There are a number of polymeric geomembranes commercially available, the most common types used for capping are:

- high density polyethylene (HDPE);
- Linear Low Density Polyethylene (LLDPE);
- polpropylene (PP).

***Low Permeability Mineral Layer**: A mineral layer which reduces the generation of leachate by minimising the infiltration of water.

If a mineral layer is being used as part of the capping system to minimise the production of leachate and to impede the release of landfill gas, it should be placed over the gas drainage layer or the waste regulating layer. The mineral layer is recommended in the Landfill Regulations as part of the capping system for both non-hazardous and hazardous sites, although in some cases there may need to be some form of sealing layer for an inert landfill. The Regulations give no indication as to the thickness or permeability of such a layer and the designer should determine the required thickness, based upon the permeability of the materials available in order to meet the desired infiltration rate. However, it is considered that a minimum thickness of 500mm should be used.

Low permeability mineral layers placed as caps in the UK have been formed using a naturally occurring fine-grained material, with a permeability of less than $1x10^{-9}$ ms^{-1}. Ideally, the material for a mineral layer should be sourced from the site. However, many sites in the UK do not have a readily available source of low permeability material suitable for capping applications. In such cases, where a mineral layer is required, alternative options that should be considered include the importation of suitable low permeability mineral layer material or the manufacture of a bentonite enriched soil (BES) material using an on-site or imported host material.

Gas Drainage Layer: A permeable layer that allows landfill gases to be collected directly beneath the artificial sealing or mineral layer.

Whilst it is envisaged that gas collection beneath the cap is to be achieved by the use of a drainage layer, it is generally possible to demonstrate that the landfill gas can be collected successfully using a system of gas extraction wells.

The gas collection layer, if used, is a continuous permeable layer that extends across the final waste levels. It allows the free flow of gas at the top of the waste mass to enable its collection and thus prevent its migration through the sealing layer(s) of the cap. The Landfill Regulations do not give guidelines for a minimum thickness for this layer or a minimum flow capacity requirement and only refer its use on non-hazardous waste landfill sites because the organic content of landfilled hazardous waste has been restricted by the Landfill Directive.

The gas collection layer may be formed from either a granular layer or a geocomposite drainage material. Therefore, material options for this layer are similar to those discussed in relation to the surface water drainage layer.

Landfill Capping

The Landfill Regulations include recommendations for capping but these can be changed on the basis of a risk assessment and the Regulations while giving some indication of the requirements are not particularly prescriptive.

This is a summary of Environment Agency guidance on landfill capping requirements based on the following guidance documents: EA "Technical guidance on capping and restoration of landfills Consultation Draft November 2004", "Landfill Regulatory Guidance Note 6 INTERPRETATION OF THE ENGINEERING REQUIREMENTS OF SCHEDULE 2 OF THE LANDFILL (ENGLAND AND WALES) REGULATIONS 2002" and IPPC Sector Guidance "Technical Requirements of the Landfill Directive and Integrated Pollution Prevention and Control (IPPC S5.02)".

Capping Guidelines in the Landfill Regulations

Layer	Category of Landfill	
	Non – hazardous	Hazardous
Soil cover > 1m*	Required	Required
Drainage layer > 0.5m*	Required	Required
Artificial sealing liner	Not Required	Required
Impermeable mineral layer*	Required	Required
Gas drainage layer	Required	Not Required

However, as a minimum, the capping system should contain a low permeability mineral layer*, a surface water drainage system layer* and cover soils*.

Typical Composition of Layers

***Soil cover above cap**: Comprise soils and/or soil-forming materials, (*i.e.* materials that are either naturally occurring or recycled which can be used as soil) to enable the planned after use to be achieved.

***Drainage Layer**: The drainage layer lies beneath the restoration soils and above the artificial sealing and/or mineral layer. The objective of the layer is to facilitate the drainage of rainwater and surface water that percolate through the restoration layer.

The Landfill Regulations recommend that the drainage layer should be a minimum of 500mm thick, but do not give an indication as to the type of material that could be used or the hydraulic conductivity of such a layer. In line with the risk based approach, and having assessed all design considerations, the designer may deviate from the recommendations made in the Landfill Regulations for this layer. This means the drainage layer may be reduced (or increased) subject to the detailed risk based design.

The materials typically used in the drainage layer are naturally occurring granular soils or secondary aggregate or geosynthetic materials for which a wide range of products are available. If agriculture is the proposed end-use then the typical types agricultural drainage systems may be suitable.

Artificial Sealing Liner: A geosynthetic barrier, which controls both the generation of leachate by minimising the infiltration of water and uncontrolled release of landfill gases / perched leachate.

