

AMGEN CYMRU



CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN
FOR PHASE 4A PART II (2023)
PERMANENT CAPPING WORKS
AT BRYN PICA LANDFILL SITE

CQA Plan Reference: AM5593 Rev1
July 2023



Project Quality Assurance

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Purpose

This document was prepared as a Construction Quality Assurance (CQA) Plan for the construction of an area of permanent capping at Bryn Pica Landfill Site for Amgen Cymru (Cynon Valley Waste Disposal Limited). Sirius Environmental Limited (Sirius) accepts no responsibility or liability for any use that is made of this document other than by the Client, Amgen Cymru, for the purposes for which it was originally commissioned and prepared.

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1 SCOPE OF THE CONSTRUCTION WORKS

1.1 General Description

The design concepts for the capping construction were developed in accordance with the PPC Permit for the site (and the associated risk assessments). The capping area to be constructed as Phase 4A Part II Permanent Capping is located in the centre of the landfill site.

The capping system design closely follows the existing site-wide capping design, utilising an LLDPE geomembrane capping liner with geocomposite protection and drainage layers (GDLs) above and below, to transmit surface seepage water (within the restoration soils) and any perched leachate and landfill gas (within the underlying waste mass) respectively. For details of the capping design used previously for the site, the CQA Method Statement and Quality Plan for the Phase 4A Capping Works should be referred to (**Report Number 1384r1v2d0714**).

The position of the proposed permanent capping area, in relation to previous capping phases, is shown on **Drawing AM5593/01/01**. The locations of tie-ins for the permanent capping area, and other infrastructure to be constructed as part of the works, as well as the tie-in and construction details for the area, are shown on **Drawing AM5593/01/02** and **Drawing AM5593/01/03**, which form part of the Specification included as **Appendix 1**.

Construction of the capping system for this phase of the works will involve:

- Removal of existing temporary capping geomembrane from the permanent capping area (where relevant);
- General trimming of waste cover soils / waste re-grade as required;
- Installation of a perched leachate collection trench in the existing waste along the north-western (provisional) and south-western edges of the permanent capping area (a shown on Section A-A' and Section D-D');
- Placement and trimming of a 300mm thick bedding/regulating soils layer over the whole open waste area, to achieve the formation levels for the geo-synthetics;
- Installation of a lower protection and drainage geo-composite over the regulated surface;

- Installation of a fully welded, 1mm thick, double-textured linear low density polyethylene (LLDPE) geomembrane cap above the lower protection and drainage geo-composite;
- Installation of an upper protection and drainage geo-composite over the LLDPE capping geomembrane;
- Tie-in to existing permanent geosynthetic capping system;
- Sealing of the capping system around protuberances;
- Installation of a 300mm thick (or greater, if placed as one layer) blinding/protection soils layer, and a further 700mm (or less, if the initial layer is greater than 300mm) of restoration soils, above the upper drainage geocomposite;
- Excavation of surface water ditches (and an associated culverted road crossing) close to the perimeter of the capping slope along the south-western edge of the permanent capping area, and above the existing Phase 3A capping system; and
- Installation of a 400mm thick unbound unsurfaced access haul road (and associated safety protection bund) along eastern side of the permanent capping area.

2 CQA SUPERVISION

2.1 General

The CQA Project Team will comprise the following:

The CQA Engineer - Office based, and responsible for the following:

- Administration of the CQA Plan;
- Attendance at selected progress, or liaison, meetings and is the key contact with the regulatory officers (NRW); and
- Production of the CQA Validation Report.

The CQA Inspector – The representative of the CQA Engineer located full time at the site during works requiring CQA supervision and responsible for the following:

- The on-site representative of the CQA Engineer;
- To be fully familiar with all CQA requirements for the project;
- Attendance at all CQA-related meetings (e.g. Pre-construction and Progress);
- Liaison with Natural Resources Wales (NRW) staff and the Employer;
- Supervision and checking of surveying or other such procedures involved in the recording of the works;
- Preparation, or overseeing the ongoing preparation of the as-built drawings;
- Assigning locations for testing and sampling;
- Keeping daily reports and records of all site operations, testing and site conditions. The records shall be used to provide certification of the preparatory and engineering works, and shall be made available to NRW if and when required;
- Reporting to the CQA Engineer any relevant observations;
- Overseeing the collection and shipping of all samples for laboratory testing;
- Reviewing the results of laboratory testing and making appropriate recommendations;
- Reporting any unresolved deviations from this CQA Plan to the CQA Engineer;
- Provision of all records and relevant data to the CQA Engineer for the preparation of the final validation report, which will be submitted to NRW for approval upon completion of the works;

- Noting and bringing to the attention of the Contractor any on-site activities that could result in damage to the liner system; and
- Supervision of the construction works, and verification that the works carried out are constructed in accordance with all requirements of the Specification and CQA Plan.

Staff undertaking the roles of the CQA Engineer and the CQA Inspector should have relevant experience in landfill construction and earthworks control or be supervised by experienced staff until relevant experience is obtained. The CVs of the CQA Project Team shall be supplied to Natural Resources Wales (NRW) prior to commencement of the works. Should changes to CQA personnel be required, NRW shall be immediately notified and the respective CV shall be issued.

2.2 Definitions

For the sake of clarification the following definitions are given:

Construction Quality Assurance (CQA)

- Means a planned and systematic pattern of all means and actions designed to provide confidence that items or services meet contractual and regulatory requirements and shall perform satisfactory in service.

Construction Quality Assurance refers to means and actions employed by the Supervisor, to assure conformity of the preparation, production and installation of this CQA Plan, the Contract Drawings, and Specification. CQA is to be provided by an independent consultant appointed by Amgen Cymru.

Construction Quality Control (CQC):

- Means “those actions that provide a means to measure and regulate the characteristics of an item or service to contractual requirements”.

Construction Quality Control refers to those actions taken by Manufacturers, Installers, Contractors, or the Employer to ensure that the materials and the workmanship meet the requirements of the Contract Drawings and Specification.

Employer:

Means “the person or persons, firm or company or other body whom own and have responsibility for the facility”. For the works undertaken at Bryn Pica Landfill Site, the

Employer is Amgen Cymru. The Employer has entered into a contract with a Contractor for the execution of the works detailed in the Specification and Contract Drawings. Personal representatives or other parties, e.g. the Supervisor, may represent the Employer on site.

Contractor:

Means 'the person or persons, firm, company or other body to whom the contract has been awarded by the Employer, and includes the Contractor's personal representatives or other parties, e.g. Sub-contractors, Manufacturers.

The Contractor shall undertake the execution of the works under the terms of the Contract.

Specification:

Means, 'that part of the Contract entered into between the Employer and the Contractor, which sets out the Employer's detailed requirements as to how the works should be constructed, tested, measured and quality assured'.

This CQA Plan is to be read in conjunction with the **Specification Reference AM5593** which is included as **Appendix 1** of this CQA Plan.

2.3 Design Changes

Any design changes required to ensure the suitability of the construction works shall be referred to the Principal Designer prior to discussions with NRW for approval.

2.4 Daily Meetings

Meetings will be held daily between the CQA Inspector and the Contractor's representative, the purpose of which is to:

- Review the work activities and locations for that day;
- Note the Contractor's installation personnel and plant for the day/shift;
- Review the previous day's progress;
- Review the work schedule;
- Discuss any interfacing with other contractors and/or site operations; and
- Discuss/highlight any problems and identify solutions.

The CQA Inspector shall report weekly in summary form to NRW and will highlight any unusual or unexpected occurrences immediately for discussion. Full records shall be kept by the CQA Inspector on a day to day basis detailing all site operations, tests carried out and the site conditions. The records will be made available for inspection by representatives of NRW.

2.5 Site Visits

It is anticipated that from time to time NRW will visit the site to review the works. During these visits the CQA Inspector shall make available all test results and daily records up to that date for inspection by NRW.

Any problem encountered during construction should be discussed with NRW upon their arrival to site prior to any subsequent site walk-over. The CQA Inspector shall discuss the problems encountered and discuss any proposed remediation methods.

2.6 CQA Requirements

The CQA requirements associated with each component of the works are detailed in the individual sections below.

2.7 CQA Proformas

All proformas in **Appendix 2** are to be completed during the works to record the specific elements, these are all to be completed and submitted as part of the CQA Validation Report.

3 LEACHATE COLLECTION DRAIN

3.1 CQA Requirements

The works shall be carried out using Construction Quality Assurance (CQA) procedures developed for the works and which form part of this CQA Plan. The CQA Inspector shall observe, record and oversee the works as required to complete the CQA programme.

The CQA procedures include for checking of various parts of the works in a systematic way and include, but are not limited to consideration of the following elements.

The CQA Inspector shall:

- Assess the method statement submitted by the Contractor for the installation of the leachate collection drain;
- Ensure that the pipe materials are delivered, handled and stored in accordance with the manufacturer's recommendations;
- Assess pipework manufacturers' quality control data and calculations confirming that the proposed pipes and connections meet the Specification prior to installation;
- Ensure that the pipework is installed at the locations indicated on the relevant drawings and in accordance with the Specification;
- Ensure that all trenches are constructed to the correct details and dimensions, and are in the positions shown on the Drawings;
- Ensure all pipework jointing is done by only experienced and qualified personnel as stated in the Specification;
- Ensure that the pipework connections are constructed in accordance with the Specification;
- Ensure that all pipework and fittings are suitable for water;
- Ensure that pipework is installed in accordance with the construction details on the drawings, that the pipes are jointed to give a water tight seal, and that there is adequate bedding, surround and cover for the pipes;
- Ensure that the correct falls have been achieved on all pipework;
- Provide continuous monitoring of the gravel placement to identify any non-compliant material; and

- Ensure that conformance testing is carried out on the gravel in accordance with the requirements of the Specification.

All laboratory testing will be undertaken by UKAS Accredited Laboratories, with accreditation for all required tests.

The CQA Inspector shall fully document each item above and the documentation shall be presented in the CQA Validation Report.

4 EARTHWORKS REQUIREMENTS

4.1 CQA Requirements

The CQA Inspector shall:

- Assess the method statement submitted by the Contractor for the installation of the bedding / regulating soils layer;
- Assess the results of source evaluation testing, as required by the Specification, and confirm whether the proposed bedding / regulating soils layer material is acceptable for use based on the particle size distribution (PSD) and chemical suitability (Inert WAC) testing requirements;
- Ensure that all material within the working area deemed unsuitable in accordance with the Specification is removed to an area agreed with Amgen Cymru's Site Manager;
- Ensure that any existing temporary capping geomembrane is removed from the capping area;
- Provide approval as to the adequacy of the prepared waste surface prior to installation of the bedding / regulating soils layer;
- Ensure that only suitable soils as defined in the Specification are used as the bedding / regulating soils layer, this is to include stone picking to remove any unsuitable particles, to ensure that the particle size limits for the bedding / regulating soils layer as defined in the Specification are adhered to during placement;
- Ensure the bedding / regulating soils layer is tied-in to existing bedding / regulating soils layer in accordance with the Specification and the construction details on the drawings;
- Ensure that the materials used for bedding / regulating soils layer are classified using the Particle Size Distribution (PSD) testing results, in accordance with the Specification;
- Ensure that the materials used for bedding / regulating soils layer are conformance tested, in accordance with the requirements of the Specification;
- Ensure that adequate compaction is applied to the bedding / regulating soils layer material, in accordance with the Specification;

- Monitor the placement and compaction of the fill materials, ensuring that the works are carried out in accordance with the Specification and the required depth is placed;
- Physically verify the undrained shear strength of cohesive materials (on a 25m grid) using a calibrated hand shear vane to ensure a minimum in-situ undrained shear strength of 40kN/m² has been achieved;
- Ensure that the immediate surface upon which the lower drainage geocomposite / LLDPE geomembrane is to be installed is smooth and free of all rocks, stones, roots, sharp objects, or debris of any kinds;
- Ensure that the surface of the bedding / regulating soils layer provides a firm foundation for the capping system with no sudden, sharp, or abrupt changes in grade, and no standing water or excessive moisture, this is to include measurements for smoothness and flatness with a lath as detailed in the Specification;
- Ensure that all areas of non-compliance are remediated in accordance with the Specification;
- Take photographs during the construction;
- Ensure that surveys / trial pit checks are undertaken in accordance with the Specification to confirm that the requisite levels and layer thicknesses have been achieved; and
- Provide written certification to the Contractor that the surface on which the lower drainage geocomposite / LLDPE geomembrane is to be installed is acceptable prior to installation, and that the slope gradients meet the requirements of the slope stability analysis (within the permanent capping area) included within the Specification. Written certification may be withdrawn in the event of surface deterioration by any cause and only re-issued by the CQA Inspector upon remedial works being compliant with the Specification.

All laboratory testing will be undertaken by UKAS Accredited Laboratories, with accreditation for all required tests.

The CQA Inspector shall fully document each item above and the documentation shall be presented in the CQA Validation Report.

5 LOWER DRAINAGE GEOCOMPOSITE

5.1 CQA Requirements

The CQA Inspector shall:

- Assess the method statement submitted by the Contractor detailing their proposed deployment and seaming techniques for the lower drainage geocomposite;
- Review the manufacturer's installation recommendations for the geocomposite;
- Ensure the minimum testing requirements for the geocomposite product to be used within the works are in accordance with the requirements of the Specification;
- Ensure that the materials are delivered, handled and stored in accordance with the Specification and the manufacturer's recommendations;
- Make a visual inspection of each roll as it is unloaded to identify any damage and record the relevant information for each roll;
- Assess all geocomposite product manufacturers' quality control certificates to confirm that the geocomposite product meets the requirements of the Specification prior to installation;
- Assess and approve, with respect to the requirements set out in the Specification, the proposed panel layout for the geocomposite to be submitted by the Contractor. The methodology shall show the Contractor's proposed start point and direction of working. The panels shall be arranged so that seams are aligned parallel to the line of maximum slope (i.e. normal to contours), wherever practicable, in accordance with accepted good practice. The panel layout shall seek to minimise the number of required heat bonded seams;
- Identify rolls from which conformance samples of the geocomposite are to be taken for laboratory conformance testing in accordance with the Specification;
- Assess the results of conformance tests to ensure compliance with the Specification. Should any materials fail to meet the requirements of the Specification, the CQA Inspector shall reject the failed roll and schedule further testing in accordance with the Specification;
- Provide written certification to the Contractor that the surface on which the geocomposite is to be installed is acceptable prior to installation. *Note the CQA Inspector may withdraw the certificate should the surface deteriorate for any cause*

prior to installation and only reissue upon remediation works being compliant with the Specification;

- Witness all panel deployment ensuring compliance with the Specification;
- Witness all seam constructions ensuring compliance with the Specification, including ensuring that panel overlaps / joints are constructed correctly and that upslope panels are placed beneath downslope panels where joints between the ends of panels are required;
- Ensure that all defects are identified on the geocomposite and witness that they are repaired in accordance with the Specification;
- Ensure that the geocomposite is installed to the base of the leachate collection drain, as shown in the Drawings;
- Ensure that a defect free tie-in with the existing drainage geocomposite in adjacent capping phases is constructed (where applicable);
- Ensure that geocomposite and seam construction continues to the back of anchor trenches (if anchor trenches, as opposed to perimeter/free edge termination trenches, are applicable);
- Ensure that geocomposite and seam construction continues into the drainage ditches around the base of the capping area (if/where required);
- Ensure that geocomposite is installed in accordance with the construction details on the Drawings and Specification at the location of leachate and gas wells;
- Provide written certification to the Contractor of areas approved to be covered with the geomembrane; and
- Ensure that on completion of the lower drainage geocomposite installation the Contractor produces a fully referenced as-built panel layout plan including all the detail listed within the Specification.

All laboratory testing will be undertaken by UKAS Accredited Laboratories, with accreditation for all required tests.

The CQA Inspector shall fully document each item above and the documentation shall be presented in the CQA Validation Report.

6 GEOMEMBRANE LINER

6.1 CQA Requirements

The CQA Inspector shall:

- Assess the method statement submitted by the Contractor detailing their proposed deployment, seaming, testing and tie-in techniques;
- Review the manufacturer's installation recommendations for the geomembrane;
- Assess and approve, with respect to the requirements set out in the Specification, the proposed panel layout for the geomembrane to be submitted by the Contractor. The drawing should show the Contractor's proposed start point and direction of working, and the panels should be arranged so that seams are aligned parallel to the line of maximum slope (i.e. normal to contours), wherever practicable, in accordance with accepted good practice. The panel layout should seek to minimise the number of required overlapped seams;
- Ensure that the materials are delivered, handled and stored in accordance with the Specification and the manufacturer's recommendations;
- Ensure all welders hold and can produce current third party certification for welding and installation to the standard indicated in the Specification, prior to any welding taking place;
- Make a visual inspection of each roll as it is unloaded to identify any damage and record the relevant information for each roll;
- Assess all manufacturers' quality control certificates prior to installation to confirm that the material meets the requirements of the Specification prior to installation;
- Identify rolls from which conformance samples of the geomembrane are to be taken for laboratory conformance testing in accordance with the Specifications;
- Assess the results of conformance tests to ensure compliance with the Specification. Should any materials fail to meet the requirements of the Specification; the CQA Inspector shall reject the failed roll and/or schedule further testing in accordance with the Specification;
- Inspect the subgrade and verify that it is in full accordance with the Specification. This includes taking measurements using appropriate equipment on areas where an

adverse change of gradient is suspected (where geomembrane is to be installed directly onto the bedding / regulating soils layer);

- Ensure that the immediate surface upon which the geomembrane is to be installed is generally smooth and free of deleterious materials which may damage the geomembrane;
- Provide written certification to the Contractor that the surface on which the geomembrane is to be installed is acceptable prior to installation. *Note the CQA Inspector may withdraw the certificate should the surface deteriorate for any cause prior to installation and only reissue upon remediation works being compliant with the Specification;*
- Witness all panel deployment ensuring compliance with the Specification;
- Witness all trial seaming ensuring compliance with the Specification, including the requirements for welding at ambient temperatures above 25°C;
- Witness all seam constructions to ensure compliance with the Specification verifying that all surfaces are completely clean, dry and free from imperfections and the correct overlap has been achieved;
- Witness all seam constructions to ensure that welding speeds and temperatures used in successful trial welds are the same used in field seaming;
- Ensure non-destructive testing is carried out in accordance with the Specification;
- Ensure that all defects / repairs and patch works are identified on the geomembrane and witness that they are repaired in accordance with the Specification;
- Ensure qualitative destructive testing is carried out in accordance with the requirements of the Specification;
- Instruct the Contractor as to the location of quantitative destructive test samples to be taken at the frequency detailed in the Specification;
- Ensure quantitative destructive test samples are sent to a laboratory accredited for all tests required within the Specification and that sub-samples are retained on site;
- Review the results of quantitative destructive testing to ensure that the testing has been undertaken in accordance with, and met, the Specification required values;
- Ensure that a defect free tie-in with the existing geomembrane of previous capping phases is constructed;

- Ensure that geomembrane and seam construction continues to the back of anchor trenches (where applicable);
- Ensure that all protuberances are sealed around in accordance with the Specification and the relevant construction details on the Drawings;
- Ensure that on completion of the geomembrane installation the Contractor produces a fully referenced as-built panel layout plan including all the detail listed within the Specification.

All laboratory testing will be undertaken by UKAS Accredited Laboratories, with accreditation for all required tests.

The CQA Inspector shall fully document each item above and the documentation shall be presented in the CQA Validation Report.

7 UPPER DRAINAGE GEOCOMPOSITE

7.1 CQA Requirements

The CQA Inspector shall:

- Assess the method statement submitted by the Contractor detailing their proposed deployment and seaming techniques;
- Review the manufacturer's installation recommendations for the geocomposite;
- Ensure the minimum testing requirements for the geocomposite product to be used within the works are in accordance with the requirements of the Specification;
- Ensure that the materials are delivered, handled and stored in accordance with the Specification and the manufacturer's recommendations;
- Make a visual inspection of each roll as it is unloaded to identify any damage and record the relevant information for each roll;
- Assess all geocomposite product manufacturers' quality control certificates to confirm that the geocomposite product meets the requirements of the Specification prior to installation;
- Assess and approve, with respect to the requirements set out in the Specification, the proposed panel layout for the geocomposite to be submitted by the Contractor. The methodology shall show the Contractor's proposed start point and direction of working. The panels shall be arranged so that seams are aligned parallel to the line of maximum slope (i.e. normal to contours), wherever practicable, in accordance with accepted good practice. The panel layout shall seek to minimise the number of required heat bonded seams;
- Identify rolls from which conformance samples of the geocomposite are to be taken for laboratory conformance testing in accordance with the Specification;
- Assess the results of conformance tests to ensure compliance with the Specification. Should any materials fail to meet the requirements of the Specification, the CQA Inspector shall reject the failed roll and schedule further testing in accordance with the Specification;
- Provide written certification to the Contractor that the surface on which the geocomposite is to be installed is acceptable prior to installation. *Note the CQA Inspector may withdraw the certificate should the surface deteriorate for any cause*

prior to installation and only reissue upon remediation works being compliant with the Specification;

- Witness all panel deployment ensuring compliance with the Specification;
- Witness all seam constructions ensuring compliance with the Specification, including ensuring that panel overlaps / joints are constructed correctly and that upslope panels are placed above downslope panels where joints between the ends of panels are required;
- Ensure that all defects are identified on the geocomposite and witness that they are repaired in accordance with the Specification;
- Ensure that a defect free tie-in with the geotextile used in this phase of the works is constructed;
- Ensure that a defect free tie-in with the existing drainage geocomposite in adjacent capping phases is constructed;
- Ensure that geocomposite and seam construction continues to the back of anchor trenches (where applicable);
- Ensure that geocomposite and seam construction continues into the drainage ditches around the base of the capping area (only where/if required);
- Ensure that geocomposite is installed in accordance with the construction details on the Drawings and Specification at the location of leachate and gas wells;
- Provide written certification to the Contractor of areas approved to be covered with restoration soils;
- Ensure that on completion of the geocomposite installation the Contractor produces a fully referenced as-built panel layout plan including all the detail listed within the Specification; and
- Ensure that interface testing between the drainage geocomposite and restoration soils is carried out in accordance with the Specification.

All laboratory testing will be undertaken by UKAS Accredited Laboratories, with accreditation for all required tests.

The CQA Inspector shall fully document each item above and the documentation shall be presented in the CQA Validation Report.

8 RESTORATION SOILS

8.1 CQA Requirements

The CQA Inspector shall:

- Assess the method statement submitted by the Contractor for the installation of the restoration soils;
- Assess the results of source evaluation testing, as required by the Specification, and confirm whether the proposed restoration soils material is acceptable for use based on the particle size distribution (PSD) and chemical suitability (Inert WAC testing) requirements, and that a 300mm (or greater, if placed as one layer) blinding/protection layer is installed above the upper drainage geocomposite, if this is required;
- Ensure that all material within the working area deemed unsuitable in accordance with the Specification is removed to an area agreed with Amgen Cymru's Site Manager;
- Ensure that restoration soils placement takes place under suitable weather conditions which are not likely to lead to instability of the soils, due to excessively wet soils / plant loading on soft soils;
- Ensure that when placing soils on slopes, the soils are deposited from the bottom upwards - The placement of cover soil on a slope with a relatively low shear strength inclusion (such as a geomembrane/geo-composite) should always be from the toe upward, towards the crest. This way, the gravitational forces of the cover soil and live load of the construction equipment are compacting previously placed soil, and working with an ever-present passive wedge and stable lower portion beneath the active wedge;
- Ensure that only suitable soils are used where required as restoration soils; this shall include checking that the particle size distribution (PSD) and chemical suitability (Inert WAC) testing requirements set out in the Specification are met, for both the lower blinding / protection soils and the upper restoration soils;
- Ensure that a minimum thickness of 700mm is maintained between wheeled plant and the upper drainage geocomposite, and a minimum thickness of 300mm is maintained between tracked plant and the upper drainage geocomposite;

- Monitor the placement of the restoration soil, ensuring that the works are carried out in accordance with the Specification; this is to include the lower 300mm (or greater, if placed as one layer) and the upper 700mm (or less, if initial layer placed is greater than 300mm) of soils;
- Continuously monitor soil placement, ensuring that the characteristics of the material do not change (within the first 300mm of soil, or the upper 700mm of soil) and ensuring that the lining system is not compromised;
- Ensure standing profile boards / travellers or depth tubes are used to monitor restoration soil thickness;
- Ensure that all areas of non-compliance are remediated in accordance with the Specification;
- Take photographs during the construction; and
- Ensure that surveys are undertaken in accordance with the Specification to confirm that the requisite levels and layer thicknesses have been achieved; soil depths are to be checked with trial pits.

All laboratory testing will be undertaken by UKAS Accredited Laboratories, with accreditation for all required tests.

The CQA Inspector shall fully document each item above and the documentation shall be presented in the CQA Validation Report.

SURFACE WATER MANAGEMENT

9.1 CQA Requirements

The CQA Inspector shall:

- Ensure that the drainage ditches adjacent to the permanent capping area, and within the Phase 4A capping area, are excavated in accordance with the relevant construction detail (Section E-E') on the drawings, and that the required falls as determined on site by the Contractor / Amgen Cymru are achieved; and
- Ensure that surveys are undertaken in accordance with the requirements of the Specification, showing the locations, levels, and falls of the surface water ditches.

The CQA Inspector shall fully document each item above and the documentation shall be presented in the CQA Validation Report.

10 HAUL ROAD CONSTRUCTION

10.1 CQA Requirements

The CQA Inspector shall:

- Ensure that the subgrade for the haul road location provides a firm foundation for the road construction works with no sudden, sharp, or abrupt changes in grade. No standing water or excessive moisture shall be allowed;
- Assess the method statement for the separation geotextile installation submitted by the Contractor detailing their proposed deployment and seaming techniques;
- Ensure that the testing requirements for the separation geotextile product to be used within the works are in accordance with the testing requirements of the Specification;
- Ensure that the separation geotextile product is delivered, handled and stored in accordance with the Specification and the manufacturer's recommendations;
- Make a visual inspection of each roll as it is unloaded to identify any damage and record the relevant information for each roll;
- Assess all separation geotextile manufacturers' quality control certificates to confirm that the geotextile meets the requirements of the Specification prior to installation;
- Assess and approve, with respect to the requirements set out in the Specification, the proposed panel layout for the separation geotextile to be submitted by the Contractor. The methodology shall show the Contractor's proposed start point and direction of working. The panel layout shall seek to minimise the number of required heat bonded seams;
- Identify rolls from which conformance samples of the separation geotextile are to be taken for laboratory conformance testing in accordance with the Specification;
- Assess the results of conformance tests to ensure compliance with the Specification. Should any materials fail to meet the requirements of the Specification, the CQA Inspector shall reject the failed roll and schedule further testing in accordance with the Specification;
- Provide written certification to the Contractor that the surface on which the separation geotextile is to be installed is acceptable prior to installation. *Note the CQA Inspector may withdraw the certificate should the surface deteriorate for any cause prior to*

installation and only reissue upon remediation works being compliant with the Specification;

- Witness all panel deployment ensuring compliance with the Specification;
- Witness all seam constructions to ensure compliance with the Specification;
- Ensure that all defects are identified on the separation geotextile and witness that they are repaired in accordance with the Specification;
- Ensure that the separation geotextile is deployed as shown on the relevant construction detail on the Drawings, and in accordance with the requirements of the Specification;
- Ensure that only suitable material as defined in the Specification are used for the road construction, and that all material deemed unsuitable is removed to an area agreed with Amgen Cymru's Site Manager;
- Ensure that the materials used for the road construction are classified using particle size distribution (PSD) testing, in accordance with the Specification;
- Monitor the placement and compaction of the fill materials for the road construction, ensuring that the works are carried out in accordance with the Specification and the required depth is placed;
- Ensure that all areas of non-compliance are remediated in accordance with the Specification;
- Take photographs during the construction; and
- Ensure the completed haul road is surveyed in accordance with the requirements of the Specification.

All laboratory testing will be undertaken by UKAS Accredited Laboratories, with accreditation for all required tests.

The CQA Inspector shall fully document each item above and the documentation shall be presented in the CQA Validation Report.

11 CQA VALIDATION REPORT

Upon completion of the capping works, the CQA Inspector/CQA Engineer will prepare a CQA Validation Report summarising the works undertaken and including all CQA documentation prepared. As a minimum this shall include:

- Description of the works;
- Completed summary sheets detailing the installation of each element of the works;
- Contractor's and manufacturer's documentation;
- Test (laboratory & field) reports, failing results / tests will also be presented (e.g. failing trail welds or air pressure tests) and correlated to the subsequent remedial works and / or re-testing;
- Interface testing results and updated slope stability calculations;
- All references to final levels in meters above ordnance datum;
- Details of all materials and equipment used;
- As-built drawings (Topographic and Panel Layout) which should include;
 - Title of Project, contract, element of works;
 - Drawing version number, with details of revision history;
 - Scale (Scale at size to be printed, e.g. 1:500 at A1);
 - Details of the Survey Grid (e.g. OSGB36, or local grid);
 - Locations of control stations / levels, benchmarks, etc. (permanent and temporary);
 - North arrow;
 - Grid intersections; and
 - Distinguish between surveys done at different times and dates.
- Photographic record of the construction;
- Daily diaries; and
- Description of non-conformances and the subsequent remediation.

Pro-Forma sheets for the onsite completion by the CQA Inspector are in **Appendix 2**.

The above report will confirm that the works have been carried out in accordance with the Specification as incorporated in this Construction Quality Assurance Plan. The report will be certified by the CQA Engineer.

APPENDIX 1
SPECIFICATION

AMGEN CYMRU



**SPECIFICATION FOR PHASE 4A PART II (2023)
PERMANENT CAPPING WORKS
AT BRYN PICA LANDFILL SITE**

Specification Reference: AM5593/01 Rev1
July 2023



Project Quality Assurance

Specification Reference : AM5593/01 Rev1

Report Date : July 2023

Prepared for : Amgen Cymru,
Cynon Valley Waste Disposal Limited,
Bryn Pica,
Llwydcoed,
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Rev	Date Issued	Amendment Details	Author	Reviewer
1	July 2023	Reference to previously approved CQA method statement report added to Section 3.1, and Note 5 on Drawings AM5593/01/02 & 03 updated to match Table 4.	JC	RH

Purpose

This document was prepared as a Specification for the construction of an area of permanent capping at Bryn Pica Landfill Site for Amgen Cymru (Cynon Valley Waste Disposal Limited). Sirius Environmental Limited (Sirius) accepts no responsibility or liability for any use that is made of this document other than by the Client, Amgen Cymru, for the purposes for which it was originally commissioned and prepared.

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1 GENERAL REQUIREMENTS

1.1 Introduction

Amgen Cymru (*Cynon Valley Waste Disposal Limited*) are seeking to install the Phase 4A Part II permanent capping area at Bryn Pica Landfill Site, Llwydcoed, Aberdare. Bryn Pica Landfill Site is located off Merthyr Road (the B4276) approximately 2.6km north-east of Aberdare, and approximately 4.2km west of Merthyr Tydfil, at National Grid Reference SO 008 052. The site address is:

Bryn Pica Landfill Site,
Llwydcoed,
Aberdare,
Rhondda Cynon Taf,
CF44 0BX

Sirius Environmental Limited (Sirius) have prepared a detailed Specification for the construction works to be undertaken. Amgen Cymru will appoint a third party independent Construction Quality Assurance (CQA) consultant to provide supervision for the duration of the capping works, on Amgen Cymru's behalf. A representative of the CQA Engineer, the CQA Inspector, shall supervise the construction works and shall advise the Contractor with regard to the on-site and off-site testing requirements.

The Construction Quality Assurance Plan (CQA Plan) and Specification (which forms an appendix to the CQA Plan) for the capping construction works have been prepared in accordance with the Environmental Permit (EP) for the site.

This Specification (Specification Reference AM5593), when read in conjunction with the CQA Plan (CQA Plan Reference AM5593) details the requirements for the installation of the capping system to be undertaken by the Contractor, and the quality control (QC) procedures that shall be followed during the capping works by the CQA Inspector, to demonstrate that the works have been undertaken in accordance with the Specification. This document also details requirements for each element of the capping works, which should be read in conjunction with the construction drawings.

1.2 Project Team

The project team shall comprise:

Waste Management Operator/Employer – Amgen Cymru

Designer – Sirius Environmental

Main Contractor – TBC

CQA – Sirius Environmental

Principal Designer – Sirius Environmental

1.3 Facilities

1.3.1 Contractor's Compound

The location and layout of the Contractor's compound shall be agreed with Amgen Cymru prior to commencement of the works on site. The Contractor shall submit their proposals to Amgen Cymru for mess facilities, plant standing, and maintenance areas. The Contractor shall site their plant standing, maintenance, and refuelling areas so that no pollution will occur. 110% secondary containment bunding shall be used for fuel/oil storage tanks where appropriate. The Contractor shall also take into account the storage and mess requirements of their sub-contractors, where appropriate.

