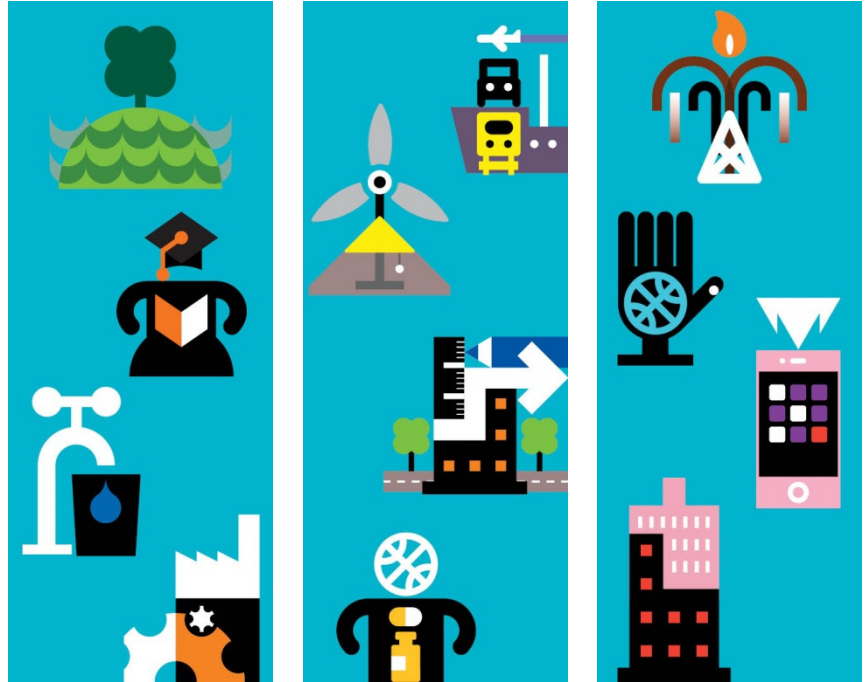




Lamby Way Landfill Capping Works Cell 4

Construction Quality Assurance (CQA) Plan

September 2016

Cardiff Council



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County Hall,
Cardiff
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1 Introduction

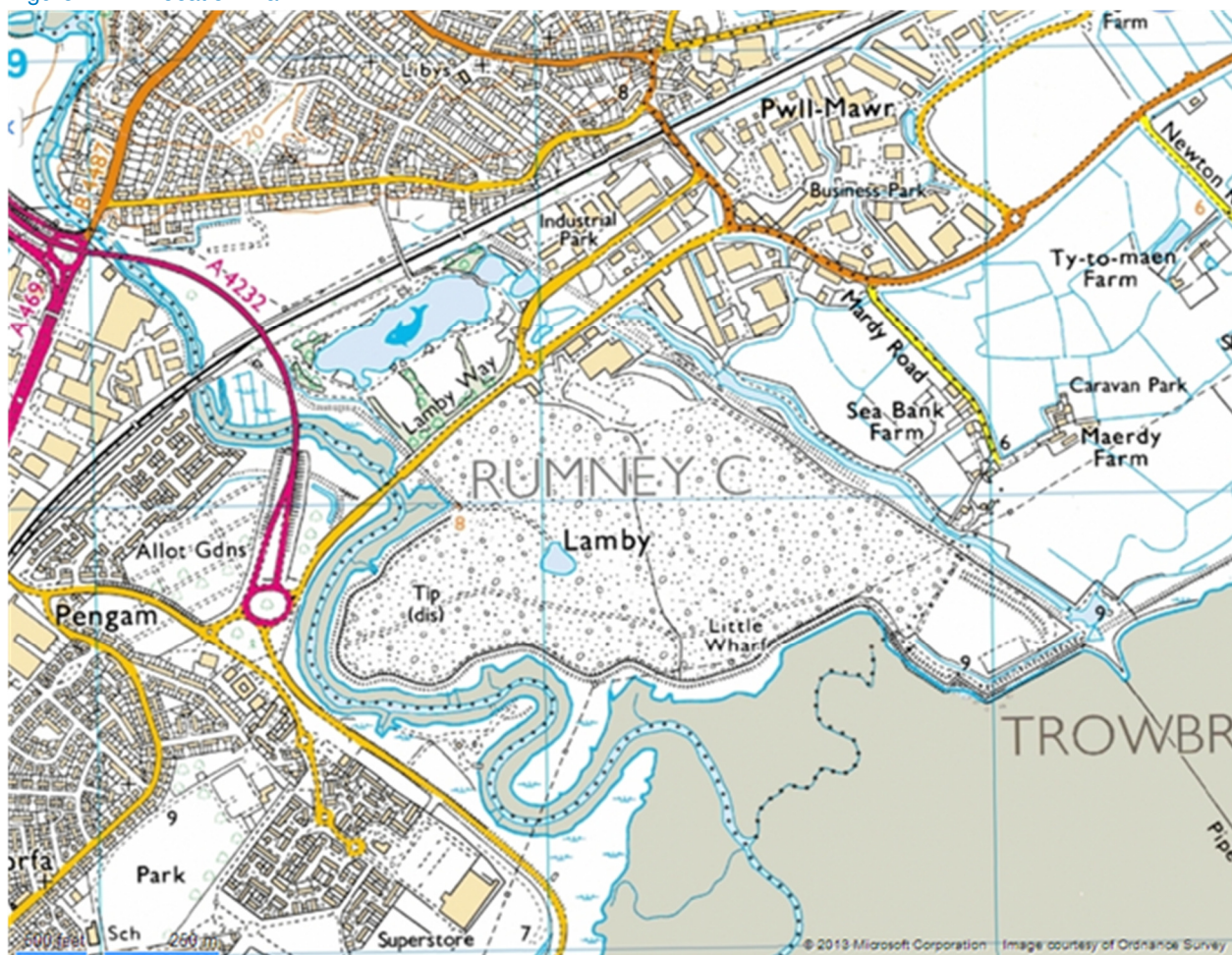
This document provides the Construction Quality Assurance (CQA) procedures that shall be undertaken for the construction of the capping works at Lamby Way Landfill site.

All other proposed works under the Contract not covered in this document shall be constructed in accordance with the requirements stated in the Contract.

1.1 Background

Lamby Way Landfill site is an integral part of the waste disposal infrastructure for the Cardiff area. It is located on land bordering the mouth of the Rhymney River, and the Severn Estuary foreshore, in the southeast of the city. It covers an area of approximately 50 hectares (ha).

Figure 1.1: Location Plan



The proposed Lamby Way Construction Works Cell 4 comprises the capping and restoration of approximately 12ha of landfill at Lamby Way. The capping and restoration works form the final part of the Authority's phased capping of the site. The phased capping ensures that the Authority complies with Natural Resources Wales IPPC Licence and associated permissions for the Lamby Way Landfill.

1.2 Scope of work

The proposed works comprise all the permanent and Temporary Works in connection with Lamby Way Landfill site and associated surface water drainage works and upgrading the service road along the southern section of the site. The area to be capped is 12ha.

The construction works will comprise construction of the capping system. The capping will include a Regulating Layer, overlain by Protective Geotextile, HDPE Geomembrane, Geocomposite Drainage Layer, and Landscaping Soils.

The works for the capping scheme shall include but not be limited to the following:

- Safe removal and disposal of Japanese Knotweed;
- Construction of associated temporary access roads (design to be undertaken by the Contractor);
- Stripping and separate temporary stockpiling of topsoil from the area to be capped;
- Placement of the capping comprising (from bottom to top):
 - 300mm Regulating Layer;
 - Protective Geotextile;
 - 1mm thick double textured HDPE Geomembrane with welded seams;
 - Geocomposite Drainage Layer (GDL);
- Placement of imported Restoration (cover) Soils (500mm subsoil and 300mm topsoil); and
- A perimeter surface water collection drain along the estimated edge of the landfill.

The following drawings relate to the proposed Lamby Way Landfill Capping Works (see Appendix A):

- SPHTT14405 – 101 - Service Information
- SPHTT14405 – 102 - Site Location and Access Routes
- SPHTT14405 – 103 – Extent of Capping Works
- SPHTT14405 – 104 – Standard Details
- SPHTT14405 – 105 – Existing Level Information
- SPHTT14405 – 106 – Leachate Wells & Surface Water Drain
- SPHTT14405 – 107 – Proposed Typical Cross-Sections
- SPHTT14405 – 108 – Previous As-Built Information

1.3 Description of Capping Works

The Capping Works shall include but not be limited to the following:

- All setting out necessary for the works;
- All clearing necessary for carrying out of the works, including removal of fauna and flora. Ground clearance to be subject to compliance with any restrictions associated with site area;
- Safe removal and disposal of Japanese Knotweed;
- Construction of associated temporary access roads (design to be undertaken by the Contractor);
- The excavation, transportation and disposal of reject material;
- Any necessary de-watering of the area;
- Stripping and stockpiling of topsoil for possible reuse;
- Preparation of the formation level including backfilling in places to provide better profiling and therefore create a suitable overall fall to the perimeter drain;
- Exposing the edge of the existing landfill to facilitate tie-in with the proposed capping liner;
- Excavation, transportation, placement and compaction of a 300mm thick Regulating Layer;
- Placement of a Protective Geotextile;
- Placement and seaming of the double textured HDPE Geomembrane;
- Placement of the GDL with the panels aligned to facilitate surface water flow down the slope;
- Backfilling of the perimeter anchor trench including the floor of the Perimeter drain;
- Excavation, transportation, placement of 500mm thick subsoil and 300mm thick topsoil;
- Local re-profiling to ensure good falls for surface water and landfill gas management as specified in Table 1.1; and
- The final landscaping is to be agreed on site with the CQA Engineer.

Table 1.1: Requirements for local reprofiling requirements

Ground Condition	Profile slope grade
Where the pipe is laid on stable ground and the fall and gas flow are in the same direction	1 in 100
Where the pipe is laid on stable ground and the fall and gas flow are in the opposite direction	1 in 50
Where the pipe is laid on landfilled waste and the fall and gas flow are in the same direction	1 in 50
Where the pipe is laid on landfilled waste and the fall and gas flow are in the opposite direction	1 in 25

1.4 Description of Additional Works

The Additional Works shall include but not be limited to the following:

- Survey and all setting out necessary for the works;
- All clearing necessary for carrying out of the works, including removal of fauna and flora;
- The excavation, transportation and disposal of reject material; and
- Construction of a haul road along the southern section of the site, as specified in Section 10 – Additional Works.

1.5 Responsibilities

It is the responsibility of Cardiff Council to employ an experienced and competent Contractor to carry out the Works, a CQA Engineer to supervise the construction and to monitor that the capping has been laid in accordance with this CQA Plan. All Contractor personnel shall be required to undertake any induction and/or site safety requirements of the Council, in addition to any induction carried out by the Contractor. New or replacement staff will also need to receive this induction prior to starting works.

The Contractor shall be responsible for, but not be limited to, the following:

- Provision of a summary of the Contractor's Construction Quality Assurance procedures;
- Provision of evidence of personnel experience/training;
- Provision, transportation and storage of geosynthetic and construction materials capable of meeting the requirements of this CQA plan;
- Provision of necessary samples of materials selected by the CQA Engineer for contamination testing;
- Construction of a temporary access road;
- Survey of levels; and
- Provision of as-built drawings. Information shall be presented that identifies the date and time of installation of the cover, the weather conditions and the site operatives involved.

For the landfill capping works the Contractor shall be responsible for, but not be limited to, the following works:

- Preparation of the formation including safe disposal of Japanese Knotweed, before placement of the Regulating Layer;
- Construction of a 300mm thick Regulating Layer;
- Installation of the Protective Geotextile Layer;
- Installation of the double textured 1mm HDPE Geomembrane against the Regulating Layer;
- Installation of the GDL over double textured HDPE Geomembrane;
- Assurance that the perimeter anchor trench is positioned such that the HDPE and GDL are securely anchored;
- Installation of a combined perimeter drain and anchor trench to securely anchor the HDPE and GDL;
- Provision of conformance tests undertaken to demonstrate the effectiveness of the HDPE Geomembrane material. This includes carrying out sampling and third party laboratory testing as described in this CQA Plan and extra sampling and testing that the CQA Engineer deems necessary;
- Provision of necessary samples of Protective Geotextile and Geocomposite Drainage material selected by the CQA Engineer for independent material property tests;
- Provision of a 'Test Location' drawing showing where test samples were taken;
- Construction of the perimeter drain within the perimeter anchor trench;
- Construction of 500mm thick subsoil and 300mm topsoil; and
- Construction of haul road along the southern section of the site, as indicated on Drawing No SPHTT14405-102 and -107.

The Contractor is:

Walters UK

The Geomembrane Contractor is:

Celtic Lining Ltd

* relevant staff members on-site have TWI/CSWIP Plastics Welder Entry Level (7.4 and 7.5) accreditation

The CQA Engineer and his inspectors shall be responsible for the following:

- Ensuring that the work is carried out in accordance with the CQA Plan;
- Certifying whether the work has been carried out in accordance with this CQA Plan and to provide written confirmation of this;
- Identifying to the Contractor any work and/or materials that are not compliant with the requirements of this Plan and requesting the Contractor make good at his own cost; and
- Submitting a copy of the CQA report to the Client upon completion of works.

In particular the CQA Engineer duties are:

- Visually inspecting the existing formation following the stripping of vegetation and acceptance of the finished surface with the Contractor for Regulating Layer;
- Visually inspecting the Regulating Layer and acceptance of the finished surface with the Contractor for HDPE Geomembrane;
- Visually inspecting the perimeter trench prior to the placement of the HDPE Geomembrane;
- Monitoring the installation of the Protective Geotextile over the Regulating Layer with the Contractor;
- Monitoring the installation of the HDPE Geomembrane over the Protective Geotextile Layer with the Contractor;
- Monitoring the installation of the GDL over the HDPE Geomembrane with the Contractor;
- Visually inspecting the placement of the Restoration Soils for the Capping Works with the Contractor;
- Visually inspecting the installation of the perimeter drain; and
- Visually inspecting the reinstatement of the peninsula environmental well.

The CQA Engineer is responsible for the certification of the works, but may delegate inspection and recording to his inspectors. The term CQA Engineer forthwith in this plan includes the CQA Engineer and his Inspectors.

The final authorisation of the works, however, cannot be delegated. It should be noted that the CQA Engineer does not have a defined role under the contract, but that the Engineer will take advice from the CQA Engineer re approval of the works or otherwise.

The CQA Engineer shall among all other specified duties be responsible for the following:

- Ensuring that the work is carried out in accordance with the technical Specification; and

- Rejecting and approving the related works undertaken under the Contract.

Manufacturer's certificates shall accompany each batch of material delivered to site. Where applicable, laboratory testing of materials shall be employed to provide additional confidence as operations progress.

The CQA Engineer is:

Geraint Roberts
Mott MacDonald
Fitzalan House, Fitzalan Road, Cardiff, CF24 0EL
Tel: (029) 2046 7800

The CQA Inspectors are:

Thomas Granes & Michael Jones
Mott MacDonald
Fitzalan House, Fitzalan Road, Cardiff, CF24 0EL
Tel: (029) 2046 7800

1.6 Services and Supplies Affected by the Works

In carrying out the earthworks, the Contractor shall comply with special requirements specified in the Specification with regards to the following services and supplies affected by the Works:

- Works Associated with Dŵr Cymru - Welsh Water:
 - The Contractor shall ensure that all works to and in the vicinity of sewers are in accordance with the requirements of Dŵr Cymru-Welsh Water, and the Special Requirements included in the Specification;
- Work Associated with British Telecommunications plc:
 - The Contractor shall note the Specific Requirements relating to British Telecommunications plc plant and equipment in the Specification.
- Work Associated with Western Power Distribution:
 - The Contractor shall note the Special requirements relating to the Electricity Generating and Distributing Companies which are listed in Volume 1 of the Specification.

1.7 Quality Control Personnel

The Contractor shall carry out Quality Control during the construction of the Works, and all personnel shall have relevant experience in landfill construction and earthworks control.

The CQA Engineer/Inspectors shall report to the Project Manager and report any unusual or unexpected occurrences immediately for discussion and agreement on matters requiring action. Full records shall be kept by the CQA Engineer on a day-to-day basis detailing all site operations, tests carried out and the site conditions. The records shall be made available for inspection.

2 Management

2.1 General

The Quality Assurance monitoring and certification shall be the responsibility of the CQA Engineer. He may either monitor the construction of the Works and/or receive reports from CQA Inspectors who monitor construction.

