

**SHIRE OF LEONORA**



**CONSTRUCTION QUALITY ASSURANCE PLAN**

**DUPLICATION OF A NEW SECONDARY LINED  
EARTH POND FOR LIQUID WASTE STORAGE  
AND HANDLING**

**LEONORA LANDFILL SITE, LEONORA**

**APRIL 2024**

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## 1 GENERAL REQUIREMENTS

### 1.1 LOCATION AND DESCRIPTION OF WORKS

The works comprise of the earthworks, lining and subsoil drainage system (as applicable) for:

- The construction of 1 new secondary lined earth pond for water storage;

The main items of work will include but are not limited to the below. Refer to the drawings for location details:

- Excavate to create embankment for new secondary pond, cut to fill and cut to spoil operations;
- Foundation preparation prior to embankment construction;
- Spoil excess excavated material in a location to be indicated on site within 1km radius;
- Install subsoil drainage behind under floor of secondary pond, as indicated on drawings, including installation of a concrete monitoring well;
- Anchor trench excavation;
- Installation of the composite lining system for the new secondary pond;
- Compliance with all Quality Assurance criteria required by the Technical Specification.

The earthworks and composite lining system and subsoil construction must be carried out under a Quality Assurance (QA) system.

This technical specification sets out both the technical requirements and the QA requirements for construction of the above works.

### 1.2 SURVEY INFORMATION AND SETTING OUT

The Contractor will be supplied with the following setting out information in AutoCAD electronic format:

- i) 3D design model in 3D DXF format;
- ii) Setout information in GENIO text format;

The following supplementary surveys are required following completion of:

All survey work shall be carried out by a licensed surveyor, in the same grid as the setout information is provided in and reduced levels to Australian Height Datum (AHD).

### 1.3 CONTRACT DRAWINGS

The following drawings form part of the works for this project:

Drawing Number	Revision	Description
11329-C1-DG-0100	A	Locality, General Arrangement and Earthwork Plan
11329-C1-DG-0010	A	Typical Cross Sections
11329-C1-DG-0011	A	Typical Details

#### 1.4 UTILITIES AND FIXTURES

Details of known utilities onsite will be shown to the Contractor by the Shire representative at the commencement of construction.

The site is not currently serviced by any utility provider (gas, water power, telephone) but these may be connected by the Principal before the site works commence. Should the services be connected, no utility, private or public, may be moved to accommodate the Contractor's equipment or its method of operation when the utility does not interfere with the Works, unless such removal is at the expense of the Contractor, and in each case subject to the approval of the utility authority concerned.

The Contractor shall take all precautions necessary to prevent damage to existing fencing, drainage structures, telephone and power lines, the landfill operator's services and other improvements during the construction period. The Superintendent may arrange for the repair of damage not made good by the Contractor and the cost of such repair shall be deducted from payments due to the Contractor.

#### 1.5 PROTECTION OF PUBLIC AND PROPERTY

The Contractor is required to keep his operations under review in order to prevent/minimise the impact of vibrations, dust, noise and other forms of pollution on property and the public.

The Contractor shall avoid interference with or damage to property on or adjacent to the site and shall provide temporary protection for and shall repair and reinstate all damage caused thereto by him, his employees, agents or sub-contractors or the employees of any such agents or sub-contractors, either directly or indirectly.

The Contractor shall prevent nuisance to the owners, tenants or occupiers of properties adjacent to the site and to the public generally.

The Contractor may, at his own discretion and cost, conduct property inspections with the agreement of the owner/occupier.

#### 1.6 PROTECTION OF WORK

The Contractor shall protect the work from all manageable effects including wind and water during the construction period.

Protection measures shall include but are not limited to:

- Provision of temporary and permanent measures to deal with and minimise the effects of erosion, deposition and inundation;
- Diversion and control of stormwater;
- Efficient dewatering of low points or trenches (by pumping if necessary);
- Construction of shoring or other slope retaining measures;

- Management of construction and public traffic; and
- Implementation and management of dust control measures.

All the above measures and any other measures that could be reasonably foreseen as becoming necessary by the contractor will be completed to the satisfaction of the Superintendent and in compliance with all relevant statutory regulations.

Once the site has been handed back to the Principal on completion of construction, the Principal shall become responsible for protecting the works, however a maintenance period will apply to defective work and workmanship as specified in the Contract Documents.

In the event that final trimming of the completed earthworks is damaged by water before the lining work covers the earthworks, then the Contractor shall be responsible for protecting the earthworks and implementing any earthwork repairs required. Refer to Remedial works below.

### 1.7 SUPPLY OF WATER

A water supply dam is available on site for the supply of the required quantities of suitable water for the proposed earthworks and for dust suppression during construction.

The site is not serviced by mains drinking water.

### 1.8 SAFETY

As a minimum, high visibility red/yellow/orange jackets and steel toe cap safety boots shall be worn on site at all times. For night time conditions high visibility reflectorised jackets shall be worn.

Ensure that at all times a person with first aid qualifications is present during working hours. In addition, provide, equip and maintain a St John Ambulance Association Industrial First Aid Kit, or similar, in an approved location at the site.

Notwithstanding the above requirements, the Contractor shall at all times comply with the appropriate provisions of the *WA Work Health and Safety Act 2020* for the period of the Works.

### 1.9 WORKING HOURS

Working hours shall be limited to between 6.00am and 6.00pm Monday to Saturday.

### 1.10 ROLES AND RESPONSIBILITIES

For the purposes of this contract, the following personnel are nominated in the following roles:

Superintendent: TBA

Principal: Manager Works and Services  
Shire of Leonora  
P.O. Box 56  
LEONORA WA 6438  
Tel: [REDACTED]

Third-party CQA: TBA  
Works Inspector: TBA  
Contractor: TBA

The Superintendent shall be responsible for administering the contract. He will be the first point of contact and all correspondence shall be directed through him to the various parties.

The third-party CQA shall be responsible for ensuring compliance of all constructed work with the requirements of this CQA Plan and the BPEM in its' current form, to the satisfaction of the Department of Environment and Regulation (DER). He will sign off on construction work as satisfying the requirements and provide documented proof of such in a construction completion report. He will work independently of the Superintendent or the Principal.

The Works Inspector shall be responsible for daily site surveillance activities and for documenting compliance with the CQA Plan. He will work under the direction of the third-party CQA.

## **1.11 MEASUREMENT AND PAYMENT**

### **1.11.1 GENERAL REQUIREMENTS**

The cost of the General Requirements shall be deemed to be included in the rates tendered under the General section of the Schedule of Prices. No additional/separate payment shall be made for any General Requirements.

## 2 EARTHWORKS

### 2.1 GENERAL

Earthworks shall include all excavation, embankment construction, compaction and trimming required to complete the following construction:

- Excavation for the construction of the new earth pond embankment and batters, and make smooth connection to existing embankment;
- The placement of excess cut material in a spoil stockpile where indicated on site.

All the above embankment construction works, except the spoil stockpile, shall be engineered fill and will comply with the relevant compaction specification as indicated in this specification.

All batters shall be formed to a smooth surface with the finish obtainable with a blade grader operating on sidelong ground and steel drum roller operating up/down slope. Batter slopes shall be smoothly shaped to a uniform plane from top to bottom. The complete inside secondary pond batter surfaces shall be statically traversed with a smooth drum roller at least once to smooth and tighten the surfaces for liner construction. Hard rock protrusions will not be accepted and the contractor will be required to remove such protrusions and repair in accordance with the specification. The batters and floor will be jointly inspected by the Superintendent and the contractor to ensure compliance with this requirement.

On completion of work all table drains and batters and adjacent areas within the cleared area shall be cleared of all rocks and litter.

### 2.2 SUBGRADE PREPARATION

Excavation shall be carried out to the shapes and levels as shown in the Drawings and to the specified tolerances.

Following excavation, the Superintendent or his designated representative shall inspect the exposed subgrade and may instruct the removal of additional unsuitable material, which may be present.

Any over-excavation below the required surface shall be backfilled with embankment quality material. Where the depth of over-excavation exceeds 0.5m, any backfilled material below the required surface shall be compacted as specified (below) for embankment construction.

Where the Superintendent instructs the Contractor to over-excavate and backfill with suitable material, the Contractor shall carry out a survey of the area to record the volume of the affected earthworks. The Contractor shall then be paid on a re-measurable basis for this over-excavation and backfilling.

Following excavation to finished level, the exposed subgrade within the footprint of the sumps and pond shall be compacted with a minimum of 8 passes of a vibrating smooth drum roller of minimum static weight of 12 tonnes.

### 2.3 EMBANKMENT MATERIAL

Embankment material shall be material obtained from the excavation works. The material shall be free from boulders and cobbles greater than 75mm and free



from clods, stumps, roots, sticks, vegetable matter or other deleterious material. Any such material encountered shall be spoiled where indicated on site.

All embankment fill shall be compacted to a minimum of 90% of Maximum Modified Dry Density (MMDD).

Moisture contents are not considered critical from a design perspective but as a guide, should lie within -5% to +3% of Optimum Moisture Content.

## 2.4 SPOIL MATERIAL

Spoil material shall be material obtained from the excavation works that is in excess of what is required to construct the embankments or that is classed as unsuitable for embankment construction on the drawings or by the Superintendent. The material shall be loaded and carted to the location indicated on site, off-loaded and spread out as required by the Principal.

Spoil material does not require compaction or addition of any moisture.

## 2.5 EMBANKMENT CONSTRUCTION

The embankments shall be constructed to the shape and levels as shown in the Drawings and to the specified tolerances.