No lodgings or caravans shall be allowed on site.

The Contractor shall ensure that adequate provision is made within the compound area for parking of all the plant, equipment, and any private vehicles owned by operatives/subcontractors, or visitors. Parking shall not be permitted in any other areas of the landfill site.

The Contractor shall be responsible for the security of the works, and all the Contractor's offices, plant, materials, services and machinery.

1.3.2 Contractor's Offices and Welfare Facilities

The Contractor shall be responsible for the provision and maintenance of welfare facilities for themselves and any of their sub-contractors. These facilities shall be as prescribed in the '*Working Rule Agreement*' published by the *Civil Engineering Construction Conciliation Board* for Great Britain. The sanitary accommodation and disposal arrangements shall comply with the requirements of the local Environmental Health Authority. The Contractor's

personnel shall not be permitted to use Amgen Cymru's mess, shower, and toilet facilities (unless otherwise agreed).

1.3.3 Fuel and Oil Installations

The Contractor's fuel and oil installations within the site shall only be provided at locations approved by Amgen Cymru. However, such approval shall not to be unreasonably withheld, or delayed.

All fuel and oil installations provided by the Contractor shall be contained within an impermeable bund capable of containing 110% of the tank capacity in the event of a spillage; 'self-bunded' items shall be permitted, subject to the Contractor being able to substantiate their efficacy.

The Contractor shall designate an area within their compound for carrying out plant maintenance and repairs. The Contractor shall ensure that all routine maintenance and repairs take place within this area. Any fuel or oil spillages shall be remediated (in a safe and controlled manner) by the Contractor, at their expense.

1.3.4 Facilities for CQA Inspector

Where required, the Contractor shall provide, service, and maintain one high-security steel ISO container, or as otherwise agreed, for the sole use of the CQA Inspector within the agreed location of their compound, subject to the approval of the CQA Inspector, which shall not be unreasonably delayed or withheld. The Contractor shall ensure that the container is provided with power supply, sufficient electricity power sockets, electric lighting and space heating, such that it will be ready for use by the CQA Inspector on the first day that CQA work is required. The Contractor shall be responsible for the maintenance of these facilities throughout the duration of the works.

All keys for the CQA Inspector's facilities shall be handed to the CQA Inspector.

1.4 Landfill Gas and Leachate Management Systems

Amgen Cymru (along with their partner *Infinis*) have installed landfill gas and leachate management systems across the Site, including areas within, and adjacent to, the proposed works. Amgen Cymru shall inform the Contractor which systems are to remain undisturbed during the period of the works, and which can be, or have been, decommissioned.

The gas extraction system at the site is operated by *Infinis* (on behalf of Amgen Cymru) who will advise on matters relating to the gas extraction system. Amgen Cymru shall remain the Contractor's point of contact for the works, and shall be given a minimum of two days' notice where movements in the gas system are required, and it will be the Contractor's responsibility to liaise with Amgen Cymru in sufficient time to allow such movements to be carried out.

Should the Contractor subsequently damage or disturb any operational system, they shall immediately inform the CQA Inspector and Amgen Cymru. Only if required by Amgen Cymru, the Contractor shall carry out such reasonable remedial measures as are deemed necessary by Amgen Cymru to reinstate any damaged or disturbed system to the same condition as immediately prior to commencement of the works, otherwise Amgen Cymru shall provide for the remediation to be completed within a timescale to be agreed with the Contractor.

1.5 PPC Permit

The area of the works is encompassed by the existing Pollution Prevention and Control (PPC) Permit for the current landfill operations. The Contractor shall not directly or indirectly compromise Amgen Cymru's ability to carry out its operations in accordance with the PPC Permit, a copy of which shall be provided by Amgen Cymru on request.

2 CONSTRUCTION REQUIREMENTS

2.1 Regulations and Site Safety

The works come under the **Construction (Design and Management) Regulations 2015** and the Main Contractor will also be appointed as the Principal Contractor.

The Contractor shall comply with the safety requirements set out in the following documents:

- Amgen Cymru - Health and Safety Policy;
- Amgen Cymru - Site User Safety Instructions;
- Amgen Cymru - General Policy Statement for Contractors Conditions of Contract and Safety Rules; and
- Amgen Cymru - Health & Safety Site Plan.

A copy of these documents is available for inspection at the landfill site office.

The Contractor shall adhere to the site Health and Safety Rules and the **DSEAR Regulations 2002**. The Contractor's performance with respect to these rules will be reviewed at each progress meeting.

2.2 CDM Area

The extent and location of the CDM area shall be agreed with Amgen Cymru prior to any works commencing on-site, and 'works' shall include the delivery of any plant, equipment, materials and/or accommodation.

The agreed area shall be demarcated on site and once demarcated, the Principal Contractor shall ensure that the requirements of the **CDM Regulations 2015** are adhered to at all times within it.

2.3 Method Statements and Risk Assessments

The Sirius Design Risk Assessment (DRA) is included as an appendix of the Pre-Construction Information (PCI).

The Contractor shall submit to Amgen Cymru for approval, prior to commencement of the works, risk assessments and method statements (RAMS) as part of the Construction Phase Health & Safety Plan (CPP) detailing the proposals for all the works to be undertaken.

2.4 Substances Hazardous to Health

A substance hazardous to health shall only be used (or generated in or about the works) where specified in the Contract, or with the consent of the CQA Inspector.

Where any substance hazardous to health is used (or generated during the works) the Contractor shall provide the CQA Inspector with:

- A copy of the assessment of the risks created by the use of that substance; and
- Details of the measures to be taken to prevent or adequately control the exposure of the persons working with (or those who may be affected by) the substance.

The information required in the above shall be provided to Amgen Cymru at least 14 days prior to the use of or incorporation into the works of substances hazardous to health or where appropriate at the commencement of the works where this is less than 14 days.

The Contractor shall advise Amgen Cymru of the information, instruction, training and supervision to be provided for the Contractor's personnel and any other person likely to enter the area in which the hazard exists. The Contractor shall ensure that provision is made for monitoring health.

Where the measures referred to above necessitate the use of protective clothing or other safety apparatus the Contractor shall:

- Provide the Employer and their staff with sufficient and suitable items of protective clothing and safety apparatus if not previously supplied;
- Arrange for the proper storage, maintenance and regular testing (and appropriate replacement of) the items provided to the Employer and their staff; and
- Arrange for appropriate training or instruction for the Employer and their staff in the use of such items.

2.5 Noise

The Contractor shall comply with any site specific noise limits and the following specific requirements:

- No work other than the operation of plant and equipment for the control of the groundwater shall take place outside the permitted hours except in case of emergency. Amgen Cymru shall be informed of any such emergency immediately;
- All mobile plant, equipment and vehicles under the control of the Contractor (or their sub-contractors and/or suppliers), and in use or calling at the site, shall be fitted with appropriate silencing equipment and shall be maintained to manufacturers' standards.

2.6 Naked Flames and Smoking

Naked flames are prohibited within the working area on site at all times. Smoking will only be permitted in areas approved by Amgen Cymru.

The Contractor shall obtain a permit to work from Amgen Cymru for any 'hot works'. The works are to be carried out away from the landfill area and at a location agreed with Amgen Cymru.

2.7 Mobile Plant

All Contractor's and subcontractors' vehicles (plant and operatives vehicles) shall be fitted with flashing amber beacons for vehicle awareness, and white noise alarms for vehicle reversing awareness. Green flashing beacons to indicate that seat belts are in operation shall also be fitted to all construction plant. These beacons shall be located in a visually prominent position and shall be used whenever vehicles are on site. No Contractor's or subcontractors' vehicles shall be allowed on site without the use of a flashing amber beacon.

All mobile plant shall be assessed for restricted rear view vision. Depending on the outcome of the assessment, additional equipment may be required to be fitted, before use on site is allowed, in order to minimise the potential risk to within acceptable limits.

2.8 Dust Nuisance

The Contractor shall take all necessary steps to eliminate the generation of dust nuisance during the works.

Existing highways, and site access roads used by the vehicles and plant of the Contractor (or of their sub-contractors or suppliers of materials), shall be kept clean and clear of all dust and mud dropped by the vehicles in any form. All dust and mud from the works spreading onto highways, or site access roads shall be immediately cleared by the Contractor through the use of mechanical plant to the approval of Amgen Cymru.

Compliance with this clause shall not relieve the Contractor of any responsibility for complying with the requirements of any Highway Authority in respect of keeping roads clean.

2.9 Communication Systems

The Contractor shall obtain the approval of Amgen Cymru prior to the commissioning of any communication equipment and, following approval, shall ensure that it does not interfere with any existing systems on the site.

2.10 Access

The general arrangement of the site is shown on the respective site layout drawings. The only entrances to the works for the use of the Contractor are via the main site entrance, no other site entrances are to be used unless stated in the Specification. Areas for site offices, welfare facilities and plant standing areas will be arranged with Amgen Cymru.

The main access road is to be kept clear at all times, as it will be used primarily by Amgen Cymru's operations traffic. The Contractor will need to make provision for providing suitable access within the site, in particular between borrow areas, stockpile areas and the Contractors compound.

The Contractor must not use the access roads used by Amgen Cymru for access into active cells unless given prior permission of Amgen Cymru. Alternative access roads must be used or constructed, the locations of which shall be agreed with Amgen Cymru prior to work commencing.

The Contractor shall carry out jointly with Amgen Cymru a condition survey of the access roads made available under the Contract prior to the commencement of any works. The Contractor shall repair and make good any damage to Amgen Cymru's landfill access roads which occur as a result of the Contractor's activities.

The Contractor's vehicles must give way to landfill traffic and not impede the movement of the traffic involved in landfill operations.

The specified speed limits within the landfill site shall be observed at all times. Non-compliance may result in the exclusion of any offender from the site.

Appropriate signage must be displayed to warn traffic of slow moving plant, particularly if the haul road access crosses the main access road.

All vehicles leaving the site must be free from mud and debris. The Contractor will be responsible and will pay for the removal of debris and any damages arising from mud and debris that leaves the site as a consequence of the works.

2.11 Permitted Hours of Working

The permitted hours of working are to be agreed with Amgen Cymru at the pre-start meeting.

Working on Sundays and Bank Holidays will not be allowed unless approved beforehand by Amgen Cymru.

2.12 Control of Surface Water

The Contractor shall carry out all necessary operations for the control of standing water (or surface water run-off), within the CDM area to enable the construction of the works, and (in doing so) shall prevent damage to the works, the site, or adjoining properties. Where these actions include measures to prevent the in-flow of water from the site, these works shall be approved by Amgen Cymru before commencement.

Any water shall only be discharged outside the CDM area and/or off-site following the receipt of approval by Amgen Cymru.

2.13 Control of Leachate

The Contractor shall carry out all necessary operations for the control of leachate, within the CDM area to enable the construction of the works, and (in doing so) shall prevent damage to the works, the site, or adjoining properties. Where these actions include measures to prevent the in-flow of leachate from the site, these works shall be approved by Amgen Cymru before commencement.

Any leachate collected shall only be discharged outside the CDM area and/or off-site following the receipt of approval by Amgen Cymru.

2.14 Disposal of Exhumed Waste

In the event that it is necessary to excavate waste in order to achieve any element or elements of this Specification (such as the perched leachate collection trench), the excavated waste shall be disposed of in the operational area of the landfill, or as otherwise directed by Amgen Cymru.

2.15 Protection of Boreholes

The Contractor shall locate, and adequately protect, existing deep ground water and landfill gas monitoring boreholes within the works area from damage during the works. The locations of the boreholes are to be confirmed with Amgen Cymru.

2.16 Inclement Weather

No materials shall be placed or compacted during inclement weather conditions, if in the opinion of the CQA Inspector, trafficking over compacted or uncompacted material would prove detrimental to the construction. Any such trafficking damage caused by the Contractor shall be repaired in accordance with the Contract at the Contractor's expense. Inclement weather conditions may include, rain, snow, freezing conditions or excessive heat as indicated by the CQA Inspector.

Following wet weather conditions, any standing water on the surface of the construction must be removed at the Contractor's expense. If instructed by the CQA Inspector, the Contractor shall remove any material rendered unsuitable by wetting at the Contractor's expense. Earthworks placement operations following inclement weather conditions shall not proceed without the prior approval of the CQA Inspector.

Any frozen material shall be allowed to thaw before use. Previously compacted material that has become frozen shall be removed from the works and stockpiled until suitable for reuse.

2.17 Tolerance limits

Tolerance limits for the work shall be as follows:

- i) Positions in plan shall be within **±50mm** of the true positions shown on or calculated from the drawings; and
- ii) Levels shall be **±50mm** of the required elevation shown on or calculated from the drawings.

2.18 Confidentiality

The whole of the tender documents and all information provided by Amgen Cymru for the purpose of or in connection with the contract shall be dealt with by the Contractor as confidential to them and not be disclosed by them other than to their employees, sub-contractors or agents as appropriate for the sole purpose of the Contract.

The Contractor shall not, except with the prior consent in writing of Amgen Cymru:

- i) Publish or advertise or permit to be published or advertised any photograph, drawing or written matter concerning the Contract or the works;
- ii) Use or permit the use of the name of Amgen Cymru in any publication or advertisement; and
- iii) Place any advertisement on any part of the works.

The Contractor shall refer all press representatives to Amgen Cymru. Photographs for publication shall not be made of any part of the works without the prior written authorisation of Amgen Cymru. Such authorisation if granted shall be in the form of itemised approvals for each exposure concerned.

3 SCOPE OF THE CONSTRUCTION WORKS

3.1 General Description

The design concepts for the capping construction were developed to accord with the PPC Permit for the site. The capping area to be constructed as **Phase 4A Part II Permanent Capping** is located in the centre of the landfill site.

The capping system design closely follows the existing site-wide capping design, utilising an 1mm double-textured LLDPE geomembrane capping liner with geo-composite drainage and protection layers (GDLs) above and below, to transmit surface water seepages (within the restoration soils) and perched leachate and landfill gas (within the underlying waste mass) respectively. For details of the capping design used previously for the site, the CQA Method Statement and Quality Plan for the **Phase 4A** Capping Works should be referred to (**Report Number 1384r1v2d0714**).

The position of the proposed permanent capping development in relation to previous capping phases is shown on **Drawing AM5593/01/01**. The locations of tie-ins for the permanent capping area, and other infrastructure to be constructed as part of the works, as well as the tie-in and construction details for this area, are shown on **Drawing AM5593/01/02** and **Drawing AM5593/01/03**.

Construction of the capping system for this phase of the works shall involve:

- Removal of existing temporary capping geomembrane from the permanent capping area (where relevant);
- General trimming of waste cover soils / waste re-grade as required;
- Installation of a perched leachate collection trench in the existing waste along the north-western (provisional) and south-western edges of the permanent capping area (a shown on Section A-A' and Section D-D');
- Placement and trimming of a 300mm thick bedding/regulating soils layer over the whole open waste area, to achieve the formation levels for the geo-synthetics;
- Installation of a lower protection and drainage geo-composite over the regulated surface;
- Installation of a fully welded, 1mm thick, double-textured linear low density polyethylene (LLDPE) geomembrane cap above the lower protection and drainage geo-composite;

- Installation of an upper protection and drainage geo-composite over the LLDPE capping geomembrane;
- Tie-in to existing permanent geosynthetic capping system;
- Sealing of the capping system around protuberances;
- Installation of a 300mm (or greater, if laid as one layer) thick blinding/protection soils layer, and a further 700mm (or less, if initial layer is greater than 300mm) of restoration soils, above the upper drainage geocomposite;
- Excavation of surface water ditches (and an associated culverted road crossing) close to the perimeter of the capping slope along the south-western edge of the permanent capping area, and above the existing Phase 4A capping system; and
- Installation of a 400mm thick unbound unsurfaced access haul road (and associated safety protection bund) along eastern side of the permanent capping area.

3.2 Slope Stability

Slope stability calculations, considering the potential for the restoration soils to slide off the capping system (translational/veneer assessment), have been carried out on the worst-case slope in the permanent capping area shown on **Drawing AM5593/01/01**. The calculations are presented in **Appendix 1**.

The slope analysed for the permanent capping area is 4m High at 1 in 3.4. The factor of safety (FoS) using a parallel submergence ratio (PSR) of 0.5 is $FOS = 2.06$. Normal practise when a geocomposite drainage layer (GDL) is utilised in the capping system is that a minimum FOS of 1.3 is required for a PSR of 0.5. With the utilisation of a GDL, the PSR of 0.5 is considered to be a worst-case for Bryn Pica. Therefore, the calculated FOS of 2.06 is believed to be sufficient for this design proposal.

If the topographic survey of the capping area undertaken by the Contractor (see Section 5.3) shows that the waste slopes are significantly different from those shown on the drawings, then further slope veneer calculations shall be undertaken by the designer to confirm that the stability of the capping slope will be maintained.

Interface shear strength testing for the blinding/protection restoration soil to upper protection and drainage geo-composite interface (the critical interface for the slope stability) is required to be carried out, using the proposed restorations soils material and the proposed upper drainage geocomposite product, to confirm that the interface parameters used in the slope stability calculations are appropriate. The restoration soils sample shall be from the material

to be used for the restoration soils blinding/protection soils layer to be installed immediately above the capping system. The slope stability calculations shall be updated according to the interface testing results, in accordance with **Section 5** of **LGG 115**, to ensure that the stability of the capping slopes will be maintained. The interface testing requirements are set out in **Appendix 3**.

The interface testing shall be carried out in accordance with **LGG 115**, with **Route B** being used for the testing frequency. **4 sets of tests** are required (as the permanent capping area is ~4,000m²) for the restoration blinding/protection soils to upper protection and drainage geo-composite interface. All interface testing results and the updated slope stability calculations shall be presented in the CQA Validation Report, with a summary detailing the significance of the results.

3.3 Principal Quantities

The principal quantities for the works are provided in the Bill of Quantities (BoQ).

3.4 Survey Information

The Contractor shall undertake an initial survey of the capping area. This shall be compared with existing surveys and, once approved by Amgen Cymru, the Contractor's survey will form the 'original ground level survey' (OGL) from which the measurement of the works shall be undertaken. Further surveys shall be required as follows:

- i) Formation levels / top of waste;
- ii) Location of existing capping systems for tie in, annotated survey to show where new capping geomembrane is welded to the existing capping geomembrane;
- iii) Locations, levels and falls of leachate collection drain pipework installed within the top of the existing waste;
- iv) Top of bedding/regulating soils layer surface;
- v) Bedding/regulating soils layer isopachyte using surveyed trial pits for depth verification;
- vi) Lower drainage and protection geo-composite panel layout, showing locations of testing / repairs;
- vii) Geo-membrane panel layout, showing locations of testing / repairs;
- viii) Upper drainage and protection geo-composite panel layout, showing locations of testing / repairs;

- ix) Top of restoration soils;
- x) Restoration soils isopachyte using surveyed trial pits for depth verification;
- xi) Location, levels, and falls of surface water ditches;
- xii) Location of haul road installed adjacent to the permanent capping area, including location of edge protection bund; and
- xiii) Haul road filtration/separation geo-textile panel layout, showing locations of testing / repairs.

The survey depth of soil layers on a cap is not accurate (due to settlement of the underlying soils/waste, and initial/primary consolidation from soil loading during the construction works). The bedding/regulating soils layer, and the restoration soil depths, are required to be manually measured using trial pits, so the tolerances of survey equipment are not relevant to the depth measurement.

3.5 Daily Journal

The Contractor shall be required to keep a detailed daily journal recording the information detailed below. The Contractor shall give Amgen Cymru reasonable access to the daily journal which will, if necessary, be made available to Amgen Cymru, Natural Resources Wales (NRW), or any other authority during and after completion of the Works if required. The Contractor will forward copies of the daily journals on a weekly basis to the Project Manager.

This information shall be recorded in an acceptable form of daily journal which shall include the following:

- date of shift;
- names of personnel in attendance during the shift;
- weather conditions, including ambient temperature;
- type of plant used; plant breakdowns and hours;
- approximate totals of earthworks carried out including identification of source and destination;
- removal of foreign matter and oversize material;
- depth of bedding / regulating soils layer and restoration soils layer;
- approximate totals for amount of geosynthetic materials deployed, seamed, bonded,

tested and repaired including width of each panel installed;

- summary of field and laboratory testing carried out;
- sample type and material taken for particular testing;
- delays;
- additional works, reasons and reference;
- deliveries;
- details of meetings and other correspondence;
- details of remedial works; and
- any other relevant information.

4 PERCHED LEACHATE COLLECTION DRAIN

4.1 General

Prior to the installation of the cap bedding / regulating soils in the permanent capping system area, a perched leachate collection drain shall be installed within the existing waste along the north-western (provisional) and south-western perimeters of the proposed permanent capping area. This is required to allow perched leachate (within the existing waste) to drain down, away from the proposed capping system. The perched leachate collection drain shall be installed in accordance with the layout on **Drawing AM5593/01/01**, and the construction details shown on **Section A-A** (provisional) of **Drawing AM5593/01/02** and **Section D-D'** (and **Detail B**) of **Drawing AM5593/01/03**.

The leachate collection drain shall be comprised of two sections (including the provisional section) flowing towards the western corner of the permanent capping system, where it shall be connected to (and discharge into) the existing leachate collection drain of the Phase 4A Part I capping area, as shown in the layout on **Drawing AM5593/01/01** (and Section D-D'). The exact location, levels, and falls of the leachate collection drain are to be agreed by the Contractor and Amgen Cymru at the commencement of the construction works, to ensure that there is a continuous fall towards the discharge/connection point.

4.2 Perched Leachate Collection Drain Pipework

The perched leachate collection drain is to be installed in a trench which shall be 300mm wide with a depth of 1,000mm, such that the pipework in the trench shall be installed within the existing waste. The trench shall be excavated adjacent to the tie-ins to the Phase 3A and Phase 4A Part I (provisional) capping phases, which bound the proposed Phase 4A Part II permanent capping area, as shown in the construction details on **Drawing AM5593/01/02** & **Drawing AM5593/01/03**. The pipework shall consist of a perforated 100mm internal diameter single-wall Polypropylene (PP) or Polyethylene (PE) pipe, with an 100mm gravel bed and surround, utilising clean 10mm to 20mm gravel. Individual sections of the pipe shall be joined using proprietary collars and 'O'-ring seals in accordance with the manufacturer's guidance. If there is a change of design and the pipework is welded, this shall be undertaken in the presence of the CQA Inspector by suitably qualified and certified pipe welders.

The specification for the perched leachate collection drain pipework is given in **Table 1** below.

Table 1: Perched Leachate Collection Drain Pipework Specification

Parameter	Requirement
Pipe Material/British Standard	Black (UV Stabilised) PP or PE or uPVC to BS4962:1989
Pipe Internal Diameter (Nominal)	100mm
Deflection of the Pipe (Under Service Load)	<5%
% Open Area (Slots/Perforations)	>3%, <10%
Perforation Location	Full circumference of pipe
Waste / Soil Density	10 kN/m ³ (Waste) / 20 kN/m ³ (Restoration Soil)
Depth of Waste / Soil	1m Waste + 1m Soil
Pipe Bed & Surround	10mm to 20mm Gravel
Pipe Joints	Proprietary Collars and O-Ring Seals

The Contractor shall submit deflection calculations to the CQA Inspector from the pipe manufacturer to demonstrate that the pipework and proposed fittings are suitable for this application (BS4962:1989).

The installation of the pipework shall only be undertaken by skilled, experienced, and certified personnel. The Contractor shall provide a summary of their experience, or that of their sub-contractor, with the materials, as well as copies of training certificates for operatives working on site.

The pipework may either be jointed in-situ, or jointed outside the area of the works and transported to its final position. In either case, care shall be taken to ensure that the perforations and ends of the pipes do not become contaminated and/or blocked with clay/other materials. If this is found to have occurred, the Contractor shall undertake cleaning of the pipework using a pressure washer, to the satisfaction of the CQA Inspector. The CQA Inspector shall carry out an inspection of the pipework prior to its installation in the trench.

4.3 Leachate Collection Drain Gravel

The gravel used for the leachate collection drain shall be hard, clean, crushed rock or gravel (10mm/20mm grading), and shall conform to the requirements contained in **Table 2** below.

The proposed source of the leachate collection drain gravel shall be evaluated by undertaking a **source evaluation test**, to ensure conformance with the requirements of **Table 2** below. Should the material conform to these requirements, it may be delivered to site as an approved source. Gravel imported to site shall then be subjected to conformance testing at a frequency of **1 sample per 500 tonnes** delivered, as shown in **Table 2** below.

Table 2: Perched Leachate Collection Drain Gravel (Bed & Surround) Specification

Material Property	Test Method	Requirement	Number of Source Evaluation Tests Required	CQA Test Frequency
Particle Size Distribution	BS 1377:1990: Part 2 Method 9 BS13242	Material passing sieve: 63mm 98-100% 40mm 80-100% 31.5mm 20-90% 20mm 0-20% 10mm 0-5%	1 (per source)	1/500 tonnes of material
10% Fines Value	BS 812 Part III	>100kN	1 (per source)	1/500 tonnes of material

4.4 Tie-in to Capping System

The lower protection and drainage geocomposite of the Phase 4A Part II permanent capping area shall be installed immediately above the leachate collection drain trench, in direct contact with the drainage gravel, as shown in the construction details on **Drawing AM5593/01/02** and **Drawing AM5593/01/03**. This is required to ensure that perched leachate which may be present beneath these capping area drains into the trench (or into the adjacent existing lower protection and drainage geo-composite).

4.5 As-Built Drawings

A survey of the leachate collection drain shall be carried out in accordance with the requirements of Section 3.4 of this Specification.

5 EARTHWORKS REQUIREMENTS

5.1 General

This section outlines the requirements for excavation and placing the engineered fill materials of the bedding/regulating soils, blinding/protection soils, and restoration soils.

The compaction of engineered fill materials shall be carried out in accordance with the Highways Agency '*Manual of Contract Documents for Highway Works (MCDHW) – Volume 1 Specification for Highway Works*' Series 600 Earthworks (2016), published by HMSO, except as amended below. The Contractor shall employ only that plant and those working methods that are suited to the materials to be handled and traversed. They shall be responsible for maintaining the nature of the suitable material so that when it is placed and compacted it remains in accordance with the Contract. Suitability shall be determined in accordance with the definitions below.

The Contractor shall submit their proposals to Amgen Cymru and the CQA Inspector regarding the extent and management of the excavations, stockpiling and filling of materials before starting works. Excavations shall not proceed without the prior approval of Amgen Cymru.

The Contractor shall not remove any materials from the site unless approved by Amgen Cymru.

After completion of the works, the Contractor is required to re-grade any stockpiles and surrounding areas where deemed necessary. This shall be carried out to the satisfaction of the CQA Inspector and Amgen Cymru.

5.2 Definitions

The following definitions shall apply to the Specification and CQA Plan wherever reference is made to the defined engineered fill material:

- 'Suitable fill material' shall comprise all that is acceptable in accordance with MCDHW;
- 'Unsuitable material' shall mean material other than suitable materials and shall include:
 - Peat, material from swamps, marshes, and bogs;
 - Logs, stumps, and perishable material;

- Material in a frozen condition;
 - Material susceptible to spontaneous combustion; and
 - Any commercial or domestic waste.
- 'rock' shall be deemed to mean hard material which, in the opinion of the Project Manager, necessitates for its loosening or removal the use of special machinery designed for rock cutting, but shall exclude any material that can be removed by normal excavating machinery and which, in any case, has a volume not exceeding 1 cubic metre or 0.25 cubic metres where the net width of the excavation is less than 2 metres.

5.3 Waste Surface Preparation

Upon completion of landfilling, the surface of the waste shall have been temporarily covered with a layer of cover soils. Prior to installing the capping system, the surface of the cover soils/waste may be required to be re-graded (remove undulations) in order to ensure that the waste slopes are consistent with the slope stability analysis, and to remove (from the cap area) any vegetation/unsuitable waste materials (to the operational cell) which, in the opinion of the CQA Inspector, may affect the performance of the cap. The re-graded surface of the waste shall be tracked following re-grading to minimise future differential settlement.

The Contractor shall undertake a topographical survey of the areas to be capped, in order to establish any requirement for re-grading of slopes, as indicated by the slope stability analyses in **Appendix 1**. This survey shall be carried out at a maximum of 28 days prior to the commencement of the capping works. The OGL survey is to be supplied to the CQA Engineer (Sirius designer) to check the accuracy against the PPC Stability Risk Assessment (SRA) and/or veneer calculations.

Any areas of existing temporary capping geomembrane shall be removed from the permanent capping area and disposed of as directed by Amgen Cymru.

The Contractor shall supply Amgen Cymru with a method statement for these works, and liaise closely with site management to ensure the works do not affect the existing operations or contravene permit requirements.

As part of the preparation, some waste may be exposed. The Contractor shall ensure that during the re-grading works the area of waste exposed at any one time shall not exceed 1,000m², in order to minimise the emission of landfill gas, control odours, and nuisance from litter, vermin, birds and insects.

If, at the end of the day, it is not possible to install the lower drainage geocomposite over the working area, the Contractor shall place a minimum of 300mm of the bedding/regulating soils layer material over the exposed waste.

If unusual or hazardous waste is encountered during the re-grading process, the Contractor shall not excavate these materials until they have been categorised, and handling precautions confirmed with Amgen Cymru.

All large articles of waste encountered during the re-grading process, such as crates, barrels, or other materials that may degrade and/or collapse at some time in the future, shall be crushed, broken up or flattened, and subsequently buried such that they are covered to a depth of not less than 1m below the surface of the waste.

In the event of perched leachate being encountered locally, saturating the waste surface, the saturated material shall be excavated and replaced with granular drainage material. The granular material shall comprise inert crushed rock, or gravel. The leachate shall be allowed to flow via a granular filled trench down the waste slope, to a more permeable waste area, to facilitate the drainage of the leachate within the waste mass. All excavated waste material which cannot be locally re-graded shall be disposed of in the active area of the landfill.

Upon completion of the re-grading works, the Contractor shall seek approval (from the CQA Inspector) for adequacy of the prepared surface to receive the bedding/regulating soils layer, and to confirm that the slope gradients (within the permanent capping area) meet the requirements of the slope stability analysis within **Appendix 1**.

5.4 Cap Bedding / Regulating Soils Layer Specification

A minimum 300mm thick layer of clayey or other suitable material with a maximum particle size of **63mm** shall form the bedding/regulating soils layer above the waste. The bedding/regulating soils layer shall be either sourced from on-site stockpiles, or imported, as necessary. The material used to form the bedding/regulating soils layer shall be a natural or recycled fill or aggregate material, and shall conform to the requirements of **Table 3** below.

The proposed source of the bedding/regulating soils layer soils shall be evaluated by undertaking a series of **three (3)** source evaluation tests, to ensure conformance with the requirements of **Table 3** below. Should the material conform to these requirements, it may be delivered to site as an approved source.

The particle size distribution (PSD) results shall be used to classify the material in accordance with MCDHW 2016 and to determine the compaction methodology from SHW. If

the material is taken from an additional source or location on site, then additional PSD testing will be undertaken from that source to assess consistency with the PSD requirements given in **Table 3**.

Table 3: Cap Bedding / Regulating Soils Specification and Source Evaluation Testing

Material Property	Test Method	Requirement	Number of Source Evaluation Tests Required
Particle Size Distribution	BS 1377:1990: Part 2 Method 9	Material passing sieve: 63mm 100% 40mm 50-100% 10mm 50-100% 2mm 30-100% 0.6mm 10-70%	3 (per source)
Chemical Suitability (if source is not a greenfield site)	Inert WAC	Waste Acceptance Criteria parameters for inert waste (in accordance with the Waste Framework Directive 2008)	3 (per source) Only required if source is not a greenfield site

5.5 Cap Bedding / Regulating Soils Placement

The bedding/regulating soils layer shall be installed over the final waste level to provide an even surface upon which to place the capping system.

Where the waste bedding/regulating soils layer is to be placed in contact with the existing bedding/regulating soils layer, the existing bedding/regulating soils layer is to be cut at a 1 in 2, or shallower. This is required so that when placement of the new bedding/regulating soils layer is undertaken, compactive effort can be utilised on both the new and the edge of the old to ensure the old and the new bedding/regulating soils layer form a single homogenous mass and firm surface for the installation of the leachate drainage geocomposite.

The surface of the waste bedding/regulating soils layer to receive the capping system shall be smooth rolled, firm, clean, and dry, and shall be free from debris, roots, angular or sharp rocks and any other deleterious materials that may cause damage to the capping system. Any such deleterious material shall be removed from the surface and any resulting depression repaired to the CQA Inspector's satisfaction. In general, firm in this context means that indentations cannot easily be made in the surface. For cohesive bedding/regulating soils layer material, the undrained shear strength of the bedding / regulating soils layer should be **>40kN/m²** to ensure that no movement will occur during or after placement of the restoration soils.

