deployment for approval prior to commencing the works. The statement shall include details of handling, placement and preservation of the layer once installed.

The gravel surface shall be inspected with the CQA Engineer and prior to geotextile placement. The CQA Engineer shall provide written advice of acceptance of the geotextile deployment to proceed.

Geotextiles shall be installed in accordance with the manufacturer's requirements and the additional requirements of this Specification.

The geotextile shall be handled in such a manner to ensure that the geotextile is not damaged in any way.

Geotextiles shall be deployed down slope in such a manner as to keep the geotextile tensioned to preclude folds and wrinkles.

Care shall be taken not to entrap stones, excessive dust or moisture that could damage the geotextile or generate clogging.

The geotextiles shall be adequately secured and weighed down during construction to ensure that the sheets remain in place prior to installation of the next layer and shall be covered as soon as practical.

13.3.2 Overlays and Repairs

Geotextiles shall be lapped a minimum of 300 mm, including end laps and stitched or heat bonded (or alternative method approved by the CQA Engineer such as by using construction adhesive compatible with the type of geotextile used).

Any holes or tears shall be repaired by placing a patch of the same geotextile over the hole or tear with a minimum 500 mm overlap in all directions. Care shall be taken when removing any soil or other

materials that may have penetrated the geotextile. Repairs shall be heat bonded or adhered using construction adhesive compatible with the type of geotextile used.

13.4 Quality Requirements

13.4.1 Quality Testing

13.4.1.1 Material Quality Assurance (MQA)

The Contractor shall provide manufacturers material property data sheets and MQC test certificates to confirm the geotextile supplied complies with the material properties, using relevant test methods as set out in Table 13.1. Test certificates shall be supplied for all corresponding roll numbers to be supplied to the project. MQA testing frequencies and properties shall be as nominated in Table 13.1.

13.4.1.2 Independent Quality Assurance (IQA)

The Contractor shall provide the CQA Engineer (at no cost to the Principal) with suitable size and number of samples for independent off site laboratory testing of properties (laboratory and tests to be determined by the CQA Engineer). Alternatively, sampling may occur under supervision of the CQA Engineer. The Contractor shall provide 2 weeks' notice of sampling to provide opportunity for a representative to be present. The Principal will be responsible for the cost of testing once the samples arrive at the nominated laboratory.

The CQA Engineer will carry out independent verification testing of samples of material supplied to site for the properties outlined in Table 13.1, at a frequency of approximately 1 test per 5,000 m^2 of material placed, to confirm the materials are compliant with the roll data provided and Table 13.1. A representative sample of approximately 1 m width of geotextile shall be cut from each sampled roll but not within the first roll wrap. Testing shall include the first and last rolls based on production order with minimum of 2 tests.

13.4.2 Inspections and Acceptance Criteria

Hold points nominated are stages of work beyond which work shall not proceed without mandatory inspection / verification and written approval from the Superintendent.

The following inspection and hold points are required during separation geotextile installation:

H-SG1	CQA Engineer's approval of WMS, panel layout plan and geotextile materials proposed to be used in the works
H-SG2	CQA Engineer's inspection and approval of gravel surface prior to separation geotextile installation
H-SG3	CQA Engineer to confirm deployment, overlaps and repairs lap width and bonding

13.4.3 Geotextiles As-Constructed Reporting

Scale drawings (hand drawn acceptable) of the separation geotextile deployment and include the following information on the drawings within 14 days of practical completion:

- Geotextile panel arrangement and date of panel placement
- Corresponding roll numbers for each placed geotextile panel
- Location and description of patches or repairs; and
- Confirmation the works have been completed in accordance with the Specification.

The CQA Engineer shall undertake inspections during the works and confirm that the materials and installation procedures comply with this Specification.

The CQA Engineer shall take photographs of the progress of the works when onsite.

The CQA Engineer shall include all these documents in the final as-constructed reporting including certification that the works have been completed in conformance with the approved Specification.

14 Tensile Reinforcement Layer

14.1 General

This Clause of the Specification is applicable to the supply and installation of the tensile reinforcement layer. The tensile reinforcement layer is required to be placed over the drainage geocomposite on the cell side batters.

14.1.1 Standards

This specification shall be read in conjunction with the following Standards and references, which are deemed to form a part of this specification:

ISO 10319 Geosynthetics – Wide Width Tensile Test

14.2 Materials

14.2.1 Manufacture

The tensile reinforcement layer shall be manufactured under strict quality control. The manufacturer shall be certified to ISO 9001. The material shall undergo regular and frequent testing in the manufacturer's laboratories according to the quality management standard ISO 9001. The manufacturer shall guarantee consistent quality through careful selection, processing and handling at all times. The manufacturer shall provide its own in-house MQA test documents covering each roll of tensile reinforcement delivered to site.

14.2.2 Packaging

The rolls packaging must be adequate for safe transportation to the point of installation. Packaging must be capable of preventing creasing or folding of the tensile reinforcement and should not be removed until immediately prior to installation.

14.2.3 Transportation, Handling and Storage

The Contractor shall be responsible for all damage to the tensile reinforcement incurred prior to and during transportation to the site.

During transportation, handling and storage the tensile reinforcement material shall be protected from ultraviolet light exposure, rain or inundation, mud, dust, puncture, cutting or other damaging deleterious conditions.

All tensile reinforcement rolls shall be inspected by the Superintendent upon delivery to site. Any damaged rolls shall be rejected, transported off-site and replaced at no cost to the Principal.

The Contractor shall store the tensile reinforcement off the ground in a location on site such that transportation and handling are facilitated. The Contractor shall ensure that the storage space(s) are flat and protected from the passage of vehicles.

The tensile reinforcement rolls shall not be dragged on the ground and should be lifted or rolled.

14.2.4 Labelling

The tensile reinforcement shall be supplied in rolls wrapped in protective covers and marked or labelled with the following information:

- Manufacturer’s name
- Product identification
- Lot number
- Roll number

- Dimensions

14.2.5 Properties

14.2.5.1 Tensile Reinforcement

A tensile reinforcement layer is required on the side batters to limit tensile loading in the underlying liner due to waste placement and to maintain stability of the lining system.

The tensile reinforcement shall be a proprietary biaxial geogrid manufactured from high modulus coated polypropylene yarns. The tensile reinforcement layer shall be rot proof, chemically stable in a landfill environment and shall have low water absorbency. The tensile reinforcement layer must not contain recycled materials. The tensile reinforcement layer shall be compliant with the properties in Table 14.1

Table 14.1 Tensile Reinforcement Properties

Property	Units	Value (MARV)	Test Method
Characteristic Initial Strength (MD)	kN/m	≥80	ISO 10319
Strain at initial strength (MD)	%	≤10	ISO 10319
Characteristic Initial Strength at 5% Strain (MD)	kN/m	≥40	ISO 10319

14.2.5.2 Protective Cover Soil

Protective cover soil will be obtained from on-site stockpiles or otherwise sourced from offsite.

The material shall typically:

- Consist of any combination of sand, clay, silt, or gravel or other approved materials;
- Be free from debris, weeds, roots, organic material or other foreign matter and meeting the criteria described in Clause 4.2.4;
- Have a maximum particle size of 19 mm.

14.3 Construction and Workmanship

14.3.1 General

The drainage geocomposite surface shall be inspected by the CQA Engineer and approval given prior to placement of the tensile reinforcement. All repairs and QA activities shall be completed prior to installation of the tensile reinforcement layer. The drainage geocomposite surface shall be free of standing water, excessive dirt, sandbags, debris or any other materials that could potentially damage the geosynthetics.

The tensile reinforcement shall be installed in accordance with the manufacturer’s installation guidelines. All panels shall be deployed vertically from the top of the slope in one single full length. There shall be no horizontal joins on the side batters. Panel edge overlaps shall be a minimum of 300 mm or in accordance with manufacturers requirements. Edge overlaps shall be free of foreign matter. The tensile reinforcement overlaps shall be joined by nylon cable ties at minimum 1 m intervals or in accordance with manufacturer's requirements.

Tensile reinforcement shall be deployed down slope in a controlled manner as to keep the material tensioned to preclude folds and wrinkles. The tensile reinforcement shall be secured in an anchor trench at the crest of the slope as shown in the drawings. The tensile reinforcement shall finish on the floor base of the slope as shown on the drawings. The tensile reinforcement shall be temporarily ballasted with sandbags or other ballast approved by the superintendent to avoid wind uplift. The ballast material shall be UV resistant and filled with sand or other soil materials which will not cause damage to the geosynthetics. The installer is responsible for assessing the extent of ballasting required.

14.3.2 Placement Work Method Statement

The Contractor shall provide a proposed panel layout and work method statement to the CQA Engineer at least 10 working days prior to scheduled deployment for approval prior to commencing the works for the tensile reinforcement. The statement shall include details of handling, placement and preservation of the layer once installed.

14.3.3 Defects and Repairs

Any rolls demonstrating any damage or creases arising from manufacture process shall be inspected by the CQA Engineer and may be rejected and replaced.

Where damage is identified during deployment and that damage is in the primary strength direction ribs (up/down slope) the material shall be replaced. Patching in the primary strength direction is not permitted. If damage is in the cross slope ribs the damaged area is to be patched without cutting the panels (i.e the material shall be doubled). Patching shall be in accordance with manufacturer's recommendations but in any case overlaps shall not be less than 300 mm and joined with cable ties at maximum 300 mm spacings.

Cable ties must be placed in a way that hard edges are positioned away from the underlying geotextile.

14.3.4 Soil Protection Layer

Protective cover soil shall be placed on the batter slopes over the tensile reinforcement in a 300 mm thick layer. The cover soil must be placed from the base of the slope upwards with plant with a mass and ground pressure not exceeding that of a CAT D3K Dozer. Plant must not directly traffic the liner and tensile reinforcement layer while placing soil protection layer.

Placement of the soil protection layer shall be to a maximum of 5 m vertically ahead of waste filling to manage tensile loads on the liner.

14.3.5 Sacrificial Geosynthetic Material

Areas of the side batters will be exposed until filling progresses to a height where the protective cover soil will be placed to cover them. This extent of the side batters shall be covered with a sacrificial geosynthetic material which may consist of separation geotextile, cushion geotextile or geomembrane from the works, or another geosynthetic material approved by the designer.

The sacrificial geosynthetic material shall be placed across the full extent of the side batters other than the base 5 m which will be covered with protective cover soil. The installer is responsible for determining and providing suitable anchorage at the top of the slope to secure the material and providing suitable ballast on the side batters to protect the material against wind uplift. The material shall not be finished in the anchor trench with other geosynthetics but may be secured by a bund or by pinning at the top of the slope outside of the extent of the lining system.

The material shall be removed ahead of the placement of the protective cover soil, with none of the sacrificial geosynthetic material permitted to remain below the protective cover soil.

14.4 Quality Requirements

14.4.1 Quality Testing

14.4.1.1 Manufacturer Quality Assurance (MQA)

The Contractor shall provide test certificates from the materials manufacturer confirming the tensile reinforcement complies with the material properties using the test method nominated in Table 14.1 for the corresponding roll numbers to be supplied to the project. Testing frequency shall be one per 4,000 m^2 of material or a minimum of two tests.