The Contractor shall ensure that uniform compaction effort is applied longitudinally to the alignment. Backfilling and embankment construction shall be done in layers not exceeding 250mm in compacted thickness. Where less than 80mm is required to be worked the underlying material shall be grader scarified to such a depth that the resulting thickness of the layer to be worked is greater than 80mm. Each layer worked shall be generally parallel to the finished pavement surface and shall where practicable extend to the full width of the embankment at that particular level.

In order to expedite embankment construction, the contractor may produce a compaction method specification backed up by calibration testing to ensure compliance with the required Dry Density Ratio (Modified Compaction).

Subject to the Contractor adequately demonstrating that he is consistently meeting the dry density requirements of this specification, the testing frequency specified in the quality control section may, at the Superintendent's discretion, be reduced to test anywhere up to every 0.75m of lift. All risk in terms of re-construction remains with the Contractor, should testing at the determined lift stage fail.

## 2.6 SURFACE LEVELS

The level of the completed duplication pond floor shall be deemed to be conforming when the level measured along a transect, is within -100mm to +100mm of the specified level at that point as determined from the Drawings. The average reduced level of the points along a transect, shall be within -50 to +50mm of the specified level.

For the completed secondary pond batter slopes, a tolerance of +/-300mm will apply, as determined from the Drawings. It should be noted that batter slope tolerance for absolute position is not as critical to the design compared to the floor tolerance.

Should the surface level lie outside of the above limits, it will be at the Superintendent's discretion as to the acceptability of the earthworks. The Superintendent may instruct the Contractor to rectify the earthworks or may accept the earthworks, as is. This will depend upon the effect that the out of

tolerance earthworks has on the design falls of the floor drainage and invert of the outlet pipe work.

Any reworking of the floor and batter slopes to correct the surface levels will be at the Contractors expense.

## 2.7 SURFACE SHAPE

The shape of the final secondary pond floor and internal batter slopes of the secondary pond surfaces shall be judged to be acceptable when the maximum deviation from a 2.4 metre straight edge placed in any position on the surface does not exceed 50mm. This requirement applies to gradual changes in surface shape and not to defects such as rutting or gauging.

## 2.8 EARTHWORKS TESTING

### 2.8.1 GENERAL

All quality control testing shall be carried out by a laboratory holding current National Association of Testing Authorities (NATA) registration for all test methods referred to in the Specifications. NATA registration for all test methods shall be held at the time of tendering and be maintained until completion of the Contract. All test reports shall be NATA endorsed by a current NATA signatory approved for the laboratory conducting the testing.

The Contractor's conformance decision shall apply to the whole of the area or part of the Work of which the sample or dimension is representative.

### 2.8.2 INSITU DENSITY – BACKFILLING AND EMBANKMENT CONSTRUCTION

For the works in general, density shall be measured insitu by use of a nuclear moisture/density meter in accordance with AS 1289. All measurements shall be made using the direct transmission mode.

In the unlikely event that the insitu density is outside the range of densities 1.3-3.05t/m<sup>3</sup> for which the nuclear moisture/density meter can be calibrated then Main Roads Test Method WA 324.1, "Dry Density: Sand Replacement Method" shall be used.

The test holes shall be backfilled immediately after sampling or testing by the persons responsible for the testing. The Contractor shall ultimately be responsible for patching holes made as a result of earthworks testing.

Rounding of all calculations should be in accordance with Australian Standard 2706-1984 "Numerical Values - Rounding and Interpretation of Limiting Values".

The conformance of any part of the Works with respect to density shall be determined by comparing the Dry Density Ratio to the limits specified in the Technical Specification i.e. 90% of Maximum Modified Dry Density (MDD).

Where the measured density is below the specified requirement, the Contractor shall carry out additional compaction until a satisfactory density, determined by additional testing, is reached. Additional testing shall be at the contractor's expense.

### 2.8.3 MOISTURE CONTENT

There is no specific requirement for acceptable moisture content for the embankment fill material or subgrade. However, as a guide, moisture should lie within -5% to +3% of Optimum Moisture Content.

#### 2.8.4 MINIMUM TESTING FREQUENCY

The minimum frequency of testing to determine the conformance of Works Processes with specified characteristics shall be as follows:

i) Field testing for secondary pond embankment fill density at a frequency not less than:

- 1 test per 2000m<sup>3</sup> of compacted soil;
- 1 test per side of pond per 0.5m lift; or
- 3 tests per site visit.

The Contractor shall arrange with the testing laboratory to deliver (via email) copies of all compaction test results for each area to the Superintendent within 24 hours of completing the test procedure or carrying out a compliance measurement.

The contractor shall arrange with the testing laboratory to accurately document each testing position and shall provide a co-ordinate and approximate level for each location. Test results not complying with this requirement shall be rejected and re-testing shall be at the contractor's expense.

Subject to the Contractor adequately demonstrating that he is consistently meeting the dry density requirements of this specification, the testing frequency specified in the quality control section may, at the Superintendents discretion, be reduced to test anywhere up to every 0.75m of lift or 1 test per 2000m<sup>3</sup> of compacted embankment.

#### 2.9 ANCHOR TRENCH EXCAVATION AND BACKFILLING

Anchor trenches shall be excavated to the shapes and in the locations indicated on the drawings. The excavated material shall be placed adjacent to the trench on the outside of the trench ready to be used for backfilling of the trench on completion of the liner installation. Should any water accumulate in the trenches during the construction period, it shall be removed by day lighting the anchor trench to the outside edge of the batter and allowed to drain prior to undertaking any further works on the trench.

Following excavation, the trench edges should be slightly rounded and trenches cleared of any debris. Prior to the placement of the liner within the trench, all trenches are to be inspected to the satisfaction of the Superintendent.

On completion of liner installation backfilling may be carried out in one layer and compacted using a vibrating smooth drum roller, filling slightly proud of the embankment crest. The backfill shall comprise general fill in accordance with Section 2.3 and compacted with a minimum of 4 passes of a 12 tonne roller.

If a hand held flat plate compactor or similar light weight equipment is used, then backfilling shall be carried out in two layers of equal thickness. The Contractor shall propose a suitable methodology in order to achieve a comparable level of compaction to the smooth drum roller.

#### 2.10 REMEDIAL WORKS

Protection of completed layers of subgrade and embankment materials shall be the responsibility of the Earthworks Contractor until such time as the liner is completely installed. This includes areas of recently completed earthworks, which are subsequently damaged by the effects of rainfall and flooding, unauthorised vehicular traffic or any incidental damage that may occur. To this end

the contractor shall make available any and all plant, materials, labour, fuel and incidentals on an as required basis for as many times as may become necessary due to damage on the internal earthworks slopes and surfaces.

## **2.11 MEASUREMENT AND PAYMENT**

### **2.11.1 EARTHWORKS**

For embankment construction the unit of measurement shall be the cubic metre of material measured in the compacted embankment. The quantity shall be calculated from triangulated survey prior to and on completion of the embankment construction. The tendered rate for embankment construction as stated below shall be deemed to include for embankment foundation compaction and subgrade preparation where required.

For cut to spoil the unit of measurement shall be the cubic metre of material measured in its original position. The quantity shall be calculated from triangulated survey prior to and on completion of the embankment construction.

The tendered rates shall include full compensation for procuring, furnishing, and placing material, including excavating and loading material, off-loading and disposing of material as specified, the cutting of benches where required, for transporting the material, for preparing, processing, shaping, watering, mixing, and compacting the material to the densities or in the manner specified herein and for removing and disposing of oversize material from the embankment after processing, for backfilling of anchor trenches, and any and all other items and incidentals required to complete the work according to this specification and the drawings. No additional payment shall be made for materials, labour, plant, fuel or incidentals required.

### **2.11.2 SUBGRADE PREPARATION**

Subgrade preparation shall be paid on a volume of material removed and replaced basis. The volume shall be calculated from a pre- and post-removal survey to be conducted by the contractor and presented to the Superintendent for evaluation. The contractor will be paid for the survey on presentation of an invoice in each instance.

### **2.11.3 ANCHOR TRENCH EXCAVATION AND BACKFILLING**

The unit of measurement shall be the metre of anchor trench excavated, backfilled and tidied as indicated on the drawings or instructed by the Superintendent in writing. The tendered rates shall include full compensation for mobilisation and demobilisation of plant as may be required, as well as all labour, fuel and materials, including providing and placing selected backfill material where required, day lighting of trenches to effect drainage, and any and all other items and incidentals required to complete the anchor trench construction work to the satisfaction of the Superintendent and to this specification and the drawings. No additional payment shall be made for materials, labour, plant, fuel or incidentals required.

### **2.11.4 REMEDIAL WORKS**

No additional payment shall be made for materials, labour, plant, fuel or incidentals required to complete any remedial works. The contractor has to allow for this eventuality in the scheduled rates.

### 2.11.5 MATERIALS TESTING

Materials testing shall be paid for on a cost plus basis under the Provisional Sum provided in the Schedule of Rates under General Items upon the presentation of an invoice from a NATA accredited laboratory. Payment will not be made for testing should the test result indicate that the specifications have not been complied with. To this end invoices shall make specific reference to test request numbers. Invoices otherwise presented shall not be paid for.

Payment for materials testing shall **NOT** include for testing required as proof of compliance with specified requirements for materials supplied to site from commercial sources. Verification of compliance with specified requirements shall accompany such materials in the form of test certificates. The cost of these tests shall be deemed to be included in the price tendered for the supply and/or installation of the material, as may be applicable.

