



Construction Quality Assurance Plan

Shoal Bay Waste Disposal Site Stage 7 Landfill Cell

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1. General

1.1 Introduction

The Construction Quality Assurance Plan (CQAP) has been developed for the purpose of providing the quality assurance and quality control framework to be implemented during the construction of the Stage 7 Landfill Cell at Shoal Bay Waste Disposal Site.

The objective of this CQAP is to ensure the highest quality standard of construction is achieved and meets all relevant requirements. Delivery of the construction program, in accordance with this CQAP and the associated Technical Specification (Technical Specification – Shoal Bay Waste Disposal Site Stage 7 Landfill Cell) is intended to provide a level of confidence to project stakeholders that the completed works have been constructed in accordance with approved specifications and industry standard best practice.

The CQAP provides a process of independent verification and record keeping ensuring compliance with the approved Technical Specification and all appropriate guidance documents. Conformance with the systems and checks of this CQAP can provide confidence that a high-quality product is delivered and installed by the Contractor. The scope of Quality Assurance and Quality Control conformance framework detailed in this CQAP included:

- Earthworks
- Geosynthetics
- Pipework
- Stakeholder roles and responsibilities
- Documentation and record keeping

Key responsibilities within this CQAP are with the Construction Quality Assurance (CQA) Consultant and the Construction Contractor. The CQA Consultant undertakes inspections and independent conformance testing during the construction phase to assess and confirm the quality of the works during construction. This role is generally undertaken by an independent party to the Contractor. The Contractor must provide for and comply with all the QA/QC requirements of this CQAP, including all specific testing and data recording as required during material production / procurement, and construction. Further delineation of key stakeholder roles and responsibilities are defined in Section 1.3

1.2 Definitions

The following terms used in this CQAP 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
Site	The area as defined by Environment Protection License EPL188-03, dated 02/07/2021
CQAP	This document

Terms	Definitions
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 CQAP.

Table 1–2: Roles

Role	Description
Contractor	The person bound to execute the work under the Contract
Contractor's Geotechnical Consultant	The Contractor's Geotechnical Consultant shall be an independent Geotechnical Inspection and Testing Authority (GITA) organisation, 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.
Independent Testing Firm	The CQA Consultant's Independent Testing Firm shall be an independent testing firm(s) engaged by the CQA Consultant to conduct quality assurance testing. The CQA Consultant's Independent Testing Firms(s) shall be National Association Testing Authorities (NATA) accredited.
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.
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 the Technical 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 Contractor 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 the Technical Specification and this document is "City of Darwin" and may also be referred to as "Council" in the Contract Documents (including this CQAP) and therefore also referred to as the Principal.
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

Role	Description
	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.
Superintendent	As defined under the head contract

1.4 Qualifications

1.4.1 CQA Consultant

The CQA Consultant must be suitably experienced construction QA/QC inspector, with specific experience in construction materials testing, earthworks, geotechnical supervision, and the testing, installation, and conformance of geosynthetics. The CQA Consultant should be an appropriately certified inspector qualified under the Geosynthetics Certification Institute or provide demonstrable experience across a minimum of three projects of similar scope to the Shoal Bay Waste Disposal Site Stage 7 Landfill Cell works.

1.5 Responsibilities

All stakeholders of the Shoal Bay Waste Disposal Site Stage 7 Landfill Cell Works are required to communicate in a timely, efficient and collaborative fashion to ensure the delivery of a high-quality project. Clear communication protocols and lines of reporting will facilitate efficient communication with the intent of reducing potential for delays to the project. Lines of communication are proposed for this project in Figure 2. The final project team may diverge from this based on the team structure and stage of delivery, however the Principal or its representative retains final authorisation.

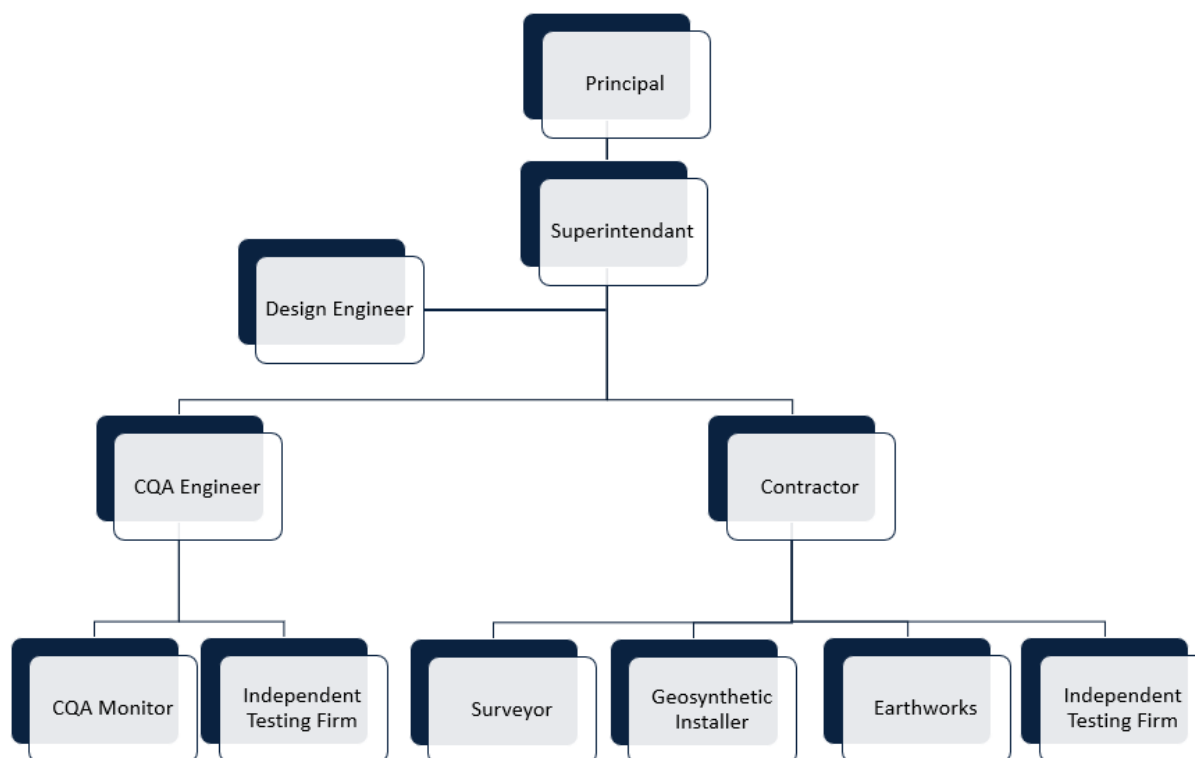


Figure 1–1: Proposed Communications Lines

Principal

The general roles and responsibilities of the Principal are as follows:

- Communicate with the CQA Consultant regarding proposed modifications and changes
- Promptly submit required any requested information to the Regulatory Authority
- Submit a CQA report including Record Drawings to the Regulatory Authority at the completion of the Works.

1.5.1 Superintendent

The Superintendent shall be the liaison between the Contractor and the CQA Consultant while keeping the Principal advised regarding work in progress. The Superintendent shall be responsible for review of schedules, attendance at meetings with the Contractor, recording and receiving samples and shop drawings, reviewing work and interpreting the Contract Documents.

Daily construction activities shall be recorded in a daily field report and colour photos of major construction activities shall be taken and labelled.

All CQA functions shall be under the Principal's authority. All coordination, reporting and issues related to non-compliance shall be directed through the Superintendent. Any requests for information, design modifications or proposed changes in the Technical Specification shall be directed through the Superintendent who shall then liaise with the relevant parties to address these.

1.5.2 Contractor

The Contractor shall select products and suppliers that meet the requirements of the Technical Specification, obtain supplier proposals, execute purchase agreements, process shop drawings, arrange for product delivery, inspect products on delivery, obtain/collect and forward product certifications and warranties, attend progress meetings, and update schedules. The Contractor shall be responsible for ensuring all CQC (Construction Quality Control) activities are undertaken in accordance with the Technical Specification.

1.5.3 CQA Consultant

The CQA Consultant shall be responsible for assessing the compliance of the completed Works with the Works Documents. This shall involve a range of activities that are described in this CQAP. Generally, the tasks will include:

- Review the Contract Documents
- Review the CQA Plan
- Review approved changes to the Contract Documents
- Reviewing and recommend rejection or approval of site-specific documentation including Contractor submittals, Manufacturer's information, Geosynthetic Installer's information and referenced standards. The Superintendent shall make the final decision on approval or disapproval of submittals
- Verify construction is performed in accordance with the Works Documents. CQA Monitors shall be assigned to every major construction activity (refer Section 2.1) related to the construction of the landfill barrier system and leachate collection and conveyance system. A minimum of one CQA Monitor shall be on-site during the relevant Works
- Attend required meetings
- Coordinate CQA Monitors to observe all CQA activities requiring monitoring
- Educate CQA Monitors on site specific CQA requirements and procedures
- Verify calibrations of CQC and CQA conformance testing equipment are correctly performed and recorded
- Verify that CQC and CQA conformance tests are properly performed, recorded, and the results meet specified requirements
- Review Contractor qualifications to verify conformance with the Works Documents
- Review warranty submittals to verify they comply with the specified warranty requirements
- Verify that the Contractor is following the approved work method statements, including relevant CQC requirements identified in the Technical Specification
- Review required submittals and recommended rejection or approval
- Report any unapproved deviations from the CQA Plan to the Superintendent as soon as practicable
- Report any activities that could result in damage to installed Works to the Superintendent as soon as practicable
- Prepare and maintain required CQA documentation
- Prepare Daily Reports for submission to the Superintendent
- Oversee the collection, marking, packaging, and shipping of CQA conformance samples for testing
- Review 'as-built' surveys and As-Constructed Drawings.