An artificial sealing liner, if used, is an impermeable geosynthetic barrier. This can be installed in conjunction with a mineral layer to form a composite seal to the waste. It will reduce the generation of leachate by minimising the infiltration of water and will control the release of landfill gases and perched leachate. However a balance needs to be struck between the short-term pollution prevention benefits an ASL will provide against the long-term sustainability of the site. The artificial sealing liner should be installed directly above the low permeability mineral layer and below the drainage layer. In certain circumstances, an artificial sealing liner could be used without an impermeable mineral layer. In such cases the designer should demonstrate that the capping system meets the desired infiltration rate.

Pozidrain 6S250D/NW8

abg creative geosynthetic engineering

POZIDRAIN 6S250D/NW8 is a geocomposite drainage layer comprising a high performance second generation single cuspated HDPE (High Density Polyethylene) core with a geotextile filter thermally bonded on both sides. The textile filters have flap extending beyond the core on both edges. The major application is its use instead of stone drainage layers in landfill containment systems.

Geocomposite Properties						
Thickness at 2kPa	(mm)	7.3			±10%	EN ISO 9863-1
Mass per unit area	(g/m^2)	840			approx	EN ISO 9864
Tensile strength MD / CMD	(kN/m)	22 / 19			-10%	EN ISO 10319
Elongation at peak MD / CMD	(%)	45 / 45			nominal	EN ISO 10319
CBR puncture resistance	(N)	3 750			-20%	EN ISO 12236
Perpendicular Water Inflow	(dimple side only)					
Water flow at 50mm head	($l/m^2 \cdot s$)	103			±30%	EN ISO 11058
At 2kPa permeability *(coefficient)*	(m/s)	2.5×10^{-3}			±30%	EN ISO 11058
Breakthrough head	(mm)	0				BS 6906 part 3
In-plane water flow MD and CMD		HG = 1.0		HG = 0.1		Hydraulic gradient
at 20kPa confining pressure	(l/m·s)	1.60	±0.15	0.48	±0.05	EN ISO 12958
at 100kPa confining pressure	(l/m·s)	1.35	±0.15	0.38	±0.05	EN ISO 12958
at 200kPa confining pressure	(l/m·s)	1.10	±0.15	0.29	±0.05	EN ISO 12958
with **soft foam** contact surfaces to simulate textile intrusion into the core due to soil pressure						
Resistance to weathering		To be covered in 14 days				EN 12224
Resistance to chemicals		Excellent				EN 14030
Design life		120 years (manufacturer's declaration)				
Geotextile Properties						
Thickness at 2kPa	(mm)	1.2			±20%	EN ISO 9863-1
Tensile strength MD/CMD	(kN/m)	9.5 / 9.5			-13%	EN ISO 10319
Pore size O_{90}	(µm)	120			±30%	EN ISO 12956
CBR puncture resistance	(N)	1600			-20%	EN ISO 12236
Dynamic perforation cone drop	(mm)	32			+20%	EN ISO 13433
Type and material	Non-woven needle-punched and heat-treated long staple fibre polypropylene					
Product Dimensions						
Standard roll dimensions	4.4 x 90 m. Other sizes on request.					

Notes

1. The values given are indicative and correspond to nominal results obtained in our laboratories and testing institutes. In line with our policy of continuous improvement the right is reserved to make changes without notice at any time.
2. The tolerance on roll length is 1.5% and on roll width is 1.0%; in multi-core products this may manifest itself between core elements.
3. Guidance on interface shear strength, creep and certain other parameters is available. Site specific tests are strongly recommended.
4. Final determination of the suitability of any information is the sole responsibility of the user. ABG will be pleased to discuss the use of this or any other product but responsibility for selection of a material and its application in any specific project remains with the user.
5. Please refer to separate sheets for fixing instructions. A COSHH certificate is available on request.

