



Technical Specification

Shoal Bay Waste Disposal Site Stage 7 Landfill Cell

Prepared for: City of Darwin
4 July 2025
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1. General

1.1 Scope of Specification

This Technical Specification is for the construction of Shoal Bay Waste Disposal Site Stage 7 Landfill Cell and includes the requirements for materials and procedures to be implemented during the works.

Where terminology in this specification is inconsistent, the Contractor shall refer to the order of precedence of documents as outlined in the Contract documents.

At all times this Specification will be considered as the minimum standards to apply. If there are conflicts between the Specification and the Drawings, the Drawings shall take precedence.

1.2 Definitions

The following terms used in this Specification shall have the meanings ascribed to them below unless the context otherwise requires:

Table 1–1 Definitions

Terms	Definitions
Contract	The agreement between the Principal and Contractor
Model	12d design model provided to the contractor to undertake the works
Drawings	The construction drawings which form part of the Contract Documents
NTEPA	Northern Territory Environment Protection Authority
Contract Documents	The documents which form the Contract
Construction Quality Assurance (CQA) Plan	Plan forming part of the Contract Documents, describing the construction quality assurance requirements for the Works
ENM	Excavated natural material. As defined in the NSW EPA excavated natural material exemption 2014 (http://www.epa.nsw.gov.au/resources/waste/rre14-excavated-natural-material.pdf)
Geosynthetic	Synthetic material (man-made plastic and fabric) used in geotechnical and construction applications
Geosynthetic Installer	Firm subcontracted by the Contractor to complete the installation of geosynthetic for the Works
MARV	Minimum average roll value calculated as per <i>GRI White Paper #10 The Dual Roles for Using MARV</i> (http://www.geosynthetic-institute.org/papers/paper10.pdf)
MaxARV	Maximum average roll value calculated as per <i>GRI White Paper #10 The Dual Roles for Using MARV</i> (http://www.geosynthetic-institute.org/papers/paper10.pdf)
Site	The area as defined by Environmental Protection Licence (EPL188)
Specification	This document
PE	Polyethylene

Terms	Definitions
VENM	Virgin excavated natural material. As defined in Schedule 1 of the <i>Protection of the Environment Operations Act 1997</i>
Work under the Contract	The work which the Contractor is or may be required to execute under the Contract and includes variations, remedial work, constructional plant and temporary works
Works	The whole of the work to be executed in accordance with the Contract, including variations provided for by the Contract, which by the Contract is to be handed over to the Principal

1.3 Roles

The following describes the roles and responsibilities as required under this technical specification.

Table 1–2: Project Roles

Role	Description
Contractor	As defined under the head contract including any designated party
Contractor's Geotechnical Consultant	The Contractor's Geotechnical Consultant shall be an independent Geotechnical Inspection and Testing Authority (GITA) organization, as defined in AS 3798 which is registered with the National Association of Testing Authorities (NATA) engaged by the Contractor for the inspection, testing, and reporting on the earthworks and other relevant works including requirements of this specification and the CQAP
Contractor's Independent Testing Firm	Independent testing firm(s) engaged by the Contractor to conduct construction quality control (CQC) testing and other testing as outlined in this Specification, which is registered with the National Association of Testing Authorities (NATA).
CQA Consultant	The Construction Quality Assurance (CQA) Consultant shall be an independent consultant, engaged by the Principal, who will review and monitor CQA progress and prepare a CQA report (also referred to as a validation report). The CQA Consultant may appoint CQA monitors to observe the works on behalf of the CQA Consultant
Construction Quality Assurance (CQA) Engineer's Independent Testing Firm	Independent testing firm(s) engaged by the CQA Consultant to conduct construction quality assurance testing
Designer's Representative (Designer)	SMEC Australia
Geosynthetics Installer	The firm responsible for the installation of any geosynthetics, including all field construction quality control activities, including (but not limited to) field seam testing, and any requirements of this specification and the CQAP. The Geosynthetics Installer shall be a sub-contractor to the Contractor, or shall be the Contractor.
Leak Location Contractor	Contractor engaged by the CQA Consultant to conduct an electrical leak location survey to detect leaks in the PE geomembrane
Principal	As defined under the head contract including any designated party. The Principal for the Purposes of this Specification is "City of Darwin" and may also be referred to as "Council" in the Contract Documents (including this Technical Specification) and therefore also referred to as the Principal.

Principal's Authorised Person	Party appointed by the Principal responsible for the administration of the construction contract
Principal's Geotechnical Consultant	If required, the Principal may appoint an independent Geotechnical Inspection and Testing Authority (GITA) Organization, as defined in AS 3798 which is registered with the National Association of Testing Authorities (NATA), or suitably qualified Geotechnical Engineer, to undertake any works as required
Principal's Registered Surveyor	If required, the Principal may appoint a Surveyor Registered in the Northern Territory
Registered Surveyor	A Registered Surveyor shall be engaged by the Contractor. All survey required under the Contract documents shall be undertaken by a Surveyor Registered in the Northern Territory
Regulatory Authority	Northern Territory Environment Protection Authority (NT EPA)
Seaming Crew	Crew responsible for the seaming activities performed by the Geosynthetic Installer, as defined by the Contractor

1.4 Materials

The Contractor shall be responsible for the sourcing, delivery, storage, preparation, handling and installation of all materials, except as modified in individual sections of this Specification.

Material and installation specifications are included in the individual sections of this Specification for each material type.

Any material imported as part of the Contractor's temporary works that is not incorporated within contracted works shall be removed from site by the Contractor progressively and at completion of the works.

1.5 Drawing List

The following drawings shall be referenced in conjunction with this technical specification and form part of the contract documents.

Table 1-3: Drawing list

Drawing no.	Drawing Name	Revision	Date
30080140-101	COVER SHEET	D	15/05/2025
30080140-102	DRAWING LIST AND LOCALITY PLAN	D	15/05/2025
30080140-103	EXISTING SITE PLAN	D	15/05/2025
30080140-105	GENERAL ARRANGEMENT PLAN	D	15/05/2025
30080140-106	STORMWATER MANAGEMENT PLAN	C	15/05/2025
30080140-111	BULK EARTHWORKS CUT/FILL PLAN	D	15/05/2025
30080140-112	GROUNDWATER DEPRESSURISATION PLAN	C	15/05/2025
30080140-113	TOP OF SELECT FILL PLAN	C	15/05/2025
30080140-114	LEACHATE COLLECTION SYSTEM PLAN	C	15/05/2025
30080140-115	FINISHED SURFACE PLAN	C	15/05/2025

Drawing no.	Drawing Name	Revision	Date
30080140-116	LEACHATE RISER PIPELINE PLAN & SECTION	C	15/05/2025
30080140-121	SITE SECTION SHEET 1 OF 4	D	15/05/2025
30080140-122	SITE SECTION SHEET 2 OF 4	D	15/05/2025
30080140-123	SITE SECTION SHEET 3 OF 4	C	15/05/2025
30080140-124	SITE SECTION SHEET 4 OF 4	C	15/05/2025
30080140-131	TYPICAL DETAILS SHEET 1 OF 3	D	15/05/2025
30080140-132	TYPICAL DETAILS SHEET 2 OF 3	C	15/05/2025
30080140-133	TYPICAL DETAILS SHEET 3 OF 3	B	15/05/2025

1.6 Adjacent Activities

The Contractor shall note the following adjacent activities which will occur at the site during the Works:

- Landfill and waste transfer station operations
- Public access to landfill and resource recovery operations
- Weighbridge operations
- Explosive ordinance burial pit operations
- Leachate collection and disposal
- Gas capture, sampling, reticulation and power generation
- Stormwater and leachate and management
- Any other works as required by Council or regulatory agencies for the maintenance or environmental management of the site.

The Contractor shall be responsible for the planning and construction of the Works to ensure that these activities are not interrupted by the Contractor's operations.

1.7 Environmental Protection Licence

The site is licensed under Environment Protection Licence (EPL 188, dated 1 July 2021). The Contractor shall undertake all Works at the site in accordance with the conditions of the Environment Protection Licence. The Contractor is to be responsible for any breaches of the licence during the construction works, associated with their construction works.

1.8 Relevant Planning Matters

In addition to the EPL (Section 1.7), in performing works under this contract, the Contractor is to satisfy conditions under the following documents:

- Environment Protection Approval 304
- Environment Protection Approval 321
- Waste Management and Pollution Control Act (WMPC Act).

1.9 Permits and Licences

The Contractor shall obtain all permits, licences and approvals required for the execution of the Works from the relevant Statutory Authorities. The Contractor shall be responsible for liaison with the Authorities as necessary throughout the Works. The Contractor is responsible for any development consent if required.

1.10 Construction Program

The Contractor shall provide a Construction Program, which satisfies the requirements provided herein.

The Works shall be undertaken progressively and in a staged manner in order to satisfy all Contractual obligations including those under the EPL. The Construction Program shall be accepted by the Principal's Authorised Person prior to undertaking the Works and the Contractor shall provide the Principal's Authorised Person with an electronic copy of the proposed and final Construction Program.

The Principal's Authorised Person may require the Construction Program be amended at any time and may direct that the Contractor complete work in one section before commencing work in another section of the site. The Contractor shall co-ordinate their activities with other Contractors, authorities or Principal employees/representatives who may be working at the site.

It shall be the responsibility of the Contractor to co-ordinate the activities of all subcontractors appointed by the Contractor and service authorities onsite.

The Construction Program shall be such that the Contractor's intentions and sequence of work are clearly defined and it shall show all significant activities for the completion of the Works including:

- Works undertaken by subcontractors appointed by the Contractor
- The supply of critically required drawings or information by the Principal (or Principal's Authorised Person)
- Approvals required from all relevant authorities
- Provision and approval of shop drawings/submittals
- Supply of major plant
- All staging of Works in sufficient detail demonstrating how earthworks and other activities will be undertaken so as to not impact on water quality discharges from the site.

Each fortnight the Construction Program shall be analysed in the light of the progress of the Works. The Contractor shall assist with all relevant information in keeping the Construction Program up to date. Where the Principal's Authorised Person so directs, the Contractor shall revise, redraw and represent the Construction Program to show his remaining activities between the date of review and the date of project completion.

1.11 Meetings

1.11.1 Start-up workshop

Prior to the start of the Works, the Principal's Authorised Person will arrange a start-up workshop. This meeting will be attended by the Contractor and his major subcontractors, the Principal and other parties the Principal may elect to attend. The purpose of the meeting is to acquaint the Contractor with the Principal's administrative requirements and policies, to give emphasis to those Contract requirements considered most essential, to introduce the Principal's Authorised Person and Contractor personnel, to reach agreement on the timing and method of all procedures related to the efficient progress of the Works, and to discuss any other items that may require clarification. The procedures for distribution of all correspondence and documents related to the Contract will also be established.

1.11.2 Progress meetings

Progress meetings will be held on an ongoing basis at a time and location to be established by the Principal's Authorised Person to discuss the progress and execution of the Work. The Contractor and any sub-contractors,

suppliers, or vendors whose presence is necessary or requested shall attend these meetings. All decisions, instructions and interpretations given by the Principal's Authorised Person at these meetings shall be binding and final. The proceedings of these meetings shall be recorded by the Principal's Authorised Person, and the Contractor will be furnished copies for his use.

Meetings may be required more frequently during bulk earthworks. Upon completion of the subgrade layer (cell) meetings shall be conducted on a weekly basis. Special meetings shall be conducted as necessary to resolve specific issues that arise during construction.

1.12 Submittals

During the pre-construction conference, the Contractor shall provide for the Principal's Authorised Person's review a complete listing of all anticipated Contractor submittals and the proposed submittal dates for each. The Contractor shall indicate items as shop drawings, compliance certificates, quality control/quality assurance documentation and test samples, material samples, guarantees, or any other documentation as requested by the Principal's Authorised Person.

All submittals should include the relevant information and of sufficient detail to verify compliance with all requirements of this Specification.

1.13 Construction Quality Control

Construction quality control (CQC) shall consist of appropriate field testing and verification, manufacturer's certification and quality control testing at the manufacturing plant or by an appropriately certified independent third party to ensure that all Works comply with the Contract Documents.

The Contractor is solely responsible for undertaking CQC testing and shall provide a Works- specific CQC plan to the Principal's Authorised Person for review.

The CQC plan shall demonstrate how construction will occur and the methods by which the materials will be supplied, placed and tested to ensure compliance with this the Contract Documents.

Works shall not commence until the CQC plan has been accepted by the Principal's Authorised Person.

All CQC testing shall be arranged by the Contractor and shall be carried out by appropriately qualified personnel.

Copies of all test results shall be sent to the Principal's Authorised Person within two days of becoming available to the Contractor. The minimum testing frequencies shall be as nominated within the various parts of the Specification.

At any stage throughout the Works, the Principal's Authorised Person may arrange for independent testing or surveying to be carried out. If that testing reveals that any Works are found to be not compliant with the Contract, the Contractor shall undertake rectification of the non-compliant items and conduct retesting in accordance with the Contract with all costs of original testing and rectification borne by the Contractor.

1.14 Construction Quality Assurance

A Construction Quality Assurance (CQA) Plan has been developed in conjunction with this Specification and shall be implemented by the Principal's Authorised Person to verify that the Works are undertaken in a manner that meets the requirements of the Contract Documents.

The Principal's Authorised Person shall engage an independent organisation (the CQA Consultant), under contract to the Principal, who shall facilitate the requirements of the CQA Plan. This shall include independent CQA monitoring, observation, testing and documentation on behalf of the Principal.

The Contractor shall cooperate fully with the Principal's Authorised Person and all representatives of the CQA Consultant during any independent CQA sampling, testing, and certification and shall ensure, at all times, safe access to the Works for the purpose of monitoring, observation, and CQA implementation. This shall include sampling of geosynthetic materials by the Geosynthetic Installer under the supervision of the CQA Consultant. The Contractor is to allow for supply of all materials required for the testing regime noted in the CQA Plan.

1.14.1 Independent Conformance Testing

The CQA Consultant shall arrange for independent conformance testing of the materials used in the Works, in accordance with the CQA Plan, to assure conformance with this Specification.

Samples shall be collected at locations designated by the CQA Consultant and all independent conformance sampling shall be witnessed by the CQA Consultant. Where sampling of geosynthetics is necessary, the sampling shall be undertaken by the Geosynthetic Installer from the relevant materials for the independent conformance testing of the material. The Contractor shall make a suitable allowance for this testing within their construction program.

The sample frequency shall be in accordance with Table 1–4. The table also identifies the indicative sample size. The sample sizes shall be confirmed by the CQA Consultant prior to construction. Sampling shall include the first and last roll. The specified frequency assumes all rolls are from a single manufacturing run. If rolls are from different manufacturing runs then the frequency shall be applied to each manufacturing run. The test frequency for all rolls where, in the opinion of the CQA Consultant, the manufacturing run cannot be identified shall be every roll for all test types. Samples shall not be taken from the outer wrap of the roll if damage is visible.

Table 1–4: Independent sample size and frequency schedule.

Material	Indicative size ¹	Frequency
Geosynthetic clay liner	1 metre by roll width	1 sample per 1,250 m ² , minimum two samples
Polyethylene geomembrane	1 metre by roll width	1 sample per 5,000 m ² , minimum two samples
Protection geotextile	1 metre by roll width	1 sample per 2,500 m ² , minimum two samples
Separation geotextile / Erosion protection geotextile	1 metre by roll width	1 sample per 5,000 m ² , minimum two samples
Drainage aggregate	20 kg bucket	1 sample per 2,500 tonnes, minimum three samples

Note:

- The first and last rolls produced based on the production run must be included as part of the sample set.

1.15 Testing

All testing in this specification including CQC testing shall be done by a NATA registered laboratory that has current registration for the nominated test procedures (Contractor's Independent Testing Firm).

All corrective work shall be re-tested in accordance with this Specification to assess compliance with the Specification. The Contractor shall submit the results of the re-testing progressively (at a minimum of a weekly basis) throughout the course of the contract.

1.16 Survey and Setting Out

Survey requirements are provided throughout this specification as well as in the Contract Documents. Work as Executed Drawings shall be prepared progressively throughout the Work by the Contractor.

Setting out of works will be the Contractor's responsibility.

Survey benchmarks certified during the works shall be maintained and protected by the Contractor, and reinstated by the Contractor if damaged by the Contractor or their sub-contractors.

The Contractor has the responsibility to check the accuracy of any calculations, drawings and other survey documents produced by the Contractor. The Contractor shall also be responsible for any liabilities such as levies or fines associated with or incurred as a result of providing incorrect information.

¹ Sample sizes are to be confirmed by the CQA Consultant and Independent Testing Laboratory

Survey requirements include, but are not limited to, the following:

- Survey must be carried out by a registered surveyor
- Survey results and calculations must be presented in the form of a topographical plan. Plan information extends to boundaries
- The plan must be drawn at scale 1:250, 1:500 or 1:1000 on A1 size sheets Different scales or plan sizes may be adopted after acceptance by the Principal's Authorised Person and/or Principal
- Terrain levels must be represented on the plans by contours at 1 metre intervals
- All levels must be related to Australian Height Datum and the origin of levels noted on the plan
- Spot levels must be taken at sufficient frequency to allow interpolation of levels from the plan to ± 0.05 metres to σ^2 (95% confidence level)
- Boundaries of the site, adjoining title information, volume determination and date of survey must be clearly denoted on the plan
- Stockpiles must be clearly denoted on the plan, and volumes / measurements of the various material type
- The plan must be signed by the surveyor to certify correctness
- Survey information is to be provided as AutoCAD DWG and DXF formats of survey data, not just plan format
- Survey must be provided on MGA and to AHD
- Survey for all earthworks must be undertaken at the same grid locations, to measure the thickness of the placed layers
- The Contractor shall supply survey data at intervals sufficient to record critical stages as summarised below and as outlined elsewhere in this specification:
 - Initial earthworks survey following clearing and grubbing, survey the elevation at all grid locations and breaks in grade
 - Upon completion of the subgrade (prior to placement of the subgrade,, survey the elevation at all grid locations and breaks in grade
 - Following completion of the subgrade, survey at the same grid locations to measure the thickness of the placed layer
 - Following completion of the leachate drainage layer, survey at the same grid locations to measure the thickness of the placed layers
 - Following completion of any soil/granular layer (i.e. subgrade, leachate drainage gravel, topsoil layer), survey at the same grid locations to measure the thickness of the placed layer
 - Before and following completion of access tracks, survey at the same grid locations to measure the thickness of the placed layer and the width of each access track
 - Before and following completion of all other fill materials, including but not limited to: select fill, sand, rip-rap, topsoil, and gravel
 - Additionally, levels and alignments shall be surveyed for the following items (survey points taken at maximum 10 m spacing and at any changes in grade or joins):
 - All anchor trenches
 - All locations of any repairs / patching to synthetic layers
 - All locations of penetrations to synthetic layers
 - All groundwater drainage (cell), including flushing points
 - All leachate pipework and gas collection trenches
 - All stormwater channels, drop-structures, drains and pipes
 - All access tracks

- All ponds
- All monitoring points (existing or new).

Survey is also required at locations of all CQA testing/sampling, refer relevant sections of the specification for details. Testing shall be surveyed to an accuracy of at least N.E +/- 1m and RL +/- 0.05m.

1.17 Witness and Hold Points

The following is a summary of witness and hold point processes:

- A hold point is a defined position in the Works beyond which work shall not proceed without mandatory verification and acceptance by the Principal's Authorised Person
- A witness point is a nominated position in the Works where the option of attendance may be exercised by the Principal's Authorised Person, after notification of the requirement
- It shall be the Contractor's responsibility to ensure that all obligations are fulfilled in regard to the witness and hold points within the Contract
- The Contractor shall give the Principal's Authorised Person a minimum 2 days notice prior to the required inspection
- Where the witness or hold point relates to the condition of a surface or installed material, the Contractor shall verify that the completed surface has achieved full conformance with the Contract Documents
- Witness or hold points may be released for part of the works only, as defined by the Principal's Authorised Person, so that the Works can be completed in a sequenced manner. The Principal's Authorised Person's acceptance of the completed items is required prior to the release of each witness or hold point
- Acceptance or release of a hold point does not constitute acceptance of quality by the Principal's Authorised Person or Principal and does not relieve the Contractor from satisfying the requirements of the Specifications or the Contract
- In some instances, the Principal's Authorised Person may delegate acceptance or witness to another party including, but not limited to the CQA Consultant
- A listing of witness and hold points can be found at Appendix A.

1.18 Works as Executed Drawings

The Contractor shall maintain a set of full-size Works as Executed Drawings and shall mark, on these Works as Executed Drawings, all changes made during construction. The Works as Executed Drawings shall be corrected daily and reviewed with the Principal's Authorised Person on a weekly basis. At a minimum, the Works as Executed Drawings shall include the as-constructed horizontal location and elevation of all buried (concealed) work as part of this project including excavation, all surface and subsurface improvements, drainage improvements, and final contours. The survey shall include breaks in grade and grid locations shall be on a 10-metre-square spacing or as defined elsewhere in this specification.

WAE drawings are to be prepared as red notations on the civil design drawings, as well as PDF, AutoCAD DWG and DXF formats of survey data, not just plan format.

The Works as Executed Drawings shall be prepared for the items outlined in Section 1.16 as a minimum.

1.19 Landfilled Waste

The Contractor shall note that parts of the site have been filled with a wide range of waste materials and the site should be considered as a Hazardous Area as defined in AS/NZS 60079, due to potential presence of landfill gas (methane, carbon dioxide and other gases) at the site, and the potential for other material such as asbestos as prescribed in NT Work Health and Safety legislation and NT WorkSafe guidance and codes of practice. The Contractor shall exercise all due caution when undertaking works, considering potential landfill gas emissions.

The Contractor shall take all necessary precautions to protect their workers and visitors to the site and shall cover all necessary measures as part of their CEMP.

1.20 Groundwater

The Contractor shall de-water such sections of the site as are necessary to permit Works to proceed as required under the Contract. The management of this water, if encountered, will need to be developed by the Contractor in accordance with all current legislation and regulatory requirements. Dewatering is further discussed in Section 7.8.

Dewatering shall be undertaken such that it does not cause damage to onsite or third-party structures.

All dewatering shall be handled and disposed of in accordance with all legislative and statutory requirements, standards, codes and guidelines, and any requirements outlined in the Contract Documents.

Dewatering shall occur prior to the start of excavation. Control water during the course of construction to:

- Maintain excavations free of water during preparation of groundwater relief trenches, subgrade / underside of GCL, placement of geosynthetics, placement of fill, construction of drainage, backfilling and all works as required
- Prevent contamination of the site or off-site including prevention of potentially contaminated water or leachate entering the stormwater or groundwater system.

The Contractor shall provide all necessary equipment and materials including pipes, wells, piping hoses and fittings, power and treatment systems to adequately control water in the excavation and discharge in accordance with any requirements outlined in the Contract Documents. Provide sufficient redundancy in each system to keep excavation free of water in the event of component failure.

1.21 Site Facilities

1.21.1 Water Supply

The Contractor shall provide potable water as required for the Contractor's site facilities. Potable water is not currently available onsite. The contractor should plan to supply all potable water from an alternative source.

The Contractor may use for the purposes of construction of the Works any water stored in the temporary sediment basin or new sediment basin constructed as part of the Works. The Contractor shall note that the sediment basins are required to be maintained in an empty state, and as such may not provide a reliable source of water for construction purposes.

If water is not available within the sediment basins on the site the Contractor shall obtain water off site for construction purposes, as required. No potable water shall be used for the construction works without the prior acceptance by the Principal's Authorised Person.

All water supply costs shall be borne by the Contractor.

1.21.2 Electricity Supply

There is no on site electricity supply available for Contractor use. The Contractor shall provide their own portable power supply as required for their facilities at the Contractors expense.

1.21.3 Wastewater / Sewer

There is no wastewater/sewer facilities available for Contractor use. The Contractor shall provide their own wastewater/sewer disposal services and facilities as required at the Contractors expense.

1.21.4 Telecommunications

The Contractor shall organise any temporary telecommunications required for site facilities and for carrying out the Works under the Contract. The Contractor shall obtain all approvals with respect to the temporary service and shall pay all fees and charges associated with the service. On completion of the Contract, the services shall be removed by the Contractor. Telecommunications costs shall be borne by the Contractor.

1.21.5 Security of the Works

The Contractor shall be responsible for all care and protection of the Works including provision and maintenance of any barriers, lights and signs and moving of them as necessary, and maintaining security of the Contractor's establishment area and the Site. The Contractor shall cover and protect all materials and surfaces against damage including from the weather and construction operations.

1.21.6 Amenities

Provide an office for the use of the Contract Administrator and nominees, in a position agreed with the Principal's Authorised Person. Make the office ready for occupation before any major site activities start. If during the progress of the Works it becomes necessary to move the office, do so without charge and with the minimum of inconvenience. Service, clean and maintain the office for the duration of the Works. Provide safe access to the office at all times. Remove the office at Completion, but not until the Principal's Authorised Person's permission is obtained.

Contractor to supply separate temporary facilities (site shed, workstation, chairs etc.) to house nominal four (4) Principal's Representatives including, but not limited to Principal's Authorised Person, CQA Consultant and other representative(s) for duration of the works.

Meeting facilities to also be supplied by Contractor for the purposes of holding regular construction progress meetings for minimum 10 persons.

1.22 Existing Services and Utilities

The location of services shown on the Drawings is based on information made available at the time of documenting and should not be relied upon by the Contractor as the locations may not be accurate or complete. Additional services may be located on the site, or services may not be in the locations as shown on the attached drawings. The Contractor must make all enquiries and investigations as to the existence of services. Responsibility for final identification, location, protection, support, relocation, disconnection, and reinstatement (active services only) of services within the area affected by works under the Contract rests solely with the Contractor.

There are live services (both public and private) within the site that shall be protected during the works. The Contractor shall be solely responsible for identification, location, protection, support, provision of temporary works or services, relocation, disconnection, and reinstatement of services within the site.

Services within or adjacent to the area of works may include, but are not limited to:

- Water supply
- Sewer
- Electrical
- Telecommunication
- Leachate
- Irrigation
- Gas extraction
- Groundwater and gas monitoring wells

- Stormwater including stormwater pumping infrastructure, clean water diversion drains, dirty water drains, sediment basins, leachate collection and storage, spillways and the like.

In the event that any service is damaged as a result of the Contractor's operations, then such damage shall be made good by the Contractor at his own expense. The Contractor shall provide temporary services whilst repairs are being carried out.

The Contractor shall liaise and co-ordinate its work with the service authorities as required to complete the Works. The Contractor shall undertake liaison with Service Authorities as required when undertaking any termination, adjustment or protection to their services. The Contractor shall comply with the requirements of the Service Authorities. The Contractor shall also be responsible for co-ordination of the depths of all services to avoid conflicts at crossing points.

The Principal's Authorised Person shall liaise between the Principal and the Contractor in relation to services maintained and/or operated by the Principal within the site or in the vicinity of the site.

1.23 Work by public utilities in vicinity of Contract

Should any public authority be required to carry out any installation or alteration of its utilities in the vicinity of the Works the Contractor shall facilitate the work as much as possible. Should the Contractor suffer any delay owing to the operations of such public authority, the Contractor shall not stop Works due to the operations of any authorities controlling the various public utilities without the permission of the Principal's Authorised Person.

1.24 Existing underground structures and buildings

Existing underground structures and buildings shall be protected by the Contractor as required by the owner of the respective structures.

The Contractor shall make all due diligence enquires with all relevant authorities (including Dial- Before-You-Dig) and inspect above ground structures and reference markers within the site.

Any information provided in relation to services on the site or in the vicinity of the site is provided as a guide only and does not relieve the Contractor of its responsibility to inform itself as to conditions within the site.

1.25 Site investigation data

The Principal has previously conducted an investigation of surface and subsurface conditions at the site:

- Geotechnical investigation conducted in May 2024 by CMW Geosciences.

Copies of the investigations are provided for information only. The Contractor shall perform their own investigation to confirm subsurface conditions.