14.4.1.2 Independent Quality Assurance (IQA)

Following delivery of the material to site the Contractor shall provide the CQA Engineer (at no cost to the Principal) with suitable size and number of samples to the CQA Engineer for off site laboratory IQA testing of properties (laboratory and tests to be determined by the CQA Engineer). The Principal will be responsible for the cost of testing once the samples arrive at the nominated laboratory.

The CQA Engineer will carry out independent verification testing of samples of material supplied to site, to confirm the materials are compliant with the roll data provided and this Specification. A representative sample of tensile reinforcement shall be cut from each sampled roll but not within the first roll wrap. Testing shall include the first and last rolls based on production with minimum of 2 tests. Samples shall be tested at the frequency nominated in Table 14.2 and meet the property test values presented in Table 14.1.

Table 14.2 Tensile Reinforcement Material Properties IQA Test Frequency

Property	Test	Units	IQA Minimum Frequency of Testing
Wide Width Tensile Strength	ISO 10319	kN/m	One sample per 4,000 m^2, including the first and last rolls (based on production order). Minimum of two tests

14.4.2 Inspections and Acceptance Criteria

Hold points nominated are stages of work beyond which work shall not proceed without mandatory inspection / verification and written approval from the Superintendent before subsequent works can be initiated.

The following inspection and hold points are required during tensile reinforcement installation:

H-TR1 CQA Engineer's approval of WMS, panel layout plan and tensile reinforcement materials proposed to be used in the works

H-TR2 CQA Engineer inspection and approval of drainage geocomposite surface prior to installation of the tensile reinforcement.

H-TR3 CQA Engineer inspection and approval of finished construction including laps and joining

The CQA Engineer and the Contractor are to inspect all tensile reinforcement material rolls throughout deployment of rolls for defects.

14.4.3 As-Constructed Reporting

The Contractor shall provide the CQA Engineer with the following listed records at the completion of the works and within 14 days of completion of the tensile reinforcement installation:

- Roll test data reports provided by the Contractor (to be provided prior to installation);
- Daily installation reports and photos;
- Completed as-built drawing/sketches, including roll numbers, panel layout and repair locations and details; and
- Confirmation the works have been completed in accordance with the Specification.

The CQA Engineer shall undertake inspections and photos during the works and confirm that the materials and installation procedures comply with this specification.

The CQA Engineer shall include all these documents in the final as-constructed reporting including certification that the works have been completed in accordance with the specification.

Appendix A – Drawings

WENTWORTH SHIRE COUNCIL
BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN

DRAWING SCHEDULE	
Drawing Number	Sheet Title
L001	LOCALITY PLAN & DRAWING SCHEDULE
L002	EXISTING FEATURES - PLAN
L003	DESIGN SUBGRADE - PLAN
L004	DESIGN BASELINER - PLAN
L005	ISOPACHTYE - SURVEY TO SUBGRADE
L006	LONGITUDINAL SECTION - MCS0
L007	CROSS SECTIONS 1 OF 3
L008	CROSS SECTIONS 2 OF 3
L009	CROSS SECTIONS 3 OF 3
L010	DETAILS - SHEET 1 OF 5
L011	DETAILS - SHEET 2 OF 5
L012	DETAILS - SHEET 3 OF 5
L013	DETAILS - SHEET 4 OF 5
L014	DETAILS - SHEET 5 OF 5
L015	SAFETY IN DESIGN

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.

0 100 200 400 600
1:10000 (A1); 1:20000 (A3)
100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE
A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	ISSUED FOR APPROVAL	21.9.23	IN	JT
B	ISSUED FOR COMMENT	28.8.23	IN	JDT
A	ISSUED FOR PRELIMINARY	28.7.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: 1:10000
SURVEYED:PRICE MERRET/MAW
SURVEY DATE:04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

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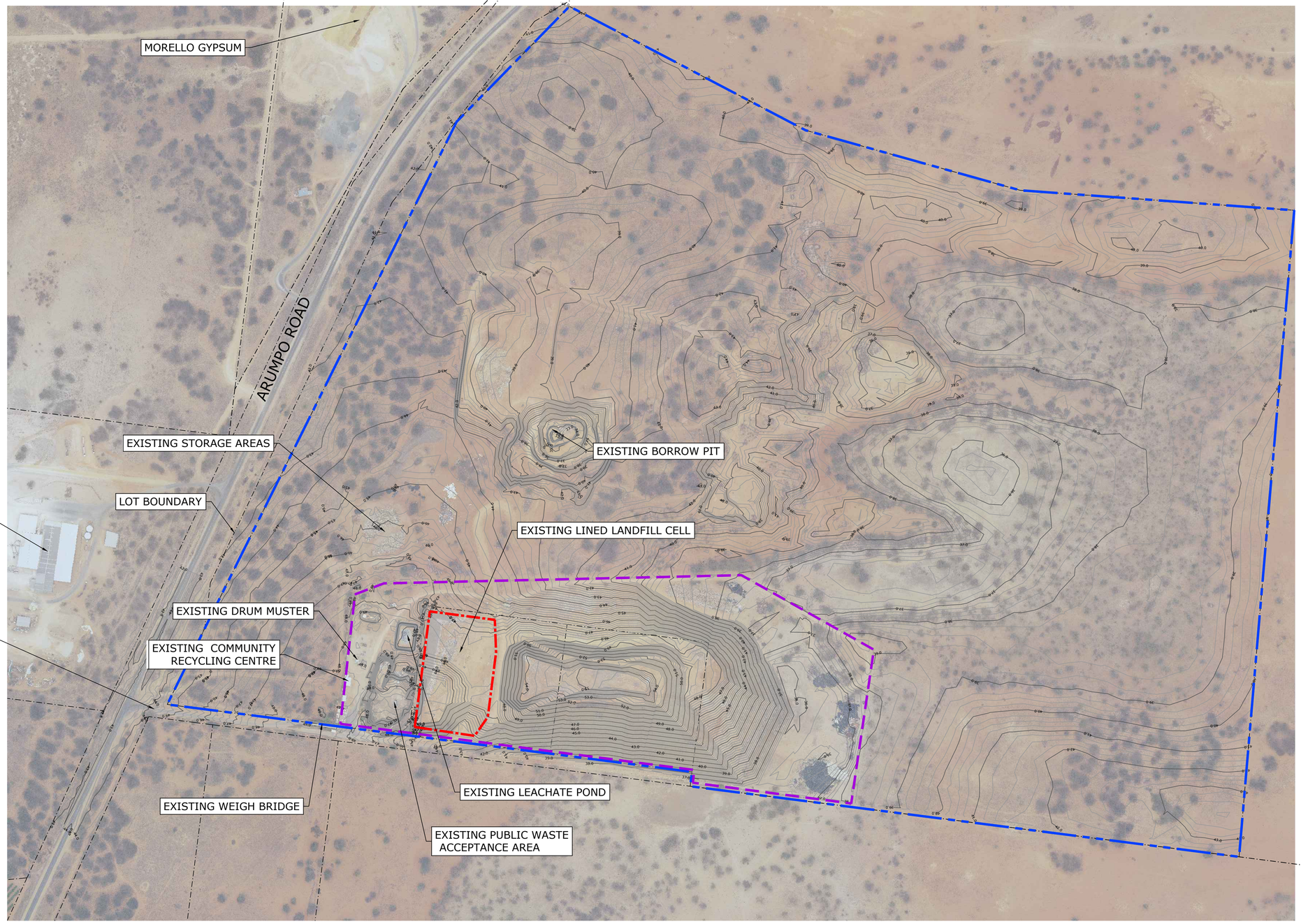
BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
LOCALITY PLAN & DRAWING SCHEDULE

FILENAME: 202597 BURONGA_S1A_CELL 1_COVER.DWG
PROJECT NUMBER 202597
DRAWING NUMBER L001
REVISION C

T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1_COVER.DWG -S1AC1 COVER- (21-09-23 4:18:29PM)



LEGEND

- SURVEY CONTOUR (MAJ 1.00m)
- SURVEY CONTOUR (MIN 0.25m)
- LICENCED AREA
- EXISTING LANDFILL FOOTPRINT
- ACTIVE CELL

NOTE:

COMBINED SURVEY;
PRICE MERRIT SURVEY 4.3.21
MAW SURVEY 18.5.23

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.

0 30 60 120 180
1:3000 (A1); 1:6000 (A3)

100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	ISSUED FOR APPROVAL	21.9.23	IN	JT
B	ISSUED FOR COMMENT	28.8.23	IN	JDT
A	ISSUED FOR PRELIMINARY	28.7.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: 1:3000
SURVEYED:PRICE MERRET/MAW
SURVEY DATE:04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

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BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
EXISTING FEATURES - PLAN

FILENAME: 202597 BURONGA_S1A_CELL 1_COVER.DWG
PROJECT NUMBER 202597
DRAWING NUMBER L002
REVISION C

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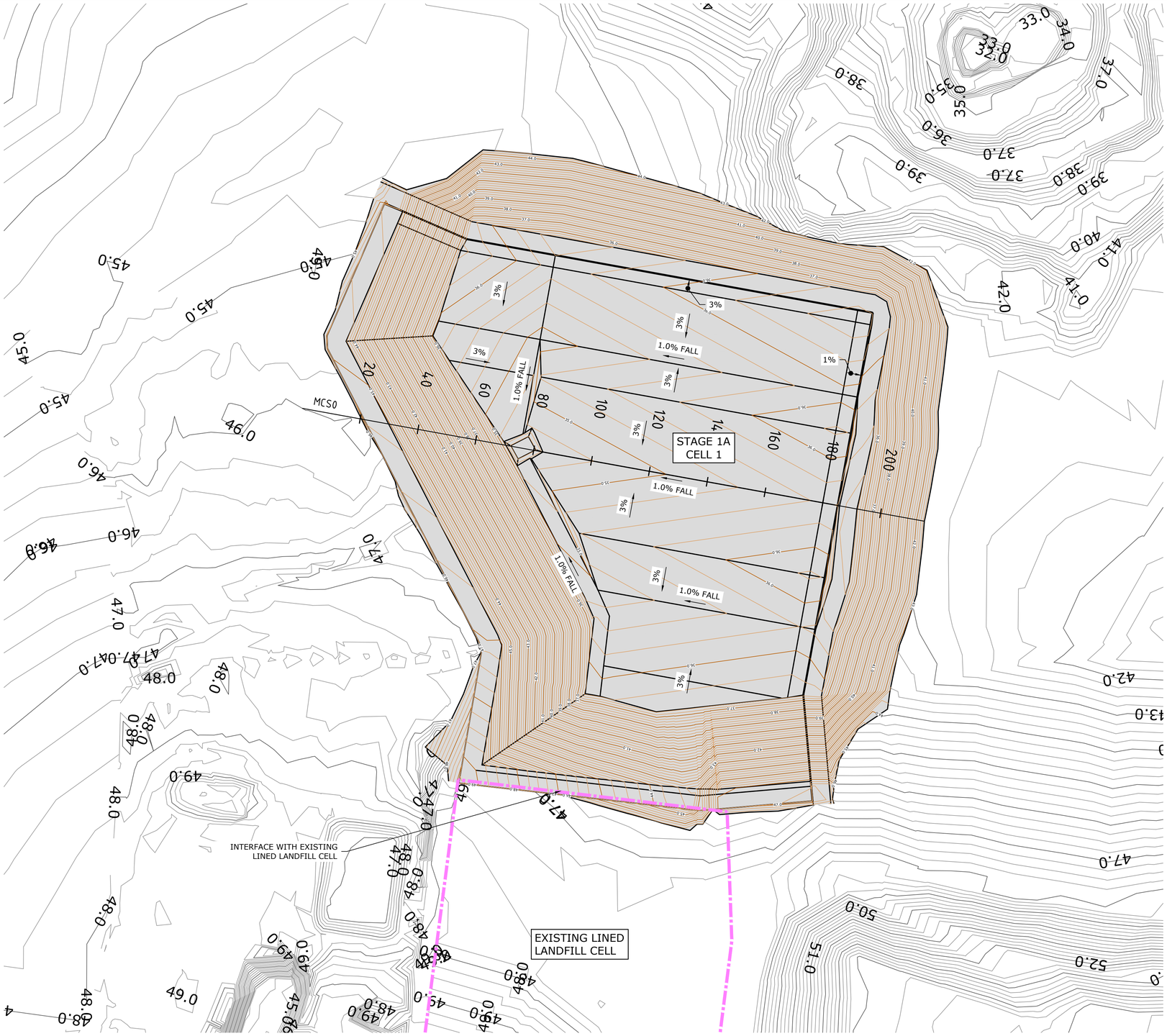

PLAN
SCALE 1:750

LEGEND

- 10.0 — SURVEY CONTOUR (MAJ 1.00m)
  SURVEY CONTOUR (MIN 0.25m)
- 10.00 — DESIGN SUBGRADE CONTOUR (MAJ 1.0m)
  DESIGN SUBGRADE CONTOUR (MIN 0.25m)
- EXISTING LINED LANDFILL CELL BOUNDARY

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.

