

Streetscene
Y-Strydynun

Civic Centre/Canolfan Ddinesig
Newport/Casnewydd
South Wales/De Cymru
NP20 4UR



Environmental Services

**Docksway Waste Disposal
Site, Area 2 Development**

2016 Capping Program CQA Plan

Project Ref: 2511
Revision No:
Date: September 2016

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Document Control Sheet

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1 General

1.1 Introduction

1.1.1 This Construction Quality Assurance (CQA) Plan is a continuation of that prepared by Peter Brett Associates LLP (PBA) in 2009. It has been reviewed and amended to reflect the current version of the Natural Resource Wales guidance document LFE5 'Using Geomembranes in Landfill Engineering'. It outlines the requirements for the installation of LLDPE. The method of application of this scheme has intentionally been replicated from that previously used to provide continuity in the integrity of the cap.

1.2 Definitions

1.2.1 This CQA Plan is devoted to Construction Quality Assurance. In the context of this document, Construction Quality Assurance and Construction Quality Control are defined as follows:

1.2.2 Construction Quality Assurance (CQA) - A planned and systematic pattern of the means and actions designed to provide confidence that items or services meet contractual and regulatory requirements, and will perform satisfactorily in service. However, the process records results at the point of measurement and cannot be treated as a guarantee or warranty of fit for purpose.

1.2.3 For this project, Construction Quality Assurance refers to means and actions employed by the CQA Site Engineer, to monitor conformity of the bund and capping system preparation, production, and installation to this CQA plan, the contract drawings and specifications. The CQA role is provided by a party who is independent of production and installation.

1.2.4 Construction Quality Control (CQC) - Those actions that provide a means to measure and regulate the characteristics of an item or service to contractual requirements.

1.2.5 For this project, Construction Quality Control refers to those actions taken by the Contractor, or the Employer to ensure that the materials and the workmanship meet the requirements of the plans and specifications.

1.2.6 "Employer" means the person or persons, firm, company or other body who own or have responsibility for the facility. The Employer has entered into a contract with the Contractor for the execution of the Works specified in the Specification and Contract Drawings. Personal representatives or other parties, e.g. the CQA Project Manager, may represent the Employer on site.

1.2.7 "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. The Contractor is the party responsible for the preparation and construction of the works to the Specifications as detailed, within the CQA Plan and Contract Documents under the technical supervision of an Engineer.

1.2.8 "CQA Project manager" means the firm, company or individual appointed by the Employer to act on his behalf for the proper execution of the Works. A personal representative will be appointed for the Works or part thereof who will normally operate from the site offices of the Employer.

1.2.9 "CQA Site Engineer" is a representative of the CQA Project Manager who is normally located at the site for the duration of the works.

1.2.10 "Field Testers" who are independent and represent the approved Test Laboratory and are normally located locally to the site.

1.2.11 The "Testing Laboratory" shall have NAMAS accreditation for the appropriate test methods described in sections 3.3 and 4.2.

- 1.2.12 “Engineer” means the person appointed by the Employer to act as engineer for the purposes of the Contract.

1.3 Personnel Duties

- 1.3.1 For the project covered by this CQA Plan, the CQA Project Manager and the Contractor have been pre-selected on the basis of their qualifications and experience in their respective disciplines. In the case of the CQA Project Manager, the personnel of the CQA Team will include:

- 1.3.2 The CQA Project Manager, who may attend site progress or pre-construction meetings and whose duties include:

- i. Review all designs, plans, and specifications
- ii. Review other site-specific documentation, including proposed layouts, and Contractor's qualifications
- iii. Administering the CQA program, i.e., assigns tasks and instructs CQA personnel, reviews field reports, and CQA related issues
- iv. Quality control of the CQA personnel
- v. Review all changes to the design, plans, and specifications
- vi. Review the Record Drawings;
- vii. Preparation of the final report.

- 1.3.3 The CQA Project Manager may delegate some or all of the above duties to the CQA Site Engineer as required.

- 1.3.4 Duties of the CQA Site Engineer will include:

- i. All the above in section 1.3.2 as necessary
- ii. Act as the on-site representative of the CQA Project Manager
- iii. Attend pre-construction, progress, site and CQA-related meetings
- iv. Prepare, or oversee the ongoing preparation of the Record Drawings
- v. Familiarise all Field Testers with the site, and the CQA requirements for the project
- vi. Assign locations for testing and sampling
- vii. Oversee the collection of samples by the Field Testers for laboratory testing
- viii. Review results of laboratory testing and make appropriate recommendations
- ix. Log relevant observations in a daily report and report to the CQA Project Manager
- x. Report any unresolved deviations from this CQA Plan to the CQA Project Manager
- xi. Provide all logs, results and relevant data to the CQA Project Manager for review and for the preparation of the final report
- xii. Review all Certifications and Documentation from the Contractor and make appropriate recommendations
- xiii. Note and brings to the attention of the Contractor any on-site activities that could result in damage to the clay bund or capping works.
- xiv. Carry out duties delegated by the CQA Project Manager.

- 1.3.5 The list of the CQA Site Engineers duties is not exhaustive and may include additional roles as required.

- 1.3.6 The Field Testers shall attend the site “on demand” and will under the direction of the CQA Site Engineer perform the following duties:
- i. Perform on-site sampling at sites specified by the CQA Site Engineer to include the collection of bulk samples and 100mm diameter core samples of clay for conformance and classification testing by the approved Test Laboratory. Also testing of the LLDPE capping system shall be undertaken as required in accordance with this plan.
- 1.3.7 Anyone standing in for the CQA Site Engineer in his absence will be required to perform all the above in sections 1.3.2 and 1.3.4 as necessary.
- 1.3.8 The Engineer shall visit the site regularly. The Engineers duties will include the following:
- i. Oversee budgetary and contractual matters
 - ii. Provide day to day management of the works
 - iii. Provide surveying services
 - iv. Setting out to specifications
 - v. Provide technical support where required
 - vi. Attend pre-construction, progress, site and CQA-related meetings
 - vii. Liaise with all parties.
- 1.3.9 The list of the Engineers duties is not exhaustive and may include additional roles as required.

1.4 Relationship with Other Documents

- 1.4.1 In the event of ambiguity or conflict between this CQA Plan and other Contract Documents, then in general the Specification shall take precedence, followed by the Contract Documents, and thence this CQA Plan. Should resolution on this basis not be possible, then the Engineer shall decide on which interpretation is applicable.

2 LLDPE Preparation of Existing Surfaces

2.1 Materials

- 2.1.1 The Contractor shall verify that the materials to be utilised for the geomembrane subgrade conform to the Specification requirements in relation to grading and/or maximum particle size. In addition the Contractor shall supply a written method statement for placement of subgrade soils to ensure that the method of soils placement is suitable to provide an adequate surface onto which the geomembrane shall be placed.

2.2 Preparation of Surface

- 2.2.1 The Contractor must take all necessary precautions to avoid damage to the geomembrane by any other materials. Specifically:
- i. Installation on rough surfaces such as concrete shall be carefully performed. If approved by the CQA Site Engineer, geotextile sections may be used by the Contractor as protection for the GEOMEMBRANE.
 - ii. The surface to be overlain by the geomembrane shall have a minimum thickness of 300mm of regulation material above any landfill which shall be smooth and free from debris, stones or other deleterious material exceeding 10mm under a 1000mm lath (for example at changes at grade due to rutting), and no large irregularity should exceed 50mm under a 3000mm lath. Measurements shall be taken at a frequency of five measurements per hectare.