The Principal does not warrant the completeness of these investigations as an assessment of the actual conditions existing at the site or the correctness of any report or test or of any interpretation deduction or conclusion. The Principal assumes no responsibility for any representations made by any of its officers or agents during or prior to the execution of this Contract.

1.26 Damage to Surrounding Areas

Following the completion of the works, the Contractor shall repair all damage to surrounding areas, including, but not limited to, roads, paths, pits, services, structures, fences, open areas and the like, to a condition equivalent to that existing at the commencement of the Contract.

1.27 Work Health and Safety

The attention of the Contractor is drawn to the Work Health and Safety Act 2011, which requires that employers ensure the health, safety and welfare of their employees. Specific attention is brought to the Works associated with:

- Working near existing overhead electrical services
- Clearance of vegetation including large trees
- Excavation and relocation of landfilled waste
- Exposure to landfill gas and leachate
- Reprofiling along existing over steepened batters
- Hot works over synthetic layers and/or within hazardous atmospheres
- Working adjacent to large batter slopes
- Risk of interaction with wildlife / feral animals.

The Contractor shall prepare a Work Health and Safety Plan in accordance with the above-mentioned Act for all work to be undertaken on the site. The Contractor shall provide specific safety procedures and/or safe work method statements to adequately address any hazards that may arise during the Works, and provide a safe work place for all activities involved in the Works. The Work Health and Safety Plan shall be submitted by the Contractor for review by the Principal's Authorised Person before work commences.

Where the specific safety procedures involve the use of shoring or other engineered protection measures, the Contractor shall provide to the Principal's Authorised Person, evidence of the design and certification of the adequacy of the proposed safety protection.

No work shall commence until the Safety Management Plan and any evidence of design certification required have been delivered to the Principal's Authorised Person.

1.28 Erosion and Sediment Control

1.28.1 General

The Contractor shall provide all temporary erosion and sediment controls necessary to protect the areas immediately adjacent to the Site from negative impacts.

It is the Contractor's responsibility to prepare and implement their own control plan for the Works with consideration to the Specification, the site Environment Protection Licence (refer Section 1.7, current at the time of undertaking the works). The Contractor shall prepare this plan with reference to:

- DOI PL (2019) Standard Specification for Environmental Management version 2.0
- Golder (2020) Water Balance, Leachate and Stormwater Management Strategies
- Landcom (2004) Managing Urban Stormwater: Soils and Construction – Volume 1 (4th Ed.), informally known as the "Blue Book" or equivalent
- Development Consent conditions for the site, and any subsequent modifications, refer Section 1.8
- Expectations with regard to erosion and sediment control issues are further discussed in Section 2.

1.28.2 Maintenance and Removal of Control Measures

The removal of temporary erosion and sediment control works shall be the responsibility of the Contractor. The extent of removal of the temporary works shall be confirmed by the Contractor with the Principal's Authorised Person before the end of the Contract. Materials used for the temporary erosion and sediment control works shall be removed from the Site or otherwise disposed of by the Contractor to the satisfaction of the Principal's

Authorised Person. Maintenance of permanent control measures entrusted into the care and control of the Contractor by the Contract up until completion shall be the responsibility of the Contractor.

1.29 Disposal of waters

Following award of the Contract, the responsibility for managing water disposal from the Site, including any temporary or permanent sediment basin(s) shall rest with the Contractor for the period defined under the Contract. Basins are required to be emptied as soon as possible after each storm event to retain maximum capacity as sediment basins.

Disposal of waters from any of these sediment basins shall be carried out in a controlled manner and the Contractor shall submit a work method statement to the Principal's Authorised Person for acceptance prior to such disposal. The work method statement shall take full account of the requirements specified in the Development Consent conditions and the Environment Protection Licence for the facility with respect to discharge of waters. Any flocculant used to achieve the required concentration of suspended solids shall be accepted by the Principal's Authorised Person prior to use.

1.30 Traffic Management

The Contractor shall prepare and submit to the Principal's Authorised Person, a Traffic Management Plan (TMP) and appropriate Traffic Control Plans (TCPs) which provide for the safe movement of Contract traffic to the Site, within the Site, between Work Areas within the site and for the safe interaction of Contract traffic with other site traffic. The TMP shall be developed in accordance with the Construction Environmental Management Plan (CEMP) for the works. The TMP and TCPs shall provide for at least the following:

- Access for and parking of Contractor's vehicles and other authorised contract related vehicles at the site
- Construction traffic movement between main excavation area, the nominated stockpile sites and the Contractor's site facilities
- Safe, unrestricted access for traffic (public) to the site facilities
- Safe management of the public accessing the site
- Safe and unrestricted access for site plant and vehicles to stockpile areas.

1.31 Environmental Management

A Construction Environmental Management Plan (CEMP) shall be prepared by the Contractor to identify and describe the measures required for environmental and human health protection during the Works. The CEMP shall be submitted for acceptance by the Principal's Authorised Person within 14 days of award of contract and not less than 14 days prior to the commencement of works. within 14 days of award of contract and not less than 14 days prior to the commencement of works.

The primary environmental matters requiring control throughout the Works include, but are not limited to, the following:

- Odour
- Landfill gas
- Leachate
- Hazardous waste excavation and relocation
- Noise
- Dust
- Fire (including bushfire)
- Sediment and erosion control
- Traffic and access

- Aboriginal and Historic Heritage
- Bushfire
- Litter, pest and vermin
- Fuel
- Drainage management
- Asbestos containing materials / hazardous waste
- Minimum Environmental Management Plan Requirements are outlined are listed in the Development Consent Conditions (refer Section 1.8).

All elements of the project have some risk of encountering waste. The Contractor shall take all necessary precautions to protect their workers and visitors to the site and shall include all necessary measures within the CEMP

It shall be the responsibility of the Contractor to provide, install and maintain the environmental control measures in accordance with the CEMP and associated environmental management plans provided to the Contractor prior to or during the Works.

The Contractor shall conduct and document regular inspections of the environmental control measures. In addition to routine inspections of environmental control measures, supplementary inspections shall be undertaken at the following times throughout the duration of the Works:

- Prior to the commencement of excavation works (to ensure all environmental control measures have been installed correctly, and in accordance with the requirements of the CEMP)
- During waste excavation and relocation works (if required)
- During and after significant rainfall events (when the generation of run-off from the site is greatest)
- During prolonged dry weather periods (when the potential for excessive dust/fibre generation is greatest).

1.32 Environmental Monitoring Well Protection

The Contractor is advised that groundwater and landfill gas monitoring wells (herein referred to as 'environmental monitoring wells') are located throughout the site. The Principal's Authorised Person shall provide the Contractor with a drawing identifying the locations of all monitoring wells within and/or adjacent to the site.

The Contractor shall protect from damage all environmental monitoring wells located within and adjacent to the Site for the duration of the Works.

Any monitoring wells within the landfill cell footprint are to be abandoned by filling with a cement bentonite slurry and trimmed to a minimum of 200mm below the design subgrade level. Well decommissioning is to be undertaken by fully cement-bentonite grouting in accordance with Figure 18.1 from "Minimum Construction Requirements for Water Bores in Australia", Fourth Edition, National Uniform Driller Licensing Committee.

The Contractor shall make good any such damage (including environmental monitoring well abandonment/replacement) due to Contractor actions or negligence.

Should the Contractor discover monitoring wells within the Site, which have not been identified on the design drawings, the Contractor shall protect those environmental monitoring wells in-place and immediately notify the Principal's Authorised Person.

1.33 Existing Roads and Drainage

All existing roads and stormwater drainage systems shall be inspected regularly by the Contractor to ensure that no construction-related debris, silt or other materials pollute the site or adjacent properties.

Any damage to perimeter roads or other structures caused by the actions of the Contractor in executing the Works shall be repaired to the satisfaction of the Principal's Authorised Person at the Contractors expense.

The Contractor shall maintain the existing roads and public streets in the area in a clean state to the satisfaction of the Principal's Authorised Person.

Contractor to clean material track from main site entry/exit point, including any material resulting from supplied materials delivered to site as part of the Works.

1.34 Dilapidation Report

Before commencement of work, arrange joint inspections with the Principal's Authorised Person, Principal and where applicable with the owners and occupants of adjoining properties and assets, including environmental monitoring wells. The Contractor is to maintain the landfill access road as trafficable during construction period. The Principal's Authorised Person will advise rehabilitation works required at the conclusion of the project.

The Contractor shall make written and photographic records of the condition of all adjoining structures, facilities, surfaces (e.g. roads), services and service pits, stormwater assets, etc. which will be used during the works or are adjacent to or incidental to the areas of use. The photographs are to be clear, in colour, suitably date stamped, appropriately coordinated with relevant site maps/ diagrams to allow for a continuous and complete depiction of all the relevant details of the surfaces, and to allow for their relative location to be readily identified. Provide two complete copies of the Dilapidation Report, being one to the Principal's Authorised Person and one to be retained onsite.

The dilapidation report is to be updated completed post construction.

The Dilapidation Report may be used by the Principal's Authorised Person as a means of assessing the responsibility for any damage and/or making good arising out of the performance of the work under the Contract.

1.35 Work Method Statements

Prior to commencement of all work the Contractor shall prepare detailed Work Method Statements (WMS) as outlined below. The work method statement shall include all the processes and equipment that the Contractor proposes to use for the transport, stockpiling, conditioning, placement and compaction of all works. The WMS shall be submitted to the Principal's Authorised Person for review. The Contractor shall incorporate any changes and submit as final.

The Contractor shall accept all risks and be responsible for determining the order of works onsite to meet its responsibilities under the Contract as well as all access and traffic control methods.

The following summarises work method statements detailed elsewhere in the Specification as required for the works. The list may not be complete, and it shall be the Contractor's responsibility to ensure that all obligations are fulfilled in regard to WMS under the Contract:

- Work Health and Safety – Section 1.27
- Disposal of Waters – Section 1.29 and 7.8.1
- Soil and Water Management – Section 2
- Field Trial – Sections 4 and 17
- Material stockpiling and segregation – Section 6
- Subgrade surface – Section 8.2
- GCL delivery, storage, handling and installation (incl repair methods) - Sections 9.3.1, 9.9, 9.11
- HDPE delivery, storage, handling and installation (incl repair methods) – Sections 10.3.1, 10.8, 10.9, 10.10
- Geotextile delivery, storage, handling and installation (incl repair methods) - Sections 11.3.1, 11.10, 11.12
- PE Pipework delivery, storage, handling and installation (incl repair methods) – Section 12.3.1, 12.5, 12.6
- Leachate drainage aggregate – Section 13.3.2

Contractor shall not deviate from accepted WMS unless written authority provided by Principal's Authorised Person.

2. Soil and Water Management

2.1 General

The work to be executed under this Part of the Specification consists of installation and implementation of measures to provide soil and water management controls. These structures may be temporary or permanent. The Contractor is to plan and carry out the whole of the Works to avoid erosion and sedimentation of the site, surrounding land, watercourses and water bodies.

The Contractor is responsible for the design of a Soil and Water Quality Management Plan embodying all control measures. The SWQMP shall be prepared by a CPESC. This SWQMP shall be submitted to the Principal's Authorised Person as a Work Method Statement. These measures are required to be consistent with all contract documents.

Construction of a new sediment pond forms part of this contract. The existing / augmented ponds can be used by the Contractor, but the Contractor is to make their own assessment of the adequacy of the ponds to manage their requirements as part of this contract. Determining staging of the work is the responsibility of the Contractor.

Sections of the existing landfill operations may flow into site sediment ponds. Areas of intermediate cap on the existing landfill face may flow into the Works Area. The Contractor needs to capture & manage all water inflows into the old and new landfill cells Works Area.

All risks associated with soil and water management at the site sit with the Contractor.

The work to be executed under this part of the Specification consists of the design and construction of structures and the implementation of measures to provide Soil and Water Management Controls. These structures may be temporary or permanent. The Contractor is to plan and carry out the whole of the works to avoid erosion and sedimentation of the site, surrounding land, watercourses, water bodies and wetlands.

The Contractor shall prepare all erosion and sediment control plans and/or soil and water management plans, and all associated calculations, to satisfy all legislative and statutory requirements, standards, codes and guidelines, and any requirements outlined in the Contract Documents.

The plan shall identify all erosion and sediment control measures the Contractor shall implement during the Works (including staging). The plan shall identify monitoring the Contractor shall undertake to ensure the Contractor complies with the surface water release criteria at the site (as per site EPL, refer Section 1.7 and taking into account any requirements of this Specification, and Development Consent conditions for the Site and any subsequent modifications, refer Section 1.8). The plan shall be submitted to the Principal's Authorised Person for review and acceptance prior to commencing any of the Works (submission of the plan forms a Hold Point for the Works).

Soil and water management shall comply with the requirements outlined within, but not be limited to, the following:

- Landcom (2004 4th Ed) Managing Urban Stormwater: Soils and Construction – Volume 1 (the “Blue Book”)
- DOIPL (2019) Standard Specification For Environmental Management version 2.0
- Development Consent conditions for the Site, refer Section 1.8, including any conditions on the discharge and/or management of stormwater.
- Environmental Protection Licence (EPL) for the Site, refer Section 1.7, including any conditions on the discharge and/or management of stormwater, groundwater and leachate
- The Waters Act 1992
- Water Regulations 1992
- National Environment Protection Council (Northern Territory) Act 1994
- Northern Territory Environment Protection Authority Act 2012
- Waste Management and Pollution Control (Administration) Regulations 1998.

The Contractor must be fully conversant of their responsibilities under such legislative requirements.

Virtually all construction activity which requires the disturbance of the soil surface and the existing vegetation, naturally predisposes the construction site to erosion. This in turn leads to sediment loss in the resultant run-off water. Since such soil disturbance is a necessary part of development, it is essential therefore to develop measures which reduce the erosion hazard of any particular construction activity. Having done that, run-off water which carries the sediment must be controlled, in such a way as to reduce the amount of that sediment leaving the site.

Sediment migration control is achieved by:

- Limiting the amount of site disturbance
- Isolating the site by diverting clean upstream “run-on” water around or separately through the development where possible
- Providing clean water and dirty water drainage systems where appropriate
- Disposal of water from clean and dirty water systems during construction in accordance with all legislative requirements and requirements of the Contract documents
- Providing an effective major stormwater system economically in terms of operation and maintenance, incorporating water quality controls
- Retaining topsoil for effective revegetation works (where possible)
- Controlling run-off and sediment movement at its point source rather than only at one final point
- Progressive revegetation of the site where possible during on-going construction to reduce the area contributing sediment. This in turn increases the efficiency and effectiveness of the entire sediment control system
- Construction of larger sediment trapping systems of a size relevant to the catchment of the site
- Filtering of any settlement of the sediment in the trapped water prior to its release to the drainage system
- Separating leachate from stormwater.

The Contractor shall propose specific erosion and sediment control measures (and other measures if required) for these materials, based on guidance provided below, which may include:

- Maximise the efficacy of site sediment basins on site to manage sediment loads, such that it maximises the potential for stormwater runoff from disturbed areas of the site to be treated to an acceptable standard prior to discharge offsite. Any overflows from the sediment basins be mixed with runoff from vegetated areas prior to discharge from site
- Minimising the potential for sediment basin overflows through use of the water for dust suppression during construction, if appropriate
- If water is to be pumped from the sediment basins and discharge from the site under dry weather conditions, undertaking water quality testing to assess the quality of the water for discharge. If water to be pumped from the sediment basins does not comply with the site EPL, the use of a flocculant such as ferric chloride (or equivalent accepted by the Principal’s Authorised Person) should be investigated by the Contractor as part of their erosion and sediment control
- Minimising effective catchment area during construction via catchment and runoff management, minimising working areas and having appropriate drainage and sediment and erosion controls
- Considering historic rainfall trends and scheduling the construction works accordingly
- Maximising the efficacy of the sediment basins on site to manage sediment loads, such that all run-off from the site passes via a sediment basin before any discharge off-site
- Regular water quality monitoring in the sediment dams and for discharged surface water
- pH adjustment as required prior to release from dams
- Aeration or other appropriate treatment process as required prior to release from dams

- Use of evaporation as a management measure (depending on seasonality).

2.1.1 Stormwater quality objectives

Any water discharged from the site shall be in accordance with the requirements outlined in:

- Site EPL (refer Section 1.7)
- Site OEMP
- Site EIS (refer Section 1.8)
-

Sediment basin water quality discharge criteria appropriate as a minimum requirement for the works are stated in “Managing Urban Stormwater: Soils and Construction” Landcom (4th Edition March 2004) as follows:

Table 2–1: Characteristic / Pollutant Measure

Total Suspended Solids	< 50mg/L
pH	> 6.5 and < 8.5
Oils and grease	none visible

As a minimum, the Principal expects the system is to function in a controlled manner up to a threshold of a 90 percentile, 5 day rain event at all times during construction, regardless of the status of completion of the permanent sedimentation basins.

As a minimum, the Contractor is to monitor the following surface water parameters as well as any other measures as set out in the abovementioned documents:

- pH
- Total suspended solids (TSS)
- turbidity (where a correlation with TSS is sought and a portable probe is available)
- Oils and grease (visual assessment). If oils and grease are visually evident, a sample will be forwarded to the laboratory for analysis.

Routine sampling will continue to be undertaken by the Principal in all active sediment basins. This may include any temporary sediment basins provided by the Contractor for the purposes of construction.

Any temporary retention measures are to be designed by the Contractor to perform to the same high standard as the permanent fixtures, regardless of the status of the construction of permanent basins. Prior to release of waters from all retention structures, water should be verified by the Contractor as meeting a total suspended sediment concentration, pH and Oil and Grease as specified. The Contractor shall progressively monitor, modify and manage the system to ensure full compliance for the duration of the Contract and maintain records of site inspections and water testing for inclusion in the Monthly Reports.

2.1.2 Erosion and Sediment Control Devices

Erosion and sediment control measures to be utilised during the landfill closure construction works include, but are not limited to:

- Steel shaker grate
- Water carts to wet exposed areas
- Woven or non-woven fabric fence
- Diversion drain with rock check dams
- Sediment basins
- Rock filter dams
- Inlet protection for stormwater pits

- Outlet energy dissipaters / level spreaders.

2.1.3 Erosion and sediment control prior to vegetation establishment

The Contractor shall be responsible for establishing suitable controls for managing erosion and sediment control during the vegetation establishment period, including inspection of non-vegetated or partially vegetated areas following rain events. The Contractor shall consider relevant guidance provided in the Blue Book when developing and implementing these control measures.

Any erosion of the final landform areas identified following rainfall shall be remediated by the Contractor to the satisfaction of the Principal's Authorised Person.

2.1.4 Vegetation Establishment

Revegetation of disturbed areas is an integral component of the site ESCP and, as such, progressive revegetation of disturbed areas shall be undertaken as soon as possible after disturbance. All exposed areas shall be revegetated (i.e. drains where not rock lined, bunds, edges of access track) Internal cell batters are discussed in Section 7.11. The condition of revegetation works shall be visually monitored and if any of the sections of planting show evidence of poor health professional advice would be sought. Any revegetation that fails would be replanted.

Vegetation establishment shall consist of hydroseed. Revegetated areas shall be underlain by a minimum depth of 100mm of topsoil (unless a different thickness is indicated on the drawings), of suitable quality to support the growth of proposed revegetation. Undertake all necessary maintenance for the establishment period which shall be a minimum of 13 weeks or as outlined in the Contract documents.

All landscaping and revegetation works shall be undertaken in accordance with City of Darwin's Engineering Requirements and Standards.

2.1.5 Unexpected Finds Procedure

A procedure for management of Excavation within Waste / Unexpected Finds is to be included in the Soil and Water Quality Management Plan. It is noted that excavation within waste may present acute risks to both workers and the environment. The Unexpected Finds Procedure is to outline management procedures for items which may pose acute risks to workers or the environment, including (but not limited to) asbestos, liquid waste drums, flammable materials, gas bottles etc. This procedure is to include classification of the material and liaison with the Principal's Authorised Person to confirm disposal requirements. Disposal may include (but is not limited to) transportation offsite to a licensed facility or to the existing facility if the waste classification is acceptable.

Soil and Water Quality Management Plan

A Soil and Water Quality Management Plan will form part of the CEMP and the following section of the specification is provided to the Contractor for information to assist in the preparation of this component of the CEMP. The Contractor is required to prepare a Soil and Water Management Plan as part of the Construction Environmental Management Plan, refer Section 1.31.

The SWQMP for the Contractor's operations shall provide a staging plan of proposed earthworks and drainage. The Contractor shall appropriately address any comments on the plan. However, such issuing of comments does not relieve the Contractor of the full responsibility to provide whatever measures are required for effective erosion and sediment control at all times.

The plan must include but not be limited to the following:

- Existing contours and finished contours of regrade areas
- Existing stormwater drainage
- Approximate location of "No Access" fencing
- Staging plan of proposed earthworks and drainage including any clean water and dirty water systems

- Staging plans demonstrating construction using nominated machinery that achieves compaction over the synthetic layers in accordance with this specification and in full consideration of synthetic layer installation requirements
- Details of proposed stormwater disposal
- Details of leachate capture and disposal
- Location of site access/s and area of stockpiles
- Location of critical areas (vegetated buffer strips, drainage lines, structures, water bodies, “wet” areas)
- Location of silt fences and other sediment control works including diagrams of such works
- Location of sediment traps
- All hydrological information and calculations relative to sediment trap size, velocities of diversion structures etc.
- Type and location of diversion works to direct run-on water around areas to be disturbed.

Sediment basins are shown on the design drawings and are to be included as a minimum; however, the Contractor is to ensure that these are suitable to ensure satisfaction of regulatory requirements insofar as quality of stormwater discharges.

The Contractor shall ensure that the construction works are staged to allow management, control and separation of leachate, sediment-laden water and clean water generated onsite and from offsite inflows.

All temporary erosion and sediment control works shall be removed by the Contractor before the end of the Contract. All materials used for the temporary erosion and sediment control works shall be removed from the site. The cost of construction and maintenance of temporary erosion and sediment control measures shall be borne by the Contractor. Maintenance of permanent control measures entrusted into the care and control of the Contractor by the Contract up until the completion of the Contract shall be the responsibility of and at the cost of the Contractor.

The responsibility for managing surface water disposal from the area of works shall rest with the Contractor for the duration of the Contract. The volume and quality of discharged waters shall be monitored.

2.2.1 General Erosion and Sediment Control Measures

It is the responsibility of the Contractor to determine the appropriate sizes and locations of erosion and sediment controls to ensure compliance with all relevant statutory authorities.

Transport of soils, earth, sand, loose debris, etc., to or from the site will be in a manner that will prevent the dropping of such material on surrounding streets. The Contractor must ensure that the wheels, tracks and body surfaces of all plant and vehicles leaving the site are free of mud etc. Run-off from all areas where the natural surface is disturbed by construction, including access road, depot and stockpile sites, are to be free of pollutants as defined in the Clean Waters Act 1970 before it is either dispersed to stable areas or directed to natural watercourses.

The Contractor is to provide and maintain slopes, crowns and drains on all excavations and embankments to ensure satisfactory drainage at all times. Water is not to pond on the works unless such ponding is part of the accepted Soil and Water Management Plan.

The Contractor is to prevent stormwater from contacting wastes, which will become leachate. Leachate must be prevented from mixing with stormwater runoff.

The cost of installation, maintenance, inspection, removal and restoration of affected areas must be borne by the Contractor.

The Contractor is to restore to the original condition at no cost to the Principal any damage, caused directly or indirectly from development works. Such works will also include the clearing of material from roads and gutters (on a daily basis), drains and pipes. Any materials removed from drains, gutters and the like will be disposed of to an accepted location.

2.2.2 Sequence of Operations

The Contractor is to reappraise the location of erosion and sediment controls as the works progress. Daily maintenance is to be undertaken to ensure effective operation.

Works shall be staged to allow the collections, treatment and disposal of runoff including any clean water and dirty water systems as deemed necessary by the Contractor.

Temporary and minor erosion and sediment controls, such as traps/barriers and silt retention/filtering structures, shall be installed as required.

All temporary sediment controls shall be removed by the Contractor and the area restored as required to satisfy this specification. All permanent structures including piped drainage systems are to be cleared of sediment in an accepted manner and not flushed into receiving waters.

2.2.3 Topsoil Stripping

All topsoil material stripped shall be stockpiled for later use, at a location nominated by the Principal. The Contractor will measure the stockpiled topsoil to verify the volume prior to proceeding onto further excavation works. Some topsoil will already be stripped by the Principal before construction commences.

2.2.4 Permanent Erosion & Sediment Controls

Sediment basins are shown on the design drawings and are to be included as a minimum however the Contractor is to ensure that these are suitable to ensure satisfaction of regulatory requirements insofar as quality of stormwater discharges, and for early-phase construction (i.e. sediment controls are also required before the basins are complete). Additional sediment basins and other permanent and semi-permanent Erosion and Sediment controls are to be designed by the Contractor as necessary to ensure satisfaction of regulatory requirements insofar as quality of stormwater discharges.

Sediment basins may require the addition of chemical additives or the use of filters to remove sediment and contamination that may be present in sediment-laden stormwater runoff. The Contractor is to ensure that discharges from sediment basins including supernatant discharge do not have an impact on the receiving environment and are compliant with water quality discharge requirements outlined in Section 2.1.

Sediment basins are to be designed to prevent overtopping or failure of the basin, and ensure clean water is diverted around the basins.

2.2.5 Channel Stabilisation

The Contractor is to ensure all channels are stabilised when high flow velocities will cause erosion and scouring of the channel base. The technique to be employed in stabilisation is dependent on the velocity of the flow which is expected and the materials for stabilisation should be chosen accordingly.

The ongoing maintenance and reappraisal of channels and their linings is to be carried out on a regular basis. Channel stabilisation may include, but not be limited to the following:

- Jute Mesh – for channels of lower gradients. After heavy rainfall the channels should be inspected to ensure they have not scoured. Any necessary restoration works shall be implemented immediately.
- Revegetation
- Geotextile Fabric or Plastic Lining – lining of drains with a properly installed geotextile fabric or plastic lining, with the outside edges of the fabric held down with rocks or wire staples, or buried.
- “Plastic” Fabrics/Natural Fabrics – a combination of natural and plastic fibres woven to form a mat that may be used to line earth drains and provide scour protection.
- Concrete, Rock, “Rip Rap”, Gabion Linings etc. – to provide permanent scour protection for outlets, inlets, channels and drains.
- Grade Stabilising Structures – erosion-resistant structures installed across a channel to promote non-erosive velocities in the downstream channel.

2.2.6 Cleaning of All Sediment/Erosion Control Structures

The Contractor shall be responsible for the operation and maintenance of the sediment basins. This includes all testing of stormwater and discharges, and ensuring that discharges meet regulatory requirements.

The Contractor is to empty, clean out or replace all sediment control structures as required to maintain efficient operation or as directed by the Principal's Authorised Person.

Major and minor sediment basins/dams/traps are to be cleaned and desilted in accordance with best practice document such as the "Landfill Blue Book".

The Contractor is to ensure that discharges from sediment basins including supernatant discharge do not have an impact on the receiving environment.

The removal of the sediment is to be done in such a manner so as not to damage the structure. If any damage occurs it is to be restored immediately at the Contractor's cost. The sediment must be disposed of in an accepted manner to an accepted location ensuring it does not enter any drainage conduit.

Where culverts have been silted up, the Contractor is to remove all silt immediately.

If the drainage system is to be flushed, such flushing must be collected to ensure none enters uncontaminated waterways. Should this occur the Contractor is to clean out and restore such contaminated waterways immediately.

Where construction work interferes with existing drains or gutters, these are to have devices placed and maintained to avoid sediment build up.

2.2.7 Stockpile Sites and Stockpiles

The Contractor shall be responsible for managing stockpiles of cut and fill materials for the duration of the Works and the establishment period as outlined in the Contract Documents. Further detail on project stockpiling is included at Section 6.

It is the Contractor's responsibility to prevent the cut and fill material stockpiles to become contaminated with unsuitable material (refer Section 7.9.5) or by other methods (such as fines contamination) which may result in the cut and fill material no longer meeting the relevant acceptance criteria in this Specification. The Principal's Authorised Person may organise independent inspections and/or testing of the cut and fill material stockpiles to verify conformance with these requirements. In the Principal's Authorised Person's opinion, if remediation of any contaminated materials is not viable then the material shall be rejected by the Principal's Authorised Person and removed from the site at the expense of the Contractor.