0 7.5 15 30 45
1:750 (A1); 1:1500 (A3)

100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE
A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	ISSUED FOR APPROVAL	21.9.23	IN	JT
B	ISSUED FOR COMMENT	28.8.23	IN	JDT
A	ISSUED FOR PRELIMINARY	28.7.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: 1:750
SURVEYED:PRICE MERRET/MAW
SURVEY DATE:04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

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BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
DESIGN SUBGRADE - PLAN

FILENAME:	PROJECT NUMBER	DRAWING NUMBER	REVISION
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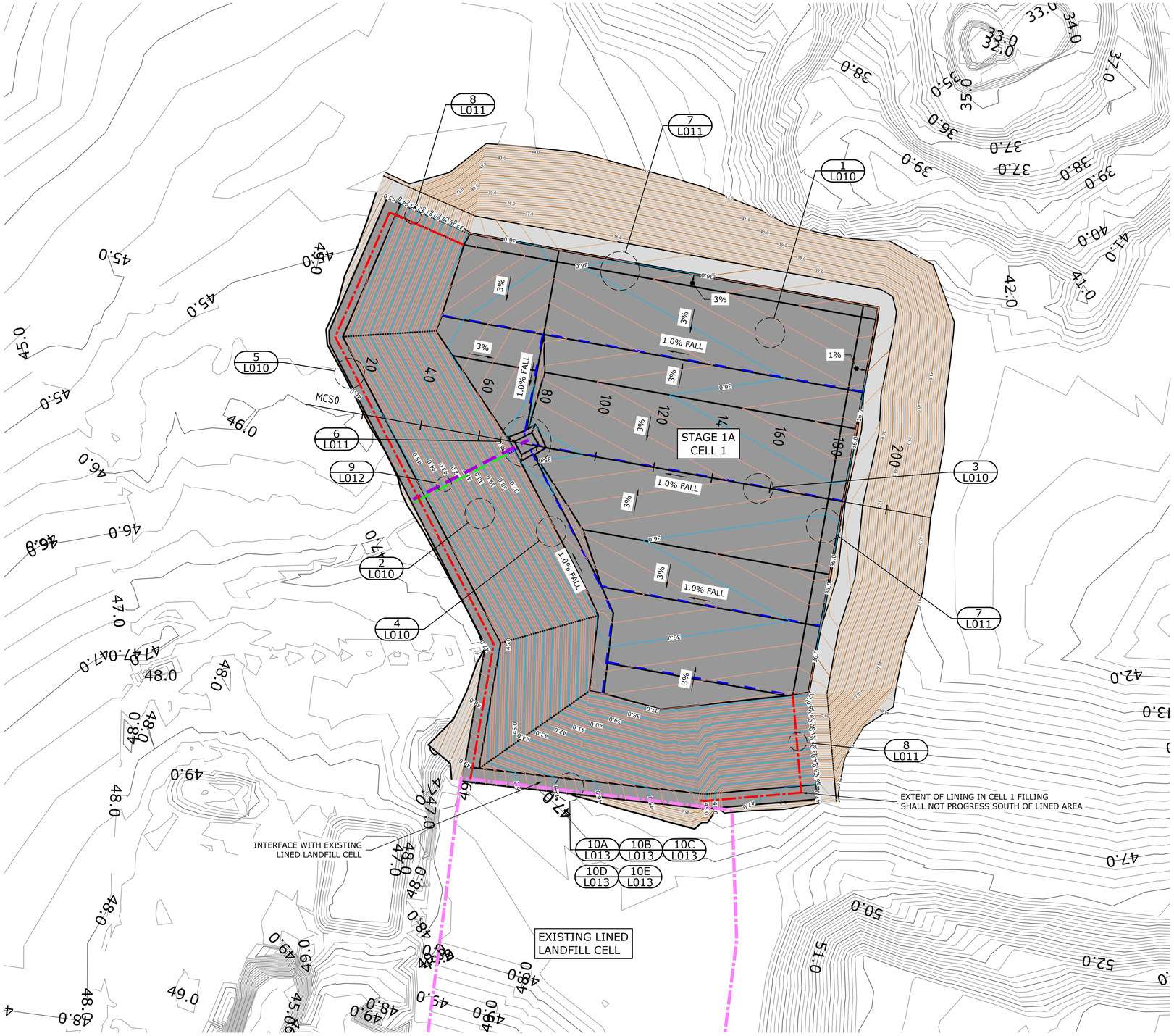
T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1_PLAN.DWG -S1AC1 SG- (21-09-23 4:20:24PM)



PLAN
SCALE 1:750

LEGEND

- SURVEY CONTOUR (MAJ 1.00m)
- SURVEY CONTOUR (MIN 0.25m)
- EXISTING LINED LANDFILL CELL BOUNDARY
- DESIGN SUBGRADE CONTOUR (MAJ 1.0m)
- DESIGN SUBGRADE CONTOUR (MIN 0.25m)
- DESIGN BASELINER CONTOUR (MAJ 1.0m)
- DESIGN BASELINER CONTOUR (MIN 0.25m)
- DN180 PERFORATED LEACHATE COLLECTION PIPE
- DN180 UNPERFORATED LEACHATE FLUSHING RISER
- DN630 LEACHATE EXTRACTION RISER
- ANCHOR TRENCH IN BASELINER

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.

0 7.5 15 30 45
1:750 (A1); 1:1500 (A3)
100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE
A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	ISSUED FOR APPROVAL	21.9.23	IN	JT
B	ISSUED FOR COMMENT	28.8.23	IN	JDT
A	ISSUED FOR PRELIMINARY	28.7.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: 1:750
SURVEYED:PRICE MERRET/MAW
SURVEY DATE:04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

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BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
DESIGN BASELINER - PLAN

FILENAME: 202597 BURONGA_S1A_CELL 1_PLAN.DWG
PROJECT NUMBER 202597
DRAWING NUMBER L004
REVISION C

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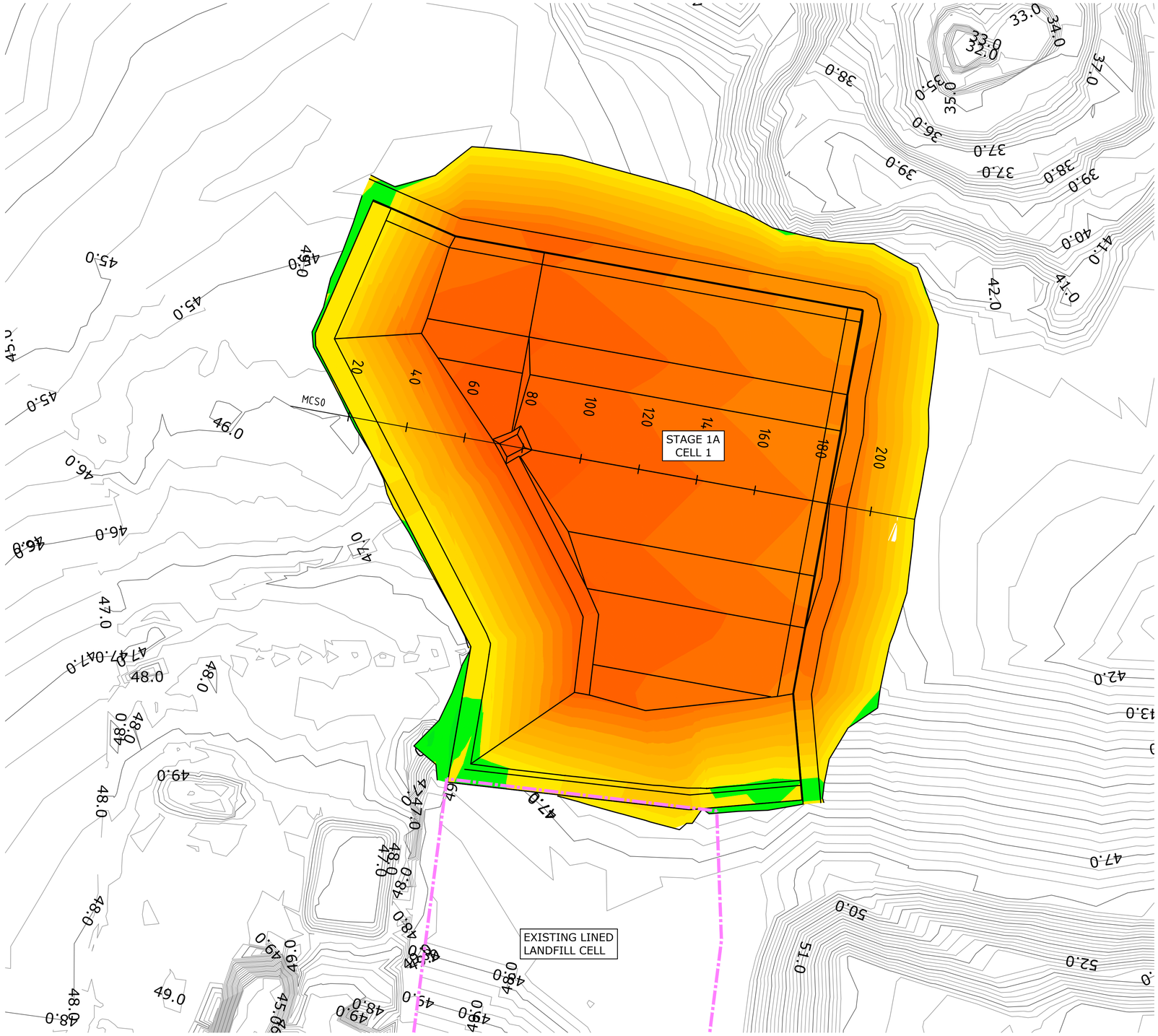