- iii. The surface shall be free from construction traffic damage, desiccation cracking, and shall not be excessively softened such that it is too weak to support the geomembrane installation. No free or standing water shall be permitted on the surface, nor shall the surface be frozen.
- iv. Placement of soil on the geomembrane shall not proceed at an ambient temperature below 5°C or above 35°C measured 50mm above the geo membrane. Equipment used for placing soil shall not be driven directly on the GEOMEMBRANE. In heavily trafficked areas such as access ramps, and in areas trafficked by rubber tyre vehicles, the soil thickness should be at least 0.7m. The following shall be complied with:

Equipment Ground Pressure	Minimum Lift Thickness
<28 kPa	0.30m
28-56 kPa	0.45m
56-112 kPa	0.60m
> 112 kPa	0.90m

- 2.2.2 Prior to the commencement of geocomposite and LLDPE installation the Contractor, in conjunction with the CQA Site Engineer, shall carefully inspect the surface on which installation is to take place, and verify that the work is satisfactory such that installation of the geocomposite and LLDPE may commence without adverse impact.
- 2.2.3 The Contractor shall provide Certification in writing that the surface on which the geocomposite and LLDPE will be installed is acceptable. This Certification of Acceptance shall be given to the CQA Project Manager prior to commencement of installation in the area under consideration. If the Contractor has any concerns regarding the surface he shall immediately notify the CQA Site Engineer. Installation of the geomembrane will be construed as Contractor's acceptance of the surface.
- 1.2.4 Once this Certification has been given the Contractor shall have full responsibility for the surface. The CQA Site Engineer shall monitor the condition of the subgrade surface, and withdraw the Certificate of Acceptance if the surface becomes unacceptable due to weather or any other reason, and no longer conforms to the specification.
- 2.2.5 The CQA Project Manager shall re-issue the Certificate of Acceptance only after the Contractor has undertaken any necessary remedial works to the satisfaction of the CQA Site Engineer and the surface again meets the requirements of the Specification.

2.3 Appurtenances including gas monitoring wells

- 2.3.1 Connection of the geomembrane to and around appurtenances shall be undertaken adhering strictly to the Drawings and specific instructions given by the Engineer / CQA Site Engineer or Manufacturer of the appurtenances. Extreme care shall be taken while seaming since neither non-destructive nor destructive testing may be feasible in these areas. The Contractor shall ensure that neither the geomembrane nor the appurtenance is damaged while making connections.
- 2.3.2 All clamps, clips, bolts, nuts, or other fasteners used to secure the geomembrane around each appurtenance shall have a life span equal to or exceeding the geomembrane.

3 LLDPE Geomembrane Specification

3.1 Manufacture

3.1.1 The geomembrane capping shall be double sided textured LLDPE. The Contractor shall allow the CQA Site Engineer to visit the manufacturing plant of the supplier, if this is requested. If possible, this visit will be prior to or during the manufacturing of the LLDPE for the specific project. The CQA Site Engineer will review the manufacturing process, quality control procedures, laboratory facilities, and laboratory testing procedures.

3.1.2 The Contractor shall ensure that each roll is individually wrapped for protection from sunlight, dust, moisture etc. and that each roll has a unique identification number, which is then referenced to supporting documentation. Roll labels and supporting documents shall include as a minimum:

- Name of Manufacturer
- Place of Manufacture
- Date and time of Manufacture
- Product identification
- Thickness of the material
- Length and width of roll
- Directions to unroll the material
- Lot number / Resin batch number
- Roll number
- Mechanical properties and composition

3.1.3 The geomembrane supplied to site shall be manufactured from one resin batch production run utilising concurrent rolls. The CQA Project Manager may vary this at his discretion for projects or where greater than 20,000m² of sheeting are applied. Prior permission must be sought by the Contractor from the CQA Project Manager for more than one production run. If permission is given the Contractor will thence be responsible for the additional conformance testing costs.

3.1.4 The geomembrane shall be manufactured from new polyethylene resin. The resin shall meet the Specifications given in Table 3-1 for density and melt flow index. Reclaimed polymer shall not be added to the resin. The use of polymer recycled during the manufacturing process is permissible up to a maximum of 5% recycled polymer by weight. Testing shall be carried out by the Contractor to demonstrate that the resin meets the Specification. The Contractor shall certify in writing that the resin does meet the Specification, and shall supply written confirmation. Any geomembrane manufactured from non-complying resin shall be rejected and, at the CQA Project Managers discretion, additional conformance testing may be required on all geomembrane supplied. The cost of additional conformance testing shall be borne by the Contractor.

In addition, the geomembrane shall:

- contain no greater than a maximum of 1% by weight of additives or extenders (not including carbon black);
- not have striations, roughness (except in the case of textured geomembrane), pinholes, or bubbles on the surface impairing thickness or serviceability;
- be produced so as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter, and
- be manufactured in a single layer (that is, thinner layers shall not be welded together to produce the final required thickness).

3.1.5 The geomembrane shall be textured and have a pore free surface. It shall be free from blemishes, abrasions and other surface defects. The Contractor shall also demonstrate, by means of independent test certificates, the properties of the proposed liner material with regard to the following:

- Biodegradation
- Thermal ageing
- Methane permeability
- Resistance to root penetration
- Resistance to attack by burrowing animals and vermin
- Resistance to soil contaminants, micro-organisms and insects

Property	Test Method ⁽¹⁾	Requirement
1. Thickness	ASTM D5994	1mm +/- 10%
2. Density	ASTM D1505	Minimum 920 g/m ³
3. Carbon Black Content	ASTM D1603	2%-3% by weigh
4. Carbon Black Dispersion	ASTM D5596	Minimum 8 out of 10 different views in categories 1 or 2 and all 10 views in Categories 1,2 or 3
5. Tensile Properties	ASTM D638 Type IV (as modified by NSF 54-1993)	
Stress at break		>11N/mm ² (textured)
Elongation at break		>250% (textured)
6. Tear Resistance	ASTM D1004	>100N ⁽²⁾
7. Puncture Resistance	ASTM D4833	>200N
8. Environmental Stress Crack Resistance Notched Constant Load	ASTM D5397	>200 hrs
9. Oxidation Induction Time	ASTM D3895	>100 mins
10. Multiaxial elongation	GRI GM4	>100%
11. Melt Flow Index	ASTM D1238E	<1.1g/10 min

Table 3-1 Geomembrane Acceptance Criteria

(1) Equivalent BS EN, DIN or ISO Test Methods may also be acceptable, subject to CQA Project Managers Approval.

(2) Values Quoted are for 1.0mm thick sheet. Pro-rata for other thicknesses

3.2 Rolls – Manufacturers Quality Control Testing

3.2.1 The geomembrane shall be tested by the manufacturer for quality control prior to delivery. The Contractor shall supply the CQA Project manager with a Quality Control Certificate for each and every different master roll of LLDPE to be provided. This shall be signed as a minimum by the manufacturing production manager. The Quality Control Certificate shall include the roll and batch numbers, unique identification number, and all the following test data:

Parameter	Test Standard
Thickness	ASTM D5994 (textured) ASTM D5199 (smooth)
Density	ASTM D1505
Carbon Black Content	ASTM D1603
Carbon Black Dispersion	ASTM D5596
Tensile Properties Strength and elongation at yield and break	ASTM D638 Type IV As modified by NSF 54
Tear Resistance	ASTM D1004
Puncture Resistance	ASTM D4833

Table 3-2 Geomembrane Testing Standards (1)

3.2.2 Textured geomembrane shall meet the Specification shown in Table 3-1. In addition, Contractor shall provide a production quality control certificate for each resin production batch to demonstrate that the following also meet the requirements of Table 3-1:

Parameter	Test Standard
Multiaxial elongation	GRI GM4
Oxidation Induction Time	ASTM D3895
Environmental Stress Crack Resistance (NCLT)	ASTM D5397
Melt Flow Index	ASTM D1238E

Table 3-3 Geomembrane Testing Standards (2)

3.2.3 The geomembrane shall be continuously monitored during the manufacturing process for all the required criteria given in Table 3-1. Failure to comply or to submit adequate certification will result in rejection of material until such times as it is provided to the CQA Project Manager.