All stockpiles shall be located in the designated Contractor stockpile area, unless otherwise accepted by the Principal's Authorised Person. Protective measures such as upstream diversion works and downstream sediment trapping devices are to be installed by the Contractor at all stockpiles in accordance with the requirements of the NT EPA. Stockpile management shall be considered as part of the SWMP submitted for the Works.

All stockpiles shall satisfy the environmental and material handling requirements of the contract documentation.

2.2.8 Protection of Adjoining Property and Repair of Damage

The Contractor is to restore to the original conditions, or equivalent, at their expense, any vegetation within "no access" areas or property altered or damaged by them during the course of construction, or caused as a direct consequence of development works, including clearing of drains and/or gutters affected by construction works.

2.2.9 Progressive Stabilisation

All areas disturbed during construction are to be stabilised as soon as possible after completion of the work. The Contractor is responsible for the adequate watering of all revegetated areas to ensure regrowth from the time of planting through to the end of the maintenance period.

2.2.10 Maintenance and Inspection

The Contractor is to provide and maintain access for cleaning out sedimentation control works. The Contractor is to inspect all temporary erosion and sedimentation control works after each rain period and during periods of prolonged rainfall. Any defects revealed by such inspections are to be rectified immediately and these works are to be cleaned, repaired and augmented as required, to ensure effective erosion and sedimentation control thereafter.

2.2.11 Removal

All temporary erosion and sedimentation control works are to be removed by the Contractor when revegetation is successfully established. All materials used for the temporary erosion and sedimentation control works are to be removed from the site and all affected areas reinstated.

3. Material Sources

Site won materials shall be utilised in this contract, if material geotechnical and geochemical parameters are compliant with the requirements outlined for each use in this Specification. Further details are provided in Chapter 6 as well as elsewhere in this technical specification.

If material is to be imported the material is to be VENM, ENM or other EPA certified General or Specific waste-exempt or EPA approved resource recovery material if accepted by the Principal. The material shall meet the relevant acceptance criteria for the layer / end use of the material.

Before import of any material to site, the Contractor is to create a schedule of all materials proposed for import, based on the approved Contract Documents. This schedule is to be used for the purpose (via the Principal's Authorised Person) of suitability for an Operational Purpose Deduction of the Waste Levy. The schedule shall be provided a minimum of 28 days shall be provided, before import.

Material acceptance criteria may be relaxed if the Contractor provides certification from an independent and suitably qualified geotechnical engineer, or the Contractor's Geotechnical Consultant, of the material suitability for the purposes of constructing a landfill cell and the other purposes and requirements as outlined by this Specification. The Principal's Authorised Person will consider deviations from the material acceptance tables in this specification.

If the Contractor wishes to nominate an alternative material, the Contractor shall submit a RFI including all relevant technical data, demonstrating compliance or otherwise with this specification, including certification by the Contractor's Geotechnical Consultant, or an independent and suitably qualified geotechnical engineer. The Principal's Authorised Person will review the RFI but isn't obligated to accept alternate materials.

Materials brought onto the site may be subject to the Waste Levy. All variations from the nominated products, thicknesses and specifications are to be accepted by the Principal's Authorised Person. The Contractor is responsible for ensuring that, where applicable, all materials used in the works are both eligible for operational purposes and appropriate records for OPD's are kept in accordance with the requirements of the NT EPA.

4. Field Trial

The Contractor shall conduct a field trial of the proposed placement methodology to confirm the relevant levels / thicknesses can be achieved with the methodology, and assess that no damage is caused to the underlying geosynthetics system or significant breakdown of leachate gravel during placement.

The contractor shall prepare a WMS for undertaking each of the field trials. These are to be submitted to the Principal's Authorised Person for acceptance. This WMS is to include all the processes and equipment that the Contractor proposes to use for the placement and compaction during each field trial. The WMS shall be submitted for review.

Details of the field trial for the landfill cell are contained in Section 5.

The work method statement shall include details of the following as a minimum:

- Method of transportation of drainage aggregate material to placement location
- Method of spreading drainage aggregate material
- Method of lift thickness control where relevant
- Details of plant and equipment to be used during placement, including calculation of ground pressure (noting max 35 kPa) and proposed drainage aggregate material thickness limits during trafficking
- Details of temporary pads or access tracks for plant exceeding allowable ground pressure limits

The Contractor shall incorporate any changes and submit as final.

- The field trial shall be undertaken on a section of the site which is representative of the site (i.e on a representative slope)
- The field trial shall be conducted over a test section that duplicates the installed condition of the leachate barrier system and is to include matching subgrade conditions and geosynthetic layers

- The test section shall be not less than 10 m wide by 10 m long
- The Contractor shall place the drainage aggregate layer onto the test section as per the proposed placement method
- When the trial placement is completed, the Contractor shall remove the placed layer (drainage aggregate) and expose the underlying geosynthetic (Geomembrane) for inspection by the Principal's Authorised Person. Most of the material may be removed using an excavator; however, care shall be taken to avoid doing any further damage to the underlying geosynthetics. Within 100 mm of the PE geomembrane, the material shall be removed by hand excavation to avoid damage to the PE geomembrane
- The Principal's Authorised Person will inspect the underlying geosynthetic for any damage caused during the placement of fill/aggregate and either accept the placement method if no damage is evident or direct further trials until a satisfactory placement method is developed. Damage to the PE geomembrane shall include any holes, creases, indentations, or scratches. Undamaged geomembrane shall be unblemished
- The Contractor shall conduct further field trials until it has been demonstrated to the satisfaction of the Principal's Authorised Person that the proposed placement method does not damage the underlying geosynthetic materials
- The Contractor shall submit a report to the Principal 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 Principal's Authorised Person shall review and approve the updated placement method prior to placement of the permanent drainage aggregate. The report and updated placement method shall be provided to the Principal's Authorised Person 10 working days prior to placement of the drainage aggregate
- The accepted placement method shall then be adopted as the placement method
- Geosynthetics materials used in Field Trial shall not be used in works and shall be part of the tested/accepted batch of materials for use in the works.

Each field trial is to be completed prior to acceptance of the installation WMS for subsequent layers (Section 11.3 and Section 12.3)

4.1 Field trial of placement method

The field trial shall be supervised by the following personnel as a minimum:

- Contractor
- Geosynthetic Installer
- Principal's Authorised Person
- CQA Consultant.

The field trial may be constructed within the proposed layer area, or in an area accepted by the Principal's Authorised Person. The Contractor shall nominate the proposed location of the field trial for acceptance, prior to undertaking the trial.

4.2 Further Field Trials

In the event that there is significant change evident in the physical characteristics of the materials proposed for placement being sourced or the imported source is changed then further Field Trials(s) shall be undertaken by the Contractor at its own cost all in accordance with the above to confirm compliance before proceeding further with the changed material or differently sourced material. If the Contractor chooses to proceed with changed material or differently sourced material in advance of a satisfactorily completed Field Trial then it shall do so at its own risk.

5. Interface Shear Strength Testing

5.1 General

Interface shear strength testing shall be conducted prior to geosynthetic materials being shipped to site for the Works, to confirm the design assumptions with site specific geotechnical materials. This section contains the technical requirements for determining the interface strength characteristics.

5.2 Standards

- ASTM D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- ASTM D5321 Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
- ASTM D6243 Standard Test Method for Determining the Internal and Interface Shear Strength of Geosynthetic Clay Liner by the Direct Shear Method
- Alternate test methods may be considered by the Principal's Authorised Person when requested in writing by the Contractor if the maximum particle size of the materials being tested prevents the use of standard direct shear methods.

5.3 Submittals

5.3.1 Prior to conducting the interface friction testing

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance prior to conducting the testing:

- Qualifications of the proposed Contractor's Independent Testing Firm
- Submittals for each soil and geosynthetic material required for testing as per the relevant sections of this specification
- Calibration data of the shear testing device for accuracy of normal stress and shearing force shall have been undertaken within the last 2 years
- Methodology from the Contractor's Independent Testing Firm to be supplied to the Designer for review, prior to testing being undertaken.

5.3.2 Following completion of the interface friction testing

The Contractor shall submit a report summarising the following to the Principal's Authorised Person for review and acceptance following completion of the testing:

- Interface strength testing results. Interface strength testing results shall consist, at a minimum, of:
 - Description of all specimen sampling and trimming procedures
 - Description of all soils used in the testing including:
 - Description of all testing equipment used
 - Description of specimen configuration and preparation conditions including (where appropriate):
 - Preparation
 - Compaction (soils only)
 - Moisture content (soils and GCL only)

- Soil gradation (soils only)
- Soil classification in accordance with ASTM D2487 (soils only)
- Description of all test conditions including:
 - Test method employed
 - Hydration information
 - Consolidation information
 - Strain rate utilised during shearing
- Vertical displacement data during hydration, consolidation and shearing
- Peak and residual strength (large displacement):
 - Shear stress-strain plots
 - Normal stress-shear stress plots
 - Failure envelope plots.
- Location and condition of the failure plane(s) within the test specimen
- Interpreted shear strength.

5.4 Execution

- The Contractor shall retain Contractor's Independent Testing Firm to perform interface shear strength testing of the interfaces
- The quantity and quality of materials required for testing shall be requested by Contractor's Independent Testing Firm within 1 week of engagement based on the required interfaces. The Contractor shall provide materials in sufficient quantity and quality for testing as requested by the Contractor's Independent Testing Firm
- Testing at low normal stresses (<25 kPa) may be performed in either tilt-table or direct shear-type apparatuses. Testing at higher normal stresses shall be performed in a direct shear-type apparatus
- Normal stresses applied to the sample shall be as outlined in Table 5–1
- Whenever possible, the soil or geosynthetic material above and below the interface materials shall also be incorporated into the testing apparatus and procedures
- All tests shall be performed under saturated conditions
- All geosynthetics shall be orientated in machine direction
- Soil samples to be in accordance with the material acceptance criteria for that material and representative of the soils above and below the synthetic layers, prepared as required by Table 5–1, and incrementally loaded in the shear box and allowed to consolidate. If source material varies in characteristics/classification, testing is to be undertaken on samples of all proposed geotechnical material sources. Number of source materials requiring testing to be confirmed with the Principal's Authorised Person
- Soil samples shall be compacted as outlined in Table 5–1, incrementally loaded in the shear box and allowed to consolidate
- GCL specimens shall be hydrated, under a minimum 10 kPa load
- GCL hydrated for minimum 48 hours, testing laboratory to confirm methodology such that the entire GCL reaches hydration
- Incremental loading rates shall not exceed 12.5 kPa/hr increments
- Vertical displacement shall be monitored during all incremental loading. Shearing shall not take place until the change in vertical displacement is less than 5% over a 12 hour period

- Interfaces strain rates shall not exceed
 - 1 mm/min for all geosynthetic-geosynthetic interfaces
 - 0.1 mm/min for and interfaces involving a GCL, soil-geosynthetic interfaces and internal GCL shear tests
- Total shear displacement is to be more than 75mm
- Geosynthetic materials shall not be affixed to a substrate for the entire area of the sample and shall be allowed to strain during shearing.

The interfaces included in Table 5–1 below shall be tested:

Table 5–1: Testing interfaces and notes

Interface: Bottom / Top	Test Method (ASTM)	Tests (minimum) per material source	Minimum Equivalent Shear Strength Parameters Required	Notes
Subgrade / GCL	D5321	3	11° peak friction angle 0kPa cohesion 9° residual friction angle 0kPa cohesion	Saturated condition Soil to 95% standard, +2% OMC Incremental loading Normal stress = 5,10,25 kPa
GCL / HDPE (SS)	D5321	1		
GCL / HDPE (SST – textured side down)	D5321	1		
HDPE / Protection GT	D5321 Method (ASTM)	1		
Protection GT / Sacrificial	D5321	1		

5.5 Interpretation

All layers shall exhibit a minimum interface friction angle and cohesion (or equivalent shear strength at 5kPa on the batter walls) in accordance with the requirements of Table 5–1.

The Contractor is to submit the report in accordance with 5.3.2, outlining conformance with this Specification, for review by the Designer's Representative will review interface friction strength requirements with consideration to GRI White Paper #11.

5.6 Acceptance

The Contractor shall retain all ownership and responsibility for the interface strength testing until final acceptance of all work under this Contract by the Principal's Authorised Person. The interface strength results shall be accepted by the Principal's Authorised Person when all of the following conditions are met:

- Required submittals are provided by the Contractor to the Principal's Authorised Person and accepted
- The Designer's Representative has provided the Principal's Authorised Person with a recommendation that the required critical interface friction strength requirements have been met.

6. Material Segregation – Site Won

6.1 General

This section outlines the requirements for separating and stockpiling different materials excavated during the works.

The Contractor is responsible for determining the order of works onsite to meet its responsibilities under the Contract.

It shall be a requirement of this contract that sourcing and placement of material for construction of the New Landfill Cell occurs in a sequence that utilises existing on-site material first and off-site material last.

The Contractor is to engage and have available a suitably experienced and qualified Geotechnical Inspection and Testing Authority (GITA) to assist the Contractor in the identification, monitoring and confirmation that the material segregation and stockpiling is being performed adequately. The Principal's Authorised Independent Geotechnical Engineer may undertake inspections, supervision and testing as required to confirm the materials management (segregation and stockpiling) is being performed adequately. The Contractor will be responsible for the rectification of any unsuitable mixing, segregation or stockpiling of any materials.

6.2 Materials

The works involve winning and reuse of other materials as outlined on the drawings and elsewhere in this technical specification. Where the materials are of a significant quantity and are required to be stockpiled on-site then they shall be done so in accordance with the principles outlined in this Chapter.

- The materials within the cell cut are described in geotechnical reports as listed in Section 1.25.

6.3 Stockpile Filling Philosophy

In planning and implementing the works, the Contractor shall incorporate all requirements, concurrent activities, and the like into its work methodology such that the Contractor is able to satisfy all contract requirements. A suggested order of work is provided below; however, the Contractor shall make its own assessment of, and be responsible for, the required order of works to deliver the contract requirements.

- Using fill material won from excavations, establish haul road between nominal stockpiles A and B
- Stockpile A is to receive material with visual properties of those listed in Table 6–1, and as defined elsewhere in this specification, refer Table 6–1. It is recommended that the Contractor maintain separate stockpiles for other materials (deleterious or other)
- Stockpile B is to receive materials considered outside of those meeting the requirements of Section 8.1 or identified by the Contractor as higher-quality material, refer Table 6–1
- Any boulders are to be stockpiled in a retrievable position for crushing for use in site access tracks where necessary
- Material types shall be consolidated and stockpiled in the same location and placed in a manner that allows excavation without significant removal of adjoining material
- Material types, locations and boundaries between material types shall be surveyed such that volumes are recorded, and measured and materials can be efficiently re-excavated
- The Contractor's GITA is to perform ongoing conformance testing of the materials as they are generated during the works in accordance with Table 6–1 to confirm the visual monitoring of the segregation
- The Principal's Independent Geotechnical Engineer may review and provide direction on the fate of any truckload of material. The contractor is to allow in their pricing for this direction. The intention is that there will be consistent site presence in the early stages of excavation, but that will likely reduce / vary across the duration of the works.

Table 6–1: Stockpile Material Specifications

	Indicative Material Specification
Stockpile A	Preferential stockpiling of “Fill” material Visual inspection indicates unsuitable for Stockpile B area, or per the specification in regard to deleterious materials, unexpected fines and the like Boulders at the southern end / easy to retrieve
Stockpile B	Visual inspection indicates a well-graded material, with a good percentage of fines, with PSD testing at a rate of 1:5,000m² for preliminary confirmation of suitability per material types in Section 8.1

Nominal stockpiles A and B shall be used for:

- Onsite material re-use purposes, as defined under this specification, and
- Other material reuse, which includes works not undertaken as part of this Contract.

The Contractor is to prepare a Material Segregation and Testing Plan, for acceptance by the Principal’s Authorised Person, prior to commencing excavation works. This plan is to identify how the Contractor proposes to identify, stockpile, segregate, test, and track material excavated under this contract.

The contractor is responsible for documentation and testing of all stockpiled material, including any residual material not used in the works and defined as Reuse - Other Material (refer Section 7.5), in a Stockpile Certification Report. The Stockpile Certification Report shall include:

- Photos per lift
- Testing results
- Certification the material does not contain waste
- A report from independent Level 1 geotech certification, if requested by the Principals Authorised Person
- Tracking of material, including logging the source coordinates and destination stockpile
- Survey of each material type and the location
- Daily reports on material source, where it was placed, and photographic summary of materials
- Summary and certificates outlining testing of the material at a minimum in accordance with Sections 6.3 and 6.5

In addition to the above, materials reused onsite will require:

- Details of where material was sourced, i.e. Stockpile Certificate
- Details of where the material was placed or used on site, including material testing, tracking, survey, volumes and the like.

6.4 Requirements for On-Site Material Re-use

As outlined in Section 3 of this specification, material won from the new cell excavation works shall be utilised for cell construction, existing cell capping and closure, or stockpiled for future use. Potential On-Site material uses are listed in Table 6–2. It is noted that other materials may be encountered, and the Contractor shall manage, sort, and reuse all materials whether listed or not.

It is a requirement of this contract to use site-won material first, prior to importation of any material.

Table 6–2: Project / Site Material Classifications – On-Site Material Re-use

	Material Specification
General Fill	Section 7.12

Select fill	Section 7.13
Topsoil	Sections 2.2.3 and 2.1.4

Where material is to be reused on-site, all testing shall conform with the minimum requirements outlined in the relevant sections of this technical specification to confirm properties and material type prior to reuse.

The Contractor must demonstrate to the Principals Authorised Person that a material type is not available or exhausted prior to importing materials to site. The Principals Authorised Person may direct further testing by the Contractor / GITA to confirm the materials are not available.

6.5 Reuse – Other Material

It is a requirement of this contract to maximise the stockpiles of material for reuse following the completion of works, either onsite during landfilling operations or offsite.

Reuse - Other material shall be defined as the remainder of the material identified in Section 6.3 and segregated and stockpiled as outlined in and the Contractors Material Segregation and Testing Plan.

Reuse - Other Material that has been segregated and stockpiled and not already used in the works shall be tested in accordance Table 6–3. The Principal’s Authorised Person may request to increase the frequency of testing. This material is to be tested by the Contractor/GITA before it is stockpiled to ensure that its properties are known before it is placed and covered by subsequent layers of material. It is the Contractors responsibility to ensure that this occurs.

Table 6–3: Project / Site Material Classifications – Reuse – Other Material

Reuse – Other	Material Specification	Material Stockpile Testing	Minimum Testing Frequency
Day cover	Well graded material, maximum particle size = 150m	PSD	1:1,000m2, min. 3 tests per stockpile

All test methods shall be as outlined elsewhere in this Technical Specification.

7. Earthworks

7.1 Definitions

In this Specification, material definitions include, but are not limited to the following. A description is provided below, Contractor shall make reference to subsequent sections of the specification for full details.

Drainage gravel: To provide hydraulic conveyance for leachate from the landfill cell.

General Fill: Derived from material excavated under the Works. All excavated material to be re-used as part of General site earthworks to the underside of the subgrade or other features as noted elsewhere.

Seal Bearing Layer: A suitably designed and engineered layer of material to support the sealing layer.

Subgrade: A firm and unyielding surface, free of sharp objects, suitable for placement of the synthetic layers in the new cell. Refer Section 8.1 for further details.

Select Fill Material: Elements such as bunds/drains, pipe backfill, access track, anchor trenches.

Topsoil: Topsoil is material containing adequate organic matter to support growth of revegetation on disturbed areas (i.e. track batters) Refer Sections 2.2.3

Other: all other material not listed above including, but not limited to: coarse rockfill, sand, aggregate, road base, rip, rap, and the like

7.2 General

The Contractor shall provide all labour, materials, and equipment necessary to clear, excavate, fill, backfill, compact and trim to grade for all earthworks included in this Contract.

The Works covered by this Specification include, but are not necessarily limited to, the following:

- Quality assurance control, verification and reporting to ensure quality aspects of the Works
- Safety of Earthworks
- Control, diversion and disposal of surface water and run-off from the site of the Works
- The setting out of the Works to the lines and levels shown on the Drawings
- Protection of services
- Stockpiling, testing, and sorting of materials
- Stripping topsoil
- Excavation and grading of subgrade (for each layer) to lines and levels shown on the Drawings
- General filling, relocation and shaping of subgrade (for each layer) as shown on the drawings
- Removal and burial of waste and unsuitable materials
- Trimming and compacting of subgrade surface (for each layer as shown on the drawings)
- Confirmation of subgrade levels (for each layer as shown on the drawings)
- Preparation of and compaction of anchor trenches
- Testing and importation of suitable materials necessary to construct the Works
- Testing and validation of materials after placement
- Forming, trimming, and compacting open drains
- Confirmation of final levels (for each layer as shown on the drawings).

All earthworks, including site preparation, shall only occur after the Contractor has implemented all erosion and sediment controls in accordance with Contractor's accepted soil and water management plan, and other water management obligations as outlined elsewhere in the Contract documents.

7.3 Standards

All earthworks shall be undertaken with independent Level 1 Geotechnical Supervision by in accordance with AS 3798-2007 Guidelines on earthworks for commercial and residential developments. Undertake all testing to the following Australian Standards (AS):

- AS 1141.3 Methods for sampling and testing aggregates – Sampling of aggregates and rock
- AS 1141.11 Methods for sampling and testing aggregates – Particle size distribution by sieving
- AS 1141.23 Methods for sampling and testing aggregates – Los Angeles value
- AS 1152 Specification for test sieves
- AS 1289 Methods of testing soils for engineering purposes
- AS 1289.3.6.1 Soil classification tests – Determination of the particle size distribution of a soil – Standard method of analysis by sieving
- AS 1289.5.1.1 Soil compaction and density tests – Determination of the dry density/moisture content relation of a soil using standard compactive effort
- AS 1289.5.8.1 Soil compaction and density tests – Determination of field density and field moisture content of a soil using a nuclear surface moisture–density gauge – Direct transmission mode
- AS 1289.2.1.1 Determination of the moisture content of a soil - oven drying method
- AS 1289.3.1.1 Soil classification tests - Calculation of the plasticity index of a soil
- AS 1289.3.6.3 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
- AS 1289.3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil
- AS 1289.5.6.1 Soil compaction and density tests - Compaction control test - Density index method for a cohesionless material
- AS 1289.5.7.1 Soil compaction and density tests - Compaction control test - Hilf density ratio and Hilf moisture variation (rapid method)
- AS 1289.6.7.2 Determination of the permeability of a soil - Falling head method for a remoulded specimen
- AS 1289.6.7.3 Determination of the permeability of a soil - Constant head method using a flexible wall permeameter
- AS 1726 Geotechnical Site Investigations
- AS 3798 Guidelines on earthworks for commercial and residential developments
- AS 4419 Soil for landscaping and garden use
- And all other standards as required by to complete the work.

7.4 Demolition of Structures

Only minor demolition of structures such as pavement and the like, is anticipated as part of the works.

The Contractor shall meet all statutory requirements for demolition including associated health and safety requirements for such work, plus meeting the requirements of service authorities (where relevant) or other relevant stakeholders including asset owners. Demolition shall be undertaken in a careful manner, with a minimum of disturbance and prevention of damage to property and injury to personnel. The Contractor shall at all times be solely liable for the care and stability of all the Works including those items being demolished.

All demolition material shall become the ownership of the Contractor and shall be disposed of by lawful means, including disposal into the existing landfill operations if accepted by the Principal.

The Contractor shall restore and make good, to a standard accepted by the Principal's Authorised Person and to match existing, all damage and defacement attributed to the Works, or caused by the Contractor.

7.5 Adjacent Structures

Provide supports to adjacent structures, work areas, drainage, slopes and landforms where necessary, sufficient to prevent damage resulting from the work under the Contract. Supports are deemed to be temporary Works.

7.6 Clearing and Grubbing

The Contractor shall make their own assessment of clearing and grubbing requirements.

The Contractor shall undertake all clearing and grubbing necessary to execute the Works including all vegetation, both living and dead, all minor man-made structures (such as fences and livestock yards), all rubbish and other materials which, are unsuitable for use in the Works, the chipping of the crowns of trees and the branches of shrubs, and the grubbing of trees and stumps from the Site. The work also includes the disposal of all materials that have been cleared and grubbed unless directed otherwise by the Principal's Authorised Person. All natural landscape features, including natural rock outcrops, natural vegetation, soil and watercourses are to remain undisturbed except where affected by the Works.

Grubbed stumps may be directed to be disposed of as directed by the Principal's Authorised Person.

The Contractor shall mow or slash and maintain grasses and other vegetative cover from areas disturbed by the Works to ground level, or a height not exceeding 20mm, prior to earthworks. This vegetation shall be mulched and stockpiled on the site and a volumetric survey of the mulched stockpile shall be undertaken. The Principal's Authorised Person will nominate the final location of the mulched vegetation. The mulched vegetation may be removed from the site to a location nominated by the Principal's Authorised Person, lawfully disposed of by the Contractor as green waste, or ultimately stockpiled on site at the completion of Works. The mulch may be used as mulch berms for erosion and sediment control where elected to do so by the Contractor, at the Contractor's own expense.

Unless shown on the drawings, vegetation clearing shall be limited to existing ground level until immediately before filling, to avoid ground disturbance and subsequent erosion and sedimentation issues. It is not expected that topsoil and roots would be removed, however the Contractor may choose to remove trees including the root mass to enable earthworks to be undertaken.

The Contractor is required to inspect the area to be cleared for the presence of known environmental or declared noxious weeds and to remove.

7.7 Quantities

All construction vehicles and all construction materials are to be weighed on the weighbridge on incoming and outgoing movements.

The Contractor shall monitor all earthworks and shall be responsible for verifying the quantities of all imported materials as well as the cut to fill during the works. Quantities of cut and fill provided in the tendering documents are provided for bidding purposes only and do not account for bulking, shrinkage, swell or excess material.

The Contractor shall monitor the number and type of loads transported to and from the existing landfill for stockpiling, with the data recorded in accordance with the Waste Levy Guidelines and will be provided weekly to the Principal.

The Contractor shall provide to the Principal's Authorised Person on a weekly basis, or as requested, quantities, types and areas of material placed during the Works for the purpose of tracking materials in accordance with the regulatory requirements e.g. DES Landfill Waste Levy.

7.8 Dewatering

The groundwater level over the site is highly variable (seasonally) and dependent upon climatic and rainfall conditions. Excavation below the groundwater level may be required as part of this project.

The management of this water, if encountered, will need to be developed by the Contractor in accordance with all current legislation and regulatory requirements. This may include local reinjection into the groundwater table, temporary storage onsite, reinfiltrating into the existing waste mass, transportation of the leachate to the existing leachate tank for off-site disposal (to sewer) as presently occurs, or tankering leachate directly to the sewage treatment plant.

In the event that groundwater is encountered which impacts on the required work scope such that dewatering is required, then the Contractor shall make an assessment (which will include the contamination of the water) to demonstrate to the Principal's Authorised Person's reasonable satisfaction that dewatering is required. If dewatering is required, the following specification requirements are applicable.

7.8.1 Dewatering Plan (if required)

Should dewatering be required, the Contractor shall submit a "Dewatering Plan" with sufficient details, including any necessary diagrams, drawings and design data and all associated costs fully detailing the proposed method to be employed in dewatering excavated areas at least 15 working days before the proposed commencement of excavation.

All dewatering shall be handled and disposed of in accordance with all legislative and statutory requirements, standards, codes and guidelines, and any requirements outlined in the Contract Documents, including but not limited to recording the volume of water extracted.

If required, dewatering shall occur prior to the start of excavation in the affected area. Control water during the course of construction to:

- Maintain excavations free of water during earthworks, preparation of subgrade (for each layer as shown on the drawings), placement of geosynthetics and GCL, placement of fill, construction of drainage, backfilling and all works as required
- Prevent contamination of the site or off-site.