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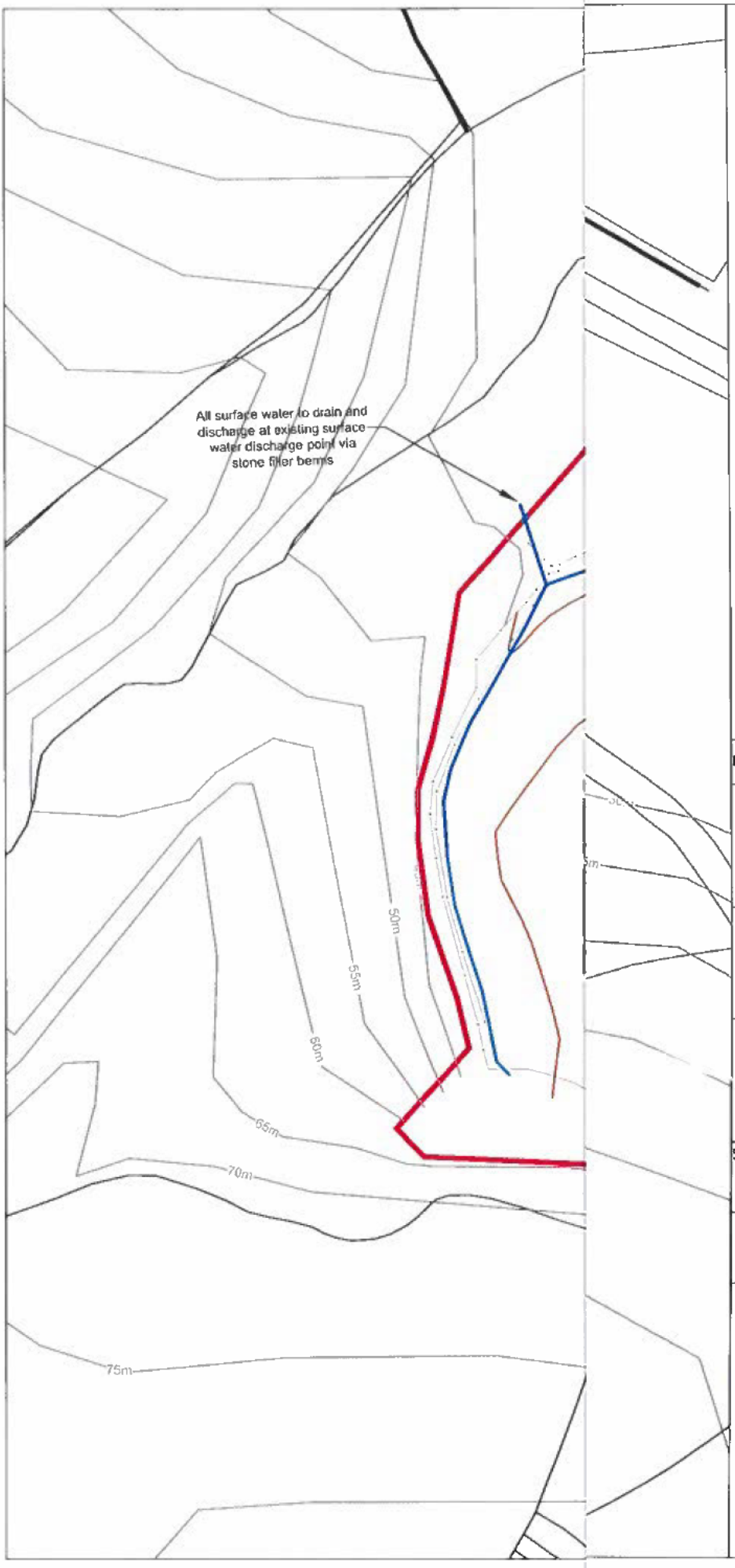
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POZI 6S250D.NW8-G.CE

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Appendix C

Surface Water Geocomposite



KEY:

- SITE BOUNDARY
- DRAINAGE RUNS
- PRE-SETTLEMENT CONTOURS
- ACCESS ROAD

Rev.No.	AMENDMENT DETAILS	BY	DATE

CLIENT

Armagh Power Generation Ltd.

DRAWING

Pre-Settlement Contours

CONTRACT

Lisbane Landfill Site Closure Plan

SHEET SIZE	DATE	SCALE	DRAWN	CHECKED
A3	31.08.16	1:1250	[redacted]	