### **3 SUBSOIL DRAINAGE**

#### **3.1 GEOTEXTILE**

The geotextile lining shall be a non-woven fabric consisting of long chain synthetic polymer fibres, composed of at least 95% by mass of polyester or polyolefins (polypropylene, polyethylene), bonded by needle punching, heat or chemical bonding processes or combinations thereof. Bonded fibres must be capable of retaining their relative position in the geotextile. The polymer fibres shall be rot proof, chemically stable and have low water absorbency.

The geotextile shall have a high ultraviolet resistance such that when tested in accordance with AS 3706.11 shall have retained strength of at least 50% after 672 hours of test exposure. The geotextile shall be free of any flaws or defects that may adversely affect the mechanical or physical properties of the fabric.

Each roll of geotextile shall be provided with a suitable covering to protect the fabric against moisture and ultraviolet radiation and marked in conformance with AS 3705.

Prior to installation, the geotextile rolls shall be stored on site under a protective cover and supported off the ground. The Contractor shall take appropriate measures to protect the geotextile from damage. This includes adhering to any other recommendations on method of storage set by the supplier/manufacturer.

The geotextile shall comply with the mechanical and hydraulic requirements shown in Tables 403.1 and 403.2 below.

Prior to the use of the geotextile for drainage lining, the Contractor shall submit to the Superintendent product certificates of compliance from the supplier, showing that the geotextile complies with all the requirements of this specification. Test results shall be reported on NATA endorsed documents.

#### **3.2 FILTER AGGREGATE**

Filter aggregate for use in backfilling trenches shall consist of hard, durable, clean gravel or crushed rock, and shall be free from organic material, clay or other deleterious substances. Unless otherwise shown on the Drawings, the aggregate shall have the Particle Size Distribution (PSD) as shown in the below Table and as determined by WA 210.1:

TABLE 3.1 CRUSHED AGGREGATE (Nominal 20 mm)

AS Sieve Size (mm)	% Passing by Mass
26.50	100
19.00	80 - 100
16.00	0 - 20
13.20	0 - 20
9.50	
6.70	
4.75	
2.36	
1.18	0 - 0.5

Prior to the use of the aggregate material for filter aggregate, the Contractor shall provide certification to the Superintendent that the aggregate conforms to the specified requirements. Test results shall be reported on NATA endorsed documents.

### 3.3 SLOTTED PIPE

Drainage pipes and associated fittings and jointing procedures shall comply with the requirements of AS 2439.1 Perforated Drainage Pipe and Associated Fittings.

Unless otherwise noted on the Drawings slotted pipe shall be nominal 100mm outside diameter.

### 3.4 FLUSH-OUT POINTS

No flush-out points are required on this project.

### 3.5 CONSTRUCTION

Sub-soil drains shall be constructed in the locations and to the cross-sectional shapes and dimensions as shown on the Drawings.

The trench for the installation of the sub-soil drain shall be excavated to the width and depth shown on the Drawings. The excavation shall have vertical sides throughout where the excavation is up to 1.5m deep. The bottom of the trench shall be not more than 50mm below the specified level of the invert of the pipe. Excess trench excavation shall be made good by filling back to grade and lightly compacting with material of permeability similar to that of the surrounding material.

Where the excavation is greater than 1.5m deep, the trench shall be excavated in accordance with the relevant requirements of the WA Work Health and Safety Act 2020. Any loose or disturbed material shall be removed from the walls of the trench.

Unsuitable material from excavations shall be disposed of in accordance with Section 2 of this Specification.

Trench excavations in rock shall be carried out in accordance with Section 2 of this Specification, where applicable.

Trenches should be graded to have reasonably smooth side and bottom faces so that the geotextile lining will not bridge cavities or be damaged by protruding/sharp objects. Cavities should be filled with granular material before placement of geotextile. The minimum grade of subsoil drainage must be 0.5%.

Prior to the placement of Geotextile, the Contractor shall afford the Superintendent an opportunity to inspect the trench excavation as verification that it conforms to the trench shape, grade line, filling and light compaction for over excavated section and removal of any protruding/sharp objects.

The Contractor shall take every reasonable care to ensure that the geotextile is not damaged during installation and backfilling operations.

Geotextile shall be placed in the excavated trench to cover the bottom and sides of the trench, with sufficient free fabric to wrap around the completed drain as shown on the Drawings. The geotextile should conform to the shape of the trench with minimal wrinkles, folds or air voids between fabric and trench, but not stretched on the soil.

Unless otherwise specified on the Drawings, the minimum overlap in longitudinal direction along the trench shall be 300mm. Successive sheets of geotextile within the trench shall be overlapped with the upstream fabric overlying the downstream fabric.

Damaged areas of geotextile may be repaired by overlaying the damaged section with a patch. The patch shall extend a minimum of 1 m beyond the area of damage.

The period between initial laying out and final cover of the geotextile with drainage backfill layer shall not exceed 14 days. Where possible and practical, geotextiles shall be placed just ahead of associated advancing construction work and covered by relevant construction materials or suitable protective sheeting within 48 hours of being placed.

Any fabric allowed to remain exposed to sunlight for a period greater than 14 days shall be removed and replaced at no cost to the Principal.

Filter aggregate bedding shall be placed on the geotextile to the depth indicated on the Drawings, and tamped level. Unless otherwise shown on the Drawings, the depth of the bedding shall be 50mm.

Slotted pipe shall be installed as shown on the Drawings and shall be placed centrally within the trench on the crushed aggregate bedding. Any required joints in slotted pipe shall be made in accordance with the manufacturer's instructions.

Filter aggregate shall be placed over the slotted pipe to the depth shown on the Drawings and tamped to a level profile. To avoid post-construction settlement, the filter aggregate material shall be compacted to its full depth to achieve effective mechanical interlock between particles. The geotextile shall be wrapped over the top of the aggregate layer with required overlap.

Where shown on the Drawings, any required drainage backfill layer shall be placed on top of the geotextile wrapped aggregate and shall be filled to the subgrade surface. This layer shall be compacted as for embankment construction in accordance with Section 2 of this Specification.

After completion of backfilling, subsoil drains shall be flushed in the presence of the Superintendent with sufficient clean water until only clean water discharges



at the outlet. Where this subsoil discharges into a concrete liner the contractor shall provide a pump to remove the flushing water from the liner.

### **3.6 MEASUREMENT AND PAYMENT**

#### **3.6.1 SUBSOIL DRAINS**

The unit of measurement shall in all cases be the metre of subsoil drain installed as shown on the drawings or instructed in writing by the Superintendent. The tendered rates shall include full compensation for providing, transporting, unloading, joining, installation, end capping, laying, flushing point and flushing where required, and any and all other items and incidentals required for completing the work according to this specification and the drawings. No additional payment shall be made for materials, labour, plant, fuel or incidentals required.

## 4 GEOSYNTHETIC CLAY LINER (GCL)

### 4.1 SCOPE OF WORK

The scope of Works comprises the supply and installation of a Geosynthetic Clay Liner (**GCL**) and associated work including, but not limited to, the quality control and testing in accordance with the Specification, Drawings and the manufacturer's recommendations.

The Works described below shall be undertaken by a qualified, experienced geomembrane installation specialist (Installer).

The Contractor shall supply all labour, materials, construction equipment, consumables, supervision, transportation, off-loading on site, supplies, equipment, testing and decommissioning and all other items necessary to complete the Works.

Works described in this Section of the Specification include:

- supply of the GCL;
- installation of the GCL including the placement, temporary and permanent anchoring and joining;
- the provision of a generic Quality Control Procedures Manual which shall, in general terms, describe the GCL installation activities and detail the associated quality control activities;
- the undertaking of all QA/QC activities relating to the installation including inspections and the documenting of all QA/QC activities such that they can be audited at any time during or after the Works; and
- completion and supply of As-Built Drawings.

### 4.2 DELIVERY, LABELING, STORAGE, HANDLING

GCL delivered to site shall be wrapped with weather and moisture proof heavy duty wrapping. Rolls with damaged wrapping shall be inspected by the Superintendent to assess the extent of hydration of the GCL. GCL with moisture content above 50% or that is judged to be water softened to the extent that it is unsuitable for use by the Contractor shall not be used. Moisture damaged portions of the GCL rolls may be cut off and the remainder of the roll used subject to prior approval by the Superintendent.

GCL rolls with damaged wrapping and not deemed as being moisture damaged by the Superintendent shall be sealed with duct tape or equivalent, to prevent moisture ingress. All rolls of GCL shall be clearly marked with the type of GCL, length and roll number. Where rolls are not numbered, the Contractor shall clearly permanently mark roll numbers on the wrapping, for reference on the As-Built panel layout drawing.

All rolls of GCL shall be delivered with the GCL tightly wrapped around a centre core, with a hole in the core suitable for the proposed spreader bar to be used during deployment.

All rolls shall be stored on the ground on a gravelled surface, suitably protected from stormwater runoff and other damage. No more than four rolls of GCL shall be stacked on top of the other. GCL rolls shall not be rolled across the ground.

### 4.3 MATERIALS IDENTIFICATION

The liner shall be delivered to site in rolls. Each roll shall be labelled to provide the following identifying data:

- roll number;
- material type; and
- roll length.

### 4.4 PLACEMENT

#### General

The GCL shall only be installed in dry weather conditions. Should light rain fall on unprotected GCL during the course of the work, it will be at the Superintendents discretion as to whether removal of the affected GCL is required or the GCL remain in place.

The installed GCL shall be subject to tensile loads on the slopes so joins are to be minimised over the length of the slope. Where joints have to occur on the slope they are to be installed as close to the bottom of the slope as possible. This includes joins that may have been formed during the manufacturing process, unless the manufacturer can demonstrate the joins are of equal or greater strength than the parent GCL on the roll.