3.2.4 Certification shall be provided to the CQA Project manager within one week of delivery of materials to site and prior to any placement.

3.3 Delivery to site

3.3.1 Transportation of the geomembrane to site is the responsibility of the Contractor. The Contractor shall be liable for any damage to the materials incurred prior to and during transportation to the site. Delivery of the geomembrane is the responsibility of the Contractor. The Contractor shall ensure handling equipment is available on site to facilitate off-loading from transport. The Contractor is liable for any damage to the materials. Delivery of the geomembrane shall be at least one week prior to installation to allow sufficient time for conformance testing in accordance with the CQA Plan.

3.3.2 Upon delivery to the site the Contractor together with the CQA Site Engineer will conduct a surface observation of all rolls for defects and for damage. This examination will be

conducted without unrolling rolls unless the CQA Site Engineer deems that this is necessary. Delivery of the rolls shall be undertaken in sufficient time for conformance testing to be undertaken in advance of placement.

3.4 Site Conformance Testing

3.4.1 After roll inspection the Contractor upon direction from the CQA Site Engineer shall remove samples of the LLDPE for submittal to an approved laboratory for testing to ensure conformance with this Specification. The Contractor must supply details of his proposed laboratory to the CQA Project manager for approval, a minimum of 10 days prior to the delivery of the geomembrane to site. Samples shall be selected by the CQA Site Engineer at a frequency of one per 10,000m² of concurrent numbered rolls of geomembrane. The CQA Site Engineer may increase the frequency of sampling at his discretion. Unless specifically agreed with the CQA Project manager, there shall be an additional requirement of conformance testing on at least one sample per batch or production run of rolls and/or per individual group of consequentially numbered rolls. The samples shall be forwarded to an approved laboratory for conformance

- As a minimum, tests to determine the following characteristics will be undertaken
- density
- carbon black content and dispersion
- thickness
- tensile characteristics (break strength, elongation at break)
- puncture resistance
- tear resistance
- environmental stress crack resistance

3.4.2 The test procedures shall comply with the requirements of the Specification. Results shall be compared against the requirements given in Table 3-1 dependant on the surface nature of the material.

3.5 Procedure for Non-conforming Materials

3.5.1 Whenever a sample fails a laboratory conformance test:-

- i. The Contractor shall replace the roll of geomembrane that is in non-conformance with the Specification with a roll that meets the Specification.
- ii. The Contractor shall remove samples for testing for all the parameters listed above by the Laboratory from the closest numerical roll on both sides of the failed roll. The CQA Site Engineer shall determine where on the roll the samples are removed from. These two samples must both conform to Specification. If either of these samples fail, every roll of LLDPE on site and every roll delivered subsequently must be tested by the Laboratory for conformance to the Specification. This additional conformance testing will be at the expense of the Contractor.

3.6 Storage and Handling on site

3.6.1 Following delivery to site, handling, storage, movement and care of the geomembrane prior to and following installation at the site, is the sole responsibility of the Contractor who shall provide any storage facilities (e.g. containers, covers, etc.) he deems necessary. During storage, the geomembrane shall be protected from direct sunlight, excessive heat or cold, puncture, cutting, or other damaging or deleterious conditions. Adequate measures shall be taken by the Contractor to prevent the liner being stolen or damaged by vandalism, and damage from accidental plant/material movement. The Contractor shall be liable for any damage to the materials incurred prior to final acceptance of the lining system by the Employer.

- 3.6.2 The Employer shall make available to the Contractor a suitable level, obstruction free area to roll out and cut the geomembrane and an adequate area for any storage facilities, however the security of storage areas shall be the Contractor's responsibility.

3.7 Pre- Construction Meeting

- 3.7.1 Prior to the installation of any LLDPE the Contractor shall attend a Pre-Construction Meeting, to be held on Site. The meeting shall be attended by senior Contractor's staff, including the specialist geomembrane installer Site Agent and General Foreman. Also present will be representatives of the Earthwork Contractor, the CQA Project Manager and the Employer.
- 3.7.2 The purpose of the meeting is to familiarise all parties with the requirements for LLDPE installation, including construction quality assurance, responsibilities, and lines of communication. Specific requirements from this meeting are to:
- Review the responsibilities of each party
 - Review the project specifications
 - Establish lines of communication
 - Confirm methods for documentation and reporting
 - Review site safety plan
 - Review the CQA plan
 - Review the proposed panel layout drawing
 - Review working methods with respect to handling
 - Review installation methods
 - Review testing methods
- 3.7.3 Progress meetings will be held between the Employer, the CQA Project manager, and the Contractor at intervals determined by the CQA Project manager. The Contractor shall be represented at a senior level, including the specialist geomembrane installer Site Agent and General Foreman.

3.8 Anchorage System

- 3.8.1 The capping shall be anchored at the base below the perimeter bund as detailed on the drawings. Anchorage of the upper temporary end of the initial phase of capping shall be beneath the temporary cover soils as detailed on the drawings.

3.9 Placement

- 3.9.1 The first length of each LLDPE roll equal to the circumference of the roll shall be discarded, and not incorporated within the permanent Works.
- 3.9.2 The Contractor shall issue to the CQA Site Engineer for approval a Panel Layout Plan showing location and type of all field panels and seams. No installation is to be undertaken until the CQA Site Engineer has given approval in writing to the Contractor that the proposed panel layout submitted is satisfactory. All installation is to be in strict accordance with the Plan unless the CQA Site Engineer gives advance approval to any site modifications.
- 3.9.3 Field panels shall be installed at the location and positions generally in accordance with the panel layout drawing. Overlaps between field panels shall be a minimum of 500mm for unwelded seams, and 100mm for welded seams. Panels shall be placed one at a time and each panel shall be shingle lapped with upslope panels overlapping those immediately downslope from them. All seaming operations shall be undertaken immediately after panel placement in order to minimize the number of unseamed panels exposed to wind. All unseamed (lapped) panels shall be weighted immediately after their placement in order to minimise the risk of wind uplift and possible damage.
- 3.9.4 For lapped capping situations all joints running downslope, which are orientated parallel or subparallel to the line of maximum slope, shall be seam welded for their entire length in accordance with this Specification. The Contractor shall ensure that:

- Equipment used shall not damage the geomembrane by handling, trafficking, leakage of hydrocarbons, or other means.
- Personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in other activities, which could damage the LLDPE.
- The method used to unroll the panels shall not cause scratches or crimps in the geomembrane and shall not damage the supporting soil.
- The prepared surface underlying the geomembrane shall not deteriorate after acceptance, and shall remain acceptable up to the time of geomembrane placement.
- The method used to place the panels shall minimize wrinkles (especially differential wrinkles between adjacent panels).
- Adequate temporary loading and/or anchoring (e.g. sand bags, tyres), not likely to damage the geomembrane, shall be placed to prevent uplift by wind
- No vehicular traffic shall travel on the geomembrane

3.9.5 The Contractor shall mark each Field panel with a unique identification code consistent with the Layout plan. This identification code shall be pre-agreed upon by the CQA Site Engineer and Contractor. The identification code shall be related, through a table or chart, to the original batch and the constituent rolls.