The CQA Consultant is to work with the Superintendent to determine whether sufficient evidence has been provided to adequately document that the Works comply with the requirements of the Works Documents.

The CQA Consultant (and assigned CQA monitors) shall provide full-time monitoring and inspection of the Works until completion.

1.5.4 CQA Monitors

The CQA Consultant may appoint CQA Monitors as necessary, typically permanent site staff (such as the Superintendent) or specialist personnel (such as Geotechnical Engineers), who will observe the Works on behalf of the CQA Consultant to provide a basis for concluding that the Works conform with the Works Documents.

1.5.5 Construction Quality Assurance Engineer's Independent Testing Firm

The CQA Consultant's Independent Testing Firm shall be an independent testing firm(s) engaged by the CQA Consultant to conduct quality assurance testing. The CQA Consultant's Independent Testing Firms(s) shall be National Association Testing Authorities (NATA) accredited.

1.6 Meetings and Communications

As elements of a liner system are generally installed in rapid succession, close collaborative communication between the CQA Consultant, Contractor and Superintendent / Principal is required. To facilitate clear and timely communication between stakeholders the following meeting and reporting framework is proposed for the project at a minimum in Table 1–3. At any stage, should issues or any matters arise that may impact the project program or quality significantly all parties must meet as soon as reasonably practicable.

Minutes for all meetings are to be recorded and distributed among attending parties, with the Principal to delegate responsibility of addressing any key issues around construction, design or quality assurance to the relevant party in accordance with the lines of communication.

Table 1–3 Meetings and Communications

Stage	Comment
Pre-Construction Meeting	The meeting provides a forum for the CQA Consultant to review the expectations of the CQAP, Technical Specification and responsibilities of each party to deliver the requirements of the Contract Documents. All parties are to review and define ongoing lines of and methods of communication, procedures for submitting work documentation. All parties are to table results of any discussion points from their own review of the Specifications and CQAP to clarify and discuss the requirements of these documents. The CQA Consultant and Contractor are to review the requirements of all field and laboratory CQA testing, and the expectations required of the Geosynthetics Installer subcontractor. The purpose of this is to ensure there is no ambiguity of the expectations from the Contractor and their Geosynthetics Installer at the time of installation. This meeting is to be held at minimum one month prior to start of construction to allow for the resolution of issues or other items raised. This meeting should be attended by the Principal, CQA Consultant and Contractor however a representative from the Geosynthetics Installer subcontractor would be beneficial
Weekly Progress Meetings	Weekly progress meetings are to be held between the Principal and the CQA Consultant. The CQA Consultant will review current and planned project progress and detail issues, non-conformances and any items requiring resolution. This forum may include the Contractor, Geosynthetics Installers representative, design engineer or others as required.
Monthly Reporting	Each month the CQA Consultant will submit a report to the Principal to summarise the works undertaken and detail completed, outstanding testing or other works. The primary intent of this report is to identify potential delays or issues with the quality assurance process.

1.7 Guidance Documents

Application of the CQAP shall consider (at minimum) the following:

- Technical Specification
- Design Documentation and Drawings
- Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites (NT EPA, 2013)
- All relevant Contract Documents and the relevant planning instruments as outlined in these documents.

1.8 Witness and Hold Points

The following list describes requirements for activities containing witness and hold points:

- A hold point is a defined position in the Works beyond which work shall not proceed without mandatory verification and acceptance by the Principal
- A witness point is a nominated position in the Works where the option of attendance may be exercised by the Principal, after notification of the requirement
- It shall be the Contractor's responsibility to ensure that all obligations are fulfilled regarding the witness and hold points within the Contract
- The Contractor shall give the Principal 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 provide complete supporting documentation 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, so that the Works can be completed in a sequenced manner. The Principal'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 or Principal and does not relieve the Contractor from satisfying the requirements of the Specifications or the Contract
- In some instances, the Principal may delegate acceptance or witness to another party including, but not limited to the CQA Consultant.

A summary of hold points for the lining works can be found in Appendix A of the Technical Specification.

2. Quality of Project Delivery

During this project, the quality of the project delivery will be measured through Quality Control and Quality Assurance processes, that consist of:

- Quality Control (QC) through the testing during manufacture and installation of construction materials (soil and gravel), geosynthetics, pipework and any other cell liner system elements as required. QC also includes accurate survey and recording of as constructed lines and levels. Quality Control processes are undertaken to monitor conformance with the Technical Specification and consist of both:
 - Manufacturers Quality Control (MQC), 3rd party testing of materials during production by the manufacturer
 - Construction Quality Control (CQC), testing and verification of materials and appropriate installation during construction.
- Quality Assurance (QA) is provided through thorough third-party inspection, supervision and the independent review of data generated through the life of the project, consisting of:
 - Manufacturers Quality Assurance (MQA), 3rd party oversight during production of materials to monitor production conformance
 - Construction Quality Assurance (CQA), work that is undertaken independently by the CQA Consultant in accordance with this CQAP to confirm the requirements of the Technical Specification. CQA refers to measures taken by the CQA organisation to assess if the Contractor follows the Technical Specification and approved Drawings for the project.

It is the responsibility of the Contractor to undertake all activities relating to the MQA/MQC/CQC requirements of the Technical Specification. It is the expectation that all documentation, reports, test results, survey or other submittals are reviewed and assessed for accuracy and completeness prior to submission for review by the CQA Consultant or Principal.

2.1 Summary

Table 2–1 provides a high-level overview of tasks associated with the Works requiring quality assurance and quality control inputs. The table does not identify responsible parties, which are defined elsewhere in this CQAP and in the approved Technical Specification.

Table 2–1 General Summary of QA/QC

Item	Detail	MQA	MQC	CQC	CQA
Earthworks	Confirmation that all materials proposed for use are in accordance with the requirements of the Technical Specification	✓			✓
	Acceptance of produced/manufactured materials for use on site based on provided data per the Technical Specification	✓	✓		✓
	Review of proposed work methodologies			✓	✓
	Installation of materials is undertaken in accordance to specifications and work methodology			✓	✓
	Review of CQC data (compaction testing, WAE survey, proof rolling, anchor trench dimensions and the like)			✓	✓
	Ongoing CQA, inspections and supervision as required of works undertaken by the Contractor				✓

Geosynthetics	Confirmation that all materials proposed for use are in accordance with the requirements of the Technical Specification	✓			✓
	Acceptance of produced/manufactured materials for use on site based on provided data per the Technical Specification	✓	✓		✓
	Review of proposed work methodologies			✓	✓
	Installation of materials is undertaken in accordance to specifications, work methodologies and manufacturer installation instructions			✓	✓
	Acceptance of CQC data - all geosynthetic seaming/testing/placement data and survey			✓	✓
	Ongoing CQA inspections and supervision during installation for adherence to Technical Specification and work methodologies				✓
Leachate Drainage and Collection	Confirmation that all materials proposed for use are in accordance with the requirements of the Technical Specification	✓			✓
	Acceptance of produced/manufactured materials for use on site based on provided data per the Technical Specification	✓	✓		✓
	Review of proposed work methodologies			✓	✓
	Installation of materials is undertaken in accordance to specifications			✓	✓
	Acceptance of CQC data (including survey)			✓	✓
	Ongoing CQA				✓

Independent Conformance Testing

All geosynthetic materials acquired for use at the Site will be subject to independent conformance testing by the CQA Consultant at their nominated NATA accredited or NATA recognised testing laboratory. The purpose of the independent conformance testing on materials as delivered to Site is to ensure that the correct materials have been supplied and no change to the physical properties of the materials has occurred during transport, for example pre-hydration of the GCL due to incorrect handling procedures.

All tests and testing frequencies specified in the following sections apply to each production run of material. If one production run has not been enough to complete the project and new material is required, the new production run is to be tested as a new individual lot. Testing cannot be conducted additively over multiple production runs or lots.

All materials must be independently sampled, tested and the CQA results reviewed prior to installation. The Contractor is to ensure that an appropriate lead time is provided in the construction program to allow for the CQA Consultant to perform and review the testing prior to installation. Generally, an allowance for 12 weeks is required – the Contractor should consider time for re-tests or procurement of new materials in construction programming. Should changes to any testing frequencies or testing methods be requested by the Contractor, complete justification must be documented and all relevant parties including the CQA Consultant, Principal and approving authority must accept the changes prior to application of any changes.

In the event of retesting of any materials due to non-conformance with the Technical Specification or this CQAP, all associated costs will be borne by the Contractor.

2.2 Geosynthetic Sampling

Independent conformance sampling is to be undertaken on site unless otherwise approved by the Principal, and the Contractor is to fully justify any change at the time of application.