Rolls of GCL shall be moved or deployed with a suitable spreader bar that is stiff enough to limit deflection over the width of the roll to ensure smooth uniform deployment of the GCL layer.

The Installer shall inspect the entire surface area of each and every sheet during unrolling and placement to ensure that there are no tears or other faults in the material.

The sub-grade for GCL installation must be smooth, with no abrupt level changes or voids and be free of standing water. The Installer is to inspect the sub-grade prior to rolling out the liner material. Should the Installer deem the sub-grade to be unacceptable, the Installer is to immediately advise the Superintendent. The Installer is not to proceed with lining if the sub-grade is not of an acceptable standard. Should the Installer lay liner over an unacceptable surface without having previously consulted with the Superintendent, the Installer/Contractor shall be responsible, at his cost, for removing the liner while the sub-grade is repaired (by others). The material damaged during this process shall be replaced by the Installer/Contractor at no cost to the Principal.

The Contractor shall submit a panel layout to the Superintendent for the installation prior to the commencement of the GCL placement. The construction of the GCL liner shall commence only after approval of the panel layout by the Superintendent.

Where possible, the GCL rolls shall not be cut in the roll direction. A minimum side overlay of 300 mm is required between panels. The GCL shall be installed with the carrier geotextile on the bottom of the GCL.

The GCL panels shall be installed in accordance with the manufacture's/suppliers installation manual. Where the manufacturer's installation manual requires different procedures compared to this Specification, these differences shall be brought to the attention of the Superintendent prior to placement of any GCL. The requirements of this Specification will apply unless a variation is approved in writing in consultation with the Superintendent.

Exposed GCL shall only be trafficked by vehicles with low ground pressure at any time, such as an all-wheel drive tele handler. The Contractor shall provide details of acceptable vehicles that may traffic the GCL. The GCL is to be covered with a geomembrane, which shall be deployed over the GCL within 24 hours and shall be deployed concurrently with GCL (i.e. not more than 3 roll widths ahead of the HDPE).

All patches or repairs of the GCL shall require the use of a hydrated sodium bentonite paste. Unless premixed bentonite paste is supplied, the Contractor shall submit details of the proposed bentonite powder to be made into paste at least 3 days prior to commencement of the GCL installation, in particular, the percentage of sodium bentonite.

All patches or repairs shall include:

- An undercoat and topcoat of bentonite paste for all overlaps. The undercoat shall fill the pores of the top geotextile of the underlying panel. The topcoat shall fill free pore space in the overlap area.
- The width of the undercoat and the topcoat shall be 200 mm, with 150 mm overlap of the two coats, and 50mm of the bentonite coats extending beyond the overlap.
- The minimum thickness of the topcoat shall be 10mm, with the top panel being firmly pressed into the paste.

The GCL shall be deployed and laid flat. If wrinkles greater than 50mm high occur in the GCL or where wrinkles extend to the edge of the roll due to manufacturing tolerances, the Superintendent shall decide whether the wrinkle shall be remediated. Such remediation may include cutting the wrinkle at the crest. A 10mm thick layer of bentonite paste shall be spread over the top of one flap of the cut and the other flap pushed over the paste to form an overlap. A 20mm thick layer of bentonite paste shall be placed over the top of the overlap extending 300mm beyond the edges of the cut and overlap. The paste shall be covered with a layer of GCL, with a 100mm perimeter of the patch to be heat bonded to the underlying GCL.

The method of placement of GCL on slopes shall not damage the underlying subgrade. If, in the opinion of the Superintendent damage is being caused as a result of the method of placement, the Installer must adopt an alternative method. The change in method shall be at no additional cost to the Principal. Any damage to the subgrade caused by installation of the liner shall be repaired at the Installer/Contractor's expense.

The GCL is to be covered with a HDPE, which shall be deployed over the GCL within 24 hours and shall be deployed concurrently with GCL (i.e. not more than 3 roll widths apart).

### **Repairs**

Rolls or panels of GCL that have been damaged shall be brought to the attention of the Superintendent, who shall judge if the panel or roll is to be replaced or may be repaired. If the Superintendent decides the damage is minor the damaged area may be patched. If a roll is deployed with significant manufacturing defects, as determined by the Superintendent, the entire roll shall be removed from site.

A patch of GCL shall be placed over the damaged area with a minimum overlay over the adjoining area of 500mm. The outer 200 mm circumference of the patch

shall be joined to the main GCL by heat bonding to the parent GCL to secure the patch.

### **Recording**

The Contractor shall record and prepare As-Built to scale Drawings of the GCL, with the layout of panels, roll numbers, location and detail of repairs and patches.

### **Anchor Trenches**

The anchor trench shall be constructed by the main contractor at the top of walls and bunds in accordance with the drawings and ready for use by the GCL installation contractor.

Temporary securing of the liner within the trench may be carried out using sand bags or by partial filling with approved compacted backfill.

Backfilling of the trenches will be arranged by the main contractor in accordance with the requirements of the drawings on completion of the installation or at intervals during installation as may be required. Backfilling shall be done in accordance with the requirements of the Earthworks Specification.

### **Panel Joins on Slopes**

Where slopes are longer than the longest continuous length of liner manufactured it is unavoidable that there will be joints on the slope. These joints are to be located as low as possible down the slope. Joints will not be permitted at the crest of the slope.

## **4.5 MEASUREMENT AND PAYMENT**

The unit of measurement for GCL liner procurement shall be the square metre of liner installed measured as slope area. The quantity shall be calculated from site records and verified by triangulated as-constructed survey taken on completion of the embankment construction.

The tendered rate shall include full compensation for procuring, delivery to site, loading rolls, off-loading and stacking rolls on site, complying with quality assurance procedures from this specification and any and all other items and incidentals required to complete the work according to this specification and the drawings. No additional payment shall be made for materials, labour, plant, fuel or incidentals required.

The unit of measurement for GCL liner installation shall be the square metre of liner installed measured as slope area. The quantity shall be calculated from site records and verified by triangulated as-constructed survey taken on completion of the embankment construction.

The tendered rate shall include full compensation for procuring, furnishing, and placing material, including loading material, off-loading and disposing of surplus material as specified, for preparing, processing, shaping, mixing and applying various compounds, temporary anchoring, sand bags inclusive of supply and filling, complying with quality assurance procedures and any and all other items and incidentals required to complete the work according to this specification and the drawings. No additional payment shall be made for materials, labour, plant, fuel or incidentals required.

## 5 GEOMEMBRANE (HDPE)

### 5.1 SCOPE OF WORK

The scope of works comprises the supply and installation of a geomembrane liner and associated work including but not limited to the quality control and testing in accordance with the Specification, Drawings and the manufacturer recommendations.

The Works described below shall be undertaken by a suitably experienced geomembrane installation specialist (Installer).

The Contractor shall supply all labour, materials, construction equipment, consumables, supervision, transportation, off loading at site, supplies, equipment, testing and decommissioning and all other items necessary to complete the Works.

Works described in this Section of the Specification include:

- installation of the HDPE including the placement, temporary and permanent anchoring, and welding;
- the provision of a generic Quality Control Procedures Manual which shall describe all HDPE installation activities and detail the associated quality control activities;
- the undertaking of all QA/QC activities relating to the installation including both non-destructive testing and destructive testing, inspections and the documenting of all QA/QC activities such that they can be audited at any time during or after the Works; and
- completion and supply of As-Built Drawings.

### 5.2 QUALITY ASSURANCE AND QUALITY CONTROL

The Contractor shall be responsible for all quality assurance and quality control for the storage and installation of the HDPE on site. This shall include the preparation of the Quality Control Procedures Manual and the undertaking of all inspections, non-destructive and destructive testing and repairs etc., and certification as detailed in this Specification.

The installation of the HDPE shall be monitored by the Superintendent. The Contractor shall accommodate all Quality Assurance activities described in this Section and in the Quality Control Procedures Manual.

The Superintendent may undertake audits of the Quality Control and Assurance procedures during the works. Should any areas of the Works show any non-conformance with the approved Quality Control Procedures Manual then, Works in the affected area shall cease until this non-conformance is resolved by either presentation of the appropriate documentation or undertaking sampling and testing, or other activity approved by the Superintendent. The Superintendent may also undertake periodic conformance testing on samples as supplied by the Contractor in accordance with this Specification.

### 5.3 SUBMITTALS

#### General

It is the responsibility of the Contractor to ensure that all of the documentation required has been submitted to the Superintendent. No HDPE installation or welding procedures will be approved prior to receipt of basic information

regarding the liner. Manufacturers' test results for the liner shall be submitted as follows:

Item	Property	Standards	Frequency
Conformance Testing (Upon shipment of geomembrane to site)	Thickness	ASTM D5994	Each roll
	Density	ASTM D1505, D792	One sample every 10,000m <sup>2</sup> , or every 10 rolls delivered to site, whichever is the greatest number of tests
	Tensile properties (yield and break stress, yield and break elongation)	ASTM D6693 type IV	
	Puncture resistance	ASTM D4833	
	Tear resistance	ASTM D1004	
	Carbon black content	ASTM D1603 or ASTM D4218	
	Carbon black dispersion	ASTM D5596	
	Stress crack resistance	ASTM D5397	One sample every 20,000m <sup>2</sup> , or resin type or manufacturing run
	Oxidative induction time	ASTM D3895, D5885	

Manufacturers' test results for the extrudate rod shall be submitted as follows:

Item	Property	Standards	Frequency
Conformance Testing (Upon shipment of extrudate rod to site)	Carbon black content	ASTM D1603 or ASTM D4218	Each resin batch
	Carbon black dispersion	ASTM D5596	Each resin batch
	Density	ASTM D1505, ASTM D792	Each resin batch
	Melt Flow Index	ASTM D1238	Each resin batch

Manufacturers' test results for the base resin shall be submitted as follows:

Item	Property	Standards	Frequency
Conformance Testing (Upon shipment of geomembrane to site)	Density*	ASTM D1505, ASTM D792	Each resin batch
	Melt Flow Index	ASTM D1238	Each resin batch

\*: Density without carbon black and additives added

The Superintendent will review the results provided and may seek additional information from the manufacturer before giving his decision. If the Installer proceeds with the installation without written authorisation from the Superintendent, it will be at the Contractor's risk and expense, and the installed material may be subject to removal and replacement at no cost to the Principal.