The surface shall be rolled and compacted such that it provides a firm formation sufficient to permit the movement of vehicles and/or welding equipment over the surface without causing rutting or other deleterious effects. The surface shall have no sudden sharp or abrupt changes in grade, and shall be free from areas excessively softened by high water content. A continuous fall shall be maintained towards the low lying areas of the regulated surface, with no areas of ponding or backfalls on the surface. The maximum particle size for the upper surface of the bedding/regulating soils layer in direct contact with the overlying lower protection and drainage geo-composite shall be **40mm (for rounded/smooth particles/stones) or 20mm (for angular/sub-angular particles/stones)**, based upon a visual assessment at the point of placement in the works.

Trial holes or marker tubes are to be located on a **25m grid** to ascertain that adequate depth of bedding/regulating soils layer has been placed in accordance with this Specification.

5.6 Cap Bedding / Regulating Soils Installation Testing Requirements

The maximum particle size for the upper surface of the bedding/regulating soils layer in direct contact with the overlying lower drainage geo-composite/LLDPE geomembrane shall be **20mm**, based upon a visual assessment at the point of placement in the Works, in accordance with the requirements of **LFE5** Section 5.5.

1 sample will be taken per 1,000 tonnes of material used for the bedding / regulating soils layer and tested for in accordance with BS1377 1990 Part 2 Clause 9.2, to confirm that the material conforms with the PSD requirements for the bedding / regulating soils layer material.

Should the bedding / regulating soils layer consist of cohesive material, hand shear vane (HSV) tests shall be undertaken on a **25m alphanumeric grid** basis to demonstrate a required undrained shear strength of **40kN/m²**. Any areas that fail to meet the required strength shall be removed and re-laid by the Contractor to the satisfaction of the CQA Inspector. The Contractor shall provide a drawing showing the location of HSV tests, results obtained and remediation undertaken as a result of failing to meet the minimum required value, for inclusion in the CQA Validation Report. If the bedding / regulating soils layer is non cohesive the hand shear vane testing requirements do not apply.

Testing shall be carried out on the bedding/regulating soils layer in accordance with **Table 4**.

Table 4. Bedding / Regulating Soils Installation Testing Requirements

Parameter	Test Method (BS 1377:1990:)	Acceptance Criteria	Testing Frequency
Cohesive Fill Only:			
In-situ Shear Strength (Hand Shear Vane)	Part 9 Test 4.4 On Site Testing	>40 kN/m ²	1 per 25m grid per layer
All Bedding / Regulating Soils Fill:			
Particle Size Distribution	Part 2 Clauses 9.2 and 9.4	Material passing sieve: 63mm 100% 40mm 50-100% 10mm 50-100% 2mm 30-100% 0.6mm 10-70%	1 per 1,000 tonnes
Chemical Suitability (if source is not a greenfield site)	Inert WAC	Waste Acceptance Criteria parameters for inert waste (in accordance with the Waste Framework Directive 2008)	1 per 2,000 tonnes (only required if source is not a greenfield site)
Thickness	Manual	>300mm (-15mm)	1 per 25m grid
Maximum Particle Size in Surface	Visual Inspection	<40mm Rounded <20mm Angular/Sub-Angular	Continuous

All laboratory testing will be undertaken by UKAS Accredited Laboratories, with accreditation for all the required tests.

Upon completion of the bedding/regulating soils layer installation the Contractor shall seek approval from the CQA Inspector as to the suitability of the prepared surface to receive the capping system. Commencement of the installation of the capping system shall not proceed until such written certification has been received.

5.7 As-Built Drawings

A survey of the top of bedding / regulating soils layer in the capping area will be carried out. This drawing will be supplied to the CQA Inspector.

6 LOWER PROTECTION & DRAINAGE GEOCOMPOSITE

6.1 General

The **lower protection & drainage geo-composite** shall be installed below the LLDPE capping geomembrane in the permanent capping area. The lower protection and drainage geo-composite is required to discharge any perched leachate beneath the landfill cap into the leachate collection pipework installed around the north-western / south-western perimeter of the permanent capping area, and also to relieve any partial gas pressures beneath the cap.

The lower drainage geocomposite shall be supplied in accordance with the parameters given in **Table 5**, and installed in accordance with **Drawings AM5593/01/01, 02 & 03**, the procedures and CQA requirements described below, and the manufacturer's recommendations. The Contractor will be required to:

- Supply and install a lower protection and drainage geo-composite on the completed bedding/regulating soils layer surface in the permanent capping area;
- Install the lower protection and drainage geo-composite over the perched leachate collection drain on the south-western and north-western (provisional) sides of the permanent capping area;
- Tie-in (**500mm underlay**) the lower drainage geocomposite below the existing lower drainage geocomposite of Phase 3A and Phase 4A Part I on the south-western and north-western sides of the permanent capping area; and
- Provide all material quality control certificates and other information described below.

6.2 Geocomposite Materials

The geocomposite product for the lower drainage geocomposite shall comprise a cuspated HDPE core, thermally bonded to a filter geotextile on both sides. The geocomposite material shall meet the requirements of **Table 5** below and conformance testing shall be carried out in line with the manufacturers' specified values for the properties set out in **Table 5** below. The Contractor shall provide a schedule of results to show that the minimum requirements can be met by typical material of the type to be used, prior to installation on-site.

If the proposed product should fail any conformance testing then this material will be rejected and referred to the CQA Inspector for discussion.

Table 5: Lower Protection & Drainage Geocomposite Specification and Conformance Testing

Material Property	Approved test method	Units	Required value	Conformance Test Frequency
Geotextile Component Properties:				
Thickness at 2kPa	ES ISO 9863-1	mm	>0.96	Not Required
Tensile Strength (MD / CMD)	EN ISO 10319	kN/m	>8.2	Not Required
CBR Puncture Strength (CBR)	EN ISO 12236	kN	>1.28	Not Required
Dynamic Perforation Cone Drop	EN ISO 13433	mm	32 ± 20%	Not Required
Pore Size of Geotextile (Mean Pore Size O ₉₀)	EN ISO 12956	mm	0.12 ± 30%	Not Required
Geocomposite Product Properties:				
Thickness at 2kPa	ES ISO 9863-1	mm	>6.5	1 per 5,000m ²
Tensile Strength (MD / CMD)	EN ISO 10319	kN/m	>16.5	1 per 5,000m ²
CBR Puncture Strength (CBR)	EN ISO 12236	kN	>3.0	1 per 5,000m ²
In-Plane Water Flow @ HG = 1.0 with soft foam platens facing the cusplate side to simulate soil action. Hard/soft foam platens are acceptable. Test is to be performed in the long and cross direction. Confining Pressures: 20kPa 100kPa 200kPa	EN ISO 12958	l/m/s	1.25** 1.02** 0.84**	1 per 5,000m ² Not Required Not Required
Geocomposite Product Durability (according to annex B: EN 13253)*:				
Material Property	Approved test method	Requirement		Tolerance
Resistance to weathering @ 50MJ/m ² radiant exposure ¹	EN 12224	Retained Strength		80%
Resistance to Oxidation (100 years)	EN ISO 13438***	Retained Strength 56 days		50%
Resistance to liquids	EN 14030	Retained Strength		50%
1. 1-4 months UV exposure depending on location/season				
* Durability test data can be supplied by the manufacturer – test frequency must not exceed 5 years.				
** Values to be achieved regardless of any manufacturer’s tolerances.				
*** Manufacturer may use alternative means of assessing oxidation to achieve 100 years.				

6.3 Delivery, Handling and Storage

The material will be delivered, handled and stored in accordance with the manufacturer's recommendations and should be delivered and stored in tight wrappings in order to offer protection from ultra violet (UV) degradation. Each roll of geocomposite delivered to site will have a label which conforms with EN 30320, and include the details below:

- Manufacturer's name, address and telephone number;
- CE mark with accrediting body's number;
- Date of manufacture;
- Product name and polymer type;
- Geocomposite batch and roll number;
- Roll length and width in metres; and
- Roll weight in kilograms.

Lifting and transportation of the geocomposite materials shall be by appropriate machinery with the use of slings and core bars. The material is not to be handled with the tines of a forklift machine, the bucket of an excavator, or any similar equipment under any circumstances.

The Contractor shall provide adequate and acceptable measures for protecting the material at all stages of the work, from all sources of potential damage such as sharp objects, boulders, cobbles etc, including weather conditions, and will be located out of the way of moving plant.

The storage area for the lower drainage geocomposite will be agreed with Amgen Cymru and prepared to the satisfaction of the Contractor prior to delivery of the material to site. The storage area will be large enough to accommodate the rolls of geocomposite flat on the ground. It will be a level, dry and well-drained area, clear from rocks and other obstacles, such that the material is protected from:

- Site Traffic;
- Standing water;
- UV radiation;
- Extreme temperatures (<0C, >60C);
- Animal and plant infestation;
- Chemicals;
- Puncture; and
- Any other environmental condition that could impact on its physical properties.

The rolls of geocomposite will not be stacked more than 3 high with nothing stacked above them. All product rolls must be kept in the appropriate packaging until such time that they are required for Installation.

Any damaged material will be excluded from the works.

6.4 Manufacturers Quality Control

Quality control certificates will be supplied to cover each roll of material delivered to site. The certificates will be supplied prior to delivery of the material to site and will contain quality control data typically according to the requirements of **Table 5**.

CE Declaration certificates are also to be included when the material is delivered.

Quality Control Certificates will be provided prior to installation and for inclusion in the CQA Validation Report as follows:

- A specification for the geocomposite which includes all properties contained in **Table 5** measured using the appropriate test methods;
- Written certification that minimum values given in **Table 5** are guaranteed by the Manufacturer; and
- Written confirmation that testing to detect needle fragments and removal of needle fragments prior to delivery of the product has taken place.

6.5 Geocomposite Conformance Sampling

As soon as practicable after the delivery of the geocomposite rolls to site, the Contractor shall cut and label samples 1m long across the entire width of selected rolls for retention and/or conformance testing as directed by the CQA Inspector. Prior to taking the conformance samples the Contractor shall remove and discard the first 1m (outside) of the roll.

Set of samples of geocomposite material shall be taken by the Contractor for the required conformance testing at the frequencies detailed in **Table 5**. All testing is to be carried out at an independent geosynthetic testing laboratory having UKAS Accreditation for each test being carried out. The Contractor shall provide the CQA Inspector with a copy of the laboratory test results as soon as possible after receipt.

If testing shows that the geocomposite does not meet any one of the minimum requirements listed in **Table 5**, then this may be cause for rejection of the material from that roll. Any

repairs, replacement or other works occasioned by the failure of the geocomposite to meet the minimum requirements listed in **Table 5** shall be carried out at the Contractor's expense.

If the geocomposite fails to meet any of the conformance testing requirements, the CQA Inspector may at their discretion accept material from elsewhere on that roll, if the Contractor can demonstrate through further laboratory testing (at their expense) at a geosynthetic laboratory approved by the CQA Inspector that this material does meet the acceptance criteria contained in **Table 5**. If the Contractor does not demonstrate to the CQA Inspector that the material meets the conformance testing requirements, the CQA Inspector shall reject all material from that roll.

Alternatively:

In the event that a conformance test fails to meet the requirements of the Specification that roll shall be rejected and will not be incorporated into the works. The rolls numbered numerically on either side of the failed sample will then be subjected to conformance testing. This procedure will continue until the extent of the sub-specification material has been determined by bracketing. The Contractor will supply any replacement rolls at their own cost.

Construction of the drainage layer will not commence until the results of the conformance tests are known and have been accepted by the CQA Inspector.

6.6 Method Statement for Geocomposite Installation

Prior to the commencement of the installation of the lower drainage geocomposite, the Contractor shall submit to the CQA Inspector a detailed Method Statement which shall include the following:

- An accurate sketch or drawing showing the proposed rolls, panel layout, and overlaps for the lower drainage geocomposite. The sketch or drawing should show the Contractor's proposed start point and proposed directions of working. All geocomposite panels shall be arranged so that seams are aligned in the direction of maximum slope, wherever practicable, in accordance with accepted good practice;
- Proposed seaming techniques (taped or heat bonding);
- Proposed seam overlap;
- Proposed method of sealing around protruding pipework;
- Proposed method of tie-ins to existing lower drainage geocomposite in adjacent capping areas.

The drainage geocomposite material will be installed in accordance with the manufacturer's recommendations. A copy of the manufacturer's installation recommendations will be provided by the Contractor to the Employer and CQA Inspector prior to works commencing. Works will not commence until the installation method is agreed.

The Contractor's method statement will become part of the CQA Procedure and a copy will be forwarded to Natural Resources Wales for approval, once approved by the CQA Inspector. Any alterations from the approved method statement shall not proceed without prior consent from the CQA Inspector.

6.7 Lower Drainage Geocomposite Installation Requirements

The installation requirements for the lower drainage geocomposite are described below.

The CQA Inspector will assign panel identification codes and maintain a record of panel/roll correspondence and the date and location of installation. Each panel will be observed for defects and a record will be kept to assure that all defects are properly repaired and tested.

Geocomposite panels will be placed directly over and in intimate contact with the bedding / regulating soils layer. Geocomposite panels shall be rolled out as close as possible to their final position, and will not be dragged into position across the subgrade except where necessary to obtain the correct overlap with adjacent sheets. The lower drainage geocomposite material shall be placed with the cusped side facing down. Sheets will be installed down the slope using a spreader bar.

All fixing and cutting details adopted for the geocomposite drainage material shall be in accordance with the manufacturer's instructions. Where possible panels should be deployed so that seams are aligned parallel to the line of maximum slope. Panels shall be deployed in such a manner that the need for any horizontal seams is minimised, and avoided where possible.

Where horizontal seams are required, they should be installed as close to the base of the slope as possible, and staggered in order to avoid a failure plane in the geocomposite forming across the slope. For horizontal joints across the slope, or any other joints between the roll ends of panels, the up-slope geocomposite sheet shall underlie the downslope geocomposite sheet. The panel overlap for these joints will be a minimum of **500mm**; any sheets installed with less than **500mm** shall be rejected.

For joints between adjacent panels (where the sides of panels meet), the sheets shall be fixed with the cusped core butt jointed, and the geotextile flap on the edge of adjacent

geocomposite sheets shall be extended across the joint shiplap style. Jointing of the sheets shall be carried out as soon as possible after the sheets have been laid.

Geocomposite panels shall be joined by butyl taping or heat bonding, dependent on the agreed seaming method. Jointing shall be carried out along the geotextile flaps on the sides of the panels. If heat bonding is the agreed seaming method, joints between the ends of the panels are not required to be heated bonded as there will be no geotextile flap. This is acceptable as the panels shall already be held in place by the joints on the sides of the panels. The CQA Inspector shall observe all jointing of panels.

Furthermore the Contractor shall ensure that:

- Equipment, plant and tools used shall not damage the geocomposite by handling, trafficking, leakage of hydrocarbons or by other means;
- Personnel working on the geocomposite shall not smoke, wear shoes likely to cause damage, or otherwise engage in any activity that could damage the geocomposite or the underlying bedding / regulating soils layer;
- The surface to receive the geocomposite shall be free from debris, roots, angular or sharp rocks and any other deleterious materials that may cause damage to the geocomposite;
- The method of placement shall be in such a manner as to avoid stresses and strains likely to cause damage to the geocomposite;
- The geocomposite shall be in continuous contact with the surface on which it is placed without stretching or bridging over humps and hollows;
- The method of deployment shall minimise wrinkles or folds;
- Only geocomposite to be used on the same working day shall be removed from the store;
- Deployment shall not take place during periods of precipitation or in the presence of excessive moisture (fog, rain, snow, and heavy dew) or in the presence wind likely to cause damage;
- Geocomposite shall not be placed over areas of ponded water;
- Direct contact with the geocomposite is to be minimised; and
- Construction plant shall not traverse over any area of geocomposite until sufficient depth of cover has been placed over it in accordance with the Contract.

In windy conditions and at the end of the working day, all exposed edges of the geocomposite should be weighted down, the geocomposite should be held down using sandbags or similar weights that will not damage the material. The CQA Inspector shall visually check for such damage. The Contractor must accept full responsibility for the adequacy of this temporary surcharge.

All geocomposite sheets will be visually inspected for damage and imperfections after deployment and any repairs required will be undertaken.

6.8 Tie-in and Construction Details

Along free edges in the permanent capping area, as demarcated on **Drawing AM5593/01/02**, the lower drainage geocomposite shall be secured in a termination/anchor trench (**300mm x 300mm**) with the overlying LLDPE geomembrane, and the upper protection and drainage geocomposite. Survey pegs shall be installed at **10m intervals** along the anchor trench to de-mark the edge of the permanent capping area. These details are shown in the construction detail (**Section B-B'** and **Section C-C'**) on **Drawing AM5593/01/02**.

Along the north-western (provisional) and south-western edges of the permanent capping area, where the leachate collection trench is installed, the lower drainage geocomposite shall be installed directly over the top of the trench, in contact with the gravel, to ensure that leachate from the geocomposite will flow into the trench, as shown in the construction detail on **Drawing AM5593/01/02 (Section A-A')** and **Drawing AM5593/01/03 (Section D-D' & Detail B)**. Beyond the trench, the lower drainage geocomposite shall be installed across to the existing lower drainage geocomposite. The lower drainage geocomposite shall be lapped under (underlaid) the existing lower drainage geocomposite, with a minimum underlap of **500mm**, as shown in the construction details (**Section A-A** and **Section D-D'**) on **Drawing AM5593/01/02** and **Drawing AM5593/01/03**. The joint between the two materials shall be butyl taped or heat bonded. The tie-ins will be observed and recorded by the CQA Inspector to confirm that a satisfactory seal is achieved.

6.9 Inspection and Approval

The installed lower drainage geocomposite shall be subject to the inspection and approval by the CQA Inspector. Approval shall be made on the basis of the following:

- i) The geocomposite has been installed in accordance with this Specification;

- ii) A visual inspection has been undertaken to confirm that all stones, sandbags or any other potentially deleterious materials have been removed from the surface of the geocomposite, that there are no visible surface defects and no folds or excessive undulations, and that the appropriate overlap between adjacent panels has been achieved; and
- iii) All necessary repairs have been made.

Where the geocomposite has not been approved the Contractor shall discuss and agree appropriate remedial measures with the CQA Inspector. These measures may include the complete removal and replacement of a panel or undertaking remedial works.

6.10 Repairs

Any damage to the lower drainage geocomposite shall be identified and repaired by either cutting out the damaged section and replacing the material, or by placing further material beneath the damaged section. A minimum overlap of **500mm** shall be achieved on all edges of the repair. Where a patch is used beneath the damaged section, the patch shall be secured to the overlying geocomposite by taping or heat bonding, dependent upon the agreed method.

6.11 As-Built Drawings

A lower drainage geocomposite as-built panel layout shall be produced, in accordance with the requirements of Section 3.4 of this Specification.

7 GEOMEMBRANE LINER

7.1 General

A welded 1mm thick, double textured LLDPE geomembrane shall be installed to form the lower permeability capping liner. The approved surface of the lower drainage geocomposite shall be covered with the geomembrane.

The geomembrane is required as a low permeability cap to limit leachate production and improve landfill gas control, and shall be welded to achieve the required performance. The geomembrane will be installed and tested under a strict CQA regime, as set out in **CQA Plan Reference AM5593**, and in line with the manufacturer's guidance document and the latest regulatory (EA/NRW) guidance document (LFE5).

The geomembrane shall be supplied in accordance with the following specifications and the manufacturer's recommendations, and installed in the locations shown and in accordance with the construction details on **Drawing AM5593/01/02**.

The Contractor shall be required to undertake the following:

- Supply and install a welded, double textured, 1mm thick, LLDPE geomembrane on the approved surface of the lower drainage geocomposite / bedding / regulating soils layer;
- Tie the geomembrane into the existing capping system previously installed at the site; and
- Provide all material quality control certificates and other information described below.

Due to previous issues with the supplied material meeting the conformance test requirements, but subsequently failing the weld testing requirements, the supplier and origin of the geomembrane must be approved by the Project Manager before ordering.

7.2 Contractor's Experience

The liner installation Contractor or sub-contractor shall have considerable experience of installing geomembrane of the type specified for the works. The Contractor shall submit to Amgen Cymru a summary of the experience of the proposed liner installation Contractor with the specified materials including an estimate of the total area installed by them in the United Kingdom over the past 3 years. As stated in the government requirements for landfill

operators, the staff installing the geomembrane liner must be suitably qualified, trained and experienced, with the following accredited personnel:

- A lead technician and a foreman accredited to at least standard level (level 1) of the BGA/TWI/CSWIP welding standard (developed by the British Geomembrane Association (BGA), Thermal Welding Institute (TWI) and the Certification Scheme for Personnel (CSWIP)); and
- All welders accredited to a minimum of entry level (level 2) of the BGA/TWI/CSWIP welding standard.

The liner installation Contractor or sub-contractor must be accredited, or working towards being accredited, to the BGA accreditation scheme.

7.3 Geomembrane Material

The geomembrane shall consist of double textured 1.0mm thick LLDPE produced from new resins and containing no fillers, plasticisers or additives of any kind with the exception of carbon black. The surface shall be unlaminated and free from blemishes, abrasions or other surface imperfections. Due to previous issues with the supplied material meeting the conformance test requirements, but subsequently failing the weld testing requirements, the supplier and origin of the geomembrane must be approved by the Project Manager before ordering.

The geomembrane shall conform to the parameters established as given in **Table 6** below.

Table 6: Geomembrane Specification and Conformance Testing

Parameter	Test Method Applicable to Conformance Testing	Requirement (LLDPE)	Manufacturer's Quality Control Test Frequency	Conformance Test Sampling Frequency
Thickness (min)	ASTM D5994	1.0mm (nom -5%) 1.0mm (-10%, 8 out of 10) 1.0mm (-15% lowest value)	Per roll	1/5000m ²
Density (max)	ASTM D1505A	<0.939 g/ml	Per 90,000kg of material	1/5000m ²
Carbon Black Content (Range)	ASTM D1603-12	2% to 3%	Per 20,000kg of material	1/5000m ²
Carbon Black Dispersion	ASTM D5596	9 of 10 in Cat. 1 or 2 1 of 10 in Cat. 3	Per 20,000kg of material	1/5000m ²
Texture Asperity Height (min.ave.)	GRI GM12	>0.40mm	Every second roll	1/5000m ²
Tensile Properties (average of 5 MD and 5 XMD) Strength At Break (min ave) Elongation at Break (min ave.)	ASTM D6693, Type IV, 50mm gauge length at 50mm/min	11N/mm 250%	Per 90,000kg of material	1/5000m ²
Puncture Resistance (min ave.)	ASTM D4833	200 N	Per 20,000kg of material	1/5000m ²
Tear Resistance (min ave.)	ASTM D1004	100 N	Per 20,000kg of material	1/5000m ²
Oxidation Induction Time (OIT) Standard OIT or High Pressure OIT	ASTM D3895 ASTM D5885	100 minutes (min. ave.) 500 minutes (min. ave.)	Per 90,000kg of material	1/5000m ²
UV Resistance	High pressure OIT by ASTM D5885, GRI-GM11	35% retained after 1,600 hours (min. ave.)	Per batch of material	Not Required

7.4 Delivery, Handling and Storage

The geomembrane material will be delivered, handled and stored in accordance with the manufacturer's recommendations and should be delivered and stored in tight wrappings in order to offer protection from ultra violet degradation. The geomembrane will be delivered to site in rolls equipped with slings and loaded in such a way as to facilitate the unloading and handling of each roll without damaging it. Upon delivery the CQA Inspector will inspect each roll for damage, and any defects or damaged areas will be recorded. Any rolls that are deemed by the CQA Inspector to be too badly damaged to be included in the works will be segregated from the rest of the material and removed from the works.

Each roll will be clearly labelled with: the manufacturers' name, address and telephone number, the product name and type, the batch and roll number, the roll length, width, and weight, and date of manufacture.

A crane or other suitable lifting equipment will be used to off-load the rolls to the storage area. Rolls will only be lifted by the supplied slings or core bars. The material is not to be handled with the tines of a forklift machine, the bucket of an excavator, or any similar equipment under any circumstances. The Contractor shall provide adequate and acceptable measures for protecting the material at all stages of the work, from all sources of potential damage such as sharp objects, boulders, cobbles etc, including weather conditions and will be located out of the way of the way of moving plant.

The storage area for the geomembrane will be agreed with Amgen Cymru and prepared to the satisfaction of the Contractor prior to delivery of the material to site. The storage area will be large enough to accommodate the rolls of geomembrane flat to the ground. It will be a level, dry and well-drained area, clear from rocks and other obstacles that could potentially damage the geomembrane. The storage area shall be such that the material is protected from:

- Site Traffic;
- Standing water;
- UV radiation;
- Extreme temperatures (<0C, >60C);
- Animal and plant infestation;
- Chemicals;

- Puncture; and
- Any other environmental condition that could impact on its physical properties.

The rolls of geomembrane will not be stacked more than 3 high with nothing stacked above them.

The Contractor shall provide adequate and acceptable measures for protecting the material at all stages of the work, from all sources of potential damage such as sharp objects, boulders, cobbles etc, including weather conditions, until completion of the contract.

Any damaged or defective rolls are to be marked and segregated by the Contractor for further investigation.

7.5 Manufacturer's Quality Control

The Contractor will supply a quality control certificate for each roll of material delivered to site and each batch of resin used in production of the geomembrane. The certificates will be supplied prior to delivery of the material to site and will contain quality control data in accordance with the test methods and requirements given in **Table 6** above. CE Declaration or UK Equivalent certificates are also to be included when the material is delivered.

The certificates will include:

- i) The manufacturer's name;
- ii) Product name and type;
- iii) Date of manufacture;
- iv) Batch number and roll number; and
- v) Values for those parameters listed in **Table 6**.

7.6 Conformance Testing

As soon as practicable after the delivery of the geomembrane rolls to site, the Contractor shall select, cut and label samples 1m long across the entire width of the selected rolls for conformance testing as directed by the CQA Inspector. Prior to taking the conformance sample the Contractor shall remove and discard the first 1m (outside) of the roll. Sets of samples shall be taken at a frequency of 1 sample per 5000m² (or at least one per batch of material supplied), as specified in **Table 6**.

The Contractor shall submit the samples for conformance testing to an independent laboratory having UKAS accreditation for each test being carried out. A copy of the results of the testing are to be forwarded to the CQA Inspector and CQA Engineer.

If testing shows that the geomembrane does not meet any one of the minimum requirements of **Table 6** then this may be cause for rejection of the material from that roll.

If the geomembrane fails to meet any of the conformance testing requirements, the CQA Inspector may at their discretion accept material from elsewhere on that roll if the Contractor can demonstrate, through further laboratory testing (at their expense) at a geosynthetic testing laboratory approved by the CQA Inspector, that this material does meet the acceptance criteria contained in **Table 6**. If the Contractor does not demonstrate to the CQA Inspector that the material meets the conformance testing requirements, the CQA Inspector shall reject all material from that roll.

Alternatively:

In the event that a conformance test fails to meet the requirements of the Specification that roll shall be rejected and will not be incorporated into the works. The rolls numbered numerically on either side of the failed sample will then be subjected to conformance testing. This procedure will continue until the extent of the sub-specification material has been determined by bracketing. The Contractor will supply any replacement rolls at his own cost. Construction of the capping membrane will not commence until the results of the conformance tests are known and have been accepted by the CQA Inspector.

7.7 Surface Preparation Prior to Geomembrane Deployment

The geomembrane will be deployed directly onto the prepared surface of the lower drainage geocomposite.

The CQA Inspector will inspect and approve the surface prior to deployment of the geomembrane. Geomembrane will not be installed at any location without the approval of the surface at that location. Should any area fail to meet the required standard for geomembrane deployment the Contractor will remediate the area to the CQA Inspector's satisfaction. The methodology for the remediation of the failed surface will be discussed and agreed with the CQA Inspector prior to remedial works taking place.

Approval of the surface may be withdrawn if the surface should deteriorate prior to deployment of the geomembrane. Approval will then be withheld until the surface has been remediated to the CQA Inspector's satisfaction.

7.8 Method Statement for Geomembrane Installation

Prior to the commencement of the installation, the Contractor shall submit to the CQA Inspector a detailed Method Statement which shall include the following:

- An accurate sketch or drawing showing the proposed rolls, panel layout, and overlaps for the geomembrane. The sketch or drawing should show the Contractor's proposed start point and proposed directions of working. All geomembrane panels shall be arranged so that seams are aligned in the direction of maximum slope, wherever practicable, in accordance with accepted good practice.;
- Proposed seaming technique or techniques and their proposed applications for a textured geomembrane. It should be noted that only thermal methods are permissible and the CQA Inspector will require double track fusion welding to be carried out wherever practical. Extrusion welding is to be kept to an absolute minimum;
- Details of the welders to be engaged on the works, including certification;
- Proposed welding machine and working procedures;
- Proposed seam overlap and preparation prior to seaming;
- Proposed acceptable temperature ranges (or setting) for extrudate and/or hot wedge welders;
- Proposed acceptable maximum seaming speed if automated machinery is to be used;
- Proposed testing techniques;
- Proposed method of sealing around protruding pipework; and
- Proposed method of tie-ins to existing capping geomembrane / between phases of capping geomembrane.

The geomembrane material will be installed in accordance with the manufacturer's recommendations. A copy of the manufacturer's installation recommendations will be provided by the Contractor to the Employer and CQA Inspector prior to works commencing. Works will not commence until the installation method is agreed.

The Contractor's method statement will become part of the CQA Procedure and a copy will be forwarded to Natural Resources Wales for approval, once approved by the CQA

Inspector. Any alterations from the approved method statement shall not proceed without prior consent from the CQA Inspector.

7.9 Deployment of Geomembrane

The geomembrane material shall be placed over the capping area, to the lines and levels shown on **Drawing AM5593/01/01**. However, in the event that additional material meeting the Specification is available, the limits of the works may be revised a little (slight extensions to the capping area permitted) to accommodate the available materials.

The Contractor will record each panel deployed and maintain a record of the date and location of installation. Each panel will be observed for defects and a record will be kept to assure that all defects are properly repaired. All geomembrane panels will be arranged in accordance with the Contractor's approved panel layout drawing.

Geomembrane panels shall be rolled out as close as possible to their final position, and will not be dragged into position across the subgrade except where necessary to obtain the correct overlap with adjacent sheets. The required overlap of between adjacent sheets shall be **150mm**.

For maximum cleanliness, unrolled sheets or groups of welded sheets shall not be dragged across the site. The geomembrane shall be suitably weighted down once installed on the slope, including all sheets to be subsequently welded. In windy conditions and at the end of the working day, all exposed edges of the geomembrane should be weighted down.

The Contractor will ensure that:

- No damage is caused to the geomembrane by the tools, plant or equipment during deployment, no welding generators are to be placed directly upon the geomembrane;
- The geomembrane will remain clean and free from any contamination;
- Personnel working on the geomembrane will not smoke, wear shoes likely to cause damage, or engage in any other activity that could damage the geomembrane;
- The method of deployment will be such as to minimise stresses or strain on the geomembrane and will not cause damage to the underlying bedding / regulating soils layer / lower drainage geocomposite;
- The geomembrane will be in intimate contact with the underlying surface without bridging over hollows or humps;

- The method of deployment will prevent wrinkles and creases in the geomembrane;
- No vehicles will track directly over the geomembrane;
- Surface water will be prevented from infiltrating beneath the deployed geomembrane;
- No geomembrane will be deployed during periods of rain, snow, or wind likely to cause damage to the geomembrane; and
- Geomembrane installation testing will be carried out in accordance with **Table 7** below.

The geomembrane of the capping system shall be secured in perimeter termination trenches (**Section B-B'** and **Section C-C'**) or welded to the geomembrane of the existing capping system (**Section A-A'** and **Section D-D'**), as shown on **Drawing AM5593/01/02** and **Drawing AM5593/01/03**.

7.9 Seaming Procedures

Only suitably qualified and experienced personnel will carry out the deployment and welding of the geomembrane liner. The welding operators and installation staff should hold a current third party certificate for installation and welding of flexible lining systems to a recognised standard, with the following specific government requirements for geomembrane installation on landfill sites applying:

- A lead technician and a foreman accredited to at least standard level (level 1) of the BGA/TWI/CSWIP welding standard (developed by the British Geomembrane Association (BGA), Thermal Welding Institute (TWI) and the Certification Scheme for Personnel (CSWIP));
- All welders accredited to a minimum of entry level (level 2) of the BGA/TWI/CSWIP welding standard.

The liner installation Contractor or sub-contractor must be accredited, or working towards being accredited, to the BGA accreditation scheme.

The Contractor will only construct field seams on each working day after trial seams have been carried out on that day to the satisfaction of the CQA Inspector. Seaming of the geomembrane sheets shall be carried out as soon as possible after the sheets have been laid.