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-6	to	-5	m	
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4	to	5	m	
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11	to	12	m	
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13	to	14	m	
14	to	15	m	
15	to	300	m	

NOTES:

1. CUT/FILL ASSESSMENT BASED ON SUPPLIED SURVEY.

LEGEND

10.0 — SURVEY CONTOUR (MAJ 1.00m)
SURVEY CONTOUR (MIN 0.25m)
EXISTING LINED LANDFILL CELL BOUNDARY

PLAN
SCALE 1:750

0 7.5 15 30 45
1:750 (A1); 1:1500 (A3)
100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE
A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	ISSUED FOR APPROVAL	21.9.23	IN	JT
B	ISSUED FOR COMMENT	28.8.23	IN	JDT
A	ISSUED FOR PRELIMINARY	28.7.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: 1:750
SURVEYED:PRICE MERRET/MAW
SURVEY DATE:04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

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BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
ISOPACHTYE - SURVEY TO SUBGRADE

FILENAME:	PROJECT NUMBER	DRAWING NUMBER	REVISION
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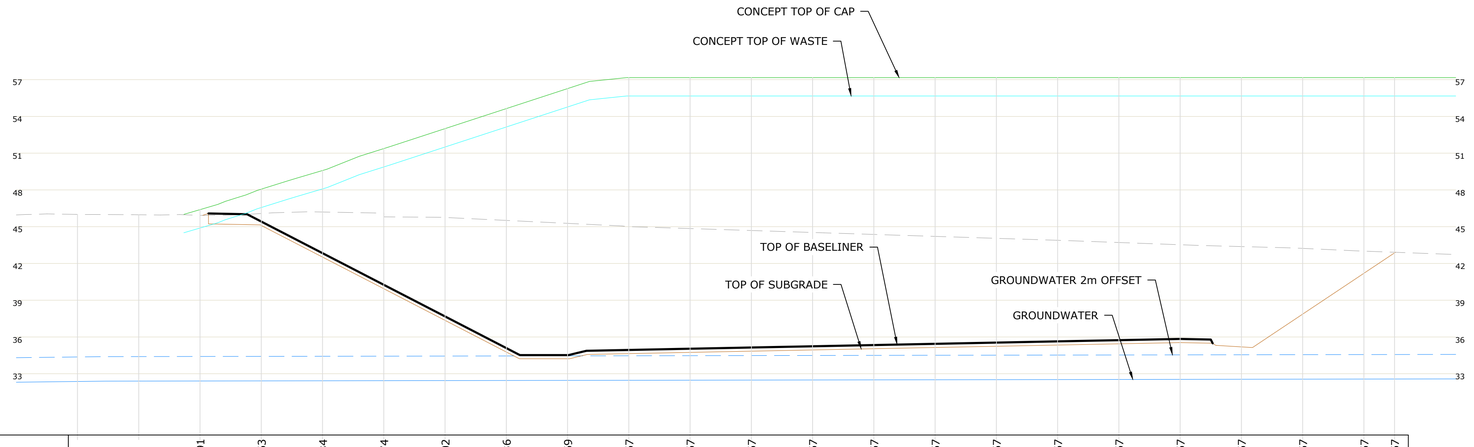
T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1_PLAN.DWG -S1AC1 ISO(1)- (21-09-23 4:20:23PM)



GRADE
DATUM: 28.00

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ToW (Concept)			44.891	46.563	48.084	49.874	51.502	53.136	54.769	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667	55.667
BASELINER				45.419	42.838	40.256	37.675	35.093	34.520	34.941	35.041	35.141	35.241	35.341	35.441	35.541	35.641	35.741	35.841											
SUBGRADE				45.101	42.519	39.937	37.355	34.773	34.220	34.641	34.741	34.841	34.941	35.041	35.141	35.241	35.341	35.441	35.541	35.189	37.865	41.199	42.865							
GROUNDWATER OFFSET 2.0m	34.369	34.400	34.409	34.417	34.425	34.433	34.441	34.450	34.458	34.466	34.474	34.482	34.491	34.499	34.507	34.515	34.523	34.532	34.540	34.548	34.556	34.564	34.568							
GROUNDWATER	32.369	32.400	32.409	32.417	32.425	32.433	32.441	32.450	32.458	32.466	32.474	32.482	32.491	32.499	32.507	32.515	32.523	32.532	32.540	32.548	32.556	32.564	32.568							
EXISTING SURVEY MERRET/MAW	46.000	45.973	45.920	46.074	46.198	46.113	45.752	45.512	45.272	45.001	44.848	44.688	44.528	44.368	44.209	44.049	43.889	43.709	43.527	43.377	43.230	43.005	42.913							
CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	215.000							

LONGITUDINAL PROFILE - MCS0

HORIZONTAL SCALE 1 : 500
VERTICAL SCALE 1 : 250

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.

0 5 10 20 30
1:500 (A1); 1:1000 (A3)

0 2.5 5 10 15
1:250 (A1); 1:500 (A3)

100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE
A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	ISSUED FOR APPROVAL	21.9.23	IN	JT
B	ISSUED FOR COMMENT	28.8.23	IN	JDT
A	ISSUED FOR PRELIMINARY	28.7.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: 1:500 HORIZ. 1:250 VERT.
SURVEYED:PRICE MERRET/MAW SURVEY DATE:04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

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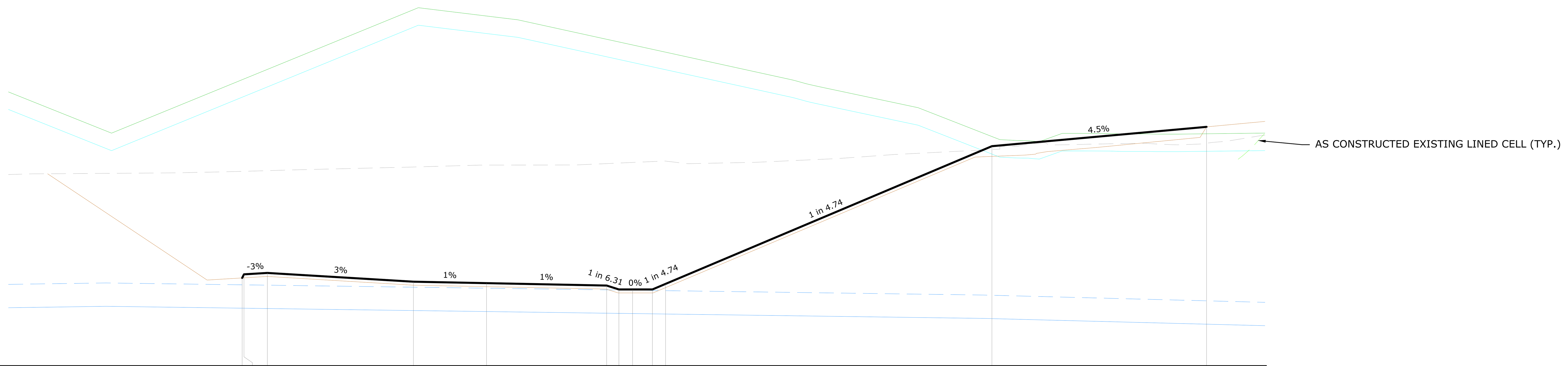
BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
LONGITUDINAL SECTION - MCS0

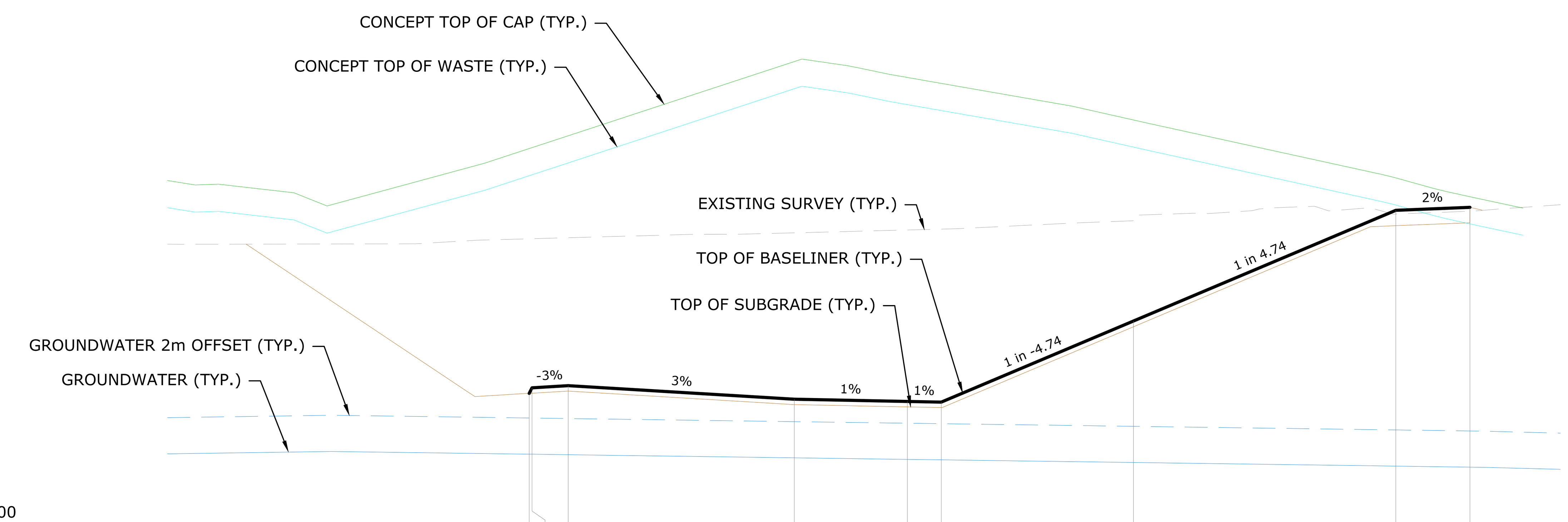
FILENAME: 202597 BURONGA_S1A_CELL 1__DETAILS.DWG
PROJECT NUMBER 202597
DRAWING NUMBER L006
REVISION C

T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1__DETAILS.DWG -S1AC1 LSECT(1)- (21-09-23 4:22:24PM)



BASELINER	35.503	35.812	35.932	35.182	35.057	34.852	34.520	34.520	34.520	34.994	46.784	48.440
SUBGRADE	35.503	35.512	35.632	34.882	34.757	34.534	34.220	34.220	34.220	34.673	45.911	48.440
GROUNDWATER 2m OFFSET	34.914	34.912	34.885	34.712	34.626	34.484	34.470	34.454	34.430	34.415	34.021	33.544
GROUNDWATER	32.914	32.912	32.885	32.712	32.626	32.484	32.470	32.454	32.430	32.415	32.021	31.544
EXISTING SURFACE	44.629	44.633	44.690	45.001	45.164	45.294	45.340	45.392	45.467	45.507	46.493	47.039
DESIGN OFFSET	-66.809	-66.500	-62.500	-37.500	-25.000	-4.435	-2.342	0.000	3.399	5.644	61.494	98.216