DRG No. 15047–507

Rev. –

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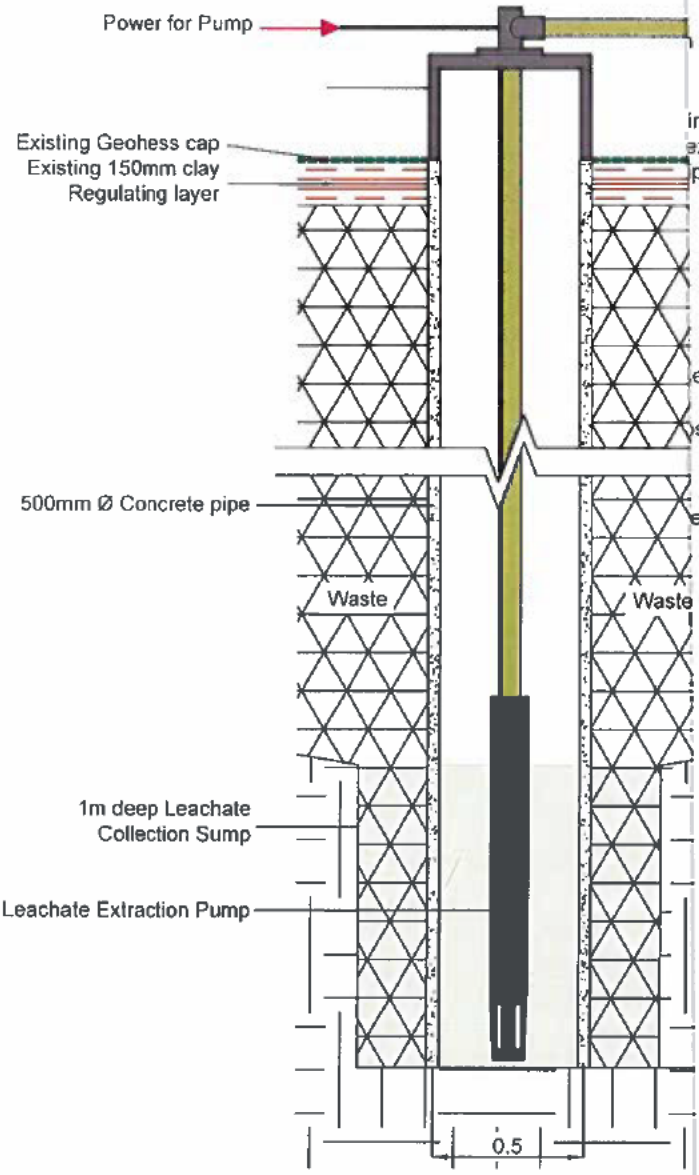
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Existing leachate extractio

KEY:

Rev.No.	AMENDMENT DETAILS	BY	DATE

CLIENT

Armagh Power Generation Ltd.

DRAWING

Leachate Extraction Detail

CONTRACT

Lisbane Landfill Site Closure Plan

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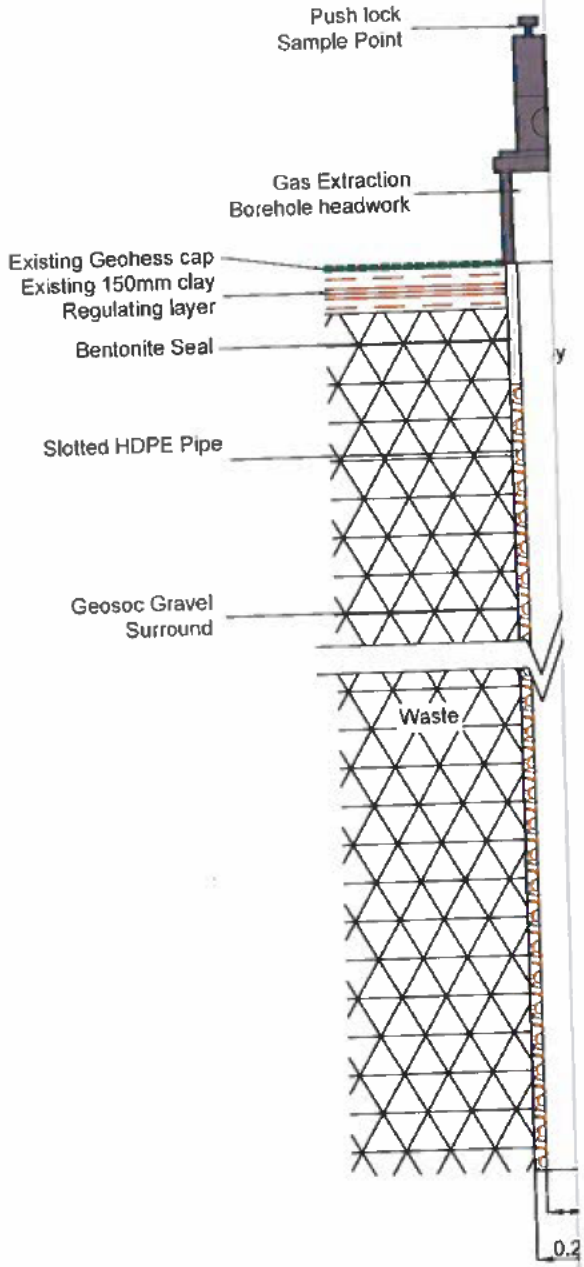
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Existing Gas Ex

KEY:

Rev.No.	AMENDMENT DETAILS	BY	DATE

CLIENT

Armagh Power Generation Ltd.