The Contractor shall provide all necessary equipment and materials including pipes, wells, piping hoses and fittings, power and treatment systems to adequately control water in the excavation and discharge in accordance with any requirements outlined in the Contract Documents. Provide sufficient redundancy in each system to keep excavation free of water in the event of component failure.

The Dewatering Plan, if required, shall be compliant with the CEMP and also include details on the location, depth and size of well-points, headers, sumps, ditches, size and location of discharge lines, capacities of pumps and standby units, re-infiltration pits and detailed description of the proposed dewatering methods to be employed to convey the water from site for adequate management as well as any necessary daily screening tests that will be undertaken. The Contractor shall be responsible for recording the volume of groundwater extracted.

The Dewatering Plan shall also outline control procedures and contingency plans to be adopted if dewatering problems arise. In the event of EPA reportable contamination being encountered the dewatering shall cease until such time as contingent measures are accepted by the Principal's Authorised Person. If required, the Contractor shall manage water removed from the excavations in such a manner as:

- tested to see if the water is contaminated
- will not endanger portions of work under construction or completed
- water shall be either treated or re-injected into the site at the locations nominated by the Contractor on the site
- will cause no inconvenience to others working near or adjacent the site
- will comply with the stipulations of required permits for disposal of water

- will not detrimentally affect the receiving water body
- will control runoff
- will comply with licensing requirements (if required)
- The Contractor is responsible for preparing areas to be used for groundwater re-injection.

7.9 Excavation

7.9.1 Extent of Work Required

The minimum extent of excavation is provided in the Drawings and in the Contract Documentation.

The Contractor shall ensure that all areas not subject to construction works are retained free from disturbance or damage for the duration of the Contract. Should these areas become disturbed or damaged they shall be reinstated by the Contractor.

The extent of excavation required shall be undertaken to enable the works to be completed and the site and surrounds left in a safe and stable condition, and which enables the ongoing activities to be safely accessed and conducted without the potential for collapse or landslide.

All non-disturbed areas of the site that may have been affected by the works are to be made safe.

At the end of each week, the Contractor shall undertake an assessment of the earthworks balance and submit a report, or as required under the Contract documents.

All loose or unstable material on or around excavated faces must be assessed by the Contractor. If assessed to be loose or unstable, then the Contractors Geotechnical Consultant must submit information regarding how the area is to be remediated to continue works in that area.

The Contractor is to provide an outline of the method to be used in the excavation, including plant to be used.

The Contractor shall assess the stability of all works during and after the works including the requirements for managing stability and falling debris. The Contractor shall demonstrate how all risks including stability and falling debris are to be managed.

The Contractor shall supply, place and maintain all pumping, ditching or other accepted measures for the removal or exclusion of water, including taking care of stormwater and wastewater reaching the site of the work from any source so as to prevent damage to the work. The Contractor is to prevent stormwater from contacting wastes.

The potential dangers associated with excavation, such as explosion hazard due to landfill gas emissions and the potential for exposure to waste materials including asbestos shall be managed in accordance with the Contractor's safety requirements outlined elsewhere in the Contract documents.

7.9.2 Excavation in Rock

7.9.2.1 Rock

Rock is defined as any monolithic material, with a volume greater than 2.0 cubic metres, defined as "other than Easy Digging or Hard Digging" by the methodology outlined in "A revision of the graphical method for assessing the excavatability of rock" (Pettifer and Fookes, 1994) (refer Figure 10, extracted and highlighted in yellow below as Figure 7-1). Proving material to be rock shall be the responsibility of the Contractor.

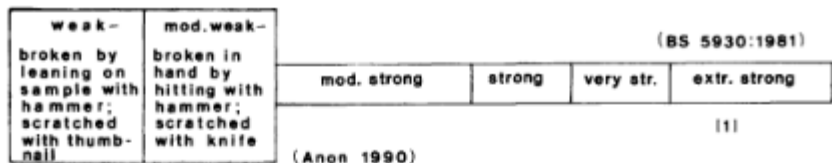


FIG. 10. Revised excavatability graph.

Figure 7-1: Extract – Figure 10 from Pettifer and Fookes

All other materials encountered in the excavation.

The Contractor shall notify the Principal immediately when rock is encountered. Determine the commencing levels for rock excavation. The actual quantity of rock excavation shall be the quantity necessarily and reasonably required to be excavated for the proper execution of the Work.

7.9.3 Excavation in All Classes of Material

Excavation shall mean excavation in all classes of material including waste, other than rock as defined in Section 7.9.2.1. The Contractor shall be responsible for excavation to the level of the sub-grade indicated on the drawings or as modified by ground improvements, such as dynamic compaction (including groundwater trenches).

Excavation is designated as “all classes” and is defined as all excavation, irrespective of the type of material or its condition. The Contractor shall be responsible for all classes of materials including the excavation, testing, placement and transport and disposal.

The Contractor shall undertake excavations in a systematic manner and excavate to the lines, dimensions, levels and other requirements specified in the drawings or as required, including but not necessarily limited to the correct levels and profiles as the basis for construction, filling and the like. Make allowance for compaction and settlement and ground improvement works.

All materials shall be handled and disposed of in accordance with all legislative and statutory requirements, standards, codes and guidelines, and any requirements outlined in the Contract Documents.

All excavation shall be undertaken in accordance with the Contractors CEMP and the “Excavation in Waste and Contaminated Materials” section of this specification (Section 7.9.4).

The Contractor shall provide all necessary support to ensure the stability of excavations during the works and to prevent detrimental settlement effects on completed work.

All excavated material shall be classified in accordance with this specification and the Contract documents.

Explosives shall not be used.

7.9.4 Excavation in Waste and Contaminated Materials

Given the nature of the site as a landfill, there is risk of contaminated fill engagement within the areas of proposed excavation. Engagement with waste is to be considered and managed by the Contractor. All excavated waste material shall be handled in accordance with the Contractor’s Unexpected Finds Procedure, refer Section 2.1.5, the WEMP, and CEMP.

All contaminated materials or contaminated water shall be handled and disposed of in accordance with all legislative and statutory requirements, standards, codes and guidelines, and any requirements outlined in the Contract Documents.

The Contractor shall decontaminate equipment that has come into contact with contaminated materials.

The Contractor shall prepare as part of their CEMP details for categorisation, storage, treatment, and management of material encountered during excavation activities and requirements of the Contractors Materials Segregation and Testing Plan (CMSTP, Section 6), and this shall be submitted to the Principal’s Authorised Person for acceptance before works commence.

7.9.5 Unsuitable Materials

Unsuitable material is that which has inadequate geotechnical or environmental characteristics to be placed and compacted as outlined in this specification or is incompatible with the Works as described in the Contract.

All soft material from the decommissioned sediment basin shall be treated as unsuitable and should be excavated and removed until competent material is found. Soft spots may need to be treated in accordance with Section 7.14. This surface and material shall be approved by the Contractor’s Geotechnical Consultant as being suitable for the placement and compaction of fill in accordance with this specification.

Material deemed to be unsuitable is to be treated in accordance with the Contractor’s project-specific CEMP and the CMSTP.

Unsuitable materials are to be removed to a location nominated by the Principal’s Authorised Person and in accordance with the CMSTP.

7.9.6 Nature of Excavated Materials

The Contractor shall be responsible for any assumptions made in relation to the nature, hardness, and types of materials to be encountered in excavations and the bulking and compaction characteristics of materials.

The estimated quantity for excavation includes all types of materials that may be encountered in the excavation, including waste, soil, and rock.

During excavation certain materials shall be separated for reuse as outlined in this Specification. The Contractor shall win suitable material from the excavation to reuse as fill, including but not limited to access track material, general, select fill, subgrade, interim and seal bearing and revegetation layers (including topsoil) to be managed in accordance with the CMSTP.

The Contractor shall conduct all necessary testing to ensure its suitability for its intended use and satisfies the criteria stipulated in the Contract documents.

The Contractor shall provide results of all requirements of the CMSTP to the satisfaction of the Principal's Authorised Person.

7.10 Stockpiles

The Contractor shall monitor stockpile slope stability and is responsible for maintaining the stockpiles in a safe condition. Stockpile heights shall be limited and benched if required to satisfy accepted safe working methods and legislative requirements. It is noted that stockpiling over synthetic layers can cause instability and is not permitted. The Contractor shall be responsible for preparing, managing and maintaining the stockpile area, including all soil and water management as required under the Contract, for the duration of the Contract until completion of the Contract. Any clearing and grubbing required for these sites, temporary erosion and sediment control measures shall be undertaken and/or implemented in accordance with the requirements of this Specification.

All stockpiles shall be located so that drainage from the stockpile is captured within the proposed sediment pond as indicated on the drawings, or additional measures proposed by the Contractor. Stockpiles shall be formed to maximum side slopes as shown on design drawings shall be arranged to minimise damage to trees and vegetation. Stockpiles shall have a drainage swale placed on the uphill side of the stockpile to divert clean surface water away from the stockpile area and sediment traps to capture sediment running off the stockpile. All stockpiles are to be enclosed by a filter fence. Revegetation of stockpiles may be required. These drainage measures shall be constructed as per the Soil and Water Management (Section 2) of this Specification.

Where new access roads are required to stockpile site areas, these will be constructed and maintained by the Contractor during the period of the Contract. The stockpile sites shall be positioned so that the stockpiled material may be transported away at any time. Any existing fencing which requires adjustment or installation of gates to facilitate access road construction will be adjusted at the Contractor's cost. Any gates required as part of fencing adjustments will be suitable boundary fence type gates fitted with padlocks.

Excavated material shall be placed in accordance with the CMSTP.

Excavated material, imported fill and all other material products shall be segregated as required in this specification. The Contractor shall maintain separate stockpiles for all materials and these shall not be mixed. Imported materials, such as sand, gravel, and the like, that are stockpiled on-site shall be stockpiled in a manner that prevents mixing with excavated material. Confine stockpiles to designated stockpile areas. Do not obstruct roadways or other site access.

7.11 Stabilisation of cut batters and stockpiles

Exposed cut surfaces within the landfill cell are to be stabilised with hydromulch. Exposed surfaces of stockpiles shall also be stabilised by hydromulching, polymer soil binder or approved equivalent.

Stabilisation is to occur within 7 days of completion of the exposed surface.

The Contractor shall prepare a mix design for the polymer soil binder and/or hydromulching for the Principal's Authorised Persons review and approval. Include details of the application rate and proposed water source.

7.12 General Fill

Derived from material excavated under the Works. General fill shall have maximum particle size of 130 mm, be free of organic material, and free of sharp objects, edges or corners that may damage the geosynthetic lining materials and be in accordance with the Contractors Material Segregation and Testing Plan. General fill shall be used as part of general site earthworks to the underside of the subgrade, or other features as noted elsewhere within the drawings.

All placement of general fill shall be in accordance with AS3798 and Level 1 Supervision and Section 6 of this Specification.

7.13 Select Fill

Prior to the delivery of imported Select Fill material, or the use of any material sourced on-site, the Contractor will submit the following information to the Principal's Authorised Person for acceptance:

- Certified pre-qualification test results from a NATA Accredited Laboratory in accordance with Table 7-1
- An estimate of quantity at the source which meets the specification and is represented by the certified pre-qualification test results.

Where the Select Fill material is to be imported material, the material shall satisfy Table 7-1 and Section 3. Where the material is to be reused from onsite excavation and stockpiling, it shall satisfy the Contractors Material Segregation and Testing Plan, and the requirements of Section 7. The Contractor will provide the required information to the Principal's Authorised Person at least 28 days prior to its proposed importation onto the site. The Contractor must not import any material onto the site until the Principal's Authorised Person has accepted its use. The Contractor is responsible for ensuring that sufficient materials are available for the Works to be performed within the required timeframes.

The acceptance criteria in Table 7-1 may be relaxed where, in the opinion of a Contractors Geotechnical Consultant, the material would be suitable for the select fill purpose. Any request to change the Select Fill shall be made in writing to the Principal's Authorised Person, who may accept or reject the request. Acceptance does not relieve the Contractor of satisfying all obligations under the Contract.

Table 7-1: Pre-qualification Acceptance Criteria – Select Fill

Property	Test Method	Acceptance Criteria	Minimum Testing Frequency
Particle size distribution - Passing 53 mm % Fines (< 0.075 mm)	AS 1141.11,12,13 or AS1289.3.6.1, 3.6.3	100% <30%	Greater of: 3 per source or per 2,000 m ³
Plasticity Index	AS 1289.3.1.1	6-25	Greater of: 3 per source or per 2,000 m ³
CBR	AS1289.5.7.1	> 5	Greater of: 3 per source or per 2,000 m ³
CBR Swell	AS1289.5.7.1	<2.5% (if placed within 1m of final pavement levels)	Greater of: 3 per source or per 2,000 m ³
Ratio of Monovalent to Divalent Cations (RMD)	ASTM 6141 and see discussion in Section 8.2		Greater of: 1 per source or per 10,000 m ³

The Contractor shall undertake geotechnical testing of the Select Fill in accordance with Table 7-4 and the Contractors Material Segregation and Testing Plan as a minimum.

7.14 Soft Spots

Soft spots in the subgrade shall be identified after Compaction and proof rolling in accordance with this specification.

The Contractor shall monitor and record the placement of fill, compaction, the surface level changes and fill quality and condition and include all such data in quality assurance documentation.

Any soft spots in the Subgrade shall be excavated down to a reasonably firm base and backfilled with Structural Fill. The material is to be compacted by conventional means until the surface level is at grade with the surrounding ground.

The cost of all soft spot excavation and replacement shall be borne by the Contractor.

7.15 Importation of Fill (General)

As outlined in Section 6, it is a requirement of this contract to use site-won material first, prior to importation of any material.

Imported fill may be required for select fill, drainage, soft spot replacement and other purposes.

All imported fill shall satisfy the requirements of this Specification and all other sections of the contract documents including all material testing records. Unless noted otherwise in this specification, imported fill shall not contain any of the following:

- Peat, vegetation, timber, organic, soluble or perishable material
- Dangerous or toxic material, or material susceptible to combustion

- Metal, rubber, plastic or synthetic material
- Construction debris.

Fill is not to be imported without the acceptance of the Principal's Authorised Person.

7.16 Placing Fill

The areas specified to be filled shall be finished to the levels and/or grades shown on the drawings, without abrupt changes of slope and/or depressions, which may hold surface water. The regraded filled surface (earthworks level) shall be prepared as outlined in this Specification and shall present a good true surface, free from rocks, clods, protrusions, and rubbish of all description and any visual contamination.

Prior to filling of each layer, the exposed subgrade materials shall not be trafficked by heavy vehicles or machinery if the surface materials are over wet. The moisture content of each layer shall be maintained at the required moisture content during compaction. Where it is necessary to increase the moisture content, each layer or part thereof shall be watered by means of an accepted sprayer delivering a uniform distribution of water over the area to be wetted (noting the requirements to protect against premature hydration of the GCL, refer Section 9.12). Adequate watering equipment shall be made available during all compaction operations.

Where the exposed subgrade is unable to support construction equipment, or it is not possible to compact the overlying pavement only because of a high moisture content, the Contractor shall perform one or more of the following:

- Allow the subgrade to dry until it will support equipment and allow compaction, or
- Scarify the subgrade to a depth of 150 mm, work as necessary to accelerate drying, and recompact when the moisture content is satisfactory.

7.17 Compaction

Compaction is required to prepare the subgrade (for each layer as shown on the drawings) during placement of the fill, and as described in this technical specification. The Contractor shall make their own assessment of the suitability of materials for conventional compaction techniques, notwithstanding the requirements for minimising noise and vibration impacts as required under the Contract and the CEMP, and the outcomes of the Field Trial of Placement method.

All compaction equipment shall be of suitable type and adequate to obtain the densities specified and shall provide satisfactory breakdown of materials to form a suitable fill.

Compaction equipment shall be operated in strict accordance with the manufacturer's instructions and recommendations. Equipment shall be maintained in such condition that it will deliver the manufacturer's rated compactive effort.

All material shall be compacted in horizontal layers or in layers up to 10% in grade from the horizontal. Slope rolling shall not be permitted unless achievement of compaction requirements and adequate layer interlock (eg. through top of each compacted layer being lightly scarified before placement of subsequent layer) can be demonstrated by this method of compaction.

All fill layers should be placed and compacted in layers not exceeding 300mm thickness and must be placed to achieve the compaction requirement as outlined in Section 7.17.1 (Compaction Requirements - Earthworks) of this specification.

Material which becomes saturated beyond acceptable moisture content levels after placement shall not be compacted until it has sufficiently dried out and is within the acceptable moisture content limits for compaction. The drying process may be assisted by aeration. Alternatively, the Contractor may transport the wet material to a stockpile site for drying out and later use as fill material. The cost of transport to stockpile for drying out and later use shall be borne by the Contractor.

If there is insufficient moisture in the material for it to be compacted as specified, water shall be added. The added water shall be applied uniformly and thoroughly mixed with the material until a homogenous mixture is obtained. The cost of such wetting or drying the material to be compacted shall be borne by the Contractor. The

Contractor shall note the requirements for hydration of the GCL, which shall not be allowed to fully hydrate until adequate cover material has been placed.

Compaction shall be undertaken to obtain the specified compaction for the full depth for each layer and for the full width of the formation over the entire length of the work. Compaction shall be completed promptly to minimise the possibility of rain damage.

Any material placed by the Contractor that has attained the specified compaction but subsequently becomes saturated so that the moisture content is greater than the apparent standard optimum, shall be dried out and uniformly recompacted to the specified compaction before the next layer of material is placed. Alternatively, the Contractor may remove the layer of saturated material to a stockpile site for drying and later re-use. The cost of the removal to stockpile, drying out and reincorporation of the wet material shall be borne by the Contractor.

7.17.1 Compaction Requirements - Earthworks

The compaction requirements in the following table apply, subject to the requirements of AS 3798.

Table 7-3: Compaction Requirements

Type	Application	Compaction Requirement
General Fill	Beneath select fill in access tracks, bunds Material excavated under the Works. used as part of General site earthworks	95% Standard Maximum Dry Density or equivalent, -3% to +3% OMC
Select Fill	Pipe support, anchor trenches	95% Standard Maximum Dry Density or equivalent, -3% to +3% OMC
	Access Track, & associated embankments Other	98% Standard Maximum Dry Density or equivalent, -3% to +3% OMC
Subgrade	As noted on drawings and described in this specification	95% Standard Maximum Dry Density or equivalent at moisture content of -3% to +3% OMC
Trench backfill	Where noted on drawings and described in this specification, including pipework trench backfill outside the cell	98% Standard Maximum Dry Density or equivalent

Note: Care to be taken in compaction testing in layers over geosynthetics, such that underlying synthetic layers are not damaged.

7.17.2 Compaction Over Liners and Other Materials

Where compaction is required over geotextiles, geosynthetic clay liners, geomembranes liners, drainage layers, pipes, or other products required to complete the works, the Contractor shall use equipment that will not cause damage to the underlying materials. Placement of material over synthetic layers will be subject to the outcomes of the Field Trial of Placement Method.

7.18 Inspection and Testing Requirements – Earthworks

This section of the specification applies to the inspection, testing, and reporting requirements for all earthworks and may be in addition to the requirements and additional testing outlined elsewhere in this specification and the contract documents.

All earthworks and testing shall be in accordance with the Australian Standards (AS) outlined in this specification.

Inspection Testing and Reporting shall be carried out in accordance with the requirements below as well as all Inspection, Testing and Reporting required by the Contractor for delivering the works to meet the requirements of Contract Documents.

The Contractor shall provide certification that the works comply with the requirements of the specification. All costs associated with demonstrating through testing that the works under the Contract comply with the Contractual requirements are to be borne by the Contractor.

The minimum required testing frequency for the works, not including re-testing, is outlined below.

Table 7-4: Inspection and Testing Requirements

Type	Test	Frequency
General Fill Subgrade	Field Density	3 tests per 2500m ² per layer, or 3 tests per 500m ³
Select Fill Revegetation layers	Laboratory Compaction	For each field density undertaken
Other fill (where field testing is required)	Moisture Content	For each field density undertaken

Notes:

- Road Pavements addressed in Section 15.

7.19 Equipment

All earthworks shall be undertaken using conventional earthmoving equipment and methods e.g. dozers, excavators, rock breakers, and other equipment typical to this type of project, subject to the outcomes of the three Field Trials for assessment of placement methods. Blasting is not permitted.

7.20 Extent of Disturbed Areas

The Contractor shall confine machinery operations to within the Site.

All disturbed, compacted or spoiled ground outside of the designated Work Area shall be revegetated as specified within Section 2.1.4 of this Specification. The Contractor shall ensure that this operation is programmed to enable germination of seed prior to the completion of works and undertake all necessary maintenance for the establishment period which shall be a minimum of 13 weeks or as outlined in the Contract documents.

7.21 Lines and Levels

The extent of earthworks shall be to the lines and levels shown in the Contract Drawings. Compacted areas shall be trimmed to line and level by machine and/or hand as necessary to produce profiles to the accuracy required by the Specification.

7.22 Tolerances

Unless specified otherwise, the tolerance for finished surfaces shall be:

Table 7-5: Allowable tolerances

Element	Tolerance
Surface drains, pavements (depth)	± 30 mm
Stripped surface (levels)	± 50 mm
Design subgrade (level)	+0, -100mm
Subgrade (thickness)	+50 mm, -0 mm
Leachate drainage gravel (thickness)	+50 mm, -0 mm
Topsoil layer (thickness)	+50 mm, -0 mm
All trenches (thickness and width)	+100 mm, -0 mm

7.23 Anchor Trenches

Where required, anchor trenches shall be excavated to the lines, depths and widths shown on the Drawings, prior to geosynthetic placement. The anchor trench shall be adequately drained to prevent ponding or softening of the adjacent soils while the trench is open.

Rounded corners with a 150 mm radius shall be provided where the geosynthetics adjoins the trench so as to avoid sharp bends in the geosynthetics. No loose soil shall be allowed to underlie the geosynthetics in the anchor trench. Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetics.

Anchor trenches shall be backfilled and compacted as 'select fill' in accordance with this Specification. Compaction equipment shall be adequate to achieve the required compaction. Care should be taken when backfilling the trenches to prevent any damage to the geosynthetics. If damage occurs, it shall be repaired prior to backfilling.

7.24 Rework

The Contractor shall undertake rework, including excavation, replacing, compaction and retesting of all sub-grade (for each layer as shown on the drawings) areas that fail to meet the requirements of this Specification at their own cost. The Contractor shall meet the cost of all additional testing.

7.25 Management of Water

Water management shall be as per Section 2 of this Specification.

The earthworks shall be so arranged that the site remains adequately drained throughout the period of construction. Any damage which results from the Contractor not observing this requirement, including the replacement and/or drying out of material which has become over- wet because of inadequate drainage, shall be rectified by the Contractor at the Contractor's expense as directed by the Principal's Authorised Person.

The Contractor shall provide and maintain the means and equipment required to sustain water at levels to suit the selected method of excavation and for the proper disposal of water entering the excavation (refer Section 7.8).

The Contractor is to be responsible for all management of groundwater and leachate flows for the duration of the contract, in accordance with all regulatory guidelines (refer Sections 1.7 and 1.8).

The Contractor must liaise with the Principal's Authorised Person throughout the contract to ensure that operational requirements of the existing landfill are met. This includes the management of leachate and

groundwater from the existing cell. The landfill is dynamic and as such may require multiple redirections throughout the contract.

8. Subgrade

8.1 General

This section includes material and installation requirements for the subgrade.

8.2 Submittals

Subgrade material can be either imported or site-won material in accordance with the order of winning material per Section 7. The Contractor is to excavate to the top of subgrade layer and assess material in accordance with AS3798 against the parameters in Table 8–2. The frequency of testing shall be in accordance with Table 8–1, or greater and shall include any locations where there is a visible change in the material as assessed by the Contractor’s Geotechnical Consultant.

If existing material is suitable, it is to be ripped and recompacted to a depth of 200mm, to form a firm, stable smooth surface on which to install the synthetic layers. The finished surface is to be compliant with the requirements of Section 8.5 and approved by the CQA Consultant.

If the existing material is unsuitable, it may be conditioned such that it is suitable, with the method to be confirmed by the Contractor’s Geotechnical Consultant or it may be removed and replaced with suitable material from the stockpile. The conditioning method is to be submitted as a RFI including all relevant technical data, demonstrating compliance or otherwise with this specification, including certification by the Contractor’s Geotechnical Consultant, or an independent and suitably qualified geotechnical engineer. The Principal’s Authorised Person will review the RFI but isn’t obligated to accept. The finished surface is to be compliant with the requirements of Section 8.5 and approved by the CQA Consultant.

Prior to the acceptance of site-won subgrade material, the Contractor will submit the following information to the Principal’s Authorised Person for acceptance:

- The stockpile certificate including all material test results
- Relevant results of interface strength testing (refer Section 4). This testing shall be undertaken immediately after achieving the top of subgrade to confirm whether the existing material will satisfy interface shear requirements.

If the site-won material is unable to be suitably conditioned, material complying with the stockpiled acceptance criteria (Table 8–2) is to be imported and placed by the Contractor. The Contractor’s Geotechnical Consultant shall identify those areas where site-won subgrade is suitable to remain, and those areas unsuitable which are to be replaced with imported subgrade. The Contractor shall submit a RFI including all relevant technical data, demonstrating material to remain and material to be removed and replaced including certification by the Contractor’s Geotechnical Consultant, or an independent and suitably qualified geotechnical engineer. The Principal’s Authorised Person will review the RFI and may seek input from the Principal’s Geotechnical Consultant on the final areas to be replaced with imported material, before accepting.

Prior to the delivery of imported subgrade, the Contractor will submit the following information to the Principal’s Authorised Person for acceptance:

- Certified pre-qualification test results from a NATA Accredited Laboratory in accordance with Table 8–1 and Table 8–2
- An estimate of quantity at the source which meets the specification and is represented by the certified pre-qualification test results
- Relevant results of interface strength testing (refer Section 4 and Section 6).

The Contractor will provide the required information to the Principal’s Authorised Person at least 28 days prior to its importation onto the site. The Contractor must not import any material onto the site until the Principal’s Authorised Person has accepted its use. The Contractor is responsible for ensuring that sufficient materials are available for the Works to be performed within the required timeframes.

Predicted volume of subgrade required to be imported to the site is to be advised to the Principal's Authorised Person.

Table 8–1: Pre-qualification testing – subgrade material

Property	Test method	Minimum test frequency
Particle size distribution	AS 1141.11, 12, 13 or AS1289.3.6.1, 3.6.3	Greater of: 3 per source or per 2,000 m ³
Atterberg Limits	AS1289.3.1.1, 3.2.1 & 3.3.1	Greater of: 3 per source or per 2,000 m ³
CBR	AS1289.5.7.1	Greater of: 3 per source or per 2,000 m ³
Organic content	AS 1289.4.1.1 or Walkley Black method	Greater of: 3 per source or per 10,000 m ³
Ratio of Monovalent to Divalent Cations (RMD) ²	ASTM 6141 and see discussion below	Greater of: 1 per source or per 10,000 m ³

RMD Assessment Method

RMD is defined as the ratio of the total molarity of monovalent cations to the square root of the total molarity of divalent cations. The molarity of Major cations (Calcium, Magnesium, Sodium, Potassium) should be determined from a test liquid generated from soil samples per the method described in ASTM 6141, Section 7. The concentration of cations should be measured in mg/L and ideally measured with a limit of detection no higher than 1 mg/L.

RMD calculated by Equation $RMD = \frac{M_M}{\sqrt{M_D}}$ Where M_M = molar concentration of monovalent cations (Na & K) and M_D = molar concentration of divalent cations (Ca & Mg) of the test liquid (Kolstad et al (2004)).

RMD calculation results that do not meet the specified acceptance criteria may be accepted by the Principal's Authorised Person based on further assessment of the test results.

The Contractor is to prepare a site-specific work method statement (WMS) for installation of the subgrade. This is to be submitted to the Principal's Authorised Person for acceptance. This WMS is to include all the processes and equipment that the Contractor proposes to use for the transport, stockpiling, conditioning, placement and compaction for the placement of the all works. The WMS shall be submitted for review. The Contractor shall incorporate any changes and submit as final.