CH. 75.000



BASELINER	36.253	36.563	36.682	35.932	35.807	35.770	40.256	46.379	46.543
SUBGRADE	36.253	36.263	36.382	35.632	35.507	35.471	39.937	45.528	46.543
GROUNDWATER 2m OFFSET	34.894	34.892	34.864	34.692	34.606	34.580	34.433	34.233	34.177
GROUNDWATER	32.894	32.892	32.864	32.692	32.606	32.580	32.433	32.233	32.177
EXISTING SURFACE	44.802	44.807	44.861	45.132	45.290	45.337	46.113	46.170	46.332
DESIGN OFFSET	-66.809	-66.500	-62.500	-37.500	-25.000	-21.251	0.000	29.003	37.202

CH. 50.000

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0 5 10 20 30 — 1:500 (A1); 1:1000 (A3)

0 2.5 5 10 15 — 1:250 (A1); 1:500 (A3)

100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	ISSUED FOR APPROVAL	21.9.23	IN	JT
B	ISSUED FOR COMMENT	28.8.23	IN	JDT
A	ISSUED FOR PRELIMINARY	28.7.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: 1:500 HORIZ. 1:250 VERT.
SURVEYED: PRICE MERRET/MAW
SURVEY DATE: 04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

NOT FOR CONSTRUCTION

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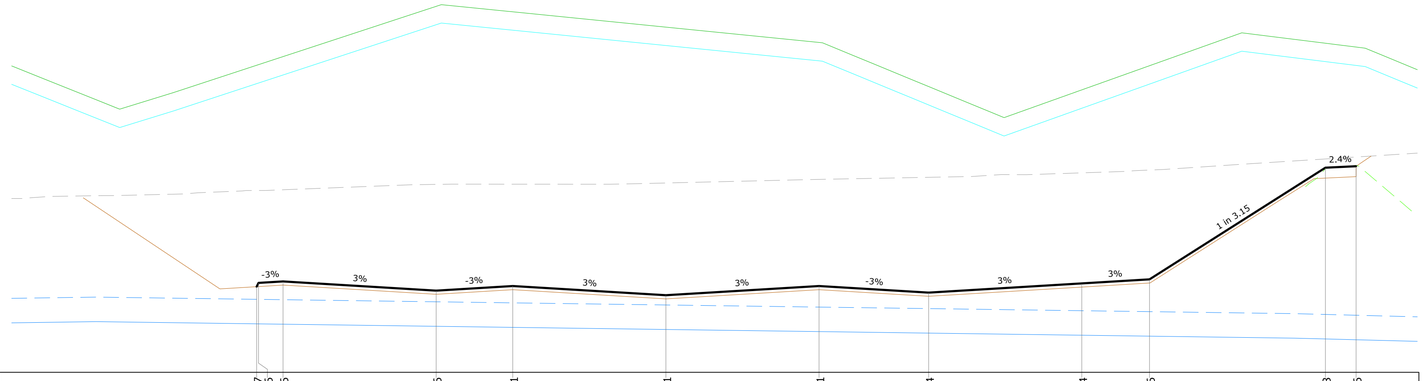
WENTWORTH SHIRE COUNCIL

BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
CROSS SECTIONS 1 OF 3

FILENAME: 202597 BURONGA_S1A_CELL 1__DETAILS.DWG
PROJECT NUMBER 202597 DRAWING NUMBER L007 REVISION C

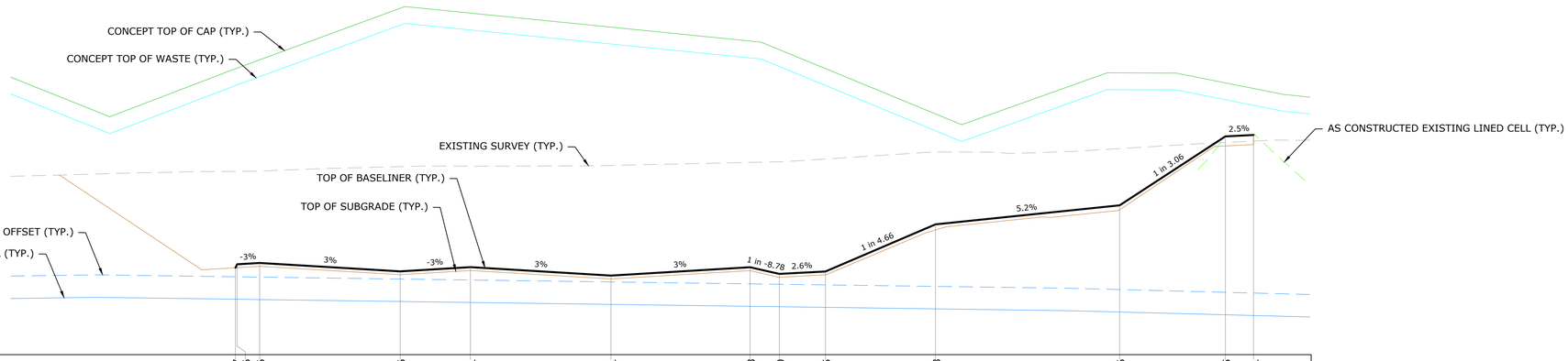
T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1__DETAILS.DWG -S1AC1 XSECT(1)- (21-09-23 4:22:27PM)



R.L. 29.000

BASELINER	35.987	35.296	36.416	35.666	36.041	35.291	36.041	35.504	36.254	36.586	45.698	45.816	
SUBGRADE	35.987	35.996	36.116	35.366	35.741	34.991	35.741	35.204	35.954	36.286	44.848	45.816	
GROUNDWATER 2m OFFSET	34.955	34.953	34.926	34.753	34.667	34.495	34.322	34.199	34.026	33.950	33.721	33.656	
GROUNDWATER	32.955	32.953	32.926	32.753	32.667	32.495	32.322	32.199	32.026	31.950	31.721	31.656	
EXISTING SURFACE	43.836	43.836	43.894	44.335	44.351	44.448	44.743	44.912	45.275	45.503	46.410	46.569	
DESIGN OFFSET	-66.809	-66.500	-62.500	-37.500	-25.000	0.000	25.000	42.895	67.895	78.948	107.664	112.675	

CH. 125.000



R.L. 28.000

BASELINER	35.737	36.046	36.166	35.416	35.791	35.041	35.783	35.190	35.405	39.603	41.296	47.435	47.561
SUBGRADE	35.737	35.746	35.866	35.116	35.491	34.741	35.483	34.889	35.105	39.101	40.905	46.585	47.561
GROUNDWATER 2m OFFSET	34.935	34.933	34.905	34.733	34.647	34.474	34.304	34.268	34.211	34.076	33.794	33.550	33.485
GROUNDWATER	32.935	32.933	32.905	32.733	32.647	32.474	32.304	32.268	32.211	32.076	31.794	31.550	31.485
EXISTING SURFACE	44.320	44.320	44.350	44.744	44.789	44.848	45.119	45.173	45.425	46.053	46.350	46.895	47.018
DESIGN OFFSET	-66.809	-66.500	-62.500	-37.500	-25.000	0.000	24.747	29.959	38.163	57.736	90.512	109.320	114.331

CH. 100.000

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.

0 5 10 20 30
1:500 (A1); 1:1000 (A3)

0 2.5 5 10 15
1:250 (A1); 1:500 (A3)

100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE
A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	ISSUED FOR APPROVAL	21.9.23	IN	JT
B	ISSUED FOR COMMENT	28.8.23	IN	JDT
A	ISSUED FOR PRELIMINARY	28.7.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: 1:500 HORIZ. 1:250 VERT.
SURVEYED:PRICE MERRET/MAW
SURVEY DATE:04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

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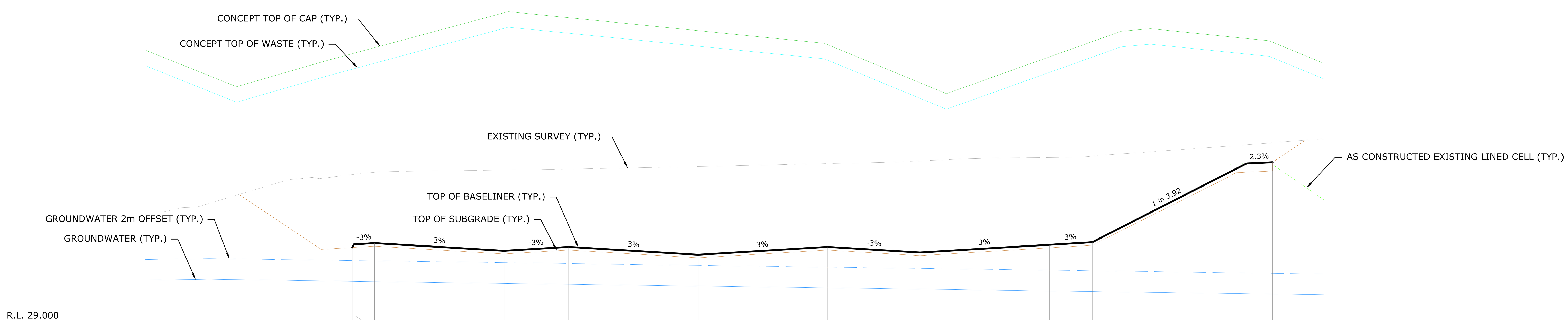
WENTWORTH SHIRE COUNCIL

BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
CROSS SECTIONS 2 OF 3

FILENAME: 202597 BURONGA_S1A_CELL 1__DETAILS.DWG
PROJECT NUMBER: 202597
DRAWING NUMBER: L008
REVISION: C

T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1__DETAILS.DWG -S1AC1 XSECT(2)- (21-09-23 4:22:28PM)



BASELINER	36.237	36.546	36.666	35.916	36.291	35.541	36.291	35.754	36.504	36.753	44.351	44.464
SUBGRADE	36.237	36.246	36.366	35.616	35.991	35.241	35.991	35.454	36.204	36.453	43.501	44.464
GROUNDWATER 2m OFFSET	34.976	34.974	34.946	34.774	34.688	34.515	34.343	34.219	34.047	33.990	33.784	33.750
GROUNDWATER	32.976	32.974	32.946	32.774	32.688	32.515	32.343	32.219	32.047	31.990	31.784	31.750
EXISTING SURFACE	43.270	43.291	43.493	43.709	43.804	44.049	44.340	44.596	44.926	45.053	46.159	46.348
DESIGN OFFSET	-66.809	-66.500	-62.500	-37.500	-25.000	0.000	25.000	42.895	67.895	76.188	106.009	111.020

CH. 150.000

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.