3.10 Expansion/Contraction and Damage

3.10.1 The Contractor will be responsible for calculation of the required amount of material that must be installed, making allowances for, inter alia, expansion and contraction of the LLDPE anticipated during the diurnal temperature range, plus material heating due to direct sunlight, to ensure that for a lapped cap application that the minimum 500mm overlap is maintained, and for welded seams that undue stresses are not developed once restoration is complete.

3.10.2 The Contractor shall make due allowance in the installation for expansion and contraction of panels to avoid the creation of folds or excessive wrinkles.

3.10.3 Any field panel or portion thereof which becomes damaged (torn, twisted, or crimped) including damage by wind or by vandalism shall be replaced or repaired. Any folds or wrinkles that develop immediately prior to soil placement shall be cut out and repaired in accordance with this specification. The geomembrane must not be allowed to over fold at any time. The CQA Site Engineer shall decide which panels must be replaced and which may be repaired. Damaged panels or portions of damaged panels which have been rejected shall be removed from the work area. Any repairs or additional works to facilitate repairs shall be undertaken at the Contractor's own expense of cost and time.

3.10.4 The uphill temporary edge of the permanent LDPE capping works of this phase shall be protected and demarked on site by a drainage stone as detailed on drawings which will enable the temporary edge to be relocated to extend to capping in the future.

3.11 Thickness Checks

3.11.1 The Contractor shall also, as part of his Quality Assurance scheme, check the material thickness at regular intervals both across the width and along the length (at the CQA Site Engineers discretion) of the roll.

3.11.2 This may be accomplished by the use of a suitable micrometer which shall also be made available to the CQA Site Engineer in the execution of his CQA activities. Should significant variations in the material thickness be noted, this may have an adverse effect on the quality of welding seams. The criteria for acceptance should be:

- No single thickness shall exceed the stated tolerance.

- The average of the measurements across a given roll width or length shall be greater than the specified thickness.

3.12 Seaming

General

- 3.12.1 Welded field seams are required to all overlaps which are orientated parallel or subparallel to the line of maximum slope in lapped capping situations and for all seams in fully welded applications. In corners and odd-shaped geometric locations, the number of field seams shall be minimized. No horizontal seam shall be less than 1.5m from the toe of the slope or the crest of an adjacent slope, except where approved by the CQA Site Engineer. No seams shall be located in areas of potential stress concentrations.
- 3.12.2 All panels to be weld seamed shall have a finished overlap of 100mm minimum i.e. seams shall be at least this distance from the edge of the panel. Failure to maintain this minimum overlap may be cause for rejection of the weld seam.
- 3.12.3 The procedure for temporarily bonding adjacent panels together shall be approved in writing by the CQA Site Engineer prior to the commencement of installation. Solvents, adhesives, hot air apparatus etc. shall not damage the geomembrane. In particular, nozzle temperature of hot air apparatus shall not be excessive.
- 3.12.4 The general seaming procedure to be used by the Contractor shall conform to the methods detailed in the EPA Technical Guidance Document No. EPA/530/SW-91/051 titled "Inspection Techniques for the Fabrication of Field Seams" published in 1991.
The following precautions shall be observed during all seaming operations:
- i. For fusion welding, a moveable protective layer of plastic may be placed directly below each overlap of geomembrane to prevent any moisture build-up between the sheets.
 - ii. Seaming shall extend to the top edge of the anchor trench.
 - iii. If required, a firm substrate shall be temporarily provided by using a flat board, a metal platen, or similar hard surface directly under the seam overlap to achieve proper support.
 - iv. If seaming operations are carried out at night, adequate illumination shall be provided.
 - v. Fishmouths or wrinkles at the seam shall be eliminated by pulling the geomembrane. Any remaining wrinkles/fishmouths shall be cut along their ridge in order to achieve a flat overlap. The cut fishmouths/wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch extending a minimum of 150mm beyond the cut in all directions.

Equipment and Personnel

- 3.12.5 Approved processes for field seaming are extrusion welding and double fusion welding. Any alternative processes proposed by the Contractor shall be reviewed by the CQA Project Manager. Only apparatus which have been specifically approved by make and model by the CQA Project manager shall be used.
- 3.12.6 The CQA Project manager shall review the list of proposed welding personnel and their experience records and welding certification, and verify that they have adequate training and experience of welding LLDPE seams using the type of equipment to be used in the project. The Contractor shall demonstrate that all staff to be utilised for welding hold a current certificate of competence as issued by the Geosynthetic Institute GSI, SWIP – PW-6 96, and shall supply copies of such certification to the CQA Project manager. At least the supervisor and Lead technician shall be accredited to Level 1 of GA/TWI/CSWIP welding standard. All additional welding personnel shall be accredited to Level 2 of BGA/TWI/CSWIP welding

standard. Additional crew members who may not be accredited as above and who carry out duties other than welding related work may also be on site. A limit of one trainee technician per crew is allowed, to be supervised directly by a supervisor or lead technician to Level 1.

Extrusion Welding

- 3.12.7 The Contractor shall ensure that extrusion welding apparatus are equipped with instrumentation indicating the temperature in the apparatus and at the nozzle. The Contractor shall also certify in writing that the extrudate is comprised of resins compatible with those utilised in the manufacture of the geomembrane sheet.
- 3.12.8 Equipment used for seaming shall not damage the geomembrane, which shall be especially protected from damage in heavily trafficked areas.
- 3.12.9 Extrusion welding apparatus shall be equipped with instrumentation indicating the temperature in the apparatus and at the nozzle. The extruder shall be purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel. Whenever the extruder is stopped, the barrel shall be purged of all heat-degraded extrudate. A smooth insulation plate or fabric shall be placed beneath the hot welding apparatus after usage.
- 3.12.10 The electric generator shall be placed outside the area to be lined. It shall be operated in accordance with the Health and Safety Executive guidelines for such equipment on site.

Fusion Welding

- 3.12.11 The Contractor shall ensure that fusion welding apparatus are equipped with instrumentation indicating the temperature in the apparatus and speed of operation.
- 3.12.12 Fusion-welding apparatus must be automated and vehicular-mounted and shall produce double welds. It shall be equipped with instrumentation indicating temperatures and pressures. It shall not damage the geomembrane, which shall be protected from damage in heavily trafficked areas. A smooth insulating plate or fabric shall be placed beneath the hot apparatus after usage.
- 3.12.13 For cross seams the edge of the cross seams shall be abraded to a smooth incline (top and bottom) prior to welding.
- 3.12.14 The electric generator shall be placed on a smooth base such that no damage occurs to the geomembrane. A grounding rod shall be utilised, if this is required by Statutory Legislation (e.g. Mines and Quarries) or manufacturers recommendations. The generator will be in accordance with Health and Safety Executive guidelines for such equipment on site.

Preparation

- 3.12.15 The seam area shall be clean and free of all moisture, dust, dirt, debris, and foreign material of any kind, immediately prior to seaming. If seam overlap grinding is required, the process shall be completed within one hour of the seaming operation and in a way that does not damage the geomembrane. Seams shall be aligned to minimise the number of wrinkles and "fishmouths". Where fishmouths occur, the material shall be cut, overlapped, and an overlapping extrusion weld shall be applied, followed by a patch if required by the CQA Site Engineer.