The CQA Engineer shall maintain an awareness of day to day matters and the progress of site operations. All CQA personnel shall be familiar with the contents of this CQA Plan and shall sign a confirmation of familiarity form, which has been appended to this document as Appendix B.

2.2 Daily Meeting

A daily meeting shall be held on site between the CQA Engineer and the Contractor's representative. The purpose of the meeting is to:

- Review the work activity and location for the day;
- Note the Contractor's installation personnel for the day/shift;
- Review the previous day's work activity;
- Review the work schedule;
- Discuss any interfacing with other Contractors/site operations; and
- Discuss/highlight any problems and potential solutions.

2.3 CQA Engineer's Reporting, Forms and Certificates

The CQA Engineer's site personnel shall provide details of site operations in the following reports:

2.3.1 Daily Summary Reports

Daily Summary Reports shall be prepared, to include the following;

- Date, project name, location, personnel involved;
- Description of weather conditions, including temperature, cloud cover and precipitation;
- Summaries of meetings held and actions recommended or taken;
- Changes to site drawings;
- Location on site of construction / installation undertaken during day;
- Contractor's equipment and personnel being utilised;
- Quantity and description of materials supplied to site;
- Calibrations or recalibrations of test equipment;
- Details of the work accomplished;
- Identification of samples tested, test methods and provision of approximate location;
- Records of observations, and descriptions of the adequacy of the work;
- Decisions made regarding approval of work and corrective actions required;
- Records of relevant CQA interested parties visiting the site; and
- Signature of the CQA Engineer.

Preferably each day's progress will be recorded in the form of a marked up copy of a suitably scaled Lamby Way Landfill site plan, showing approximate locations of the test areas noted with an approximate northing and easting.

A typical report form is appended to this document as Appendix C.

2.3.2 Corrective Measures Reports

If the material placed fails to meet the specification within this CQA Plan due to the workmanship or quality of source material, a corrective measures report shall be produced by the Contractor with a unique identification number, which shall include the following information:

- Location of the problem;
- Reason for failure, giving probable cause;
- How and when the problem was located;
- Notes of any disagreement between the Contractor and the CQA Engineer, as to whether a problem exists;
- Suggested corrective action;
- Description of corrective action undertaken;
- Suggestions on how methodology can be altered to prevent reoccurrence of the problem; and
- Signature of the CQA Engineer agreeing corrective action and agreeing that corrective measures have been appropriately carried out in accordance with the corrective measures report.

The corrective action can be proposed by the Contractor, but the CQA Engineer must state, prior to the works being undertaken, whether the proposed remedial works are acceptable. The signature of the CQA Engineer demonstrates that the remedial work proposed has been undertaken as described in the report.

A typical report form is appended to this document as Appendix D.

2.4 Contractor's Reporting Requirements

i. Roll Test Data Reports

These reports provide the roll information required for the HPDE Geomembrane and GDL detailed in Sections 5 and 6, respectively.

ii. Formation Acceptance Reports

Formation Acceptance Reports shall be completed by the CQA Engineer and signed by the Contractor for each material placed and are required for the following:

- Top of the existing restoration/cover soil layer;
- Top of the Regulating Layer;
- Top of the Protective Geotextile;
- Top of the HPDE Geomembrane; and

- Top of the Geocomposite Drainage Layer.

These reports shall include a description of the area accepted by the Contractor before material is placed.

The Formation Acceptance Sheets are provided in Appendix E.

- iii. Panel Layout Drawings for the Protective Geotextile, HPDE Geomembrane and the Geocomposite Drainage Layer for the Capping Works

Panel layout drawing requirements are detailed in Sections 4, 5 and 6 of the CQA Plan.

2.5 Maintenance of Records

The CQA Engineer shall be responsible for the control and storage of all records regarding the installation of the cover. The CQA Engineer shall maintain the original copy of all records, with copies being held by the Contractor. The CQA Engineer shall maintain the original records until the CQA Report has been produced and handed to the Client. A copy of any laboratory and field test results shall be kept along with the remaining project information.

The CQA Engineer is responsible for controlling the distribution of all documents pertaining to quality assurance. This shall require him to set up procedures whereby:

- Each issue of each document has a unique identification;
- A record is kept of the distribution of each document; and
- A record is kept of confirmation of receipt and confirmation of familiarity of important documents.

CQA Proforma sheets are appended to this document as Appendix F. Each of the CQA Proforma sheets shall be completed as part of the works for the CQA Engineer.

2.6 Survey of Levels

The Contractor shall provide square grids of levels at 20m centres. These initial level surveys shall be carried out on completion and approval by the CQA Engineer of the surface preparation for the landfill capping works:

- Existing ground surface; and
- Top of the Regulating Layer.

The Contractor shall use site survey stations are shown on the drawings. The Contractor shall install additional stations as is necessary for setting out the Works.

2.7 Site Visit

It is anticipated that the Natural Resources Wales may periodically visit the site during the construction works. During these visits, the CQA Engineer supervising the works shall make available all test results compiled up to date.

2.8 Design Changes

Any significant design changes, required to ensure the suitability of the construction works, shall be referred to the CQA Engineer for approval. Following approval by the CQA Engineer, the design changes shall be notified to Natural Resources Wales for their information.

3 General Earthworks for the Capping Works

3.1 General

Earthworks shall be carried out in accordance with the Specification for Highways Works (SHW), Series 600 March 1998 (Volume 1), amended November 2006, published by Her Majesty's Stationery Office, as modified and supplemented by the additional particular requirements specified in the Contract and this section. This document should be read in conjunction with Specification for Highways Works (SHW), Series NG 600 March 1998 (Volume 2), amended November 2005, Notes for Guidance on the Specification.

Insofar as any of the particular requirements may conflict or be inconsistent with any other provision of the Specification, the particular requirements shall always prevail. A copy of the Specification for Highway Works, Series 600 shall be kept on site at all times. Reference to Tables 6/1 6/2 and 6/5 in the SHW shall be taken to refer to the Tables in Appendix G.

The above documents are referred to throughout this CQA Plan as the "Specification for Highway Works" or "SHW".

The Contractor shall provide a summary of the Contractor's Construction Quality Assurance procedures with the Method Statement for the Works to be carried out.

In sourcing materials for the works, the Contractor shall endeavour to:

- Avoid purchasing materials from environmentally sensitive locations;
- Purchase materials from sources that follow environmentally good practices, and comply with all relevant environmental legislation;
- Seek the following information about materials when making product choices;
- The embodied energy in the material (or associated carbon dioxide emissions);
- The impacts associated with extraction of the source material;
- The pollution associated with the manufacture of the product;
- The sustainability of the resources from which it was derived;
- The recycled content of the material;
- Emissions affecting the wellbeing of users during and after construction;
- Problems arising from the disposal of materials after use;
- Increase the use of recycled materials where possible;
- Source materials locally to minimise transport costs;
- Ensure that purchasing to avoid waste is explicitly targeted; and
- Ensure any environmental purchasing requirements are followed by Sub-Contractors.

3.2 Treatment of Japanese Knotweed

It is anticipated that Japanese Knotweed will be encountered during the construction of the Works. The Contractor shall ensure that all areas of Knotweed are identified and clearly marked on site prior to the commencement of Works. As a minimum, the Contractor shall ensure that:

- No soil infested with Knotweed must be moved without the prior approval of the CQA Engineer;

- Infested soil shall be excavated for a minimum depth of 1m below ground level (bgl) to ensure the complete removal of all underground parts of the Knotweed. Additional depths of excavation may be required if the Knotweed is still apparent below 1m bgl;
- Where the Japanese Knotweed has to be removed from site, it shall be buried at a minimum depth of 10m bgl within a licensed and approved tipping site;
- The infested soil is securely covered during transportation off site to prevent contamination of roads;
- The infested soil shall not be moved to a site where Knotweed has not yet invaded;
- Under no circumstances will the shallow burial of Knotweed infested soil be allowed; and
- All machines and vehicles used in the excavation and transportation of the infested soil shall be thoroughly cleaned to the approval of the CQA Engineer prior to their use in or upon any other aspect of the Works.

3.3 Disposal of Unacceptable Class U1B and U2 Material

It is anticipated that unacceptable Class U1B, Class U2 and hazardous materials will be encountered during the Works and shall be treated in accordance with the SWH Specification. Known hazardous materials likely to be encountered include waste and leachate.

The Contractor shall excavate and safely dispose of any waste and contaminated material encountered during the works.

The Contractor shall ensure that appropriate duty of care information is held and that a licensed waste carrier is in place.

The Contractor shall make arrangements for the safe disposal of the contaminated and waste materials arising from the Works.

Disposal of hazardous material shall comply with pre-agreed requirements of the Environmental Authority etc. for disposal including specific sites.

3.4 Tolerances in Construction Thicknesses

The thickness of the compacted materials forming the cap shall be measured perpendicular to the line of the slope.

The thickness of the Regulating Layer for the Capping shall be within a tolerance of +50mm to -0mm.

The settled thickness of the Restoration Soils for the Capping after 12 months exposure and weathering shall be thickness + 50mm to -0mm.

Where the tolerances are exceeded, the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the level in compliance with the Specification.

The thickness of the Regulating Layer and Restoration Soils shall be certified by the CQA Engineer and shall be achieved using a measuring aid.

3.5 Anchor Trenches

The Contractor shall allow for the excavation of the anchor trench along the perimeter of the landfill as indicated on drawings.

Sharp edges to the key-in trench shoulders shall be removed to leave a gently rounded profile which will support the geomembrane sheet without “folding” of the sheet. Material underlying the geomembrane and ancillary geotextile support shall be firm at all locations, free from large stones (no greater than 50mm nominal size) and sharp objects. Anchor trenches shall be maintained free of water prior to and throughout the installation sequence. Where anchor trenches are cut in clay soils, which are susceptible to drying and shrinkage, the length of exposed excavation shall be limited to avoid such drying out processes.

3.6 Temporary Access Road

The Contractor shall design and construct a temporary access road for the Works. The route of the access road shall be submitted to the Engineer for approval prior to construction, not less than 2 weeks prior to construction.

3.7 Contamination Testing of Material

As part of the construction of the capping works, all material that may be imported to site shall require contamination testing to ensure that risks are not posed to human health and/or groundwater and to the properties of the capping liner.

Testing for imported materials shall comprise laboratory analysis at a rate of 1 sample per 1,000m³ (or 2 per source for regulating layer). Material to be tested at a UKAS accredited laboratory shall include the Regulating Layer and Restoration Soils. Materials must comply with requirements of the soil screening value (SSV) limits detailed in Table 3.1. Soils containing the weed material listed in Table 3.2 shall not to be imported to site.

Table 3.1: Contamination limiting values for imported materials

Contaminant	Threshold Value (mg/kg)
Antimony	3,300
Arsenic	170
Beryllium	63
Boron	46,000
Cadmium	560
Chromium (III)	33,000
Chromium (VI)	220

Contaminant	Threshold Value (mg/kg)
Copper	44,000
Nickel	3,400
Elemental Mercury (Hg)	30
Inorganic Mercury (Hg ²⁺)	240
Selenium	1,800
Vanadium	5,000
Zinc	170,000
Lead	1,300
Petroleum Hydrocarbons (Aliphatic and Aromatic EC >05-70)	5,000
Acenaphthene	29,000
Acenaphthylene	29,000
Anthracene	150,000
Benz[a]anthracene	49
Benzo[a]pyrene	11
Benzo[b]fluoranthene	13
Benzo[ghi]perylene	1,400
Benzo[k]fluoranthene	370
Chrysene	93
Dibenz[ah]anthracene	1.1
Fluoranthene	6,300
Fluorene	20,000
Indeno[123-cd]pyrene	150
Naphthalene	1,200
Phenanthrene	6,200
Pyrene	15,000
Phenol	440

Table 3.2: Soils containing the following weed material not to be imported to site

Scientific Name	English Name
Aegopodium podagraria	Ground Elder
Calystegia spp. Convolvulus spp	Bindweeds
Equisetum spp	Marestail, Horsetail
Heracleum mantegazzianum	Giant Hogweed
Fallopia spp	Japanese Knotweed
Cirsium arvense	Creeping Thistle

4 Regulating Layer for the Capping Works

4.1 General

Prior to the installation of the Regulating Layer, any sharp objects shall be removed from the temporary cap layer. The CQA Engineer shall inspect the state of the existing graded landfill waste prior to the installation of the Regulating Layer.

The Regulating Layer shall be placed on top of the existing graded landfill waste and the Contractor shall achieve a thickness of at least 300mm. The aim of this layer is to provide a uniform, smooth and firm layer on which to place the Protective Geotextile.

4.2 Material Specification

The soil materials for use as the Regulating Layer below the capping system for the capping works area shall comprise material from stockpiles on the Lamby Way landfill site.

The material shall be free from weeds, building materials and other foreign objects. The maximum particle size shall be 100mm. Regulating material shall comply with Class 2A, 2B or 7C in accordance with Series 600 of the Specification of Highway Works (see Appendix G for grading requirements).

Any material imported for use as Regulating Layer material shall consist of clean, non-calcareous fine grained or graded soil with a typical particle size less than 20mm (whilst still conforming to Class 2A, 2B or 7C material) with no sharp angles.

Acceptable materials shall meet the requirements of Clause 601 of the SHW and tables in Appendix G, to the satisfaction of the CQA Engineer.

Particle Size Distribution (including sedimentation) testing frequency on placed materials shall be 5 per hectare. The Engineer may instruct the Contractor to undertake other tests as necessary (see table in Appendix G) to prove that the Regulating Layer material meets this Specification.

4.3 Preparation of Formation Prior to Placement of Regulating Layer

The Contractor shall prepare the formation surface of the existing restoration by breaking up and removing any haul roads, clearing of vegetation, any sharp objects, trimming and filling such that it is in a suitable condition to receive the Regulating Layer.

The formation surface shall be sufficiently firm to form a suitable working surface for the plant being operated. Any soft or loose material in the formation surface shall be removed and replaced with compacted acceptable material, Class 2A, 2B, 2C or 7C, specified within the tables in Appendix G.

After preparing the graded landfill waste or restoration soil formation surface and prior to placing the Regulating Layer, the Contractor shall inspect the surface and remove any objects which exceed ± 25 mm under a 1,000mm lath.

Prior to the installation of the Regulating Layer, the subgrade shall be prepared by re-grading and compaction to ensure an even surface has been achieved free from any ruts, bumps or depressions that could result in ponding. The surface shall be rolled with at least 4 passes of a smooth-wheeled roller having a mass per metre roll of 4,400 – 6,000kg, or equivalent method to be agreed in advance by the Engineer. When each area of the surface has been prepared, the Contractor shall notify the Engineer so that an inspection can be made.

The Contractor shall complete a Formation Acceptance Sheet, which he shall provide to the CQA Engineer. If the Contractor is concerned about the quality of the subgrade he shall notify the CQA Engineer immediately.

The CQA Engineer or his inspectors shall inspect the subgrade daily and identify any areas to the Contractor who shall arrange for them to be remediated. Following approval the formation surface shall be surveyed by the Contractor to provide a grid of levels at 5m centres. The surveyed levels shall be agreed with the CQA Engineer.

4.4 Placement of Regulating Layer

The Regulating Layer shall be placed and compacted in accordance with the Highways Agency Specification for Highway Works (SHW), Series 600.

Prior to placement of the Protective Geotextile, the Regulating Layer shall be rolled to ensure as smooth a surface as reasonably possible. Rutting between adjacent passes of the roller shall not exceed 20mm in depth. No standing water or excessive moisture shall be allowed.

Prior to placement of the Protective Geotextile, the Contractor shall make the Regulating Layer surface available for inspection by the CQA Engineer.

Prior to placement of the Protective Geotextile, the Engineer shall be given at least four working hours' notice to inspect the surface.

5 Protective Geotextile for the HDPE Geomembrane

5.1 Material Specification

The Protective Geotextile (PG) shall be placed to form a continuous layer over the Regulating Layer to prevent the intrusion of the underlying Regulating Layer into the HDPE. The properties to be met by the material are specified in Table 5.1.

The Protective Geotextile shall be a non-woven needle-punched product manufactured from polyethylene (PE) or polypropylene (PP) comprising prime staple fibres and containing an active UV inhibitor.

The Contractor shall provide to the CQA Engineer confirmation from the geotextile manufacturer that the geotextile has been tested in the factory to detect needle fragments and that there is a robust process in place for detecting and removing these prior to the product leaving for the site. This confirmation should also specify the accuracy of the testing.