### Quality Control Procedures Manual

The Contractor shall submit the Quality Control Procedures Manual to the Superintendent at least 3 days prior to the supply of any HDPE to the site (except in the case where the HDPE is supplied by the Principal). The Manual shall include but not be limited to the following:

- experience of proposed installation personnel;
- storage and handling procedures;
- trial weld procedures;
- welding procedures;
- weld repair procedures;
- non-destructive testing procedures;
- destructive testing procedures, and;
- pro-forma sheets for recording of installation and test results.

### Site Records

The Contractor shall submit all quality forms, test results and other documentation indicated in the Quality Control Procedures Manual to demonstrate compliance with the Quality system for the Works and to demonstrate the compliance of the installed HDPE with this Specification.

Copies of these records and tests, as well as records of corrective action taken when results are unsatisfactory, shall be available for inspection by the Superintendent, within one working day following an inspection, test or action. As-Built to scale Drawings (A3 size) shall be provided of all test positions and defects within 14 days of completing the liner. Neatly drawn, hand annotated drawings will be acceptable.

Site records shall document the following information:

Item	Property	Standards	Frequency
Start-up test weld	Welding equipment		Checked daily at start of works, and whenever the welding equipment is shut-off for more than one hour. Also after significant changes in weather conditions.
	Weld conditions		Test weld strips will be required whenever



			personnel or equipment are changed. Also after significant changes in weather conditions.
Destructive weld testing	Onsite, hand tensiometer in peel and shear	ASTM D6392	Every weld
	Offsite – weld seam strength in peel and shear	ASTM D6392	Every 300m (fusion weld) Every 220m (extrusion weld)
Non-destructive weld testing		Air pressure test, ASTM D5820 Vacuum test, ASTM D5641	All seams over full length
Visual Inspection of geomembrane	Tears, punctures, abrasions, cracks, indentations, thin spots or other faults in the material		Every roll
Thickness of geomembrane	Onsite		Five per 200m, 40m apart, taken at the edge of the sheet

#### 5.4 MATERIAL SPECIFICATION

The HDPE material shall be free of holes, blisters, blemishes, striations, bubbles, roughness, undispersed raw materials, and contamination by foreign matter to the satisfaction of the Superintendent. The edges of the liner shall be straight and free from nicks and cuts. Rolls damaged in transport, storage and/or handling may have the damaged section removed, subject to the approval of the Superintendent. HDPE rolls of poor manufactured quality shall be rejected by the Superintendent. The Superintendent shall decide whether the poor quality is related to manufacture or subsequent handling, and make the appropriate decisions related to replacement and/or repair responsibility.

The material for the Works shall be HSD150, 1.5 mm HDPE (smooth/textured) liner as supplied by GSE Lining Technology Co. Ltd. in Thailand.

Alternative manufacturers may be considered by the Superintendent provided that the HDPE is a spray-on textured membrane and meets the following properties:

**Table 2.4.1: HDPE Geomembrane Material Properties**

Texture	Units	Value	Test
Property			
Thickness (minimum)	mm	1.35	ASTM D5994
Density (min)	g/cm <sup>3</sup>	>0.94	ASTM D1505
Tensile Properties (each direction)			ASTM D6693
- Strength at yield	N/mm	>22	
- Elongation at yield	%	>12	
- Strength at break	N/mm	>37	
- Elongation at break	%	>600	
Tear Resistance	N	>187	ASTM D1004
Puncture Resistance	N	>500	ASTM D4833
Carbon Black Content	%	2 – 3	ASTM D1603
Carbon Black Dispersion	Rating	90% Cat 1 or 2, rest Cat 3	ASTM D5596
Oxidative Induction Time (OIT)	Minutes	>100	ASTM D3895
Standard OIT or		>400	ASTM D5885
Oven aging @ 85° C	%	>55	ASTM D3895
Standard OIT, % retained after 90 days		>80	ASTM D5885
Environmental Tensile Load Crack Resistance	Hr	>500	ASTM D5397

The Contractor shall document the arrival of all HDPE rolls delivered to the site. At a minimum, the roll numbers, roll length, roll width, roll type (including surface finish), condition and date of delivery of the HDPE material shall be documented. A copy of this shall be forwarded to the Superintendent on a weekly basis. The Contractor shall also confirm that there is sufficient HDPE onsite to complete the works, inclusive of normal wastage.

## 5.5 DELIVERY, LABELING, STORAGE AND HANDLING

### General

Delivering of the HDPE to site is the responsibility of the Contractor (except in the case where the HDPE is supplied by the Principal) who shall ensure that there is no damage to the materials incurred prior to and during delivery to the site.

## Labelling

Each HDPE roll shall be clearly labelled at arrival on site. Any roll delivered to the site without the proper labelling shall be brought to the attention of the Superintendent. Each package of welding rod or extrusion welding beads shall be clearly labelled and shall include the manufacturers name, product identification name/number, resin lot or batch number and the package number.

Labels on each roll shall identify:

- the thickness of the material;
- the length and width of the roll;
- the manufacturer;
- product identification, and;
- roll number.

Each roll of HDPE delivered to site shall also be cross-referenced to the resin used and date of manufacture of the HDPE.

## Storage

The Contractor is responsible for protection of the HDPE from the elements. The HDPE rolls shall be protected from dirt, mud, dust, fire and damage at all times prior to installation. The Contractor remains responsible for any damages to the material during storage. The rolls shall be stacked in such ways that access for roll identification and conformance testing is possible. The integrity and legibility of roll labels must be maintained during storage.

The HDPE materials shall be stored on plastic pallets or other suitably approved surface which is free draining and clear of sharp objects and stones. Timber pallets, particularly those with nails present, shall not be used.

## Handling

Handling, storage, and care of the HDPE prior to and following installation at the site, is the responsibility of the Contractor. Sufficient space for storage of the HDPE rolls at the site shall be provided by the Principal.

## 5.6 SURFACE PREPARATION AND COVERING OF GCL

The HDPE shall be placed on top of the GCL with the textured side facing down. The Earthworks Contractor shall be responsible for preparing and maintaining the surface to receive the HDPE to provide a firm, unyielding foundation for the HDPE with no sudden, sharp or abrupt changes or break in grade, to the satisfaction of the Superintendent.

Where minor surface irregularities on the subgrade are present such as tyre marks from the telehandler, then the Superintendent may instruct the Lining Contractor to hand rake these areas smooth. Minor erosion channels may also be sand filled and raked smooth prior to placement of the GCL, at the discretion of the Superintendent.

The GCL is to be covered with a HDPE, which shall be deployed over the GCL within 24 hours and shall be deployed concurrently with GCL (i.e. not more than 3 roll widths apart). No HDPE shall be placed onto an area of GCL that has become softened by moisture, unless approved by the Superintendent. This would only apply where the moisture content of the GCL was less than 50%. The Contractor is to ensure that the GCL has no wrinkles in it prior to placement of the HDPE.

Any damage to the GCL caused by installation of the HDPE liner shall be brought to the attention of the Superintendent and be repaired at the Contractor's expense.

## 5.7 ANCHOR TRENCH

Refer to anchor trench requirements for GCL installation above.

## 5.8 HDPE PLACEMENT

### Layout Drawings

The Contractor shall produce panel layout drawings prior to HDPE installation commencing, to allow the Superintendent time to comment on the layout. The Drawings shall indicate the panel configuration and location of seams. The layout drawings must be approved by the Superintendent prior to the installation of any HDPE. The layout drawings shall be suitable for use as the As-Built Drawings and shall include unique panel identification numbers, dimensions, seam layout, and any other applicable details.

As far as practical, HDPE panels are to be placed perpendicular to the slope.

### Field Panel Placement

#### Location

Field panels shall be installed at the location and positions indicated in the Layout Drawings, as approved or modified.

#### Weather Conditions

HDPE jointing and welding shall not proceed at an ambient temperature above 40°C unless otherwise authorised by the Superintendent. Where temperature forecasts predict hotter weather than 40°C, then HDPE jointing must be restricted to mornings only. The Lining Contractor shall record the daily temperatures as part of his QA activities. In order to limit potential bridging, corner/valley welds shall only be completed during early mornings when the temperature is lowest and the liner panels have contracted to their maximum extent.

HDPE jointing shall not be done during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, in the presence of excessive wind or dust. The HDPE shall not be installed unless weather conditions are conducive to welding in accordance with the requirements of this Specification.

#### Method of Placement

The Contractor shall ensure that:

- no more HDPE is laid out at any one time than can be reasonably welded in one day;
- no equipment used shall damage the HDPE by handling, trafficking, leakage of hydrocarbons or other means;
- no personnel working on the HDPE shall smoke, wear damaging shoes, or engage in other activities that could damage the HDPE. The Contractor shall provide adequate protection to the HDPE from any equipment or concentrated personnel traffic associated with the construction;
- exposed GCL shall only be trafficked by vehicles with low ground pressure at any time, such as an all-wheel drive tele handler. The Contractor shall

provide details of acceptable vehicles that may traffic the GCL in order to place the HDPE.