DRAWING

Gas Extraction Well Detail

CONTRACT

Lisbane Landfill Site Closure Plan

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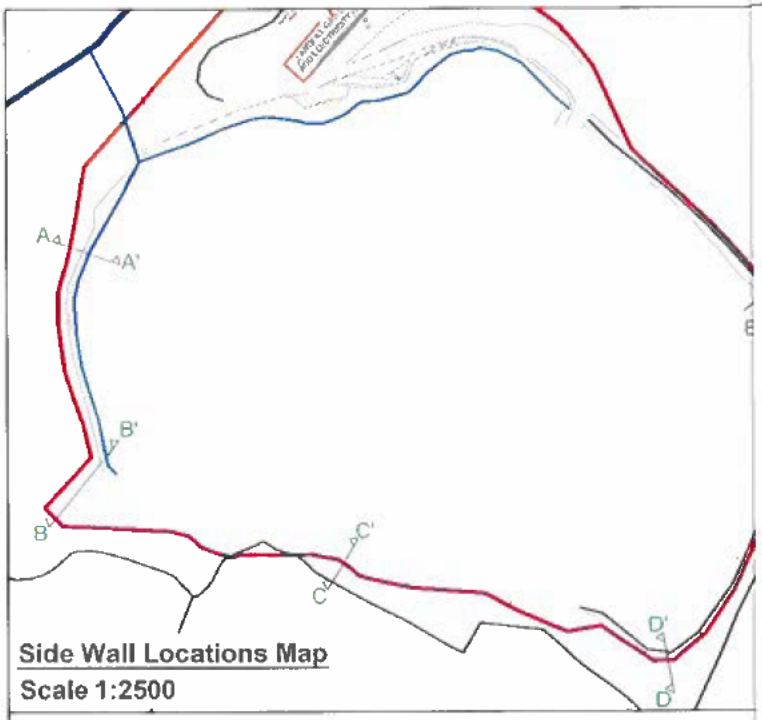
DRG No. 15047–505

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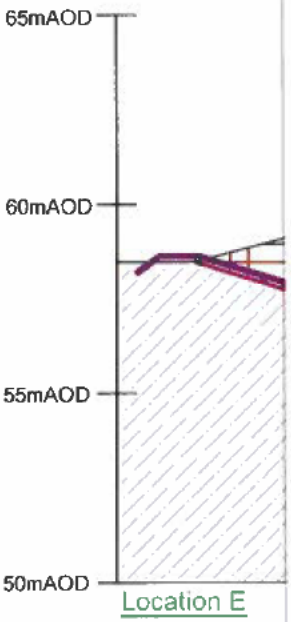
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Side Wall Locations Map
Scale 1:2500



Location E

KEY:

Rev.No.	AMENDMENT DETAILS	BY	DATE

CLIENT

Armagh Power Generation Ltd.

DRAWING

Staged Side Walls 2

CONTRACT

Lisbane Landfill Site Closure Plan

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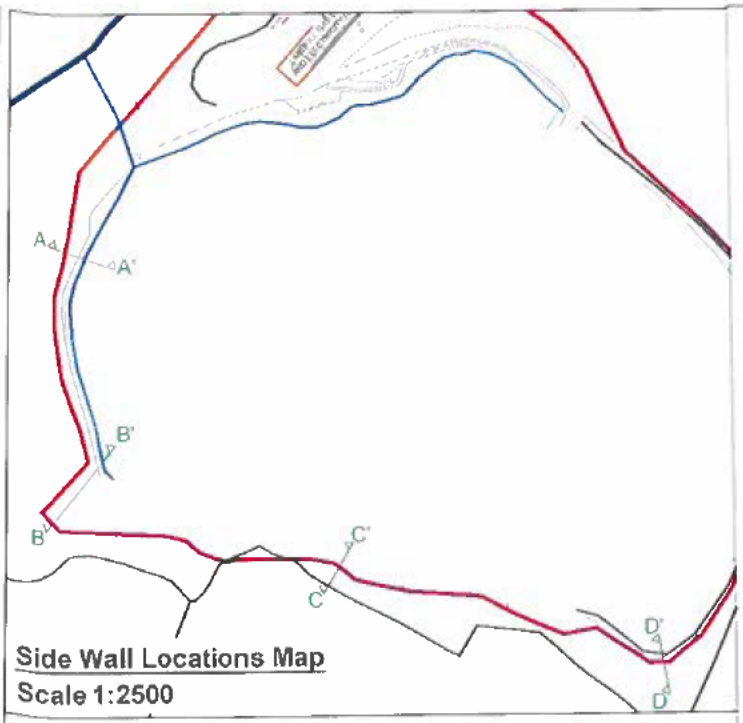
DRG No. 15047–504