8.3 Material

- Subgrade material shall not contain any of the following:
 - Peat, vegetation, timber, organic, soluble, or perishable material
 - Actual or potential acid sulphate soils
 - Organic clays and silts
 - Dangerous or toxic material
 - Material susceptible to combustion
- Material used in this layer will be as outlined in Section 3 and comply with Table 8–1 and Table 8–2.

² RMD shall be calculated using test results for material with respect to procedure outlined in Kolstad, D. C., Benson, C. H., and Edil, T. D. (2004). 'Hydraulic conductivity and swell of nonprehydrated GCLs permeated with multispecies inorganic solutions.' J. Geotech. Geoenviron. Eng., 130(12), 1236–1249

Table 8–2: Pre-qualification acceptance criteria – subgrade

Material characteristic	Acceptance criteria
Particle size distribution	
% Passing 53 mm	100%
% Fines (< 0.075 mm)	5-30%
Atterberg limits	
Plasticity index	6-35
CBR	> 5
% Organic content	<2%
Ratio of monovalent to divalent cations (RMD) ³	> 0.15 M ^{0.5}

8.4 Installation

All filling shall be in accordance with AS3798 and Level 1 Supervision and Section 7 of this Specification. The Contractor provides certification that all filling and related work is in accordance with the requirements of the Contract.

Additional requirements include:

- Place and compact subgrade material in 300 mm maximum compacted lifts, to the lines and grades indicated
- Grade out soil berms and undulations on site to provide a smooth unyielding surface
- Proof-roll all subgrade layers at completion of rough grading and excavations in accordance with RMS Test Method T198
- Conduct proof-rolling operations as necessary to determine the soundness and suitability of existing material
- The Contractor shall match compaction methods to the material and location
- Fill and compact undercut and over excavated areas to meet final grades providing positive surface drainage
- Any desiccations, cracks, or inconsistencies in subgrade layers shall be remediated as directed by the Principal's Authorised Person.

8.5 Finished Surface

The finished surface of the subgrade layer shall be:

- Smooth, flat, firm and unyielding to the satisfaction of the Principal's Authorised Person before the surface is finally trimmed (if required) and rolled with a final pass of the smooth drum roller
- Free of debris, roots, angular material (such as sharp rocks), desiccation cracks and sudden changes in grade. If required, the surface shall be raked or graded to remove any material penetrating out of the surface greater than 10 mm or any holes extending below the surface more than 15 mm. Pockets, holes, or discontinuities shall be repaired.

³ RMD shall be calculated using test results for material with respect to procedure outlined in Kolstad, D. C., Benson, C. H., and Edil, T. D. (2004). "Hydraulic conductivity and swell of non-prehydrated GCLs permeated with multispecies inorganic solutions." J. Geotech. Geoenviron. Eng., 130(12), 1236–1249.

RMD calculation results that do not meet the specified acceptance criteria may be accepted by the Principal's Authorised Person on further review of laboratory results, refer discussion in Section 9.2.

- All construction stakes, hubs, or other items used for grade control shall be removed and the void filled with processed material
- Maintained at sufficient moisture content to prevent desiccation
- Sufficiently dry for installation of the GCL
- Suitable to meet the placement requirements of the GCL
- The Geosynthetic Installer and the Contractor are to sign a certificate of subgrade acceptance for each day that geosynthetic materials are placed, prior to inspection by the CQA/Principal's Authorised Person
- The Contractor remains responsible at all times for subgrade condition, including after acceptance or where subgrade acceptance was not provided.

8.6 Quality Control Testing

The Contractor shall undertake geotechnical testing of the subgrade layer in accordance with Table 7-4 as a minimum.

8.7 Acceptance

- The Contractor shall retain all ownership and responsibility for the subgrade until final acceptance of all work under this contract by the Principal's Authorised Person
- The subgrade layer shall be accepted by the Principal's Authorised Person when all of the following conditions are met:
 - Principal's Authorised Person has received and reviewed the as-built survey of the completed subgrade showing conforming layer thickness within the allowable tolerances
 - Compaction test results have been received and show compliance with the requirements of this Specification
 - Details of all defects identified and repairs performed have been submitted to the Principal's Authorised Person for review and acceptance
 - Inspection of all anchor trenches and receipt of required submittals
 - The CQA Consultant has provided the Principal's Authorised Person with a recommendation that the conditions of final acceptance have been met
 - The Principal's Authorised Person has inspected and accepted the completed subgrade.

9. Geosynthetic Clay Liner

9.1 General

This section contains the technical requirements for geosynthetic clay liner (GCL).

The Principal's Authorised Person may reject any GCL that does not meet or exceed the requirements of this section.

Any GCL rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

9.2 Standards

9.2.1 Australian Standards

Relevant Australian standards are as follows:

- AS 1289 Methods of testing soils for engineering purposes
- AS 1289.3.6.2 Soil classification tests—Determination of the particle size distribution of a soil – Analysis by sieving in combination with hydrometer analysis (subsidiary method)
- AS 3706.1 Geotextiles - Methods of test - General requirements, sampling, conditioning, basic physical properties and statistical analysis
- AS 3706.4 Geotextiles - Methods of test - Determination of burst strength - California bearing ratio (CBR) - Plunger method.

9.2.2 American Society for Testing and Materials Standards

Relevant American Society for Testing and Material (ASTM) standards are as follows:

- D4354 Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
- D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
- D5888 Standard Guide for Storage and Handling of Geosynthetic Clay Liners
- D5889 Standard Practice for Quality Control of Geosynthetic Clay Liners
- D6072 Standard Practice for Obtaining Samples of Geosynthetic Clay Liners
- D6102 Standard Guide for Installation of Geosynthetic Clay Liners
- D6495 Guide for Acceptance Testing Requirements for Geosynthetic Clay Liners.

9.2.3 Geosynthetic Research Institute Standards

Relevant Geosynthetic Research Institute (GRI) standards are as follows:

- GCL3 Specification for Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners.

9.3 Submittals

9.3.1 Prior to delivery of geosynthetic clay liner to site

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance prior to delivery of GCL to site (per GCL product):

- Manufacturer's certificate of compliance stating conformance with the requirements of this Specification
- Manufacturer's quality control and assurance test results
- Certification that the GCL supplied for this work was manufactured as consecutive rolls from a single lot or from consecutive lots. If the GCL is not manufactured from consecutive lots, the manufacturer shall provide certification of quality and consistency of the product characteristics
- Statement on the origin of the bentonite, bentonite supplier's name and production plant, and bentonite brand name and type
- Copies of quality control certificates issued by the bentonite supplier to verify conformance with Table 9–1
- Manufacturer's certification (per 50 tonnes of product) that the bentonite form is natural sodium bentonite powder
- Note: Bentonite powder consisting of > 80 wt% sodium as activated bentonite may be used with acceptance from the Principal's Authorised Person. Acceptance shall be sought prior to construction and prior to selection of GCL manufacturer
- Complete description of the manufacturer's shipping, handling and storage procedures
- Manufacturer's installation procedures and requirements
- Work method statement for GCL delivery, storage, handling and installation. This shall include seaming and jointing, procedures for testing and repairing, proposed handling equipment and restraining methods, and other information that shall promote proper use
- Relevant results of interface strength testing (refer Sections 4 and 6).

9.3.2 Prior to installation of geosynthetic clay liner

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance prior to installation of GCL:

- Delivery, storage and handling log for all GCL rolls to be used in the Works, including delivery dockets, roll number and identification, delivery inspection checklist, details of storage and handling
- Proposed panel placement drawing, showing the location and reference number of all panels and expected seams, connections and penetrations, panel dimensions and layout, and the order of panel installation
- Survey of the underlying surface in accordance with Section 1.16
- Results of independent material conformance testing as provided by the CQA Consultant.

9.3.3 Following installation of geosynthetic clay liner

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance following installation of GCL:

- Panel placement and seaming log, providing details on panel number and associated roll number, date and time placed, date and time seamed, condition of receiving surface, weather conditions and precipitation events, QA checks performed, and all other relevant information
- Finalised panel placement drawing showing the as-built location of all panels, seams, connections and penetrations
- Defect and repairs log, showing details of all defects identified and any repairs completed.

9.4 Manufacturers Quality Control

The manufacturer shall follow a quality control program, accepted by the Principal's Authorised Person, throughout the manufacturing of all GCL for the Works.

Manufacturer's quality control submissions shall include:

- Date of manufacture
- Lot number, roll number, length and width
- Bentonite manufacturer quality control documentation for the particular lot of clay used in the production of the rolls delivered
- Geotextile manufacturer quality control documentation for the particular lots of geotextiles used in the production of the rolls delivered
- Cross-referencing list delineating the corresponding geotextile and bentonite lots for the materials used in the production of the rolls delivered
- Quality control program laboratory-certified reports
- The manufacturer's approved quality assurance stamp and the technician's signature.

The frequency of sampling and testing shall be in accordance with Table 9–1.

The Principal's Authorised Person may reject any GCL rolls that have not been sampled and/or tested in accordance with this section.

All GCL rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

9.5 Manufacturers Quality Assurance

The manufacturer shall follow a quality assurance program, accepted by the Principal's Authorised Person, throughout the manufacturing of all GCL for the Works.

The frequency of sampling and testing shall be in accordance with ASTM D4354.

The Principal's Authorised Person may reject any GCL rolls that have not been sampled and/or tested in accordance with this section.

All GCL rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

9.6 Material

The GCL shall:

- Be new, first quality products manufactured for the Works
- Be a proprietary product comprising a layer of natural sodium bentonite powder of uniform thickness and consistency, reinforced by stitch-bonding or needle-punching to fully integrate the cover and carrier geotextile/s and constrained by thermally locking. Note: Bentonite powder consisting of > 80 wt% sodium as activated bentonite may be used with acceptance from the Principal's Authorised Person. Acceptance shall be sought prior to selection of GCL manufacturer
- Certified as needle-free by the manufacturer
- Comply with the acceptance criteria specified in Table 9–1.
- Be suitable for the proposed installation environment, including but not limited to installation requirements, chemical compatibility and slope stability.

The Contractor shall supply manufacturer's quality control and assurance testing results in accordance with the testing frequencies identified in Table 9–1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the roll lots. In addition to this, manufacturer's certification (per 50 tonnes of product) that the bentonite form is natural sodium bentonite powder shall be provided for all the GCL rolls supplied.

If required by the Principal's Authorised Person, a sample of the GCL shall be provided (per product) and the Principal's Authorised Person and/or CQA Consultant may undertake an inspection of the manufacturer's

facility. The Contractor shall cooperate fully with the Principal's Authorised Person and CQA Consultant to allow this inspection to occur.

Table 9–1: Acceptance criteria – GCL

Property	Test method	Acceptance criteria	Minimum testing frequency
Bentonite clay			
Bentonite clay – particle size (min.)	AS 1289.3.6.2	80% passing 75 micron sieve (powdered)	every 50 tonnes
Bentonite clay – free swell index (min.)	ASTM D5890	24 mL/2g or cm ³ /2g	every 50 tonnes
Bentonite clay – fluid loss (max.)	ASTM D5891	18 mL	every 50 tonnes
Bentonite clay – montmorillonite content (min.)	CSIRO x-ray diffraction	70%	every 50 tonnes
Bentonite clay – carbonate content (max.)	CSIRO x-ray diffraction	2 wt%	every 50 tonnes
Bentonite clay – cation exchange capacity (min.)	Methylene blue method	70 meq/100g or cmol/kg	every 50 tonnes
Geotextile			
Geotextile configuration:	-	Carrier: Woven + non-woven Cover: Non-woven	NA
Carrier geotextile mass (MARV)	AS 3706.1	Woven: 100 g/ m ² Non-woven: 200 g/ m ²	every 20,000 m ²
Cover geotextile - mass (MARV)	AS 3706.1	Non-woven: 200 g/ m ²	every 20,000 m ²
Durability of geotextile and reinforcing yarns (min.) ⁴	Section 5.6.2 of GRI-GCL3	65%	yearly
Geosynthetic clay liner			
GCL mass per unit area @ 0% moisture (MARV) ⁵	ASTM D5993	4,000 g/ m ²	every 4,000 m ²
Bentonite clay mass per unit area @ 0%	ASTM D5993	3,700 g/ m ²	every 4,000 m ²

⁴ Value represents the minimum percent strength retained from the as-manufactured value after oven aging at 60°C for 50 days

⁵ Mass of the GCL and bentonite clay shall be measured after oven drying per the stated test method

moisture (MARV) (4)			
Bentonite clay moisture content (max.)	ASTM D5993	35%	every 4,000 m ²
California bearing ratio (CBR) burst strength (MARV)	AS 3706.4	3,000 N	every 5,000 m ²
Strip tensile strength (MARV) (Machine Direction)	ASTM D6768	12 kN/m	every 20,000 m ²
Peel strength (MARV)	ASTM D6496	600 N/m	every 4,000 m ²
Hydraulic conductivity (max.)	ASTM D5887	5×10^{-11} m/s	every 25,000 m ²

Note: The GCL acceptance criteria above are provided as minimum criteria. The GCL utilised shall be suitable to withstand the application for the design life of the cell, when considered in conjunction with the relevant liner profile. This is to include consideration of (but not be limited to) internal & external forces, interface shear, internal shear strength and environmental exposure.

9.7 Warranty

- The Manufacturer shall warranty his materials for a minimum of 20 years
- The Installer shall warranty his workmanship for a minimum of 1 year.

9.8 Roll and Sample Identification

All GCL rolls and samples shall be identified in accordance with ASTM D4873. Each roll or panel shall carry a label which identifies, as a minimum:

- Product name, grade and name of manufacturer
- Date of manufacture, batch number
- Roll number
- Roll length
- Roll weight
- Roll width
- Handling guidelines
- Reference numbers to raw material batch and laboratory certified reports
- The manufacturer's approved quality assurance stamp and the technician's signature
- The Principal's Authorised Person may reject any GCL rolls or samples that have not been identified in accordance with this section.

All GCL rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

9.9 Delivery, Storage and Handling

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of GCL, including repair methods. The work method statement shall be submitted to the Principal's Authorised Person and/or CQA Consultant for review and acceptance prior to delivery of the GCL to site.

The delivery, storage and handling components of the work method statement shall be developed in accordance with the guidance provided below:

- Delivery, storage and handling of all GCL rolls and samples shall be undertaken in accordance with the manufacturer's instructions and ASTM D5888 as a minimum
- Rolls shall be delivered to site, handled and stored in such a manner that no damage occurs to the rolls
- Rolls shall be wrapped with weather and moisture-proof wrapping to prevent any contact with water prior to installation. In the event that it is suspected that roll/s may have come into contact with water, the Principal's Authorised Person and/or CQA Consultant shall inspect the moisture content of the bentonite of the effected roll/s and reject the roll/s if they are damaged beyond use. All GCL rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor
- Roll cores shall be sufficiently strong to ensure that they do not deflect by more than half their diameter during delivery, storage and handling
- Rolls shall be stored in a location away from construction traffic but sufficiently close to the installation area to minimise handling. The storage area shall be level, dry, well-drained and stable, and shall protect the product from precipitation, chemicals, excessive heat, UV radiation, standing water, vandalism and animals
- GCL roll stacks shall be limited to the height at which installation personnel can safely manoeuvre the handling equipment. The recommended maximum stack height is three rolls
- Rolls shall be handled using a spreader or stinger bar. The bar shall be capable of supporting the full weight of the rolls without significant bending. Under no circumstances shall the rolls be dragged, lifted from one end, lifted in the middle of the roll, lifted with the forks of a forklift or pushed to the ground from the delivery vehicle. The Contractor may nominate alternate handling equipment and plant for acceptance by the Principal's Authorised Person as part of their work method statement
- The Contractor shall inspect all GCL rolls for defects and damage upon delivery.

The Principal's Authorised Person may reject any GCL rolls that have not been delivered, stored or handled in accordance with this section.

All GCL rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

9.10 Preparation of Receiving Surface

Prior to placement of GCL, the receiving surface shall exhibit the following characteristics:

- The surface shall be smooth, flat, firm and unyielding to the satisfaction of the Principal's Authorised Person and the CQA Consultant
- In accordance with Manufacturer's Requirements
- Sufficiently dry for installation of the GCL
- The surface shall not exhibit visible deformation, rutting, yielding and/or show signs of distress or instability during final proof rolling (if required)
- The surface shall be free of debris, roots, angular material (such as sharp rocks), desiccation cracks, abrupt breaks, indentations, sudden changes in grade, defects and/or imperfections that may result in damage to the overlying materials
- No loose, coarse-grained material shall remain on the surface. If required, the surface shall be raked or graded to remove any material penetrating out of the surface greater than 10 mm

- The surface shall promote drainage and excessive water shall not be allowed to pond on the surface
- The surface shall not be pebbly, tracked, rutted or otherwise disturbed by the equipment deploying overlying materials or other traffic. Pockets, holes, or discontinuities shall be repaired
- All construction stakes, hubs, or other items used for grade control shall be removed and any voids filled. Any unsuitable material shall be over-excavated to a depth of 100 mm and replaced with accepted material
- The surface shall be maintained at sufficient moisture content to prevent desiccation during the Works.

The receiving surface shall be surveyed as per the requirements of Section 1.16.

Placement of GCL shall not proceed until the receiving surface has been inspected and accepted by the Principal's Authorised Person and the CQA Consultant.

9.11 Installation

9.11.1 General

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of GCL. The work method statement shall be submitted to the Principal's Authorised Person for review and acceptance prior to delivery of the GCL to site.

The installation component of the work method statement shall be developed in accordance with the guidance provided below, and the manufacturer's guidelines. If there is discrepancy between the manufacturers guidelines and, the guidance below, seek guidance from the Principal's Authorised Person.

The Principal's Authorised Person may reject any GCL rolls that have not been installed in accordance with this section.

All GCL rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

9.11.2 Weather conditions

The Contractor shall consider the weather conditions on a daily basis to confirm they are suitable for placement of GCL. The Contractor is responsible for determining sequencing and protection of works to prevent premature hydration of the GCL, in accordance with manufacturer requirements. Protection and covering requirements are further discussed in Section 9.12.

GCL shall not be placed or seamed:

- If moisture prevents proper subgrade preparation, panel placement and/or panel seaming
- During precipitation, during hail, during periods of excessive fog, in standing water, on excessively wet surfaces, in the presence of excess moisture (such as dew and/or ponded water) and/or under any other conditions which may cause premature hydration of the GCL
- During periods of excessive winds (>30 kph) or when gusting wind conditions interfere with handling operations.

9.11.3 Traffic

Equipment used shall not damage the GCL by handling, trafficking, leakage of hydrocarbons, or by other means.

No vehicle shall be allowed to traffic directly on the GCL unless accepted by the Principal's Authorised Person. Prior to acceptance, the Contractor shall provide the Principal's Authorised Person the following information:

- Guidance from the manufacturer on suitable plant for trafficking for the proposed GCL and confirmation that the Contractor shall only use this plant
- Guidance from the manufacturer on suitable trafficking method for the proposed GCL and confirmation that the Contractor shall only use this trafficking method

- Certification from the manufacturer that the above trafficking method and plant shall not void the warranty for the proposed GCL.

9.11.4 Placement

GCL shall be placed in accordance with the following:

- The GCL shall be placed and seamed in accordance with this Specification, the Contract Drawings, the accepted work method statement, the manufacturer's instructions and ASTM D6102. Any contradictions shall be clarified with the Principal's Authorised Person
- Prior to placement, each roll shall be inspected by the Contractor for damage and/or defects. If damage or defects are identified, the roll shall be inspected by the Principal's Authorised Person and the CQA Consultant and accepted or rejected
- The protective wrapping on the rolls shall be maintained at all times prior to installation
- GCL shall be protected at all times from damage due to exposure to sunlight, dirt, dust and other hazards
- GCL shall be placed such that the panels are anchored at the crest of the slope and form a continuous layer down the slopes and to the toe of the slope (as shown on drawings)
- The arrangement of the GCL panels shall be in accordance with the accepted panel placement drawing and any changes accepted by the Principal's Authorised Person
- Installation shall progress from the highest elevations to the lowest
- GCL shall not be allowed to 'bridge over' voids or low areas. The GCL shall be placed to allow intimate contact with the subgrade or underlying geosynthetic
- GCL shall be installed without undergoing excessive buckling, wrinkling or tensioning
- GCL shall not be dragged across an unprepared surface. If the GCL is dragged across an unprepared surface, it shall be inspected by the Principal's Authorised Person and/or CQA Consultant for defects and repaired or rejected if necessary
- Where there is a geosynthetic layer below, the installation of the GCL shall be undertaken in a matter so as not to damage the underlying layer
- Sandbags or equivalent ballast shall be used as necessary to temporarily hold the GCL in position and prevent uplift by wind. In case of high winds, continuous loading shall be placed along edges of panels to minimise wind flow under the panels. Sandbag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the GCL
- Care should be taken to avoid contaminating the upper surface of the GCL with bentonite powder from the within the GCL
- GCL installed on slopes shall be fixed in anchor trenches as shown on the Contract Drawings and Section 7.23. GCL panels shall be anchored as soon as possible
- Personnel working on the GCL shall not smoke, wear damaging shoes, excessively traffic or engage in other activities which may damage the GCL. GCL in heavy traffic areas shall be protected by a geosynthetic overlay
- GCL rolls shall be freely suspended during placement
- The method used to unroll the GCL shall not cause bridging or excessive wrinkles
- After placement, the GCL shall be free of excessive buckles, wrinkles, ripples, creases, folds and irregular stressing before the overlying cover material or geosynthetic is placed.

9.11.5 Seaming

GCL shall be seamed in accordance with the following:

- All seams shall be overlapped and sealed with bentonite paste

- All seams shall be ‘shingled’ down-slope to promote runoff (roof tile fashion)
- End seams shall be overlapped a minimum of 500 mm and side seams shall be overlapped a minimum of 300 mm
- For batters with a 10% grade or steeper, transverse (cross-slope) seams shall be minimised. If required, transverse seams shall be overlapped a minimum of 1,500 mm. Transverse overlaps shall be immediately anchored
- Cross seams shall not be within 1,500 mm of the toe of the batter.
- The overlap zone shall be kept clean and shall not be contaminated with loose soil or other debris. There shall be no folds or wrinkles in the overlap zone and no plant traffic or foot traffic shall occur over the finished overlap
- Bentonite paste shall be applied continuously across the overlap zone at a rate of 400 grams per metre
- Bentonite used for seaming shall comply with the relevant bentonite acceptance criteria in Table 9–1
- Care shall be undertaken to avoid contaminating the upper surface of the GCL with bentonite paste.

9.12 Protection and Covering

The GCL shall be protected from damage and premature hydration due to precipitation, wind and other environmental conditions.

Covering and confinement activities shall be coordinated to ensure the following:

- On a daily basis, only those areas of GCL which can be covered to within 3 m of all edges shall be installed. All edges which are not completely covered shall be protected with anchored tarpaulins
- The overlying layer (HDPE/LLDPE layer, refer Sections 10 and 22 respectively) shall be placed as soon as practicable, in accordance with the GCL manufacturer’s instructions or as accepted by the Principal’s Authorised Person. Notwithstanding these requirements, the GCL should be protected from the elements and covered with temporary / permanent cover as appropriate
- The Contractor is to manage the risk associated with premature hydration of the GCL, in conjunction with construction sequencing and weather conditions. Any materials which have hydrated prematurely will be replaced by the Contractor at their expense
- The GCL layer shall be installed in accordance with the accepted work method statement (refer Section 10).

If the placed GCL panels have hydrated prematurely without confinement, then the affected GCL panels shall be removed and replaced by the Contractor at their own expense.

9.13 Defects and Repairs

The Contractor shall be responsible for inspecting the placed GCL to identify any damage or faults in the material. The Principal’s Authorised Person and/or CQA Consultant may also undertake inspections of the placed GCL to identify any damage or faults in the material. Any areas of GCL damaged during installation shall be repaired in accordance with the manufacturer’s instructions and the accepted work method statement. All repairs shall be verified by the Principal’s Authorised Person.

Repairs shall be made using a new piece of GCL of the same material type and thickness with a minimum 500 mm overlap beyond the repair area in each direction.

Bentonite paste shall be applied across the overlap zone around the repair area at a rate of 400 grams per metre. Bentonite used for repairs shall comply with the relevant bentonite acceptance criteria in Table 9–1.

The Contractor shall submit to the Principal’s Authorised Person for review a log containing details of any defects identified and repairs carried out.

9.14 Acceptance

The Contractor shall retain all ownership and responsibility for all GCL until final acceptance of the GCL by the Principal's Authorised Person.

The GCL shall be accepted by the Principal's Authorised Person when all of the following conditions are met:

- Required submittals are provided by the Contractor to the Principal's Authorised Person and accepted
- Adequacy of all field seams, penetrations and repairs is verified by the Principal's Authorised Person
- Details of all defects identified and repairs performed have been provided by the Contractor to the Principal's Authorised Person and accepted
- The CQA Consultant has provided the Principal's Authorised Person with a recommendation that the conditions of final acceptance have been met
- The Principal's Authorised Person has inspected and accepted the finished surface/s.

10. HDPE geomembrane

10.1 General

This section contains the technical requirements for high density polyethylene geomembrane for the cell construction.

The Principal's Authorised Person may reject any PE geomembrane that does not meet or exceed the requirements of this section.

Any PE geomembrane rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

10.2 Standards

10.2.1 American Society for Testing and Materials Standards

Relevant American Society for Testing and Material (ASTM) standards are as follows:

- D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
- D1004 Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting
- D1204 Standard Test Method for Linear Dimensional Changes of Non-rigid Thermoplastic Sheeting or Film at Elevated Temperature
- D1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
- D1505 Standard Test Method for Density of Plastics by the Density Gradient Technique
- D1603 Standard Test Method for Carbon Black in Olefin Plastics
- D8117 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Colorimetry
- D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
- D4354 Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
- D4437 Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes
- D4439 Standard Terminology for Geosynthetics
- D4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
- D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
- D5199 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
- D5397 Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
- D5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
- D5641 Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
- D5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes
- D5820 Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

- D5885 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Colorimetry
- D5994 Standard Test Method for Measuring the Core Thickness of Textured Geomembranes
- D6370 Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)
- D6392 Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
- D6395 Standard Practice for Non-destructive testing of Geomembrane Seams using Spark Test
- D6693 Standard Test Method for Determining Tensile Properties of Non-Reinforced Polyethylene and Non-Reinforced Flexible Polypropylene Geomembranes
- D7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
- D7466 Standard Test Method for Measuring Asperity Height of Textured Geomembranes.

10.2.2 Geosynthetic Research Institute Standards

Relevant Geosynthetic Research Institute (GRI) standards are as follows:

- GM9 Standard Practice for Cold Weather Seaming of Geomembranes
- GM10 Specification for the Stress Crack Resistance of Geomembrane Sheet
- GM13 Standard Specification for Test Methods, Test Properties, and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
- GM14 Standard Guide for Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes
- GM17 Standard Specification for Test Methods, Test Properties, and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
- GM19 Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes
- GM20 Standard Guide for Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using Control Charts
- GM29 Standard Practice for Field Integrity Evaluation of Geomembrane Seams (and Sheet) Using Destructive and/or Non-destructive Testing.

10.3 Submittals

10.3.1 Prior to delivery of polyethylene geomembrane to site

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance prior to delivery of PE geomembrane to site (per PE geomembrane product):

- Manufacturer's certificate of compliance outlining conformance with the requirements of this Specification
- Manufacturer's quality control and assurance test results
- Certification that the PE geomembrane supplied for this work was manufactured as consecutive rolls from a single lot or from consecutive lots. If the PE geomembrane is not manufactured from consecutive lots, the resin manufacturer shall provide certification of quality and consistency of the resin characteristics
- Statement on the origin of the resin, its identification (type and lot number), resin supplier's name and production plant, resin brand name and type, and the maximum amount of recycling polymer material added to the raw resin

- Copies of quality control certificates issued by the resin supplier which shall include testing conducted to verify conformance with Table 10–1
- Certifications that the PE geomembrane and extrudate produced for the Works have the same properties and are of the same resin
- Complete description of the manufacturer’s shipping, handling and storage procedures
- Manufacturer’s installation procedures and requirements
- Work method statement for PE geomembrane delivery, storage, handling and installation. This shall include seaming and jointing, welding, procedures for testing and repairing, proposed handling equipment and restraining methods, and other information that shall promote proper use
- Relevant results of interface strength testing (refer Section 4 and Section 6).