0 5 10 20 30
1:500 (A1); 1:1000 (A3)

0 2.5 5 10 15
1:250 (A1); 1:500 (A3)

100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE
A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	ISSUED FOR APPROVAL	21.9.23	IN	JT
B	ISSUED FOR COMMENT	28.8.23	IN	JDT
A	ISSUED FOR PRELIMINARY	28.7.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: 1:500 HORIZ. 1:250 VERT.
SURVEYED: PRICE MERRET/MAW
SURVEY DATE: 04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

NOT FOR CONSTRUCTION

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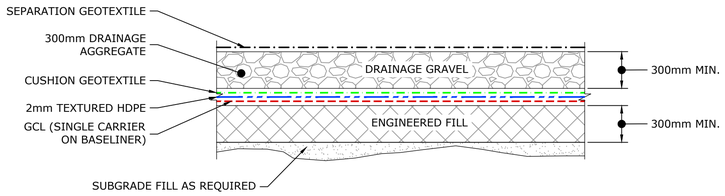
WENTWORTH SHIRE COUNCIL

BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
CROSS SECTIONS 3 OF 3

FILENAME: 202597 BURONGA_S1A_CELL 1__DETAILS.DWG

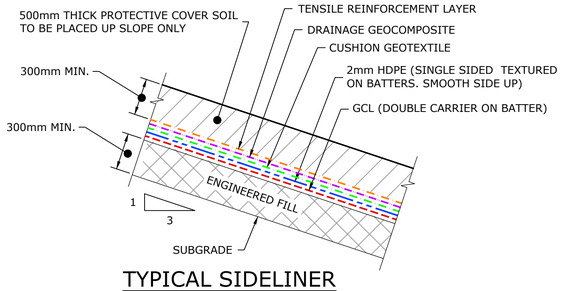
PROJECT NUMBER: 202597
DRAWING NUMBER: L009
REVISION: C

T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1__DETAILS.DWG -S1AC1 XSECT(3)- (21-09-23 4:22:29PM)



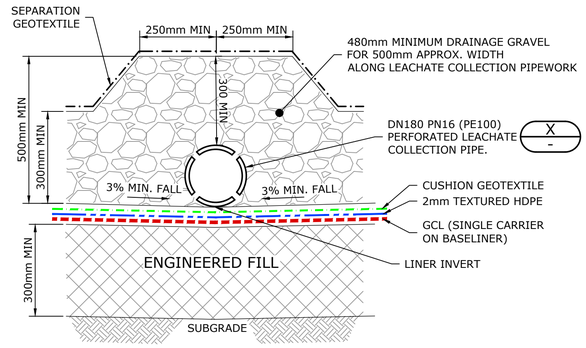
TYPICAL BASELINER

DETAIL 1 / L004
SCALE 1:25



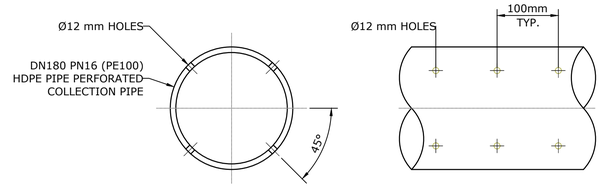
TYPICAL SIDELINER

DETAIL 2 / L004
SCALE 1:25



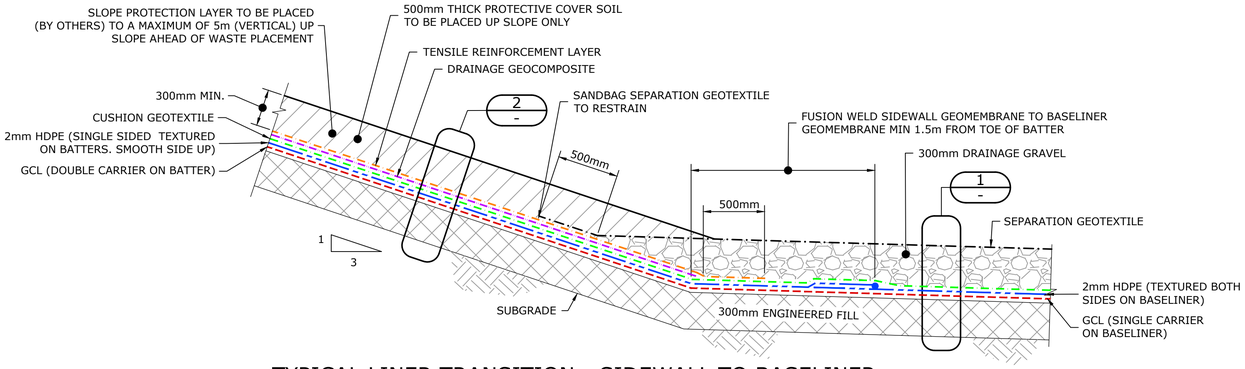
TYPICAL DN180 LEACHATE COLLECTION PIPE GRAVEL PLACEMENT

DETAIL 3 / L004
SCALE 1:10



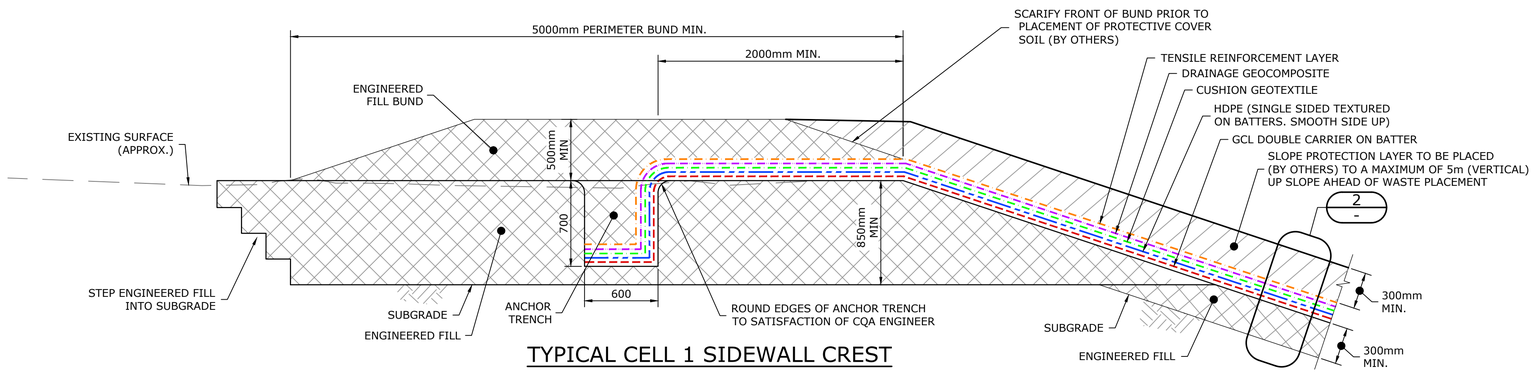
LEACHATE COLLECTION PIPE PERFORATION

DETAIL X / -
SCALE 1:5



TYPICAL LINER TRANSITION - SIDEWALL TO BASELINER

DETAIL 4 / L004
SCALE 1:25



TYPICAL CELL 1 SIDEWALL CREST

DETAIL 5 / L004
SCALE 1:25

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.

0 0.25 0.5 1.0 1.5
1:25 (A1); 1:50 (A3)

0 0.1 0.2 0.4 0.6
1:10 (A1); 1:20 (A3)

0 0.05 0.1 0.2 0.3
1:5 (A1); 1:10 (A3)

100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
C	ISSUED FOR APPROVAL	21.9.23	IN	JT
B	ISSUED FOR COMMENT	28.8.23	IN	JDT
A	ISSUED FOR PRELIMINARY	28.7.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: AS SHOWN
SURVEYED:PRICE MERRET/MAW
SURVEY DATE:04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

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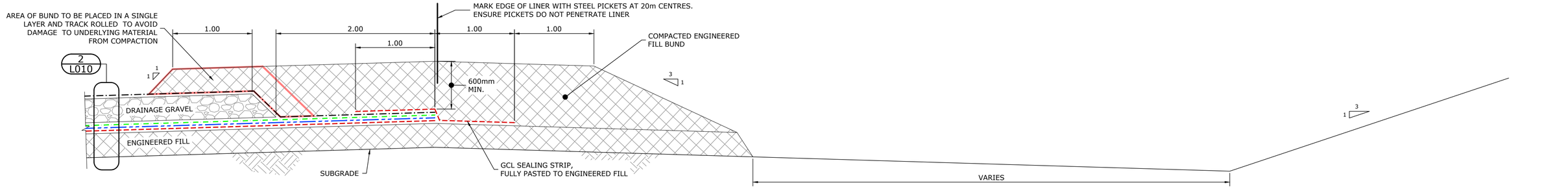
WENTWORTH SHIRE COUNCIL

BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
DETAILS - SHEET 1 OF 5

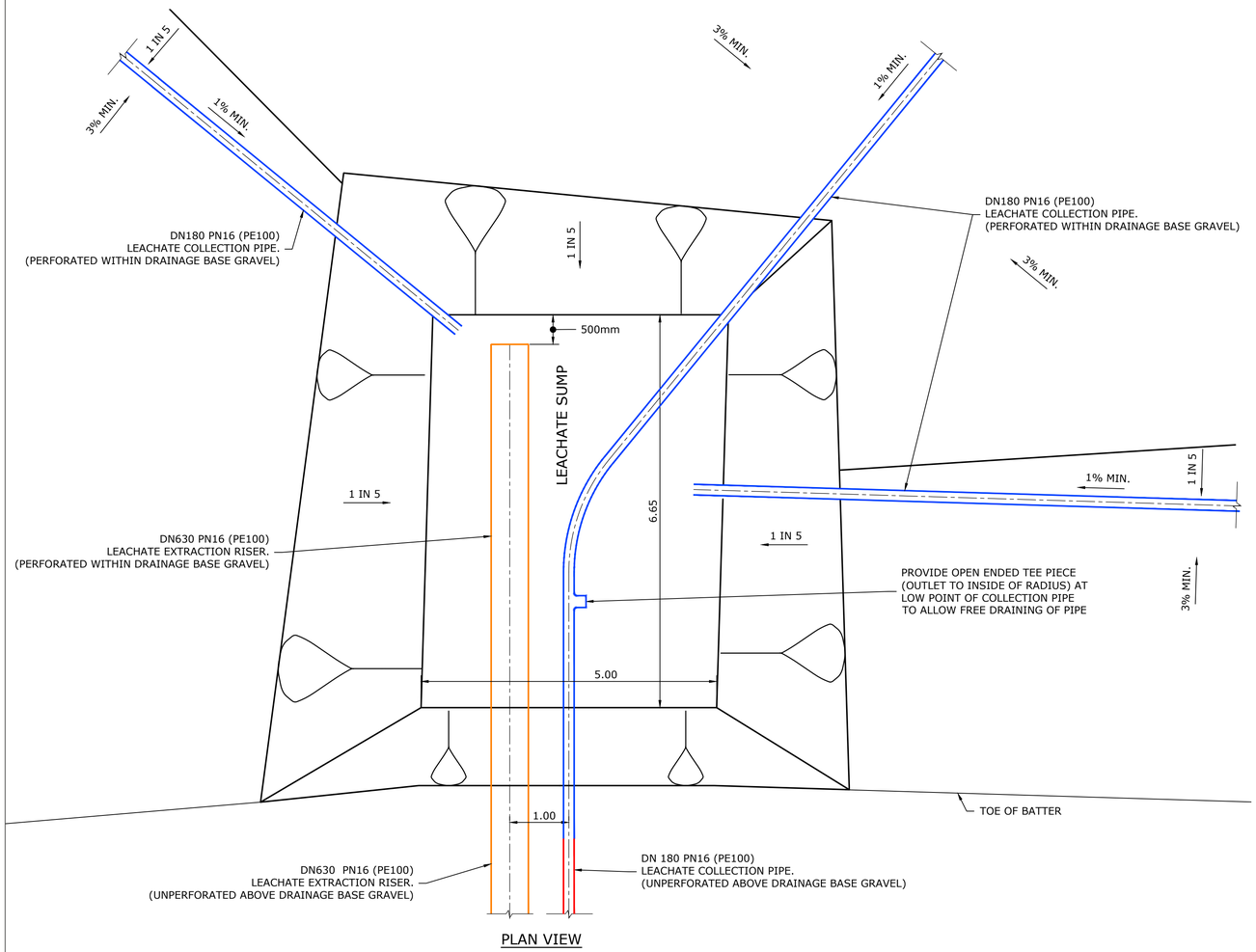
FILENAME: 202597 BURONGA_S1A_CELL 1__DETAILS.DWG
PROJECT NUMBER 202597
DRAWING NUMBER L010
REVISION C