The general seaming procedure will be such that:

- The welding equipment does not damage the geomembrane;
- All surfaces of the geomembrane to be seamed are clean, dry and free from dust, dirt, debris and foreign material of any kind prior to seaming;
- Twin track fusion welding will be the welding method utilised, extrusion welding will only be used where fusion welding is not possible, with the permission of the CQA Inspector;
- Wedge and/or extrudate temperatures or settings are maintained within a range approved by the CQA Inspector;
- Where seam overlap grinding is necessary it shall not remove more than 10% of the nominal geomembrane thickness and does not extend more than 12mm on either side of any proposed extrusion seam. Grinding will not take place more than one hour prior to seaming;
- Temporary heat bonding of adjacent panels, or any pre-heating during seaming, will not cause any damage or overheating to the geomembrane. The use of adhesives shall not be permitted;
- Where a seam runs into an anchor trench the weld will extend to the back edge of the trench. Any seam defects falling within the anchor trench will be repaired in accordance with the Specification;
- Seams will be aligned so as to minimise the number of wrinkles and 'fishmouths'. Where the overlap does not meet the requirements of the Specification it will be patched in accordance with the Specification; and
- Seaming shall not take place:
 - During any period of rain or snow, unless the CQA Inspector is satisfied that measures have been implemented to allow the seam to be made on dry geomembrane materials;
 - At ambient temperatures lower than 5°C or higher than 25°C, unless approved by the CQA Inspector, during periods of high relative humidity or wind speed;
 - Over frozen or saturated ground;
 - Over ponded water;
 - During periods of darkness unless approved by the CQA Inspector and subject to the Contractor providing adequate lighting.

At the beginning of each shift, the Contractor shall demonstrate to the CQA Inspector that the ambient temperature is within the acceptable range (5°C of 25°C), and also record the surface temperature of the geomembrane, using suitable equipment.

If the Contractor wishes to carry out welding at ambient temperatures below 5°C, or above 25°C, they shall demonstrate by trial seaming that the seam is equivalent to those produced under approved conditions, and that the overall quality of the geomembrane welding is not adversely affected.

As stated in GRI GM9, where cold weather seaming is carried out at temperatures below 0°C, the speed of the welding device is likely to be slower than when seaming at temperatures above 0°C (32°F). Furthermore, the rate should decrease with decreasing sheet temperature. Cold temperature seaming requires more frequent trial seams than when welding at temperatures above freezing. For example, if the Specification requires two trial seams a day at temperatures above freezing, the number should be increased by one per day for each 7.5°C (13.5°F) less than freezing. Trial seams should be made at the discretion of the CQA Inspector.

If the Contractor carries out welding at ambient temperatures of above 25°C, trial welds are required to be undertaken more frequently, as temperatures above 25°C can impact the performance of the geomembrane welding (see Section 5.9.1 below). If welding is carried out at above 25°C, the Contractor shall ensure that the geomembrane is covered with drainage geocomposite (where applicable) as soon as is reasonably practicable following placement, and shall check the geomembrane for wrinkles following return to cooler temperatures.

The Contractor will clearly mark the minimum overlap on the edge of the underlying geomembrane panel prior to welding the seam.

7.9.1 Trial Seams

The Contractor will perform trial seams with each seaming machine and operator at least at the start of each shift and following any period of machine stoppages greater than 1 hour or change of operator in the presence of the CQA Inspector and in accordance with the requirements of **Table 7** below. In addition, trial seams should also be carried out where weather conditions have changed such that there will be an effect on the welding efficiency of the machinery, and if there is any doubt about the effectiveness of the welding equipment.

If hot weather seaming is carried out at ambient temperatures of above 25°C, the Contractor will perform trial seams with each seaming machine and operator at a rate of two per day and following any period of machine stoppages greater than 1 hour or change of operator in the presence of the CQA Inspector and in accordance with the requirements of **Table 7** below.

The trial seams will be at least 3m long for both fusion seams and extrusion seams. The trial seams shall be marked with the time, date, temperature (ambient and geomembrane), welding machine type and welding machine number.

On completion of the trial seam, the Contractor shall cut a total of six 110mm long and 25mm wide field tabs normal to the seam at the start, centre and end of the seam (3 pairs), and subject the tabs to field destructive testing. Three specimens shall be tested in peel mode and three in shear mode. The seam will be deemed to have passed qualitative destructive testing if in all six samples, the failure occurs solely in the geomembrane and does not enter the seam. The seam will be deemed to have failed qualitative destructive testing if any of the samples, any of the failure enters the seam. Geomembrane Weld Failure Codes are presented in **Appendix 2**.

If a trial seam fails field destructive testing as specified above then the entire operation will be repeated. The seaming machine and the operator will not be allowed to perform field seaming until the deficiencies are corrected and both machine and operator have achieved passing trial seams. The parameters for the seam testing are shown in **Table 7**.

If any of the additional specimens fail, the welding equipment shall be inspected and a report made of any defects and the corrective action taken. Welding may continue after two further consecutive full trial seams are achieved without failure.

Should three test welds fail in any 24 hour period, two samples will be sent to an independent laboratory for testing. If the test results indicate failure the machine shall be returned to the manufacturer for repair. If the test results indicate a pass the equipment may be used subsequent to two further consecutive full trial seams being achieved without failure. The equipment should not be used until the test results are known. If the equipment fails five times in any 48 hour period it shall be returned to the manufacturer for repair with a record kept of the service.

The CQA Inspector will verify that trial seaming is performed at the appropriate intervals and that passing results are achieved prior to any production seaming by the apparatus/seamer.

The CQA Inspector will observe the field testing of each trial seam and will maintain a log of all trial seam data.

Table 7: Geomembrane Installation Testing

Parameter	Test Method	Test Frequency	Requirement for Textured LLDPE
Start Up Test Weld			
Welding Equipment and Operative	Visual and peel and shear using appropriate equipment	Daily at the start of works and after 1hr stoppages and after any significant changes in welding conditions. For ambient temperatures of above 25°C the minimum frequency shall be 2 per day.	Test fails outside welded area
Non-Destructive Weld Testing			
Dual Track Welds (Fusion welds)	Air Pressure Test ASTM D5820	Continuous – every weld	Inflate to 1.9-2.2 bar and maintain pressure over 5 minutes
Extrusion Welds	Vacuum Box ASTM D5641	Continuous – every weld	No bubbles witnessed
Destructive Weld Testing LLDPE			
<i>On-site</i>	Peel and shear using appropriate equipment	Every weld	Failure to be outside weld
<i>Off-site</i> - Seam peel strength and bonded seam strength Shear Elongation and Peel Separation	ASTM D6392 GRI GM19	1 per 200m of seam or If less than 200m of seam is deployed in a single day there is still the requirement to take a minimum of one per day.	Fusion Weld: Shear Test >10.5N/mm Peel Test >8.8 N/mm Extrusion Weld: Shear Test >0.5 N/mm Peel Test >7.6 N/mm Fusion Weld: Shear Elongation >50% Peel Separation <25% Extrusion Weld: Shear Elongation >50% Peel Separation <25%

7.9.2 Seaming Methodology

The panels will be deployed in accordance with a method statement and proposed panel layout drawing issued by the Contractor prior to commencement of the works; the method statement and proposed layout will be submitted for approval to the CQA Inspector.

The CQA Inspector will utilise a seam numbering system that is a combination of the panel numbers being joined. For example, the seam joining panels No 1 and 2 would be seam No

1/2. The CQA Inspector will maintain a log of seaming data for each seam including the source roll for each panel, date, identification of the seamer and machine, ambient and machine temperatures. All seams will be observed for visual integrity and any defects will be logged to verify that they are properly repaired and tested.

The minimum overlap for both fusion and extrusion welded seam shall be **150mm**. During construction, this overlap shall be clearly marked on the edge of the underlying sheet prior to seaming. Failure to maintain the minimum overlap may be cause for rejection of the seam.

The Contractor shall perform field seams only after satisfying the trial seam conditions as specified above.

7.9.2.1 Fusion Welding

Wherever possible the seams in the geomembrane will be fusion welded with a double seam.

Fusion welded seams will be formed by working in one direction only.

7.9.2.2 Extrusion Welding

Extrusion seaming will only be used with the approval of the CQA Inspector where:

- Double seam welding is not practicable;
- Defects in the geomembrane need to be repaired; and/or
- Patches have to be welded over the location of field test samples.

The width of extrusion seams will not be less than 30mm. Prior to forming an extrusion seam adjacent panels will be temporarily secured by heat bonding and the seam surfaces scarified by grinding to provide a key and to remove surface oxidation.

The extrudate material used for extrusion welding shall be identical in composition to that of the geomembrane and supplied by the Geomembrane supplier.

The extruder will be purged prior to the commencement of any extrusion seaming or after any stoppage in seaming until all heat degraded extrudate has been removed from the barrel.

7.10 Sampling and Testing

Sampling and testing shall be carried out in accordance with the requirements of **Table 7**.

7.10.1 Qualitative Destructive Testing

The Contractor will take a tab sample from the beginning and end of each completed seam. The tabs will be nominally 25mm wide and at least 105mm long with all tabs being tested for peel and shear failure. The seam will be deemed to have passed qualitative destructive testing if the failure occurs solely in the geomembrane and does not enter the seam. The seam will be deemed to have failed qualitative destructive testing if any of the failure enters the seam. Geomembrane Weld Failure Codes are presented in **Appendix 2**.

If the tab sample fails field qualitative destructive testing the Contractor shall either:

- Reconstruct the seam between two field tabs which have been shown to pass the qualitative destructive field testing, in accordance with the agreed method statement; or
- Undertake further qualitative destructive tests to identify the area of the field seam that is deemed as inadequate.

Further qualitative destructive testing shall be undertaken by cutting further tabs on either side of the location of the failed field tab, with the additional tabs being taken approximately 3m from the location of the failed tab. These further field tabs shall be subjected to qualitative destructive testing in accordance with the agreed method statement. If both tabs pass the qualitative destructive testing, then the Contractor shall cut a laboratory sample from a section of the passed seam. If either sample fails, the Contractor shall cut further field test tabs approximately 3 metres from the location of the failure until they can identify an area bounded by two passed field tabs. The CQA Inspector may direct the taking of additional tab samples and qualitative destructive testing at any location along the length of the seam. The Contractor shall reconstruct the failed seam between the locations of the passed tabs in accordance with the agreed method statement.

The welding equipment used for seaming where the failure has occurred shall be taken out of service until it has passed a trial seam.

7.10.2 Quantitative Destructive Testing

The Contractor will recover samples for quantitative destructive testing at a frequency of one sample from a minimum of every **200m of welding, or one sample per day per machine, whichever occurs more frequently**, at locations as directed by the CQA Inspector. The Contractor shall submit the samples for conformance testing and will send a copy of the

results of the testing to the CQA Inspector. This shall not relieve the Contractor from any of their obligations under the Contract.

Each sample will be at least 0.3 metres wide by 1.2 metres long with the seam centred lengthways. One 25mm wide tab will be cut from each end of the sample. The remaining sample will be cut into two parts with one additional 25mm wide tab being cut from each of the two parts. The tabs will be tested in the field for failure in peel and shear in accordance with the Specification.

The two sample parts shall be distributed as follows:

- i) one part measuring 300mm x 600mm, to the Contractor; and
- ii) one part measuring 300mm x 600mm, to the CQA Inspector for retention.

The Contractor shall forward their sample to the testing laboratory for quantitative destructive testing in accordance with ASTM D6392. This testing shall involve peel mode and shear mode tests from tabs taken alternately throughout the sample. The laboratory shall report quantitative results and the mode of failure for the tests carried out.

The seam will be deemed to have passed quantitative destructive testing if in all five tabs:

- i) Failure occurs solely on the parent material and does not enter the seam;
- ii) The peel and shear strength of all 5 samples exceeds these requirements specified in **Table 7**; and
- iii) The peel separation and shear elongation of all 5 samples must meet the minimum requirements specified in **Table 7**.

In the event of a failed destructive test the Contractor may do either of the following:

- i) Replace or cap the entire seam length i.e. remove the seam and re-seam;
- ii) Extract further samples for destructive testing a minimum of 3m in both directions (if applicable) from the location of the failed test. If these samples pass quantitative destructive testing, the seam shall be reconstructed between these locations by capping in accordance with this Specification. If these samples fail qualitative destructive testing, then further samples from along the seam shall be taken and laboratory tested until the failed seam is bounded by two passed locations, then the seam shall be reconstructed in accordance with this Specification.

7.10.3 Non-Destructive Seam Testing

The Contractor shall carry out a risk assessment and submit method statements to the CQA Inspector for their proposed method of carrying out non-destructive testing of welded seams. Any extrusion welded seams shall be tested by vacuum box testing. Fusion welded seams shall be tested by Air Pressure Testing. All seams shall be non-destructively tested along their entire length (including patches and repairs) by the Contractor in the presence of the CQA Inspector.

The CQA Inspector will verify that the procedures outlined for non-destructive testing are adhered to by the Contractor. The CQA Inspector will record the date and time, identification of the person performing the test, pressure values and the pass/fail conditions for all seams. In the event of a field seam failing non-destructive testing (including the air pressure continuity test), the Contractor shall identify and repair the failed area. The Contractor shall then subject the repair to further non-destructive testing. The CQA Inspector will verify that all failed conditions are properly remediated and retested, and verify that all data is complete.

7.10.3.1 Air Pressure Testing

All fusion seams shall be air pressure tested. The air channel formed between the twin welds shall be sealed at both ends. An inlet valve and pressure gauge shall be fitted at opposite ends of the air channel to be tested. The channel shall then be pressurised to a maximum pressure of 2.2 bar and a minimum pressure of 1.9 bar. Following removal of the pressure source, the pressure shall be allowed to equalise for one minute to allow for the stabilisation of the temperature effects. The change in pressure shall then be recorded over the next five minute period. If the pressure decreases by more than 10% of the original pressure over the 5 minute period then the fusion seam will be deemed to have failed the test.

Upon completion of the air pressure test, the channel shall be deflated from the opposite end to which the pressure source was applied to confirm that the full length of seam had been pressurised.

If a seam fails the air pressure test, or indicates a blockage in the channel, the test length shall be incrementally reduced until the failure area has been clearly identified. In the case of identifiable points of failure, the seam shall be repaired using an extrusion weld and the test repeated. If specific points of failure cannot be identified to the satisfaction of the CQA Inspector then the whole seam shall be repaired in accordance with the requirements of the Specification.

7.10.3.2 Vacuum Box Testing

Extrusion seams shall be tested over their entire length using the purpose made equipment which produces a vacuum over the tested area, in accordance with the method specification set out in ASTM D5641. A detergent water solution shall be applied to the full test area prior to the application of the test equipment. A vacuum of -0.4 bar shall be applied after the box is seated over the prepared seam. Upon application of the vacuum, bubbling of the solution should indicate the location of a leak in the seam. The vacuum shall be applied for a period of not less than 30 seconds. The location of any leaks shall be marked in an indelible manner and then the seam repaired in accordance with the Specification. A minimum overlap of 50mm is required between adjacent box positions along the seam.

7.10.4 Defect Repair

All discontinuities in the geomembrane (whether caused by damage, or failure of geomembrane or seams, failure to conform with the Specification, or by sampling or testing or other factors), will be repaired by the Contractor in the following manner:

- Point defects;
 - a) The area will be prepared by grinding and an extra layer of extrudate applied.
- Large faults;
 - a) The faulted area will be cut back to remove all imperfections and will be overlain with a single piece of compatible geomembrane to give a minimum overlap of 100mm in all directions. The area will then be prepared and seamed in accordance with this Specification.
- Seam faults;
 - a) Faulted extrusion seams will be overlain with a single piece of compatible geomembrane with a minimum overlap of 100mm in all directions to form a cap strip. The repair may then be completed as for large faults; and
 - b) Faulted fusion seams will be cut back to remove the upper flap, prepared by grinding and extrusion welded in accordance with this Specification.

Excessive creases or folds left in the geomembrane after welding shall be cut out and rewelded with the insertion of a fillet if necessary, but care should be taken during deployment of the geomembrane to keep the necessity for such repairs to a minimum.

The CQA Inspector will log each defect requiring repair with a unique code and then, using the same code, verify that each defect is properly repaired and tested. Non-destructive testing of all repairs will be observed by the CQA Inspector.

7.10.5 Testing Review

The CQA Inspector will review all destructive and non-destructive testing data, including a walkover prior to the placement of the covering layer and record that all testing has been completed to their satisfaction.

7.11 Temporary Surcharge

The Contractor shall be responsible for providing adequate temporary loading and/or anchoring measures (e.g. in the form of durable sandbags or similar weights without sharp edges and not likely to damage the geomembrane) on the geomembrane in the permanent capping area, immediately after deployment, to protect the geomembrane from damage by the wind or to prevent slippage during the works. These measures shall remain in place until the overlying layers are placed over the geomembrane, unless otherwise directed by the CQA Inspector. On steep embankments, suspension of sandbags or other weights by ropes may be required.

7.12 Tie-in and Construction Details

7.12.1 Tie-in to Existing Capping Geomembrane (Weld)

On the north-western and south-western edges of the permanent capping area, the geomembrane shall be tied-in to the existing geomembrane liner of the completed capping systems of Phase 3A and Phase 4A, in the locations shown and according to the construction detail on **Drawings AM5593/01/02 & 03**. The geomembrane shall be extended above the leachate collection trench such that the tie-in is constructed adjacent to the existing anchor trench on the edge of the existing capping systems. The tie-ins will be fusion welded where possible. Where fusion welding is not reasonably practicable, extrusion welding may be used. The tie-ins will be observed and recorded by the CQA Inspector to confirm that a satisfactory seal is achieved.

7.12.2 Free Edges (Termination Trench)

Along 'free edges' in the permanent capping area, as demarcated on **Drawing AM5593/01/01** (marked as **Section B-B'** and **Section C-C'**), the geomembrane shall be secured in a termination trench (300mm x 300mm) along with the upper and lower protection

and drainage geo-composite layers. Survey pegs shall be installed at **10m intervals** (or longer, where agreed) along the anchor trench to de-mark the edge of the permanent capping area. These details are shown in the construction detail on **Drawing AM5593/01/02**.

7.12.3 Protuberances

Where leachate / gas wells or HDPE pipework are required to pass through the cap, the area around the penetration will be sealed with a 150mm wide, 500mm deep ring of hydrated bentonite powder/granules.

Where the well / HDPE pipework passes through the restoration soils, it shall be placed within oversized pipework, with the void inside the oversized pipework to be subsequently filled with hydrated bentonite powder/granules to within 100mm of the top of the pipe boot.

To comply with the DSEAR requirements the Contractor shall form and install a geomembrane boot detail with a minimum distance of **2.2m** from the outside of the pipe boot.

The construction detail for protuberances is shown on **Drawing AM5593/01/02**.

7.13 As-Built Drawings

A geomembrane as-built panel layout shall be produced, in accordance with the requirements of Section 3.4 of this Specification.

8 UPPER PROTECTION & DRAINAGE GEOCOMPOSITE

8.1 General

The upper protection and drainage geo-composite shall be installed above the LLDPE capping geomembrane in the permanent capping area. The upper drainage geocomposite is required to discharge seepage rainwater into the surface water collection system.

The upper drainage geocomposite shall be supplied in accordance with the parameters given in **Table 8**, and installed in accordance with **Drawing AM5593/01/02**, the procedures and CQA requirements described below, and the manufacturer's recommendations. The Contractor will be required to:

- Supply and install an upper protection and drainage geo-composite above the LLDPE capping geomembrane in the permanent capping area;
- Tie (**500mm overlap**) the upper drainage geocomposite into the existing upper drainage geocomposite of Phase 3A and Phase 4A on the south-western and north-western sides of the permanent capping area;
- Provide all material quality control certificates and other information described below; and
- Complete interface testing as required in **Appendix 3** (upper drainage geocomposite to restoration soils).

8.2 Geocomposite Materials

The geocomposite product for the upper protection and drainage geocomposite shall comprise a cusped HDPE core, thermally bonded to a filter geotextile on both sides. The geocomposite material shall meet the requirements of **Table 8** below and conformance testing shall be carried out in line with the manufacturers' specified values for the properties set out in **Table 8** below. The Contractor shall provide a schedule of results to show that the minimum requirements can be met by typical material of the type to be used, prior to installation on-site.

If the proposed product should fail any conformance testing then this material will be rejected and referred to the Principal Designer for discussion.

Table 8: Upper Protection & Drainage Geo-composite Specification and Conformance Testing

Material Property	Approved test method	Units	Required value	Conformance Test Frequency
Geotextile Component Properties:				
Thickness at 2kPa	ES ISO 9863-1	mm	>0.96	Not Required
Tensile Strength (MD / CMD)	EN ISO 10319	kN/m	>8.2	Not Required
CBR Puncture Strength (CBR)	EN ISO 12236	kN	>1.28	Not Required
Dynamic Perforation Cone Drop	EN ISO 13433	mm	32 ± 20%	Not Required
Pore Size of Geotextile (Mean Pore Size O ₉₀)	EN ISO 12956	mm	0.12 ± 30%	Not Required
Geocomposite Product Properties:				
Thickness at 2kPa	ES ISO 9863-1	mm	>6.5	1 per 5,000m ²
Tensile Strength (MD / CMD)	EN ISO 10319	kN/m	>16.5	1 per 5,000m ²
CBR Puncture Strength (CBR)	EN ISO 12236	kN	>3.0	1 per 5,000m ²
In-Plane Water Flow @ HG = 1.0 with soft foam platens facing the cusplate side to simulate soil action. Hard/soft foam platens are acceptable. Test is to be performed in the long and cross direction. Confining Pressures: 20kPa 100kPa 200kPa	EN ISO 12958	l/m/s	1.25** 1.02** 0.84**	1 per 5,000m ² Not Required Not Required
Geocomposite Product Durability (according to annex B: EN 13253)*:				
Material Property	Approved test method	Requirement		Tolerance
Resistance to weathering @ 50MJ/m ² radiant exposure ¹	EN 12224	Retained Strength		80%
Resistance to Oxidation (100 years)	EN ISO 13438***	Retained Strength 56 days		50%
Resistance to liquids	EN 14030	Retained Strength		50%
1. 1-4 months UV exposure depending on location/season				
* Durability test data can be supplied by the manufacturer – test frequency must not exceed 5 years.				
** Values to be achieved regardless of any manufacturer’s tolerances.				
*** Manufacturer may use alternative means of assessing oxidation to achieve 100 years.				

8.3 Delivery, Handling and Storage

The material will be delivered, handled and stored in accordance with the manufacturer's recommendations and should be delivered and stored in tight wrappings in order to offer protection from ultra violet degradation. Each roll of geocomposite delivered to site will have a label which conforms with EN 30320, and including the details below:

- Manufacturer's name, address and telephone number;

- CE mark with accrediting body's number;
- Date of manufacture;
- Product name and polymer type;
- Geocomposite batch and roll number;
- Roll length and width in metres; and
- Roll weight in kilograms.

Lifting and transportation of the geocomposite materials shall be by appropriate machinery with the use of slings and core bars. The material is not to be handled with the tines of a forklift machine, the bucket of an excavator, or any similar equipment under any circumstances.

The Contractor shall provide adequate and acceptable measures for protecting the material at all stages of the work, from all sources of potential damage such as sharp objects, boulders, cobbles etc, including weather conditions and will be located out of the way of moving plant.

The storage area for the upper drainage geocomposite will be agreed with Amgen Cymru and prepared to the satisfaction of the Contractor prior to delivery of the material to site. The storage area will be large enough to accommodate the rolls of geocomposite flat to the ground. It will be a level, dry and well-drained area, clear from rocks and other obstacles, such that the material is protected from:

- Site Traffic;
- Standing water;
- UV radiation;
- Extreme temperatures (<0C, >60C);
- Animal and plant infestation;
- Chemicals;
- Puncture; and
- Any other environmental condition that could impact on its physical properties.

The rolls of geocomposite will not be stacked more than 3 high with nothing stacked above them. All product rolls must be kept in the appropriate packaging until such time that they are required for Installation.

Any damaged material will be excluded from the works.

8.4 Manufacturers Quality Control

Quality control certificates will be supplied to cover each roll of material delivered to site. The certificates will be supplied prior to delivery of the material to site and will contain quality control data typically according to the requirements of **Table 8**.

CE Declaration certificates are also to be included when the material is delivered.

Quality Control Certificates will be provided prior to installation and for inclusion in the CQA Validation Report as follows:

- A specification for the geocomposite which includes all properties contained in **Table 8** measured using the appropriate test methods;
- Written certification that minimum values given in **Table 8** are guaranteed by the Manufacturer; and
- Written confirmation that testing to detect needle fragments and removal of needle fragments prior to delivery of the product has taken place.

8.5 Geocomposite Conformance Sampling

As soon as practicable after the delivery of the geocomposite rolls to site, the Contractor shall cut and label samples 1m long across the entire width of selected rolls for retention and/or conformance testing as directed by the CQA Inspector. Prior to taking the conformance samples the Contractor shall remove and discard the first 1m (outside) of the roll.

Set of samples of geocomposite material shall be taken by the Contractor for the required conformance testing at the frequencies detailed in **Table 8**. All testing is to be carried out at an independent geosynthetic testing laboratory having UKAS Accreditation for each test being carried out. The Contractor shall provide the CQA Inspector with a copy of the laboratory test results immediately on receipt.

If testing shows that the geocomposite does not meet any one of the minimum requirements listed in **Table 8**, then this may be cause for rejection of the material from that roll. Any

repairs, replacement or other works occasioned by the failure of the geocomposite to meet the minimum requirements listed in **Table 8** shall be carried out at the Contractor's expense.

If the geocomposite fails to meet any of the conformance testing requirements, the CQA Inspector may at their discretion accept material from elsewhere on that roll if the Contractor can demonstrate through further laboratory testing (at their expense) at a geosynthetic laboratory approved by the CQA Inspector that this material does meet the acceptance criteria contained in **Table 8**. If the Contractor does not demonstrate to the CQA Inspector that the material meets the conformance testing requirements, the CQA Inspector shall reject all material from that roll.

Alternatively:

In the event that a conformance test fails to meet the requirements of the Specification that roll shall be rejected and will not be incorporated into the works. The rolls numbered numerically on either side of the failed sample will then be subjected to conformance testing. This procedure will continue until the extent of the sub-specification material has been determined by bracketing. The Contractor will supply any replacement rolls at their own cost.

Construction of the drainage layer will not commence until the results of the conformance tests are known and have been accepted by the CQA Inspector.

8.6 Method Statement for Geocomposite Installation

Prior to the commencement of the installation of the upper drainage geocomposite, the Contractor shall submit to the CQA Inspector a detailed Method Statement which shall include the following:

- An accurate sketch or drawing showing the proposed rolls, panel layout, and overlaps for the upper drainage geocomposite. The sketch or drawing should show the Contractor's proposed start point and proposed directions of working. All geocomposite panels shall be arranged so that seams are aligned in the direction of maximum slope, wherever practicable, in accordance with accepted good practice;
- Proposed seaming techniques (taped or heat bonding);
- Proposed seam overlap;
- Proposed method of sealing around protruding pipework;
- Proposed method of tie-ins to existing upper drainage geocomposite in adjacent capping areas.

The protection and drainage geo-composite material will be installed in accordance with the manufacturer's recommendations. A copy of the manufacturer's installation recommendations will be provided by the Contractor to the Employer and CQA Inspector prior to works commencing. Works will not commence until the installation method is agreed.

The Contractor's method statement will become part of the CQA Procedure and a copy will be forwarded to Natural Resources Wales (NRW) for approval, once approved by the CQA Inspector. Any alterations from the approved method statement shall not proceed without prior consent from the CQA Inspector.

8.7 Upper Drainage Geocomposite Installation Requirements

The installation requirements for the upper drainage geocomposite are described below.

The CQA Inspector will assign panel identification codes and maintain a record of panel/roll correspondence and the date and location of installation. Each panel will be observed for defects and a record will be kept to assure that all defects are properly repaired and tested.

Geocomposite panels will be placed directly over and in intimate contact with the LLDPE capping geomembrane. Geocomposite panels shall be rolled out as close as possible to their final position, and will not be dragged into position across the subgrade except where necessary to obtain the correct overlap with adjacent sheets. The upper drainage geocomposite material shall be placed with the cusped side facing up. Sheets will be installed down the slope using a spreader bar.

All fixing and cutting details adopted for the geocomposite drainage material shall be in accordance with the manufacturer's instructions. Where possible panels should be deployed so that seams are aligned parallel to the line of maximum slope. Panels shall be deployed in such a manner that the need for any horizontal seams is minimised, and avoided where possible.

Where horizontal seams are required, they should be installed as close to the base of the slope as possible, and staggered in order to avoid a failure plane in the geocomposite forming across the slope. For horizontal joints across the slope, or any other joints between the ends of panels, the upslope geocomposite sheet shall overlie the downslope geocomposite sheet. The panel overlap for these joints will be a minimum of **500mm**; any sheets installed with less than **500mm** shall be rejected.

For joints between adjacent panels (where the sides of panels meet), the sheets shall be fixed with the cusped core butt jointed, and the geotextile flap on the edge of adjacent geocomposite sheets shall be extended across the joint shiplap style. Jointing of the sheets shall be carried out as soon as possible after the sheets have been laid.

Geocomposite panels shall be joined by taping or heat bonding, dependent on the agreed seaming method. Jointing shall be carried out along the geotextile flaps on the sides of the panels. If heat bonding is the agreed seaming method, joints between the ends of the panels are not required to be heated bonded as there will be no geotextile flap. This is acceptable as the panels shall already be held in place by the joints on the sides of the panels. The CQA Inspector shall observe all jointing of panels.

Furthermore the Contractor shall ensure that:

- Equipment, plant and tools used shall not damage the geocomposite by handling, trafficking, leakage of hydrocarbons or by other means;
- Personnel working on the geocomposite shall not smoke, wear shoes likely to cause damage, or otherwise engage in any activity that could damage the geocomposite or the underlying geomembrane;
- The surface to receive the geocomposite shall be free from debris, roots, angular or sharp rocks and any other deleterious materials that may cause damage to the geocomposite;
- The method of placement shall be in such a manner as to avoid stresses and strains likely to cause damage to the geocomposite and underlying geomembrane;
- The geocomposite shall be in continuous contact with the surface on which it is placed without stretching or bridging over humps and hollows;
- The method of deployment shall minimise wrinkles or folds;
- Only geocomposite to be used on the same working day shall be removed from the store;
- Deployment shall not take place during periods of precipitation or in the presence of excessive moisture (fog, rain, snow, and heavy dew) or in the presence wind likely to cause damage;
- Geocomposite shall not be placed over areas of ponded water;
- Direct contact with the geocomposite is to be minimised; and

- Construction plant shall not traverse over any area of geocomposite until sufficient depth of cover has been placed over it in accordance with the Contract.

In windy conditions and at the end of the working day, all exposed edges of the geocomposite should be weighted down, the geocomposite should be held down using sandbags or similar weights that will not damage the material. The CQA Inspector shall visually check for such damage. The Contractor must accept full responsibility for the adequacy of this temporary surcharge.

All geocomposite sheets will be visually inspected for damage and imperfections after deployment and any repairs required will be undertaken.

8.8 Tie-in and Construction Details

Along free edges in the permanent capping area, as demarcated on **Drawing AM5593/01/02**, the upper drainage geocomposite shall be secured in a termination/anchor trench (**300mm x 300mm**) with the underlying LLDPE geomembrane and the lower protection and drainage geocomposite. Survey pegs/marker posts shall be installed at **10m intervals** along the anchor trench to de-mark the edge of the permanent capping area. These details are shown in the construction detail on **Drawing AM5593/01/02**.

Along the north-western (provisional) and south-western edges of the permanent capping area, where the leachate collection trench is installed, the upper drainage geocomposite shall be installed to the edge of the geomembrane tie-in, such that it discharges directly onto the existing upper drainage geocomposite of the previous capping systems, as shown in the construction details (**Section A-A' and Section D-D'**) on **Drawing AM5593/01/02 & Drawing AM5593/01/03**. The upper drainage geocomposite shall overlap the existing upper drainage geocomposite by a minimum of **500mm**, and the joint shall be butyl taped or heat bonded, dependent upon the agreed method. The tie-ins will be observed and recorded by the CQA Inspector to confirm that a satisfactory seal is achieved.

8.9 Inspection and Approval

The installed upper drainage geocomposite shall be subject to the inspection and approval by the CQA Inspector. Approval shall be made on the basis of the following:

- iv) The geocomposite has been installed in accordance with this Specification;
- v) A visual inspection has been undertaken to confirm that all stones, sandbags or any other potentially deleterious materials have been removed from the surface of the

geocomposite, that there are no visible surface defects and no folds or excessive undulations, and that the appropriate overlap between adjacent panels has been achieved; and

- vi) All necessary repairs have been made.

Where the geocomposite has not been approved the Contractor shall discuss and agree appropriate remedial measures with the CQA Inspector. These measures may include the complete removal and replacement of a panel or undertaking remedial works.