Trial Seams

- 3.12.16 Trial seams to verify that seaming conditions are adequate, shall be made on fragment pieces of geomembrane of the same type, thickness and general condition as that to be used in the installation. Such trial seams shall be made at the beginning of each seaming period, and at least once each five hours for each seaming apparatus used, and also if the welding apparatus is turned off for any reason. Each field operator and every welding plant shall make at least one trial seam for each welding period. Trial seams shall be made under the same conditions as actual seams and will be performed with the geomembrane in contact with the same subgrade type that the actual welding of the seam overlays. The trial seam sample shall

be at least 1.5m long by 0.3 m wide after seaming with the seam centred lengthwise. Seam overlap shall be to Specification.

- 3.12.17 The Contractor shall cut five specimens, each 25mm wide, and a minimum of 150mm apart, from the trial seam sample. All specimens will be tested in peel using a field mechanical tensiometer. The use of hand held 'mole grips' is not permitted. Samples shall be shown to demonstrate a film tear bond (FTB) mode of failure.
- 3.12.18 If any specimen fails, the entire operation shall be repeated. If any of the additional specimens fail, the seaming apparatus and welder shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.
- 3.12.19 No geomembrane seaming shall take place until each seaming apparatus and welder meets these requirements.

Weather

- 3.12.20 No seaming of the geomembrane shall be undertaken at ambient temperatures below 5°C or above 35°C, measured approximately 50mm above the geomembrane surface. In all cases, the geomembrane shall be completely dry prior to seaming, and protected from wind damage at all times.
- 3.12.21 If the Contractor wishes to seam at ambient temperatures below 5°C or above 35°C, he shall demonstrate that the seam is equivalent to those produced under normally approved conditions, and that the overall quality of the geomembrane is not adversely affected. The demonstration shall be undertaken prior to any seaming work and the method shall include trial seaming under the conditions proposed by the Contractor, followed by field non-destructive and destructive testing of the seam, and laboratory analysis of the seam and adjacent LLDPE material to verify no adverse affects. If the demonstration proves successful, the CQA Site Engineer will give approval in writing. In addition, an addendum to the Contract between the Employer and the Contractor will be prepared specifically stating that the seaming procedure does not cause any physical or chemical modification to the geomembrane that will generate short or long-term damage. Allowance must be made for expansion and contraction.

3.13 Non-Destructive Testing

- 3.13.1 The purpose of non-destructive tests is to check seam continuity. The Contractor shall non-destructively test all field seams over their entire length using a vacuum test, ultrasonic test or air pressure test (for double fusion seams). Spark testing shall NOT be used. The CQA Project Manager shall approve in advance which type of testing is to be undertaken on each seam, and shall witness the testing of each seam. Testing shall be carried out as seaming progresses, not at the completion of all field seaming. It shall not be done before sunrise or after sunset.
- 3.13.2 All sections of seam which fail the non-destructive test shall be repaired in accordance with this Specification. The CQA Site Engineer shall witness such repairs and their re-testing.

Vacuum Test

- 3.13.3 The CQA Site Engineer shall inspect the equipment prior to the commencement of testing and ensure that it is in compliance with the Specification.

The equipment shall comprise:

- A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.
- A steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections.

- A rubber pressure/vacuum hose with fittings and connections.
- A bucket and applicator.
- A soapy solution.

The testing procedure will be:

- i. In the case of a fusion weld, the flap must be removed with an approved cutter to expose the seam for testing.
- ii. Energize the vacuum pump and reduce the tank pressure to 34 kPa gauge (minimum).
- iii. Wet a strip of seam which is 150 mm larger in area than the vacuum box with the soapy solution.
- iv. Place the box over the wetted area.
- v. Close the bleed valve and open the vacuum valve.
- vi. Ensure that a leak tight seal is created.
- vii. For a period of not less than 15 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.
- viii. If no bubble appears after 15 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 75mm overlap, and repeat the process.
- ix. All areas where soap bubbles appear shall be marked with an approved marker that will not damage the geomembrane and repaired in accordance with the Specification.

Ultrasonic Test

3.13.4 The CQA Site Engineer shall inspect the equipment prior to the commencement of testing and ensure that it is in compliance with the Specification.

The equipment shall comprise:

- A frequency generator capable of producing frequencies in the range 5 to 15MHz.
- A transmitter/receiver head equal to the width of the seam, and capable of being moved at a rate of 1.5 to 2.1 metres per minute along the seam being tested. The transducer head shall be designed to give continuous surface to surface thickness measurements once calibrated, and shall be provided with a continuous contact medium (such as water) at the interface between the test head and the membrane.
- A monitor for viewing the ultrasonic signal and capable of triggering an audible alarm when a discontinuity is detected.

The test procedure will be:

- i. prior to use the equipment shall be calibrated to the appropriate material thickness.
- ii. the water source shall be activated, and it shall be verified that water is flowing freely from the probe.
- iii. the audio signal shall be activated and proper operation verified by lifting the probe off the geomembrane.
- iv. the probe shall be placed directly on the extrusion weld and slowly moved along the seam while viewing the monitoring scheme.
- v. any fault detected by audio or visual signal shall be marked and repaired in accordance with the Specification.

Air Pressure Test (Double Fusion Seam)

- 3.13.5 The CQA Site Engineer shall inspect the equipment prior to the commencement of testing and ensure that it is in compliance with the Specification.
- 3.13.6 The following procedures are applicable to those processes which produce a double seam with an enclosed space.

The equipment shall comprise:

- An air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining a pressure between 150 to 175 kPa and mounted on a cushion to protect the geomembrane.
- A rubber hose with fittings and connections.
- A sharp hollow needle, or other approved pressure feed device.

The testing procedure will be:

- i. Seal both ends of the seam to be tested.
- ii. Insert needle or other approved pressure feed device into the tunnel created by the fusion weld.
- iii. Insert a protective cushion between the air pump and the geomembrane.
- iv. Energize the air pump to a pressure between 150 to 175 kPa, close valve, and sustain pressure for not less than 5 minutes.
- v. If loss of pressure exceeds 15 kPa or does not stabilize, locate faulty area and repair in accordance with the specification.
- vi. To verify that there is airflow through the entire tunnel, remove the seal at the end of the tunnel away from the air source and listen for escaping air. If it is found that the channel is blocked, the entire seam must be non-destructively tested by vacuum testing in accordance with the specification.
- vii. Remove needle or other approved pressure feed device and seal repair in accordance with the specification.

3.14 Destructive testing

Qualitative Destructive Testing

- 3.14.1 The Contractor shall cut out a 25mm wide field tab from the seam sample strip from the beginning and end of each completed field seam and shall subject it to qualitative destructive testing in peel and shear modes using a mechanical field tensiometer. Specimen locations and subsequent repairs shall be carefully labelled and fully documented by the CQA Site Engineer.
- 3.14.2 The seam will be deemed to have passed qualitative destructive testing if the failure occurs solely in the parent material and does not enter the seam. If a field tab fails qualitative destructive testing, the Contractor shall either:
- i. reconstruct the seam between two tabs shown to have passed qualitative destructive testing; or
 - ii. cut out further test specimens at a distance of 3m each side of the failed tab and subject these to qualitative destructive testing. If these tabs pass qualitative destructive testing, the contractor shall cut a laboratory sample from the passed area and reconstruct the seam between the passed locations in accordance with this

specification. If either sample fails, the contractor shall cut and test further field tabs until he identifies an area bounded by two passed locations. The contractor shall then reconstruct the failed seam in accordance with this specification.