10.3.2 Prior to installation of polyethylene geomembrane

The Contractor shall submit the following to the Principal’s Authorised Person for review and acceptance prior to installation of the PE geomembrane:

- Delivery, storage and handling log for all PE geomembrane rolls to be used in the Works, including delivery dockets, roll number and identification, delivery inspection checklist, details of storage and handling
- Proposed panel placement drawing, showing the location and reference number of all panels and expected seams, connections and penetrations, panel dimensions and layout, and the order of panel installation
- Survey of the underlying surface in accordance with Section 1.16
- Results of independent material conformance testing as provided by the CQA Consultant.

10.3.3 Following installation of polyethylene geomembrane

The Contractor shall submit the following to the Principal’s Authorised Person for review and acceptance following installation of the PE geomembrane:

- Panel placement log, providing details on panel number and associated roll number, date and time placed, condition of receiving surface, weather conditions and precipitation events, QA checks performed, and all other relevant information
- Trial weld log, recording all trial welds and testing undertaken
- Field welding log providing details of all field welding undertaken, including:
 - Weld type
 - Weld ID number
 - ID numbers of panels to be joined
 - Name of welder
 - Details of equipment used
 - Ambient air temperature
 - Geomembrane surface temperature
 - Weld temperature
 - Any problems or issues arising during welding.
- Field sampling and testing results, including non-destructive and destructive tests
- Results of electrical leak location survey as provided by the CQA Consultant
- Finalised panel placement drawing showing the as-built location of all panels, seams, connections and penetrations
- Defects and repairs log, showing details of all defects identified and repairs completed.

10.4 Manufacturer's Quality Control

The manufacturer shall follow a quality control program, accepted by the Principal's Authorised Person, throughout the manufacturing of all PE geomembrane for the Works.

Manufacturer's quality control submissions shall include:

- Date of manufacture
- Lot number, roll number, length and width
- Manufacturer quality control documentation for the particular lot of resin used in the production of the rolls delivered
- Cross-referencing list delineating the corresponding resin used in the production of the rolls delivered
- Quality control program laboratory-certified reports
- The manufacturer's approved quality assurance stamp and the technician's signature. The frequency of sampling and testing shall be in accordance with Table 10-1.

The Principal's Authorised Person may reject any PE geomembrane rolls that have not been sampled and/or tested in accordance with this section.

All PE geomembrane rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

10.5 Manufacturer's Quality Assurance

The manufacturer shall follow a quality assurance program, accepted by the Principal's Authorised Person, throughout the manufacturing of all PE geomembrane for the Works.

The frequency of sampling and testing shall be in accordance with ASTM D4354.

The Principal's Authorised Person may reject any PE geomembrane rolls that have not been sampled and/or tested in accordance with this section.

All PE geomembrane rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

10.6 Material

The PE geomembrane shall:

- Be manufactured of new, first-quality resin and shall be compounded and continuously manufactured specifically for the Works. The resin manufacturer shall certify each batch for the acceptance criteria listed in Table 10-1
- Comply with the acceptance criteria specified in Table 10-1
- Not contain more than 1 percent non-volatile pigment or fillers other than carbon black
- Not be factory seamed.

The Contractor shall supply manufacturer's quality control and assurance testing results in accordance with the testing frequencies identified in Table 10-1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the roll lots.

If required by the Principal's Authorised Person, a sample of the PE geomembrane shall be provided (per product) and the Principal's Authorised Person and/or CQA Consultant may undertake an inspection of the manufacturer's facility. The Contractor shall cooperate fully with the Principal's Authorised Person and CQA Consultant to allow this inspection to occur.

All material in this contract is to be as follows, in accordance with Table 10–1.

- Floor: Double-sided Smooth
- Walls: Single-sided Textured (textured side down).

Table 10–1: Acceptance criteria - HDPE geomembrane

Property	Test method	Acceptance criteria		Minimum testing frequency
		2 mm HDPE (Single-Sided Textured)	2 mm HDPE (Double-Sided Smooth)	
Resin ⁶				
Density (HDPE min., LLDPE max.)	ASTM D1505 or D792 (method B)	0.932 g/cm ³	0.932 g/cm ³	per resin lot
Melt index (maximum) ⁷	ASTM D1238	1.0 g/10 min	1.0 g/10 min	per resin lot
Sheet				
Thickness (min. average)	ASTM D5199 (smooth) ASTM D5994 (textured)	1.9 mm	2.0 mm	every roll
Thickness (min.)				
Lowest individual of 8 of 10 readings	ASTM D5199 (smooth)	1.8 mm	-	every roll
Lowest individual of 10 readings	ASTM D5994 (textured)	1.7 mm	1.8 mm	
Asperity height (min. average) ^{8,9}	ASTM D7466	0.4 mm	-	every 2 nd roll
Density (min.)	ASTM D1505 or D792 (method B)	0.94 g/cm ³	0.94 g/cm ³	90,000 kg
Tensile properties (min. average) ¹⁰				
Yield strength	ASTM D6693 Type IV	29 kN/m	29 kN/m	9,000 kg
Break strength		53 kN/m	53 kN/m	
Yield elongation		12%	12%	
Break elongation		100%	700%	
Tear resistance (min. average)	ASTM D1004	249 N	249 N	20,000 kg

⁶ Base resin density without carbon black or additives added

⁷ Conducted at 190°C with 2.16 kg mass applied

⁸ Alternate the measurement side for double sided textured sheet

⁹ Of 10 readings; 8 out of 10 must be > 0.29 mm, and lowest individual reading must be > 0.21 mm

¹⁰ Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of five test specimens each direction:

- HDPE yield elongation is calculated using a gage length of 33 mm
- HDPE break elongation is calculated using a gage length of 50 mm
- LLDPE break elongation is calculated using a gage length of 50 mm at 50 mm/min

Puncture resistance (min. average)	ASTM D4833	534 N	640 N	20,000 kg
Stress crack resistance ¹¹	ASTM D5397	500 hours	500 hours	per each formulation
Dimensional stability	ASTM D1204	+2%	+2%	90,000 kg
Carbon black content (range)	ASTM D4218 ¹²	2 to 3%	2 to 3%	9,000 kg (HDPE) or 20,000 kg (LLDPE)
Carbon black dispersion (category) ¹³	ASTM D5596	Cat 1, 2 or 3 only	Cat 1, 2 or 3 only	20,000 kg
Oxidative induction time (OIT) (min. average) ¹⁴ standard OIT	ASTM D8117	100 min	100 min	90,000 kg
AND high pressure OIT	ASTM D5885	400 min	400 min	
Oven aging at 85°C (min. average) - standard OIT	ASTM D8117	55% retained at 90 days	55% retained at 90 days	per each formulation
AND - high pressure OIT	ASTM D5885	80% retained at 90 days	80% retained at 90 days	
UV resistance (min. average) ¹⁵ - high pressure OIT ¹⁶	ASTM D7238/ ASTM D5885	50% retained after 1600 hours	50% retained after 1600 hours	per each formulation

Note:

- The HDPE geomembrane acceptance criteria above are provided as minimum criteria. The PE geomembrane utilised shall be suitable to withstand the application for the design life of the cell, when considered in conjunction with the relevant liner profile. This is to include consideration of (but not be limited to) internal & external forces, interface shear and environmental exposure

¹¹ 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

¹² Other methods such as ASTM D1603 (tube furnace) or ASTM D6370 (TGA) are acceptable if an appropriate correlation to ASTM D4218 (muffle furnace) can be established

¹³ Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3

¹⁴ The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

¹⁵ The condition of the test should be 20 hour UV cycle at 75°C followed by 4 hour condensation at 60°C

¹⁶ UV resistance is based on percent retained value regardless of the original high pressure OIT value

10.7 Roll and sample identification

All PE geomembrane rolls and samples shall be identified in accordance with ASTM D4873. Each roll or panel shall carry a label which identifies, as a minimum:

- Product name, grade and name of manufacturer
- Date of manufacture, batch number
- Material thickness
- Roll number
- Roll length
- Roll weight
- Roll width
- Handling guidelines
- Reference numbers to raw material batch and laboratory certified reports
- The manufacturer's approved quality assurance stamp and the technician's signature.

The Principals Authorised Person may reject any HDPE geomembrane rolls or samples that have not been identified in accordance with this section.

All PE geomembrane rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

10.8 Delivery, storage and handling

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of PE geomembrane, including repair methods. The work method statement shall be submitted to the Principals Authorised Person for review and comment prior to delivery of the PE geomembrane to site.

The delivery, storage and handling components of the work method statement shall be developed in accordance with the guidance provided below:

- Delivery, storage and handling of all PE geomembrane rolls and samples shall be undertaken in accordance with the manufacturer's instructions and ASTM D4873 as a minimum
- Rolls shall be delivered to site, handled and stored in such a manner that no damage occurs to the rolls
- Roll cores shall be sufficiently strong to ensure that they do not deflect by more than half their diameter during delivery, storage and handling
- Rolls shall be stored in a location away from construction traffic but sufficiently close to the installation area to minimise handling. The storage area shall be level, dry, well-drained and stable, and shall protect the product from precipitation, chemicals, excessive heat, UV radiation, standing water, vandalism and animals
- PE geomembrane roll stacks shall be limited to the height at which installation personnel can safely manoeuvre the handling equipment. The recommended maximum stack height is three rolls
- Rolls shall be handled using a spreader stringer bar. The bar shall be capable of supporting the full weight of the rolls without significant bending. Under no circumstances shall the rolls be dragged, lifted from one end, lifted in the middle of the roll, lifted with the forks of a forklift or pushed to the ground from the delivery vehicle. The Contractor may nominate alternate handling equipment and plant for acceptance by the Principal's Authorised Person as part of their work method statement
- The Contractor shall inspect all PE geomembrane rolls for defects and damage upon delivery.

The Principal's Authorised Person may reject any PE geomembrane rolls that have not been delivered, stored or handled in accordance with this section.

All PE geomembrane rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

10.9 Preparation of receiving surface

Prior to placement of PE geomembrane, the underlying GCL shall be free of:

- Any of debris, roots, angular material (such as sharp rocks), or loose, coarse-grained material on or immediately below the GCL
- Excessive wrinkles preventing intimate contact between the GCL and PE geomembrane
- Any panels that have hydrated prematurely without confinement
- Excessive bentonite powder and/or paste on the surface. The foundation material underlying the GCL shall:
 - Be smooth, flat, firm and unyielding to the satisfaction of the Principal
 - Be free of abrupt breaks, indentations and/or sudden changes in grade
 - Promote drainage and excessive water shall not be allowed to pond on the surface of the GCL.

Placement of PE geomembrane shall not proceed until the underlying GCL has been inspected and accepted by the Principal. The overlying PE geomembrane shall be placed immediately following acceptance of the GCL panels to protect the underlying GCL.

The Principal's Authorised Person may reject any underlying GCL or underlying foundation material which does not meet these requirements. Any GCL rejected by the Principal's Authorised Person shall be removed from the site at the expense of the Contractor. Any rejected foundation material shall be removed and/or remediated to the satisfaction of the Principal.

10.10 Installation

10.10.1 General

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of PE geomembrane. The work method statement shall be submitted to the Principal's Authorised Person for review and comment prior to delivery of the PE geomembrane to site.

The installation component of the work method statement shall be developed in accordance with the guidance provided below, and the manufacturer's guidelines. If there is discrepancy between the manufacturers guidelines and, the guidance below, seek guidance from the Principal's Authorised Person.

The Principal's Authorised Person may reject any PE geomembrane rolls that have not been installed in accordance with this section.

All PE geomembrane rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

10.10.2 Weather conditions

The Contractor shall consider the weather conditions on a daily basis to confirm they are suitable for placement of PE geomembrane.

PE geomembrane shall not be placed or seamed:

- If moisture prevents proper subgrade preparation, panel placement and/or panel seaming
- During precipitation, during hail, during periods of excessive fog, during periods of excessive dust, in standing water, on excessively wet surfaces, in the presence of excess moisture (such as dew and/or ponded water)
- During periods of excessive winds (>30 kph) or when gusting wind conditions interfere with handling operations

- When sheet temperatures are lower than 0° or higher than 65° as measured by a calibrated infrared thermometer or surface thermocouple.

10.10.3 Traffic

Equipment used shall not damage the PE geomembrane by handling, trafficking, leakage of hydrocarbons, or by other means.

No vehicle shall be allowed to travel directly on the PE geomembrane unless accepted by the Principal. Prior to acceptance, the Contractor shall provide the Principal's Authorised Person the following information:

- Guidance from the manufacturer on suitable plant for trafficking for the proposed PE geomembrane and confirmation that the Contractor shall only use this plant
- Guidance from the manufacturer on suitable trafficking method for the proposed PE geomembrane and confirmation that the Contractor shall only use this trafficking method
- Certification from the manufacturer that the above trafficking method and plant shall not void the warranty for the proposed PE geomembrane.

10.10.4 Placement

PE geomembrane shall be placed in accordance with the following:

- The PE geomembrane shall be placed and seamed in accordance with this Specification, the Contract Drawings, the accepted work method statement and the manufacturer's instructions. Any contradictions shall be clarified with the Principal
- Prior to placement, each roll shall be inspected by the Contractor for damage and/or defects, including tears, abrasion, indentation, cracks, thin spots or any other faults or defects. If damage or defects are identified, the roll shall be inspected by the Principal's Authorised Person and accepted or rejected
- PE geomembrane shall be protected from damage due to exposure to sunlight, dirt, dust and other hazards
- PE geomembrane shall be placed such that the panels are anchored at the crest of the slope and form a continuous layer down the side walls and slopes and across the base
- The arrangement of the PE geomembrane panels shall be in accordance with the accepted panel placement drawing and any changes accepted by the Principal
- Installation shall progress from the highest elevations to the lowest
- PE geomembrane rolls shall be placed in an orderly fashion which shall minimise or prevent surface water from flowing below previously installed PE geomembrane
- PE geomembrane shall not be allowed to 'bridge over' voids or low areas. The PE geomembrane shall be placed to allow intimate contact with the subgrade or underlying geosynthetic
- PE geomembrane shall be installed without undergoing excessive buckling, wrinkling or tensioning
- PE geomembrane shall not be dragged across an unprepared surface. If the PE geomembrane is dragged across an unprepared surface, it shall be inspected for defects and repaired or rejected if necessary
- Where there is a geosynthetic layer below, the installation of the PE geomembrane shall be undertaken in a manner so as not to damage the underlying layer
- Sandbags or equivalent ballast shall be used as necessary to temporarily hold the PE geomembrane in position and prevent uplift by wind. In case of high winds, continuous loading shall be placed along edges of panels to minimise wind flow under the panels. Sandbag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the PE geomembrane
- Only those PE geomembrane rolls which can be seamed or permanently anchored on at least two sides on the same day shall be placed on a daily basis. All other sides shall be temporarily anchored
- PE geomembrane installed on slopes shall be fixed in anchor trenches as shown on the Contract Drawings and Section 7.23. PE geomembrane panels shall be anchored as soon as possible. The Geosynthetic

Installer shall program anchor trenches backfilling when the temperature is coolest to minimise effects of material expansion

- Personnel working on the PE geomembrane shall not smoke, wear damaging shoes, excessively traffic or engage in other activities which may damage the PE geomembrane. PE geomembrane in heavy traffic areas shall be protected by a geosynthetic overlay
- PE geomembrane shall be cut from each roll with an approved hook blade knife with flat zones on each end
- PE geomembrane rolls shall be freely suspended during placement
- The method used to unroll the PE geomembrane shall not cause bridging, excessive wrinkles, scores, scratches and/or crimps
- Folds and wrinkles caused by PE geomembrane panel placement or thermal expansion shall be minimised
- After placement, the PE geomembrane shall be free of excessive buckles, wrinkles, ripples, creases, folds and irregular stressing before the overlying cover material or geosynthetic is placed.

10.10.5 Seaming

PE geomembrane shall be seamed in accordance with the following guidance.

10.10.5.1 General

- The PE geomembrane shall be field seamed into a continuous sheet across the Works by using either dual hot wedge fusion welding or extrusion welding seams
- Dual hot wedge fusion welding shall be the preferred method of welding and shall be used for primary welds between adjacent PE geomembrane panels. Extrusion welding shall only be used for detailed work, repair work, or in areas inaccessible for dual hot wedge fusion welding (where accepted by the Principal)
- PE geomembrane placement shall be limited to that which can be seamed in one day
- Trail seams shall be completed each day as per Section 10.11
- All seams shall be 'shingled' down-slope to promote runoff (roof tile fashion)
- All field seaming operations shall be supervised by the Seaming Foreman and no field seams shall be made without the Seaming Foreman present
- Prior to welding, the prepared weld surfaces shall be free of dust, dirt, debris, markings foreign material and any other potential contaminants that would inhibit welding. Where contamination does occur, the prepared surfaces shall be thoroughly cleaned and the weld completed
- There shall be no free moisture in the weld area during welding. If free moisture is located in the weld area, mitigation measures during seaming shall be employed as accepted by the Principal
- The Geosynthetic Installer shall have an independently calibrated handheld temperature measuring device to confirm the temperatures of each and every welding machine prior to the commencement of any test or field welds. All information regarding the results gained from the temperature device shall be recorded for each welding machine
- Any electric generators used in welding shall be placed on a smooth base such that no damage occurs to the underlying PE geomembrane
- Adjacent to anchor trenches, seaming shall extend up the panels a minimum of 300 mm past the crest of the anchor trench.

10.10.5.2 Weld locations

PE geomembrane panel placement shall take into consideration the site geometry including:

- Field seams shall be orientated parallel to the line of maximum slope
- For batters with a 10% grade or steeper, transverse (cross-slope) seams shall not be permitted

- No cross seams shall be allowed within 1,500 mm of the toe of any slope
- In corners and odd shaped geometric locations, the number and total length of field seams shall be minimised
- Seams shall not be located at low points
- All cross seams shall be offset at least 600 mm from the cross seam of the adjacent panel and be extrusion or wedge welded where they intersect
- All primary welds used to connect panel ends to sheets shall form T-joints (tees). These T- connections shall have a distance of at least 500 mm. The welding seams of the PE geomembrane cannot cross (no cruciform connections)

10.10.5.3 Dual hot wedge fusion welding

- The dual hot wedge fusion welding shall be conducted using the split head wedge fusion weld method, fusing the upper and lower overlapped PE geomembrane panels
- The welding equipment shall be capable of continuously monitoring and controlling the temperature in the zone of contact where the machine is actually fusing the PE geomembrane so as to ensure that changes to environmental conditions shall not adversely affect the integrity of the weld
- Seams shall have a finished overlap of a minimum of 150 mm for dual hot wedge fusion welding but in any event, sufficient overlap shall be provided to allow peel tests to be performed on the seam
- The dual hot wedge fusion welding shall form two contact fusion areas of a minimum width of 15 mm and a 5 mm minimum wide void between each of the separate parallel weld zones.

10.10.5.4 Extrusion welding

- The extruder may be a combination sheet pre-heat and extruder type or a combination dynamic mixing assembly and extruder type
- The extrudate shall be manufactured from the same resin type used in the manufacture of the relevant PE geomembrane being welded. All physical properties shall be identical to those possessed by the raw PE geomembrane material. The Geosynthetic Installer shall provide certification from the manufacturer that the relevant PE geomembrane and extrudate produced for the Works have the same properties and are of the same resin for each batch
- During welding, the Geosynthetic Installer shall be responsible for regularly checking, calibrating and recording of:
 - Preheat air flow and temperature at the nozzle
 - Extrudate flow and temperature at the barrel outlet
- Seams shall have a finished overlap of a minimum of 75 mm for extrusion welding but in any event, sufficient overlap shall be provided to allow peel tests to be performed on the seam
- The minimum width of the surface extruded bead shall be 30 mm
- Prior to welding, oxidation by-products shall be removed from the weld area by grinding or buffing. Grind marks shall not be deeper than 10% of the PE geomembrane thickness. Seam grinding shall be been completed less than one hour before seam welding. The end of welds more than five minutes old shall be ground to expose new material before restarting a weld
- Prior to welding, the extruder shall be purged until all the heat-degraded extrudate is removed
- Welding shall be undertaken in one direction only
- A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

10.10.5.5 Pipe boots

- If pipe boots are required, they may be constructed in the factory or in the field in accordance with relevant details. Pipe boots to conform with minimum requirements of “Typical Plastic Pipe Boot Details” by the Fabricated Geomembrane Institute”.

All pipe boot seams shall be spark tested with acceptable pipe boots showing no spark. Alternative testing methods may be allowed at the discretion of the Principal.

10.10.5.6 Cell 5B Tie-In

- Requirements for tie-in seaming between Cell 5B and 7A are per all other seams as delineated in this Technical Specification
- Adequacy of achieved weld strength / break locations during testing are to be assessed by the on-site CQA Engineer, noting the condition of the existing parent material

10.11 Trial seams

Trial seams shall be performed on fragment pieces of PE geomembrane to verify that seaming conditions are satisfactory and to supply test specimens for the CQA program.

Trial seams shall be conducted at the beginning of each seaming period and at least once each four hours for each seaming apparatus used that day. Trial seams shall be repeated if any welding stoppage exceeds one hour and if weather conditions change. Trial seams shall be made under the identical conditions as the actual seams.

Each seamer shall make at least one trial seam each day for each seam method for each seaming equipment apparatus to be used that day.

Trial seams shall be a minimum of 1,350 mm by 300 mm with seam centred.

The trial seam sample shall be cut into three subsamples (450 mm by 300 mm with seam centred).

The two subsamples from each end shall immediately be tested onsite for peel and shear strength in accordance with GM19.

If either specimen does not meet the acceptance criteria, the seamer and seaming apparatus and/or methods shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive trial seams are successful.

The central portion of the trial seam sample shall be labelled and provided to the CQA Consultant for destructive testing at the CQA Consultant's Independent Testing Firm. At the discretion of the CQA Consultant, trial seams may be subjected to destructive testing. The Principal's Authorised Person may reduce the frequency of trial seam destructive testing at the CQA Consultant's Independent Testing Firm, in consultation with the CQA Consultant, if the field tensiometer appears adequate for assuring trial seam quality.

If a trial seam sample records a non-conforming result for a test conducted at the CQA Consultant's Independent Testing Firm, a destructive test seam sample shall be taken by the Contractor from the seams completed by the seamer during the shift related to the considered trial seam. These samples shall be forwarded to the CQA Consultant's Independent Testing Firm by the Contractor and, if they recording non-conforming test results, the length of seam represented by the test sample shall be rejected.

The conditions of this section are considered as met for a given seam if a destructive seam test sample has already been taken from the considered seam(s).

10.12 Field seam sampling and testing

10.12.1 General

Testing parameters, requirements and anticipated schedules shall be continuously reviewed by the Contractor to ensure that adequate personnel and proper equipment shall be available.

Field seam sampling and testing shall be performed after seaming to verify that the mechanical characteristics of the seams do not compromise the PE geomembrane integrity.

Test results shall be provided to the Principal's Authorised Person in accordance with Section 1.13.

10.12.2 Destructive seam testing

Destructive seam samples shall be taken and tested in accordance with Table 10–2.

Repair patches shall be extrusion welded over the areas where destructive seam samples have been taken and shall be subjected to non-destructive testing.

The location of each destructive seam sample shall be up to the discretion of the Principal's Authorised Person and CQA Consultant and designated on a copy of the panel placement drawing, along with the date and time of sampling and the sample number.

Destructive test samples shall be a minimum of 1350 mm by 300 mm with seam centred.

The destructive seam sample shall be cut into 3 subsamples (450 mm by 300 mm with seam centred).

The two subsamples from each end shall be taken and tested on-site for peel and shear strength. If both on-site subsamples meet the acceptance criteria of Table 10–2, the central portion of the test sample shall be labelled and provided to the CQA Consultant for destructive testing at the CQA Consultant's Independent Testing Firm.

If either on-site or off-site test results do not meet the acceptance criteria listed in Table 10–2, the length of seam represented by the test sample shall be rejected.

Table 10–2: Destructive seam testing requirements

Test description	Test method	Minimum test frequency ¹⁷	Acceptance criteria ¹⁸
Peel strength ¹⁹	ASTM D6392	1 test per 150 m ²⁰ (or part thereof)	As per GM19
Shear strength	ASTM D6392	1 test per 150 m ²¹ (or part thereof)	As per GM19

10.12.3 Non-destructive seam testing

All seams shall be non-destructively tested over the entire length of seam by at least one of the methods in Table 10–3. The tests shall be undertaken no earlier than one hour after welding. In addition to the above tests, the welds shall be visually inspected to assess the quality of the workmanship and the appearance of the welded seam.

Table 10–3: Non-destructive seam testing requirements

Test description	Test method	Minimum test frequency	Acceptance criteria
Vacuum box	ASTM D5641	All seams shall be tested by at least one of these three test methods as appropriate	No imperfections
Air pressure ²²	ASTM D5820		Refer Table 10–4
Spark test	ASTM D6365		No spark

Notes

1. All needle punctures shall be repaired as per the requirements of this Specification.

¹⁷ A minimum of one series of destructive tests shall be performed each day that seaming is performed

¹⁸ All destructive test results shall be based on Film-Tear Bond (FTB) criteria. All samples which produce seam failures shall be considered unacceptable

¹⁹ Peel strength testing shall be performed on both Weld A and Weld B

²⁰ When ambient air temperatures during seaming operations are less than 10°C, testing frequency shall be increased to one test per 75 linear meters

²¹ When ambient air temperatures during seaming operations are less than 10°C, testing frequency shall be increased to one test per 75 linear meters

²² All hypodermic needle punctures shall be repaired as per the requirements of this Specification

Table 10–4: Air pressure test ranges

Geomembrane thickness	Minimum pressure	Maximum pressure	Maximum pressure differential ²³
1.0 mm	170 kPa	210 kPa	25 kPa
1.5 mm	190 kPa	250 kPa	20 kPa
2.0 mm	210 kPa	250 kPa	10 kPa
2.5 mm	210 kPa	250 kPa	10 kPa
3.0 mm	210 kPa	250 kPa	10 kPa

Notes

1. Observe and record the pressure 5 minutes after the initial reading. If the loss of pressure exceeds that shown, or if the pressure does not stabilise, the faulty area should be located and repaired.

10.12.4 Pipe boot seam testing

All pipe boot seams shall be spark tested with acceptable pipe boots showing no spark. Alternative testing methods may be allowed at the discretion of the Principal.

10.12.5 Non-conforming test results

If any test specimen does not meet the acceptance criteria listed, the test series shall be considered unacceptable and all material or length of seam represented by the test series shall be rejected. The Geosynthetic Installer may, at no additional compensation, take additional samples for quality control testing in an attempt to minimise the amount of material represented by the non-conforming test result.

In the event of discrepancies between the CQA Consultant's test results and the Contractor's test results, the Contractor shall be responsible for arranging a third independent testing firm to verify test results.

An acceptable length of seam shall be defined as a length of seam which lies between conforming destructive test locations and has passed non-destructive seam testing.

10.12.6 Field testing summary

The Geosynthetic Installer shall prepare a field testing summary for all installed PE geomembrane. For each PE geomembrane layer, a separate copy of the panel placement drawing shall be utilised for this summary and shall indicate the PE geomembrane layer represented. On each sheet, the following information shall be recorded:

- The location, date, sample number and test result (conforming/non-conforming) of each destructive test series
- The location, identification number and date of each non-destructive air pressure seam test including the length of the tested seam and the result of the test (conforming/non-conforming)
- The location, date and lengths of non-destructive vacuum box testing performed on a daily basis and the result of the tests (conforming/non-conforming)
- The location, identification number and date of each non-destructive spark test including the length of the tested seam and the result of the test (conforming/non-conforming).