T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1__DETAILS.DWG -S1AC1 DET(1)- (21-09-23 4:22:18PM)



TEMPORARY TERMINATION - FLOOR DETAIL

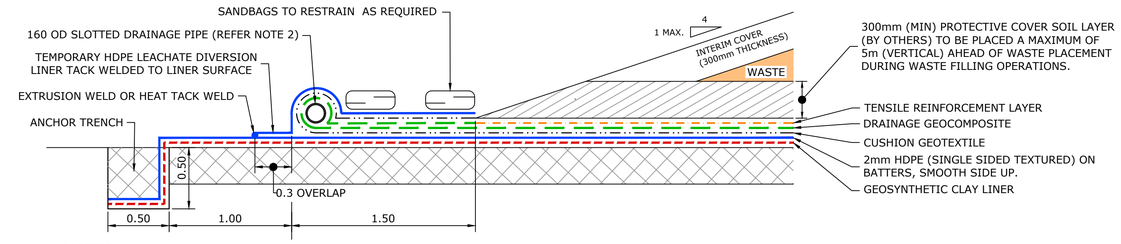
SCALE 1:25 — 7 / L004



PLAN VIEW

TYPICAL EDGE SUMP ARRANGEMENT

DETAIL — SCALE 1:50 — 6 / L004



NOTES:

1. DRAINAGE PIPE TO BE SLOTTED AG PIPE OR SIMILAR PRODUCT, AS APPROVED BY THE DESIGNER. DRAINAGE PIPE TO DRAIN INTO LEACHATE DRAINAGE AGGREGATE PERPENDICULARLY DOWNSLOPE FROM THE TEMPORARY LINER TERMINATION.
2. WHEN CONSTRUCTING THE INTERFACE BETWEEN THE SIDELINER TEMPORARY TERMINATION AND THE ANCHOR TRENCH AT THE CRESH OF THE SIDEWALL SLOPES, THE GEOSYNTHETIC LAYERS MUST SIT FLAT ACROSS THE BASE OF BOTH ANCHOR TRENCHES. THE ANCHOR TRENCH INTERSECTION MAY BE ROUNDED TO ENABLE THIS.
3. SURVEY INSIDE OF ANCHOR TRENCH BEFORE COVERING.

TEMPORARY TERMINATION - WALL DETAIL

SCALE 1:25 — 8 / L004

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.

0 0.5 1 2 3
1:50 (A1); 1:100 (A3)
100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
B	ISSUED FOR APPROVAL	21.9.23	IN	JT
A	ISSUED FOR COMMENT	28.8.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: AS SHOWN
SURVEYED:PRICE MERRET/MAW
SURVEY DATE:04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

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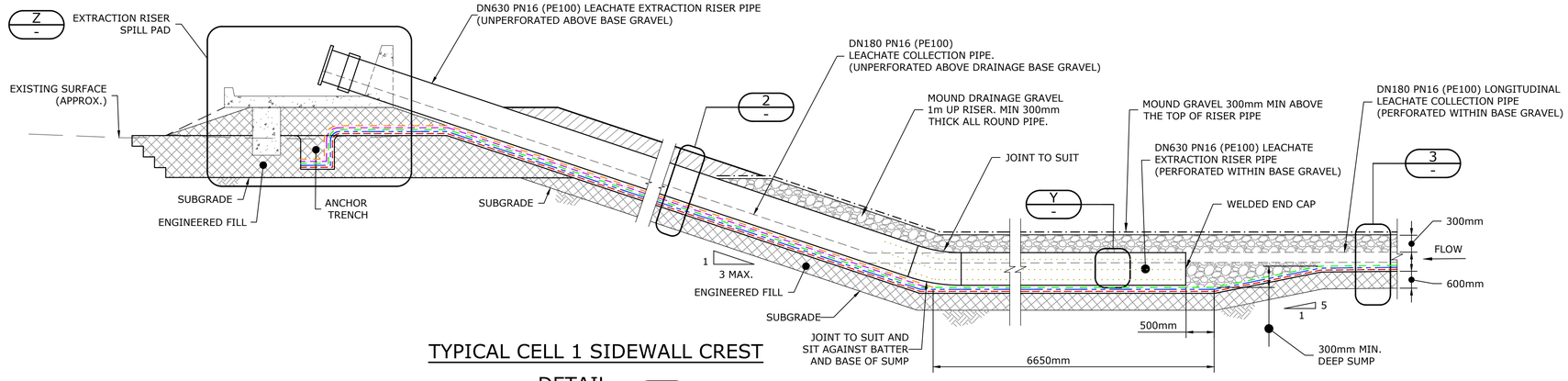
BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
DETAILS - SHEET 2 OF 5

FILENAME: 202597 BURONGA_S1A_CELL 1__DETAILS.DWG
PROJECT NUMBER 202597
DRAWING NUMBER L011
REVISION B

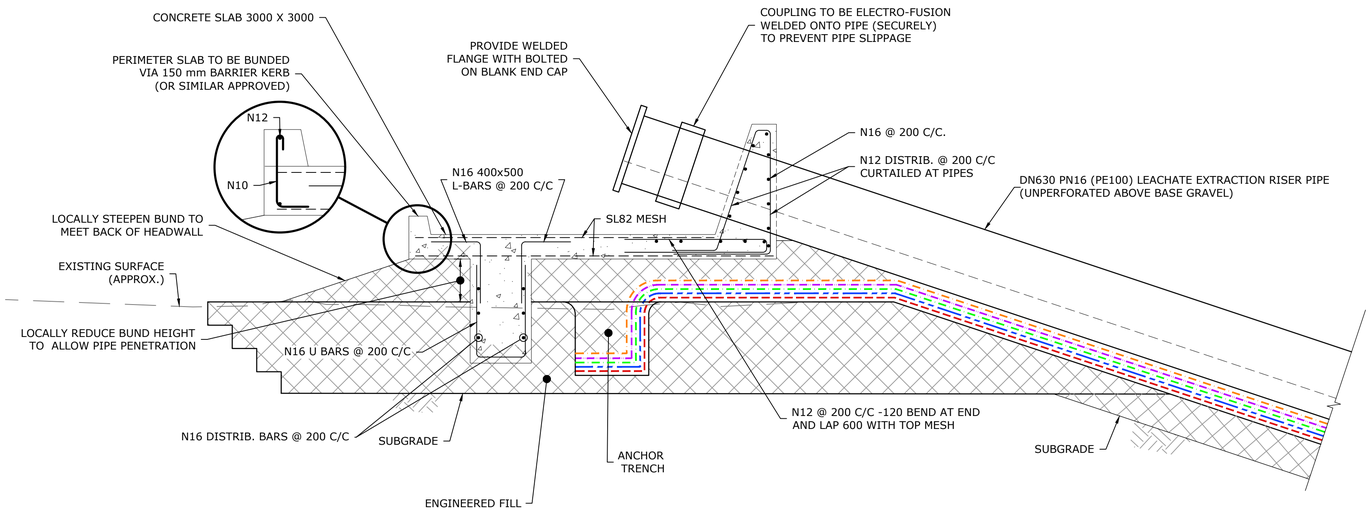
T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1__DETAILS.DWG -S1AC1 DET(2)- (21-09-23 4:22:20PM)



TYPICAL CELL 1 SIDEWALL CREST DETAIL

9 / L004

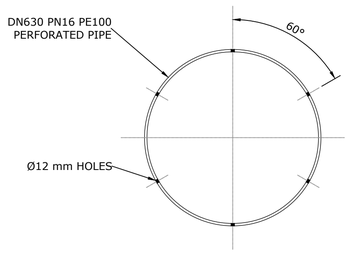
SCALE 1:50

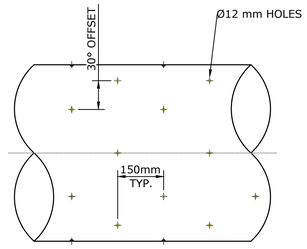


EXTRACTION RISER SPILL PAD DETAIL

Z / -

SCALE 1:25





LEACHATE EXTRACTION RISER PIPE PERFORATION DETAIL

Y / -

SCALE 1:10

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.

0 0.5 1 2 3 — 1:50 (A1); 1:100 (A3)

0 0.25 0.5 1.0 1.5 — 1:25 (A1); 1:50 (A3)

100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
B	ISSUED FOR APPROVAL	21.9.23	IN	JT
A	ISSUED FOR COMMENT	28.8.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: AS SHOWN
SURVEYED: PRICE MERRET/MAW
SURVEY DATE: 04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

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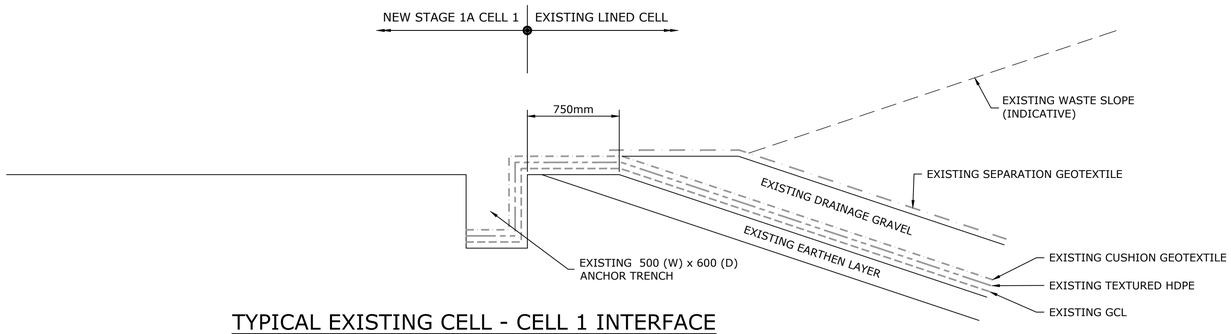
WENTWORTH SHIRE COUNCIL

BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
DETAILS - SHEET 3 OF 5

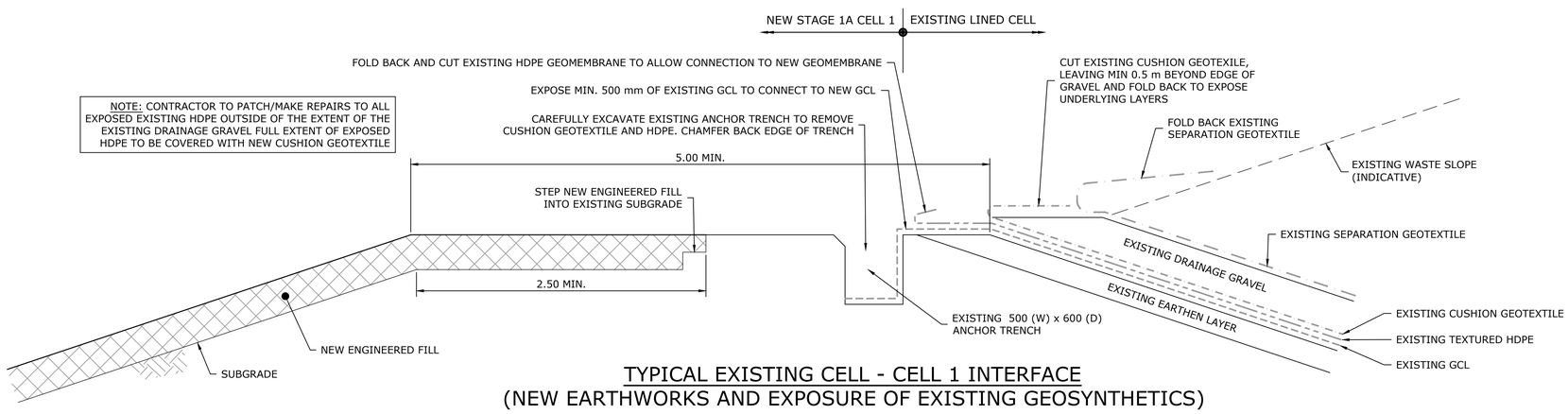
FILENAME:	PROJECT NUMBER	DRAWING NUMBER	REVISION
202597 BURONGA_S1A_CELL 1__DETAILS.DWG	202597	L012	B

T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1__DETAILS.DWG -S1AC1 DET(3)- (21-09-23 4:22:22PM)



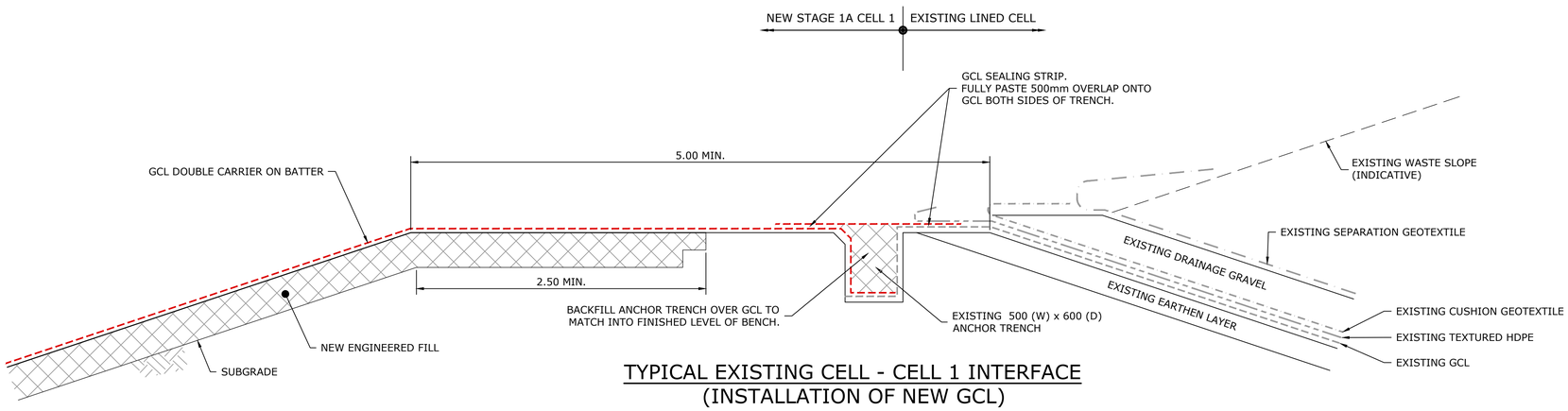
TYPICAL EXISTING CELL - CELL 1 INTERFACE
(EXISTING CONDITION)

DETAIL 10A L004
SCALE 1:25



TYPICAL EXISTING CELL - CELL 1 INTERFACE
(NEW EARTHWORKS AND EXPOSURE OF EXISTING GEOSYNTHETICS)

DETAIL 10B L004
SCALE 1:25



TYPICAL EXISTING CELL - CELL 1 INTERFACE
(INSTALLATION OF NEW GCL)

DETAIL 10C L004
SCALE 1:25

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.

0 0.25 0.5 1.0 1.5
1:25 (A1); 1:50 (A3)
100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
B	ISSUED FOR APPROVAL	21.9.23	IN	JT
A	ISSUED FOR COMMENT	28.8.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: AS SHOWN
SURVEYED: PRICE MERRET/MAW
SURVEY DATE: 04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

NOT FOR CONSTRUCTION

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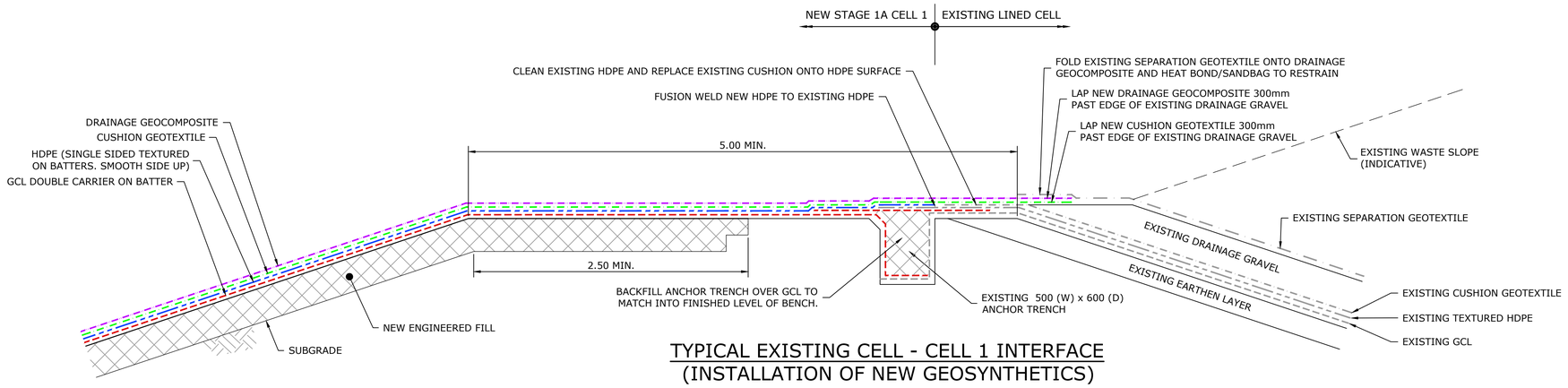
WENTWORTH SHIRE COUNCIL

BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
DETAILS - SHEET 4 OF 5

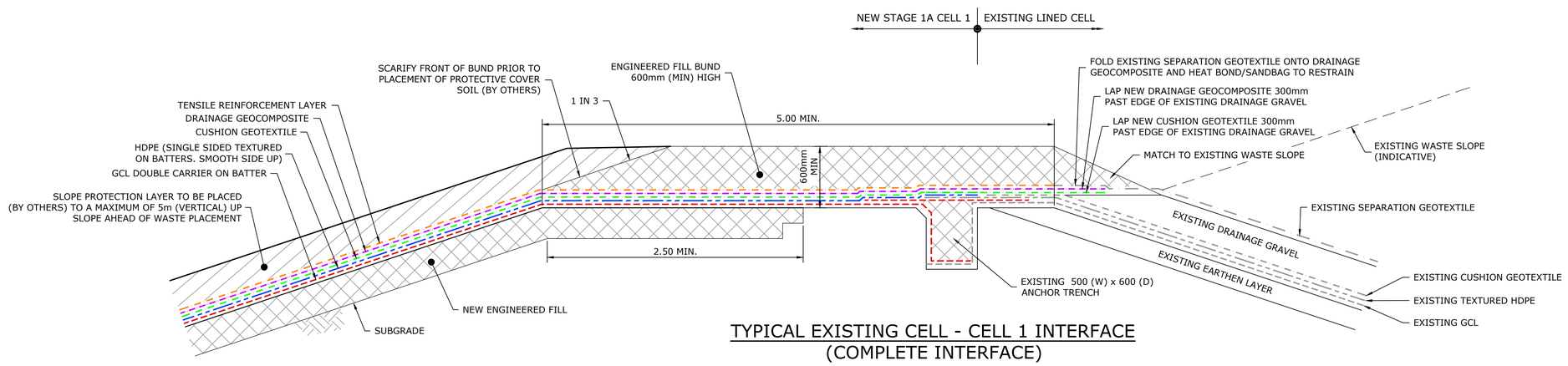
FILENAME: 202597 BURONGA_S1A_CELL 1__DETAILS.DWG
PROJECT NUMBER 202597
DRAWING NUMBER L013
REVISION B

T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1__DETAILS.DWG -S1AC1 DET(4)- (21-09-23 4:22:23PM)



TYPICAL EXISTING CELL - CELL 1 INTERFACE
(INSTALLATION OF NEW GEOSYNTHETICS)

DETAIL 10D L004
SCALE 1:25



TYPICAL EXISTING CELL - CELL 1 INTERFACE
(COMPLETE INTERFACE)

DETAIL 10E L004
SCALE 1:25

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.

0 0.25 0.5 1.0 1.5
1:25 (A1); 1:50 (A3)
100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

SHEET SIZE A1

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.
B	ISSUED FOR APPROVAL	21.9.23	IN	JT
A	ISSUED FOR COMMENT	28.8.23	IN	JDT

COORDS: MGA94 ZONE 54
DATUM: ALL LEVELS TO A.H.D.
SCALE: AS SHOWN
SURVEYED:PRICE MERRET/MAW
SURVEY DATE:04.03.21
APPROVED / PROJECT LEADER
ANDREW SEATON-STEWART

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WENTWORTH SHIRE COUNCIL

BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
DETAILS - SHEET 5 OF 5

FILENAME: 202597 BURONGA_S1A_CELL 1__DETAILS.DWG
PROJECT NUMBER 202597
DRAWING NUMBER L014
REVISION B

T:\2020\202597 BURONGA LANDFILL EXPANSION - WENTWORTH SHIRE COUNCIL\4_WORKING\1 CAD\CELL DESIGN STG 1A - CELL 1\202597 BURONGA_S1A_CELL 1__DETAILS.DWG -S1AC1 DET(5)- (21-09-23 4:22:24PM)

Location Address:	Buronga Landfill, Wentworth, NSW	
PROJECT OR DESIGN ELEMENT:	Client	Project Number/Location Code:
Landfill Stage 1A Cell 1	Wentworth Shire Council	202597

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. Principal; Principal to make safe waste slopes where required by Contractor.	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
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 Principal Principal to remove waste from earthworks areas prior to construction. Principal to cut waste slopes back to a maximum grade of 1:3 where slopes exceed 1:3	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
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 Principal Principal to approve contractor WHS plan and ensure obligations fulfilled. Principal to ensure that waste is removed from interface area prior to construction and that waste batter slopes is stable and cut to a maximum grade of 1:3.	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 assosciated 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

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

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*

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.

SHEET SIZE A1

100mm ON ORIGINAL DRAWING - DO NOT SCALE DRAWING

COORDS: MGA94 ZONE 54
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BURONGA LANDFILL EXPANSION
STAGE 1A - CELL 1 DESIGN
SAFETY IN DESIGN

FILENAME: 202597 BURONGA_S1A_CELL 1__DETAILS.DWG
PROJECT NUMBER 202597 | DRAWING NUMBER L015 | REVISION B

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