5.2 Conformance Testing

Samples shall be taken from rolls of Protective Geotextile selected by the Engineer at a rate of 1 per 10,000m² or one per batch, whichever is less. Samples shall be submitted for conformance testing (Table 5.1) at a UKAS accredited laboratory for all required tests to confirm that the properties of the material meet the manufacturer's specification. Samples shall be 1m long by the roll width and shall not include the first linear metre of the roll.

Table 5.1: Protective Geotextile Conformance Testing Requirements

Properties	Test Method	Required Value
Mass per Unit Area	BS EN ISO 9864	600g/m ²
Nominal Thickness	BS EN ISO 9863-1	4.0mm
CBR Puncture Resistance	BS EN ISO 12236	6,400N
Strip Tensile Strength	BS EN ISO 10319	26kN/m (both directions)

In addition to the above conformance procedure, if any material appears to be visually defective upon installation it shall be removed to an extent as directed by the CQA Engineer who may request additional conformance testing. This additional testing shall be carried out at the expense of the Contractor.

5.3 Delivery and Storage

The Protective Geotextiles shall be delivered to site in suitable packaging to protect the rolls from degradation by ultra violet light and shall be maintained in the packaging until required for use in the Works.

On delivery to site, the rolls will be off-loaded to storage using suitable plant. The rolls shall be placed on bearers unless recommended otherwise by the manufacturer. Should this be the case, the storage area shall be firm, clean and rolled flat to avoid damage (physical and chemical) to the geotextile. The rolls shall be stored no more than two high, or as per the manufacturer's recommendations.

The Contractor and CQA Engineer shall examine all rolls on delivery for damage in transportation and shall record the details of any damage together with the relevant manufacturer's reference numbers for each roll. Damaged rolls shall be set aside until the extent of damage and rejection of material can be determined.

The Contractor shall supply to the CQA Engineer a copy of the manufacturer's quality control documentation covering the delivered material. All manufacturers' quality control documentation shall be supplied prior to any installation. The Engineer shall review the data to verify that it meets the requirements of Table 5.1. Any non-conforming material shall be rejected.

The Protective Geotextile material shall be delivered, stored and handled strictly in accordance with the manufacturer's instructions. The handling equipment and storage method employed shall ensure no damage to the material. Adequate measures shall be provided for protecting the materials at all stages of the work from all sources of potential damage or contamination until completion of the works.

Prior to any Protective Geotextile installation, the Contractor shall submit to the CQA Engineer a schematic plan showing the proposed layout of the Protective Geotextile panel installation for agreement. The panel layout should seek to minimise the length of heat bonded overlaps.

5.4 Installation

Following approval of the placed Regulating Layer by the CQA Engineer installation of the Protective Geotextile may proceed.

The Protective Geotextile shall be installed with a minimum overlap to adjacent panels of 300mm. The overlap shall be carefully heat bonded ensuring no overheating or damage to the geotextile or the underlying Regulating Layer.

Upon deployment, each panel shall be adequately weighted as required to prevent any movement prior to heat bonding and placement of the overlying Restoration Soils.

To prevent any damage to the geotextile, installation personnel shall wear suitable footwear. No plant shall travel on the geotextile and no potentially damaging equipment or objects shall be placed on the Protective Geotextile or the underlying Regulating Layer.

5.5 Damage, Defects and Repairs

The Engineer shall visually inspect all areas of the Protective Geotextile including overlaps during deployment and upon completion prior to placement of the overlying HDPE Geomembrane for the identification of damage, defects, and any sign of contamination by foreign matter. Any damage or defects identified as a result of such inspection shall be clearly marked, to assure the appropriate remedial measures are undertaken by the Contractor in accordance with this specification and to the satisfaction of the Engineer.

The Engineer shall advise the Contractor of any panels, or portions of panels, which are to be replaced or repaired. Damaged panels or portions of damaged panels, which have been rejected, shall be removed from the Works area and replaced with new material.

Any areas of geotextile damage shall be repaired by the placement of a suitably sized patch of the same geotextile material ensuring a minimum overlap of 500mm in all directions from the damaged area. The patch shall be securely heat bonded in place. All repairs will be undertaken in the presence of and to the satisfaction of the Engineer.

5.6 Verification of Installation

The CQA Engineer shall verify that the installation of the geotextile is completed to the requirements of the CQA Plan, which incorporates this CQA Plan, including any repairs, prior to granting formal written approval for the placement of the Restoration Soils.

On completion of installation the Contractor shall submit to the CQA Engineer a fully referenced as-constructed layout plan showing panel/roll reference numbers, and any repair and sample locations.

6 HDPE Geomembrane for the Capping Works

6.1 General

A welded double textured 1mm High Density Polyethylene (HDPE) Geomembrane shall be installed over the Protective Geotextile. The minimum thickness of the HDPE Geomembrane is to be 1mm.

The preparation of the Regulating Layer and Protective Geotextile receiving the HDPE Geomembrane shall be as described in Sections 4.3 and 5.4 of the CQA Plan.

6.2 Material Specification

The properties to be met by the material are specified in Table 6.1 and in Appendix H.

Table 6.1: 1mm HDPE Geomembrane Conformance Testing Requirements

Properties	Test Method	Units	Nominal value	Testing Frequency (minimum)
Thickness – mls (min.ave.)			Nom. (-5%)	Per roll
▪ Lowest individual for 8 out of 10 values	D 5994		-10%	Per roll
▪ Lowest individual for any of the 10 values			-15%	Per roll
Asperity Height mls (min. ave.) ⁽¹⁾	D 4833	mm	0.25	90,000kg
Density (min.ave.)	D 1505/D 792	g/cc	0.940	Every 2nd roll ⁽²⁾
Tensile Properties (min.ave.) ⁽³⁾				9,000 kg
▪ Yield Strength	D 6693	kN/m	15	
▪ Break Strength	Type IV	kN/m	10	
▪ Yield Elongation		%	12	
▪ Break Elongation		%	100	
Tear resistance (min. ave.)	D 1004	N	125	20,000kg
Puncture resistance (min. ave.)	D 4833	N	267	20,000kg
Stress Crack Resistance ⁽⁴⁾	D 5397 (App.)		300hr	Per GRI GM10
Carbon Black Content (range)	D 1603 ⁽⁵⁾	%	2.0 – 3.0	9,000 kg
Carbon Black Dispersion	D5596		Note ⁽⁶⁾	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) ⁽⁷⁾				
(a) Standard OIT	D 3895		100min.	90,000kg
- or -				
(b) High Pressure OIT	D 5885		400min.	
Oven Aging at 85oC ^{(7), (8)}	D 5721			
(a) Standard OIT (min, ave) - % retained after 90 days	D 3895		55%	
- or -				
(b) High Pressure OIT (min .ave.) - % retained after 90 days	D 5885		80%	Per each Formation
UV Resistance ⁽⁹⁾	GM11			

Properties	Test Method	Units	Nominal value	Testing Frequency (minimum)
(a) Standard OIT (min. ave.) - or -	D 3895		N.R. ⁽¹⁰⁾	Per each Formation
(b) High Pressure OIT (min. ave.) - % retained after 1600hrs ⁽¹¹⁾	D 5885		50%	
Notes				
⁽¹⁾ Of 10 readings; 8 out of 10 must be >0.18mm, and lowest individual reading must be ≥ 0.13mm; also see Note 6.				
⁽²⁾ Alternate the measurement side for double sided textured sheet				
⁽³⁾ Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.				
Yield elongation is calculated using a gage length of 33mm				
Break elongation is calculated using a gage length of 50mm				
⁽⁴⁾ The SP-NCTL test is not appropriate for testing geomembrane with textured or irregular rough surfaces. Test should be conducted on smooth edges or textured rolls or on smooth sheets the same formulation as being used for the textured sheet materials. The yield stress used to calculate load for the SP-NCTL test should be the manufacturer's mean value Via MQC testing.				
⁽⁵⁾ Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established				
⁽⁶⁾ Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 Category 3				
⁽⁷⁾ The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.				
⁽⁸⁾ It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.				
⁽⁹⁾ The condition of the test should be 20hr. UV cycle at 75°C followed by 4hr condensation at 60°C.				
⁽¹⁰⁾ Not recommended since the high temperature of the Std-OIT test procedures an unrealistic result for some of the antioxidants in the UV exposed samples.				
⁽¹¹⁾ UV resistance is based on percentage retained value regardless of the original HP-OIT value.				

In addition to the above conformance procedure, if any material appears to be visually defective upon installation it shall be removed to an extent as directed by the CQA Engineer who may request additional conformance testing. This additional testing shall be carried out at the expense of the Contractor.

The 1mm HDPE Geomembrane, including seams, shall have a maximum permeability equivalent to 1m of clay with a maximum permeability of 1×10^{-9} m/sec.

The frequency of individual tests and the number of samples required are described in Table 6.1. The manufacturer is to provide the relevant quality and testing certification and warranties to the Contractor for issue to the CQA Engineer.

6.3 Delivery, Handling and Storage

The HDPE Geomembrane material shall be delivered, handled and stored in accordance with the manufacturer's recommendations. Each roll of HDPE Geomembrane delivered to site shall be identified with the name of the manufacturer, product name and type, batch number, date of manufacture and physical dimensions.

The Contractor shall supply to the CQA Engineer a quality control certificate for each batch of HDPE Geomembrane material delivered to site as detailed in Section 6.7 below.

The CQA Engineer shall be informed at least seven days in advance of the delivery of the HDPE Geomembrane, to enable the CQA Engineer to witness the unloading of the material, if required. Appropriate machinery should be made available for lifting and transporting the membrane. Lifting and carrying should involve the use of slings and core bars. Under no circumstances should the HDPE Geomembrane be handled by the tines of a forklift machine, the bucket of an excavator or any similar equipment.

A visual inspection of each roll shall be made as it is unloaded to identify if any packaging has been damaged. Rolls with damaged packaging should be marked and set aside for further inspection by the CQA Engineer. The packaging should also be repaired prior to the roll being placed in storage. The CQA Engineer shall complete a checklist sheet upon viewing each delivery, as shown in Appendix F.

The Contractor shall select a dedicated storage area on the site that is away from high traffic areas, dry and stored on bearers to support their weight (unless recommended otherwise by the manufacturer) above a well prepared flat surface. In addition, the storage area should protect the HDPE Geomembrane from:

- Precipitation;
- Standing water;
- UV Radiation;
- Chemicals;
- Excessive heat (>70° C) and sparks;
- Freezing;
- Vandalism, animal and plant infestation;
- Puncture; and
- Any other environmental condition that could impact on its physical properties.

Rolls shall be stored in a manner that precludes sliding or rolling from the stacks. Rolls must not be stored more than two rolls high and shall be covered by protective sheeting to prevent damage by UV light. All opened rolls must be temporarily covered to prevent damage caused by UV rays.

The outer layer of any roll shall not be used but shall be cut off the roll and stored for subsequent disposal off site.

6.4 Installation

The HDPE Geomembrane shall be installed by a specialist Contractor with previous experience of HDPE Geomembrane deployment. The Contractor shall provide the CQA Engineer with the panel layouts for the HDPE Geomembrane prior to the commencement of the works. Any changes to the panel layout shall be agreed by the CQA Engineer prior to installation of any altered panels. The drawing shall show as a minimum:

- The location and alignment of panels;

- The proposed direction of working; and
- The reference of the panels/seams.

The Contractor shall, wherever possible, align the seams between panels so that they are normal to the contours.

Throughout deployment, the Contractor shall undertake a survey to pick up all panels, seams and repairs and provide a drawing showing the panel layout for inclusion in the CQA Report.

6.5 Inspection of Formation

Following completion of the formation for the HDPE Geomembrane a visual inspection shall be carried out by the CQA Engineer and the Contractor shall rectify any surface irregularities.

6.6 Deployment

Prior to HDPE Geomembrane deployment, Natural Resources Wales shall be given one week's written notice by the Contractor.

The Contractor shall produce, for approval by the CQA Engineer, a method statement and quality control procedure which will clearly demonstrate that the completed HDPE Geomembrane shall satisfy the maximum permeability criteria given in Section 6.2 of this CQA Plan and will continue to do so in the future. The method statement shall be submitted to the CQA Engineer not less than one week prior to the commencement of the construction works.

Before deployment of the HDPE Geomembrane the Contractor shall submit to the CQA Engineer a Method Statement outlining the Contractor's proposed method of working. The Method Statement shall include the following:

- Proposed seaming techniques and welding machine types;
- Proposed seam overlap and preparation prior to welding;
- Proposed acceptable temperature settings for hot wedge apparatus; and
- Proposed non-destructive testing methods.

Each deployed panel shall be assigned an individual number, agreed with the CQA Engineer, to record the order of deployment. The panels should also be marked with the date of deployment and the roll number from which the panel was taken. In order to provide an accurate panel layout drawing after completion of the works a survey should be carried out on every panel joint and repair position. As part of the Contractor's records for geomembrane installation, he shall include welding temperatures.

The placement of the HDPE Geomembrane will require the use of equipment capable of freely suspending the HDPE Geomembrane roll, and a spreader bar and core pipe will also be required for supporting the roll and to allow it to unroll freely during deployment. The core bar and spreader bar shall not bend or flex excessively when a full roll is lifted.

The HDPE Geomembrane panels shall be secured in the perimeter anchor trench.

Panels should be placed from the highest elevation to the lowest within the area to be covered to facilitate drainage in the event of precipitation. Panels placed on flat areas require no particular orientation. The Contractor should wherever possible align the seams between panels so that they are normal to the contours.

Panels shall be placed free from tension or stress and without wrinkles or folds. It is not permissible to stretch the HDPE Geomembrane in order to fit a designated area. Panels shall not be dragged across the Regulating Layer into position.

To prevent damage of the HDPE Geomembrane the installation shall not take place in adverse weather conditions such as strong wind, snow or during rainfall or extremes of temperature. The CQA Engineer is to note and record the temperature and weather conditions at least at the beginning of each day and also at appropriate intervals.

After deployment of each panel the edges of the HDPE Geomembrane shall be weighted down by sandbags or other suitable methods which shall avoid risk of damage to the HDPE membrane.

The edges of all HDPE Geomembrane panels shall be checked by the CQA Engineer to verify thickness using a micrometer. Should the thickness fall outside the acceptable limits shown in Table 6.1, the panel shall be removed from the Works.

6.6.1 Installation within the anchor trench

The sequencing of geomembrane and anchor trench completion shall generally be:

1. Excavate anchor trenches.
2. Install capping lining, and barrier system - lay in anchor trench as required.
3. Attach new geomembrane to old - extrusion weld - if required.
4. Backfill anchor trench - if required.
5. Seam adjacent geomembrane panels.
6. Install cover soils - spread carefully from thickened plant roadways, ensuring that surface water run-off beneath the cover soils is avoided

Where the anchor trench already exists adjacent to the previously capped areas, the anchor trench will not be excavated. The new geomembrane will be laid across the trench and welded to the existing geomembrane, as indicated on the drawings.

6.6.2 Sealing around Protruded Pipework

All penetrations through the Geomembrane shall be sealed to prevent water infiltration and air ingress. The Contractor shall provide an appropriate sealing mechanism around the gas pipework and the leachate collection manhole.

A “pipe boot” will be introduced of suitable impermeable material. Details of the boot are shown on Drawing No. SPHTT-14405-104.

6.7 Quality Assurance

Prior to placement of any HDPE Geomembrane the Contractor shall supply for the CQA Engineer’s approval, copies of the HDPE Geomembrane manufacturer’s Quality Assurance/Quality Control certificates as verification of the materials supplied being in accordance with the requirements of the specification. Each Certificate shall contain the following information as a minimum:

- Thickness;
- Density;
- Tensile Properties;
- Tear Resistance;
- Puncture Resistance;
- Carbon Black Content; and
- Carbon Black Dispersion.

Should any of the Certificates indicate that the roll material properties do not meet with the acceptance criteria outlined in Table 6.1, the CQA Engineer may reject that roll at the Contractor’s own cost.

The Contractor shall obtain and pass on to the CQA Engineer the manufacturer’s warranty covering materials and workmanship of the HDPE Geomembrane.

6.8 Seaming

Seaming of the HDPE Geomembrane should be undertaken by either the dual hot wedge fusion or extrusion welding methods. The overlap at the joint of the panels shall be a minimum of 100mm and the surfaces of the panels shall be adequately prepared before welding (e.g. grinding and cleaning).