8.10 Repairs

Any damage to the upper drainage geocomposite shall be identified and repaired by either cutting out the damaged section and replacing the material, or by placing further material beneath the damaged section. A minimum overlap of **500mm** shall be achieved on all edges of the repair. Where a patch is used beneath the damaged section, the patch shall be secured to the overlying geocomposite by taping or heat bonding, dependent upon the agreed method.

8.11 Interface Testing

Interface testing to determine interface shear strengths between the upper drainage geocomposite and restoration soils shall be carried out at an independent geosynthetic testing laboratory with UKAS accreditation to the specifications in **Appendix 3**. Further details of the interface testing requirements are set out in Section 3.2 of this Specification.

8.12 As-Built Drawings

An upper drainage geocomposite as-built panel layout shall be produced, in accordance with the requirements of Section 3.4 of this Specification.

9 RESTORATION SOILS (INCLUDING CAP BLINDING/PROTECTION SOILS)

9.1 General

Following placement of the upper protection and drainage geo-composite, restoration soils shall be placed above the permanent capping area, to a minimum final depth of 1,000mm (perpendicular to the slope). The first **300mm** (or greater, if placed as one layer) of soils shall be placed by the Contractor, with the remainder placed either by the Contractor as part of these works or (subject to agreement) by top up material at a later date (by the site operator) depending on material availability. Both the first **300mm** (or greater, if placed as one layer) of soils, and the final **700mm** (or less, if the initial layer is greater than 300mm) of soils shall be subject to the surveying / trial pitting requirements outlined in Section 3.4 of this Specification, and set out in **Table 10** below.

If the final **700mm** (or less, if the initial layer is greater than 300mm) of soils are placed at a later date, the site manager shall be responsible for recording and reporting the relevant data for the soils to NRW, on commencement and placement of the final top up soils. This data is to be presented in a letter CQA validation report containing records of depth checks, and a final survey. Amgen Cymru shall (if required) agree a procedure with NRW prior to commencing any top up works. The CQA Inspector shall be required to be in attendance during the soil top up works, unless otherwise agreed with the CQA Engineer.

The material to be used for the restoration layer shall be sourced from on site, or imported, as directed by Amgen Cymru. The material shall be free from any unsuitable material, or any other deleterious materials/objects, such as timber or steelwork, that may potentially cause damage to the capping system below.

Unsuitable material shall include:

- i) Material in a frozen condition or susceptible to spontaneous combustion;
- ii) Any industrial, commercial, or domestic waste;
- iii) Any excessively wet material which does not provide a firm surface sufficient to permit the movement of plant or vehicles without causing excessive rutting; and/or
- iv) Any material greater than **40mm** in any dimension in the first **300mm** (or greater, if placed as one layer) of the restoration soils above the upper protection and drainage geo-composite, and any material greater than **150mm**, in any dimension, for the remaining **700mm** (or less, if the initial layer is greater than 300mm) soils.

The Contractor shall excavate and handle the material from on-site locations (or temporary stockpiles) in such a manner that the nature and consistency of the material is not adversely affected. Where more than one type (source) of material is encountered, the Contractor shall, wherever practicable, excavate in such a manner that the materials can be separated. The materials will be rejected for use if they contain material that the CQA Inspector believes will potentially damage the upper drainage geo-composite, or the capping geomembrane below.

9.2 Placement

The restoration soils shall be placed as soon as practicable after the upper protection and drainage geo-composite has been placed. The restoration soils shall be spread in layers to the required thickness to form a smooth even profile without undulations, hollows or depressions. Restoration soils shall not be placed in wet weather which, in the opinion of the CQA Inspector, is likely to lead to stability issues due to construction plant tracking over / placing excessively wet soils.

The Contractor shall undertake the placement of the restoration soils in a careful and systematic manner that does not affect the integrity of or cause damage or displacement to the capping system. The method employed should prevent the formation of any wrinkles and creases and/or any 'folding over' in the capping system.

Under no circumstances (other than for the safety of the Works) shall plant be driven directly on the capping system. A minimum thickness of **300mm** of material shall be placed at any location over the capping system before any of the Contractor's tracked plant is allowed to traverse over the capping area. A minimum thickness of **700mm** of material, at any location, shall be maintained between the geo-synthetic capping layers and wheeled haulage vehicles. The CQA Inspector shall supervise the trafficking of tracked plant / wheeled haulage vehicles, to ensure that these minimum thicknesses are maintained.

The Contractor's placement method shall ensure that no lateral stresses are induced in the underlying layers of the capping system. The soils shall be placed in a single loose lift, with light compaction being achieved by the machine tracks. In general, the methods employed shall comprise the following:

- i) Placing restoration soils working upslope;
- ii) Tipping of fresh material on previously placed material;
- iii) Casting material by 360° excavator (using a bucket without teeth);

- iv) Pushing of material up and over the face of the tipped load allowing it to fall vertically onto the underlying layers; and
- v) Preloading of the underlying layers with discrete mounds of material, to prevent the generation of excessive wrinkles or folds, and infilling between mounds.

The Contractor shall control the depth of restoration soils placement by using free standing profile boards, or travellers. The Contractor shall ensure that the bases of the profile boards or travellers are flat and of such construction that they do not cause damage to the underlying geosynthetic capping system.

Any damage or disturbance to the capping system during the placement of the soils shall be repaired by the Contractor, in accordance with this Specification.

The restoration soils shall not be compacted except by the passage of bull-dozer / tracked excavator machine tracks. Compaction plant (rollers) shall not be used. The final surface of the soils shall be graded to achieve the required levels and profile, and shall be free from any bumps and hollows, to the satisfaction of Amgen Cymru.

9.3 Restoration Soils Material Selection

The soil used to form the restoration layer shall be a natural geological material (soil or crushed rock) and shall conform to the requirements contained in **Table 9** below. In the event that the materials are won from sites that are not greenfield sites, then the chemistry of the soils shall be shown to be suitable for the proposed works by a review of source contamination reports.

The proposed source of the restoration soils shall be evaluated by undertaking a series of three (3) source evaluation tests, to ensure conformance with the requirements of **Table 9** below. Should the material conform to these requirements, it may be delivered to site as an approved source.

Table 9: Restoration Soils Specification and Source Evaluation Testing

Material Property	Test Method	Requirement	Number of Source Evaluation Tests Required
Particle Size Distribution	BS 1377:1990: Part 2 Method 9	Material passing sieve: 40mm 100% 10mm 50-100% 2mm 30-100% 0.6mm 10-70%	3 (per source)
Chemical Suitability (if source is not a greenfield site)	Inert WAC	Waste Acceptance Criteria parameters for inert waste (in accordance with the Waste Framework Directive 2008)	3 (per source) Only required if source is not a greenfield site

In the event that available sources for the restoration soils have coarser constituents than specified in **Table 9** above, then either the soils will be placed above the blinding/protection layer meeting this grading, or a cylinder test may be undertaken to evaluate suitability of the source restoration soil material for use as the protection/blinding layer. The blinding/protection layer may be taken from another source to the restoration soils, which shall be source evaluation tested to confirm conformance with the requirements of **Table 9** above, or may be taken from soils screened from the restoration soils source (to remove coarser particles). If cylinder testing is undertaken, then the cylinder testing results shall be included in the CQA Validation Report.

9.4 Restoration Soils Installation Testing

During and following the placement of the restoration soils, the Contractor and CQA Inspector shall be required to carry out the below testing.

For the first **300mm** (or greater, if placed as one layer) of the restoration soils (the blinding/protection layer) placed above the upper protection and drainage geo-composite, the Contractor shall take conformance samples at a frequency of **1 sample per 1,000 tonnes** of material, and send the sample to an independent, UKAS accredited laboratory approved by the CQA Inspector, for particle size distribution (PSD) testing, to ensure conformance with the requirements of **Table 10** below.

For the upper **700mm** (or less, if the initial layer is greater than 300mm) of the restoration soil placed above the blinding/protection layer, the Contractor shall take conformance samples at a frequency of **1 sample per 2,000 tonnes** of material, and send the sample to

an independent, UKAS accredited laboratory approved by the CQA Inspector, for particle size distribution (PSD) testing, to ensure conformance with the requirements of **Table 10** below.

If the source of the restoration soils (all layers) is not a greenfield site, then conformance sampling for Inert WAC testing shall also be required, at a frequency of **1 sample per 2,000 tonnes** of material.

The CQA Inspector shall carry out trial pitting in the placed restoration soils on a **25m grid**, to verify that an adequate depth of restoration soils has been placed in accordance with this Specification, in accordance with **Table 10** below. Trial pitting logs and the trial pitting grid layout shall be included in the CQA Validation Report.

The CQA Inspector shall also carry out a visual inspection of the restoration soils to ensure that the maximum particle size requirements set out in **Table 10** are met, for both the lower **300mm** (or greater, if placed as one layer) and the upper **700mm** (or less, if the initial layer is greater than 300mm) of soils. Any particles that are too large shall be removed from the restoration soils.

Table 10. Restoration Soils Installation Testing Requirements

Material Property	Test Method	Acceptance Criteria	Testing Frequency
Particle Size Distribution	BS 1377:1990: Part 2 Clause 9.2	Material passing sieve (*blinding/protection layer): 40mm 100%* 10mm 50-100% 2mm 30-100% 0.6mm 10-70%	1 per 1,000 tonnes (lower 300mm, or greater if placed as one layer) 1 per 2,000 tonnes (upper 700mm, or less if lower layer is greater than 300mm)
Chemical Suitability (if source is not a greenfield site)	Inert WAC	Waste Acceptance Criteria parameters for inert waste (in accordance with the Waste Framework Directive 2008)	1 per 2,000 tonnes (only required if source is not a greenfield site)
Maximum Particle Size	Visual	Any particle greater than 40mm in any dimension in the first 300mm (or greater, if placed as one layer) of the restoration soils above the upper drainage geo-composite. Any particle greater than 150mm in any dimension in the upper 700mm (or less, if protection layer greater than 300mm) of the restoration soils.	Continuous

Thickness ¹	Manual	>300mm (-15mm) or >1000mm (-25mm) dependent on thickness of layers placed	1 per 25m Grid
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1. Trial pitting for soils thickness checking shall be carried out before the survey of the top of the restoration soils.

9.5 Protuberances

During placement of the restoration soils around any protuberance the Contractor shall batter back the soils to allow for future installation of any headworks by the Employer, unless otherwise directed by the CQA Inspector or Amgen Cymru. A stockpile of restoration soils shall be left adjacent to each protuberance, to allow backfilling at a later date.

The Contractor shall take all reasonable precautions against causing damage or disturbance to protuberances and any associated installations; and, at the start of the contract the Contractor shall inspect the condition and alignment of these with the CQA Inspector. A similar inspection shall be carried out following the completion of the work around each protuberance. Should the Contractor cause any damage or disturbance they shall immediately carry out remedial works in accordance with this Specification.

9.6 As-Built Drawings

Surveys shall be carried out, and as-built drawings shall be produced for the restoration soils in accordance with the requirements of Section 3.4 of this Specification.

10 SURFACE WATER MANAGEMENT

10.1 General

Surface water management (SWM) infrastructure is required to be constructed for the capping area of the Phase 4A Part II capping works. The surface water management works required include the excavation of surface water ditches within the restoration soils along the western perimeter of the permanent capping area, and within the existing restoration soils of the Phase 4A capping works.

10.2 Surface Water Ditches

Surface water ditches required for this phase of capping include a ditch running along the western edge of the permanent capping area and extending across the existing Phase 4A capping area, towards the south-west. This layout is shown on **Drawing AM5593/01/01**. The exact locations, levels and falls of the new ditches and the locations of junctions are to be agreed on-site with the Contractor and Amgen Cymru, at the commencement of the capping works.

The surface water ditches are to be constructed (cut and fill) as shown in the construction detail **Section E-E'** on **Drawing AM5593/01/03**. Continuous falls are to be maintained in the base of the ditches in the correct directions which are to be agreed with the Contractor and Amgen Cymru at the commencement of the capping works, to ensure that surface water from the capping area drains away from the capping area.

10.3 As-Built Drawings

Surveys of the surface water management works shall be carried out in accordance with the requirements of Section 3.4 of this Specification.

11 HAUL ROAD CONSTRUCTION

11.1 General

The existing haul road which runs on top of the capped waste to the north of the Phase 4A Part II permanent capping area is to be extended towards the south as part of the capping works. The new section of haul road is to be constructed to the east of the capping area, in the location shown and in accordance with the construction detail on **Drawing AM5593/01/03** (and Note 12).

The haul road is to be ~400mm thick and shall be comprised of an 150mm thick running layer, over a 250mm thick Type 1 (or 6F2) sub-base, over a separation geotextile on the formation of the road. The waste / cover soils surface at the road location is to be inspected by the CQA Inspector prior to the construction of the road. Any unsuitable materials as defined in Chapter 5 of this Specification are to be removed to the satisfaction of the CQA Inspector.

Hardcore material and Type 1 material shall be imported to site by the Contractor who shall make all arrangements necessary for sourcing the material. The hardcore material placed shall be 6 inch quarried stone or 6F2 class material (as defined in MCDHW), or 6F5 class material (as defined in MCDHW), and shall be comprised of hard, durable material. This material is to be agreed with the site management team prior to import.

The Contractor shall submit their proposals to Amgen Cymru and the CQA Inspector regarding the extent and management of stockpiling and filling of materials before starting works. The Contractor shall not remove any materials from the site unless approved by Amgen Cymru.

After completion of the works, the Contractor is required to re-grade any stockpiles and surrounding areas where deemed necessary. This shall be carried out to the satisfaction of Amgen Cymru.

11.2 Separation & Filtration Geotextile

11.2.1 General

The requirements for the separation and filtration geotextile used to line the formation of the haul road are set out below.

The geotextile shall be supplied in accordance with the parameters given in **Table 11**, and installed in accordance with the construction details on **Drawings AM5593/01/02 & 03**, and the procedures and CQA requirements described below.

11.2.2 Material

The material installed for the separation and filtration geotextile shall be a non-woven geotextile (*Terram 1,000* or similar approved) conforming to the specification set out in **Table 11**. Laboratory confirmation testing will be arranged by the Contractor and carried out at an independent laboratory with UKAS accreditation for each test being carried out. The mass per unit area test has been removed as this is not an indicator of performance.

Table 11: Haul Road Separation & Filtration Geotextile Specification

Physical Properties:				
Polymer type:	Prime quality polypropylene fibre (UV stabilised) with no post-consumer fibres			
Fabric construction:	Nonwoven fabric manufactured from mechanically entangled fibre			
	Approved test method	Units	Requirement	Test Frequency
Thickness @ 2kPa:	EN ISO 9863-1	mm	>0.8	1/5,000m² or part thereof
Mechanical Properties:				
Static puncture strength (CBR)	EN ISO 12236	kN	1.5 (min. ave.)	1/5,000m² or part thereof
Tensile strength (md/cmd)	EN ISO 10319	kN/m	8 (min. ave.)	1/5,000m² or part thereof
Tensile extension (md/cmd)	EN ISO 10319	%	>50	1/5,000m² or part thereof
Dynamic Perforation Resistance	EN ISO 13433	mm	<40	1/5,000m² or part thereof
Drainage Properties:				
Opening Size O ₉₀	EN ISO 12956	µm	50 to 120	1/5,000m² or part thereof
Permeability	EN ISO 11058	litres/m²/s	>40	1/5,000m² or part thereof
Durability (according to annex B: EN 13253)*:				
	Approved Test Method	Requirement		Tolerance
Resistance to weathering @ 50MJ/m² radiant exposure ¹	EN 12224	Retained Strength		80%
Resistance to Oxidation (100 years)	EN ISO 13438**	Retained Strength 56 days		50%
Resistance to liquids	EN 14030	Retained Strength		50%
1. 1-4 months UV exposure depending on location/season				
* Durability test data can be supplied by the manufacturer – test frequency must not exceed 5 years.				
** Manufacturer may use alternative means of assessing oxidation to achieve 100 years.				

Conformance testing of the above parameters will be carried out at a UKAS accredited laboratory.

11.2.3 Delivery, Handling and Storage

The material will be delivered, handled and stored in accordance with the manufacturer's recommendations and should be delivered and stored in tight wrappings in order to offer protection from ultra violet degradation. Each roll of geotextile delivered to site will have a label which conforms with EN30320, and including the details below:

- Manufacturer's name, address and telephone number;
- CE mark with accrediting body's number;
- Product identification and polymer type;
- Geotextile batch and roll number;
- Roll length and width in metres; and
- Roll weight in kilograms.

Lifting and transportation of the geotextile materials shall be by appropriate machinery with the use of slings and core bars. The material is not to be handled with the tines of a forklift machine, the bucket of an excavator, or any similar equipment under any circumstances.

The Contractor shall provide adequate and acceptable measures for protecting the material at all stages of the work, from all sources of potential damage such as sharp objects, boulders, cobbles etc, including weather conditions and will be located out of the way of the way of moving plant.

The storage area for the separation geotextile will be agreed with Amgen Cymru and prepared to the satisfaction of the Contractor prior to delivery of the material to site. The storage area shall be large enough to accommodate the rolls geotextile flat on the ground. It will be a level, dry and well-drained area, clear from rocks and other obstacles, such that the material is protected from:

- Site Traffic;
- Standing water;
- UV radiation;
- Extreme temperatures (<0C, >60C);

- Animal and plant infestation;
- Chemicals;
- Puncture; and
- Any other environmental condition that could impact on its physical properties.

The rolls of geotextile will not be stacked more than 3 high with nothing stacked above them. All product rolls must be kept in the appropriate packaging until such time that they are required for installation.

Any damaged material will be excluded from the works.

11.2.4 Manufacturers Quality Control

Quality control certificates will be supplied to cover each roll of material delivered to site. The certificates will be supplied prior to delivery of the material to site and will contain quality control data typically according to the requirements of **Table 11** above.

The manufacturer's Declaration of Performance shall be included in the documentation.

Quality Control Certificates will be provided prior to installation and for inclusion in the CQA Validation Report as follows:

- A Specification for the geotextile which includes all properties contained in **Table 11** measured using the appropriate test methods;
- Written certification that minimum values given in **Table 11** are guaranteed by the Manufacturer; and
- Written confirmation that testing to detect needle fragments and removal of needle fragments prior to delivery of the product has taken place.

11.2.5 Geotextile Conformance Sampling

As soon as practicable after the delivery of the geotextile rolls to site, the CQA Engineer shall cut and label samples 1m long across the entire width of selected rolls for retention and/or conformance testing as directed by the CQA Inspector. The first 1m of the roll shall not be used for the conformance testing.

Set of samples of geotextile material shall be taken by the Contractor for the required conformance testing at the frequencies detailed in **Table 11**. All testing is to be carried out at

an independent geosynthetic testing laboratory having UKAS Accreditation for each test being carried out. The Contractor shall provide the CQA Inspector with a copy of the laboratory test results immediately on receipt.

If testing shows that the geotextile does not meet any one of the minimum requirements listed in **Table 11**, then this may be cause for rejection of the material from that roll. Any repairs, replacement or other works occasioned by the failure of the geotextile to meet the minimum requirements listed in **Table 11** shall be carried out at the Contractor's expense.

If the geotextile fails to meet any of the conformance testing requirements, the CQA Inspector may at their discretion accept material from elsewhere on that roll if the Contractor can demonstrate through further laboratory testing (at their expense) at a geosynthetic laboratory approved by the CQA Inspector that this material does meet the acceptance criteria contained in **Table 11**. If the Contractor does not demonstrate to the CQA Inspector that the material meets the conformance testing requirements, the CQA Inspector shall reject all material from that roll.

Alternatively:

In the event that a conformance test fails to meet the requirements of the Specification that roll shall be rejected and will not be incorporated into the works. The rolls numbered numerically on either side of the failed sample will then be subjected to conformance testing. This procedure will continue until the extent of the sub-specification material has been determined by bracketing. The Contractor will supply any replacement rolls at their own cost.

Installation of the separation geotextile layer will not commence until the results of the conformance tests are known and have been accepted by the CQA Inspector.

11.2.6 Installation

The separation geotextile panels shall be joined by either heat bonding or by sewing using methods to be approved in advance by the CQA Inspector. Overlaps on panels will be **300mm**.

In windy conditions and at the end of the working day, all exposed edges of the geotextile should be weighted down, the geotextile should be held down using sandbags or similar weights that will not damage the material. The CQA Inspector shall visually check for such damage.

All geotextile sheets will be visually inspected for damage and imperfections after deployment and any repairs required will be undertaken.

11.2.7 Inspection and Approval

The installed separation geotextile shall be subject to inspection and approval by the CQA Inspector. Approval shall be made on the basis of the following:

- i) The geotextile has been installed in accordance with this Specification;
- ii) A visual inspection has been undertaken to confirm that all stones, sandbags or any other potentially deleterious materials have been removed from the surface of the geotextile, that there are no visible surface defects and no folds or excessive undulations, and that the appropriate overlap between adjacent panels has been achieved; and
- iii) All necessary repairs have been made.

Where the geotextile has not been approved the Contractor shall discuss and agree appropriate remedial measures with the CQA Inspector. These measures may include the complete removal and replacement of a panel or undertaking remedial works.

11.2.8 Repairs

Any faulted areas on the geotextile shall be overlain with a single piece of compatible geotextile. The patch shall have a minimum overlap of **500mm** in all directions. Any patches required shall be heat bonded to the same standard as the original geotextile.

11.3 Placement of Road Materials

Placement of the unbound sub-base (Type 1 or 6F5) and unbound running layer (Type 4 or bespoke grading) shall be monitored by the CQA Inspector to ensure that only suitable materials and acceptable particle sizes are included, and that the correct compaction methodology is implemented.

The Contractor shall control the depth of placement by using free standing profile boards or travellers.

The unbound materials shall be subject to the classification, placement and compaction requirements within Table 8/4 (Type 1/Type 4) or Table 6/4 (6F5) of MCDHW, in accordance with the relevant class of material.

The subbase materials shall not contain any unsuitable materials as defined in Chapter 5 of this Specification.

In the event of leachate or excessive surface water ingress into the haul road material, appropriate remedial action shall be discussed with Amgen Cymru, the Principal Designer and the CQA Inspector, following which an agreed solution shall be established. All remedial measures shall be completed and approved by the CQA Inspector prior to the placement of any fill material at the site of the ingress.

11.3.1 Haul Road Material Conformance & Testing Requirements

1 sample will be taken per 2,500 tonnes of the sub-base materials used for the haul road and tested for Particle Size Distribution (PSD) in accordance with BS1377 1990 Part 2 Clause 9.3. The PSD results shall be used to confirm the grading of the material (Type 1/Type 4/6F5), or classify the material in accordance with MCDHW 2016 and to determine the compaction methodology from the Specification for Highway Works (Table 8/4 or Table 6/4), in accordance with **Table 12** below.

Table 12: Haul Road Material Conformance & Testing Requirements

Parameter	Test Method (BS 1377:1990:)	Acceptance Criteria	Testing Frequency
Subbase/Running Layer:			
Particle Size Distribution (per source / per layer)	Part 2 Clause 9.3	To Confirm PSD and Determine Classification for Placement and Compaction	1 per 2,500 tonnes

All laboratory testing will be undertaken by UKAS Accredited Laboratories, with accreditation for all the required tests.

11.4 Edge Protection Bunds

On the edges of the haul road, the Contractor may be required to install edge protection bunds.

The edge protection bunds shall be constructed with a side-slope gradient of 1 in 1 as shown in the construction detail (**Section C-C'**) on **Drawing AM5593/01/03**. The top of the edge protection bunds shall be >1m above the final running surface of the road.

The edge protection bunds shall be constructed using suitable engineered fill material which shall be subject to the requirements for classification, placement, compaction and testing for engineered fill in Chapter 5 of this Specification.

11.5 As-Built Drawings

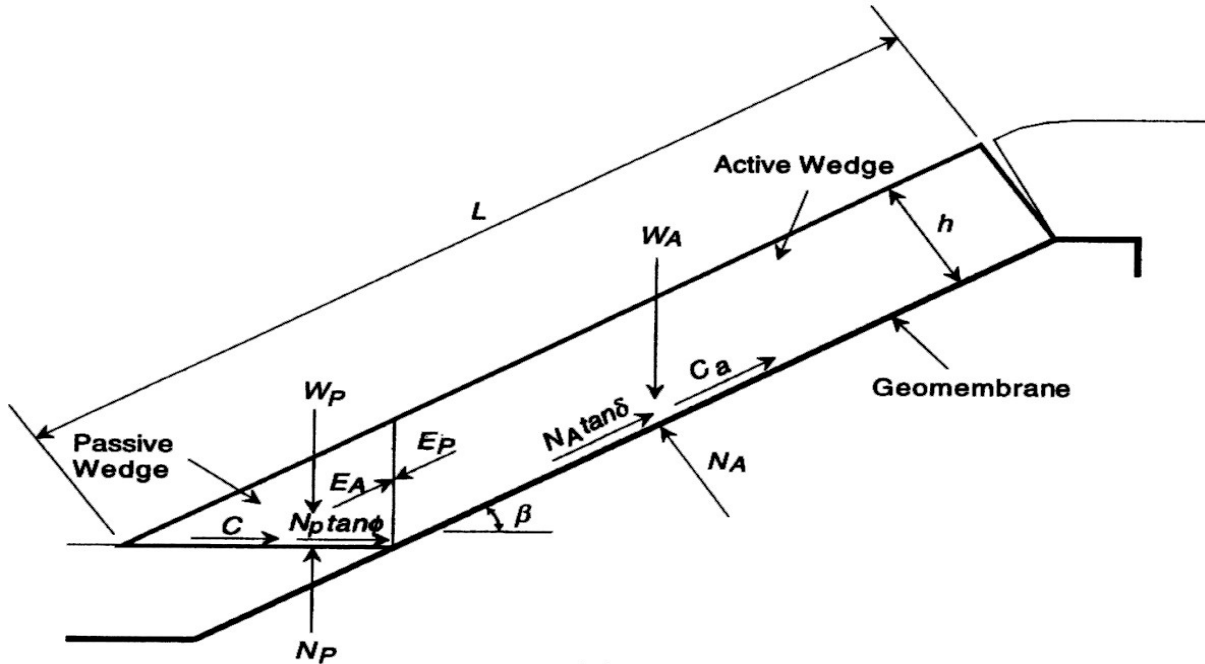
Surveys of the new section of haul road shall be carried out in accordance with the requirements of Section 3.4 of this Specification.

APPENDIX 1

**SLOPE STABILITY
VENEER CALCULATIONS
(IN ADDITION TO SRA)**

Capping system stability PSR = 0.0

Geometry:



(b) Finite slope

Input Parameters

Cover soils unit weight (dry), γ_{dry}	17	kN/m ³
Cover soils unit weight (saturated), γ_{sat}	19	kN/m ³
Cover soils internal shear strength, ϕ	25	Deg.
Cover soils cohesion, c	5	kPa
Thickness of cover soils, h	1.00	m
Height of slope, H	4	m
Slope angle, β	16.39	Deg.
Geosynthetic interface shear strengths:		
Cover soil/Geocomposite friction angle, d1	24	Deg.
Cover soil/Geocomposite cohesion intercept, a1	2	kPa
Geocomposite/Geomembrane friction angle, d2	22	Deg.
Geocomposite/Geomembrane cohesion intercept, a2	1	kPa
Geomembrane/Geocomposite friction angle, δ_3	22	Deg.
Geomembrane/Geocomposite cohesion intercept, α_3	1	kPa
Geocomposite/Regulating layer friction angle, δ_3	22	Deg.
Geocomposite/Regulating layer cohesion intercept, α_3	1	kPa
Parallel submergence ratio, PSR	0.0	
Geosynthetic tensile strengths:		
Geocomposite	15	kN/m
Geomembrane	11	kN/m
Geocomposite	15	kN/m



PROJECT Bryn Pica Capping 2023

1 in 3.4 4m High GDL

Job No. AM5593

Made By: J Camfield

Date: 31/03/2023

Checked: R Hanley

Reviewed: R Hanley

1. Stability of Cover Soils

Calculated Parameters

Length of slope, L	14.176	m
Thickness of water, h_w	0.000	m
Weight of active wedge, W_A	209.587	kN
Weight of passive wedge, W_P	31.399	kN
Pore pressure perp. to slope, U_n	0.000	kN
Pore pressure in interwedge surface, U_h	0.000	kN
Force normal to active wedge, N_A	201.070	kN
Vert pp on passive wedge, U_V	0.000	kN
a	56.737	
b	-153.226	
c	15.510	

Factor of Safety against cover soils sliding 2.60

2. Integrity of Geosynthetics

(i) Geocomposite

Mobilised shear stress at upper interface	50.585	kN
Shear strength at lower interface	107.584	kN
Tension developed in the GDL	0.000	kN
Tensile strength of the GDL	15	kN

Factor of Safety against rupture No Tension

(ii) Geomembrane

Shear strength at upper surface	107.584	kN
Mobilised shear stress at upper interface	50.585	kN
Shear strength at lower interface	107.584	kN
Tension developed in the GM	0.000	kN
Tensile strength of the GM	11	kN

Factor of Safety against rupture No Tension

(ii) Geocomposite

Shear strength at upper surface	107.584	kN
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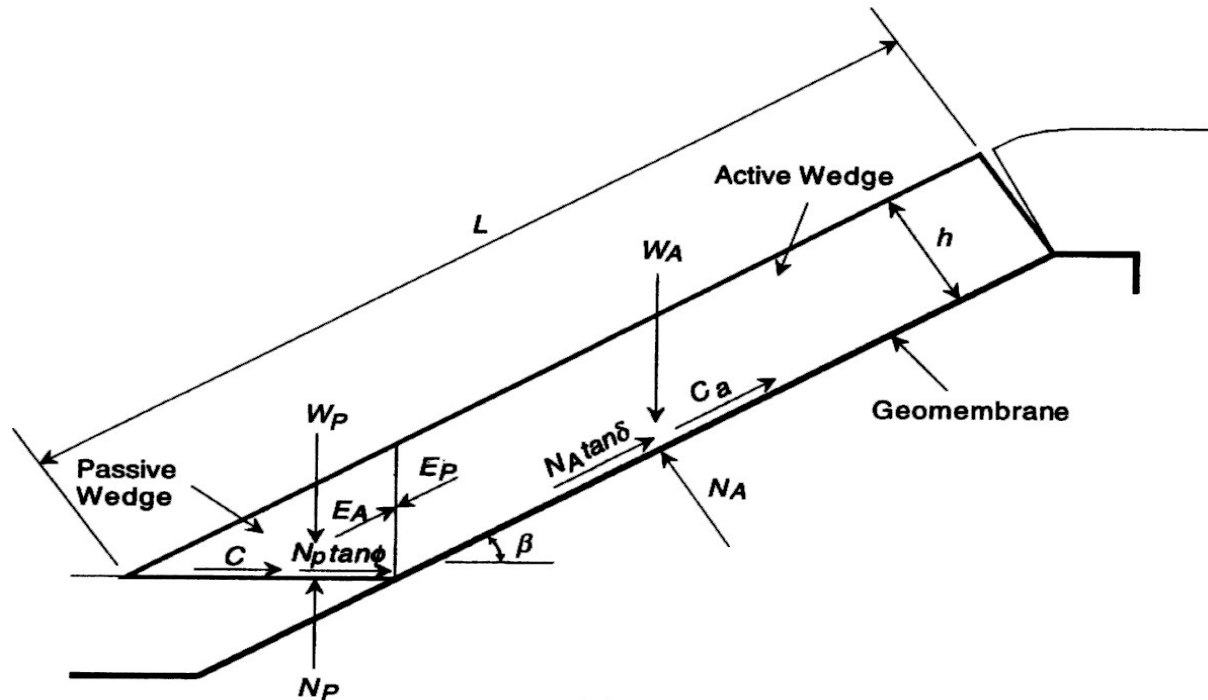
Mobilised shear stress at upper interface	50.585	kN
Shear strength at lower interface	107.584	kN
Tension developed in the GDL	0.000	kN
Tensile strength of the GDL	15.000	kN

Factor of Safety against rupture

No Tension

Capping system stability PSR 0.25

Geometry:



(b) Finite slope

Input Parameters

Cover soils unit weight (dry), γ_{dry}	17	kN/m ³
Cover soils unit weight (saturated), γ_{sat}	19	kN/m ³
Cover soils internal shear strength, ϕ	25	Deg.
Cover soils cohesion, c	5	kPa
Thickness of cover soils, h	1	m
Height of slope, H	4	m
Slope angle, β	16.39	Deg.
Geosynthetic interface shear strengths:		
Cover soil/Geocomposite friction angle, d1	24	Deg.
Cover soil/Geocomposite cohesion intercept, a1	2	kPa
Geocomposite/Geomembrane friction angle, d2	22	Deg.
Geocomposite/Geomembrane cohesion intercept, a2	1	kPa
Geomembrane/Geocomposite friction angle, d3	22	Deg.
Geomembrane/Geocomposite cohesion intercept, a3	1	kPa
Geocomposite/Regulating layer friction angle, d3	22	Deg.
Geocomposite/Regulating layer cohesion intercept, a3	1	kPa