- the method used to unroll the panels shall not cause scratches or crimps in the HDPE, shall not damage or move the GCL below or damage the subgrade below the GCL;
- the prepared surface underlying the HDPE and GCL must not be allowed to deteriorate after acceptance, and must remain suitable for HDPE placement;
- all geosynthetic elements immediately underlying the HDPE must be kept clean and free of debris;
- the panels shall be placed with the textured side down and in contact with the GCL (care is to be taken when placing textured HDPE over the GCL not to move GCL panels around);
- the method used to place the panels shall preclude folds, wrinkles that may become folds, bridging (trampolining) and differential wrinkles between adjacent panels.
- cross seams must be kept to a minimum on slopes and where unavoidable, must not be located within 1m of the toe of the slope.
- no cross seams are permitted within 1m of the crest of the slope.
- seams shall be staggered so that any seams in adjoining panels are spaced more than 300 mm apart.
- ballast loading must be sufficient to prevent uplift in case of high winds. The loading shall be spread out and must not cause damage to the HDPE.
- joints shall be orientated so that overlaps are in the down-slope direction (roof tile effect).
- No longitudinal joints will be allowed in the valley inverts where there will be the highest concentration of leachate (either ponding or flowing).

### **Damage**

The Contractor shall inspect all HDPE prior to welding for damage. Any damage shall be brought to the attention of the Superintendent, for a decision on whether the damage shall be repaired or the panel replaced. No welding shall be carried out before the Superintendent makes the decision. The Superintendent may inspect HDPE panels for damage, after placement and prior to welding. Any field panel or portion thereof which becomes seriously damaged (torn, twisted or crimped) shall be replaced by the Contractor. Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area.

## **5.9 REQUIREMENTS OF PERSONNEL UNDERTAKING FIELD WELDING**

Personnel performing welding operations shall be qualified by experience as indicated below.

- Personnel performing welding operations shall be qualified by experience or by successfully passing welding tests and at least one welder (Master Welder) shall have welded a minimum of 2,50,000 m<sup>2</sup> of HDPE using the same type of welding apparatus in use at the site.
- The Master Welder, the most experienced welder, shall directly supervise less experienced welders, as required.

No field welding shall take place unless the Master Welder is present.

## 5.10 WELDING EQUIPMENT AND PRODUCTS

### Approved processes for field welding.

Only extrusion welding or fusion welding, using approved equipment shall be used.

#### Extrusion Process

The extrusion apparatus shall be equipped with gauges giving the temperature in the apparatus and at the nozzle. The Contractor shall provide documentation for the extrudate to the Superintendent and shall certify that the extrudate is the same material as the HDPE sheet to be welded. The extruder shall be purged before beginning a weld and until all heat-degraded extrudate has been removed from the barrel. Whenever, the extruder is stopped, the barrel shall be purged of all heat degraded extrudate.

#### Fusion Process

The fusion-welding apparatus shall be equipped with gauges giving the applicable temperatures and pressures. The edge of the cross seams to be fusion welded shall be ground to a smooth incline (top and bottom) prior to welding. A temporary movable protective layer may be used directly below each overlap of HDPE that is to be welded to prevent build-up of moisture between the sheets.

#### Generator

The electric generator shall be placed on a smooth base such that no damage occurs to the HDPE or be mounted on pneumatic, rubber tyres. Similarly, a smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage to protect the HDPE. The HDPE should not be damaged during welding and the HDPE shall be especially protected from damage in trafficked areas.

## 5.11 SEAM LAYOUT

The seam layout shall be in accordance with the Layout Drawings provided by the Contractor. No panels not specifically shown on the Layout Drawing shall be used without the Superintendent's prior approval.

In general, seams shall be oriented down the slope where the slope is greater than 10H:1V, i.e. oriented up and down the slope. In corners and odd-shaped geometric locations, the number of seams shall be minimised. No seams shall be located in areas of potential stress concentrations. Cross slope seams are only permitted where specifically approved in writing by the Superintendent. The Contractor shall plan the seam and panel layout to minimise wastage and seams.

No cross-shaped seams shall be allowed unless approved by the Superintendent. All fusion joints between panels are to form T-joints, with panel layouts being staggered to achieve this. Seams orientated parallel to the cross slope direction of slopes steeper than 10H:1V shall be offset 1m from the toe of the slopes on the floor.

All seams and joints shall be numbered or named, which shall be cross-referenced to the Layout Drawings, field notes and records of the Contractor. Seam numbers shall be marked on the Layout Drawings and altered as required on the As-Built Drawings.

## 5.12 WELDING METHOD

The preferred welding method to be employed shall be the dual-track fusion welding process. Extrusion welding shall be used for repairs and patches. Single-track fusion welding methods or possible other welding methods shall only be used with prior written approval from the Superintendent. The Contractor shall maintain at least one spare, operable welding unit of each type employed on the Works site at all times.

## 5.13 WELD PREPARATION

General weld preparation procedures, temporary bonding procedures, general equipment settings, including acceptable extrudate or wedge temperatures, rate or advancement, etc., and welding procedures, shall be specified in the Contractor's Quality Control Procedures Manual.

Prior to welding, the weld area shall be clean and free of moisture, dust, dirt, debris, markings and foreign material. Where abrading is required, the process shall be completed according to the Manufacturer's instructions within one hour of the welding operation and in a way that does not damage the HDPE. Abrasion of the HDPE surface shall not extend outside the weld bead or weld surface area.

Seams shall be aligned to minimise the number of wrinkles. Artificially induced cooling of the extrudate welds using water or other means is not permitted. Care shall be exercised to ensure that non-destructive testing of the extrudate and/or other activities does not cause artificial cooling of the weld.

The Contractor shall record the following information on the HDPE surface adjacent to the weld:

- Unique seam number.
- Welding device number and operating temperature.
- Welding technician's initials; and
- Date and time.

This information must be recorded onto the Contractor's QA documentation at the end of the day's welding activities. If this information is entered directly into the Contractor's QA documentation at the time of the weld being carried out, then only the unique seam number is required to be recorded on the surface adjacent to the weld.

## 5.14 OVERLAPPING AND TEMPORARY BONDING

The panels of HDPE shall be overlapped by a minimum of 75 mm for extrusion welding and 125 mm for fusion welding. The overlap shall be sufficient to allow peel tests to be performed on the weld, and to provide enough space to form a reliable air channel between dual fusion welds for testing.

The procedure used to temporarily bond adjacent panels together shall not damage the HDPE; in particular, the temperature of the air at the nozzle of any spot welding apparatus shall be controlled such that the HDPE is not damaged. No solvent or adhesive shall be used unless the product is approved in writing by the Superintendent (samples shall be submitted for testing and evaluation).

## 5.15 GENERAL WELDING PROCEDURES

The general welding procedure used by the Contractor shall be as follows:

- For fusion welding, a movable protective layer of plastic may be placed directly below each overlap of HDPE that is to be welded. This is to prevent any moisture build-up between the sheets to be welded.
- Welding shall extend to within 0.6m of the outside edge of panels to be placed in the anchor trench.
- Wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The overlap shall be welded and any portion where the overlap is inadequate shall then be patched with a patch of the same HDPE in accordance with this Specification (extending a minimum of 150 mm beyond the cut in all directions).
- All cuts and patches shall be formed with rounded edges and ends, to prevent stress concentrations in the HDPE. All cuts shall be removed or be ended off with a round cut-out.

### 5.16 T-SEAMS

Prior to welding commencing, the Contractor will be required to produce a trial T-seam to demonstrate strength and continuity of the weld produced if they propose not to treat the T-seam as a repair and patch it.

The trial T-seam shall also be tested for continuity by vacuum box testing to the satisfaction of the Superintendent. On completion thereof, one 25 mm specimen shall be cut from the double weld tracks with a dye along the line of each track of the underneath weld (a total of 2 specimens) and shall be subject to the same testing criteria as described below under Destructive Weld Testing.

T-seams will not be permitted within 50mm of another T-seam. Where T-seams are within 50 to 300mm of each other, the area must be treated as a repair and patched.

### 5.17 TRIAL WELD TESTING

Each welding technician shall qualify to operate on a daily basis, by performing a trial weld prior to welding activities or at times designated by the Superintendent. These trial welds shall be performed using each type of welding device to be employed by the welding technician during that period. The Superintendent may also require that a trial weld be performed using each device at the conclusion of welding activities, whenever welding equipment is shut-off for more than an hour or when significant changes in weather conditions occur. Welding devices that have not produced a passing trial weld will not be permitted to perform production welding.

Trial welds shall be performed in the presence of the Master Welder, who will document the procedure, date, time and test results for each welding technician. The trial weld documentation is to be available for inspection by the Superintendent at any time during the Works.

Trial welds shall be made on “fragment” pieces of HDPE liner to verify that welding conditions are adequate. The trial weld sample shall be at least 0.3m wide and 2.0m long for fusion welds or 1.0m long for extrusion welds with 125mm overlap, with the weld centred length-wise. All trial welds shall be performed under the same weather conditions as production welding.

Three specimens each (25mm) wide shall be cut from the trial weld sample by the Contractor - one near each end and one near the mid-point. The two near end specimens shall be tested in peel and the mid-point sample tested in shear.