Whichever method is employed in the works, the Contractor shall perform trial seams with each seaming machine at the start of each shift, following machine shut down, operator change and after every four hours of continuous welding. The trial seams should be at least 3m long and should be witnessed by the CQA Engineer. On completion of the trial, tabs are to be taken at the start, middle and end of the seam and destructively tested as described in Section 6.12. Should the trial seam fail these tests then the machine shall not be used in the works until a successful trial seam has been achieved.

All test welds shall have minimum acceptable values given in Table 6.2 for both textured and smooth sheets. Seam Strength and Related Properties of Thermally Bonded Smooth and Textured High Density Polyethylene (HDPE) Geomembrane.

Table 6.2: Seam strength and related properties of thermally bonded smooth and textured HDPE Geomembranes

Description	Units	Mimumum Value	Method
Geomembrane Nominal Thickness 1mm			
Hot Wedge Seams ⁽¹⁾			
Shear strength ⁽²⁾	N/25mm	350	ASTM D 6392
Shear elongation at break ⁽³⁾	%	50	
Peel strength ⁽²⁾	N25mm	263	
Peel separation	%	25	
Extrusion Fillet Seams			
Shear strength ⁽²⁾	N/25mm	350	ASTM D 6392
Shear elongation at break ⁽³⁾	%	50	
Peel strength ⁽²⁾	N25mm	225	
Peel separation	%	25	
Notes			
⁽¹⁾ Also for hot air and ultrasonic seaming methods			
⁽²⁾ Value listed for shear and peel strengths are for 4 out of 5 test specimens: the 5 th specimen can be as low as 80% of the listed values			
⁽³⁾ Elongation measurements should be omitted for field testing.			

Should the dual hot wedge fusion method of welding be employed, an extrusion weld must be applied over the seam at all T-junctions, defect repairs and where fusion welding is impracticable.

All extrusion welding undertaken on the HDPE Geomembrane shall be carried out using the appropriate weld rod (i.e. HDPE as opposed to LLDPE).

Seaming shall not be permitted under the following circumstances:

- During rain or snow unless proper precautions are taken which allow the seam to be made under dry conditions;
- Frozen ground conditions;
- During temperatures below 5° C or above 35° C; and
- Over areas of standing water.

6.9 Non-Destructive Seam Testing

Non-Destructive testing shall be undertaken by the Contractor and witnessed by the CQA Engineer on all completed seams. The following non-destructive tests shall be employed in the works:

Air Pressure Testing

Air Pressure non-destructive testing (APT) shall be undertaken on all fusion weld seams. The APT is carried out on the central hollow core between the two parallel seams created by the dual hot wedge fusion process. The test shall be undertaken by sealing both ends of the hollow core and inserting an air pressure gauge connected to a pump or air compressor. The seam shall be pressurised to a minimum air pressure

of 2 bar (30psi) and the isolation valve shut off. The air pressure shall be allowed to stabilise in the channel for two minutes and the stabilised pressure recorded. The air pressure shall then be monitored for a further five minutes. The seam shall be deemed to have passed the test if the decrease in pressure is less than 10% (0.2 bars, 3psi) of the starting air pressure after the five minute test. Following testing the air is to be released from the air channel from the opposite end of the seam to the air pressure gauge and the pressure drop to zero shall be witnessed by the CQA Engineer.

All APT results should be marked by the Contractor in indelible marker adjacent to the seam where the air pressure gauge was sited. The following information should be included:

- Date of test;
- Time of start of test and recorded air pressure;
- Time of completion of test and recorded air pressure;
- Initials of test operative and CQA Engineer; and
- The reference of the panels/seams.

Vacuum box testing:

Vacuum box testing shall employ purpose made equipment, which produces a vacuum over the tested area. A detergent/water solution shall be applied to the full test area prior to application of the test equipment, which will display any leaks by bubbling of the solution. The CQA Engineer shall confirm that no leaks are present under application of the vacuum.

The Contractor shall maintain full records of all non-destructive testing which shall be provided to the CQA Engineer on a regular basis.

If the seam fails during vacuum box testing, repairs shall be undertaken in accordance with 6.15.

6.10 Qualitative Destructive Seam Testing

The Contractor shall cut a 25mm wide tab from the beginning and end of each field seam and subject them to qualitative destructive testing in peel and shear modes using a tension-meter or similar method. The seam will be deemed to be acceptable if failure in the tab sample solely occurs in the parent material and does not enter the seam. Should a field tab fail the destructive test the Contractor shall:

- Reconstruct the seam between the two tab locations and re-test; or
- Cut further tabs from each side of the failure point and undertake such destructive testing until a successful result is achieved. The seam shall then be repaired as necessary.

The CQA Engineer may request further tabs for destructive testing at any location on the seams.

6.11 Third Party Conformance Testing

The Contractor shall carry out destructive and/or non-destructive conformance tests to demonstrate the suitability of the HDPE Geomembrane. This shall include carrying out sampling and testing as described in this specification, and additional sampling and testing that the CQA Engineer may deem necessary.

The Contractor under the supervision of the CQA Engineer shall obtain HDPE Geomembrane samples for the following tests by an independent laboratory. The properties to be met by the HDPE Geomembrane and the testing requirements are specified in Table 6.1.

As soon as practicable after delivery of the HDPE Geomembrane material to the site, the Contractor shall cut a sample 1m wide across the entire width of the roll, after the first lap has been discarded. This sample shall be used for testing.

The Contractor shall submit the sample to an independent geosynthetic testing laboratory for conformance testing. The conformance testing will be undertaken to ensure that the material meets all the parameters shown in Table 6.1. Conformance sampling shall be undertaken at a frequency given in Table 6.3.

Table 6.3: Number of rolls in batch to be sampled

Number of Rolls in Batch	Number of Rolls in Batch to be Sampled
1 – 2	1
3 – 8	2
9 – 27	3
28 – 64	4
65 – 125	5
126 – 216	6
217 – 343	7
344 – 512	8
513 – 729	9
730 - 1000	10

Should any sample fail to meet the criteria shown in Table 6.1, more conformance samples shall be removed from other rolls for further testing. The roll from which the failed sample was removed shall not be used in the works pending further conformance testing.

Interface Friction Angles

The Contractor shall carry out conformance testing to show that the proposed geosynthetics for the capping system meet the required minimum interface friction values as indicated Table 6.4 below. All testing shall be carried out under both saturated and “dry” conditions. The soils used in the tests shall be those proposed for both the Regulating Layer and the Restoration Soils. Both peak and residual values shall be reported.

Table 6.4: Interface Friction Angle Acceptance Criteria

Interface	Test Method	Interface Friction Angle (min)
Regulating Soil / Protection Geotextile	pr ENSIO 12957-: 1997 Modified after Weeks	16°
Protection Geotextile / Smooth HDPE	pr ENSIO 12957-: 1997 Modified after Weeks	>16°
Smooth HDPE / Type 2 Geocomposite Drain	pr ENSIO 12957-: 1997 Modified after Weeks	>16°
Textured HDPE / Type 1 Geocomposite Drain	pr ENSIO 12957-: 1997 Modified after Weeks	>16°
Geocomposite Drain / Restoration Soil	pr ENSIO 12957-: 1997 Modified after Weeks	>16°

6.12 Third Party Destructive Seam Testing

The Contractor shall cut two 1,000mm long by 300mm wide seam tabs from both fusion and extrusion welds for destructive testing by a geosynthetics testing laboratory at a frequency of 1 sample per 100m of each type of seam. One sample shall be retained by the CQA Engineer and the other sent for testing and both samples shall be individually referenced for location of the tested seam within the works.

The CQA Engineer shall arrange for the tabs to be tested to failure at the geosynthetics laboratory and shall be deemed to have passed destructive testing if:

- The failure occurs solely in the parent material and does not enter the seam; and
- The peel strength and shear strengths are equal to or exceeds that indicated in the manufacturer's specified limits.

Should any of the samples fail destructive testing, the Contractor shall investigate the seam at either side of the failed sample location. Further sample tabs shall be removed from the seam and tested in the laboratory until satisfactory tests are obtained. The Contractor shall then reconstruct the failed area of seam and re-test.

6.13 Anchor Trenches

To ensure the HDPE Geomembrane panels are secured, the edge panels need to be placed within an anchor trench along the perimeter of the landfill.

Backfilled material shall be placed as soon as practicable and compacted in layers to provide a secure anchorage system. The location of the anchor trenches and construction details are shown on the drawings.

The Contractor is responsible for ensuring all exposed edges of the HDPE Geomembrane are adequately weighted down so that the HDPE Geomembrane is not displaced by windy conditions. If the HDPE

Geomembrane is displaced due to wind (or suffers with damage) the material must be rejected due to the likelihood of overstressing. No materials shall be used as weights if they pose a risk of damaging the HDPE Geomembrane.

6.14 Protection of the HDPE Geomembrane

The HDPE Geomembrane shall be protected at all times from damage by construction plant. No vehicles shall be permitted to travel on the HDPE Geomembrane until the full depth of the capping material has been placed. Low ground pressure equipment shall be used for spreading the Restoration Soil overlying the HDPE and GDL. No construction plant shall be permitted to travel over the Restoration Soils unless the Contractor provides evidence to the CQA Engineer that no damage to the capping and HDPE Geomembrane will result.

Any damage to the HDPE Geomembrane shall be reported to the CQA Engineer as soon as it is apparent. Repairs, carried out in accordance with the manufacturer's recommendations shall only be undertaken with the prior approval of the CQA Engineer. Any repair work approved by the CQA Engineer shall be carried out at the Contractor's expense.

6.15 Defects and Repairs

A photographic record of each deployed panel of the HDPE Geomembrane shall be kept by the Contractor. Each deployed panel of the HDPE Geomembrane shall be visually inspected by the CQA Engineer for defects or installation damage prior to installation of the Geocomposite Drainage Layer. Any defects shall be photographed, identified and given individual reference numbers, recorded and marked by the CQA Engineer.

Minor point defects may be repaired by extrusion welding, whilst larger damaged areas may be overlain by a single piece of HDPE Geomembrane material with a minimum overlap of 100mm in all directions. The patch may be fusion or extrusion welded and non-destructively tested as previously described.

All repairs shall be subject to non-destructive testing and if deemed necessary by the CQA Engineer, destructive testing. All associated repairs will be shown on the HDPE Geomembrane Panel Layout Drawing with the individual Repair Reference Number.

6.16 Panel Layout

The panel layout shall be agreed by the CQA Engineer prior to commencement of the Capping Works. Any changes to the layout in panels shall be agreed with the CQA Engineer prior to the installation of any altered panels.

6.17 Installation Approval

The installed HDPE Geomembrane shall have to be approved by the CQA Engineer prior to the placement of the Geocomposite Drainage Layer. Approval will consist of a visual inspection, all necessary repairs have been undertaken and their locations recorded and all tests to seams or patches have been completed, recorded and approved by the CQA Engineer.

7 Geocomposite Drainage Layer

7.1 General

A Geocomposite Drainage Layer (GDL) shall be installed over the HDPE Geomembrane, as indicated on the drawings.

7.2 Material Specification

The GDL shall comprise a drainage layer with a geotextile thermally bonded on both the top and bottom side. The geotextile employed shall be a non-woven needle-punched polypropylene material manufactured from virgin staple fibres of polyethylene (PE) or polypropylene (PP). The geotextile is to

- Provide filtration (top surface);
- Prevent migration of fines from the restoration soils above into the GDL;
- Protect the Geomembrane; and
- Provide the required interface friction between surfaces.

A suitable protective Geotextile may be provided and placed over the GDL to prevent migration of fines from the Restoration Soils. The GDL requirements are provided in Table 7.1.

7.3 Handling and Storage

Each roll delivered to site shall be so labelled as to identify the manufacturer, product name and type, batch number, date of manufacture, dimensions and weight of roll.

If any roll of GDL fails to meet the requirements of Table 7.1, the CQA Engineer may, at his discretion, accept material from elsewhere on the roll, provided that further testing proves that the remainder of the roll meets the parameters required.

The material shall be delivered, unloaded, handled and stored in accordance with the manufacturer's recommendations. The material shall be stored on site in a prepared well drained level area and shall be protected from the following:

- Standing water;
- UV radiation;
- Excessive heat; and
- Puncture.

7.4 Deployment

The GDL shall be deployed so that the material can drain the soils above. The material shall be laid in accordance with the manufacturer's specification and recommendations.

All panels are to be deployed such that they are free from wrinkles or folds and free from tension or stress. Any damaged panels shall be removed from the works. The GDL shall not be installed until the HDPE membrane has been approved by the CQA Engineer.

All panels shall be temporarily weighted to prevent movement and all stone material placed over the GDL panels shall be placed in such a way as to avoid parting of the panels at their overlaps.

7.5 Installation

The GDL shall be laid over the HDPE Geomembrane and in panels with the edges overlapping as per the manufacturer's specification and recommendations, a copy of which shall be provided to the CQA Engineer for his information. As with the HDPE Geomembrane installation, a panel layout plan shall be provided and agreed by the CQA Engineer prior to any installation. The panels shall be laid such that the drains run down slopes to facilitate rapid drainage. The rolls of GDL shall be installed normal to the contours.

The methodology of installation of the GDL shall be agreed with the CQA Engineer. Care must be taken to ensure no damage occurs to the HDPE Geomembrane during the GDL deployment and jointing operations.

The end of each panel along the perimeter shall be restrained, along with the HDPE Geomembrane, in the perimeter anchor trench and the inner anchor trench formed within the landfill area. On installation of the GDL, the anchor trenches shall be backfilled with suitable material and compacted in layers.

As well as providing drainage system for the capping soils the GDL shall provide protection to the HDPE Geomembrane. The protection shall be equivalent to that of a Geofabrics HPS3, or equivalent subject to the approval of the CQA Engineer.

A suitable protective Geotextile may be provided and placed over the GDL to prevent migration of fines from the Restoration Soils.

7.6 Third Party Conformance Testing

Conformance testing shall be carried out at frequency of 1 per 10,000m² per material type.

The Contractor shall undertake shear testing on the geocomposite drain under saturated conditions. The geocomposite shall not fail in the bonding area between the geotextile and geonet. The Contractor is to submit Quality Control / Product Development test data.

Geocomposite drainage layer shall consist of a cusped HDPE (high density polyethylene) sheet bonded on both sides to a geotextile filter fabric. Drainage layer shall be permeable on one side only. The side that is against the sub-formation shall be flat. Drainage cores permeable on both sides or cores with stitched geotextile shall not be permitted.

Adjacent sheets shall be fixed with the core butt joined. The geotextile flap on the edge of the drainage sheet shall be extended across the joint shiplap style. All fixing and cutting details shall be in accordance with the manufacturer's instructions.

Backfill material shall not contain sharp objects or stone bigger than 150mm diameter. Normal compaction can be used adjacent to the drainage sheet. On horizontal surfaces the backfill shall be placed on an advancing face, the machines working on top of previously placed backfill. Mechanical plant should not operate directly on the drainage sheet; unless protected by 150mm of backfill material.

The GDL shall conform to the parameters shown in Table 7.1 below.

Table 7.1: Geocomposite Drainage Layer Specification and Testing

Properties	Test Method	Required Value – Type 1
Composite nominal thickness @ 2kPa	EN ISO 9863-1	5.0mm (min)
Mass per unit area (composite)	EN ISO 9864	600g/m ² (min)
In-plane water flow MC/CD at 20kpa pressure with soft platens	EN ISO 12958	0.80l/m.sec M.C. (min.) (HG=1.0) 0.80l/m.sec C.D. (min.) (HG=1.0)
Tensile Strength of Geotextile	EN ISO 10319	9kN/m (min)
Puncture Resistance of Geocomposite	EN ISO 12236	3000N (min)
Perpendicular water inflow at 50mm head (geocomposite)	EN ISO 11058	95l/m ² /s (min)

7.7 Quality Assurance

Each roll of GDL delivered to site should be marked by the manufacturer to indicate the following:

- Type of material;
- Material thickness;
- Roll and batch numbers; and
- Roll dimension.

A Production Quality Assurance Certificate shall be provided by the manufacturer for retention by the Engineer and copied to the CQA Engineer.

7.8 Third Party Testing

The GDL shall be subjected to Conformance Testing to ensure that the material properties are in accordance with the manufacturer's Specifications. The test material shall be removed from rolls on site at a frequency of one test for every 20 rolls. A one metre wide strip across a full roll shall be removed from rolls specified by the CQA Engineer. This sample shall be sent to a geosynthetic laboratory for testing. The material shall be tested for the parameters shown in Table 7.2.