The following methodology should be followed during the sampling process:

- Prior to the sampling event, the CQA Consultant is to confirm with the reporting laboratory:
 - The appropriate sample sizes required by the laboratory for the testing in this CQAP
 - The sample collection, handling and packaging requirements for each geosynthetic material to be assessed including (but not limited to) GCL, HDPE and Geotextiles.
- All sampling of geosynthetics is to be done by the Geosynthetics Installer contractor under the supervision of the CQA Consultant or appointed monitor
- Geosynthetic rolls to be sampled will be selected by the CQA Consultant at the time of sampling. The CQA Consultant is to confirm samples are from the nominated rolls
- Geosynthetic samples are to be collected using the appropriate tools. Samples must be collected on a flat, clean, solid surface and in good weather conditions. The Geosynthetics Installer must adhere to industry best practice and the sampling methodology must be accepted by the CQA Consultant at the time of sampling
- Samples should be collected from material that has been visually inspected in the field and considered undamaged and suitable for assessment. Material to be sampled should not present with any visible imperfections or manufacturing defects. Should the outer wrap of material appear to be flawed, marred, blemished or otherwise it is to be discarded, and sampling undertaken from the inner competent material. The outer damaged material should be discarded and not incorporated into the Works
- All sample labels are to include (at minimum):
 - Sample and roll number
 - Date sampled and identification of sampler
 - Project identification (name and ID)
 - Material and source
 - Location of test

The CQA Consultant will dispatch the samples to their independent testing laboratory. The samples should be packaged for shipping in a manner that will protect the materials during transit. The Contractor is to provide suitable shipping crates to maintain sample integrity during transport and appropriate loading plant (such as a forklift) to place pallets on transport for transfer to the laboratory.

2.3 Conformance Results

All independent conformance test results will be reviewed and reported by the CQA Consultant to the Principal. Review of data will include:

- Ensuring the correct test methods were used and under the correct conditions
- Comparison of the results against the requirements of the Technical Specification.

The Principal will be notified immediately of any non-conforming testing. The CQA Consultant will summarise the issues and recommend if non-conformances require rejection of supplied materials. Non-conforming results may be retested to confirm the results. If the sample passes the retest both results must be reported. Non-conforming results require the Contractor to remove and replace all rolls between the sampled roll and the nearest conforming rolls on either side (in order of roll production). The number of rolls to be removed may be reduced should the Contractor undertake additional testing and verification of these materials. The Contractor must undertake the full conformance testing range on the rolls to be verified, not only for the failed test. Any replacement material that is required for the Site is subject to the specified independent conformance testing.

All CQA testing will be recorded, with a summary provided for the Principal as part of the weekly and monthly reporting.

2.4 CQA Documentation

All CQA data generated during construction must be accurately recorded by the CQA Consultant and will include logs, inspection/testing summaries and photographs. Photographs must be of a high quality and include all phases of the works, problem areas and repairs, all major features and proof of correct material placement, installation, and testing.

The level of documentation required for the project will be reviewed with the Principal at the Pre-Construction Meeting and may be adjusted from the minimum recommended in this CQAP, typically subject to the phase of the project. The recommended documentation required by the CQA Consultant during the project is summarised in Table 2–2.

All documentation and supporting photographs are to be provided to the Principal and kept readily available for reference.

Table 2–2 Minimum Recommended CQA Reporting

Item	Detail
Receival Report	All materials under the purview of the CQA Consultant are to be receipted on arrival to site with an inspection report. The inspection report is to confirm the ‘as received’ condition of materials and that the handling and unloading methods, site transport of all materials are appropriate / in accordance to the associated work method statement or best practice. All geosynthetics received at the site must be appropriately packaged for protection. GCL, HDPE and geotextiles shall be wrapped in waterproof protective coverings. The CQA Consultant and Contractor are to confirm all rolls received have complete packaging and labelling, with incomplete or damaged materials rejected or quarantined at the time of receipt.
Daily Inspection Summaries	Date, identification of CQA staff, weather and relevant project details. Details of work in progress by Contractor and associated CQA/CQC tasks required. Installation and testing details of geosynthetics installed for the day to confirm panel arrangement, seaming and testing. Detail that installation/placement, field testing and protection measures of soils/gravels/geosynthetics has been undertaken in accordance to the appropriate methodologies. Record of significant discussions and decisions undertaken, noting relevant parties and inputs. Document to be signed by the CQA Consultant.
Weekly / Monthly Reporting	Acceptance of produced / manufactured materials for use on site in accordance with the requirements of the Technical Specification. Review of proposed work methodologies. Installation of materials in accordance to specifications, work methodologies and manufacturer installation instructions. Acceptance of CQC data - all geosynthetic seaming/testing/placement data and survey. Ongoing CQA inspections and supervision during installation for adherence to Technical Specification and work methodologies.
Final CQA Report	The final CQA report must include: A summary of all works undertaken.

All survey (by others), work as executed drawings, and final plan showing location.

All CQA documentation, comprised the preceding reports and all supporting photographs detailing every stage of construction.

All QA/QC documentation required by the Technical Specification and this CQAP.

Summaries of all non-conformances, issues, remedial works, deviations from the design and variations from the Technical Specification or this CQAP.

A statement by the CQA Consultant that there is enough information to demonstrate that the works were constructed in accordance with the approved designs and specifications.

2.5 Non-conformances and Corrective Actions

Any deviations from the Technical Specification, this CQAP or other Contract Documents are to be reported to the CQA Consultant for notification to the Principal within 24 hours of occurrence. Notification will be in the form of a non-conformance report (NCR) which is to detail the nature, extent and a full summary of the non-conformance. The Contractor must provide all appropriate supporting documentation (such as survey, test results, photographs), in addition to a proposed rectification strategy to allow submission by the CQA Consultant of a complete NCR.

The Corrective Action Plan (CAP) for items pertaining to the QA/QC or Technical Specification shall be prepared by the CQA Consultant and Principal in consultation with the appropriate parties as required (Geosynthetics Installer, pipework contractors or others). Any NCR's that require amendment to the design will be escalated to the Design Engineer.

If a major deviation to the approved designs or the CQAP occurs, the Principal may be required to seek clarification from the EPA and will be assessed on a case-by-case basis. Minor deviations can be administered by the CQA Consultant by reporting any minor deviations in the Final CQA Report, with CQA Consultant confirmation that any variation did not compromise the required outcomes of the Environmental Authority, guidelines or the design.

At the pre-construction meeting, the NCR format and CAP is to be agreed upon by all parties, prior to beginning works.

3. Field Trial

Prior to the placement of geosynthetic materials, a field trial of the proposed methodologies for placement of the leachate barrier system materials is to be conducted by the Contractor. The field trials are to be undertaken in accordance with the requirements of the Field Trial Section of the Technical Specification. Prior to undertaking any field trials, the Principal is to approve the Work Method Statement developed for the field trial prepared by the Contractor. During the field trial, the CQA Consultant is to:

- Visually confirm that field trial preparation and completion are undertaken in accordance with the approved work method statements provided by the Contractor
- Visually confirm the underlying geosynthetics are placed in accordance with the approved work method statements and the manufacturer's instructions
- Witness the field trial and provide recommendations
- Inspect the underlying geosynthetics for damage and deficiencies following completion of the field trial
- Review any relevant test results/reports
- Review of field trial report prepared by the Contractor, including the updated placement method.

4. Earthworks

4.1 Summary

All requirements of this section relate specifically to the earthworks required for the proposed earthworks that form the barrier system at the Site. The Contractor must review all QA/QC documentation for accuracy and completeness prior to submission for CQA Consultant review, any incomplete or unreviewed submittals will be rejected by the CQA Consultant. All submittals must meet the requirements of the Technical Specification and this CQAP.

Approval of the submittals by the Principal will be subject to the recommendation of the CQA Consultant.

4.2 General Procedures

The CQA Consultant shall:

- Review all test results/reports provided by the Contractor for the proposed materials to confirm that the materials are uniform and match the required properties given in the Technical Specification
- Advise the Principal about the need to do additional source assessment testing if visual inspections identify that the properties of the materials appear to have changed significantly
- Inspect fill material stockpiles prior to use and advise the Principal of the presence of any unsuitable material
- Visually inspect that equipment, processing and placement is being undertaken in accordance with the Specification and approved work method statements.

4.3 Material Acceptance

Prior to the delivery (and installation) of any materials to site, all MQC / MQA procedures and testing data is to be reviewed and accepted as conforming to the requirements of the Technical Specification.

The Contractor is to provide the complete and reviewed MQA / MQC data to the CQA Consultant in accordance with the Technical Specification. The CQA Consultant will assess whether the test methods, testing frequency, results and documentation meet the requirements of the Technical Specification and subsequently recommend the release of relevant hold / witness points as required.

4.4 Quantities

If requested by the Principal, the CQA Consultant shall review and comment on any quantity re-measurements submitted by the Contractor.

4.5 Extent of disturbed areas

The CQA Consultant shall notify the Principal if the Contractor is witnessed working outside the Works Area shown on the Contract Drawings or as described in the Technical Specification or Contract Documents.

4.6 Clearing and grubbing

If requested by the Principal, the CQA Consultant shall inspect and comment on any clearing and grubbing works undertaken by the Contractor.

4.7 Excavation

Excavation includes possible further trimming of the existing surface, excavation of the anchor trenches, excavation of the leachate collection trenches and groundwater system, removal of overfilled waste/fill associated with the intra-cell bund connections.

The CQA Consultant shall verify the following during excavation:

- Material that is unsuitable for use shall be excavated and disposed by the Contractor
- Excavation slopes shall be finished in conformance with the required lines and grades
- All debris and loose material is removed from the finished surfaces
- The Contractor has implemented protective measures to ensure that the excavation areas are not damaged during periods of inclement weather.