All trial weld specimens shall be tested in the field by the Contractor using an electrically operated tensiometer where the force exerted is displayed. The Contractor shall supply evidence demonstrating that the tensiometer has been calibrated within the previous 12-month period.

The shear test specimen shall, at a minimum, meet a strength of ninety-five percent (95%) of the tensile yield strength of the parent HDPE material where it fails in the material (i.e. film tear bond). Both tracks of dual-track fusion welds shall be tested for peel adhesion. Peel strength of welds shall meet at least 65% of the tensile strength of the parent HDPE material where it fails in the material.

A specimen will be deemed to have failed if:

- It fails in the weld. (i.e. the weld is weaker than the material and does not hold);
- It fails in the material at less than 65% of the parent material's tensile yield strength for peel, or;
- If it fails in the material at less than 95% of the parent material's tensile yield strength for shear.

The tensile yield strength of the parent material will be determined before testing the trial welds by testing a 25mm wide strip cut with either shears or a die.

If any one of the three specimens fails, the entire trial weld is considered to have failed. In the event that a trial weld fails, the entire trial weld procedure shall be repeated after the appropriate adjustments to the welding device and/or operator has been made. If a second trial weld fails, the welding device and/or the welding technician shall be rejected and shall not be used for welding until such time as the deficiencies are resolved, verification of the resolution is provided, and a successful trial weld performed.

## 5.18 NON-DESTRUCTIVE WELD CONTINUITY TESTING

### General

The Contractor shall non-destructively test all field and factory welds over their full length by the vacuum testing method (for extrusion welds), air pressure test (for double fusion welds only), or other approved method. A trial will be required in the presence of the Superintendent to demonstrate the effectiveness of the Contractor's apparatus and methods prior to field welding commencing. Vacuum testing and air pressure testing are described below.

The purpose of the non-destructive test is to check the continuity of welds. It does not provide any information on weld strength. Continuity testing shall be done as the welding work progresses. Any welds that fail non-destructive testing shall be repaired in accordance with this Specification. Welds, which cannot be non-destructively tested because of seam geometry, shall be capped.

All test equipment shall be in calibration and conform to the manufacturer's Specifications. The Contractor shall submit current calibration certificates for all equipment used.

### Vacuum Testing

The equipment shall comprise the following:

- A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge showing the pressure in the box;

- A steel vacuum tank and pump assembly equipped with a pressure controller and connections;
- A rubber pressure/vacuum hose with fittings, pressure gauge linked to the window housing and connections; and
- A soapy solution to be applied over seam area.

Each section of the weld to be tested shall be tested to a vacuum pressure of at least minus 35kPa. Each section of seam shall be vacuum tested for a period of not less than 10 seconds by examining the HDPE through the viewing window for the presence of soap bubbles. Adjoining areas to be tested shall have a minimum 75mm overlap between sections.

### **Air Pressure Testing**

The following procedures are applicable only to those processes that produce a double weld with an enclosed air channel. All double welds with an enclosed air channel shall be air pressure tested.

The equipment shall comprise of the following:

- an air pump (manual or motor driven) capable of generating and sustaining a pressure of 300 kPa;
- a rubber hose with fittings and connections;
- a sharp hollow needle or other approved pressure feed device; and
- a calibrated pressure gauge capable of reading pressures up to 300 kPa, with a tolerance of less than 5 kPa.

The following procedures shall be used:

- seal both ends of the weld to be tested;
- insert needle with pressure gauge, or other approved pressure feed device within 300mm of one of the sealed ends, into the air channel created by the fusion weld; and then
- energise the air pump and pressurise the channel to 210 kPa (30 psi). Close the valve and sustain the pressure for a minimum of 5 minutes. A pressure drop of less than 15kPa (2 psi) is allowable, but the air pressure is still required to stabilise for a minimum of 5 minutes.

If loss of pressure exceeds 15 kPa (2 psi), or does not stabilise, locate the faulty area and repair in accordance with this Section. If, in the judgement of the Superintendent, significant changes in HDPE temperature occur during the test (e.g., due to cloud cover), the test shall be repeated after the HDPE temperature has stabilised.

Cut the end of weld opposite to the pressure gauge and observe that the pressure drops. If the pressure does not drop, locate the obstruction(s) in the weld, repair, and retest the weld.

Remove the needle or other approved pressure feed device and repair all holes and damage made to the air channel by extrusion welding over the damage.

Alternative testing procedures may be considered by the Superintendent based on submission of relevant information by the Contractor. If an alternative testing procedure is to be considered the Contractor shall submit information to the Superintendent at least 5 days before the procedure is to be used.

## 5.19 DESTRUCTIVE WELD CONTINUITY TESTING

The Contractor shall perform destructive weld tests at selected locations. The Superintendent shall choose the test locations. The Superintendent reserves the right to vary the testing frequency depending on results of samples tested. The purpose of these tests is to evaluate field weld strength. Weld strength testing shall be done as the welding work progresses, not at the completion of all field welding.

### **Location and Frequency**

Destructive test samples shall initially be collected at a minimum frequency of one test location per 300m of seam length or at intervals designated by the Superintendent. Once the Lining Contractor has established that the weld quality is consistently good then the Superintendent may elect to increase the spacing between destructive tests. As a guide, if the initial 2000m of destructive seam testing all passes then the sampling spacing may be increased to 500m. Should any destructive tests subsequent fail then the sampling interval must be decreased back to 200m until a further ten consecutive tests pass.

Test locations shall be determined during welding, and may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding. Test locations shall be located near the top of the slope where appropriate to limit cutting and patching on the slope liner. Test locations on the floor of the cell shall generally be located on the higher parts of the floor, away from the main leachate collection pipe work.

### **Sampling Procedure**

The Contractor shall cut samples at locations designated by the Superintendent as welding progresses to obtain laboratory test results before the HDPE is covered by another material. Each sample shall be numbered and the sample number and location identified on the panel Layout Drawing.

All holes in the HDPE resulting from destructive weld sampling shall be repaired and tested in accordance with the repair procedures in this Specification. Cuts to remove the samples shall be rounded to prevent stress concentrations in the HDPE.

### **Size of Samples**

The samples shall be a minimum 0.3m wide by 0.4m long with the weld centred length-wise. The sample length shall be increased to provide material for additional laboratory testing or archiving. Two specimens shall be cut from each end of the sample for preliminary field tests.

Each portion of the test sample shall be labelled with a unique number for the sample, and referenced to the joint number from where the sample was taken. The sample number shall be noted on the As-Built Drawings. The Superintendent may direct the Contractor to reduce the length of the sample removed from the welds, if the Superintendent is satisfied that field testing indicates high quality welds.

### **Preliminary Field Testing - Weld Destructive Tests**

Two (2) specimens, one from each end of the weld destructive sample, shall be removed and tested for peel adhesion by the Contractor in accordance with ASTM D6392, while in the field. The results of this testing shall be evaluated in accordance with the criteria detailed in this Specification.

If either of the two field specimens fails, the entire destructive test is considered to fail and additional destructive test samples shall be taken in accordance with the procedures of this Specification.

If the laboratory destructive testing is to be performed on-site, the requirement for preliminary field weld destructive testing may be waived by the Superintendent.

### **Preliminary Field Testing - Weld-end Tests**

The Contractor may, if agreed by the Superintendent, perform an additional preliminary destructive test. This test shall take the form of a single specimen obtained from one end of the completed fusion weld. This will be a quality control test and, as such, shall be addressed in the Quality Control Procedures Manual.

Upon completion of a fusion weld, a specimen shall be removed from one or both ends and tested by the Contractor for peel adhesion in accordance with the procedures detailed in this Specification. Both tracks of the dual-track fusion weld shall be tested and evaluated. The weld shall not fail in the weld area. If one or both of these specimens fail, a complete destructive test sample shall be taken as previously detailed in this Specification.

### **Weld Evaluation Criteria**

Each weld sample must satisfy both the shear and peel criteria. All testing and evaluation shall be carried out in accordance with ASTM D4437.

**Shear** - The weld shear strength shall be, at a minimum, equal to 95% of the rated yield tensile strength of the HDPE sheet, as specified in the minimum property values provided by the Contractor/Principal from the HDPE manufacturer.

**Peel Adhesion** - The weld peel strength shall be equal to or greater than 65% of the rated tensile yield strength of the HDPE, as specified in the minimum property values provided by the Contractor/Principal from the HDPE manufacturer in accordance with this Specification.

For both shear and peel tests, where the strength is measured to be less than 95% and 65% respectively of the minimum property value provided by the HDPE manufacturer, the testing laboratory shall test the tensile yield strength of a sample of HDPE adjacent to the seam, sampled at least 50mm from the weld area of the seam. If this value is lower, it shall be regarded as the rated tensile yield strength of the material.

For both shear and peel tests the specimen shall fail in the HDPE sheet not in the weld area. This is referred to as "film tear bond," (FTB). The specimen shall be defined as failing in the weld if any portion of the weld exhibits separation across more than 10% of the width. Each track of a dual-track fusion weld shall be considered to be a separate weld for the purpose of calculating the percentage separation. If more than one specimen fails in shear, the entire weld destructive test sample shall be considered as failing.

### **Failed Destructive Sample Procedure**

The Contractor shall reconstruct the deficient weld once the extent has been determined. All welds that are to be reconstructed shall be bound by passing destructive tests.