Table 7.2: GDL Conformance Test Requirements

Parameters	Test Reference
Puncture Resistance (N)	BS EN ISO 12236
Plunger Displacement (mm)	BS EN ISO 12236
Cone Drop Penetration (mm)	BS EN 918
Tensile Strength (kN/m)	BS EN ISO 10319
Thickness under 2kPa (mm)	BS EN 964/1
In-plane water flow	BS EN ISO 12958

Should the conformance test results not meet the manufacturer's specified properties, then that roll shall not be used and further conformance tests undertaken on other rolls designated by the CQA Engineer.

7.9 Defects and Repairs

The GDL installation shall be inspected by the CQA Engineer. Should there be any signs of damage, defects or contamination, these shall be clearly marked. Remedial measures will be undertaken by the Contractor in accordance with this specification.

Any damage to the GDL shall be repaired by placing a suitably sized patch of the same material and an overlap of at least 500mm shall be achieved in all directions should be heated and secured in place. All repaired sections of the GDL shall be marked on the panel drawings.

7.10 Placement of Material within the Anchor Trenches

The perimeter anchor trench housing the perimeter drain shall be backfilled with 40mm nominal size aggregate not exhibiting sharp edges. The backfill material shall be placed as soon as practicable and compacted in layers to provide a secure anchorage system.

8 Restoration Soils

8.1 General

The Restoration Soils shall be obtained from a suitable source and shall be free from any deleterious material, which should be removed and disposed. The capping system shall receive a minimum of 800mm thickness (300mm of topsoil and 500mm subsoil). The final restoration levels of the capped area shall be as indicated on Drawing SPHTT14405 - 103.

Restoration Soils required shall be obtained from a suitable non-waste source and shall be free from any deleterious material as specified in BS 3882:2007, with contamination levels not exceeding the limiting values in Table 3.1.

Restoration Soils shall be native topsoil or subsoil free from chemical and other pollutants, pests, perennial weeds, building materials and artefacts. Soils containing weed material listed in Table 3.2 not to be imported to site.

8.2 Restoration Soils and Requirements

All soil materials to be approved prior importation on to the site. Acceptable material shall meet the following requirements:

Lower 500mm

Class 2C (in accordance with Series 600 of the Specification of Highway Works)

pH 5.0 – 8.0

Upper 300mm

Class 5A & 5B (grading in accordance with Table 1 in BS3882:2007)

pH 5.5 – 7.5

Imported topsoil shall be collected from one source. No unsuitable material shall be incorporated within the topsoil layers. Unsuitable materials shall include but not be limited to the following:

- Materials susceptible to spontaneous combustion;
- Domestic, commercial or industrial waste;
- Frozen matter;
- Materials with dimensions greater than 125mm;
- Materials with a moisture content greater than the minimum permitted for such material unless otherwise directed by the CQA Engineer; and
- Any material with the potential to damage the cover.

Placement of the soils shall be carried out in a manner that minimises compaction of the materials. The Contractor shall exercise care during soil placement so as not to damage any protrusions.

The thickness of the restoration soils shall be controlled by the Contractor using profile boards and mobile traveller, or similar suitable method, and shall be verified visually by the CQA Engineer.

8.3 Inclement Weather Conditions

No material shall be imported or placed during inclement weather conditions, if in the opinion of the CQA Engineer, trafficking over compacted or un-compacted material would prove detrimental to the construction. Any such trafficking damage caused by the Contractor shall be repaired in accordance with this Specification. Inclement weather conditions may include rain, snow, freezing conditions or excessive heat indicated by the CQA Engineer on site.

Following wet conditions, any standing water on the surface of the construction shall be removed. Earthworks placement operations following inclement weather conditions shall not proceed without the prior approval of the CQA Engineer.

Any material frozen in stockpiles shall be removed and put to one side until thawed.

The works may also be stopped if safety is compromised as a result of inclement weather conditions. Work resumption after interruptions due to inclement weather conditions shall be at the agreement of the CQA Engineer.

9 Perimeter Drainage System

9.1 General

The perimeter drainage system generally comprises perforated pipes buried in granular materials in trenches installed around the perimeter of the landfill cap. An impermeable membrane will be laid at the bottom and on the two sides of the trenches leaving the top open for receiving the surface water running off from the landfill cover. The general arrangement of the drainage system is shown on the drawings.

The drainage material shall not be classed as a waste.

9.2 Drainage Material Specification Requirements

The material shall consist of clean non calcareous and coarse graded with no sharp angles. The grading of aggregate for use as drainage material shall be Type B BS 13242:2002 20/40 aggregate, in accordance with Table 9.1.

Table 9.1: Grading of Aggregate Drainage Material

British Standard Sieve Size (mm)	Percentage Passing (%)
	20/40
80	100
63	98-100
40	40-99
20	0-20
10	0-5

Source: Volume 1 Specification for Highway Works Series 500 Drainage and Service Ducts Table 5/5

9.3 Pipe Material Specification Requirements

The construction of the perimeter drains shall be constructed in accordance with the Specification for Highway Works and shall follow the details shown on the drawings.

The pipe materials shall either be HDPE pipes with a minimum design life of 60 years.

9.4 Geotextile Separator

The backfilled drainage trench shall be covered with Terram 1000 geotextile separation layer (or similar approved) prior to placement of the subsoil and topsoil.

A geotextile shall be placed to surround the granular backfill within the perimeter drain. The geotextile surrounding the granular backfill shall be of a type suitable to provide good infiltration of inflowing groundwater.

The geotextile shall be protected at all times against physical or chemical damage. Geotextiles shall be kept in the wrappings provided by the manufacturer until required for use in the works. The method of installation shall not impose stresses or strains likely to cause damage to the geotextile. The method of installation shall ensure that the geotextile is in continuous contact with the surface on which it is placed without stretching or bridging over humps or hollows. Construction equipment and vehicles must not run or operate directly on the geotextile.

Joints shall be formed by overlapping the material by a minimum of 300mm.

10 Additional Works

10.1 General

The following additional works shall be carried out in accordance to this Specification.

- Construction of a Service/Haul Road.

10.2 Service Road

Construction of the haul road shall be as detailed in drawing SPHTT14405 – 107. The thickness will be verified by visually assessing the thickness to ensure the vehicles are not causing rutting or damage to the underlying materials.

The material to be used shall be Class 6F2 and shall be placed in accordance with the SHW, of which the relevant Tables are provided in Appendix G.

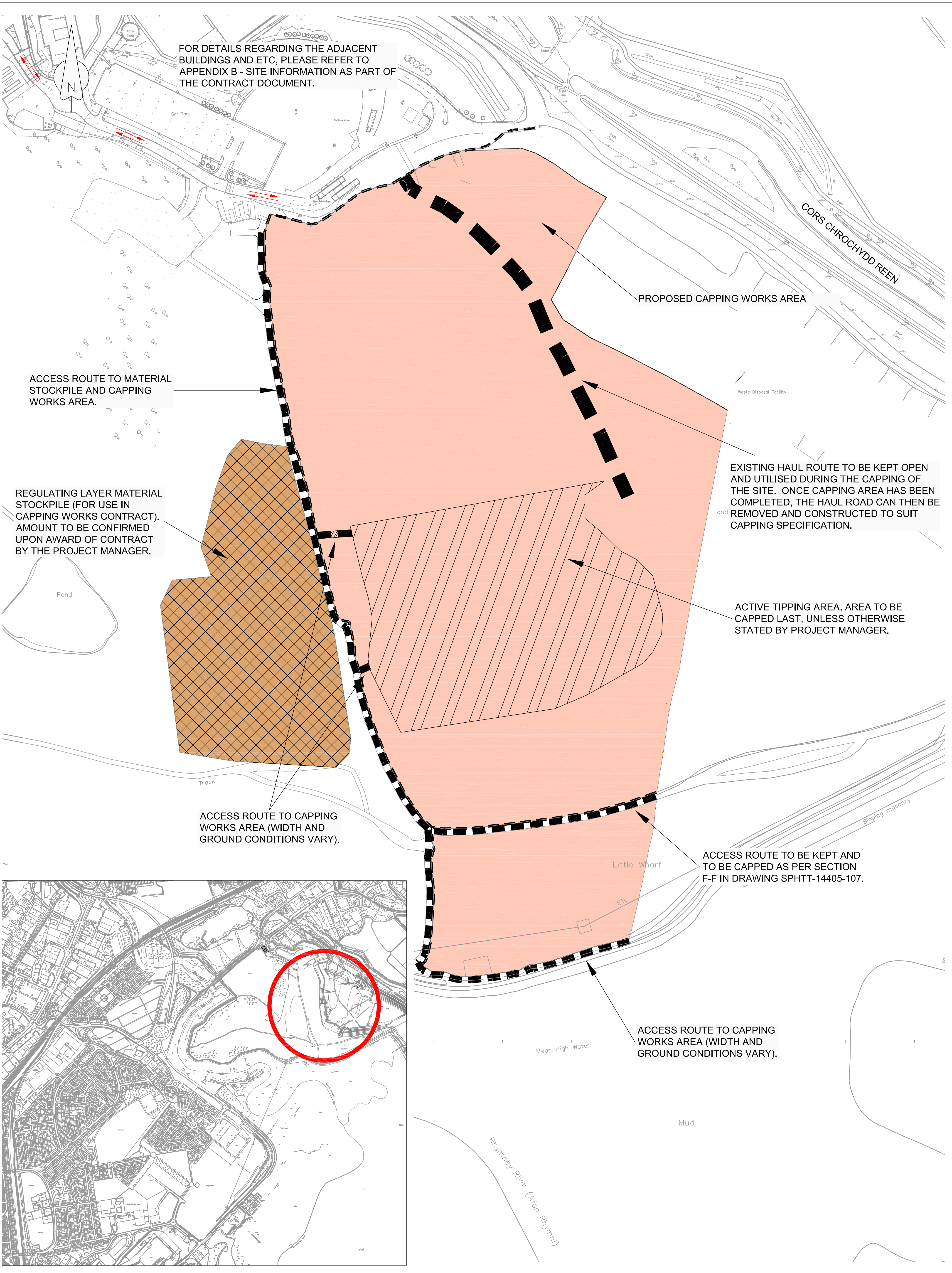
No unsuitable material shall be incorporated within the haul road subgrade. Unsuitable materials shall include but not be limited to the following:

1. Materials susceptible to spontaneous combustion;
2. Domestic, commercial or industrial waste;
3. Frozen matter;
4. Sharp objects; and
5. Any material with the potential to damage the underlying lining system.

Appendices

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Appendix A. Drawings

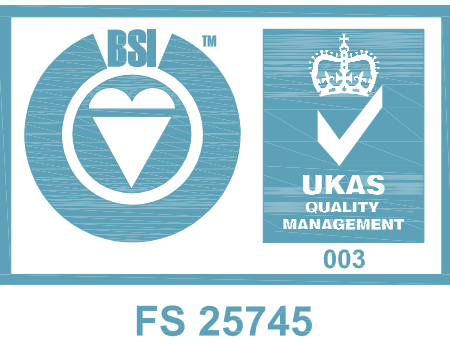


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CYNGOR DINAS CAERDYDD
THE CITY OF CARDIFF COUNCIL



DESIGN CONTRACTS AND DELIVERY
DYLUNIO CONTRACTAU A DARPARU
Andrew Gregory
DIRECTOR FOR CITY SERVICES
CYFARWYDDWR GWASANAETHAU'R DDINAS

Rev	By	Date	Description of Amendment	Chk.by	Date
C	MJH	14/10/16	Issued for construction	TB	14/10/16
B	MJH	22/04/16	Redrawn	TB	22/04/16
A	MJH	08/04/16	Notes amended	TB	08/04/16

Project
**LAMBY WAY
LANDFILL SITE
CAPPING WORKS CELL 4**

Title
**SITE LOCATION
AND
ACCESS ROUTES**

Checked TB	Path
Drawn MJH	Project Number
Scale 1:1250@A1	SPHTT-14405
Date APR15	Drawing Number
	102

County Hall, Atlantic Wharf, Cardiff CF10 4UW
Telephone 029 2287 2456

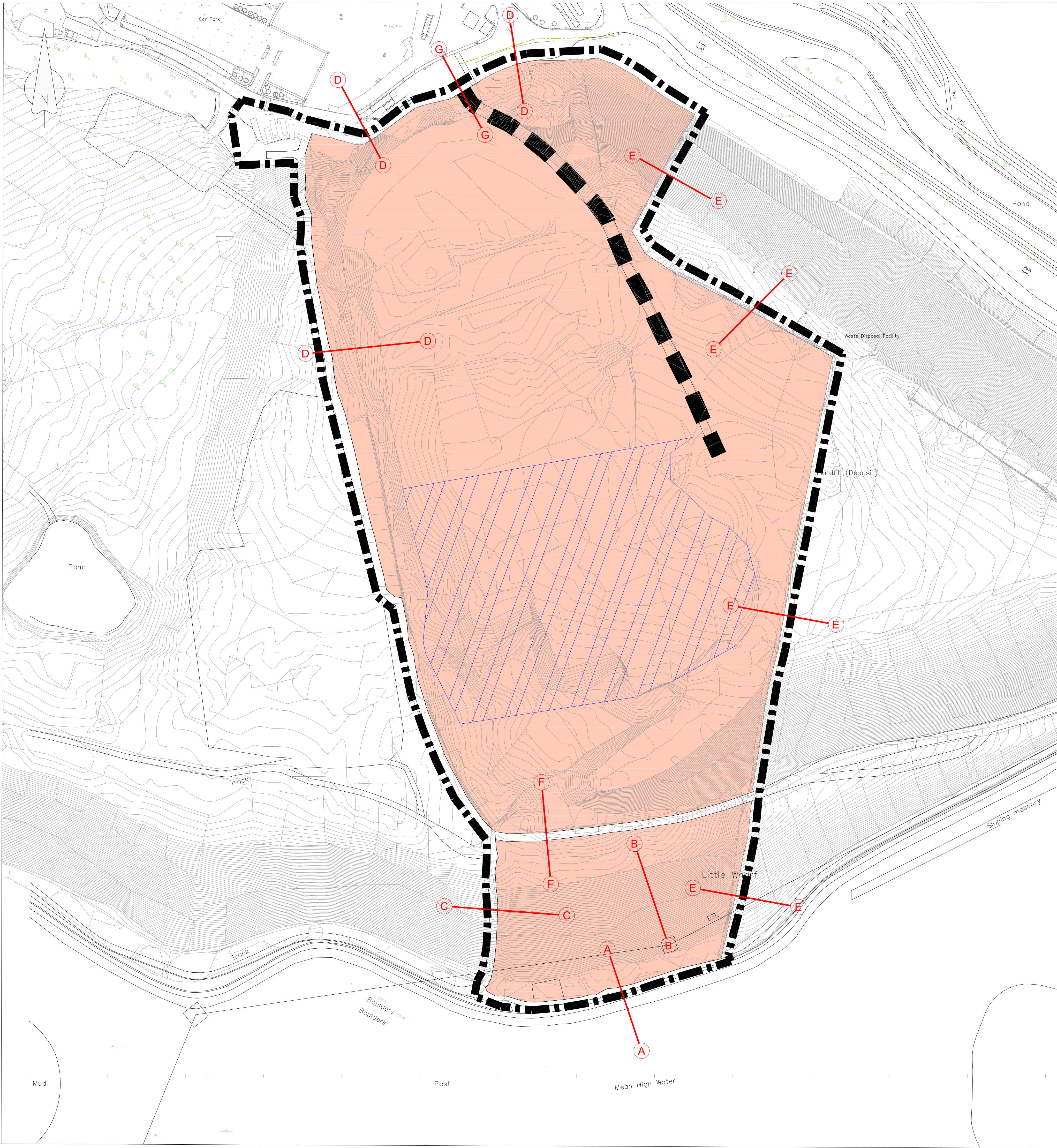
KEY

- SITE EXTENTS
- PROPOSED AREA FOR CAPPING 13ha (130,000m²)
- A—A

CROSS-SECTION LOCATIONS
- ACTIVE TIPPING AREA (RESTRICTIONS APPLY PLEASE REFER TO APPENDIX 1/7 FOR DETAILS)
- EXISTING HAUL ROAD

NOTES

1. REFER TO DRAWING SPHTT-14405-107-PROPOSED TYPICAL CROSS-SECTIONS FOR ALL SECTION DETAILS.
2. SETTING OUT DETAILS TO BE CONFIRMED ON SITE UPON COMPLETION OF TOPOGRAPHICAL SURVEY.
3. FOR DETAILS OF THE EXISTING LINER LOCATION, PLEASE REFER TO DWG SPHTT-14405-PREVIOUS AS-BUILT INFORMATION.