Parallel submergence ratio, PSR 0.25

Geosynthetic tensile strengths:

Geocomposite	15	kN/m
Geomembrane	11	kN/m
Geocomposite	15	kN/m



PROJECT Bryn Pica Capping 2023

1 in 3.4 4m High GDL

Job No. AM5593

Made By: J Camfield

Date: 31/03/2023

Checked: R Hanley

Reviewed R Hanley

1. Stability of Cover Soils

Calculated Parameters

Length of slope, L	14.176	m
Thickness of water, h_w	0.250	m
Weight of active wedge, W_A	216.444	kN
Weight of passive wedge, W_P	31.630	kN
Pore pressure perp. to slope, U_n	32.892	kN
Pore pressure in interwedge surface, U_h	0.313	kN
Force normal to active wedge, N_A	174.845	kN
Vert pp on passive wedge, U_V	1.062	kN
a	58.618	
b	-141.852	
c	13.973	

Factor of Safety against cover soils sliding 2.32

2. Integrity of Geosynthetics

(i) Geocomposite

Mobilised shear stress at upper interface	57.967	kN
Shear strength at lower interface	110.331	kN
Tension developed in the GDL	0.000	kN
Tensile strength of the GDL	15	kN

Factor of Safety against rupture No Tension

(ii) Geomembrane

Shear strength at upper surface	110.331	kN
Mobilised shear stress at upper interface	57.967	kN
Shear strength at lower interface	110.331	kN
Tension developed in the GM	0.000	kN
Tensile strength of the GM	11	kN

Factor of Safety against rupture No Tension

(ii) Geocomposite

Shear strength at upper surface	110.331	kN
Mobilised shear stress at upper interface	57.967	kN

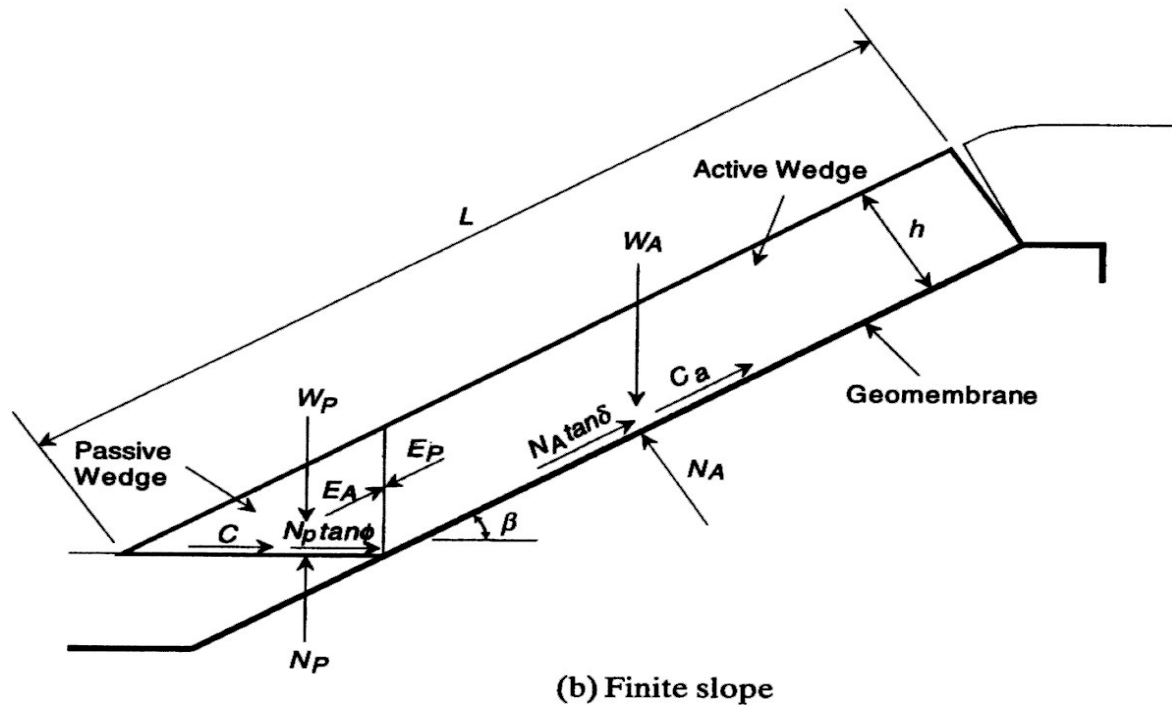
Shear strength at lower interface	110.331	kN
Tension developed in the GDL	0.000	kN
Tensile strength of the GDL	15	kN

Factor of Safety against rupture

No Tension

Capping system stability PSR 0.5

Geometry:



Input Parameters

Cover soils unit weight (dry), γ_{dry}	17	kN/m ³
Cover soils unit weight (saturated), γ_{sat}	19	kN/m ³
Cover soils internal shear strength, ϕ	25	Deg.
Cover soils cohesion, c	5	kPa
Thickness of cover soils, h	1	m
Height of slope, H	4	m
Slope angle, β	16.39	Deg.
Geosynthetic interface shear strengths:		
Cover soil/Geocomposite friction angle, d1	24	Deg.
Cover soil/Geocomposite cohesion intercept, a1	2	kPa
Geocomposite/Geomembrane friction angle, d2	22	Deg.
Geocomposite/Geomembrane cohesion intercept, a2	1	kPa
Geomembrane/Geocomposite friction angle, d3	22	Deg.
Geomembrane/Geocomposite cohesion intercept, a3	1	kPa
Geocomposite/Regulating layer friction angle, d3	22	Deg.
Geocomposite/Regulating layer cohesion intercept, a3	1	kPa
Parallel submergence ratio, PSR	0.5	
Geosynthetic tensile strengths:		
Geocomposite	15	kN/m
Geomembrane	11	kN/m
Geocomposite	15	kN/m



PROJECT Bryn Pica Capping 2023

1 in 3.4 4m High GDL

Job No. AM5593

Made By: J Camfield

Date: 31/03/2023

Checked: R Hanley

Reviewed: R Hanley

1. Stability of Cover Soils

Calculated Parameters

Length of slope, L	14.176	m
Thickness of water, h_w	0.500	m
Weight of active wedge, W_A	222.839	kN
Weight of passive wedge, W_P	32.323	kN
Pore pressure perp. to slope, U_n	63.568	kN
Pore pressure in interwedge surface, U_h	1.250	kN
Force normal to active wedge, N_A	150.568	kN
Vert pp on passive wedge, U_V	4.250	kN
a	60.424	
b	-130.438	
c	12.551	

Factor of Safety against cover soils sliding 2.06

2. Integrity of Geosynthetics

(i) Geocomposite

Mobilised shear stress at upper interface	66.742	kN
Shear strength at lower interface	113.078	kN
Tension developed in the GDL	0.000	kN
Tensile strength of the GDL	15	kN

Factor of Safety against rupture No Tension

(ii) Geomembrane

Shear strength at upper surface	113.078	kN
Mobilised shear stress at upper interface	66.742	kN
Shear strength at lower interface	113.078	kN
Tension developed in the GM	0.000	kN
Tensile strength of the GM	11	kN

Factor of Safety against rupture No Tension

(ii) Geocomposite

Shear strength at upper surface	113.078	kN
Mobilised shear stress at upper interface	66.742	kN

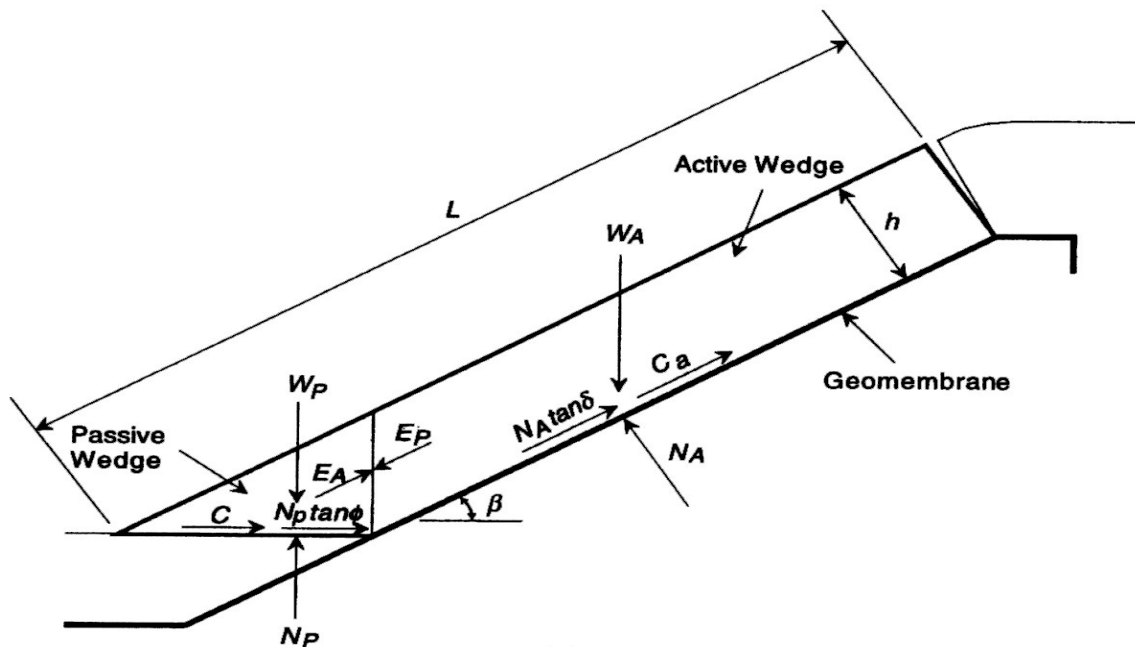
Shear strength at lower interface	113.078	kN
Tension developed in the GDL	0.000	kN
Tensile strength of the GDL	15	kN

Factor of Safety against rupture

No Tension

Capping system stability PSR : 1.0

Geometry:



(b) Finite slope

Input Parameters

Cover soils unit weight (dry), γ_{dry}	17	kN/m ³
Cover soils unit weight (saturated), γ_{sat}	19	kN/m ³
Cover soils internal shear strength, ϕ	25	Deg.
Cover soils cohesion, c	5	kPa
Thickness of cover soils, h	1	m
Height of slope, H	4	m
Slope angle, β	16.39	Deg.
Geosynthetic interface shear strengths:		
Cover soil/Geocomposite friction angle, d1	24	Deg.
Cover soil/Geocomposite cohesion intercept, a1	2	kPa
Geocomposite/Geomembrane friction angle, d2	22	Deg.
Geocomposite/Geomembrane cohesion intercept, a2	1	kPa
Geomembrane/Geocomposite friction angle, d3	22	Deg.
Geomembrane/Geocomposite cohesion intercept, a3	1	kPa
Geocomposite/Regulating layer friction angle, d3	22	Deg.
Geocomposite/Regulating layer cohesion intercept, a3	1	kPa
Parallel submergence ratio, PSR	1.0	
Geosynthetic tensile strengths:		
Geocomposite	15	kN/m
Geomembrane	11	kN/m
Geocomposite	15	kN/m



PROJECT Bryn Pica Capping 2023

1 in 3.4 4m High GDL

Job No. AM5593

Made By: J Camfield

Date: 31/03/2023

Checked: R Hanley

Reviewed: R Hanley

1. Stability of Cover Soils

Calculated Parameters

Length of slope, L	14.176	m
Thickness of water, h_w	1.000	m
Weight of active wedge, W_A	234.244	kN
Weight of passive wedge, W_P	35.093	kN
Pore pressure perp. to slope, U_n	118.276	kN
Pore pressure in interwedge surface, U_h	5.000	kN
Force normal to active wedge, N_A	107.860	kN
Vert pp on passive wedge, U_V	16.999	kN
a	63.810	
b	-107.493	
c	10.049	

Factor of Safety against cover soils sliding 1.59

2. Integrity of Geosynthetics

(i) Geocomposite

Mobilised shear stress at upper interface	90.457	kN
Shear strength at lower interface	118.573	kN
Tension developed in the GDL	0.000	kN
Tensile strength of the GDL	15	kN

Factor of Safety against rupture No Tension

(ii) Geomembrane

Shear strength at upper surface	118.573	kN
Mobilised shear stress at upper interface	90.457	kN
Shear strength at lower interface	118.573	kN
Tension developed in the GM	0.000	kN
Tensile strength of the GM	11	kN

Factor of Safety against rupture No Tension

(ii) Geocomposite

Shear strength at upper surface	118.573	kN
Mobilised shear stress at upper interface	90.457	kN
Shear strength at lower interface	118.573	kN
Tension developed in the GDL	0.000	kN

Tensile strength of the GDL

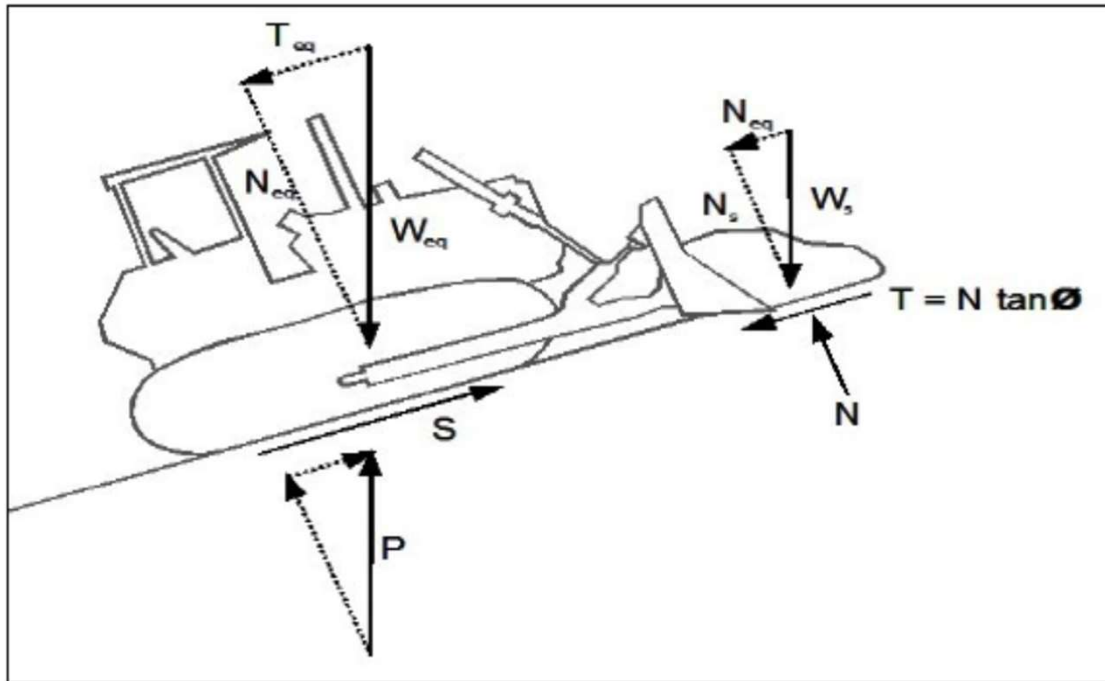
15 kN

Factor of Safety against rupture

No Tension

Capping system stability: Effect of plant loading

Geometry:



Input Parameters

Cover soils unit weight (dry), g_{dry}	17	kN/m^3
Cover soil internal shear strength, ϕ	25	Deg.
Cover soil cohesion, c	5	kPa
Thickness of cover soil, h	1	m
Height of slope, H	4	m
Slope angle, β	16.39	Deg.

Geosynthetic interface shear strengths:

Cover soil/Geocomposite friction angle, $d1$	24	Deg.
Cover soil/Geocomposite cohesion intercept, $a1$	2	kPa
Geocomposite/Geomembrane friction angle, $d2$	22	Deg.
Geocomposite/Geomembrane cohesion intercept, $a2$	1	kPa
Geomembrane/Geocomposite friction angle, $d3$	22	Deg.
Geomembrane/Geocomposite cohesion intercept, $a3$	1	kPa
Geocomposite/Regulating layer friction angle, $d3$	22	Deg.
Geocomposite/Regulating layer cohesion intercept, $a3$	1	kPa



PROJECT Bryn Pica Capping 2023

1 in 3.4 4m High GDL

Job No. AM5593

Made IJ Camfield

Date: 31/03/2023

Check R Hanley

Review R Hanley

I (Influence Factor)

W_b (Bulldozer Weight)

w (Track Length)

b (Track Width)

Force per unit area

Equivalent Force/ unit width

acceleration of plant

acceleration due to gravity

Dynamic Force per unit width

Effective Equipment Force normal to failure Plane

Cohesive Force Along Failure plane of Passive Wedge

1		
230	kN	
3.2	m	
0.91	m	
45	kPa	
144	kN/m	
2	m/s ²	
9.81	m/s ²	
29.3578		
138.1483		
17.71956		
15	kN/m	
11	kN/m	
15	kN/m	

Geosynthetic tensile strengths:

Geocomposite

Geomembrane

Geocomposite

1. Stability of Cover Soil

Calculated Parameters

Length of slope, L	14.176	m
Weight of active wedge, W _A	209.587	kN
Weight of passive wedge, W _P	31.399	kN
Pore pressure perp. to slope, U _n	0.000	
Pore pressure in interwedge surface, U _h	0.000	
Force normal to active wedge, N _A	201.070	kN

a	123.883	
b	-221.444	
c	20.136	

Factor of Safety against cover soil sliding

1.69

2. Integrity of Geosynthetics

(i) Geocomposite

Mobilised shear stress at upper interface	77.618	kN
Shear strength at lower interface	107.584	kN
Tension developed in the GDL	0.000	kN
Tensile strength of the GDL	15	kN

Factor of Safety against rupture

No Tension

**PROJECT Bryn Pica Capping 2023**

Job No. AM5593

Made IJ Camfield

Date: 31/03/2023

Check R Hanley

Review R Hanley

(i) Geomembrane

Shear strength at upper surface	107.584	kN
Mobilised shear stress at upper interface	77.618	kN
Shear strength at lower interface	107.584	kN
Tension developed in the Geomembrane	0.000	kN
Tensile strength of the Geomembrane	11	kN

Factor of Safety against rupture**No Tension****(i) Geocomposite**

Shear strength at upper surface	107.584	kN
Mobilised shear stress at upper interface	77.618	kN
Shear strength at lower interface	107.584	kN
Tension developed in the Geocomposite	0.000	kN
Tensile strength of the Geocomposite	15	kN

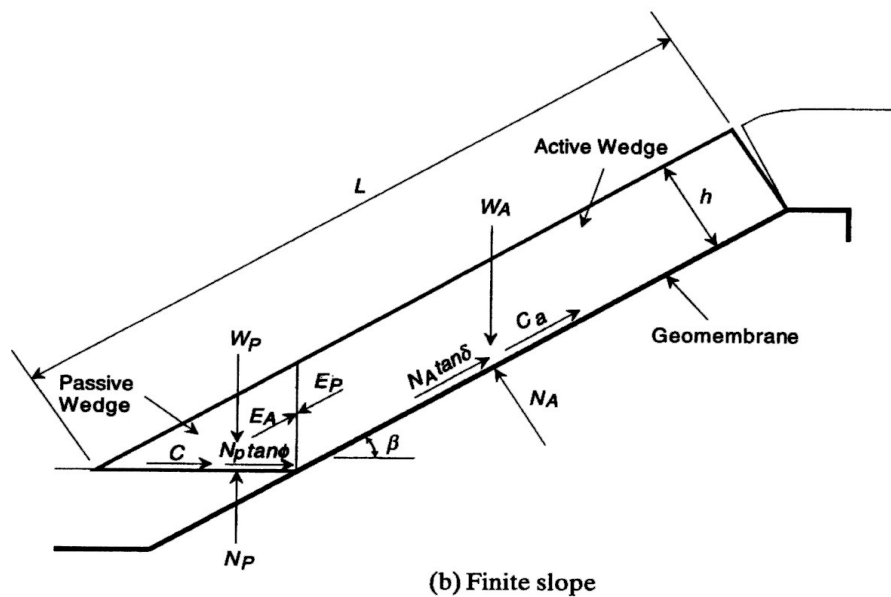
Factor of Safety against rupture**No Tension**

Capping system stability: Effect of gas pressure

Aim: To assess the stability of the drainage material and integrity of the geosynthetic lining system

Approach: Use the approach proposed by Koerner & Daniels, 1997.

Geometry:



Input Parameters

Cover soil unit weight, γ	17	kN/m ³
Cover soil internal shear strength, ϕ	25	Deg.
Cover soil cohesion, c	5	kPa
Thickness of cover soil, h	1	m
Height of slope, H	4	m
Slope angle, β	16.39	Deg.

N.B. Consider only interface at base of geosynthetics on which gas pressure acts.

Geosynthetic interface shear strengths:

Geocomposite/Regulating layer, δ_3	22	Deg.
Geocomposite/Regulating layer, α_3	1	kPa

Gas pressure	5.0	kPa
--------------	-----	-----

Ignores strength of geosynthetic layers

**PROJECT Bryn Pica Capping 2023****1 in 3.4 4m High GDL**

Job No. AM5593

Made IJ Camfield

Date: 31/03/2023

Check R Hanley

Review R Hanley

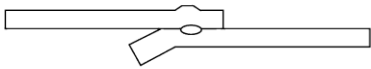
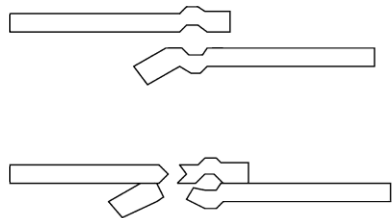
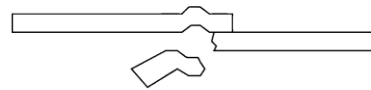
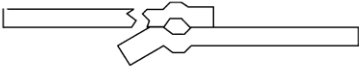
1. Stability of Cover Soil**Calculated Parameters**

Length of slope, L	14.176	m
Weight of active wedge, W_A	209.587	kN
Weight of passive wedge, W_P	31.399	kN
Pore pressure perp. to slope, U_n	0.000	
Pore pressure in interwedge surface, U_h	0.000	
Force normal to active wedge, N_A	201.070	kN
Force normal to active wedge from gas pressure, N_G	70.88	kN
a	56.737	
b	-86.486	
c	7.053	

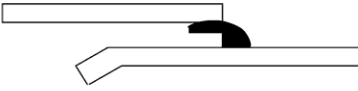
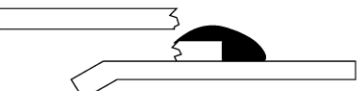
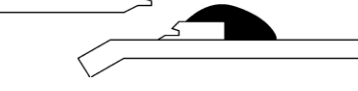
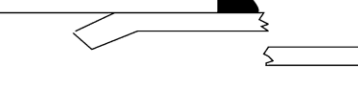
Factor of Safety against geocomposite sliding**1.44**

APPENDIX 2
GEOMEMBRANE WELD
FAILURE CODES

FUSION WELD FAILURE CODES

UNTESTED SPECIMEN DUAL HOT WEDGE FUSION WELD		
<u>TYPES OF FAILURE</u>	PASS/FAIL CODE	DESCRIPTION
	FAIL 1	ADHESION FAILURE
	FAIL 2	FTB BREAK AT SEAM EDGE
	FAIL 3	FTB BREAK AT SECOND SEAM EDGE
	FAIL 4	FTB BREAK AT SECOND SEAM EDGE
	PASS 1	FTB BREAK IN SHEETING
	PASS 2	FTB BREAK AT SEAM EDGE

EXTRUSION WELD FAILURE CODES

UNTESTED SPECIMEN EXTRUSION WELD		
TYPES OF FAILURE	PASS/FAIL CODE	DESCRIPTION
	FAIL 1 (F1)	ADHESION FAILURE
	FAIL 2 (F2)	ADHESION FAILURE
	FAIL 3 (F3)	ADHESION FAILURE
	FAIL 3 (F3)	ADHESION FAILURE
	FAIL 3 (F3)	ADHESION FAILURE
	FAIL 3 (F3)	ADHESION FAILURE
	FAIL 3 (F3)	ADHESION FAILURE
	FAIL 3 (F3)	ADHESION FAILURE
	FAIL 3 (F3)	ADHESION FAILURE
	FAIL 3 (F3)	ADHESION FAILURE

APPENDIX 3

**INTERFACE SHEAR STRENGTH
TESTING REQUIREMENTS**

LGG 115 SHEAR BOX TEST CHECK LIST

Client:

Questions	Client to Confirm	Guidance
Interface	Site Sampled Upper Drainage Geocomposite / Restoration Soils	Interface 1 Vs. interface 2
Shear Box	Yes	Large Shear Box (300 mm * 300 mm), direct shear
Method	LGG 115	BS EN ISO 12957 – 1 and/or LGG 115
Test Frequency	4 (LGG 115 Route B)	Minimum 1 per 10,000 m ² , need multiple to calculate the standard deviation
Normal Stress, Pressure (kPa)	20, 50, 150kPa	20, 50, 100 kPa 50, 150, 300 kPa
Shearing Rate (mm/min)	1mm/min	Typically, 1 mm/min, clays to be run slower, 0.1 mm/min
Dry Density	To be Determined	To be determined by compaction trial with 2.5 kg rammer
Consolidation	1 hours	For submerged interfaces, 1 hour or 24 hours for soils
Test Saturation	Submerged	Dry, as received or submerged
Sequence of Material in Situ	Upper Drainage Geocomposite Restoration Soils	The order of material when put in the ground
Thickness of Soil	100mm	Minimum of 50 mm, typically 100 mm to be ran in the Shear Box
Moisture Content	As received	Tested as received; we can calculate a range of moisture content for each soil
Interfaces Spacing	1mm	Typically, 0.5 – 1 mm
Interface Orientation	Machine Direction	Machine Direction or Cross Direction or both
Photographs	Yes	Before & After tests
Factor of Safety	1.3	Ratio e.g. 1.4
Slope Angle	16.39	Eg 20 degrees
Category of Soil	Soils to be Characterised	How were the design interface shear parameters obtained, we can characterise the soils
Material ID	Chosen Geocomposite Product (sample taken from site) / Site Derived Soils	Technical data sheet, date of manufacture, roll number
Category of GCLs and Geocomposites		Yes/No
Are they derived from published sources of generic values for the geosynthetics e.g. EA report TR1?		No
Are they derived from unpublished generic values for the geosynthetics in the designer's database?		Yes
Are they derived from test values in the particular manufacturer's database for similar geosynthetics?		No
Are they based on test values from previous works on the site for similar geosynthetics from a different manufacturer?		No
Are they based on test values (at least 4 sets) from previous works on the site for the particular geosynthetics from the same manufacturers?		No
Soil Characteristics		Client or Laboratory to Confirm
The particle size distribution (d ₈₅)		Laboratory
The allowable range of the protector density		Laboratory
Cohesion of the soil		Laboratory
Soil conditions		Laboratory
Allowable range of moisture content		Laboratory
Liquid and plastic limits		Laboratory

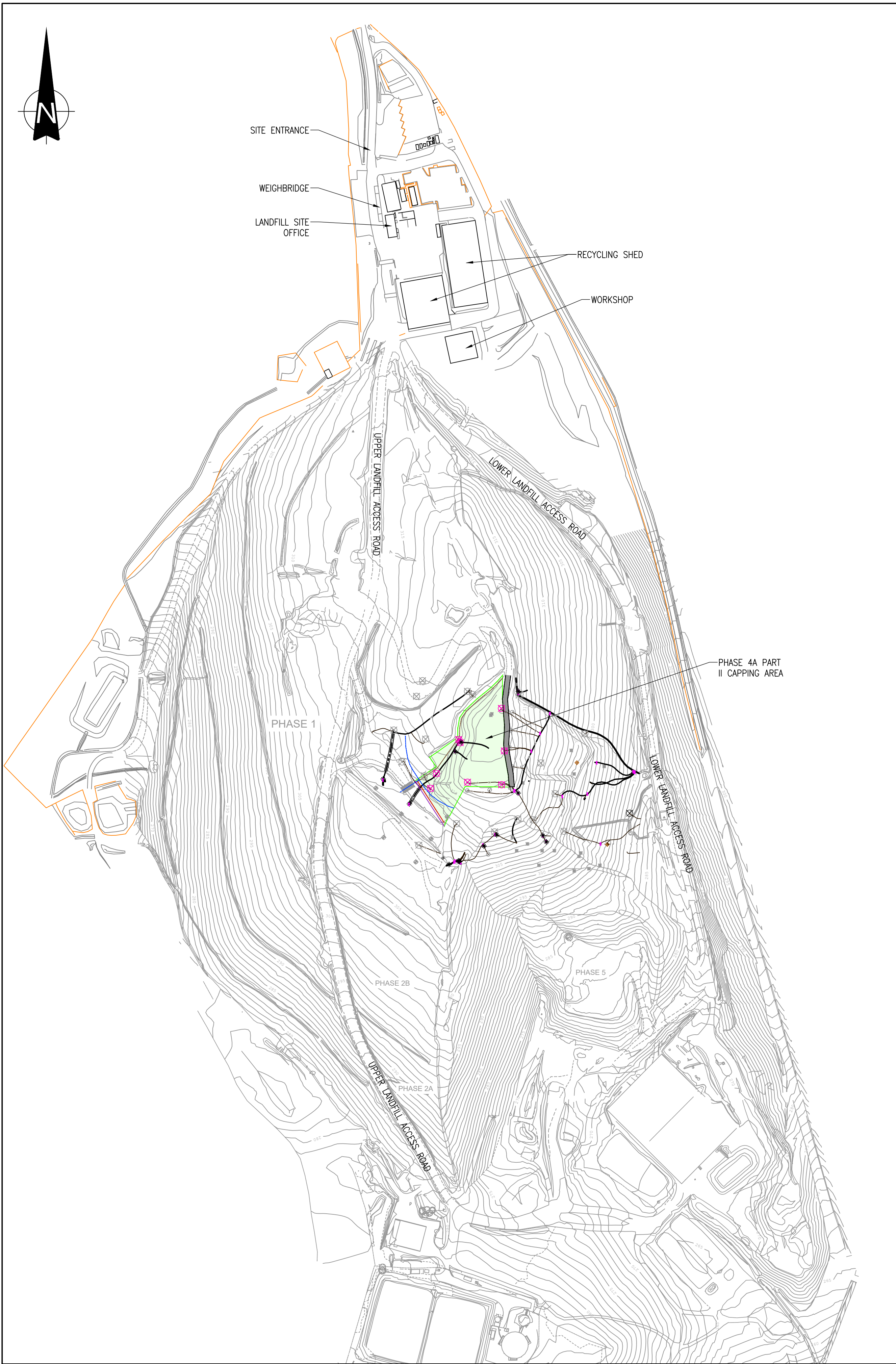
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AM5593/01/01

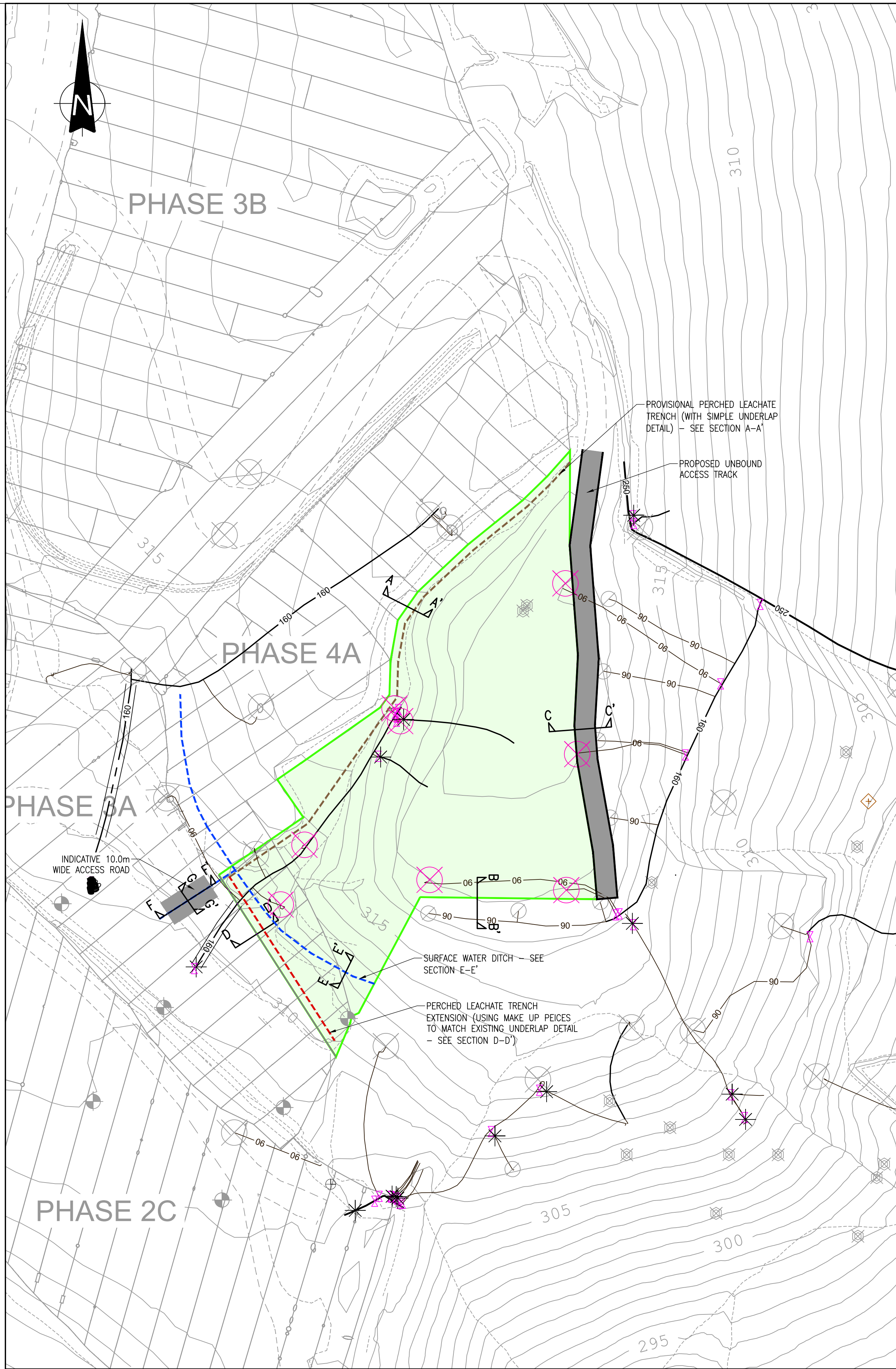
AM5593/01/02

AM5593/01/03

Drawing 5619 GI06



GENERAL ARRANGEMENT OF
PROPOSED CAPPING WORKS
SCALE 1:2000



PLAN SHOWING GENERAL
ARRANGEMENT OF CAPPING WORKS
SCALE 1:500

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NOTES

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2. DO NOT SCALE FROM THIS DRAWING.
3. ANY ANOMALIES IDENTIFIED WITH THE DETAILS SHOWN ON THIS DRAWING ARE TO BE BROUGHT TO THE ATTENTION OF SIRIUS ENVIRONMENTAL PRIOR TO CONSTRUCTION WORKS COMMENCING.
4. THE CAPPING SYSTEM SHALL NOT BE PLACED ON ANY SLOPE STEPPER THAN 1(V):3(H).