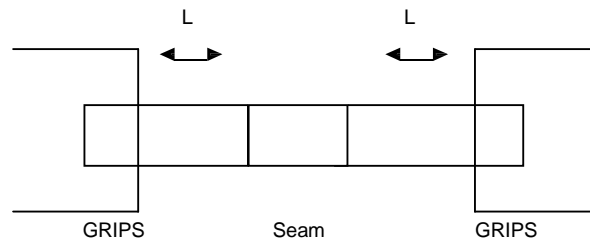
3.14.3 The CQA Engineer reserves the right to request the cutting and destructive testing of further field tabs in accordance with the specification at any location along the length of the seam.

Test	Method*	Requirements @ 1mm thickness
Fusion Seams⁽¹⁾	ASTM D6392-08	
Shear strength ⁽²⁾ , N/25mm		263
Shear elongation ⁽³⁾ , %		50
Peel Strength ⁽²⁾ , N/25mm		219
Peel Separation, %		25
Extrusion Seams	ASTM D6392-08	
Shear strength ⁽²⁾ , N/25mm		263
Shear elongation ⁽³⁾ , %		50
Peel Strength ⁽²⁾ , N/25mm		190
Peel Separation, %		25

Table 3-4 Field Seam – Destructive test criteria for Seam strength and related properties for Thermally Bonded Smooth and Textured Linear Low Density Polyethylene (LLDPE) Geomembranes (S.I. Units).

Notes:

1. Also for hot air and ultrasonic seaming methods
2. Values listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values
3. Elongation measurements should be omitted for field testing



Quantitative Destructive Testing

3.14.4 Destructive seam tests shall be performed on samples collected from locations selected by the CQA Site Engineer, who will witness the removal of the samples and the subsequent repair and non-destructive testing of repair seams. The purpose of these tests is to evaluate seam strength and integrity.

3.15 Location and Frequency

3.15.1 The CQA Site Engineer will select where seam shall be collected at a minimum average frequency of one test per day or per 200m of seam length, whichever is the greater. Test locations shall be determined during seaming, and may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming. The Contractor shall not be informed in advance of the locations where the seam samples will be taken. The CQA Site Engineer reserves the right to increase the frequency in accordance with actual performance results of samples taken.

3.16 Sampling Procedures

3.16.1 Samples shall be cut from the geomembrane by the Contractor and witnessed by the CQA Site Engineer. Each sample shall be numbered and the sample number and location identified on the panel layout drawing. The CQA Site Engineer shall ensure that all holes in the

geomembrane resulting from the destructive seam sampling are repaired in accordance with the repair procedures described in the Specification.

3.16.2 The samples shall be at least 0.3m wide by 1.15m long with the seam centred lengthwise. One 25mm wide strip shall be cut from each end of the sample and these shall be tested in the field as specified below. The remaining sample shall be cut into three equal parts and distributed as follows:

- One portion, measuring 300 mm x 300 mm, to the Contractor for laboratory testing.
- One portion, measuring 300 mm x 450 mm, to the CQA Site Engineer for his own laboratory testing, or archive storage as determined by the CQA Project manager.
- One portion, measuring 300 mm x 300 mm, to the Employer for archive storage.

3.17 Testing

Field

3.17.1 The two 25 mm wide strips shall be tested in the field by tensiometer by the Contractor for peel, and shall not fail in the seam.

3.17.2 The CQA Site Engineer will witness all field tests and mark all samples and portions with their number, and will also log the date, time, ambient temperature, number of welding unit, name of technician, welding apparatus temperatures and speeds, pass and fail descriptions.

Laboratory

3.17.3 The CQA Site Engineer shall be responsible for approving the selected Testing Laboratory to be utilised for the testing of the destructive tests.

3.17.4 Laboratory Testing shall include “Seam Strength” (ASTM D4437 as modified in NSF Appendix A and with no requirement for sample conditioning time) and “Peel Adhesion” (ASTM D 638 with 25mm wide strip, testing at 50mm per minute). At least 5 specimens shall be tested for each test method. Specimens shall be selected alternately by test from the samples (i.e. peel, shear, peel, shear...). At least 4 out of 5 specimens shall meet the minimum acceptable values, indicated in the Specification. The Laboratory’s test results shall be available to the CQA Project Manager within two working days of the date of sampling who will review laboratory tests results as soon as they become available, documenting all results so that cross-referencing to location, date, time, welder etc is readily understood.

3.18 Procedures in the Event of Test Failure

3.18.1 Should any sample fail a destructive test, irrespective of whether it is conducted by the Contractor’s laboratory, or by field tensiometer, then the CQA Project manager will discuss the matter with the Contractor. The Contractor shall have two options:

- i. The Contractor may repair the seam between any two passed destructive test locations; or
- ii. The Contractor may trace the welding path to an intermediate location, 3m minimum from the location of the failed test (in each direction) and take a sample for an additional destructive field test at each location. If these additional samples pass the tests, then full laboratory samples shall be taken. If these laboratory samples pass the tests, then the seam shall be repaired between these locations by capping. If either sample fails, then the process shall be repeated to establish the zone in which

the seam should be repaired. All acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken.

- 3.18.2 Whenever a sample fails, additional testing may be required for seams that were formed by the same welder and/or seaming apparatus or seamed during the same time shift.
- 3.18.3 If a fusion type seam fails destructive testing and the Contractor chooses to cap the seam, the only acceptable capping method is described in below. Applying topping is NOT an approved method of capping.

3.19 Defects and Repairs

- 3.19.1 All areas of the geomembrane will be examined for defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be swept or washed by the Contractor if required by the CQA Site Engineer. This examination of the geomembrane shall precede any seaming of that section.
- 3.19.2 Each suspect location may be non-destructively tested by the Contractor using the methods described above. Each location which fails non-destructive testing shall be marked by the CQA Site Engineer and repaired by the Contractor. Work shall not proceed with any materials which will cover repairs until non-destructive or destructive test results with passing values are available.
- 3.19.3 Any seam failing a destructive or non-destructive test shall be repaired by the Contractor. Repair procedures shall be agreed upon between the CQA Site Engineer and the Contractor. The procedures available include:
- patching, used to repair large holes, tears, undispersed raw materials, short lengths of failed seams and contamination by foreign matter,
 - grinding and reseaming, used to repair small sections of extruded seams;
 - spot seaming, used to repair small tears, pinholes, or other minor, localized flaws;
 - capping, used to repair large lengths of failed seams;

In addition, the following provisions shall be satisfied:

- i. Surfaces of the geomembrane which are to be repaired shall be abraded no more than one hour prior to the repair.
- ii. All surfaces must be clean and dry at the time of repair.
- iii. All seaming equipment used in repairing procedures must be approved. The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the CQA Site Engineer.
- iv. Patches or caps shall extend at least 150mm beyond the edge of the defect.
- v. 'Topping' of failed fusion welds with an extrusion weld is NOT permitted. Failed extrusion welds must be capped or cut out and the sheet repositioned.
- vi. The geomembrane below large caps should be appropriately cut to avoid water or gas collection between the two sheets.
- vii. Where any water is found to have collected beneath the sealed geomembrane, the Contractor shall cut out and roll back the geomembrane, remove the water and repair the clay beneath to the satisfaction of the CQA Site Engineer before re-sealing the geomembrane.
- viii. The CQA Site Engineer shall witness every repair and its subsequent testing.