4.8 Subgrade preparation

During subgrade preparations the CQA Consultant shall verify the following:

- The subgrade is smooth, free of voids, and composed of satisfactory materials
- The subgrade is compacted as specified
- The lines and levels of the top surface of the subgrade is correct
- The subgrade surface is scarified as specified prior to placement of the first lift of fill.

4.9 Filling

Filling includes the placement and compaction of fill to create subgrade surface, construction of perimeter and intercell separation bunds, backfilling anchor trenches, and placement of drainage aggregate.

During filling the CQA Consultant shall verify the following:

- Sudden braking or sharp turns of machinery are not made
- Slippage of filling and compaction equipment is not occurring on side slopes. This is especially important when the fill layer is underlain by geosynthetics
- There are no thin areas of fill which could allow underlying geosynthetics to be punctured or torn
- Loose lifts are no greater than the specified maximum allowable thickness
- Fill contains no large clods or other material prohibited by the Contract Documents
- Fill is placed to the lines and levels shown in the Contract Documents
- Placement of drainage aggregate in accordance with the Contract Documents.

4.10 Compaction

During compaction the CQA Consultant shall verify the following:

- Verify the specified minimum number of passes are being made over all areas of each lift of fill (if applicable)
- Visually observe fill placement around all penetrations and verify that fill placed around penetrations does not contain voids and is adequately compacted
- Inspect pipes which penetrate fill layers for damage due to placement and compaction equipment
- Verify the surface of each lift is adequately scarified prior to placement of the next lift of fill

- Verify low ground pressure equipment is used when compaction is required over piping, geosynthetics, or other appurtenances.

4.11 Material tests

- Check CQC material test results to verify that the material is uniform and matches the required properties given in the Contract Documents.
- Advise the Superintendent about the need to do additional source assessment testing if the properties of a source appear to have changed significantly.

4.12 In-place moisture content and density tests

Verify the following during testing of the in-place fill:

- CQC moisture content and density tests are performed at the specified frequency.
- Additional CQC tests are taken where test results are not in compliance with the Contract Documents or the fill is visibly suspect.
- The Contractor performs corrective action as a result of failed tests in compliance with the Contract Documents and submits documentation describing the corrective measures taken.
- The Contractor uses nuclear gauges in the direct transmission mode to measure density.

4.13 Tolerances

The CQA Consultant shall review, if requested by the Principal, as-built survey data of the completed surfaces to confirm that conforming layer thickness are within the allowable tolerance.

4.14 Anchor trenches

The CQA Consultant shall confirm the following when inspecting anchor trenches:

- The anchor trench is constructed to the correct dimensions
- Termination points of geosynthetic layers within the anchor trench are correct
- Corners of the anchor trench are slightly rounded to avoid sharp bends in the geosynthetics
- Loose fill or objectionable materials such as geosynthetic scraps and food containers are removed from the bottom of the anchor trench prior to placement of geosynthetics
- The anchor trench is dewatered (pumped out) if standing water is present in the bottom of the trench
- The anchor trench is backfilled with approved fill placed at the specified moisture content and density
- Compaction work within the anchor trench does not damage the geosynthetics.

4.15 Stockpiles

The CQA Consultant shall inform the Principal if the Contractor is witnessed to not be managing stockpiles in accordance with the requirements of the Technical Specification and the approved work method statement.

4.16 Protection

The CQA Consultant shall:

- Inspect the Contractor has removed puddles and excess moisture from the fill surface prior to placement of additional fill

- Look for areas of erosion after each rainfall event
- Inspect for damage due to freezing and/or desiccation
- Ensure the Contractor repairs damaged areas and re-establishes grades.

4.17 Weather conditions

The CQA Consultant shall monitor along with the Superintendent that earthworks do not occur during periods of excessive rain, freezing temperatures, or if other detrimental weather conditions exist.

4.18 Defects and repairs

If a fill layer does not conform to the Contract Documents, the CQA Consultant will, if requested, assist the Principal in defining the extent of the area requiring repair. This shall be done using additional testing and visual inspection.

After repairs have been made, ensure CQC retests are performed to check the repaired areas. In general, CQC retests shall be performed at the same frequency as the rest of the project.

Additional CQC testing shall be performed as required in suspect areas.

4.19 Acceptance

Acceptance of all earthworks activities is subject to a recommendation by the CQA Consultant based on advice from the Level 1 Inspector that all works undertaken by the Contractor meet the requirements of the Technical Specification and this CQAP. Acceptance does not remove the obligation of the Contractor to satisfy the requirements of the Technical Specification or other any other requirements under the contract.

This recommendation shall be based on, but not limited to, the following:

- Review of all submittals, including CQC test results from the Contractor
- Review of CQA test results
- Relevant monitoring and inspections undertaken.
- The above items are also to be summarised in the monthly progress report.

5. Geosynthetic Clay Liner

This section contains the requirements for the geosynthetic clay liner (GCL) in addition to the general requirements in the preceding sections.

The Principal may reject any GCL that does not meet or exceed the requirements of this section. Any GCL rejected by the Principal shall be removed from the site and replaced at the expense of the Contractor.

The Contractor must review all QA / QC documentation for accuracy and completeness prior to submission for CQA Consultant review, any incomplete or unreviewed submittals will be rejected by the CQA Consultant. All submittals must meet the requirements of the Technical Specification and this CQAP.

5.1 Material Acceptance

Prior to the delivery and installation of any materials to site, all MQC / MQA procedures and testing data is to be reviewed and accepted as conforming to the requirements of the Technical Specification.

The Contractor is to provide the complete and reviewed MQA / MQC data to the CQA Consultant in accordance with the requirements of the Technical Specification. The CQA Consultant will review and assess whether the appropriate test methods, testing frequency, results and documentation supplied meet the requirements of the Technical Specification.

5.2 Independent Conformance Testing

Independent conformance of the GCL as delivered to site must be undertaken in accordance with the requirements of Section 5 and Table 5–1.

Table 5–1 lists the testing required to be completed and accepted as conforming by the CQA Consultant prior to installation.

Table 5–1 Independent Conformance Testing

Test	Test Method	Frequency
GCL Mass per Unit Area	ASTM D5993	1 test per 2,500 m ² , including the first and last rolls (based on production order): minimum of two tests
Bentonite Clay – Mass per unit area @ 0% moisture	ASTM D5993	1 per 1,250 m ² , including the first and last rolls (based on production order): minimum of two tests
Peel strength	ASTM D6496	1 per 1,250 m ² , including the first and last rolls (based on production order): minimum of two tests
Tensile properties – machine direction	ASTM D6768	1 per 5,000 m ² , including the first and last rolls (based on production order): minimum of two tests
CBR burst strength	AS 3706.4	1 per 5,000 m ² , including the first and last rolls (based on production order): minimum of two tests

Bentonite Clay – Fluid Loss	ASTM D5891	1 per 1,250 m ² , including the first and last rolls (based on production order): minimum of two tests
Bentonite Clay – Free Swell Index	ASTM D5890	1 test per 2,500 m ² , including the first and last rolls (based on production order): minimum of two tests
Bentonite Clay – Cation exchange capacity	Methylene blue method	1 test per 2,500 m ² , including the first and last rolls (based on production order): minimum of two tests
Hydraulic conductivity	ASTM D5887	1 test per 10,000 m ² , including the first and last rolls (based on production order): minimum of two tests
Bentonite Clay – Montmorillonite content and carbonate content	CSIRO X-ray diffraction	1 test per 10,000 m ² , including the first and last rolls (based on production order): minimum of two tests

5.3 Roll and sample identification

The CQA Consultant shall verify rolls and samples are identified in accordance with the Specification.

5.4 Delivery, storage and handling

The CQA Consultant shall fill out a receiving inspection report for each delivery of GCL. The CQA Consultant shall be present during delivery and unloading to verify the following:

- Rolls are handled and stored in such a manner that no damage occurs to the GCL
- Rolls are handled and stored in accordance with the approved work method statement and the manufacturer's instructions
- GCL rolls are packaged in opaque, waterproof, protective coverings. GCL rolls delivered without complete packaging, labelling and documentation shall be either rejected or quarantined based on inspections by the CQA Consultant
- Each roll is labelled in accordance with the requirements of the Technical Specification
- Rolls which are damaged beyond use are removed from the site.
- If the CQA Consultant determines any damaged GCL rolls or partial rolls are suitable for use, written justification for doing so shall be provided to the Principal.

5.5 GCL Installation Procedures

5.5.1 Subgrade Condition

Prior to and during GCL placement, the CQA Consultant and Contractor must monitor the subgrade conditions to ensure optimal conditions for placement of the GCL. Subgrade conditions may change during GCL deployment due to weather, vehicular traffic or other factors causing damage to the receiving surface after initial

approval by the Principal, subsequently ongoing monitoring of the receiving surface is required. The CQA Consultant shall confirm the following through inspections of the receiving surface:

- The receiving surface is complete and has been accepted by the Principal, including lines, levels and associated geotechnical requirements (material and placement acceptance)
- The receiving surface is free of defects or imperfections that may result in damage to the GCL, this may include excessive moisture (ponding of surface water or breakup/movement in receiving surface), abrupt breaks, sharp objects, or other foreign material
- Subgrade conditions meet the requirements of the manufacturers installations specifications.

The CQA Consultant shall include review and acceptance of the subgrade conditions, including any remedial works required in each daily inspection report during GCL placement.

The Geosynthetic Installer, the Contractor and the CQA Consultant shall sign a certificate of subgrade acceptance for each day that GCL is placed.