KEY

- 18.5— SITE SURVEY
- PROPOSED CAPPING AREA
- PROPOSED HAUL ROAD
- PROVISIONAL PERCHED LEACHATE TRENCH (WITH SIMPLE UNDERLAP DETAIL) - SEE SECTION A-A'
- PERCHED LEACHATE TRENCH (EXTENSION OF EXISTING USING MAKE-UP PIECES TO MATCH EXISTING UNDERLAP DETAIL) - SEE SECTION D-D'
- PERMITER SURFACE WATER DITCH - SEE SECTION E-E'
- GAS WELL (WITHIN PROPOSED CAP AREA)

REV	DESCRIPTION	DATE	BY
-----	-------------	------	----

CLIENT



AMGEN CYMRU
BRYN PICA
LLWYDCOED
ABERDARE
CF44 0BX
TEL: 01685 870770
FAX: 01685 874684



4245 Park Approach, Thorpe Park, Leeds. LS15 8GB. 0113 264 9960

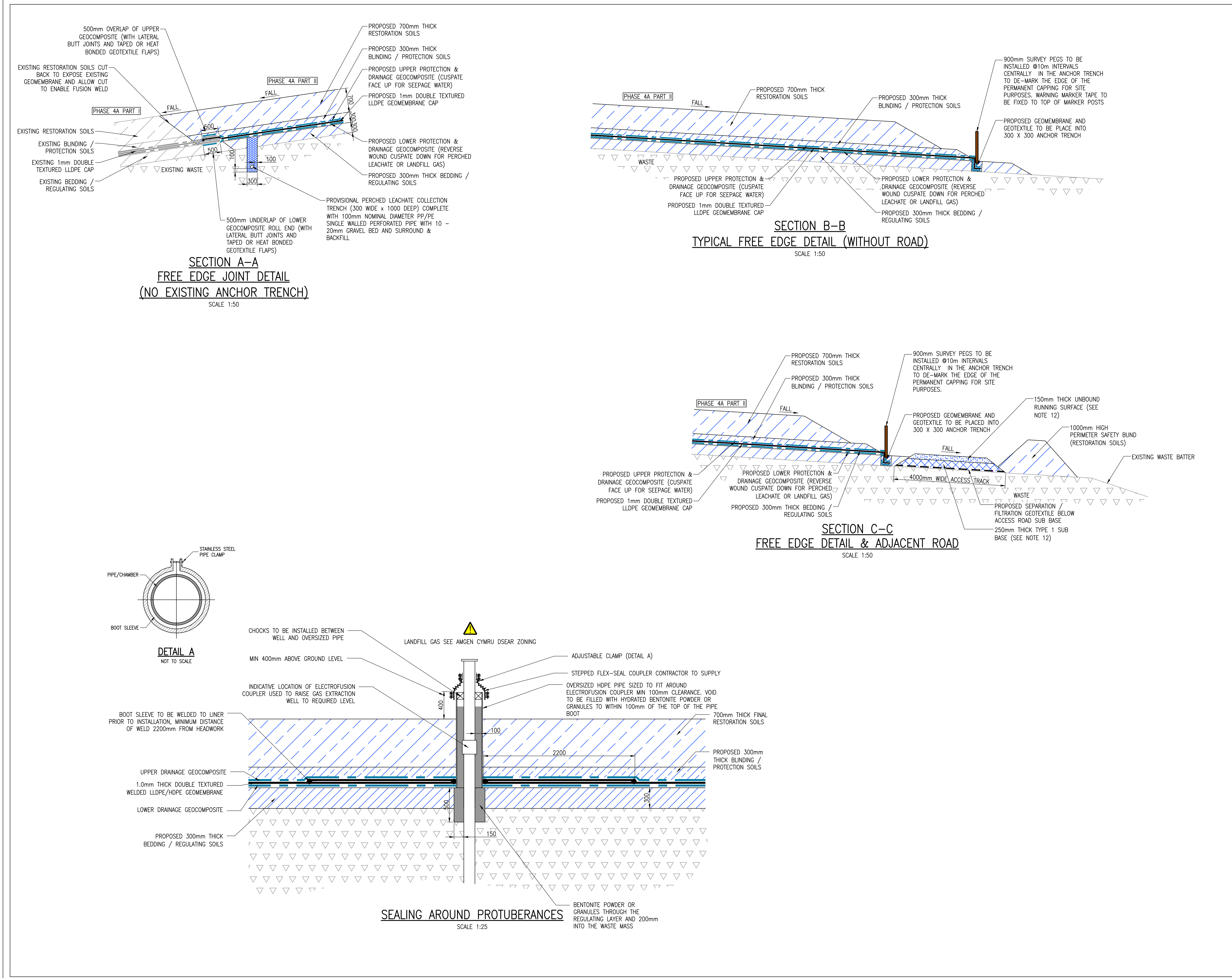
JOB TITLE

BRYN LANDFILL SITE
2023 CAPPING WORKS

DRAWING TITLE

LOCATION OF PROPOSED
CAPPING WORKS

DRAWN	DATE	APPROVED	DATE
M.C	29/03/2023	R.H	29/03/2023
SCALE	SHEET	DRAWING NUMBER	REVISION
AS SHOWN	A1L	AM5593/01/01	0



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- THE CAPPING SYSTEM SHALL NOT BE PLACED ON ANY SLOPE STEPPER THAN 1(V):3(H).
- BEDDING/REGULATING SOILS - THIS LAYER SHALL CONFORM TO THE REQUIREMENTS OF TABLE 4 WITH A MAXIMUM PARTICLE SIZE OF 63mm TO PROTECT THE GEOSYNTHETIC LAYERS ABOVE
- BEDDING/REGULATING SOILS SURFACE - PREPARATION OF THIS LAYER SURFACE SHALL INVOLVE ROLLING WITH A SMOOTH DRUM ROLLER AND REMOVING ALL STONES GREATER THAN 40mm ROUNDED OR 20mm ANGULAR TO PROTECT THE GEOSYNTHETIC LAYERS ABOVE
- BLINDING/PROTECTION SOILS - THE FIRST 300mm OF RESTORATION SOILS (OR GREATER, IF LAID AS ONE LAYER) SHALL CONFORM TO THE GRADING REQUIREMENTS OF TABLE 9 WITH A MAXIMUM PARTICLE SIZE OF 40mm TO PROTECT THE GEO-SYNTHETIC LAYERS BELOW
- RESTORATION SOILS - FOR THE RESTORATION SOILS ABOVE THE BLINDING/PROTECTION SOILS (>300mm ABOVE GEO-MEMBRANE, OR GREATER WHERE FIRST LAYER IS GREATER) THE GRADING REQUIREMENTS OF TABLE 9 SHALL NOT APPLY, ALTHOUGH THE MAXIMUM PARTICLE SIZE IS LIMITED TO 150mm (FOR SUBSEQUENT PIPEWORK TRENCHING OR SOLAR INFRASTRUCTURE)
- GEOMEMBRANE PROTRUSIONS - TOP-HAT (BOOT) DETAIL FOR GAS WELLS SHALL HAVE A MINIMUM 2.2m RADIUS, WHERE POSSIBLE. HOWEVER, AN ALTERNATIVE INSTALLATION METHOD/PROCEDURE (IN ACCORDANCE WITH THE DSEAR REGULATIONS & ICOPS) MAY BE AGREED
- GEOCOMPOSITES - THE LOWER & UPPER PROTECTION & DRAINAGE GEOCOMPOSITE SHALL HAVE A MINIMUM CBR PUNCTURE RESISTANCE OF 3.0kN AND A MINIMUM IN-PLANE FLOW TRANSMISSIVITY OF 1.2 l/m/s FOR A HYDRAULIC GRADIENT OF 1.0, UNDER A CONFINING PRESSURE OF 20kPa WITH SOFT PLATTENS FACING CUSPATE
- GEOMEMBRANE - THE GEOMEMBRANE SHALL BE 1mm THICK DOUBLE TEXTURED LLDPE IN ACCORDANCE WITH GRI-GM 17
- ACCESS ROAD SUBGRADE - THE ACCESS ROAD CONSTRUCTION SHOWN IS BASED ON A SUBGRADE CBR ABOVE 4.5%. WHERE THE CBR IS LESS THAN 4.5% BUT ABOVE 2.5%, AN ADDITIONAL 100mm OF TYPE 1 STONE (COMPACTED IN ACCORDANCE WITH TABLE 8/4 OF THE SHW) SHALL BE REQUIRED BELOW THE PROPOSED SUB-BASE OR AN ADDITIONAL 200mm OF CAPPING STONE (SF2 OR ALTERNATIVE APPROVED) COMPACTED IN ACCORDANCE WITH TABLE 6/4 OF THE SHW

1	CHANGED PARTICLE SIZE IN NOTE 5 FROM 75mm TO 63mm	07/07/2023	JC
REV	DESCRIPTION	DATE	BY

CLIENT



AMGEN CYMRU
BRYN PICA
LLWYDCOED
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FAX: 01685 874684

JOB TITLE

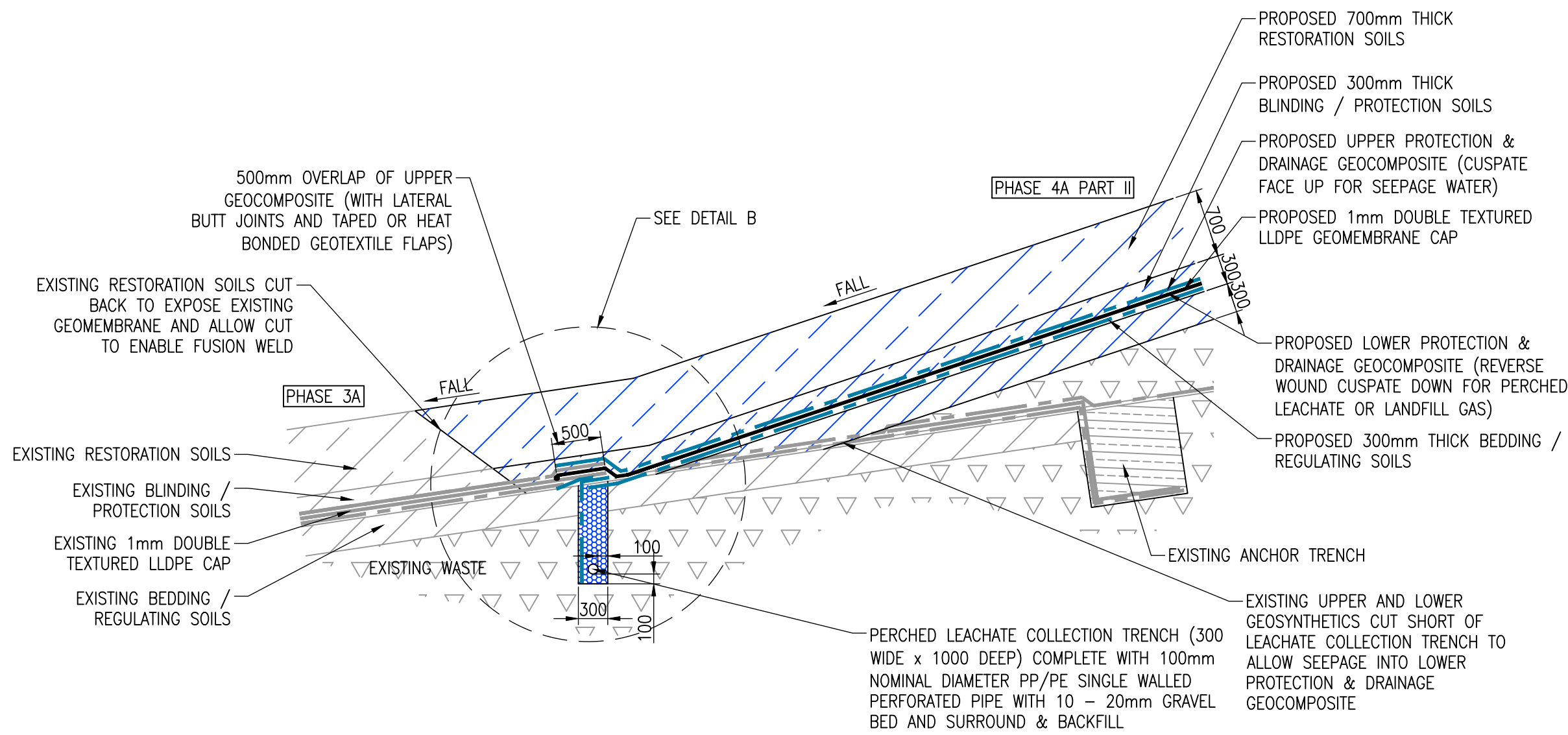
BRYN LANDFILL SITE
2023 CAPPING WORKS

DRAWING TITLE

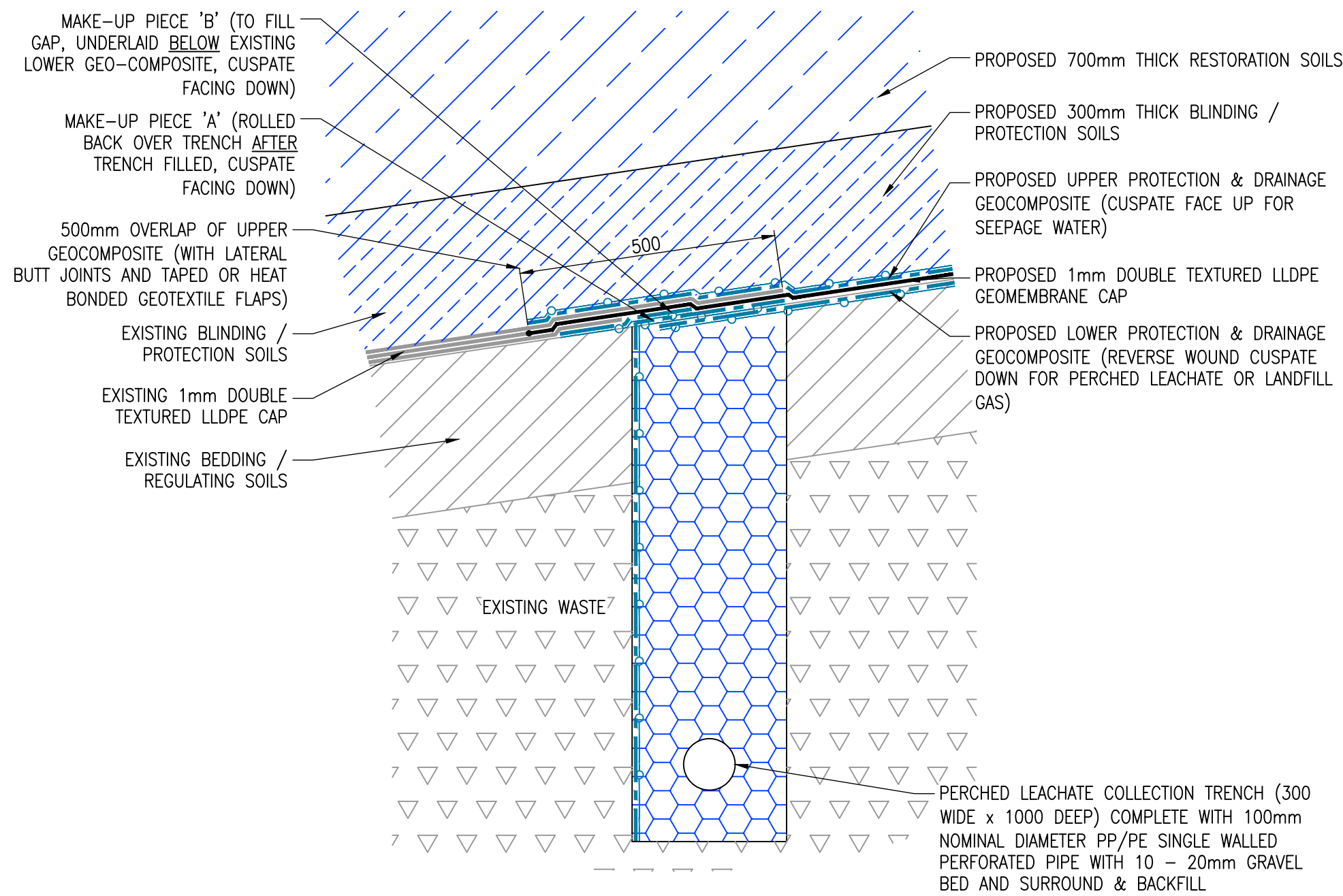
CAPPING CONSTRUCTION
DETAILS SHEET 1

DRAWN	DATE	APPROVED	DATE
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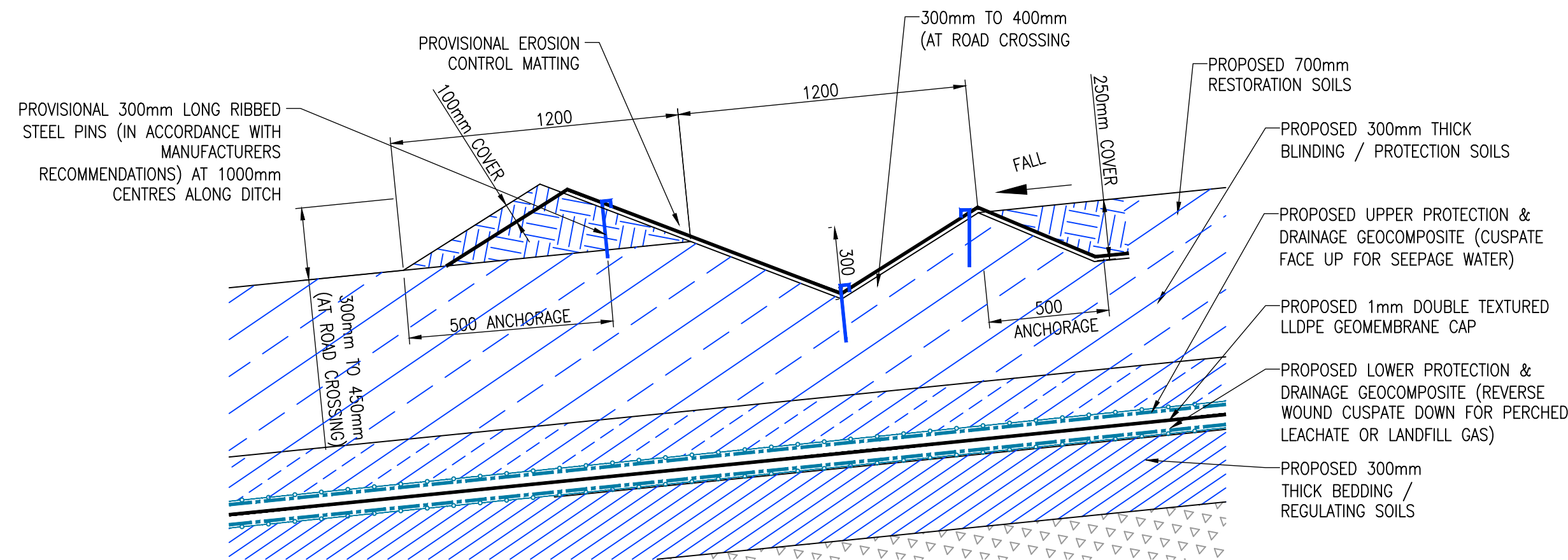
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As Shown	A1L	AM5593/01/02	1



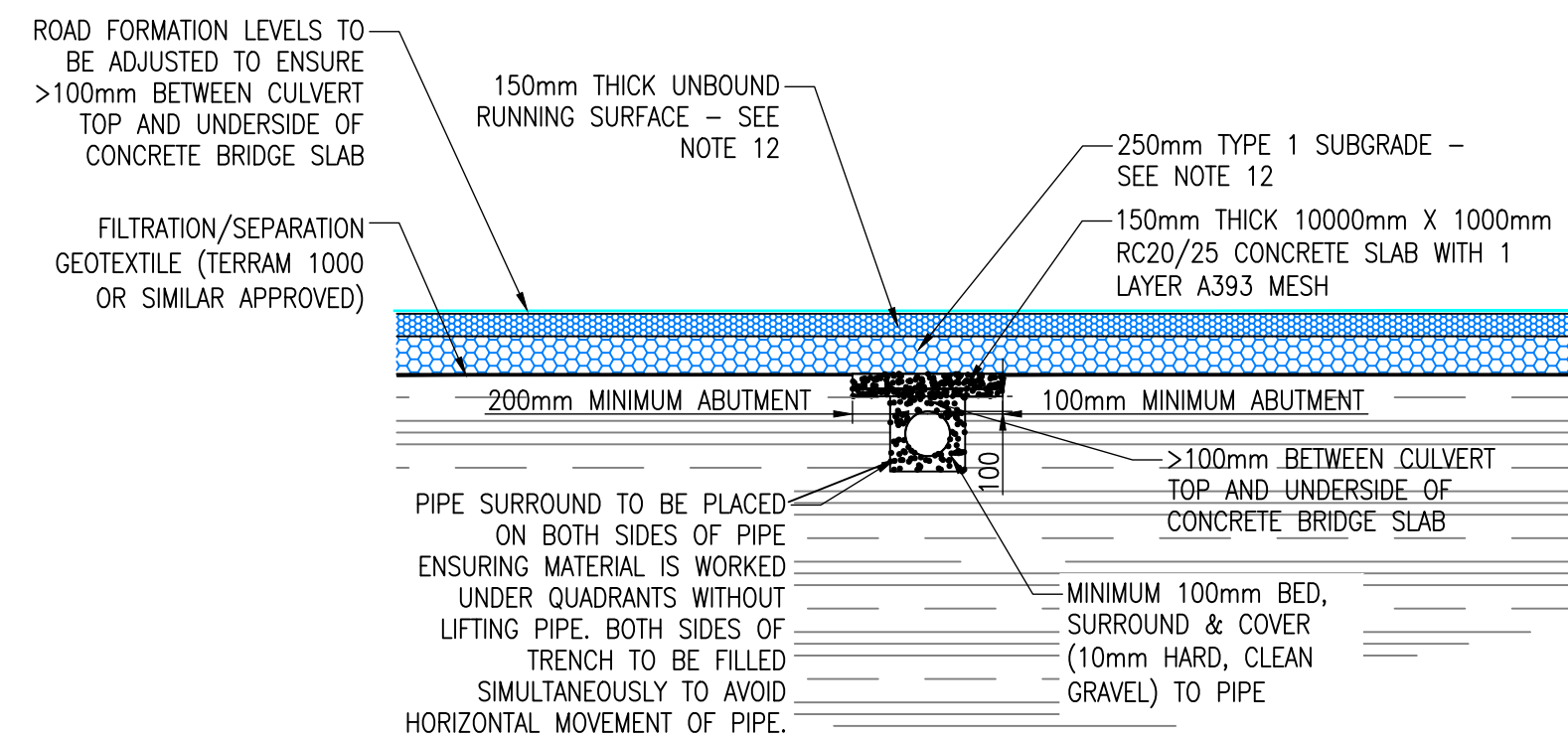
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ANCHOR TRENCH JOINT DETAIL
(SHOWING OVERTIP LEVEL DIFFERENCE TIE IN)
SCALE 1:50



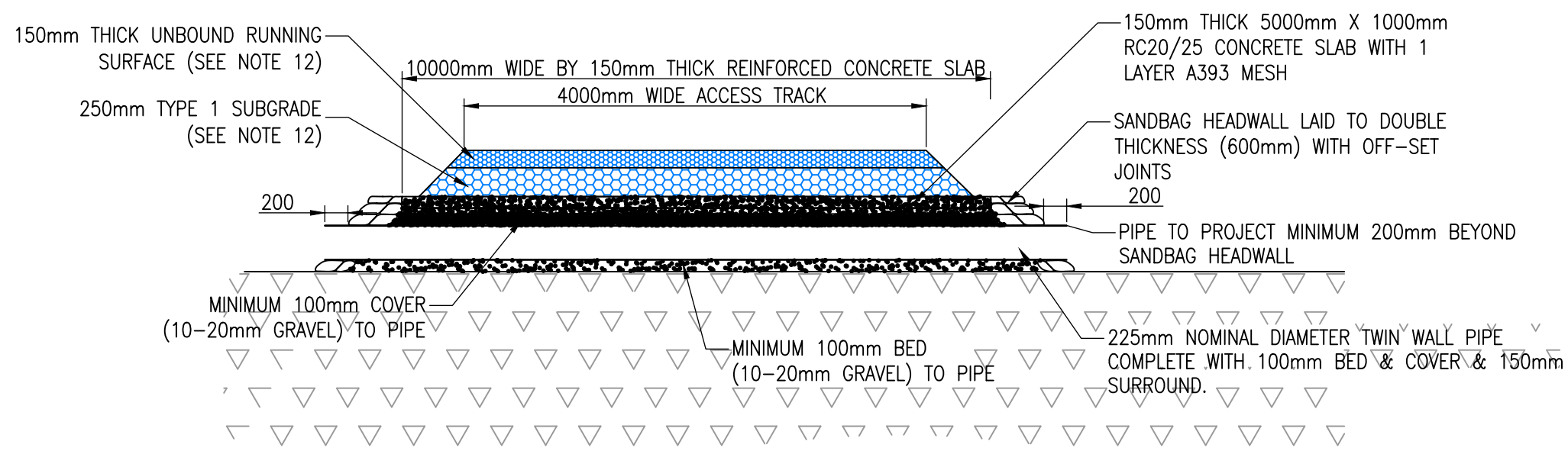
DETAIL B
ANCHOR TRENCH JOINT DETAIL
SCALE 1:10



SECTION E-E'
SURFACE WATER DITCH
SCALE 1:20



SECTION G-G' CROSS SECTION
THROUGH CULVERT ROAD CROSSING
SCALE 1:50



SECTION F-F' CULVERT ROAD CROSSING DETAIL
SCALE 1:50

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- THE CAPPING SYSTEM SHALL NOT BE PLACED ON ANY SLOPE STEPPER THAN 1(V):3(H).
- BEDDING/REGULATING SOILS - THIS LAYER SHALL CONFORM TO THE REQUIREMENTS OF TABLE 4 WITH A MAXIMUM PARTICLE SIZE OF 63mm TO PROTECT THE GEOSYNTHETIC LAYERS ABOVE
- BEDDING/REGULATING SOILS SURFACE - PREPARATION OF THIS LAYER SURFACE SHALL INVOLVE ROLLING WITH A SMOOTH DRUM ROLLER AND REMOVING ALL STONES GREATER THAN 40mm ROUNDED OR 20mm ANGULAR TO PROTECT THE GEOSYNTHETIC LAYERS ABOVE
- BLINDING/PROTECTION SOILS - THE FIRST 300mm OF RESTORATION SOILS (OR GREATER, IF LAID AS ONE LAYER) SHALL CONFORM TO THE GRADING REQUIREMENTS OF TABLE 9 WITH A MAXIMUM PARTICLE SIZE OF 40mm TO PROTECT THE GEO-SYNTHETIC LAYERS BELOW
- RESTORATION SOILS - FOR THE RESTORATION SOILS ABOVE THE BLINDING/PROTECTION SOILS (>300mm ABOVE GEO-MEMBRANE, OR GREATER WHERE FIRST LAYER IS GREATER) THE GRADING REQUIREMENTS OF TABLE 9 SHALL NOT APPLY, ALTHOUGH THE MAXIMUM PARTICLE SIZE IS LIMITED TO 150mm FOR SUBSEQUENT PIPEWORK TRENCHING OR SOLAR INFRASTRUCTURE)
- GEOMEMBRANE PROTRUSIONS - TOP-HAT (BOOT) DETAIL FOR GAS WELLS SHALL HAVE A MINIMUM 2.2m RADIUS, WHERE POSSIBLE. HOWEVER, AN ALTERNATIVE INSTALLATION METHOD/PROCEDURE (IN ACCORDANCE WITH THE DSEAR REGULATIONS & ICOPS) MAY BE AGREED
- GEOCOMPOSITES - THE LOWER & UPPER PROTECTION & DRAINAGE GEOCOMPOSITE SHALL HAVE A MINIMUM CBR PUNCTURE RESISTANCE OF 3.0kN AND A MINIMUM IN-PLANE FLOW TRANSMISSIVITY OF 1.2 lms FOR A HYDRAULIC GRADIENT OF 1.0, UNDER A CONFINING PRESSURE OF 20kPa WITH SOFT PLATTENS FACING CUSPATE
- GEOMEMBRANE - THE GEOMEMBRANE SHALL BE 1mm THICK DOUBLE TEXTURED LLDPE IN ACCORDANCE WITH GRI-GM 17
- ACCESS ROAD SUBGRADE - THE ACCESS ROAD CONSTRUCTION SHOWN IS BASED ON A SUBGRADE CBR ABOVE 4.5%. WHERE THE CBR IS LESS THAN 4.5% BUT ABOVE 2.5%, AN ADDITIONAL 100mm OF TYPE 1 STONE (COMPACTED IN ACCORDANCE TABLE 8/4 OF THE SHW) SHALL BE REQUIRED BELOW THE PROPOSED SUB-BASE OR AN ADDITIONAL 200mm OF CAPPING STONE (8F2 OR ALTERNATIVE APPROVED) COMPACTED IN ACCORDANCE WITH TABLE 6/4 OF THE SHW

1	CHANGED PARTICLE SIZE IN NOTE 5 FROM 75mm TO 63mm	07/07/2023	JC
REV	DESCRIPTION	DATE	BY

CLIENT



AMGEN CYMRU
BRYN PICA
LLWYDCOED
ABERDARE
CF44 0BX
TEL: 01685 870770
FAX: 01685 874684



4245 Park Approach, Thorpe Park, Leeds. LS15 8GB. 0113 264 9960

JOB TITLE

BRYN LANDFILL SITE
2023 CAPPING WORKS

DRAWING TITLE

CAPPING CONSTRUCTION
DETAILS SHEET 2

DRAWN	DATE	APPROVED	DATE
M.C	29/03/2023	A.K	29/03/2023

SCALE	SHEET	DRAWING NUMBER	REVISION
As Shown	A1L	AM5593/01/03	1

APPENDIX 2
CQA PROFORMAS



Daily Site Record Sheet

Date:		Site:	
Weather:		CQA Plan Ref:	

Visitors to Site:			
List of Plant	Hours of Operation	Comments	

Prepared by:		Signed:	
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[illegible]



Surface Acceptance Certificate

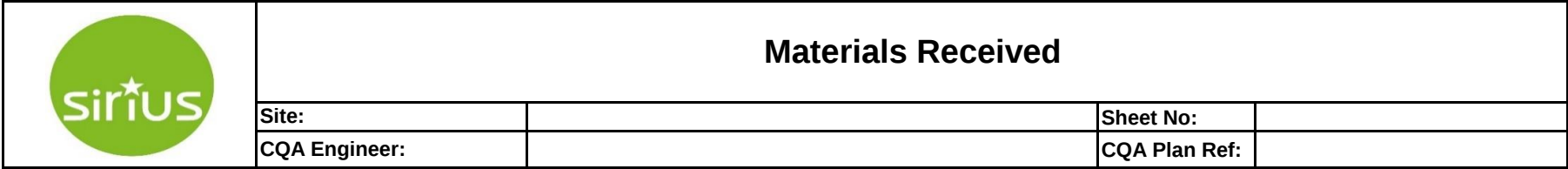
Site:		Sheet No:	
CQA Engineer:		CQA Plan Ref:	

Area of Subgrade under consideration:	
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I the undersigned, a duly appointed representative of Sirius Environmental Limited, have visually observed the subgrade described above and confirm the subgrade is an acceptable surface upon which to install

This certification is based on observation of the surface of the subgrade only. No subterranean inspections or tests have been performed by Sirius Environmental Limited, and Sirius Environmental Limited makes no representations or warranties regarding the conditions which may exist below the surface of the subgrade.