The Contractor shall trace deficient welds by grinding through the top sheet of the seam air channel, extrusion weld the channel, and pressure test sections of the seam between channel seal welds. Deficient extrusion welds shall be traced by taking field specimens from the weld at 3m intervals until the Contractor has confidence that, destructive samples, which will pass laboratory testing can be

obtained. A full laboratory destructive sample will then be taken at that location and tested. If one or both of these samples fail the laboratory weld destructive test, then the procedure is repeated in that direction until passing laboratory results are obtained. For the purposes of tracing a weld, the weld is considered to be the path of the given fusion welding apparatus or extrusion welding device/technician combination and may, if necessary, extend beyond any given welding period. Tracing which requires obtaining more than two specimens in either direction from the location of the initial failed destructive weld sample shall be brought to the attention of the Superintendent. The Superintendent shall decide if the whole seam is to be rejected, or if the Contractor may continue identifying the segment of the defective seam.

At such time that the initial destructive sample failure rate of 10% or greater is reached, the Superintendent shall be notified so that a review of the Contractor's performance may be conducted.

## 5.20 REPAIRS

### General

All weld and non-weld areas of the HDPE shall be visually inspected by the Contractor for signs of damage, defective welds, blisters, punctures, undispersed raw materials, and any sign of contamination by foreign matter. Defective welds shall include completed welds that have been formed using equipment that is subsequently identified as being defective.

Any defective or flawed areas observed shall be marked, repaired, tested; or removed from the installation and disposed of. Unless otherwise approved by the Superintendent, all air channels produced by the dual track fusion welding process shall be sealed at both ends and at any location where the air channel is severed and made discontinuous. The appropriate parties shall agree upon the method of sealing. All repairs (patches, caps, etc.) may, at the discretion of the Superintendent, be destructively tested.

### Patching

Patches shall be used to repair defects such as holes (including areas from which destructive test samples were obtained) and pinholes (excluding non-destructive testing air pressure needle holes) which penetrate the entire HDPE thickness, tears and crazing. Small surface blemishes and localised flaws which do not penetrate the entire thickness of the HDPE shall also be patched, or as instructed by the Superintendent.

Areas of crazing shall be cut longitudinally (along the length). The ends of all holes shall be rounded, to prevent further propagation, prior to patching. Patches may be used to cover areas of undispersed raw material or contaminated by foreign substances (gasoline, oil, etc.), if approved by the Superintendent.

Patches shall extend a minimum of 150mm beyond the limits of the defect and all corners of patches shall be rounded. Patches shall follow the contour of the defective area and remain free of crimping or pinching. The HDPE material used for patches must, at a minimum, meet the requirements of this Specification.

Patches and defect areas shall be free of dirt, moisture, debris and markings. Patches shall be temporarily bonded by heat welding. Chemical adhesives and tape are prohibited without prior approval of the Superintendent. The perimeter of the patch shall be abraded with a hand-held grinder to produce a bevelled edge. Patches shall be temporarily installed by heat welding along the entire perimeter of the patch and defective areas. The patch shall be installed flat along all edges with

no wrinkles or folds. The patch weld area shall be abraded no more than 1 hour in advance of permanent welding. Heat welding and abrasion shall not cause excessive melting, wear or puncturing of the HDPE material; such occurrences shall be considered defects and shall be repaired by patching.

Patching or repairs that require more than two passes of a welding procedure shall be considered as a defect and be covered by a patch. Patches covering parts of other patches are not acceptable.

### **Capping**

A cap is a patch of extended length and may be used to repair failed welds. Caps shall extend a minimum of 150mm beyond the limits of the defective weld and all corners shall be rounded. Caps shall be installed as detailed in this Specification for patches.

A cap used to repair a failed weld or portion of a weld shall be destructively tested if it exceeds 35m in length or if the weld is of questionable quality. Caps over failed welds shall be carried out only with the approval of the Superintendent if no other method of repair is feasible. Where welds are being repaired by caps, the failed weld shall be cut out, and the cap welded using fusion welding over most of the joint. The length of extrusion weld required to close-off the cap shall be kept to a minimum and shall be closed-off after the fusion weld has been pressure tested.

### **Grinding and Welding**

Grinding and extrusion welding shall be used to repair sections of defective extrusion weld less than 0.3m in length. Areas requiring repair shall be abraded no more than 1 hour prior to the repair being made.

In consultation with the Superintendent, where the reason for a failed dual-track fusion weld has been determined with certainty, and is not related to faulty welding equipment, the failed part of the weld may be repaired (if less than 5 m long) by bevelling the edge (if required), abrading the sheet surface and applying an extrusion weld along the exposed edge (flap) of the seam.

Failed welds repaired in this manner must conform to the requirements of this Specification. If the length of the failed portion of the fusion weld exceeds 5m, or if the flap is not wide enough to allow destructive testing of the extrusion weld (without first testing through the fusion weld), then the weld must be reconstructed by capping.

## **5.21 HDPE WRINKLES AND BRIDGING**

Due to the use of a smooth-textured HDPE over the GCL, the “Velcro” effect has been found to limit the HDPE wrinkle and bridge size. Should wrinkles or bridging larger than 300mm high develop, these shall be cut and welded as a seam if the overlap is sufficient, in accordance with this Specification. Where the overlap is not sufficient, the wrinkle shall be cut and patched or capped as detailed in this Specification.

## **5.22 MATERIALS IN CONTACT WITH THE HDPE**

The Contractor shall place all materials located on top of a HDPE layer in such a manner as to ensure that the following conditions are satisfied:

- No damage to the HDPE;
- No slippage of the HDPE on underlying layers; and
- No tensile stresses are created in the HDPE.

Material placement on top of the HDPE shall be in accordance with the requirements specified in this Specification. The Contractor shall ensure that damage to the HDPE does not occur during placement of this material.

Exposed HDPE shall only be trafficked by vehicles with low ground pressure at any time, such as an all-wheel drive tele handler. The Contractor shall provide details of acceptable vehicles that may traffic the GCL.

In addition, the Contractor shall not place materials on the HDPE at ambient air temperatures below 0°C or above 40°C, unless approved by the Superintendent.

### 5.23 LINING SYSTEM ACCEPTANCE

The Contractor shall retain all responsibility for the HDPE in the lining system until acceptance by the Superintendent.

The HDPE lining system shall be accepted when:

- the installation is finished;
- all documentation of installation is completed;
- verification of the adequacy of all field welds and repairs, including associated testing, is complete; and
- written certification documents, including As-Built Drawings have been received by the Superintendent.

All portions of the HDPE shall be fully tested by the Contractor and approved and accepted by the Superintendent prior to the installation of overlying layers. Portions of the HDPE installation which are to be approved as complete shall be cleaned by the Contractor to remove any debris, scrap HDPE, mud, or other material resulting from the installation activities which would interfere with the inspection of the HDPE.

The Contractor shall verify that all identified repairs have been completed, all non-destructive testing has been performed, and all destructive test samples from the area to be approved have either been passed or are bound by passing destructive tests and the failed welds reconstructed.

Upon satisfactory completion the Superintendent shall approve the installation, or a portion of the installation. As necessary, the approval process will be staged and will occur as the work progresses rather than as a single unit at the end of the installation process.

### 5.24 MEASUREMENT AND PAYMENT

#### 5.24.1 HDPE LINER PROCUREMENT

The unit of measurement for HDPE liner procurement shall be the square metre of liner installed measured as slope area. The quantity shall be calculated from site records and verified by triangulated as-constructed survey taken on completion of the embankment construction.

The tendered rate shall include full compensation for procuring, delivering to site, stacking and storing, recording required information on arrival, including loading material, off-loading material, wastage requirements and overlaps, complying with quality assurance procedures and any and all other items and incidentals required to procure and deliver the liner material according to this specification and the drawings. No additional payment shall be made for materials, labour, plant, fuel or incidentals required.

### 5.24.2 HDPE LINER INSTALLATION

The unit of measurement for HDPE liner installation shall be the square metre of liner installed measured as slope area. The quantity shall be calculated from site records and verified by triangulated as-constructed survey taken on completion of the embankment construction.

The tendered rate shall include full compensation for placing material, including loading material, off-loading and disposing of surplus material as specified, wastage requirements and overlaps, for preparing, shaping, welding, testing, complying with quality assurance procedures, repairs, temporary anchoring, sand bags inclusive of supply and filling, and any and all other items and incidentals required to complete the work according to this specification and the drawings. No additional payment shall be made for materials, labour, plant, fuel or incidentals required.



## HOLD POINTS

In addition to hold points specified or implied in other sections of this specification, the following hold points are considered critical to the CQA and shall apply to the works:

Hold Point		Information to be provided by the Contractor	Inspection required
1	Start of construction works	Initial base topographical survey	Superintendent to verify adequacy of survey base.
2	Excavation to subgrade level		Check for presence of highly permeable strata such as windblown sand and laterite gravel.
3	Foundation Preparation	Provide testing results	Superintendent to verify.
3	Commencement of bulk earthworks	Provide testing results	Check source of fill material and presence of unsuitable material.
4	Final trimming of floor and inside walls of cell	Topographical survey	Tolerances achieved on side slopes and floor of cell, presence of sharp objects at finished level.
5	Placement of GCL	Delivery Dockets and roll ID numbers	Check for damage and defects, patching, bentonite paste seals, panel overlap and orientation, trench preparation. Check that QA and as-built information has been recorded on GCL and match supplied QA documentation.
6	Placement of HDPE liner	Manufacturer's QA documentation on HDPE where not supplied by the Principal	Check for damage and defects, patching, repairs, seams, panel overlap and orientation, non-destructive & destructive testing.
7	Liner installation completion	Installers QA documentation and as-built information and drawings	Check that QA and as-built information has been recorded on HDPE and match supplied QA documentation.

The Contractor shall inform the Superintendent at least 2 days in advance of each hold point, to allow the Superintendent to undertake the required inspection.