5.5.2 Deployment

The following deployment requirements are to be monitored through inspections, with acceptance or other details summarised as part of the CQA Consultants' daily report.

- Deployment and handling of GCL is undertaken in accordance with the approved work method statement and manufacturer's instructions
- Field panels are deployed at the locations and positions indicated on the Contractor's approved panel placement drawing. The CQA Consultant shall monitor that the identification code (roll number), location, and date of installation of each field panel are recorded by the Geosynthetics Installer
- Each roll is visually inspected for damage and deficiencies with consideration to colour, thickness, needle punching, presence of needles or broken needles, and sewing density or other faults in the material
- Any damaged or defective rolls are identified, inspected and approved or rejected based on criteria within the Specification
- Any visible or suspected damage is recorded and reported, and relevant rolls are tagged and segregated for further investigation
- Weather conditions are acceptable for installation (with consideration to manufacturer's instructions)
- Winds are not so high as to cause damage during installation
- Any rolls or panels which have been displaced by wind are inspected for damage and approved or rejected
- Equipment used for installation and cover are in accordance with the approved work method statement
- The Contractor has adequate ballasts (e.g. sandbags) on hand and they are properly deployed to prevent uplift of the panels by wind
- Rolls are laid reasonably flat with a minimum of wrinkles so that they contain no areas that can fold over during covering
- Rolls are placed with the correct side facing up (where relevant)
- The Contractor cuts out and repairs waves that are so large as to cause folding of the GCL when they are covered
- There are no tensile stresses in the deployed GCL
- Construction personnel are not smoking or wearing shoes that could damage the GCL
- GCL which has been hydrated prior to being covered is removed and replaced. Hydrated GCL is defined as material, which has become soft as determined by squeezing the material with finger pressure or material that has exhibited swelling.
- Seams are constructed as specified and in accordance with manufacturer's instructions, lapped in the correct direction (where relevant) and seams are not placed in locations prohibited by the Specification

- Overlaps are constructed in accordance with the requirements of the Specification
- Bentonite paste is placed along the entire overlap width at the rate as per manufacturer's instructions
- Adhesives or other approved seaming methods recommended by the manufacturer are used if horizontal seams are allowed on slopes
- Rolls are not dragged across the receiving surface or other deployed GCL. This can result in damage to the GCL. A sacrificial rub sheet may be used to alleviate this problem
- Rolls are not being damaged during placement or covering
- GCL is not hydrated prior to covering.

5.5.3 Protection

The CQA Consultant shall visually inspect to confirm that only GCL panels which can be anchored and covered before the end of the day is removed from the packaging. If exposed GCL cannot be covered before the end of the day, the Geosynthetics Installer is to cover with a plastic cover material and ballast until construction can resume. GCL should have a minimum coverage extending from its edge by 3m that is suitably anchored (sandbags or similar) and made of a waterproof membrane i.e. builders' plastic.

It is imperative that GCL panels are protected by the Geosynthetics Installer from rain events. The Installer shall consider grades, drainage lines or other potential flow paths that may lead to hydration of the GCL. The CQA Consultant shall nominate corrective actions where necessary.

5.5.4 Penetrations

The CQA Consultant shall undertake inspections and review Contractor documentation to confirm the following:

- Penetrations are located as shown on the plans
- Penetrations are constructed and tested as per the Specification and the manufacturer's instructions
- Installation is undertaken in accordance with the approved work method statement, which includes any adjustments made as a result of the field trial - refer Technical Specification.

5.5.5 Weather conditions

The CQA Consultant shall monitor that GCL placement does not occur during periods of excessive rain, freezing temperatures, or other detrimental weather conditions as nominated in the Technical Specification.

5.6 Defects and repairs

The CQA Consultant shall visually inspect GCL for damage after placement. Damaged areas shall be marked. The CQA Consultant shall document the location of the damaged panels, repairs which were performed and panels which were rejected in the daily report.

The CQA Consultant shall visually inspect to confirm that all deficiencies have been repaired in accordance with the requirements of the Technical Specification and the manufacturer's instructions prior to final acceptance.

5.7 Acceptance

Acceptance of the GCL by the Principal is subject to a recommendation by the CQA Consultant that all works undertaken by the Contractor meet the requirements of the Technical Specification and this CQAP. Acceptance does not remove the obligation of the Contractor to satisfy the requirements of the Technical Specification or other any other requirements under the contract.

This recommendation shall be based on, but not limited to, the following:

- Review of all submittals, including CQC test results from the Contractor

- Review of CQA test results
- Relevant monitoring and inspections undertaken.
- The above items are also to be summarised in the monthly progress report.

6. HDPE Geomembrane

This section contains the QA / QC requirements for the geomembrane in addition to the general requirements in the preceding sections.

The Principal may reject any geomembrane that does not meet or exceed the requirements of this section. Any geomembrane rejected by the Principal shall be removed from the site and replaced at the expense of the Contractor.

The Contractor must review all QA / QC documentation for accuracy and completeness prior to submission for CQA Consultant review, any incomplete or unreviewed submittals will be rejected by the CQA Consultant. All submittals must meet the requirements of the Technical Specification and this CQAP.

6.1 Material Acceptance

Prior to the delivery and installation of any materials to site, all MQC / MQA procedures and testing data is to be reviewed and accepted as conforming to the requirements of the Technical Specification. Prior to installation, the CQA Consultant is to review the qc documentation from the resin supplier and confirm via the manufacturers roll listing that the resin proposed and reviewed was used to manufacture the rolls delivered to site.

The Contractor is to provide the complete and reviewed MQA / MQC data to the CQA Consultant in accordance with the Technical Specification. The CQA Consultant will confirm that the appropriate test methods, frequency, results and documentation meet the requirements of the Technical Specification.

6.2 Independent Conformance Testing

Independent conformance of the geomembrane as delivered to site must be undertaken in accordance with the requirements of Section 6 and Table 6–1.

Table 6–1 lists the testing required to be completed and accepted as conforming by the CQA Consultant prior to installation. Test results are to be assessed against the requirements of the Technical Specification.

Table 6–1 Geomembrane Independent Conformance Testing

Test	Test Method	Frequency
Thickness	ASTM D5199 (smooth) ASTM D5994 (textured)	1 test per 5,000 m2, including the first and last rolls (based on production order): minimum of two tests
Asperity height (textured)	ASTM D7466	1 test per 5,000 m2, including the first and last rolls (based on production order): minimum of two tests
Density	ASTM D1505 or ASTM D792	1 test per 5,000 m2, including the first and last rolls (based on production order): minimum of two tests
Tensile properties (yield and break stress, yield and break elongation)	ASTM D6693	1 test per 5,000 m2, including the first and last rolls (based on production order): minimum of two tests
Puncture resistance	ASTM D4833	1 test per 5,000 m2, including the first and last rolls (based on

		production order): minimum of two tests
Tear resistance	ASTM D1004	1 test per 5,000 m2, including the first and last rolls (based on production order): minimum of two tests
Carbon black content	ASTM D1603 or ASTM D4218	1 test per 5,000 m2, including the first and last rolls (based on production order): minimum of two tests
Carbon black dispersion	ASTM D5596	1 test per 5,000 m2, including the first and last rolls (based on production order): minimum of two tests
Stress crack resistance	ASTM D5397	1 test per 10,000 m2, including the first and last rolls (based on production order): minimum of two tests
Standard oxidative induction time, and; High pressure oxidative induction time	ASTM D8117 ASTM D5885	1 test per 10,000 m2, including the first and last rolls (based on production order): minimum of two tests

6.3 Roll and sample identification

The CQA Consultant shall verify rolls and samples are identified in accordance with the Specification.

6.4 Delivery, storage and handling

The CQA Consultant shall fill out a receiving inspection report for each delivery of PE geomembrane. The CQA Consultant shall be present during delivery and unloading to verify the following:

- Rolls are handled and stored in such a manner that no damage occurs to the PE geomembrane
- Rolls are handled and stored in accordance with the approved work method statement and the manufacturer's instructions
- HDPE geomembrane rolls are packaged in opaque, waterproof, protective coverings
- Each roll is labelled in accordance with the Specification
- Rolls which are damaged beyond use are removed from the site.

6.5 Preparation of surface to receive geomembrane

The CQA Consultant is to inspect and approve the receiving surface prior to placement of any materials. Ongoing monitoring is to be undertaken to observe for any changes to the surface due to weather, vehicular traffic or other factors. The CQA Consultant shall verify the following during inspections of the receiving surface:

- The receiving surface is complete and accepted by the Principal
- The receiving surface is free of defects or imperfections that may result in damage to the PE geomembrane
- The receiving surface is free from abrupt breaks, sharp objects, or other foreign material
- The receiving surface has not been damaged by inclement weather

- If the receiving surface is subgrade or fill materials, verify the surface is compacted in accordance with the Specification, does not have areas of roughness that may prevent direct contact of the PE Geomembrane on the surface, and is not pebbly, or tracked and rutted by equipment.

The Geosynthetic Installer, the Contractor and the CQA Consultant shall sign a certificate of subgrade acceptance for each day that geomembrane materials are placed.