- 3.19.4 Each repair shall be logged by the CQA Site Engineer. Each repair shall be non-destructively tested using the methods described above as appropriate. Large caps may be of sufficient extent to require destructive test sampling, at the discretion of the CQA Site Engineer.
- 3.19.5 When seaming of the geomembrane is completed (or when seaming of a large area is completed) and prior to placing overlying materials, the CQA Site Engineer shall identify all excessive geomembrane wrinkles. The Contractor shall cut and re-seam all wrinkles.
- 3.19.6 All these seams will be tested All areas of the geomembrane will be examined by the CQA Site Engineer for defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of examination. The LLDPE surface shall be swept or washed by the Contractor if required by the CQA Site Engineer. This examination of the LLDPE shall precede any seaming of that section.
- 3.19.7 Each suspect location may be non-destructively tested by the Contractor using the methods described above as appropriate. Each location, which fails non-destructive testing, shall be marked by the CQA Site Engineer and repaired by the Contractor. Work shall not proceed with any materials that will cover repairs until non-destructive or destructive test results with passing values are available.
- 3.19.8 The CQA Site Engineer shall witness every repair and its subsequent testing. The CQA Site Engineer shall log each repair. Each repair shall be non-destructively tested using the methods described above as appropriate.

3.20 Temporary Liner Surcharge

- 3.20.1 The Contractor shall be responsible for the LLDPE liner at all times during the contract. He shall take whatever measures are required to ensure stability of the geomembrane and to protect it from damage from whatever cause. These measures will include temporary surcharge (e.g. filled sandbags) to prevent slippage of the liner or lifting due to wind. Any consequences arising from the contractor's failure to properly secure the liner material during the contract shall be repaired at the Contractor's expense.

3.21 Geomembrane Acceptance

- 3.21.1 The Contractor shall retain all ownership and responsibility for the geomembrane until the Employer accepts the installation. Acceptance shall take place in accordance with the Conditions of Contract, which allow for "practical completion" of parts of the Works. The Contractor shall cease to be responsible for the part of the Works immediately after issue of a Certificate of Completion for that part of the Works. No part of the Works will be accepted until verification of the adequacy of all field seams and repairs, (including associated testing) and all documentation has been received.
- 3.21.2 The Contractor will need to place protective materials over the Geomembrane before the Employer can accept the installation. The CQA Site Engineer will allow the covering of the geomembrane in an area only after all of the following for the relevant area have been satisfied:
- All documentation requested in the Specification has been received from the Contractor and is approved by the CQA Site Engineer.
 - All anchor trenches have been backfilled and compacted in accordance with the Specification.
 - Connections to all appurtenances have been completed to specification and to the CQA Site Engineer satisfaction.
 - All construction debris has been removed from the geomembrane, which has been swept clean to the satisfaction of the CQA Site Engineer.

4 Geocomposite Drainage Material

4.1 Acceptance of Geocomposite Drainage Material Prior to Placement

- 4.1.1 The geocomposite drainage layer shall consist of a cusped HDPE (high density polyethylene) sheet bonded on both sides to a geotextile filter fabric. The other side that is against the geomembrane shall be flat and impermeable. Drainage layer shall be permeable on one side only. Drainage cores permeable on both sides shall not be permitted. The geocomposite drain shall possess the properties as listed in Table 8-1.

Properties	Test Method	Required Value
In plain water flow (long & cross direction @ H.G 1.0 and 100kPa with soft foam platens to simulate soil action)	BSEN ISO 12958	0.75 l/m/s
Thickness at 2kPa	BSEN 964-1	5.4mm
Static puncture resistance CBR	BSEN ISO 12236	3,300N
Min roll width		4.4m

Table 4-1 Required Properties of Geocomposite Drainage Materials

- 4.1.2 The contractor shall provide the CQA Site Engineer all the manufactures test certificates guaranteeing the geocomposite delivered to site meets the criteria set out in Table 8-1.

4.2 Delivery of Geocomposite Drainage Material

- 4.2.1 All geocomposite drainage materials shall be approved in writing by the CQA Site Engineer and sources of supply shall not be changed without his approval. The manufacturer or supplier of each geocomposite drainage material shall provide the following information for each separate consignment of each material delivered to the site:

- a) Product name and grade/number.
- b) Name and address or producer/supplier.
- c) Batch or code number.
- d) Manufacturing characteristics and constituents including
 - Composition and type of constituent filaments, fibres, threads, films, tapes etc and any additives used in the manufacturing process.
 - Method of manufacture.
- e) Consignment number and delivery date.

- 4.2.2 Each consignment shall be numbered and the delivery date recorded. A consignment is considered to be the number of rolls or packages delivered at one time. Testing of the geocomposite drainage material is not required.

4.3 Geocomposite Drainage Material Layout

- 4.3.1 The CQA Engineer will examine drawings submitted by the Contractor which show details of:

- a) The location and orientation of each roll or sheet.
- b) The location of all connections joints and overlaps appropriate to manufacturer's requirements.

- 4.3.2 The layout of individual rolls or sheets shall be such that the number of joints and overlaps is minimised as far as practicable.

4.4 Geocomposite Drainage Material Storage

- 4.4.1 The geocomposite material must be stored in a “dry store” to protect the material from the elements. No geocomposite drainage material shall be exposed to daylight (or any other source or ultra-violet radiation) for a period in excess of 8 hours, unless the manufacturer gives approval.

4.5 Geocomposite Drainage Material Handling

- 4.5.1 Care shall be taken to avoid damaging the geocomposite drainage material on removal of any wrappings and during the installation process or at any other time when the contractor is responsible for the works. Any resulting damage, or any geocomposite drainage material exposed to daylight for longer than the specified period, shall be inspected by the engineer and the condition noted. Damaged lengths of geocomposite drainage material shall be replaced with new material unless the CQA Site Engineer authorises repair by an approved method.

4.6 Placement

- 4.6.1 Adjacent sheets shall be fixed with the core butt joined. The geotextile flap on the edge of the drainage sheet shall be extended across the joint shiplap style. All fixing and cutting details shall be in accordance with the manufacturer’s instructions. Backfill material shall not contain sharp objects or stone bigger than 150 mm diameter. Normal compaction can be used adjacent to the drainage sheet. On horizontal surfaces the backfill shall be placed on an advancing face, the machines working on top of previously placed backfill. Mechanical plant should not operate directly on the drainage sheet; unless protected by 200 mm of backfill material.
- 4.6.2 The CQA Site Engineer will keep daily records of the progress or formation preparation, geocomposite drainage material installation and coverage. The daily record shall include the under-noted details.
- a) Date.
 - b) Area and location of formation preparation completed.
 - c) Area and location of geocomposite drain installation.
 - d) Area and location of geocomposite drain covered by fill.
 - e) Consignment reference of each roll or sheet.
 - f) Levels and positions of installed geocomposite drain.
 - g) Details and locations of any damage to the geocomposite drain.
 - h) Details and locations of any repairs.
 - i) Any variations from the Method Statement or working drawings.
- 4.6.3 Overlying materials should be placed carefully so as to prevent damage or creasing of the material. Fill should be gently placed from a low level. Dumping fill material from a loader bucket positioned at height is unacceptable.
- 4.6.4 A maximum allowable ground pressure of 30Kpa will determine the suitability of construction plant used to spread materials over the geocomposite drain and any construction plant.

5 Documentation

5.1 General

- 5.1.1 The CQA Project Manager will document that all quality assurance requirements have been properly addressed and satisfied.

5.1.2 The CQA Project Manager is to obtain the following documents from the contractors at various times prior to and throughout the course of the works.