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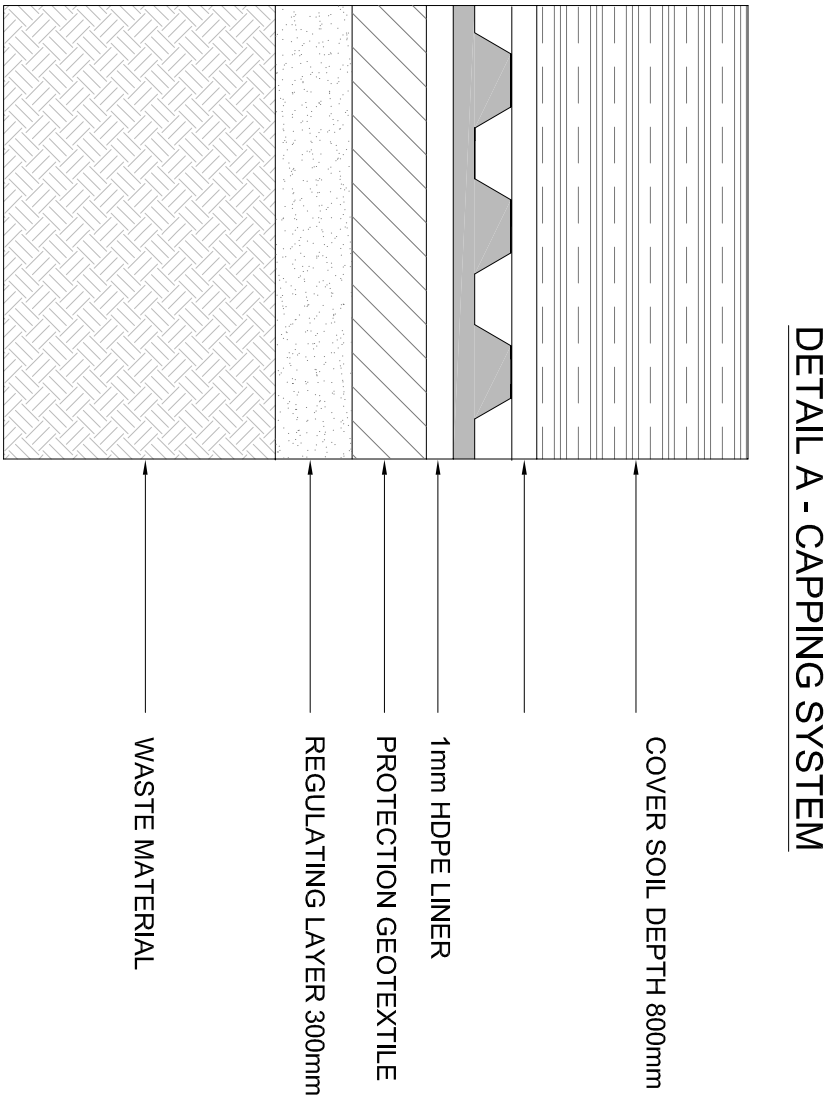


DESIGN CONTRACTS AND DELIVERY
DYLUNIO CONTRACTAU A DARPARU
Andrew Gregory
DIRECTOR FOR CITY SERVICES
CYFARWYDDWR GWASANAETHAU'R DDINAS

FOR CONSTRUCTION					
Rev	By	Date	Description of Amendment		
C	MJH	14/10/16	Issued for construction	TB	14/10/16
B	MJH	22/04/16	Redrawn	TB	22/04/16
A	MJH	08/04/16	Notes amended	TB	08/04/16

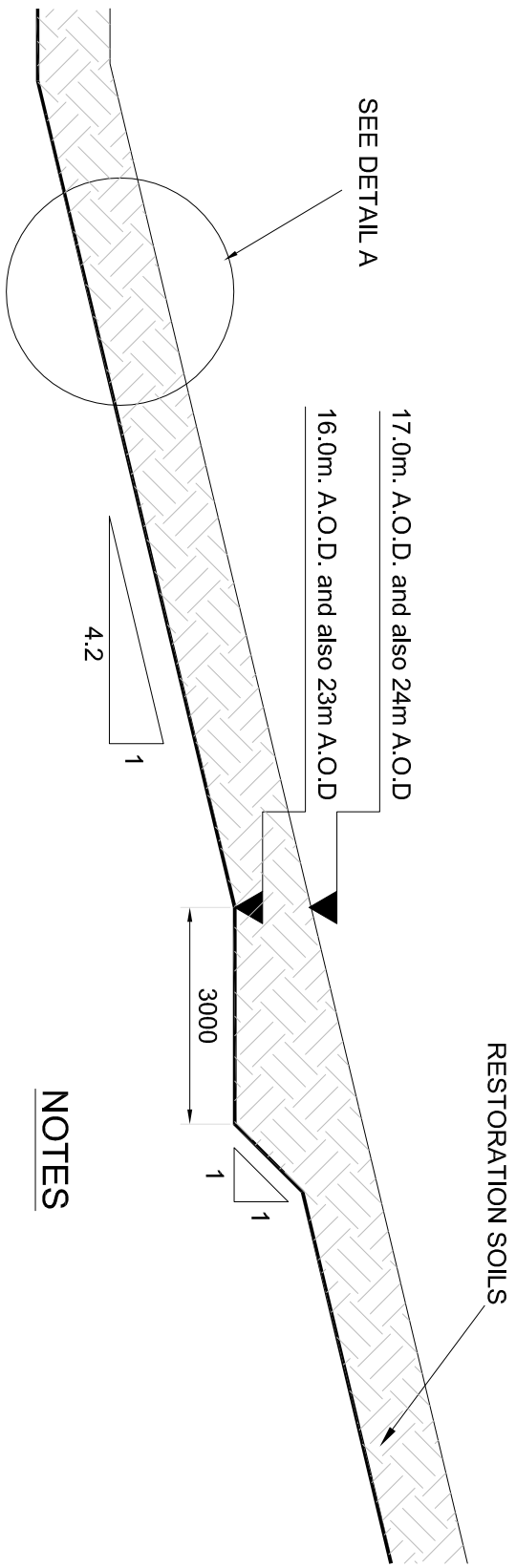
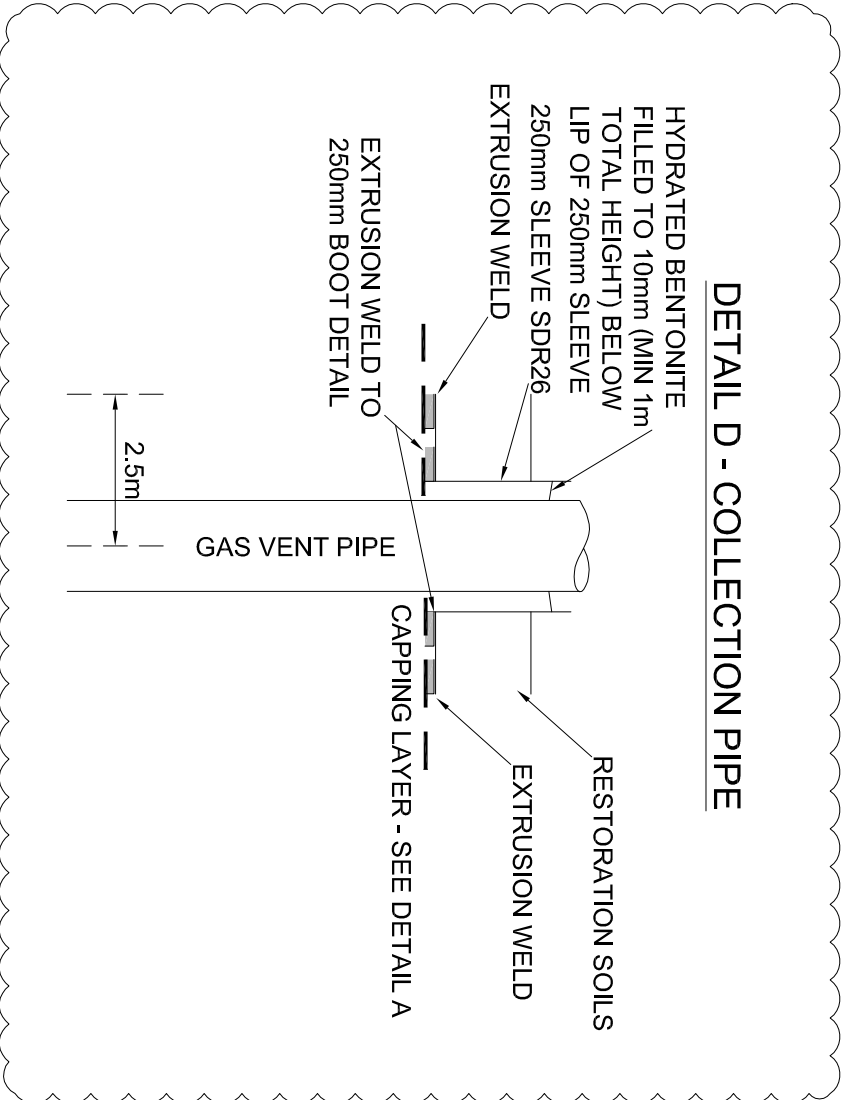
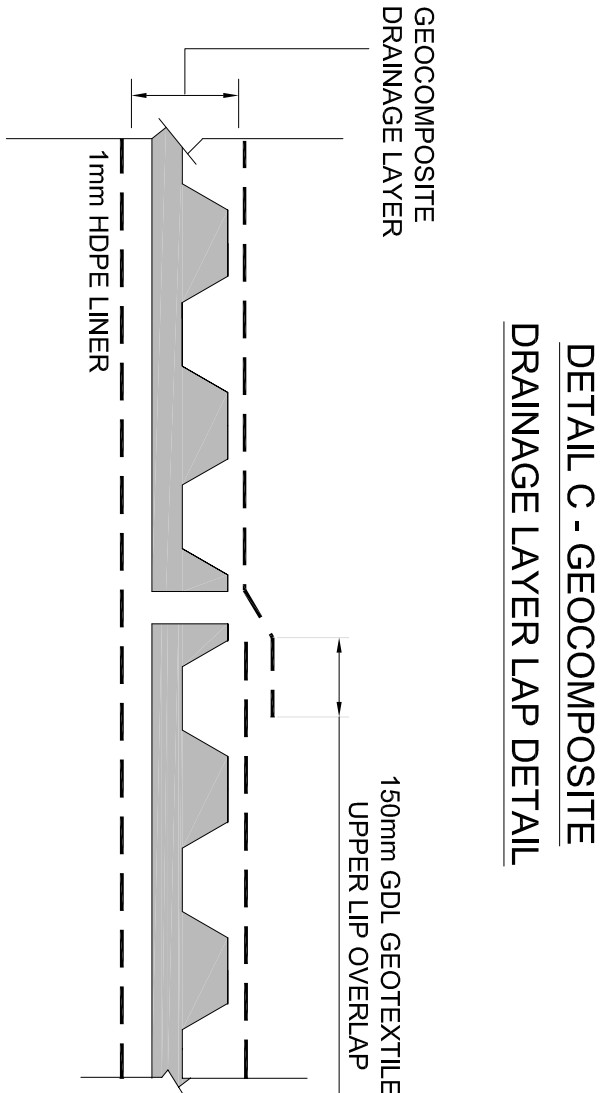
Project	LAMBY WAY LANDFILL SITE CAPPING WORKS CELL 4
Title	EXTENT OF CAPPING WORKS

Checked	TB	Path	
Drawn	MJH	Project Number	SPHTT-14405
Scale	1:1250@A1	Drawing Number	103
Date	APR'15		
do not scale drawing except for planning application purposes			
County Hall, Atlantic Wharf, Cardiff CF10 4UW Telephone 029 2287 2456			



NOTE

GEOCOMPOSITE DRAIN TO BE COMPATIBLE WITH TEXTURED HDPE.

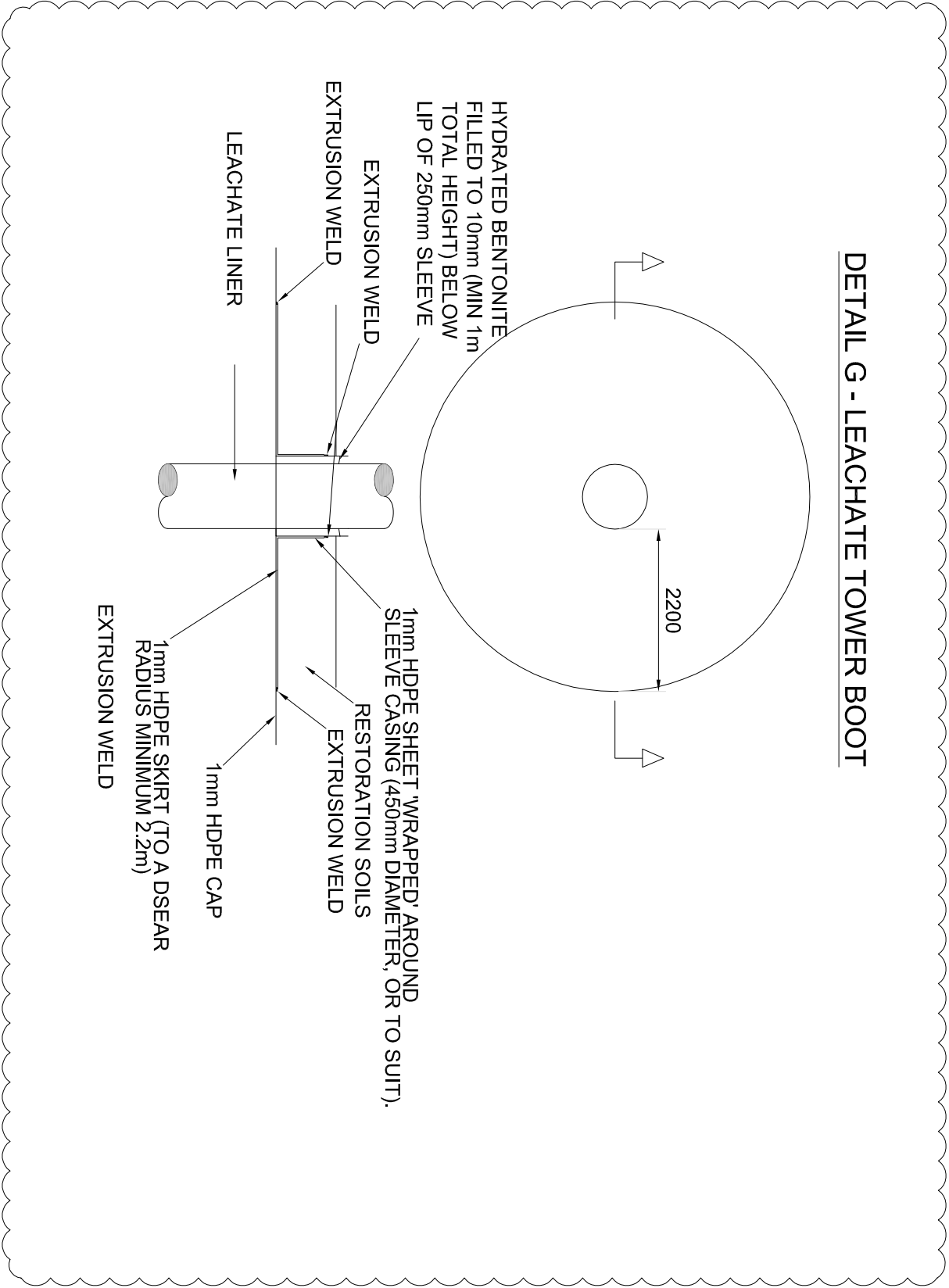


NOTES

OUTSIDE EDGE OF BENCH TO FOLLOW 16m. CONTOUR, POST-REGULATING LAYER.

GEOCOMPOSITE DRAINAGE LAYER TO OVERLAP ON BENCH BY 3.0m. IF REQUIRED.

NO LAPS OF GEOCOMPOSITE DRAINAGE LAYER WILL BE ALLOWED ON SIDE SLOPES. EXCEPT AT INTERMEDIATE BENCHES.