6.6 Installation

The CQA Consultant shall visually inspect and monitor the following during installation:

- Installation is undertaken in accordance with the approved work method statement and manufacturer's instructions
- Each roll is visually inspected for damage and deficiencies with consideration to tears, punctures, abrasions, cracks, indentations, thin spots, or other faults in the material
- Any damaged or defective rolls are identified, inspected and approved or rejected based on criteria within the Specification. This may include blemishes, holes, indentations, thin spots, tears and punctures
- Any repair works are conducted in accordance with the requirements of the Technical Specification
- Weather conditions are acceptable for installation (with consideration to manufacturer's instructions)
- Winds are not so high as to cause damage during installation
- Any rolls or panels which have been displaced by wind are inspected for damage and approved or rejected
- Equipment used for installation and cover are in accordance with the approved work method statement
- The Contractor has adequate ballasts (e.g. sandbags) on hand and they are properly deployed to prevent uplift of the panels by wind
- Field panels are installed at the locations and positions indicated on the Contractor's approved panel placement drawing. The CQA Consultant shall verify that the identification code, location, and date of installation of each field panel are recorded
- Rolls are laid reasonably flat with a minimum of wrinkles so that they contain no areas that can fold over during covering
- Rolls are placed with the correct side facing up (where relevant)
- The Contractor cuts out and repairs waves that are so large as to cause folding of the PE geomembrane when they are covered
- There are no tensile stresses in the deployed PE geomembrane
- Construction personnel are not smoking or wearing shoes that could damage the PE geomembrane
- Seams are constructed as specified and in accordance with manufacturer's instructions. Also verify seams are not placed in locations prohibited by the Specification
- Rolls are not dragged across the receiving surface or other deployed PE geomembrane. This can result in damage to the PE geomembrane. A sacrificial rub sheet may be used to alleviate this problem
- Rolls are not being damaged during placement or covering
- The Geosynthetic Installer provides enough slack in the deployed geomembrane to account for the temperature fluctuations anticipated
- After a significant drop in temperature, the PE geomembrane has not pulled away from the subgrade or anchor trench

6.7 Trial seams

The CQA Consultant shall be present when trial seams are performed to visually confirm they are conducted in accordance with the requirements of the Technical Specification. Test results for each trial seam shall be recorded by the Geosynthetics Installer on the relevant geomembrane trial seam data sheet.

6.8 Field seams

The CQA Consultant shall monitor the following during field seaming:

- Seaming equipment is in good condition and is functioning properly
- Field seams are laid out as shown on the approved panel layout drawing
- Seams are of high quality. Special attention shall be given to high stress points such as valleys, ridges and at penetrations
- Seam areas are clean and free of moisture, dust, dirt, and foreign material
- If grinding of the surfaces to be seamed is required, the grinding marks are oriented perpendicular to the seam direction and no marks extend beyond the extrudate after placement
- The depth of the grinding marks is no greater than 10% of the sheet thickness
- Where extrusion welds are terminated long enough to cool, they are ground prior to applying new extrudate over the existing seams.
- Each seam constructed shall be recorded on a geomembrane seam log by the Geosynthetics Installer.

6.9 Field sampling and testing

6.9.1 Destructive Seam Testing

The CQA Consultant shall:

- Select locations where seam samples will be cut out for CQA testing. The Geosynthetic Installer shall not be informed in advance of the locations where the seam samples will be taken
- Verify seam strength testing is done as the seaming work progresses, not at the completion of field seaming
- Verify seams are labelled in accordance with the Specification
- Verify CQA seam test results and repairs are being documented by the Geosynthetic Installer appropriately
- Verify seams which fail CQA and / or CQC destructive seam testing are repaired in accordance with the Specification.

6.9.2 Non-Destructive Seam Testing

The CQA Consultant shall verify:

- All seams are visually inspected to assess the quality of the workmanship and the appearance of the welded seam
- All seams are non-destructively tested as seaming work progresses and seams which fail are repaired
- The outcome of all non-destructive seam test results is documented appropriately by the Geosynthetic Installer

6.10 Electrical Leak Location Survey

The CQA Consultant shall be responsible for engaging a Leak Location Contractor on behalf of the Principal to undertake electrical leak location surveys (ELLS) following the installation of all HDPE geomembrane layers. Electrical leak location surveys shall be undertaken in accordance with Section 7.

6.11 Defects and Repairs

The CQA Consultant shall visually inspect PE geomembrane for damage after placement. Damaged areas shall be marked. The CQA Consultant and Geosynthetics Installer shall document the location of the damaged panels, repairs which were performed and panels which were rejected on a geomembrane repair log. The CQA Consultant shall visually inspect and verify that all deficiencies have been repaired in accordance with the Specification and the manufacturer's instructions prior to final acceptance.

6.12 Acceptance

Acceptance of the Geomembrane by the Principal is subject to a recommendation by the CQA Consultant that all works undertaken by the Contractor meet the requirements of the Technical Specification and this CQAP. Acceptance does not remove the obligation of the Contractor to satisfy the requirements of the Technical Specification or other any other requirements under the contract.

- Review of all submittals, including CQC test results and survey of the HDPE panel layout
- Review of CQA test results
- Relevant monitoring and inspections undertaken.
- The above items are also to be summarised in the monthly progress report.

7. Electrical Leak Location Survey

7.1 General

This section contains the requirements for undertaking electrical leak location surveys. The CQA Consultant shall be responsible for engaging a Leak Location Contractor to undertake ELLS as required under the Technical Specification for the Works.

The Contractor is responsible for ensuring that the Site area to be surveyed is appropriately presented and prepared to the requirements of the ELLS contractor prior to arriving at Site.

Two types of leak location surveys shall be undertaken:

- Arc testing leak location survey (following installation of each HDPE geomembrane layer), otherwise referred to as 'Bare Liner' testing
- Dipole leak location survey (following installation of the leachate drainage aggregate).

7.2 Standards

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

- D6747 Standard Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes
- D7007 Standard Practices for Locating Leak in Geomembranes Covered with Water or Earth Materials
- D7953 Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Arc Testing Method

Alternate test methods may be considered by the CQA Consultant in consultation with the Principal when requested in writing by the Contractor.

7.3 Submittals

7.3.1 Pre-qualification of leak location contractor

The CQA Consultant shall submit to the Principal the following for review and approval prior to selection of an ELLS Contractor.

- Qualifications of the proposed ELLS Contractor including the number of years the ELLS Contractor has performed the proposed survey methods
- Certification that the ELLS Contractor has previously tested a minimum of 90 ha of geomembrane liner and a minimum of 45 ha of the proposed survey method on at least five projects
- Certification that the ELLS shall be supervised by a professional or technician with a minimum of 18 ha of liner testing experience using the proposed method on at least three projects.

7.3.2 Prior to conducting the leak location surveys

The ELLS Contractor shall submit the following to the Principal for review and approval prior to conducting the leak location surveys:

- Work method statement for leak location surveys, including any information on any permanent electrodes and wires required during construction, and any installation instructions to be provided to the Contractor prior to the installation of the geomembrane and leachate drainage aggregate layer.

7.3.3 Following completion of the leak location surveys

The ELLS Contractor shall submit the following to the Principal for review and approval following completion of each of the ELLS:

- A report containing the methods, details and results of the leak location surveys, including a list of leak locations and rectification works proposed to be undertaken by the Contractor / Geosynthetics Installer.

7.3.4 Preparation and support

Prior to the survey being conducted, the CQA Consultant, in consultation with the ELLS Contractor, shall verify the Contractor / Geosynthetic Installer has suitably prepared the Works for the survey.

7.4 Execution

7.4.1 Arc testing leak location survey

The arc testing leak location survey shall be performed after the installation of each PE geomembrane layer in accordance with ASTM D7953.

The Leak Location Contractor shall be responsible for calibrating equipment utilised to achieve optimum data quality and sensitivity for the site conditions. The survey works best when the geomembrane is in intimate contact with the subgrade. Wrinkles are an impediment to conducting a good survey and defects on wrinkles may not be detected.

Therefore, it is usually in the interest of the project to conduct the survey when the liner system is cool and flat, such as in the morning or during the night.

Working on slopes can create safety hazards with slippery surfaces and may require additional harnessing and slower survey rates. The Leak Location Contractor shall account for this in their work method statement. Leak locations shall be logged, visibly marked, and reported to the CQA Consultant and Principal for repair.

7.4.2 Dipole leak location survey

The dipole leak location survey shall be performed after the placement of the drainage aggregate layers in accordance with ASTM D7007.

The Leak Location Contractor shall be responsible for calibrating equipment utilised to achieve optimum data quality and sensitivity for the site conditions.

Manual measurements shall be made to verify leak signals and to pinpoint the leak positions on top of the soil confining layer for excavation while the survey personnel are on site. Within 300 mm of the liner, the Contractor's labourers shall hand excavate possible leak locations to expose the liner.

Additional manual measurements shall be made to guide the Contractor's personnel while they excavate the leak, if required.

After the identification and excavation of a leak, the soil around the leak location shall be tested while the leak is uncovered and cleaned to check for adjacent leaks. Leak locations shall be logged, visibly marked, and reported to the CQA Consultant and Principal for repair.

7.5 Reporting

The ELLS Contractor shall report the general results of the survey to the CQA Consultant and Principal during the daily progress of the field work.

Prior to the demobilisation of the survey personnel from the site, the ELLS Contractor shall submit a list of locations of the leaks detected to the CQA Consultant and Principal.

The ELLS Contractor shall submit a report documenting the field work and results of the surveys to the CQA Consultant and Principal following completion of the field work. The report shall be certified by the CQA Consultant and summarised in the CQA Consultant's monthly report.

8. Geotextiles

8.1 General

This section contains the QA / QC requirements for the geotextiles in addition to the general requirements in the preceding sections. The Principal may reject any geotextile that does not meet or exceed the requirements of this section.