²³ Observe and record the pressure 5 min after the initial reading. If the loss of pressure exceeds that shown, or if the pressure does not stabilize, the faulty area should be located and repaired

10.13 Arc testing leak location survey

10.13.1 General

Following the installation of each PE geomembrane layer, the Leak Location Contractor engaged by the CQA Consultant shall conduct an arc testing leak location survey to detect leaks in the PE geomembrane.

10.13.2 Preparation and support

The Contractor shall be responsible for preparing the survey area for the leak location survey. The Contractor shall be responsible for completing installation work around the edge of each PE geomembrane layer that provides electrical isolation of the PE geomembrane for the electrical leak location surveys. The Principal's Authorised Person may provide further details on this procedure if requested.

The Contractor shall ensure effective electrical isolation around areas being surveyed to reduce false negative and false positive results, proper equipment Setup and calibration

The Contractor shall ensure proper site preparation, such as the PE geomembrane surface is clean and dry, and confirm proper electrodes contact prior to the survey.

10.13.3 Repairs

The Geosynthetic Installer shall be responsible for repairing any leaks found. Repairs shall be undertaken in accordance with Section 10.14.

After the leak is repaired, the Leak Location Contractor shall retest the area to ensure the leak was repaired and that there are no other leaks in the vicinity of the repair.

10.14 Defects and repairs

The Contractor shall be responsible for inspecting the placed PE geomembrane to identify any damage or faults in the material. The Principal's Authorised Person and/or CQA Consultant may also undertake inspections of the placed PE geomembrane to identify any damage or faults in the material. Any areas of PE geomembrane damaged during installation shall be repaired by the Contractor. All repairs shall be verified by the Principal.

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of PE geomembrane. The work method statement shall be submitted to the Principal's Authorised Person for review and comment prior to delivery of the geomembrane to site.

The installation component of the work method statement shall include work methods for defects and repairs, developed in accordance with the guidance provided below:

- All repairs shall be undertaken in accordance with this Specification, the accepted work method statement and the manufacturer's instructions. Any contradictions shall be clarified with the Client's Representative. All repairs shall be verified by the Client's Representative
- Patches and cap strips shall have rounded edges (minimum radius of 75 mm), shall be made of the same geomembrane and shall extend a minimum of 150 mm beyond the edge of defects. All patches shall be of the same compound and thickness as the PE geomembrane being patched over. Patches shall be seamed using extrusion (fusion) welding
- Punctures, pin holes, blisters, small tears and localised imperfections shall be repaired using a patch in the geomembrane barrier. Punctures due to NDT in the air channel may be repaired by extrusion weld
- Large tears and lengths of seam shall be repaired using a cap strip. No reseaming over existing seams shall be permitted
- Tears which lie on slopes greater than 5% or which lie in areas of stress and have sharp ends shall have all sharp ends rounded prior to repair

- The PE geomembrane below large patches and cap strips shall be cut as necessary to prevent moisture or gas collection between sheets
- Wrinkles which exist at the end of seaming operations and which may become creased or trapped during backfilling shall be cut and resealed. Excessive wrinkles shall be defined as a wrinkle which at the time of covering, and in the opinion of the Principals Authorised Person, meets any of the following criteria:
 - Is nominally >200 mm in height
 - May fold during backfilling
 - May become trapped within the gravel
 - May adversely impede the flow along the surface of the geomembrane
- ‘Fishmouths’ or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut ‘fishmouths’ or wrinkles shall be sealed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 150 mm beyond the cut in all directions. All corners of the patch shall be rounded with a 25 mm minimum radius
- All repair seams shall be made in accordance with the requirements of Section 10.10.5
- Each repair shall be required to pass non-destructive tests (refer Section 10.12.3). Large cap strips may require destructive testing (refer Section 10.12.2), as directed by the Principal.

The Contractor shall submit to the Principals Authorised Person for review a log containing details of any defects identified and repairs carried out.

10.15 Acceptance

The Contractor shall retain all ownership and responsibility for all PE geomembrane until final acceptance of all work under this Contract by the Superintendent.

PE geomembrane shall be accepted by the Principal’s Authorised Person when all of the following conditions are met:

- Required submittals are provided by the Contractor to the Principal’s Authorised Person and approved
- Adequacy of all field seams, penetrations and repairs is verified by the Principal
- The electrical leak location survey has been completed and all required repairs have been completed by the Contractor
- Details of all defects identified and repairs performed have been provided by the Contractor to the Principal’s Authorised Person and accepted
- The CQA Consultant has provided the Principal’s Authorised Person with a recommendation that the conditions of final acceptance have been met
- The Principals Authorised Person has inspected and accepted the finished surface/s.

11. Geotextiles

11.1 General

This section contains the technical requirements for geotextile.

The Principal's Authorised Person may reject any geotextile that does not meet or exceed the requirements of this section.

Any geotextile rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

11.2 Standards

11.2.1 Australian Standards

Relevant Australian standards are as follows:

- AS 2001.2.3 Methods of test for textiles - Physical tests - Determination of breaking force and extension of textile fabrics
- AS 3704 Geosynthetics-Glossary of Terms
- AS 3705 Geotextiles-Identification, marking and general data
- AS 3706.3 Determination of tearing strength - Trapezoidal method
- AS 3706.4 Determination of burst strength - California bearing ratio (CBR) - Plunger method
- AS 3706.7 Determination of pore-size distribution - Dry-sieving method
- AS 3706.9 Determination of permittivity, permeability and flow rate

11.2.2 American Society for Testing and Materials Standards

Relevant American Society for Testing and Material (ASTM) standards are as follows:

- D4354 Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
- D4355 Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water
- D4439 Standard Terminology for Geosynthetics
- D4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity
- D4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles
- D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
- D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile
- D4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
- D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
- D5199 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
- D5514 Standard Test Method for Large Scale Hydrostatic Puncture Testing of Geosynthetics
- D6767 Standard Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test

11.2.3 Geosynthetic Research Institute Standards

Relevant Geosynthetic Research Institute (GRI) standards are as follows:

- GT12(a) Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials
- GT13(a) Test Methods and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate

11.3 Submittals

11.3.1 Prior to delivery of geotextile to site

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance prior to delivery of geotextile to site (per geotextile product):

- Manufacturer's certificate of compliance outlining conformance with the requirements of this Specification
- Manufacturer's quality control and assurance test results
- Certification that the geotextile supplied for this work was manufactured as consecutive rolls from a single lot or from consecutive lots. If geotextile is not manufactured from consecutive lots, the manufacturer shall provide certification of quality and consistency of the product characteristics
- Statement on the origin and identification of the fibres and polymers, including the supplier's name and production plant
- Complete description of the manufacturer's shipping, handling and storage procedures
- Manufacturer's installation procedures and requirements
- Work method statement for geotextile delivery, storage, handling and installation. This shall include seaming and jointing, procedures for testing and repairing, proposed handling equipment and restraining methods, and other information that shall promote proper use
- Results of compression testing
- Relevant results of interface strength (Refer Section 4).

11.3.2 Prior to installation of geotextile

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance prior to installation of the geotextile:

- Delivery, storage and handling log for all geotextile rolls to be used in the Works, including delivery dockets, roll number and identification, delivery inspection checklist, details of storage and handling
- Proposed panel placement drawing, showing the location and reference number of all panels and expected seams, connections and penetrations, panel dimensions and layout, and the order of panel installation
- Results of independent material conformance testing as provided by the CQA Consultant.

11.3.3 Following installation of geotextile

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance following installation of the geotextile:

- Panel placement log, providing details on panel number and associated roll number, date and time placed, condition of receiving surface, weather conditions and precipitation events, QA checks performed, and all other relevant information
- Finalised panel placement drawing showing the as-built location of all panels, seams, connections and penetrations

- Defects and repairs log, showing details of all defects identified and repairs completed.

11.4 Manufacturers Quality Control

The manufacturer shall follow a quality control program, accepted by the Principal's Authorised Person, throughout the manufacturing of all geotextile for the Works.

Manufacturer's quality control submissions shall include:

- Date of manufacture
- Lot number, roll number, length and width
- Polymer quality control documentation used in the production of the rolls delivered
- Fibre quality control documentation used in the production of the rolls delivered
- Geotextile manufacturer quality control documentation for the particular lots of geotextiles used in the production of the rolls delivered
- Quality control program laboratory-certified reports
- The manufacturer's approved quality assurance stamp and the technician's signature.

The frequency of sampling and testing shall be in accordance with Table 11–1.

The Principal's Authorised Person may reject any geotextile rolls that have not been sampled and/or tested in accordance with this section.

All geotextile rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

11.5 Manufacturers Quality Assurance

The manufacturer shall follow a quality assurance program, accepted by the Principal's Authorised Person, throughout the manufacturing of all geotextile for the Works.

The frequency of sampling and testing shall be in accordance with ASTM D4354.

The Principal's Authorised Person may reject any geotextile rolls that have not been sampled and/or tested in accordance with this section.

All geotextile rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

11.6 Material

The Primary function of floor separation geotextile is separation to prevent mixing of fine soils and drainage media. Floor protection geotextile acts as a cushioning layer to prevent liner damage from puncture/abrasion. The same material is to be used for the Erosion Protection Geotextile where it will serve a similar function to contain the select fill and prevent erosion of the material to clog or block the leachate collection system.

The geotextile shall:

- Be manufactured of new, first-quality products manufactured for the Works
- Certified as needle-free by the manufacturer
- Comply with the acceptance criteria specified in Table 11–1.

Table 11–1: Acceptance criteria – geotextile

Property	Test method	Acceptance Criteria		Minimum testing frequency
		Separation Geotextile/Erosion Protection Geotextile	Protection Geotextile ²⁴	
Woven/Non-woven	-	Non-woven	Non-woven	-
Polymer	-	Polyester	Polyester	-
Formation	-	Needle punched	Needle punched	-
Mass per unit area (MARV)	AS 3706.1	-	1000 g/ m ²	every 2,500 m ²
Wide width tensile strength (MARV)	AS 3706.2a	-	-	every 5,000 m ²
Grab tensile strength (MARV)	AS 3706.2b	1,100 N	4,000 N	every 5,000 m ²
Grab elongation (MARV)	AS 3706.2b	-	50%	every 5,000 m ²
Trapezoidal tear strength (MARV)	AS 3706.3	400 N	1,200 N	every 5,000 m ²
CBR burst strength (MARV)	AS 3706.4	2,250 N	9,000 N	every 5,000 m ²
Permittivity (MARV)	AS 3706.9	0.5 s ⁻¹	-	every 5,000 m ²
Pore size (MaxARV)	AS 3706.7 ²⁵	120µm	-	every 5,000 m ²
UV stability (typical) ²⁶	ASTM D7238	70%	70%	per each formulation

Note:

- The geotextile acceptance criteria above are provided as minimum criteria. The geotextile utilised shall be suitable to withstand the application for the design life of the cell, when considered in conjunction with the relevant liner profile. This is to include consideration of (but not be limited to) internal & external forces, interface shear and environmental exposure

11.7 Compression testing (hydrostatic puncture testing)

The protection geotextile shall be capable of limiting strain within the underlying HDPE geomembrane to less than 3%.

²⁴ Preliminary specification only. Refer Section 11.7

²⁵ Alternate test method as per GRI GT13a) ASTM D4751

²⁶ Strength retained after 500 hours

The proposed protection geotextile shall be assessed by the Contractor by undertaking compression testing in accordance ASTM D5514 (or approved equivalent test method) at 550 kPa, with the proposed overlying drainage aggregate and proposed underlying HDPE geomembrane(s). The results of the compression testing shall be provided to the Principals Authorised Person to verify the proposed protection geotextile can meet the HDPE geomembrane strain acceptance criteria.

The Contractor shall provide manufacturer's quality control and assurance test results for the protection geotextile material used in compression testing (tested for all the parameters identified in Table 11-1) to confirm the material properties of the geotextile. In addition to this requirement, the Principal's Authorised Person may organise independent testing of this protection geotextile to verify the material properties of the geotextile. The Contractor shall provide sufficient samples of the material to allow this testing to occur.

If requested by the Contractor, alternate protection arrangements may be considered at the discretion of the Principal.

A preliminary specification for the protection geotextile is included in Table 11-1 for undertaking bidding purposes only.

11.8 Warranty

- The Manufacturer shall warranty the materials for a minimum of 2 years.
- The Installer shall warranty his workmanship for a minimum of 1 year.

11.9 Roll and Sample Identification

All geotextile rolls and samples shall be identified in accordance with AS 3705. Each roll or panel shall carry a label which identifies, as a minimum:

- Product name, grade and name of manufacturer
- Date of manufacture, batch number
- Material thickness
- Roll number
- Roll length
- Roll weight
- Roll width
- Handling guidelines
- Reference numbers to raw material batch and laboratory certified reports
- The manufacturer's approved quality assurance stamp and the technician's signature.

The Principal's Authorised Person may reject any geotextile rolls or samples that have not been identified in accordance with this section.

All geotextile rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

11.10 Delivery, Storage and Handling

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of geotextile, including repair methods. The work method statement shall be submitted to the Principal's Authorised Person for review and comment prior to delivery of the geotextile to site.

The delivery, storage and handling components of the work method statement shall be developed in accordance with the guidance provided below:

- Delivery, storage and handling of all geotextile rolls and samples shall be undertaken in accordance with the manufacturer's instructions and ASTM D4873 as a minimum
- Rolls shall be delivered to site, handled and stored in such a manner that no damage occurs to the rolls
- Rolls shall be wrapped with weather and moisture-proof wrapping to prevent any contact with water prior to installation. In the event that it is suspected that roll/s may have come into contact with water, the Principal's Authorised Person shall inspect the moisture content of the effected roll/s and reject the roll/s if they are damaged beyond use. All geotextile rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor
- Roll cores shall be sufficiently strong to ensure that they do not deflect by more than half their diameter during delivery, storage and handling
- Rolls shall be stored in a location away from construction traffic but sufficiently close to the installation area to minimise handling. The storage area shall be level, dry, well-drained and stable, and shall protect the product from precipitation, chemicals, excessive heat, UV radiation, standing water, vandalism and animals
- Geotextile roll stacks shall be limited to the height at which installation personnel can safely manoeuvre the handling equipment. The recommended maximum stack height is three rolls
- Rolls shall be handled using a spreader or stinger bar. The bar shall be capable of supporting the full weight of the rolls without significant bending. Under no circumstances shall the rolls be dragged, lifted from one end, lifted in the middle of the roll, lifted with the forks of a forklift or pushed to the ground from the delivery vehicle. The Contractor may nominate alternate handling equipment and plant for acceptance by the Principal's Authorised Person as part of their work method statement
- The Contractor shall inspect all geotextile rolls for defects and damage upon delivery.

The Principal's Authorised Person may reject any geotextile rolls that have not been delivered, stored or handled in accordance with this section.

All geotextile rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

11.11 Preparation of Surface to Receive Geotextile

Prior to placement of geotextile, the receiving surface shall exhibit the following characteristics:

- The surface shall be smooth, flat, firm and unyielding to the satisfaction of the Principal's Authorised Person and CQA Consultant
- The surface shall not exhibit visible deformation, rutting, yielding and/or show signs of distress or instability during final proof rolling (if required)
- The surface shall be free of debris, roots, angular material (such as sharp rocks), desiccation cracks, abrupt breaks, indentations, sudden changes in grade, defects and/or imperfections that may result in damage to the overlying materials
- No loose, coarse-grained material shall remain on the surface. If required, the surface shall be raked or graded to remove any material penetrating out of the surface greater than 10 mm
- The surface shall promote drainage and excessive water shall not be allowed to pond on the surface
- The surface shall not be pebbly, tracked, rutted or otherwise disturbed by the equipment deploying overlying materials or other traffic. Pockets, holes, or discontinuities shall be repaired
- All construction stakes, hubs, or other items used for grade control shall be removed and any voids filled. Any unsuitable material shall be over-excavated to a depth of 100 mm and replaced with accepted material
- The surface shall be maintained at sufficient moisture content to prevent desiccation during the Works.

Where geotextile is being placed over a geosynthetic material, the underlying geosynthetic shall be free of excessive wrinkles preventing intimate contact between the underlying geosynthetics and/or foundation materials.

The receiving surface shall be surveyed as per the requirements of Section 1.16.

Placement of geotextile shall not proceed until the receiving surface has been inspected and accepted by the Principal's Authorised Person and CQA Consultant.

The Principal's Authorised Person may reject any underlying geosynthetic or underlying foundation material which does not meet these requirements. Any geosynthetic rejected by the Principal's Authorised Person shall be removed from the site at the expense of the Contractor. Any rejected foundation material shall be removed and/or remediated to the satisfaction of the Principal's Authorised Person.

11.12 Installation

11.12.1 General

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of geotextile. The work method statement shall be submitted to the Principal's Authorised Person for review and comment prior to delivery of the geotextile to site.

The installation component of the work method statement shall be developed in accordance with the guidance provided below, and the manufacturer's guidelines. If there is discrepancy between the manufacturers guidelines and, the guidance below, seek guidance from the Principal's Authorised Person.

The Principal's Authorised Person may reject any geotextile rolls that have not been installed in accordance with this section.

All geotextile rolls rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

11.12.2 Weather Conditions

The Contractor shall consider the weather conditions on a daily basis to confirm they are suitable for placement of geotextile.

Geotextile shall not be placed or seamed:

- If moisture prevents proper subgrade preparation, panel placement and/or panel seaming
- During precipitation, during hail, during periods of excessive fog, during periods of excessive dust, in standing water, on excessively wet surfaces, in the presence of excess moisture (such as dew and/or ponded water)
- During periods of excessive winds (>30 kph) or when gusting wind conditions interfere with handling operations.

11.12.3 Traffic

Equipment used shall not damage the geotextile by handling, trafficking, leakage of hydrocarbons, or by other means.

No vehicle shall be allowed to travel directly on the geotextile unless accepted by the Principal's Authorised Person. Prior to acceptance, the Contractor shall provide the Principal's Authorised Person the following information:

- Guidance from the manufacturer on suitable plant for trafficking for the proposed geotextile and confirmation that the Contractor shall only use this plant
- Guidance from the manufacturer on suitable trafficking method for the proposed geotextile and confirmation that the Contractor shall only use this trafficking method
- Certification from the manufacturer that the above trafficking method and plant shall not void the warranty for the proposed geotextile.

11.12.4 Placement

Geotextile shall be placed in accordance with the following:

- The geotextile shall be placed and seamed in accordance with this Specification, the Contract Drawings, the accepted work method statement and the manufacturer's instructions. Any contradictions shall be clarified with the Principal's Authorised Person
- Prior to placement, each roll shall be inspected by the Contractor for damage and/or defects, including tears, abrasion, indentation, cracks, thin spots or any other faults or defects. If damage or defects are identified, the roll shall be inspected by the Principal's Authorised Person and accepted or rejected
- Geotextile shall be protected from damage due to exposure to sunlight, dirt, dust and other hazards
- Geotextile shall be placed such that the panels are anchored at the crest of the slope and form a continuous layer down the slopes and to the toe (as shown on the drawings)
- The arrangement of the geotextile panels shall be in accordance with the accepted panel placement drawing and any changes accepted by the Principal's Authorised Person
- Installation shall progress from the highest elevations to the lowest
- Geotextile rolls shall be placed in an orderly fashion which shall minimise or prevent surface water from flowing below previously installed geotextile
- Geotextile shall not be allowed to 'bridge over' voids or low areas. The geotextile shall be placed to allow intimate contact with the subgrade or underlying geosynthetic
- Geotextile shall be installed without undergoing excessive buckling, wrinkling or tensioning
- Geotextile shall not be dragged across an unprepared surface. If the geotextile is dragged across an unprepared surface, it shall be inspected for defects and repaired or rejected if necessary
- Where there is a geosynthetic layer below, the installation of the geotextile shall be undertaken in a manner so as not to damage the underlying layer
- Sandbags or equivalent ballast shall be used as necessary to hold the geotextile in position and prevent uplift by wind. In case of high winds, continuous loading shall be placed along edges of panels to minimise wind flow under the panels. Sandbag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the geotextile
- Sandbags (or equivalent ballast) over sacrificial geotextile are to be of sufficient quality and spacing for long-term installation, 20kg sandbags roped in both directions at a minimum spacing of 3x3m is required.
- Only those geotextile rolls which can be seamed or permanently anchored on at least two sides on the same day shall be placed on a daily basis. All other sides shall be temporarily anchored
- Geotextile installed on slopes shall be fixed in anchor trenches as shown on the Contract Drawings and Section 7.23. Geotextile panels shall be anchored as soon as possible
- Personnel working on the geotextile shall not smoke, wear damaging shoes, excessively traffic or engage in other activities which may damage the geotextile. Geotextile in heavy traffic areas shall be protected by a geosynthetic overlay
- Geotextile rolls shall be freely suspended during placement
- The method used to unroll the geotextile shall not cause bridging, excessive wrinkles, scores, scratches and/or crimps
- After placement, the geotextile shall be free of excessive buckles, wrinkles, ripples, creases, folds and irregular stressing.

11.12.5 Seaming

Geotextile shall be seamed in accordance with the following:

- Geotextile seams shall be formed by overlapping the edges of the geotextile panels by a minimum of 200 mm and thermally bonding the seam or sewing the seam together with continuous stitches located a minimum of 100 mm from the overlapped edges. A two- thread, double-locked stitch shall be used. The proposed seaming method shall be in accordance with the manufacturer's instructions
- Equipment used for thermal bonding and/or sewing shall be inspected and accepted by the Principal's Authorised Person prior to use. If requested by the Principal's Authorised Person, the Geosynthetic Installer shall prepare a trial seam for inspection and/or testing prior to acceptance
- The Contractor shall ensure that the seaming method does not result in damage to the underlying geosynthetics
- Sewing procedures shall conform to the manufacturer's instructions. Spot sewing shall not be allowed
- Thread used to sew panels of geotextile together shall be polymeric thread with physical and chemical-resistance properties that equal or exceed those of the geotextile. The thread colour shall contrast with the geotextile colour and shall be approved for use by the manufacturer
- Adhesive may be used to seam the geotextile subject to acceptance from the Principal's Authorised Person. The adhesive shall be approved by the manufacturer for use in seaming their product. If requested by the Principal's Authorised Person, the Geosynthetic Installer shall prepare a trial seam for inspection and/or testing prior to acceptance
- Documentation of seam strength shall be provided by the Contractor to CQA Consultant. Seam strength to equal or exceed 75% of parent material strength when tested in accordance with AS 3706.2 (parent material strength) and AS 3706.6 (seam strength). The Principal's Authorised Person may organise independent testing of the completed seams to verify conformance with this requirement. The Geosynthetic Installer shall repair any locations where samples are taken in accordance with Section 11.13.

11.13 Defects and Repairs

The Contractor shall be responsible for inspecting the placed geotextile to identify any damage or faults in the material. The Principal's Authorised Person and/or CQA Consultant may also undertake inspections of the placed geotextile to identify any damage or faults in the material. Any areas of geotextile damaged during installation shall be repaired by the Contractor. All repairs shall be verified by the Principal's Authorised Person.

Any geotextile that has been damaged (by tears, holes or otherwise) during installation shall be repaired by patching a new piece of geotextile of the same material type and thickness with a minimum 300 mm overlap beyond the repair area in each direction. Any soil or other foreign material that may have penetrated the damaged geotextile onto the surface of the underlying layer or within the underlying layer shall first be removed to the satisfaction of the Principal's Authorised Person before any repair work is undertaken.

The Contractor shall submit to the Principal's Authorised Person for review a log containing details of any defects identified and repairs carried out.

11.14 Acceptance

The Contractor shall retain all ownership and responsibility for all geotextile until final acceptance of all work under this Contract by the Principal's Authorised Person.

Geotextile shall be accepted by the Principal's Authorised Person when all of the following conditions are met:

- Required submittals are provided by the Contractor to the Principal's Authorised Person and accepted
- Adequacy of all field seams, penetrations and repairs is verified by the Principal's Authorised Person
- The Principal's Authorised Person is satisfied that sufficient sandbags or equivalent ballast have been placed across the surface of any geotextile to be left exposed at the completion of the Works
- Details of all defects identified and repairs performed have been provided by the Contractor to the Principal's Authorised Person and accepted

- The CQA Consultant has provided the Principal's Authorised Person with a recommendation that the conditions of final acceptance have been met
- The Principal's Authorised Person has inspected and accepted the finished surface/s.

12. PE Pipe

12.1 General

All plastic pipe shall be in accordance with this Specification and the applicable referenced standards listed below.

12.2 Standards

12.2.1 Australian Standards

- AS 4130 Polyethylene (PE) Pipes for Pressure Applications
- AS 4129 Fittings for Polyethylene (PE) Pipes for Pressure Applications
- AS 4131 Polyethylene (PE) Compounds for Pressure Pipes and Fittings
- AS 1463 Polyethylene Pipe Extrusion Compounds
- AS 2033 Installation of Polyethylene Pipe Systems
- AS 2698.2 Plastic Pipes and Fittings for Irrigation and Rural Applications Polyethylene Rural Pipes.

12.2.2 Water Services Association of Australia

- Relevant Water Services Association of Australia standards are as follows:
- 02-2002
- 03-2002
- WSA 01-2004 Polyethylene Pipe Code
- WSA PS 318: Marking Tape, Detectable.

12.3 Submittals

12.3.1 Prior to delivery of PE pipework to site

- The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance prior to delivery of PE pipework to site (per PE pipework product):
- Product manufacturer
- Product name
- Manufacturer's certificate of compliance outlining conformance with the requirements of this Specification
- Manufacturer's quality control and assurance procedures
- Manufacturer's quality control and assurance test results
- Complete description of the manufacturer's shipping, handling and storage procedures
- Manufacturer's installation procedures and requirements
- Work method statement for PE pipework delivery, storage, handling and installation. This shall include jointing, procedures for testing and repairing, proposed handling equipment and restraining methods, and other information that shall promote proper use.

12.3.2 Prior to installation of PE pipework

- The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance prior to installation of the PE pipework:
- Delivery, storage and handling log for all PE pipework to be used in the Works, including delivery dockets, pipework identification, details of storage and handling.

12.3.3 Following installation of PE pipework

- The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance following installation of the PE pipework:
- As-built survey of all pipework showing conforming lines and levels
- Defects and repairs log, showing details of all defects identified and repairs completed.

12.4 Materials

The Contractor shall submit two (2) samples of each type of piping proposed for use. The submittal shall also include recommended methods of jointing, and a Certificate of Compliance for each type of pipe. The submittal shall be provided to the Principal's Authorised Person at least 15 working days prior to intended use.

Unless noted otherwise on the Drawings, all PE pipe is to be PE100 and have a minimum SDR of 9.

All PE pipeline installed outside the cell footprint is to have Detectable Marking Tape placed above the pipeline, in accordance with WSA PS 318.

12.5 Delivery, storage and handling

The Contractor shall prepare a work method statement for delivery, storage, handling and installation of PE pipework and fittings, including repair methods. The work method statement shall be submitted to the Principal's Authorised Person for review and comment prior to delivery of the PE pipework to site.

The delivery, storage and handling components of the work method statement shall be developed in accordance with the guidance provided below:

- Delivery, storage and handling of all PE pipework and fittings shall be undertaken in accordance with the manufacturer's instructions
- PE pipework shall be delivered to site, handled and stored in such a manner that no damage occurs to the PE pipework
- PE pipework shall be stored in a location away from construction traffic but sufficiently close to the installation area to minimise handling. The storage area shall be level, dry, well-drained and stable, and shall protect the product from chemicals, excessive heat, UV radiation, vandalism and animals
- The Contractor shall inspect all PE pipework and fittings for defects and damage upon delivery.

The Principal's Authorised Person may reject any PE pipework and fittings that have not been delivered, stored or handled in accordance with this section.

All PE pipework and fittings rejected by the Principal's Authorised Person shall be removed from the site and replaced at the expense of the Contractor.

12.6 Installation

The Contractor shall prepare a work method statement for delivery, storage, handling, drilling, and installation of PE pipework and fittings. The work method statement shall be submitted to the Principal's Authorised Person for review and comment prior to delivery of the PE pipework to site.