Clay works:

- i. Copies of laboratory test results of source clay; (electronic copies preferred)
- ii. Working method statement for clay placement
- iii. Working method statement for clay protection
- iv. Specification for all clay compaction plant used during the works
- v. Copies of laboratory test results of clay (electronic copies preferred)
- vi. Survey drawings of pre and post construction placement to prove material thicknesses

LLDPE works:

- i. Production Plant and Raw Materials Quality Control details
- ii. Roll Quality Control Certificates
- iii. Storage Facility Requirements
- iv. Installation Panel Layout Drawing
- v. Temporary bonding and anchorage details
- vi. Installation equipment and Personnel details

5.1.3 The CQA Project Manager shall

- i. Acknowledge receipt of contractors documents in writing
- ii. Review the documentation and then, in writing, either acknowledge that the documentation is acceptable, or provide a listing of adjustments or additional documentation to be provided.

5.1.4 Upon receipt of these adjustments/additional documentation from the Contractor the CQA Project Manager will again undertake the above procedures.

5.1.5 Should the CQA Project Manager not receive information, or the information is unsatisfactory or not in compliance with the Specification then the CQA Project Manager at his discretion may reject any materials supplied or installed, and the Works shall not be allowed to proceed until receipt of satisfactory information.

5.1.6 The CQA Site Engineer will maintain at the site pertinent documents, such as:

- i. A complete set of plans and specifications
- ii. CQA plan
- iii. Checklists and progress charts
- iv. Test procedures/results
- v. Daily logs, diary and weather records
- vi. Record of site visitors
- vii. Acknowledgements of Contractor Submissions.

5.2 Daily Records from Contractor

- 5.2.1 The CQA Site Engineer shall obtain daily from the Contractor Reports/Records summarising the Contractors activities to include:
- i. Nature and type of work carried out
 - ii. Progress
 - iii. Daily number of lorry movements and loads of clay imported to site
 - iv. Number of loads rejected with reasons
 - v. The amount and locations of LLDPE
 - vi. The length and location of placed seams completed and the operator and equipment used
 - vii. Change of layout drawings (if applicable)
 - viii. Location and results of repairs
 - ix. Location of destructive test samples
 - x. Destructive test results
 - xi. Problems encountered
 - xii. Pumping/drainage details
 - xiii. List of plant used
 - xiv. List of personnel.

5.3 Daily CQA Records

- 5.3.1 In addition the CQA Site Engineer shall maintain field notes, minutes and memorandums of all meetings/discussions with the Employer/Contractor/Engineer or any other person in a logical and systematic manner. The CQA Site Engineer shall maintain a Daily Diary that contains:
- i. Prevailing weather conditions; i.e. temperature wind speed and direction and precipitation records
 - ii. Contractors site labour and plant
 - iii. Field notes
 - iv. Progress and work undertaken (cross referenced to Site Layout Plan)
 - v. Minutes of all meetings/discussions with the Employer/Contractor/Regulatory Authorities
 - vi. Construction problems and solutions with corrective actions taken
 - vii. Maintain a Photographic Record
 - viii. Record of site visitors.
- 5.3.2 All of the above may be utilised and included within the final CQA Report.

5.4 Observation Logs and Testing Data Sheets

- 5.4.1 Testing data sheets maintained by the CQA Site Engineer will contain, as a minimum, the following information:
- i. An identifying sheet number and test referencing scheme for cross referencing and document control

- ii. Date, project name, location, and other identification
- iii. Summary weather conditions
- iv. Descriptions and locations of ongoing construction, referenced to diary notes
- v. Equipment and personnel, including subcontractors
- vi. A summary of test results
- vii. Decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality
- viii. A site plan showing proposed work areas and test locations; referenced to diary notes
- ix. Signature of the CQA personnel.

5.4.2 In addition to the above data, stock control of the deliveries of LLDPE shall include the following CQA check list:

Delivery

Delivery Date/Time
Condition on Lorry
Height Stacked
Comments on Delivery

Unloading

Off-load Date/Time
Equipment Used
Correct Code Bar Usage
Off-loading Comments

Inspection (Undertaken to check that items described

On the delivery note are the same as those delivered)

Date/Time
Product Name/Type
Manufacturer
Batch Code No.
Consignment No.
Date of Manufacture
Serial No.
Assessment of Packaging
Damage to Roll
Description of Damage
Comments Action

Storage

Level Storage
Storage Height
Stability
Base of Stack Off Ground
Store Covering
Comments Action

Identification (Entry of data into database once identification has been confirmed)

Manufacturer
Product
Date of Manufacture
Batch No.

Serial No.
Consignment No

Extraction

Extraction Date/Time of Extraction
Serial No. of Roll

Transit

Plant used to Move Materials
Core Bar Used Correctly
Damage Inspection
Comments of Transit

Temporary Store

Date/Time Temporary Store
Ground Condition
Stack Height
Level Storage
Stability
Covering
Comments on Temporary Store

5.4.3 All of the above may be utilised and included within the final CQA Report.

5.5 Weekly CQA Report

5.5.1 A summary weekly report will be prepared by the CQA Site Engineer to include the following information:

- i. Date, project name, location, and other identification
- ii. Summary of weather conditions
- iii. Summary of construction progress, referenced to diary notes
- iv. Summary of equipment and personnel in each working area
- v. Summary of sampling, referenced to diary notes
- vi. A summary of test results received
- vii. A record of site visitors
- viii. Problems encountered and remedial actions taken
- ix. A site plan showing work areas summary progress and test locations; referenced to diary notes

5.5.2 Weekly reports may be utilised and included within the final CQA Report.

5.6 Revision/Amendments to specification

5.6.1 The Employer and the CQA Project Manager will be made aware of any significant recurring non-conformance with Specifications. The CQA Project Manager will determine the cause of the non-conformance and may recommend appropriate changes in procedures or specifications. These changes will be submitted to the Employer for approval. The changes will also be submitted to the Environment Agency where appropriate. When this type of evaluation is made, any alterations will be documented and will form an addendum to the Specification.

5.7 Photographs

5.7.1 Photographs will serve as a record of work progress, problems, and mitigation activities.

The basic files will be saved as JPEGs in a referenced chronological order on a site computer. The files will also be backed up onto CD. Selected prints may form part of the CQA Report.

5.8 As Constructed Drawings

- 5.8.1 The CQA Project Manager shall check and approve "As Constructed Drawings" which will indicate the actual construction details installed.
- 5.8.2 As Constructed Drawings shall be to scale, and shall include:
- i. Pre construction levels of surface on a grid basis
 - ii. Completion levels of clay and capping
 - iii. All sample test locations with unique reference numbers
 - iv. Cross-referencing system to any relevant photographs and construction problems.
- 5.8.3 The As Constructed Drawings approved by the CQA Project Manager will form part of the CQA Report.

5.9 Construction Quality Certificates

- 5.9.1 The CQA Project Manager shall issue Construction Quality Certificates on completion of the works or parts thereof to the Contractor and the Employer.
- 5.9.2 The CQA Project Manager shall not issue any Completion Certificates until all records and documentation have been received from the Contractor, that all laboratory test results are satisfactory, that all liner installation and protection works have been satisfactorily completed and the as constructed drawings have been checked.

5.10 Completion Report

- 5.10.1 At the completion of the Project the CQA Project Manager will provide to the Employer and Environment Agency a signed "Report on the Construction Quality Assurance Monitoring for the Clay Liner" (abbreviated as "CQA Report") which will describe the works undertaken in compliance with the plans and specification, physical sampling and testing, and any other observations the CQA Project Manager regards as pertinent. As a minimum it shall include:
- i. Project description
 - ii. Contractors submissions
 - iii. Summary weather records
 - iv. Daily logs
 - v. Sample records/results
 - vi. Photographic records
 - vii. As constructed drawings
 - viii. Completion certificates.

Figures