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

The Contractor must review all QA / QC documentation for accuracy and completeness prior to submission for CQA Consultant review, any incomplete or unreviewed submittals will be rejected by the CQA Consultant. All submittals must meet the requirements of the Technical Specification and this CQAP.

8.2 Material Acceptance

Prior to the delivery and installation of any materials to site, all MQC / MQA procedures and testing data is to be reviewed and accepted as conforming to the requirements of the Technical Specification.

The Contractor is to provide the complete and reviewed MQA / MQC data to the CQA Consultant in accordance with the requirements of the Technical Specification. The CQA Consultant will assess whether the appropriate test methods, frequency, results and documentation supplied meet the requirements of the Technical Specification.

8.3 Independent Conformance Testing

Independent conformance of the Geotextiles as delivered to site must be undertaken in accordance with the requirements of Section 8, and Table 8–1. Table 8–1 lists the testing required to be completed and accepted as conforming by the CQA Consultant prior to installation. Test results to be assessed against the requirements of the Technical Specification.

Table 8–1 Geotextile Independent Conformance Testing

Test	Test Method	Frequency	Separation	Protection
Mass per unit area	AS 3706.1	1 test per 2,500 m ² , including the first and last rolls (based on production order): minimum of two tests		Yes
Grab Tensile Strength	AS 3706.2b	1 per 5,000 m ² , including the first and last rolls (based on production order): minimum of two tests	Yes	Yes
Trapezoidal tear strength	AS 3706.3	1 per 5,000 m ² , including the first and last rolls (based on production order): minimum of two tests	Yes	Yes
CBR burst strength	AS 3706.4	1 per 5,000 m ² , including the first and last rolls (based on production order): minimum of two tests	Yes	Yes
Pore size	ASTM D6767	1 per 5,000 m ² , including the first and last rolls (based on production order): minimum of two tests	Yes	
Permittivity	AS 3706.9	1 per 5,000 m ² , including the first and last rolls (based on production order): minimum of two tests	Yes	

Wide width tensile strength	AS 3706.2a	1 per 5,000 m ² , including the first and last rolls (based on production order): minimum of two tests		
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8.4 Roll and sample identification

The CQA Consultant shall verify rolls and samples are identified in accordance with the Specification.

8.5 Delivery, storage and handling

The CQA Consultant shall fill out a receiving inspection report for each delivery of geotextile. The CQA Consultant shall be present during delivery and unloading to verify the following:

- Rolls are handled and stored in such a manner that no damage occurs to the geotextile
- Rolls are handled and stored in accordance with the approved work method statement and the manufacturer's instructions
- Geotextile rolls are packaged in opaque, waterproof, protective coverings
- Each roll is labelled in accordance with the requirements of the Technical Specification
- Rolls which are damaged beyond use are removed from the site.

8.6 Geotextile Installation Procedures

8.6.1 Receiving surface

The CQA Consultant is to inspect and approve the receiving surface prior to placement of any materials. Ongoing monitoring by the CQA Consultant is to assess for any damage through the works from weather, traffic or other impacts to the prepared surface. The CQA Consultant shall confirm the following through inspections and review of the Contractors CQC data:

- The receiving surface is complete and accepted by the Principal
- The receiving surface is free of defects or imperfections that may result in damage to the geotextile
- The receiving surface is free from abrupt breaks, sharp objects, or other foreign material
- The receiving surface has not been damaged by inclement weather
- If the receiving surface is subgrade or fill materials, the surface is compacted / finished in accordance with the requirements of the Technical Specification and not 'pebbly' or tracked and rutted by equipment.

Installation

The CQA Consultant shall undertake site inspections to monitor and confirm the following during installation:

- Installation is undertaken in accordance with the approved work method statement and manufacturer's instructions
- Each roll is visually inspected for damage and deficiencies with consideration to colour, thickness, needle punching, presence of needles or broken needles, and sewing density or other faults in the material
- Any damaged or defective rolls are identified, inspected and approved or rejected based on criteria within the Specification
- Weather conditions are acceptable for installation (with consideration to manufacturer's instructions)
- Winds are not so high as to cause damage during installation
- Any rolls or panels which have been displaced by wind are inspected for damage and approved or rejected

- Equipment used for installation and cover are in accordance with the approved work method statement
- The Contractor has adequate ballasts (e.g. sandbags) on hand and they are properly deployed to prevent uplift of the panels by wind, the CQA consultant is to confirm ballasting is installed in accordance with the design specifications.
- Field panels are installed at the locations and positions indicated on the Contractor's approved panel placement drawing. The CQA Consultant shall verify that the identification code, location, and date of installation of each field panel are recorded by liaison with the Geosynthetics Installer and Contractor
- Rolls are laid reasonably flat with a minimum of wrinkles so that they contain no areas that can fold over during covering
- Rolls are placed with the correct side facing up (where relevant)
- There are no broken needles present in the geotextiles
- The Contractor cuts out and repairs waves that are so large as to cause folding of the geotextile when they are covered
- There are no tensile stresses in the deployed geotextile
- Construction personnel are not smoking or wearing shoes that could damage the geotextile
- Seams are constructed as specified and in accordance with manufacturer's instructions, lapped in the correct direction (where relevant) and that seams are not placed in locations prohibited by the Specification
- Sewn, heat bonded, and overlapped seams are constructed in the specified locations
- Sewn seams are constructed using the correct overlap, thread type and stitch type
- Stitch bonded seams are inspected for skipped stitches
- Heat bonded seams are inspected for discontinuities
- The geotextile is not being burned through during the fabrication of heat bonded seams
- Rolls are not dragged across the receiving surface or other deployed geotextile. This can result in damage to the geotextile. A sacrificial rub sheet may be used to alleviate this problem
- Rolls are not being damaged during placement or covering
- Check the manufacturer's instructions to determine the maximum allowable exposure time for the deployed geotextile. If the allowable exposure time has been exceeded, determine if the geotextile has been damaged. If needed, request the performance of additional CQA tests to confirm that the physical properties of the textile have not diminished due to exposure
- Staples or pins are not used to hold geotextiles in place if the geotextile will be placed immediately above other geosynthetics
- Rolls are inspected for evidence of clogging from eroded or windblown soil
- Geosynthetic overlap and connection details are as per the design drawings and requirements of the Technical Specification.

8.7 Defects and repairs

The CQA Consultant shall visually inspect geotextile for damage after placement. Damaged areas shall be marked. The CQA Consultant shall document the location of the damaged panels, repairs which were performed and panels which were rejected in the daily report.

The CQA Consultant shall visually inspect and record in the daily and monthly reporting that all deficiencies have been repaired in accordance with the Specification and the manufacturer's instructions prior to final acceptance.

8.8 Acceptance

Acceptance of the Geotextiles by the Principal is subject to a recommendation by the CQA Consultant that all works undertaken by the Contractor meet the requirements of the Technical Specification and this CQAP. Acceptance does not remove the obligation of the Contractor to satisfy the requirements of the Technical Specification or other any other requirements under the contract. This recommendation shall be based on, but not limited to, the following:

- Review of all submittals, including CQC test results from the Contractor
- Review of CQA test results
- Relevant monitoring and inspections undertaken.
- The above items are also to be summarised in the monthly progress report.

9. Polyethylene Pipe (PE) Pipe

9.1 General

The CQA Consultant or appropriate CQA Monitor shall undertake inspections and review of the Contractors CQC data to confirm the following for plastic pipework, valves, fittings and other items associated with all plastic pipework required during construction of the Leachate Drainage and Collection Layer. The Contractor must review all QA / QC documentation for accuracy and completeness prior to submission for CQA Consultant review, any incomplete or unreviewed submittals will be rejected by the CQA Consultant. All submittals must meet the requirements of the Technical Specification and this CQAP.

9.2 Equipment

Confirm equipment used to place and cover pipe is in accordance with the Contract Documents and the manufacturer's recommendations during inspections.

9.3 Delivery, storage and handling

Be present during delivery and unloading to monitor the following:

- Pipe and appurtenances are not damaged during shipping, storage, and handling
- Deliveries are properly recorded
- The correct material type, strength, and pipe sizes have been delivered
- The size, number and location of pipe perforations are as specified
- Pipes with gouges deeper than 10% of the wall thickness are rejected or repaired before use
- Out-of-round pipe which cannot be properly joined together is rejected.

9.4 Manufacturer Quality Control

Monitor that pipe is sampled and tested in accordance with the approved manufacturer's quality control manual and test results not meeting the requirements results in the rejection of applicable pipe.

9.5 Independent conformance testing

Table 9–1 lists the independent conformance testing shall be performed on the plastic pipework prior to installation with the details recorded as part of the daily CQA reporting. Measurements are to be made of the supplied pipe and confirmed against the requirements of the contract drawings or as described in the Technical Specification or Contract Documents.