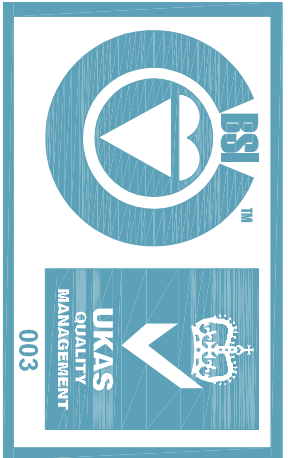


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Andrew Gregory
DIRECTOR FOR CITY SERVICES
CYFAIRYDDWR GYMRANLETHLWYR DDINAS

CARDIFF
CAERDYDD

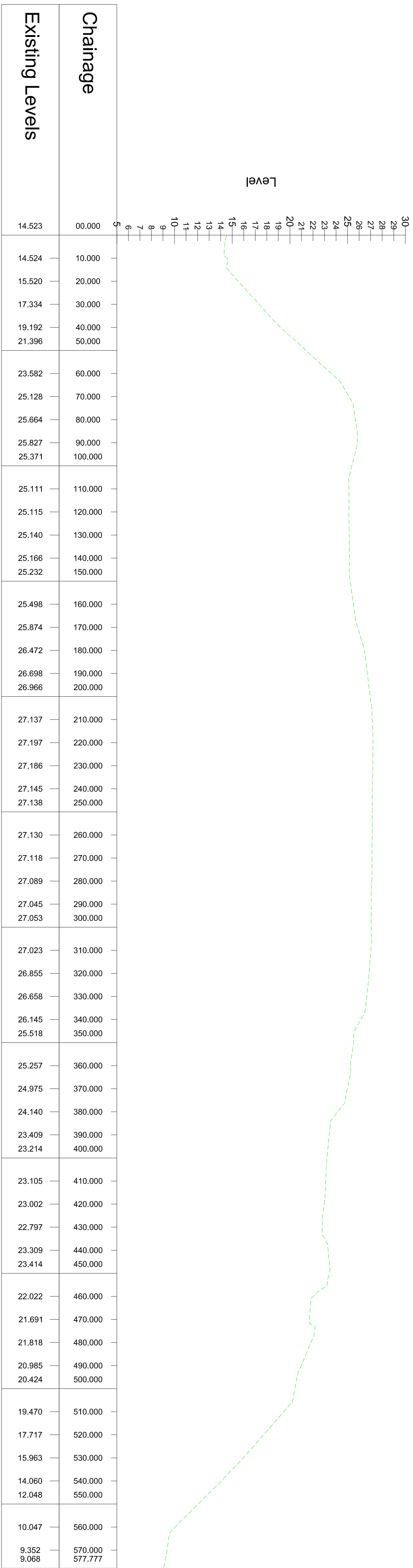
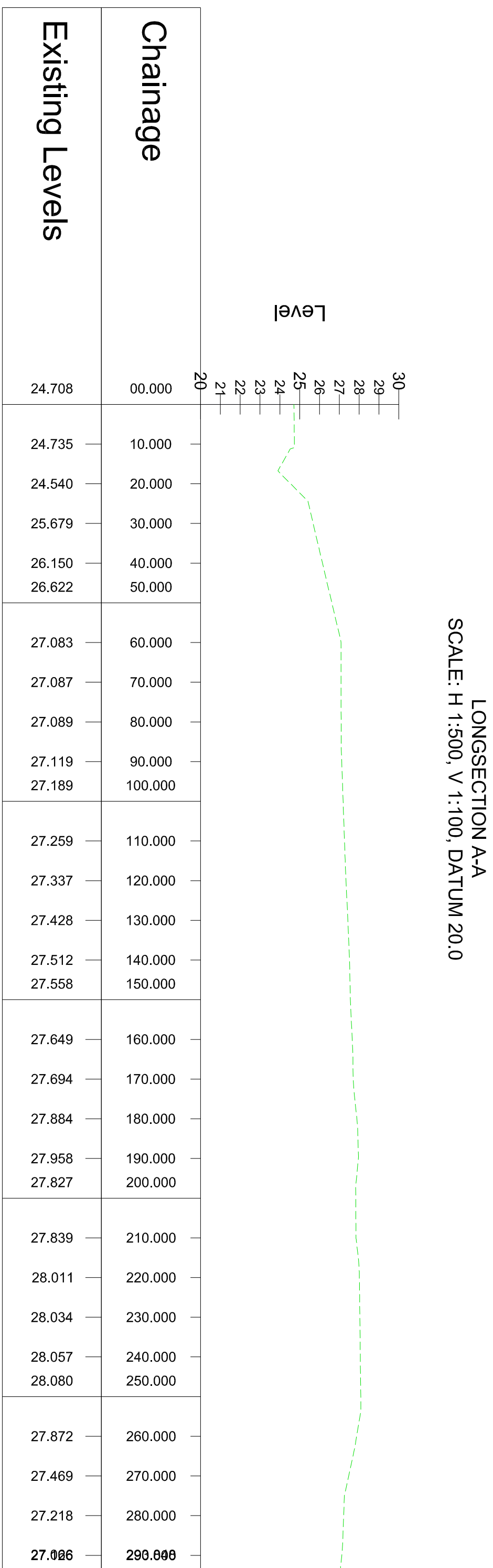
Rev	By	Date	Description of Amendment
A	MJH	08/04/16	Project name amended
B	MJH	14/10/16	Issued for construction - pipe boot detail amended

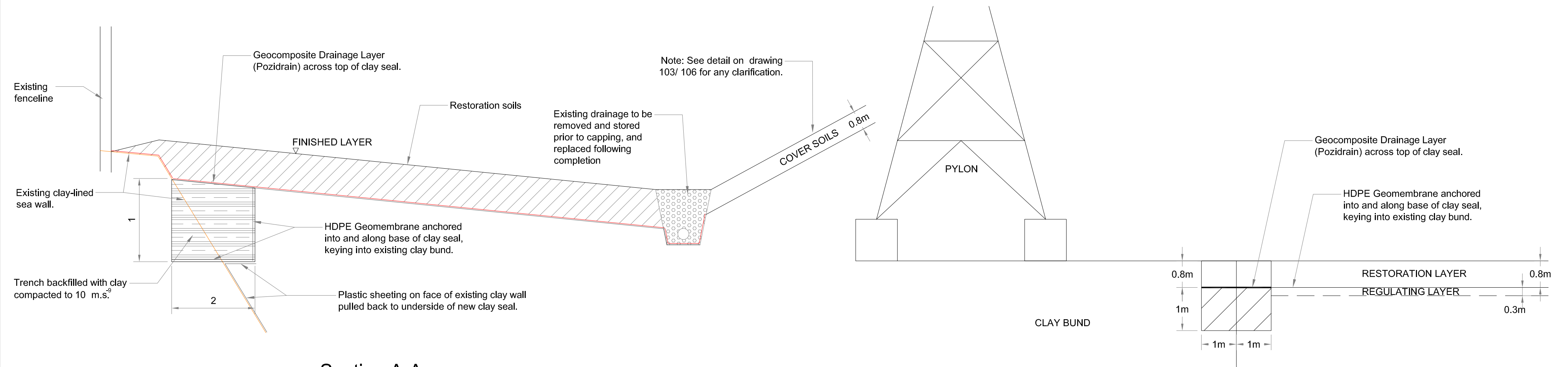
FOR CONSTRUCTION

Project	Project Name
LAMBY WAY LANDFILL SITE	CAPPING WORKS CELL 4

Checked	TB	Project Number	SPHTT-14405	Drawing Number	104
Drawn	MJH	Scale	NTS		
Date	APR 15				

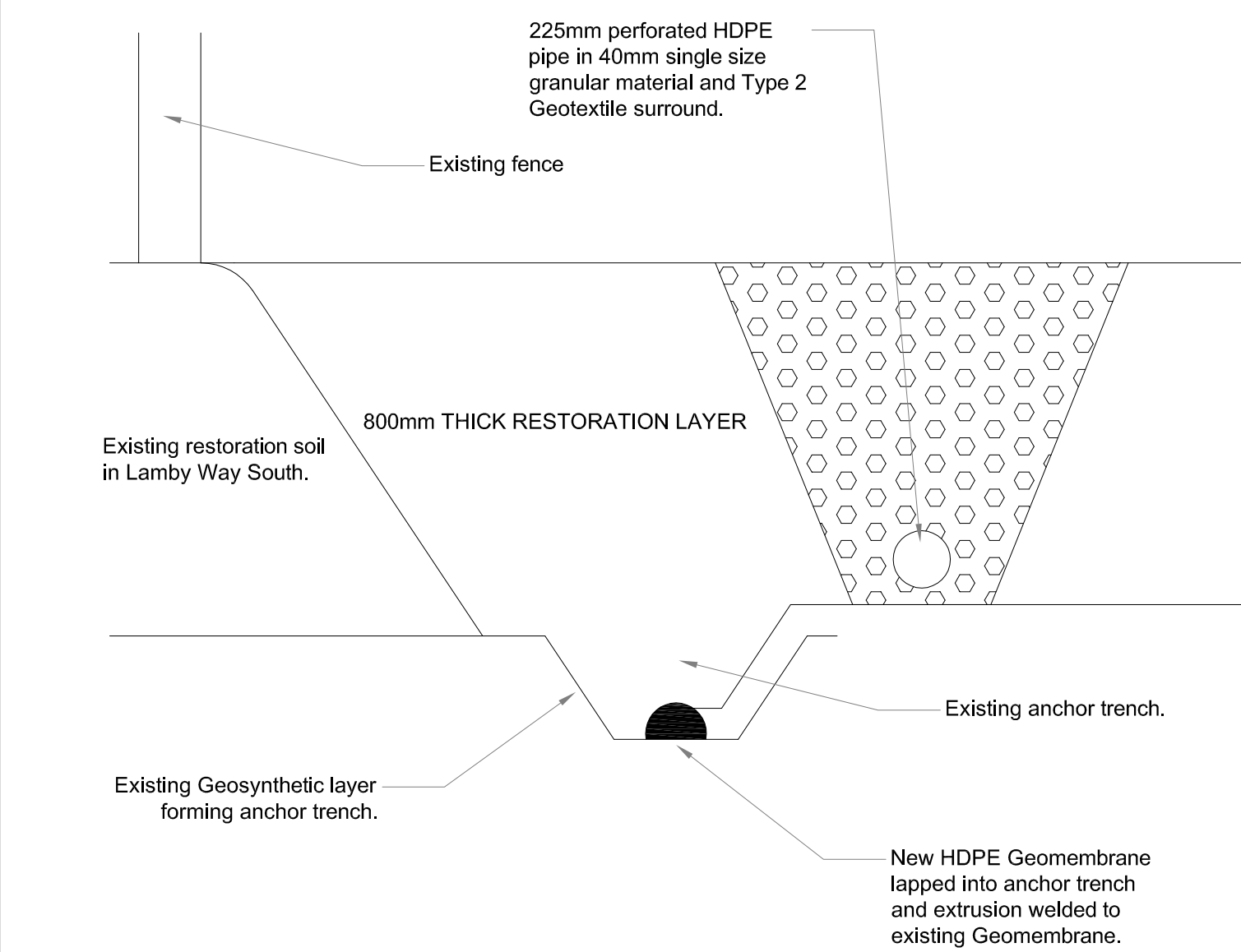
County Hall, Atlantic Wharf, Cardiff CF10 4UW
Telephone 029 2287 2486