Sirius Environmental Representative:	
Name:	Signature:
Date:	Position:



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	CQA Engineer:		CQA Plan Ref:	

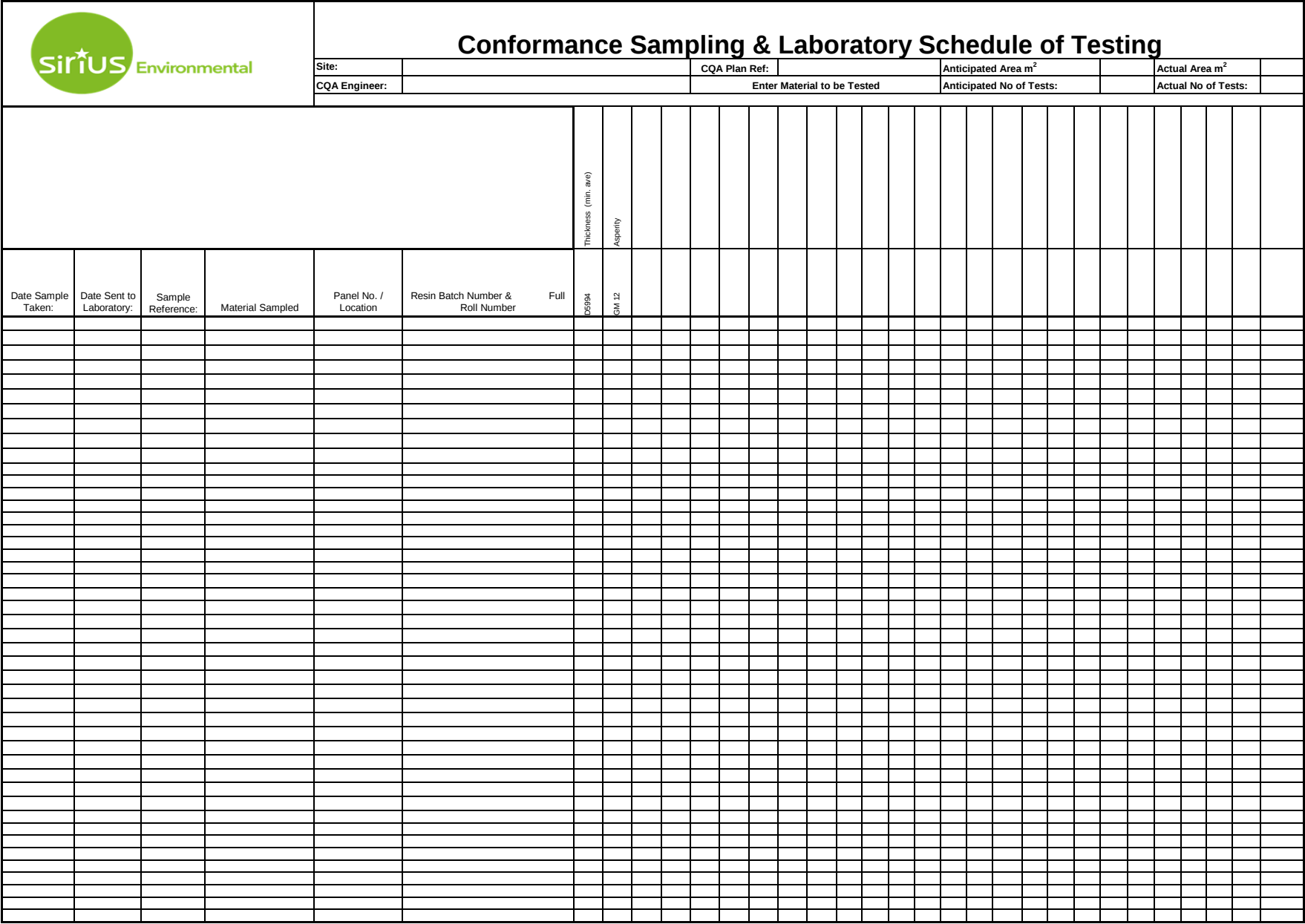
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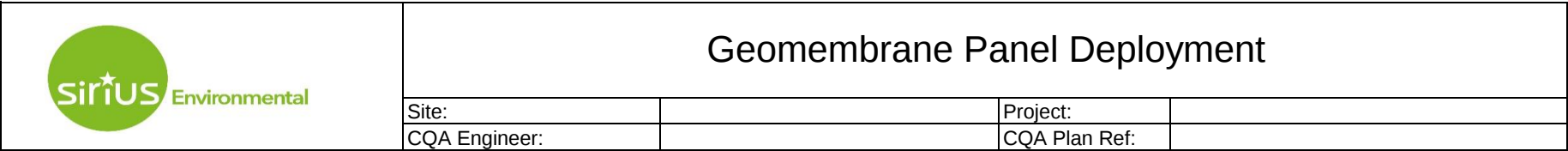
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	Geomembrane Panel Deployment			
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	CQA Engineer:		CQA Plan Ref:	

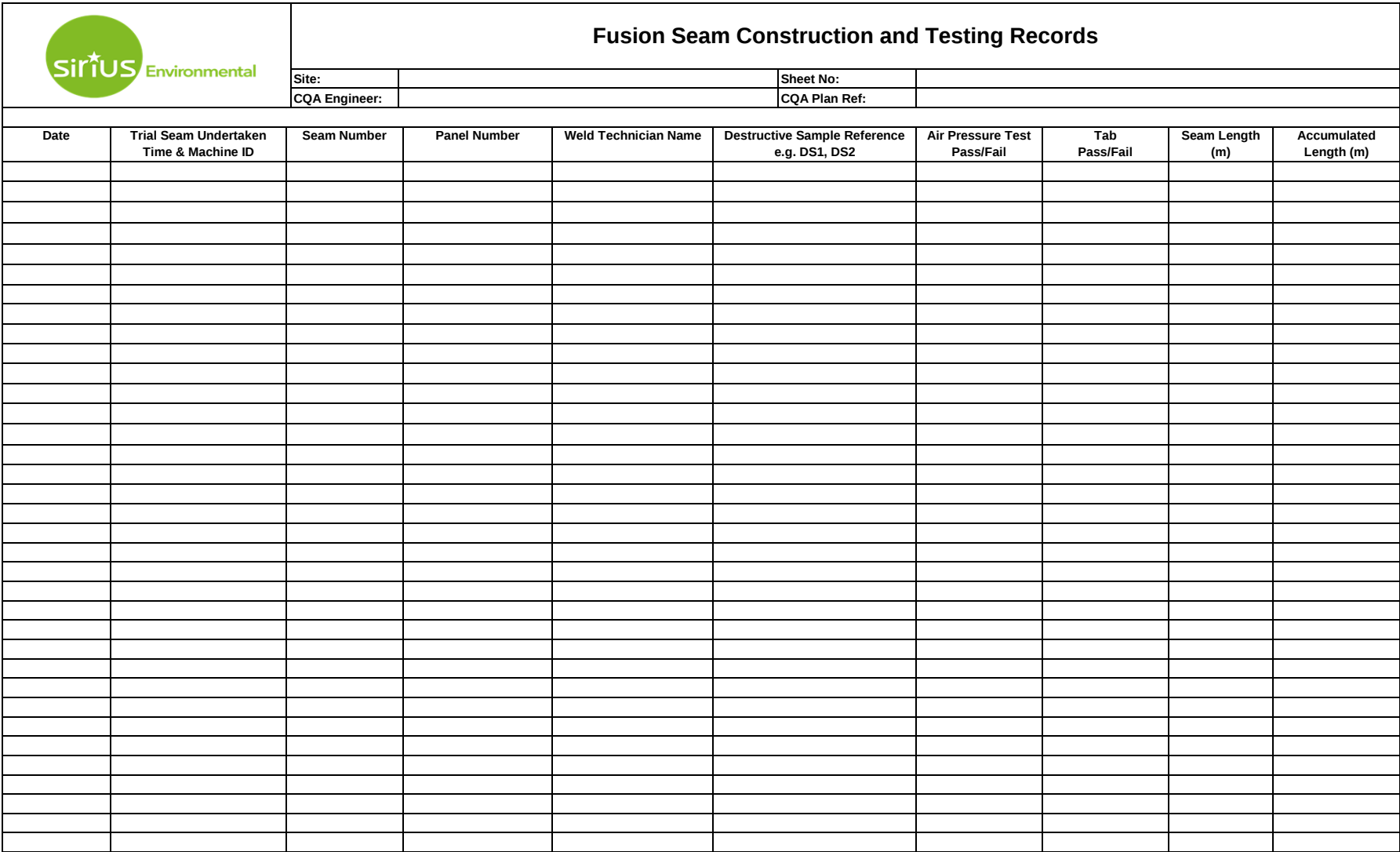
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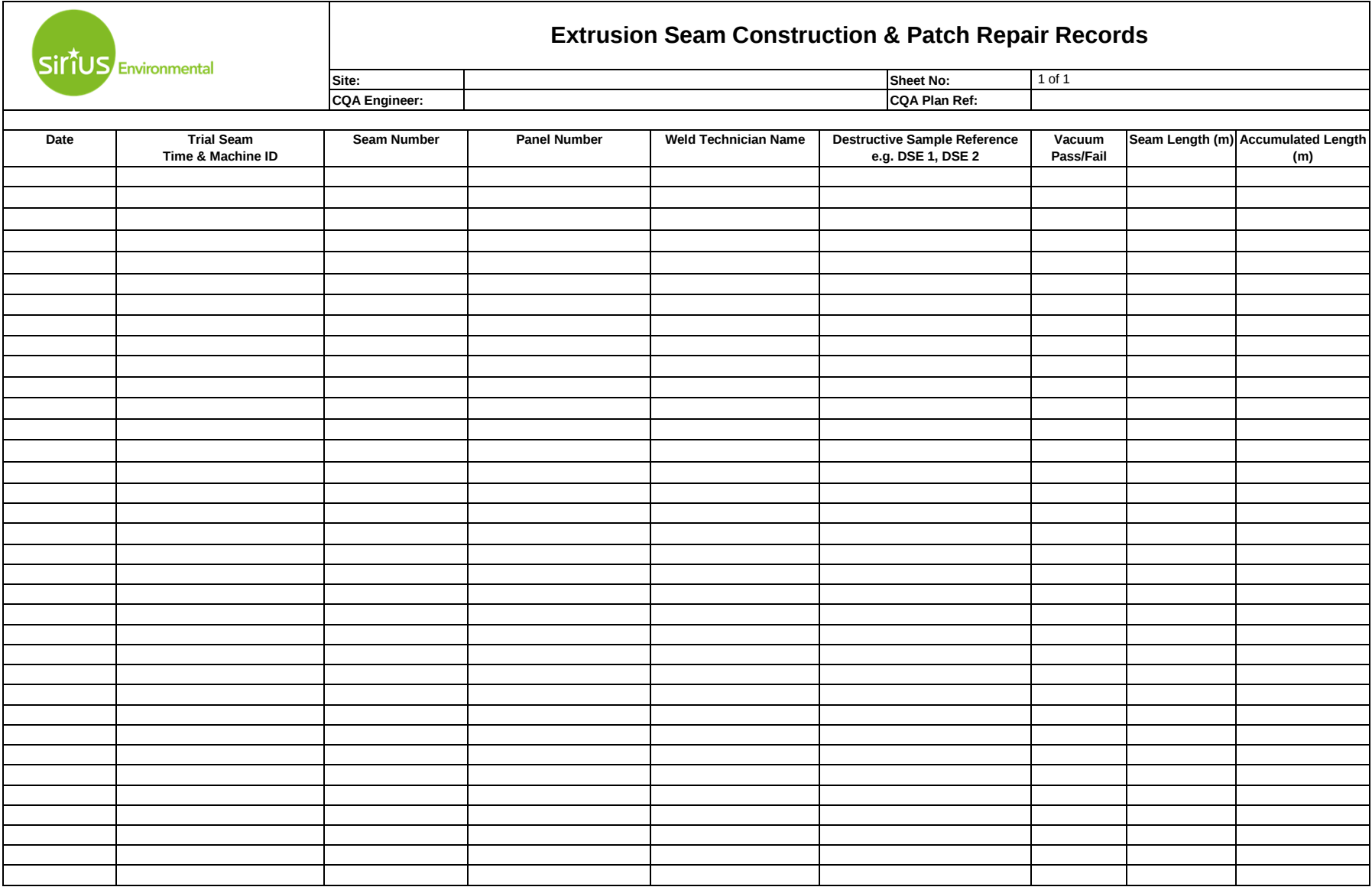
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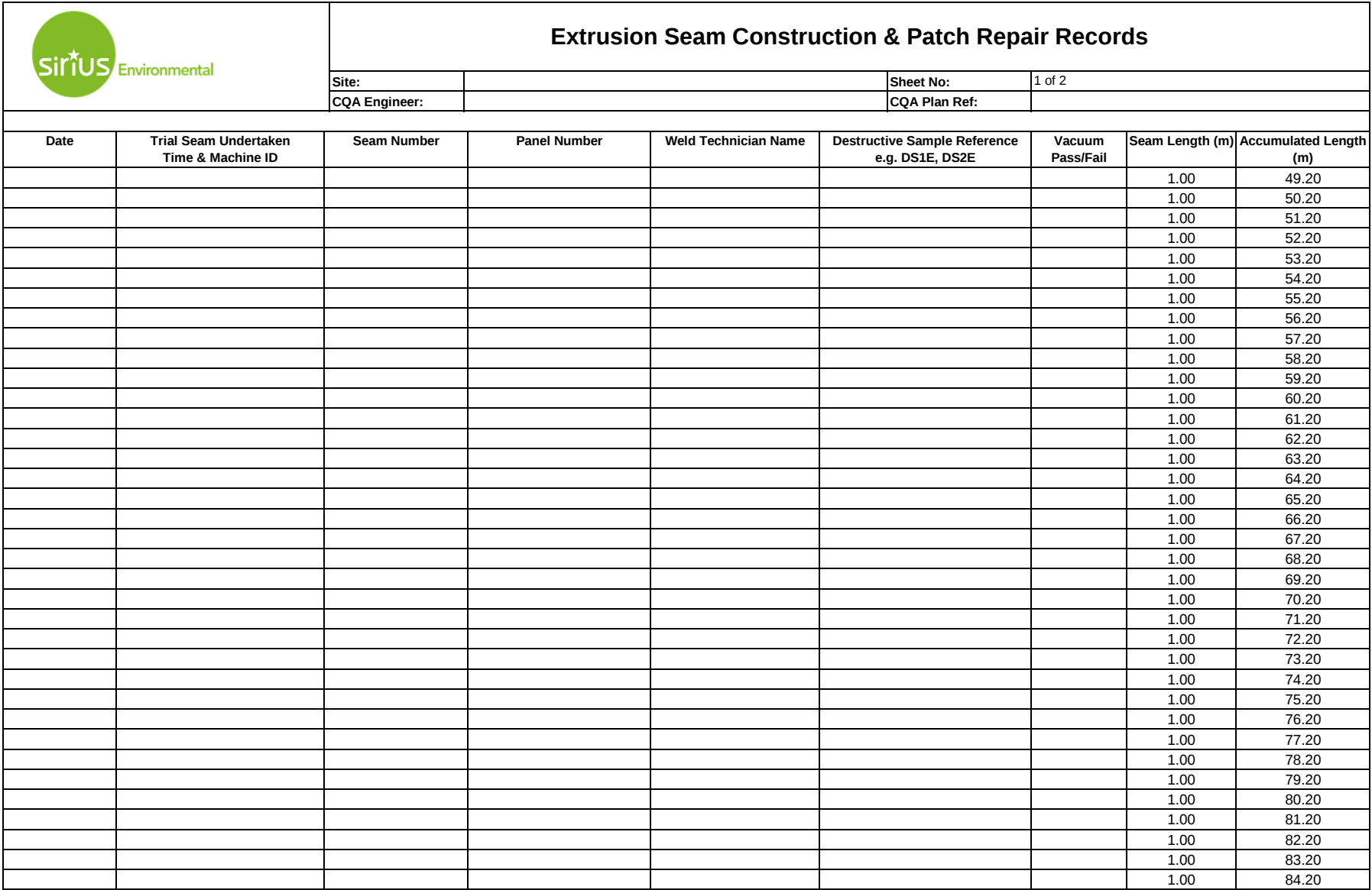
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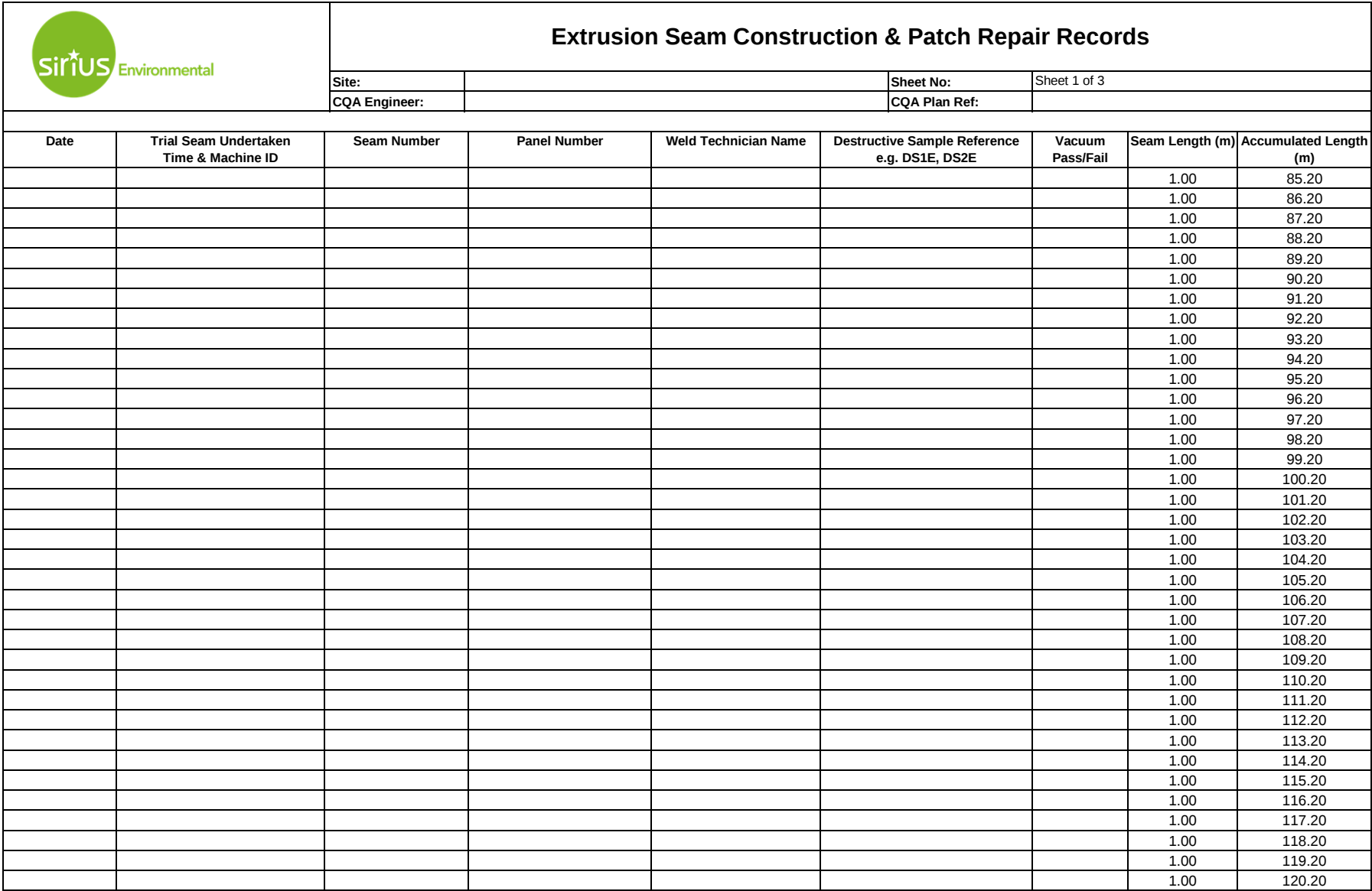
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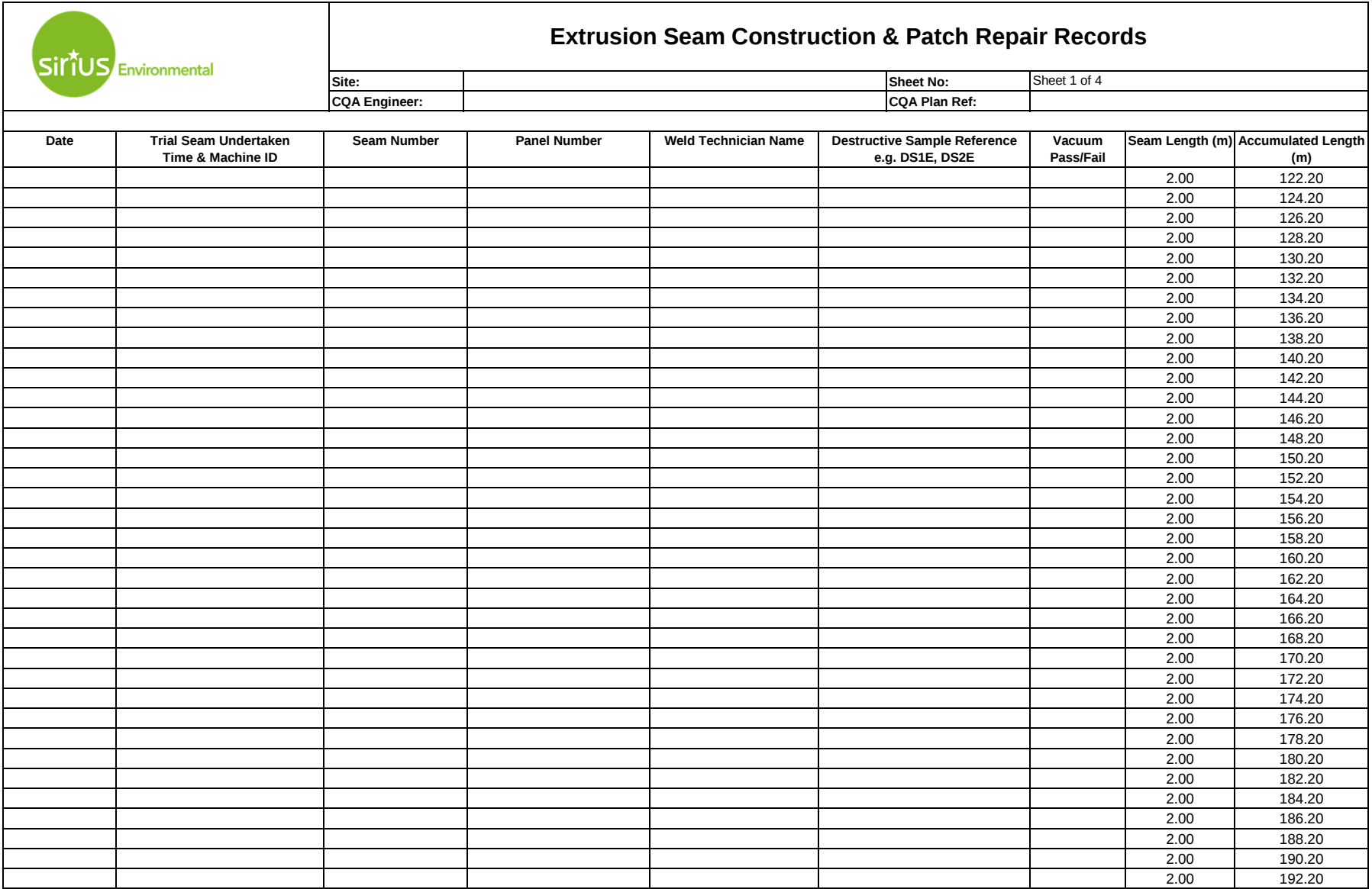
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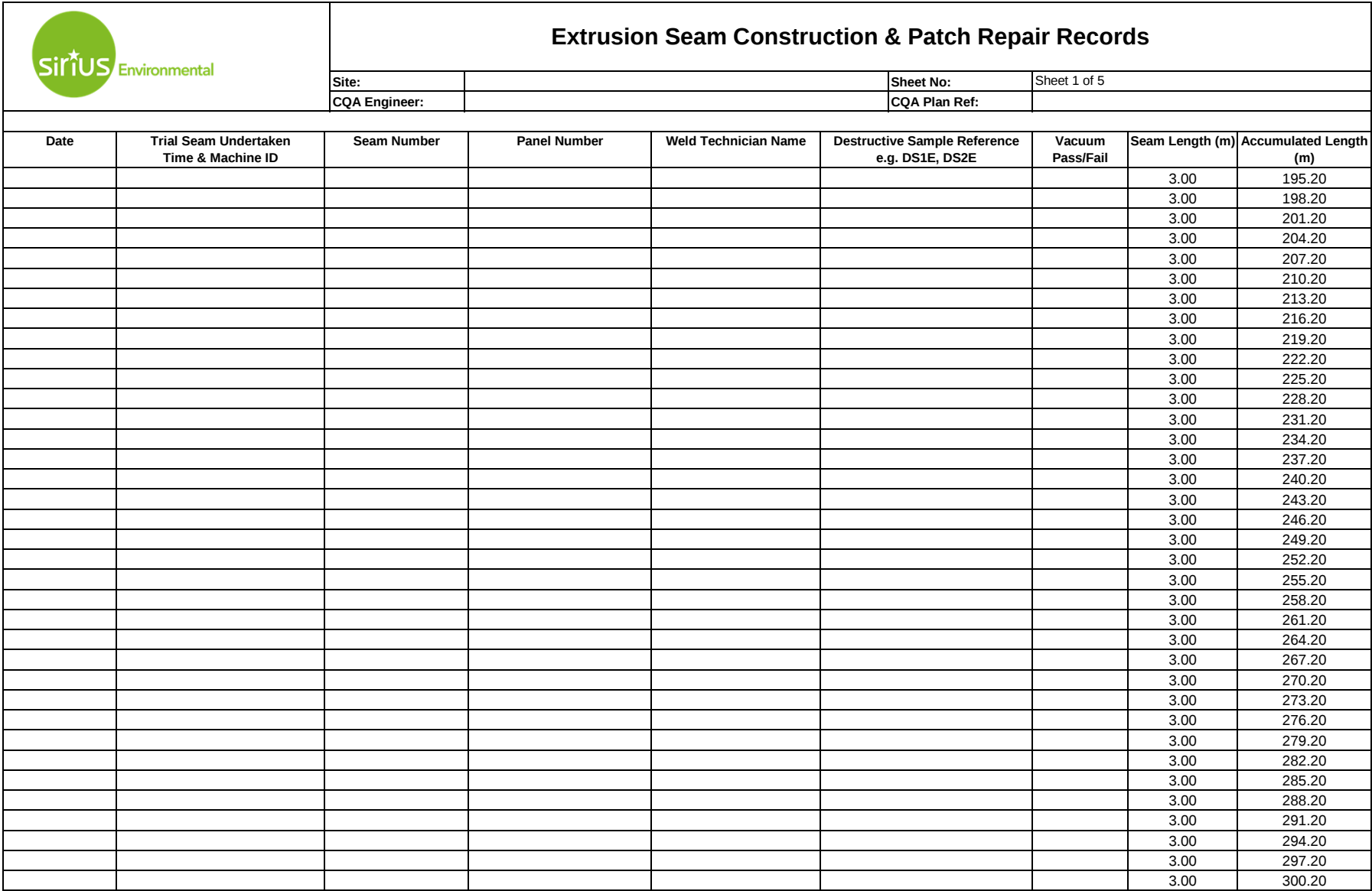


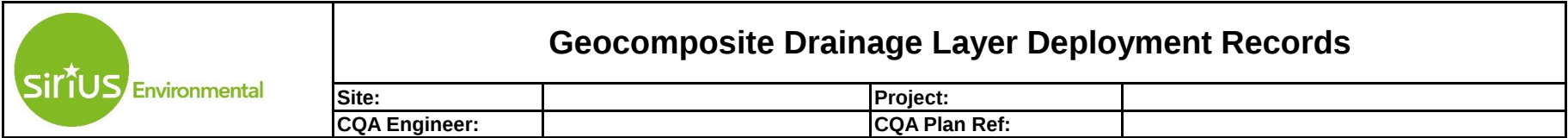












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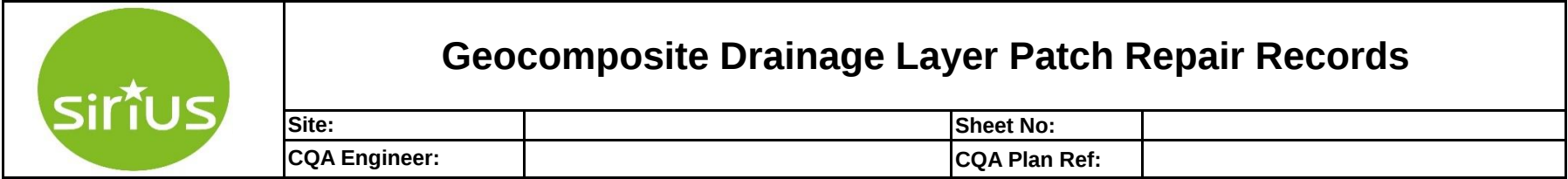
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	Site:		Project:	
	CQA Engineer:		CQA Plan Ref:	

	CQA Engineer:		CQA Plan Ref:	

	CQA Engineer:		CQA Plan Ref:	

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	Geocomposite Drainage Layer Patch Repair Records			
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	CQA Engineer:		CQA Plan Ref:	

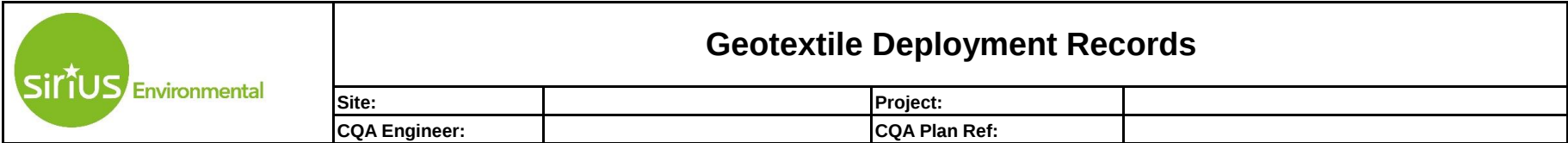
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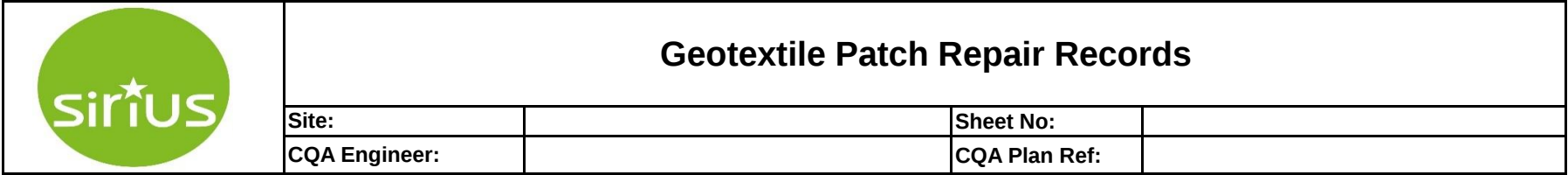
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	Site:		Project:
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	Geotextile Deployment Records		
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	CQA Engineer:		CQA Plan Ref:

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	Geotextile Patch Repair Records			
	Site:		Sheet No:	
	CQA Engineer:		CQA Plan Ref:	

SITUS Site: _____

	Site:		Sheet No:	

CQA Engineer:

	CQA Engineer:		CQA Plan Ref:	
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Sketch Drawing - Panel Layout/Patch Repair/Sample Location

Date:		Site:	
Sheet No:	of	CQA Engineer:	