Table 9–1 PE Pipe Independent Conformance Testing

Test Type	Test Method	Frequency
Pipe Dimensions	Field measurement	Spot check of each shipment of pipe
Pipe Perforation Dimensions	Field measurement	Spot check of each shipment of pipe

9.6 Installation

The CQA Consultant is to note the following during pipe installation inspections and record as part of the daily reporting:

- Pipe installation is conducted in accordance with the manufacturer's recommendations
- Pipe is carried to the place of installation and not dragged
- Defective or damaged pipe is not used
- Pipe is not laid when trench conditions or weather is unsuitable
- Pipe is not installed if standing water is present
- Pipe and accessories are carefully lowered into the trench
- Pipe is placed at the lines and grades indicated in the Contract Documents and the Contractor does not lay pipe on blocks to produce the specified grade
- Specified bedding is used, and the bedding is graded to provide a cradle for proper support of the pipe
- The full length of each section of pipe rests solidly upon the pipe bedding layer with recesses excavated to accommodate couplings and joints
- Compaction requirements are being met for bedding layers located around the pipe
- Perforated pipe is installed in accordance with the Contract Documents
- Pipe and fittings are free of dirt, oil, or other contaminants
- The interior of pipe and accessories are thoroughly cleaned of foreign matter before being lowered into the trench
- Pinch bars and tongs for aligning or turning pipe are used only on the bare ends of pipe
- When work is not in progress, open ends of pipes, fittings, and valves are securely plugged or capped so that no trench water, earth or other substance enters the pipe and fittings.
- Installation is undertaken in accordance with the approved work method statement, which includes any adjustments made as a result of the field trial in accordance with the requirements of the Technical Specification.

9.7 Defects and repairs

The CQA Consultant shall visually inspect plastic pipework for damage after placement. Damaged sections shall be marked. The CQA Consultant shall document the location of the damaged pipe, repairs which were performed and pipe that was rejected in the daily report.

The CQA Consultant shall visually inspect and confirm that all deficiencies have been repaired in accordance with the Specification prior to final acceptance.

9.8 Acceptance

Acceptance of the PE Pipe by the Principal is subject to a recommendation by the CQA Consultant that all works undertaken by the Contractor meet the requirements of the Technical Specification and this CQAP.

Acceptance does not remove the obligation of the Contractor to satisfy the requirements of the Technical Specification or other any other requirements under the contract.

This recommendation shall be based on, but not limited to, the following:

- Review of all submittals, including CQC test results from the Contractor
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

- The above items are also to be summarised in the monthly progress report.

10. Drainage Aggregates

10.1 General

The CQA Consultant or appropriate CQA Monitor shall review all submittals, including test results and reports provided by the Contractor to confirm that the drainage aggregate meets the requirements of the Technical Specification.

10.2 Material Acceptance

Prior to the delivery and installation of any materials to site, all manufacturers quality control and manufacturers quality assurance procedures and testing data is to be reviewed and accepted as conforming to the requirements of the Technical Specification.

The Contractor is to provide the complete and reviewed MQA/MQC data to the CQA Consultant in accordance with the Technical Specification. The CQA Consultant will confirm that the appropriate test methods, frequency, results and documentation meet the requirements of the Technical Specification.

10.3 Independent conformance testing

Table 10–1 lists the independent conformance testing to be undertaken by the CQA Consultant. All samples will be submitted to the CQA Consultants Independent Testing Firm for analysis.

Table 10–1 Drainage Aggregate Independent Conformance Testing

Test Type	Test Method	Frequency
Particle size distribution	AS 1141.11 or AS1289.3.6.1,3.6.3	1 per 2,000m ³

10.4 Field trial

The CQA Consultant Shall verify the following during the field trial:

- The field trial is carried out as per Contract Documents
- Geosynthetic layers are installed / placed and seamed as per the Contract Documents
- Oversize and angular material within the subgrade which could damage geosynthetics has been removed prior to placement
- Geosynthetics are not being damaged by placement equipment. Placement equipment shall be observed from the front side as leachate drainage aggregate is being spread over the geosynthetics. The leachate drainage aggregate shall be carefully removed and the underlying geosynthetics observed
- Excessive fines have not been generated as a result of handling and placement of the leachate drainage aggregate.

10.5 Delivery, storage and handling

The CQA Consultant shall inspect drainage aggregate stockpiles prior to use and advise the Superintendent of the presence of any unsuitable material or contamination as per the requirements of the Technical Specification.

10.6 Preparation of surface to receive drainage aggregate

The CQA Consultant is to inspect and approve the receiving surface prior to placement of any materials. Ongoing monitoring by the CQA Consultant is to assess for any damage through the works from weather, traffic or other impacts to the prepared surface. The CQA Consultant shall confirm the following during inspections of the receiving surface:

- The receiving surface is complete and accepted by the Principal
- The receiving surface is free from abrupt breaks, sharp objects, or other foreign material
- The receiving surface has not been damaged by inclement weather

10.7 Installation

The CQA Consultant shall verify through inspections and monitoring of the works the following during installation:

- Installation is undertaken in accordance with the approved work method statement, which includes any adjustments made as a result of the field trial in accordance with the requirements of the Technical Specification
- Trafficking with heavy machinery is avoided after placement
- Oversize and angular material which could damage geosynthetics has been removed prior to placement
- Underlying geosynthetics are not being damaged by placement equipment. Placement equipment should be observed from the front side as drainage aggregate is being spread over the underlying geosynthetics
- Excessive fines have not been generated as a result of handling and placement of the drainage aggregate
- Wind-borne and water-borne fines do not contaminate the drainage aggregate after placement
- Erosion controls are placed such that the drainage aggregate is not contaminated by fines
- Watch for ponds of water on top of the drainage aggregate which may be an indication that it is contaminated by an excessive amount of fines
- Wrinkles in underlying geosynthetics are not folding over onto themselves during aggregate placement
- Low ground pressure equipment is being used where specified.

10.8 In situ conformance testing

The CQA Consultant shall review and agree with the Superintendent where in situ conformance testing shall be undertaken as well as monitor the sampling. The CQA Consultant shall review the test results to confirm the material conforms to the requirements of the Specification.

10.9 Defects and repairs

If an area of drainage aggregate does not conform to the Specification, the CQA Consultant shall assist the Principal in defining the extent of the area requiring repair. This shall be done using additional testing and visual inspection.

10.10 Acceptance

Acceptance of the Drainage Aggregate by the Principal is subject to a recommendation by the CQA Consultant that all works undertaken by the Contractor meet the requirements of the Technical Specification and this CQAP.

Acceptance does not remove the obligation of the Contractor to satisfy the requirements of the Technical Specification or other any other requirements under the contract.

This recommendation shall be based on, but not limited to, the following:

- Review of all submittals, including CQC test results from the Contractor
- Review of CQA test results
- Relevant monitoring and inspections undertaken.

The above items are also to be summarised in the monthly progress report.

11. Other

11.1 Groundwater drainage aggregate

The CQA Consultant shall undertake review of Contractor provided documentation and undertake periodic inspections to monitor the following:

- Satisfactory compliance records are provided for all materials required for construction of groundwater relief drains
- Work method statement for groundwater relief drain installation satisfies the requirements of the Technical Specification
- As-built survey records are provided to show conforming trench dimensions and conforming pipelines and levels. Ensure that the pipe has minimum 1% uniform grade.
- Inspect the completed trench to verify that the base and walls are smooth and satisfactory for placement of separation geotextile
- Inspect the installed pipework prior to backfilling to ensure it is installed in accordance with the Contract Drawings.
- Review CQC test results / reports and ensure they meet specification requirements
- Inspect the completed groundwater relief drains prior to backfilling. Ensure that the geotextile is sufficiently lapped and will provide effective separation between the filter aggregate and surrounding fill material.

12. Reporting

CQA Reporting is to be consistent with the requirements outlined in Table 4 and be sufficient to summarise the acceptance of material and installation, works undertaken, issues identified, and solutions implemented, relevant communications including RFI's and approved variations from the design documentation and Technical Specification.

12.1 Final report

At the completion of work, the CQA Consultant shall be responsible for writing a final report on CQA activities performed at the site. The draft Final Report shall be completed and submitted to the Superintendent no more than 28 days after completion of construction and shall include, at a minimum, the following information:

- Brief description of the Works including type of facility, name of site, location, name of Principal, Superintendent, Contractor and Geosynthetic Installer
- A reviewed copy of all CQC reports undertaken, including earthworks, geosynthetics and other works aforementioned in this CQA Plan
- Detailed description of the lining and capping systems, including surface area, cross sections and a summary of all materials used
- Chronological summary of construction activities
- Photographic documentation, including photographs of the site at different phases of construction, photographs of construction details and photographs of all CQA operations
- General record of activities, such as dates of performance of CQA operations, number and names of CQA Monitors and number and names of Geosynthetic Installer's personnel
- Manufacturer's certification sheets and MQC/MQA documentation
- Summary of MQA and CQA test results and confirmation of material suitability
- Sampling and testing locations
- Copies of all CQA data sheets and records completed during the Works
- All CQA field and laboratory test results as well as a summary of these results
- Discussion of special problems encountered and their solutions
- Discussion of significant changes from design and material specifications
- As built survey records and CQC reports
- Record Drawings which include the final geomembrane panel placement layout and all survey conformance data:
 - Plan view of the perimeter of the cell
 - The installed alignments and grades of the groundwater drainage system within the cell
 - Finished installed contours of the prepared subgrade within the cell (determined prior to placement of the geosynthetics)
 - The installed alignments and grades of the leachate collection pipework within the cell (all determined prior to placement of the leachate drainage layer)
 - Finished installed contours of the leachate drainage layer and covering geotextile within the cell
 - All test locations, showing as a minimum: approximate location, identification number, date sampled and type of testing completed.

A summary statement sealed and signed by the CQA Consultant documenting that CQA was conducted in accordance with the CQAP and, based on visual observations and data generated in accordance with the CQA

Plan, the Works shown in the Contract Drawings were constructed in accordance with Contract Documents except as properly authorised and documented in the CQA Final Report.



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