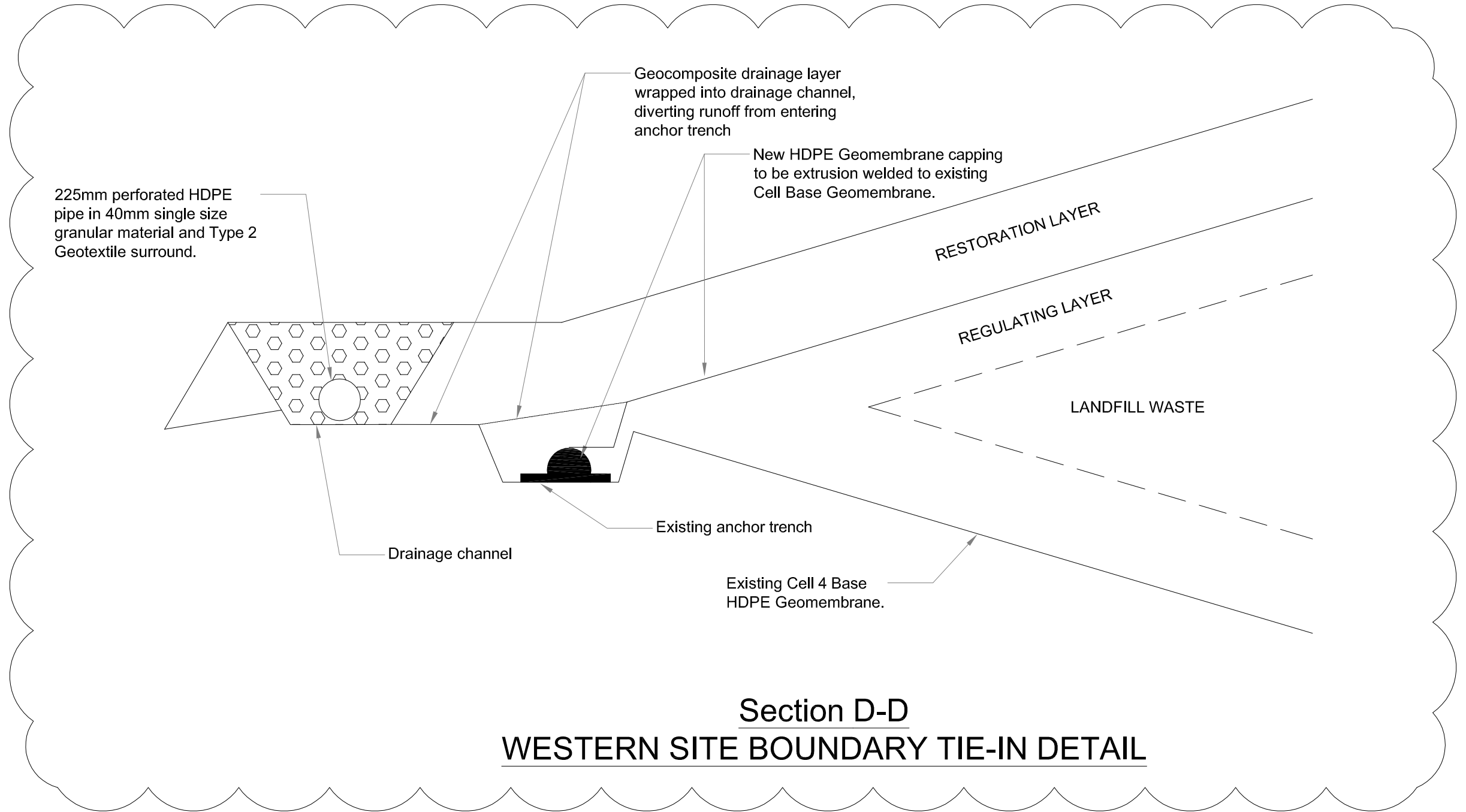


Section A-A
Seawall Detail

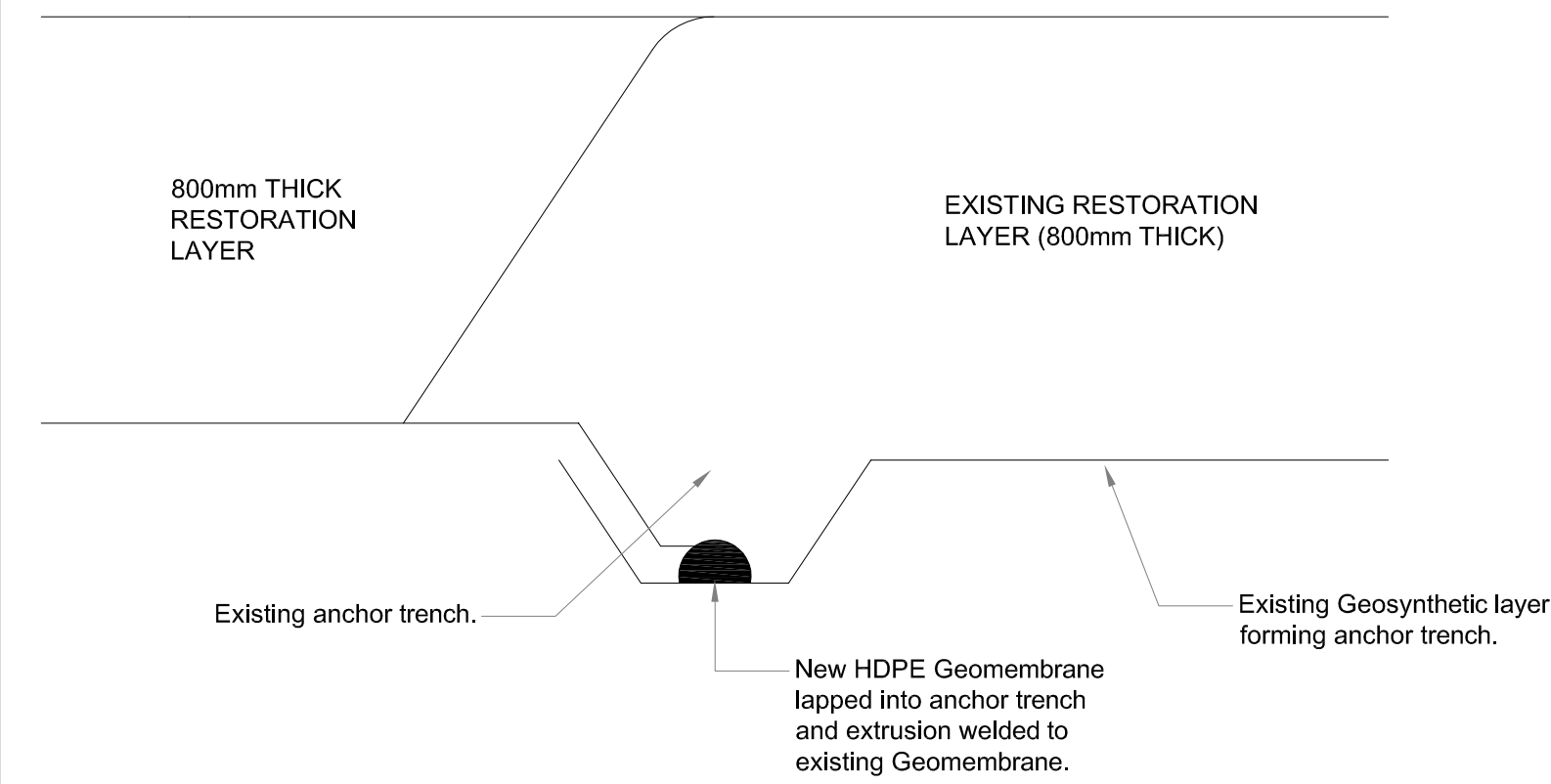
Section B-B
PYLON CLAY BUND DETAIL



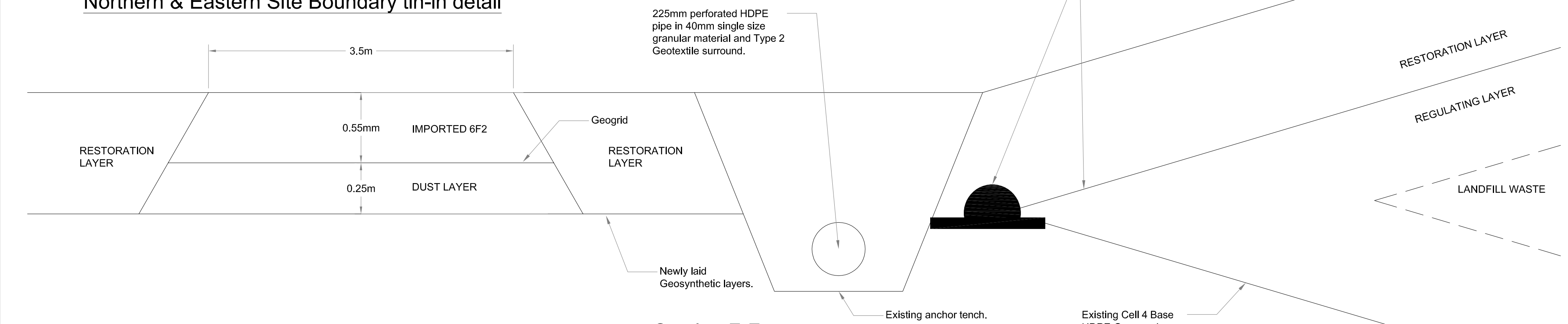
Section C-C
Tie-in Detail Along Slope



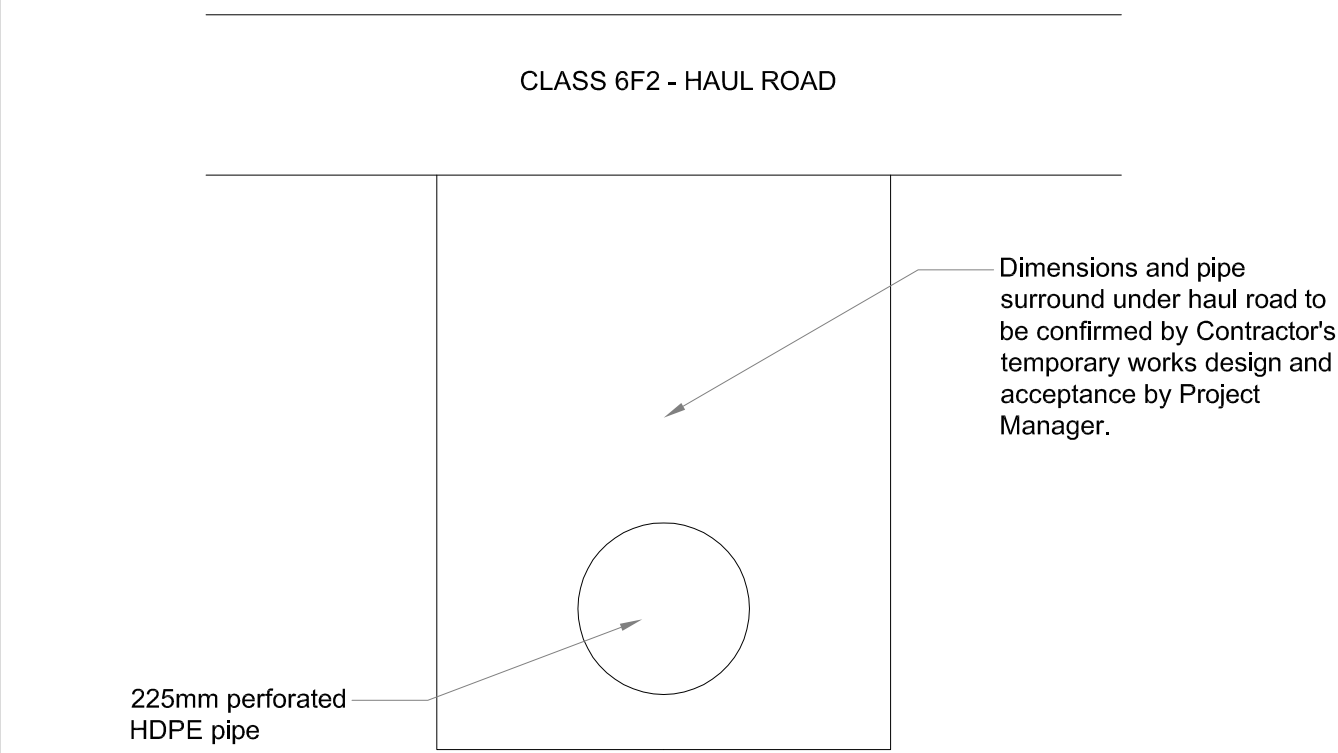
Section D-D
WESTERN SITE BOUNDARY TIE-IN DETAIL



Section E-E
Northern & Eastern Site Boundary tie-in detail

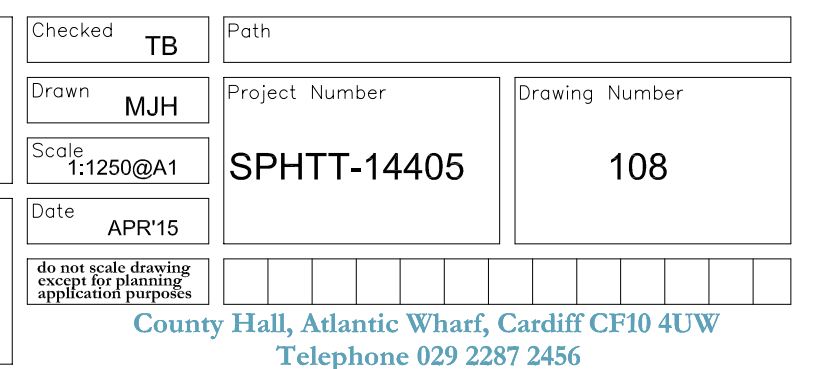


Section F-F
Haul Road Construction & Southern
Slope Tie-in Detail



Section G-G
Indicative Drainage at Haul Road Location

ALL POINTS ARE TO GPS COORDINATES WITH NO STATION POINTS ON THE SITE.



Appendix B. Confirmation of Familiarity with CQA Plan

All listed staff to confirm their familiarity with the above Quality Management Document(s) by signing and dating this form against their names. The holder of this document shall also sign to confirm familiarity and to confirm that all appropriate staff responsible to the holder are aware of the document contents. The original signed form shall be retained with the document, and a copy returned to the Company Quality System Manager, for record purposes.

[illegible]

Appendix C. Daily Summary Report

Date	Location					
Personnel Involved						
Weather Conditions (temp, cloud cover, rainfall)						
Summary of Meetings or Significant Discussions				Actions recommended / taken		
Location on site of Construction undertaken (see attached plan)						
Plant and Personnel being utilised						
Materials supplied to site: Description				Quantity		
Details of work accomplished						
Samples tested	Location of sample (see attached site plan)			Location of corrective action (see attached site plan)		
	Panel No.	Northing	Easting	Action required	Northing	Easting
Records of observations						
Decisions made		Relevant visitors		Signature of CQA Engineer		

Appendix D. Corrective Measures Report

Date	
Location of Problem (see attached site plan)	
Reason for Failure	Probable Cause
How and when was problem located?	
Notes of any disagreement between Contractor and CQA Engineer about the problem	
Suggested Corrective Action	Details of Corrective Action Undertaken
How can methodology be altered to prevent recurrence of this problem?	
Signature of CQA Engineer	

Appendix E. Formation Acceptance Sheets

Date:	Client:
Location:	
Partial/ Final Acceptance	
This document only applies to the acceptability of the _____ at Lamby Way Landfill Capping Works. We accept that the _____ provides a suitable surface on which to place the_____. Description of the area accepted: Accepted by: Contractor's Agent: CQA Engineer: Signature: Signature: Print Name: Print Name:	
Acceptance Number: -361053 - ____-	Area accepted: Numbers to

Appendix F. CQA Proforma Sheets

Project: Lamby Way Landfill Capping Works Cell 4
Project No: 361053

Mott MacDonald Ltd

Protective Geotextile Panel Deployment Summary

[illegible]

Project: Lamby Way Landfill Capping Works Cell 4
Project No: 361053

Mott MacDonald Ltd

HDPE Geomembrane Panel Deployment Summary

[illegible]

Mott MacDonald Ltd

[illegible]

Welding Technicians:

CQA Inspectors:

Project: Lamby Way Landfill Capping Works Cell 4
Project No: 361053

Mott MacDonald Ltd

Geocomposite Drainage Layer Panel Deployment Summary

[illegible]

Project: Lamby Way Landfill Capping Works Cell 4
Project No: 361053

Mott MacDonald Ltd

Delivery, Storage and Compliance Record

Product:

[illegible]

Appendix G. Highways Agency Specification for Highway Works (SHW), Series 600 – Acceptable Earthworks Materials: Classification and Compaction Requirements

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability (In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)				Compaction Requirements in Clause 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested In Accordance With:	Acceptable Limits Within:-					
									Lower	Upper				
General Cohesive Fill	2	A	-	Wet cohesive material	Regulating Layer	Any material or combination of materials, other than chalk.	(i) grading	BS 1377: Part 2	Table 6/2	Table 6/2	Table 6/4 Method 1	2	A	-
							(iv) MCV	Clause 632	7	12				
	2	B	-	Dry cohesive material	Regulating Layer	Any material or combination of materials, other than chalk.	(i) grading	BS 1377: Part 2	Table 6/2	Table 6/2	Table 6/4 Method 12	2	B	-
							(iv) MCV	Clause 632	12	15				
	2	C	-	Stony cohesive material	Restoration Layer	Any material or combination of materials, other than chalk.	(i) grading	BS 1377: Part 2	Table 6/2	Table 6/2	Table 6/4 Method 12	2	C	-
							(iv) MCV	Clause 632	7	15				
Topsoil	5	B	-	Imported topsoil	Topsoil	Multipurpose grade complying with BS 3882	-	-	-	-	-	5	B	-

Class				General Material Description	Typical Use	Permitted constituents (All subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability (In addition to requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)				Compaction Requirement in Clause 612	Class		
							Property (see Exceptions in Previous column)	Defined and Tested in accordance with:	Acceptable Limits Within:					
									Lower	Upper				
Selected Granular Fill	6	F	2	Selected granular material (coarse grading)	Haul Road	Any material or combination of materials, other than unburnt colliery spoil and argillaceous rock. (Property (i) in next column shall not apply to chalk.) Recycled aggregate.	(i) grading	BS 1377:Part 2	Table 6/2	Table 6/2	Table 6/4 Method 6 of the SHW	6	F	2
							(ii) optimum mc	BS 1377: Part 4 (vibrating hammer method)	-	-				
							(iii) mc	BS 1377: Part 2	Optimum mc – 2%	Optimum mc + 2%				
Selected Granular Fill	7	C	-	Selected granular material	Regulating Layer	Any material or combination of materials, other than unburnt colliery spoil and chalk. (Properties (viii), (x) and (xii) in text column shall apply when metallic reinforcing elements, facing units or fastenings are used)	i) Grading	BS 1377: Part 2	Table 6/2	Table 6/2	Table 6/4 Method 1 of the SHW	7	C	-
							(ii) mc	BS 1377: Part 2	Optimum mc – 2%	Optimum mc + 2%				
							(iii) MCV	Clause 632	-	-				

Percentage by Mass Passing the Size Shown																					
Class	Size (mm)		Size (mm) BS Series													Size (microns) BS Series				Size microns	Class
	500	300	125	90	75	37.5	28	20	14	10	6.3	5	3.35	2	1.18	600	300	150	63	2	
2A& 2B			100											80-100					15-100		2A& 2B
2C			100											15-80					15-80		2C
6F2			100	80-100	65-100	45-100				15-60		10-45				0-25			0-12		6F2
7C			100		85-100				83-100					80-100		60-100			15-45	0-20	7C

Appendix H. Testing Equipment for Manufacturing Quality Control of HDPE Geomembrane Rolls Delivered to Site

Table H.1: High Density Polyethylene (HDPE) Geomembrane (Textured)

Table 2(b) – High Density Polyethylene (HDPE) Geomembrane - Textured

Properties	Test Method	Test Value							Testing Frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mils (min. ave.) (1)	D 7466	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	every 2 nd roll (2)
Density (min. ave.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	90,000 kg
Tensile Properties (min. ave.) (3) • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	11 kN/m 8 kN/m 12% 100%	15 kN/m 10 kN/m 12% 100%	18 kN/m 13 kN/m 12% 100%	22 kN/m 16 kN/m 12% 100%	29 kN/m 21 kN/m 12% 100%	37 kN/m 26 kN/m 12% 100%	44 kN/m 32 kN/m 12% 100%	9,000 kg
Tear Resistance (min. ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min. ave.)	D 4833	200N	267 N	333 N	400 N	534 N	667 N	800 N	20,000 kg
Stress Crack Resistance (4)	D 5397 (App.)	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	per GRI GM10
Carbon Black Content (range)	D 4218 (5)	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	9,000 kg
Carbon Black Dispersion	D 5596	note (6)	note (6)	note (6)	note (6)	note (6)	note (6)	note (6)	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) (7) (a) Standard OIT — or — (b) High Pressure OIT	D 3895 D 5885	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	90,000 kg
Oven Aging at 85°C (7), (8) (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	per each formulation
UV Resistance (9) (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs (11)	GM11 D 3895 D 5885	N.R. (10) 50%	N.R. (10) 50%	N.R. (10) 50%	N.R. (10) 50%	N.R. (10) 50%	N.R. (10) 50%	N.R. (10) 50%	per each formulation

- (1) Of 10 readings; 8 out of 10 must be ≥ 0.18 mm, and lowest individual reading must be ≥ 0.13 mm; also see Note 6.
- (2) Alternate the measurement side for double sided textured sheet
- (3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm
- (4) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
- (5) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3
- (7) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(8) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
- (9) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
- (10) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
- (11) UV resistance is based on percent retained value regardless of the original HP-OIT value.