The installation component of the work method statement shall be developed in accordance with the guidance provided below:

- Work is to be carried out in accordance with the Polyethylene Pipe Code WSA 01-2004 by a contractor trained and accredited in polyethylene pipe installation
- The PE pipework and fittings shall be placed and seamed in accordance with this Specification, the Contract Drawings, AS 2033, the accepted work method statement and the manufacturer's instructions. Any contradictions shall be clarified with the Principal's Authorised Person
- Prior to placement, each pipe shall be inspected by the Contractor for damage and/or defects. If damage or defects are identified, the PE pipework shall be inspected by the Principal's Authorised Person and accepted or rejected
- Perforations shall be drilled to the size, number and location indicated on the Contract Drawings. Perforated pipework shall be thoroughly cleaned of drilling wastes or other foreign matter and any hanging beads removed before installation
- PE pipework shall be installed in a manner so as to provide for expansion and contraction as recommended by the manufacturer
- PE pipework shall be placed on an even bed of supporting material in accordance with the Contract Drawings. Bedding sand shall be as indicated in Section 1.1
- PE pipework shall lay free on the base with no induced strain. Where there is evidence of induced pipe strain, the Contractor shall be required to eliminate the strain. The Contractor shall also remove and replace any fitting, which induces a torque or strain to the pipe
- PE pipework shall be cut in a manner so as to ensure square ends. Burrs at cut ends shall be removed prior to installation so that a smooth unobstructed flow be obtained
- Pipe joints shall be butt-fusion welded in accordance with the manufacturer's instructions
- PE pipework and fittings shall be held firmly in position and protected from damage while drainage aggregate or other backfilling material is being placed
- All pipe and fittings shall be clean upon installation and kept so during the progress of the Works
- Any PE pipework that becomes either partially or fully clogged and/or damaged before final acceptance shall be cleaned/repared to the satisfaction of the Principal's Authorised Person, and/or replaced.
- Once placed areas with pipes should not be trafficked by machinery.

12.7 Defects and Repairs

The Contractor shall be responsible for inspecting the placed PE pipework and fittings to identify any damage or faults in the material. The Principal's Authorised Person and/or CQA Consultant may also undertake inspections of the placed PE pipework and fittings to identify any damage or faults in the material. Any areas of PE pipework damaged during installation shall be repaired by the Contractor in accordance with the manufacturer's instructions. All repairs shall be verified by the Principal's Authorised Person.

The Contractor shall submit to the Principal's Authorised Person for review a log containing details of any defects identified and repairs carried out.

12.8 Acceptance

The Contractor shall retain all ownership and responsibility for all PE pipework and fittings until final acceptance of all work under this Contract by the Principal's Authorised Person.

PE pipework and fittings shall be accepted by the Principal's Authorised Person when all of the following conditions are met:

- Required submittals are provided by the Contractor to the Principal's Authorised Person and accepted

- The Contractor has submitted the required as-built surveys of the completed PE pipework and fittings showing conformance with the Contract Drawings, and this has been accepted by the Principal's Authorised Person
- Details of all defects identified and repairs performed have been provided by the Contractor to the Principal's Authorised Person and accepted
- The CQA Consultant has provided the Principal's Authorised Person with a recommendation that the conditions of final acceptance have been met
- The Principal's Authorised Person has inspected and accepted the installed PE pipework and fittings.

12.9 Flushing Points and Protection

Flushing points shall be installed as shown on the Drawings. Protection shall be installed at the outlet of all flushing points, to provide protection from mechanical damage. Toe drain outlets are to be surrounded by mass concrete for a minimum of 200mm radius around the pipework, or 200mm width around the flushing point, and 200mm deep (replacing the topsoil). Mass concrete protection to be graded to tie in with finished surface. Concrete to be minimum 25MPa. Marker post to identify the location of each flushing point.

Marker posts to be placed at the toe and crest of the waste mass in line with the flushing points, to aid in location of flushing points for maintenance.

13. Leachate drainage aggregate

13.1 General

This section contains the technical requirements for the leachate drainage aggregate. The relevant requirements for the drainage aggregate in Section 6 shall be considered alongside guidance provided in this section.

The Principal's Authorised Person may reject any component of the drainage aggregate that do not meet or exceed the requirements of this section.

Any component of the drainage aggregate rejected by the Principal's Authorised Person shall be remediated at the expense of the Contractor.

13.2 Standards

13.2.1 Australian Standards

Relevant Australian standards are as follows:

- AS 1141.3.1 Methods for Sampling and Testing Aggregates – Sampling of aggregates and rock
- AS 1141.11 Methods for Sampling and Testing Aggregates – Particle size distribution/dry sieve
- AS 1289.6.7.1 Methods for Testing Soils for Engineering Purposes – Determination of the permeability of a soil
- 1141.24 Methods for Sampling and Testing Aggregates – Aggregate soundness – Evaluation by exposure to sodium sulphate solution
- 1141.23 Methods for Sampling and Testing Aggregates – Los Angeles value.

13.3 Submittals

13.3.1 Prior to delivery of drainage aggregate to site

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance prior to delivery of the drainage aggregate to site (per material source):

- Material source
- Certification that the material is VENM or ENM
- Pre-qualification test results/reports demonstrating that the proposed material complies with the material property requirements of this section of the Specification (refer Section 13.4)
- Completion of compression testing as per Section 11.7 to confirm compatibility of proposed drainage aggregate with proposed underlying protection geotextile
- Estimated quantity of material which is represented by the pre-qualification test results/reports
- Information on the parent geology of the material
- Relevant results of interface strength testing (refer Section 4).

13.3.2 Prior to conducting the field trial of drainage aggregate placement

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance prior to conducting the field trial:

- Work method statement for field trial methodology, including proposed location of the field trial
- Work method statement for installation of the drainage aggregate.

The WMS prepared for placement of the aggregate layer shall include consideration of (but not limited to) trafficability, maximum traffic loads all to be in accordance with manufacturer guidelines.

- The drainage aggregate shall be placed in a manner and with appropriate equipment such that damage does not occur to the previously installed geosynthetic layers or pipework
- The below placement techniques shall be utilised to protect the underlying geosynthetics:
 - The maximum allowable ground pressure for plant trafficking the aggregate layer shall be in accordance with manufacturer guidelines, so as not to damage the underlying layers
 - Minimum of 300mm of cover shall be maintained between the equipment tires/tracks and the GCL at all times during the covering process
 - The fill shall not be pushed down-slope, but spread by pushing up from slope bottom. The distance the fill falls onto the geosynthetics is limited to a maximum of 600mm
 - Spread fill in the same direction as unseamed overlaps to avoid separation of seams and joints.
 - If placement causes “waves” in the underlying lining system, the Contractor shall be required to place fill material on the liner rather than push the material into place
 - Any waves which could potentially fold over shall be repaired either by cutting out excess material or, if possible, allowing the geosynthetics to contract due to temperature reduction. In no case shall material be placed over the geosynthetics that could result in the geosynthetics folding
 - Wrinkling or creasing of the geosynthetics is to be repaired by the Contractor as specified by the product manufacturer
 - Maintain proper overlap of unseamed geosynthetics
 - Avoid over-stressing geosynthetics and seams
 - No material shall be placed in areas where the geosynthetics are not in contact with the supporting subgrade.

13.3.3 Prior to placement of drainage aggregate

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance prior to placement of the drainage aggregate:

- A report containing the methods, details and results of the field trial
- Updated work method statement for installation of the drainage aggregate based on the results of the field trial
- Survey of the underlying surface in accordance with Section 1.16.

13.3.4 Following placement of drainage aggregate

The Contractor shall submit the following to the Principal's Authorised Person for review and acceptance following placement of drainage aggregate:

- As-built survey of the completed surface showing conforming layer thickness within the allowable tolerances
- CQC testing results/reports showing compliance with the requirements of this Specification
- Defect and repairs log, showing details of all defects identified and any repairs completed.

13.4 Materials

Leachate drainage aggregate shall:

- Be selectively sourced material from on-site or imported from an accepted source. Imported material shall be classed as VENM or ENM

- Not contain any unsuitable materials identified in Section 7.9.5 unless accepted by the Principal
- Be rounded to sub-angular
- Be clean, hard, sound and durable material that will maintain the required performance under the maximum loads likely to be imposed on it in service
- Be non-reactive in mildly acidic conditions
- Have a calcium carbonate content of less than 8.5% by mass
- Be relatively uniform in grain size
- Comply with the acceptance criteria specified in Table 13–1.

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 19 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

Compression testing shall be completed on the proposed leachate drainage aggregate with the proposed underlying protection geotextile to confirm the HDPE geomembrane is sufficiently protected. Refer to Section 11.7 for compression testing requirements.

If required by the Principal's Authorised Person, a sample of the material shall be provided (per source) and the Principal's Authorised Person and/or CQA Consultant may undertake an inspection of the material source. The Contractor shall cooperate fully with the Principal's Authorised Person and CQA Consultant to allow this inspection to occur.

The Principal's Authorised Person may organise independent testing of the material to verify conformance with the requirements of this section.

Table 13–1: Acceptance criteria – drainage aggregate

Property	Test Method	Acceptance Criteria	Minimum test frequency
Constant head permeability	AS 1289.6.7.1	$> 1 \times 10^{-3}$ m/s	Greater of: 1:10,000m ³ or 3 per source
Particle size distribution: Passing 53 mm Passing 37.5 mm Passing 19 mm Passing 0.075 mm	AS 1141.11 or AS 1289.3.6.1	100% Minimum 95% Maximum 10% $\leq 2\%$	Greater of: 1:1,000m ³ or 3 per source
Calcium carbonate content		$< 8.5\%$ wt	Greater of: 1:10,000m ³ or 3 per source
Soundness (Sodium Sulphate Method)	AS1141.24	Less than 12 percent loss by weight after 5 cycles	Greater of: 1:10,000m ³ or 3 per source
Los Angeles Abrasion	AS1141.23	Percent shall be no greater than 50 after 500 revolutions	Greater of: 1:10,000m ³ or 3 per source

13.5 Dipole leak location survey

13.5.1 General

Following the placement of the leachate gravel layer in the cell floor, the Leak Location Contractor engaged by the CQA Consultant shall conduct a dipole leak location survey to detect leaks in the PE geomembrane.

13.5.2 Repairs

The Geosynthetic Installer shall be responsible for repairing any leaks found. Repairs shall be undertaken in accordance with Section 10.14.

After the leak is repaired, the Leak Location Contractor shall retest the area to ensure the leak was repaired and that there are no other leaks in the vicinity of the repair.

14. Groundwater Depressurisation

14.1 Pipe

Where shown on the drawings the Contractor shall install DN160 HDPE pipe or accepted equivalent, as shown on the Drawings. The requirements for installation are as outlined in Section 12.

14.2 Drainage aggregate

This section is for drainage aggregate surrounding groundwater and subsoil pipes. Leachate drainage aggregate within the cell is discussed in Section 13.

14.2.1 Characteristics and supply

Drainage aggregate shall comply with the acceptance criteria specified in and the following performance criteria

- Nominally 20-40 mm
- Be clean, hard, durable and sound
- Be free of debris, pockets of clay and other deleterious or organic material
- Non-reactive in mildly acidic conditions
- Be relatively uniform in grain size.

Prior to delivery of the drainage aggregate on site, the Contractor shall submit the following to the Principal's Authorised Person for review and acceptance:

- Information on the parent geology and certified test results/reports demonstrating that the proposed aggregate complies with the material properties listed in this section
- A 10 kg sample of the proposed aggregate.

Table 14–1: Acceptance criteria – Drainage aggregate

Property	Test method	Acceptance criteria	Minimum test frequency
Particle Size Distribution - Max. particle size - Passing 37.5mm - Passing 13.2mm	AS 1141.11,12,13 or AS1289.3.6.1, 3.6.3	50 mm 90% <2%	1 per source
Constant head permeability	AS1289.5.7.1	$> 1 \times 10^{-3}$ m/s	1 per source

At commencement of the works, one load will be delivered to site for a visual inspection by the Principal's Authorised Person. The Contractor will be required to source an alternative drainage aggregate if acceptance is not granted by the Principal's Authorised Person (the Principal's Authorised Person will be required to provide details of the non-conformance in writing). Once the material has been accepted the Principal's Authorised Person will continue to carry out visual inspections and reject any loads which do not conform.

14.2.2 Installation of drainage aggregate

Drainage aggregate shall be placed to the limits and minimum depths indicated on the Drawings.

The drainage aggregate shall be placed in a manner and with appropriate equipment such that damage does not occur to the underlying geosynthetics or pipework.

The Contractor, at no additional cost to the Principal's Authorised Person and in accordance with the relevant provisions of this Specification, shall repair any damage that occurs to the geosynthetics as a consequence of the drainage aggregate placing operation.

The Principal's Authorised Person may direct removal of a layer of drainage aggregate (at the Contractor's cost) to inspect underlying geosynthetics for damage. Any damaged geosynthetics shall be removed and replaced at the Contractor's cost.

14.2.3 Defects and Repairs

- The Principal's Authorised Person may direct the Contractor to remove a section of the subsoil layer to inspect underlying geosynthetics for damage. Any damaged geosynthetics shall be removed and replaced.
- The Contractor shall repair any damage that occurs to the geosynthetics as a consequence of the placement of subsoil layer in accordance with the provisions of the Specification.
- The Principal's Authorised Person shall direct the extent of work rejected because of failed compaction tests. The Contractor shall undertake all necessary remedial work, including retesting, to reinstate the work to the specified standard.
- The Contractor shall submit to the Principal's Authorised Person for review details of any defects identified and repairs carried out.

14.3 Acceptance

The Contractor shall retain all ownership and responsibility for the subsoil drainage until final acceptance of all work under this contract by the Principal's Authorised Person.

The subsoil drainage shall be accepted by the Principal's Authorised Person when all of the following conditions are met:

- Principal's Authorised Person has received and reviewed the as-built survey of the completed subsoil drainage showing conforming levels within the allowable tolerances.
- Details of all defects identified and repairs performed have been submitted to the Principal's Authorised Person for review and acceptance.
- The CQA Consultant has provided the Principal's Authorised Person with a recommendation that the conditions of final acceptance have been met.
- The Principal's Authorised Person has inspected and accepted the completed subsoil drainage.

15. Appurtenances

15.1 Concrete

15.1.1 General

The supply of concrete and concrete construction shall be in accordance with this Specification and the applicable referenced standards listed below.

15.1.2 Standards

- AS 1012 Methods of testing concrete
- AS 1275 Metal screw threads for fasteners
- AS 1379 Specification and supply of concrete
- AS 1478 Chemical admixtures for concrete, mortar and grout – Admixtures for concrete
- AS/NZS 1554.3 Structural steel welding – Welding of reinforcing steel
- AS 2350 Methods of Testing Portland and Blended Cements
- AS 2758.1 Aggregates and rock for engineering purposes – Concrete aggregates
- AS 3582.1 Supplementary cementitious materials for use with Portland and blended cement - Fly-ash
- AS 3582.2 Supplementary cementitious materials for use with Portland and blended cement - Slag - Ground granulated iron blast-furnace
- AS 3583 Methods of test for supplementary cementitious materials for use with Portland and blended cement
- AS 3600 Concrete structures
- AS 3610 Formwork for concrete
- AS 3725 Design for installation of buried concrete pipes
- AS 3735 Concrete structures retaining liquids
- AS 3799 Liquid membrane-forming curing compounds for concrete
- AS 4100 Steel Structures
- AS/NZS 4671 Steel reinforcing materials
- AS/NZS 4680 Hot-dip galvanised (zinc) coatings on fabricated ferrous articles
- TfNSW R53 Concrete (for General Use), Mortar and Grout

15.2 Cast in situ concrete

Where concrete is required for the construction of drainage structures, mass concrete surround, anchors, or repairs to existing structures, all concrete works shall comply with the following specification:

- TfNSW QA Specification R53 Concrete (for General Use), Mortar and Grout
- AS 3600 – Concrete Structures.

Site mixed concrete must not be permitted unless specifically accepted in writing.

15.2.1 Pre-Mixed Concrete

Pre-Mixed Concrete (Ready Mixed Concrete) shall be as set out below:

- Exposure Category: U
- Strength grade: S40
- Cement type: SR (sulphate resisting)
- Admixtures: None
- Maximum water / cement ratio: 0.35
- Maximum aggregate size: 20 mm
- Min (Max) cementitious content: 500 kg/m³
- Maximum 56 day drying shrinkage: 750×10^{-6}
- Density at 28 days : 2400 kg/m³
- Slump: 80 + 15 mm

15.2.2 Manufacturers Certification

The Contractor shall provide written certification from the concrete manufacturer / supplier that the all supplied concrete will meet or exceed the requirements of the Specification.

15.2.3 Construction Quality Control

The Contractor shall take samples of all concrete used in executing the Works for quality control testing and carry out tests as described in AS 3600. At least 1 sample per concrete delivery shall be collected and tested. The sampling and the making, curing, capping and testing of test specimens shall be in accordance with AS 1012 and must be carried out by a NATA approved laboratory.

The Contractor shall provide the results of all tests within 24 hours of tests being completed.

If the material does not conform, the Contractor shall remove from site and replace, at Contractor's expense.

15.2.4 Reinforcement

The Contractor may be directed to provide test certificates to check compliance of the reinforcement with the Drawings and the Specification. If so requested, the Contractor shall provide details of the grade and origin of all reinforcement plus test certificates, by an accepted NATA laboratory.

Reinforcement must not be spliced, welded or bent on Site unless specifically shown on the Drawings.

The Contractor must provide at least 24 hours' notice before any concrete is poured to allow inspection of the reinforcement. Construction must not proceed until the reinforcement has been inspected and approved.

Reinforcement shall be maintained in the specified position until the pouring of concrete is completed.

Reinforcement shall be stored clear of the ground and working areas and shall be protected from deterioration due to exposure.

The cover shall be the distance between the outside of any reinforcement including fitments and tie-wires and the nearest concrete surface.

Under no circumstances shall vehicular traffic including mixers be permitted to pass over fixed reinforcement.

15.2.5 Formwork

Formwork shall be in accordance with AS3610 & TfNSW Spec R53.

15.2.6 Curing

Concrete shall be moist cured for a minimum of 7 days in accordance with TfNSW Spec R53.

15.3 Rip rap

Dumped stone riprap shall consist of hard, dense, durable stone placed on the bed or banks in such a manner as to ensure that the completed layer is stable, has a reasonably uniform surface and has the larger rock fragments uniformly distributed within the riprap.

Rock rip rap is to comprise at least two layers of rock. The rock shall be placed such that the specified requirements for slopes, crest and toe levels, layer thickness are satisfied. Rocks shall be wedged and locked together such that they are not free to move. Rock should be placed in position, and not rolled or dropped. The method of rock placement shall be such as to:

- Minimise breakdown on handling and production of fines;
- Minimise the segregation of various grades of rock;
- Restrict water contamination.

Rock shall satisfy the following criteria for the types as shown on the drawings:

Table 15–115–2: Stone Rip-rap

Parameter	Value
Blanket Thickness (mm)	300
D_{min}	40
D_{50} (mm)	150
D_{max}	200

Other criteria shall be as follows:

- Rock shall have a minimum dry density of 2600kg/m³;
- Rock size (D_{50}) shall be as shown on the drawings
- Igneous rock shall have not more than 10% (by volume) olivine material and shall exhibit no zones of secondary alteration such as chloritisation;
- Free from dust, clay, dirt and other deleterious material
- Rock shall have a saturated point load strength index (Is 50) no less than 5.0 MPa.

The ratio of the maximum dimension to the minimum dimension, measured at right angles to the maximum dimension, shall not exceed 2.5.

The Principal's Authorised Person, may at their discretion, reject rock delivered to the site that is not in accordance with this specification, or is otherwise not in a suitable condition, unless an alternate rock has been accepted in writing by the Principal's Authorised Person. Such material shall be replaced at no cost to the Principal.

Rip-rap shall be placed on a Geotextile as shown on the drawings and in accordance with Chapter 11 of this specification. Geotextile shall be BIDIM A39 or accepted equivalent.

Laying shall commence at the toe of the slope and shall progress upwards, each stone being firmly embedded into the slope and against the adjoining stones. The rip-rap shall be thoroughly packed as construction progresses, so that the finished surface is tight and uniform and conforms to the design slope.

15.4 Energy Dissipating Water Spreaders

Rock supplied under this section shall be as for rip rap.

Rock shall be placed to the depth and dimensions shown on the drawings and shall be underlain by separation geotextile and extend:

- Three times the width of the channel at the outlet;
- A minimum length of 5 m; and
- Three times the width of the channel plus the length of the spreader at the downstream end.

15.5 Marker Posts

All access tracks and other locations shown on the drawings, including but not limited to the flushing points), and the access track to the new cell, are to be delineated with flexible guide-posts to TfNSW QA SPECIFICATION R131 GUIDE POSTS (or accepted equivalent).

Marker posts to be installed in accordance with manufacturers requirements. Marker posts to be a minimum height of 1m above finished surface level.

15.6 Fencing

Fencing for the works shall include all fencing required to safely undertake the work as shown on the drawings and defined in the Contract documentation as well as all other works deemed necessary to safely complete the works.

Fencing shall include, but is not limited to the following:

- Removal, relocation and/or replacement of existing fencing within the limit of works or site boundary
- Fencing to control access to the site and to control access to adjoining operational areas including roads, existing landfill operations, stormwater drains and basins, steep embankments, and areas of the site controlled by others
- Safety barriers adjacent to steep embankments resulting from excavation. The Contractor shall make its own assessment of the type necessary to ensure safety of persons or equipment in accordance with all legislation
- Permanent fencing around the new landfill cell, leachate pond and sediment basin.

15.6.1 Existing Fencing

All existing fences shall remain where not affected by the works, and made good if damaged or temporarily altered.

The Contractor shall undertake all removal, relocation and replacement of existing fencing within the limit of works or site boundary including fencing to control access to adjoining operational areas including roads, stormwater drains and basins, steep embankments, and areas of the site controlled by others.

15.6.2 Temporary Fencing

The Contractor shall supply and install 1800mm high temporary fencing surrounding work areas to protect open excavations or “impound” machinery. The Contractor shall install an appropriate fence for their security needs and safety requirements.

The fence shall satisfy the requirements of:

- AS 1725 - Galvanised Rail-less Chainwire Security Fences and Gates
- AS 2423 - Galvanised Wire Fencing Products

Temporary fencing shall be removed once all works are completed.

15.6.3 Permanent Fencing

Where noted on the plans, the Contractor shall supply and install electric fencing of the same style and height as currently exists on the site.

Where noted, the Contractor shall supply and install 1 vehicular access gate (with 2 x 3 m gates to provide 6 m openings) and 2 personnel access gates (0.9m wide) to suit the safety fence. Gates shall be full fence height in accordance with AS1725. The location of gates will be nominated by the Principal.

Appendix A

Witness and Hold Point Summary Table

Witness and Hold Point Summary Table

The following summarises witness and hold points detailed elsewhere in the Specification as required for the works. The list may not be complete and it shall be the Contractor's responsibility to ensure that all obligations are fulfilled in regard to submittals under the Contract.

Submitting and/or acceptance does not remove the obligation of the Contractor to satisfy the requirements of the Contract, the technical specification or other requirements under the contract.

The Principal's Authorised Person and Principal may witness and be copied into all correspondence.

Witness and hold points include, but are not limited to:

Table 15-3: Summary of Witness and Hold Points – New Cell

Description	Witness	Hold
General		
Provision of required pre-construction submittals, management plans and details of proposed testing firm(s)		✓
Site-specific Construction Environmental Management Plan, including review and update of the Waste Exhumation Management Plan and Unexpected Finds Management, if required – Section 1.31		✓
Site-specific Soil and Water Management Plan – Section 2		✓
Material Segregation and Testing Plan – Section 6.3		✓
Site-specific WHS Management Plan – Section 1.27		✓
Site-specific Traffic Management Plan – Section 1.30		✓
Material Quality Assurance – Sections 9.5, 10.5 and 11.5		✓
Progressive Construction Quality Control (CQC)		✓
Progressive reports of the CQAP documentation – Section 1.14	✓	✓
Dilapidation Report – Section 1.34		✓
Construction program – Section 1.10		✓
Weekly Volumetric Reports – Section 7.7	✓	
Inspection and Testing Programs (ITPs) – Section 7.18		✓
ITP test results - Section 7.18	✓	
All relevant Licenses and Approvals – Section 1.9		✓
Survey, WAE plans, drawings and other records – Sections 1.16 and 1.18	✓	✓
Field Trial– Section 4		✓
Interface Friction Testing – Section 5		✓
Compression Testing – Section 11.7		✓
Earthworks		
Installation of E&SC measures	✓	
Earthworks work method statement prior to clearing and grubbing as per Sections 7.6 , 7.9 and 7.16		✓

Description	Witness	Hold
Survey following completion of clearing and grubbing as per Section 1.16		✓
Excavation to required lines and levels, and survey as per Section 1.16		✓
Access Road Construction		
Minimum cover soil thickness over landfilled waste – Section 7.17		✓
Subgrade		
Excavation to top of subgrade layer		✓
Assessment of site-won material for suitability		✓
Determination of any required conditioning	✓	
Receipt of required submittals - Section 8.2	✓	✓
Receipt of conforming subgrade test results as per Sections 7.17		✓
Receipt and approval of required submittals prior to placement of subgrade layer as per Section 8.2	✓	✓
Receipt and approval of required submittals following placement of subgrade layer as per Section 8.2		✓
Survey of completed subgrade as per Section 1.12	✓	
Earthworks Level 1 reporting as per AS3798 – Section 7.3	✓	
Survey of all anchor trenches prior to placement of synthetic liners – Section 1.16 and 7.23		✓
Acceptance of subgrade Layer – Section 8.7		✓
GCL		
Receipt of required submittals prior to delivery of GCL - Section 9.3.1		✓
Receipt of required submittals prior to installation of GCL - Section 9.3.2		✓
Receipt of required submittals following installation of the GCL - Section 9.3.3		✓
Backfill of anchor trenches – Section 7.23	✓	
Inspection of completed GCL prior to covering – Section 9.14	✓	✓
PE geomembrane		
Receipt of required submittals prior to delivery of PE geomembrane - Section 10.3.1		✓
Receipt of required submittals prior to installation of PE geomembrane – Section 10.3.2		✓
Receipt of required submittals following installation of the PE geomembrane - Section 10.3.3		✓
Backfill of anchor trenches – Section 7.23	✓	
Inspection of completed PE geomembrane prior to covering – Section 10.15	✓	✓

Description	Witness	Hold
Geotextile		
Receipt of required submittals prior to delivery of geotextile to site - Section 11.3.1		✓
Receipt of required submittals prior to installation of geotextile - Section 11.3.2.		✓
Receipt of required submittals following installation of the geotextile – Section 11.3.3		✓
Backfill of anchor trenches – Section 7.23	✓	
Inspection of completed geotextile prior to covering – Section 11.14	✓	✓
PE Pipe		
Receipt of required submittals prior to delivery of PE Pipework to site - Section 12.3.1		✓
Receipt of required submittals prior to installation of PE Pipework - Section 12.3.2		✓
Receipt of required submittals following installation of the PE Pipework - Section 12.3.3		✓
Inspection of completed PE pipework prior to covering – Section 12.8	✓	✓
Leachate Drainage Aggregate		
Receipt and approval of required submittals prior to delivery of drainage aggregate to site as per Section 13.3.1		✓
Receipt and approval of required submittals prior to conducting field trial of drainage aggregate placement as per Section 13.3.2		✓
Inspection of field trial showing suitable placement procedures	✓	✓
Receipt and approval of required submittals prior to placement of drainage aggregate as per Section 13.3.3		✓
Inspection of placement of drainage aggregate	✓	
Receipt and approval of required submittals following placement of drainage aggregate as per Section 13.3.4	✓	✓
Inspection of completed drainage aggregate - Section 13.3.4	✓	✓
Surface water drainage		
Inspection of completed surface water drains (various)	✓	✓
Appurtenances		
Installation of appurtenances (various) in accordance with Section 15.1.2	✓	✓
WAE documentation – Section 1.18	✓	✓



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