Rev. –

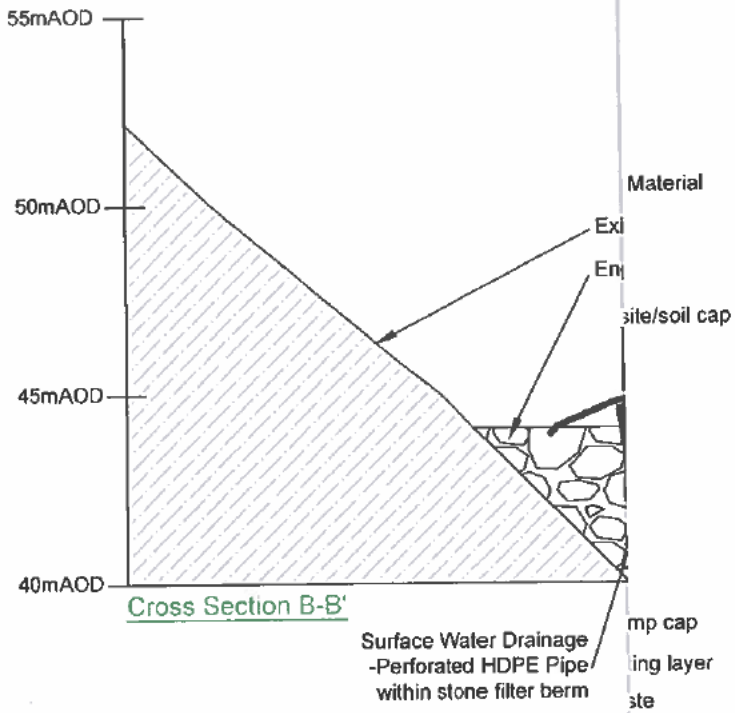
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Side Wall Locations Map
Scale 1:2500



Cross Section B-B'

KEY:

Rev.No.	AMENDMENT DETAILS	BY	DATE

CLIENT
Armagh Power Generation Ltd.

DRAWING
Staged Side Walls 1

CONTRACT
Lisbane Landfill Site Closure Plan

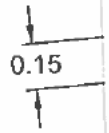
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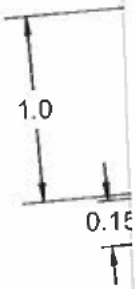
DRG No. 15047-503 Rev. –

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Rev.No.	AMENDMENT DETAILS	BY	DATE

CLIENT

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DRAWING

Capping Design

CONTRACT

Lisbane Landfill Site CQA Plan

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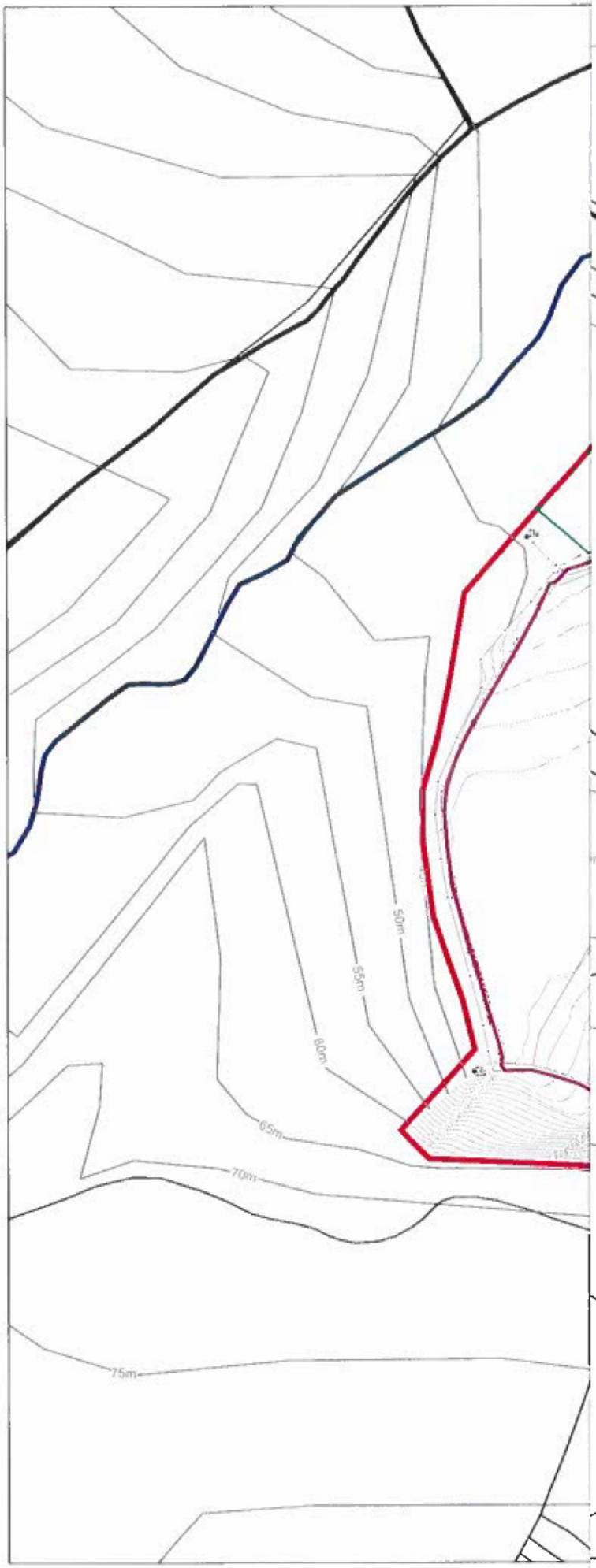
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KEY:

- SITE BOUNDARY
- NON-HAZARDOUS LANDFILL LINER
- LANDFILL GAS EXTRACTION NETWORK
- ACCESS ROAD

Rev.No.	AMENDMENT DETAILS	BY	DATE

CLIENT

Armagh Power Generation Ltd.

DRAWING

Current Site Layout

CONTRACT

Lisbane Landfill Site CQA Plan

SHEET SIZE	DATE	SCALE	DRAWN	CHECKED
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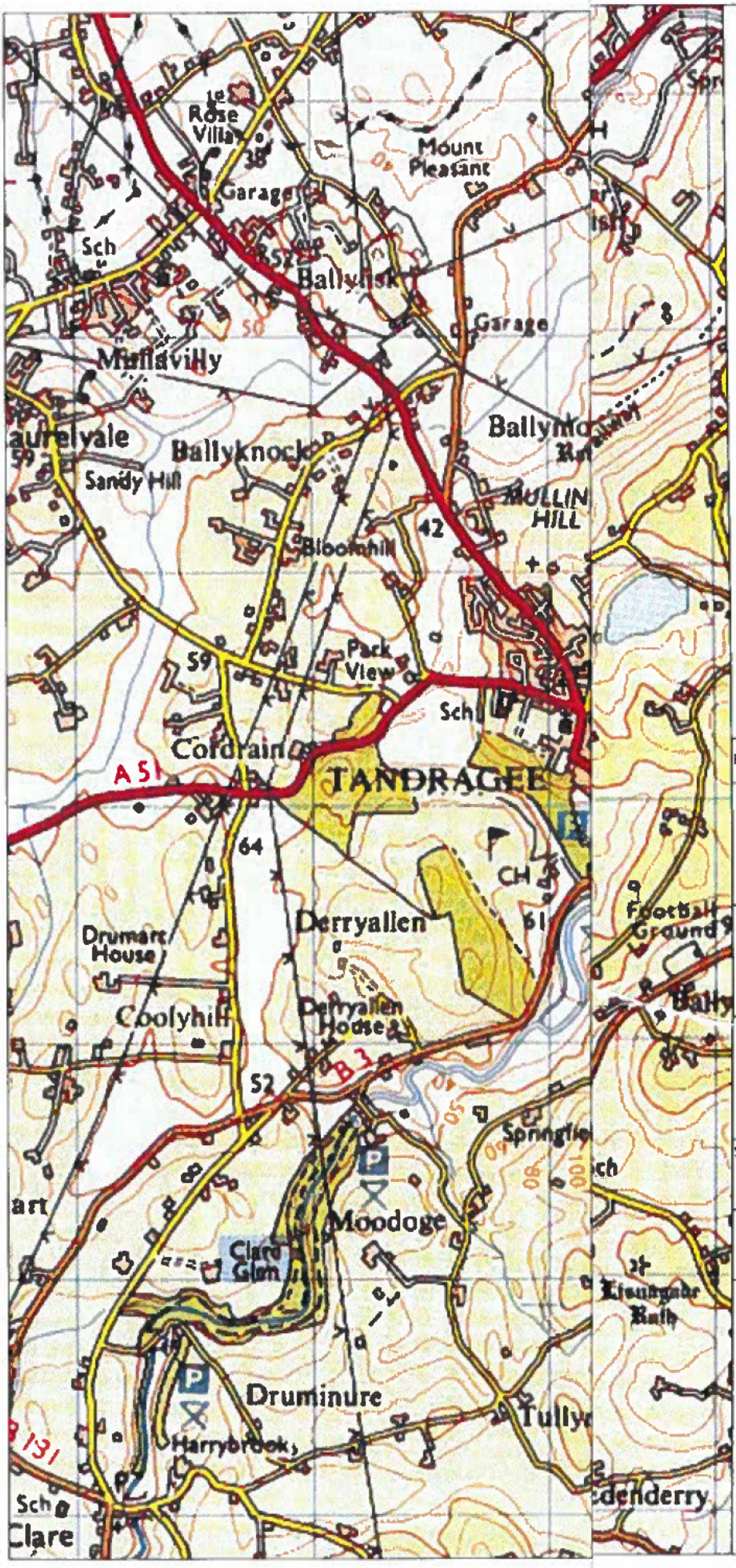
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KEY:

SITE LOCATION

Rev.No.	AMENDMENT DETAILS	BY	DATE

CLIENT

Armagh Power Generation Ltd.

DRAWING

Site Location

CONTRACT

Lisbane Landfill Site CQA Plan

SHEET SIZE	DATE	SCALE	DRAWN	CHECKED
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Appendix A

Drawings

9 CQA Validation Report

An individual CQA Validation Report shall be submitted upon the completion of each phase of cap prior to the placement of restoration materials.

The CQA Validation Report will provide the following information:

- All conformance certificates for materials used;
- The results of all field and laboratory testing to include any failed tests, details of remedial action taken and re-tests;
- Final as-built plans and surveys including engineering details of the work;
- Copies of the CQA Supervisor's daily/weekly records;
- Records of any problems or non-compliance and the solution applied;
- An appropriate selection of photographs showing progress, compliance, noncompliance and any remedial actions; and
- Validation that all aspects of works have been completed in accordance with this CQA Plan unless otherwise agreed in advance with NIEA.

Following the installation of the cap and prior to placement of restoration materials around the gas wells, the wells shall be extended by fusion welding extensions to the HDPE pipework. The wells shall be protected using concrete manhole rings or sand bags that will be lifted and infilled or left in-situ as the restoration materials are placed around them. The extensions of the gas wells shall continue vertically in sections as required during the placement of the restoration soils. Details of the landfill gas extraction wells and their extension is shown on Drawing 15047-505.

8.3 Surface Water Drain

The falls of the site and the installation of the cap will divert all storm water from the site to the north western boundary. Storm water will enter a 300mm diameter perforated HDPE pipe along the perimeter of the landfill for discharge off site at the existing single outfall location. The HDPE pipe is located within a clean drainage stone berm that shall provide filtration surface water run-off during the placing of restoration materials.

The surface water discharge point shall be monitored on a monthly basis with further means of filtration utilised if deemed necessary (i.e. stone berm appropriately increased or geotextile filter material installed within berm). Other surface water monitoring, both upstream and downstream of the landfill will continue on a monthly basis as per the Permit to assess the effect of the placement of restoration materials on the watercourse.

8 Ancillaries

8.1 Leachate Extraction and Management

Leachate is currently extracted from the landfill through two extraction points; LEP A and LEP B. The leachate is pumped to the on-site leachate treatment plant prior to disposal off site for further treatment. Although leachate production is expected to decrease, the leachate extraction and management system shall continue on site during and after the completion of capping and infilling of restoration materials.

The cap, whether GCL or soil, shall be carefully placed around the existing leachate extraction points with bentonite powder poured around the wells to offer further mitigation against escape of landfill gases and ingress of water. The placement of capping materials in the immediate vicinity to the leachate extraction points will be carried out by hand to reduce any risk of damaging the infrastructure.

Following the installation of the cap and prior to placement of restoration materials around the extraction points, the wells shall be extended by installing concrete manhole extension rings and fusion welding extensions to the HDPE pipework. The extensions of the leachate extraction points shall continue vertically in sections as required during the placement of the restoration soils. Details of the leachate extraction wells and their extension is shown on Drawing 15047-506.

8.2 Gas Extraction and Management

Landfill gas is currently extracted from the landfill by 23 gas wells and managed through the on-site gas plant. The gas is primarily utilised within a landfill gas generator to produce electricity that powers the site with surplus power exported to the grid. A back-up flare is also present on site to manage the landfill gas when the engine is not in operation. The gas extraction and management system shall continue on site during and after the completion of capping and infilling of restoration materials.

The cap, whether GCL or soil, shall be carefully placed around the existing landfill gas wells with bentonite powder poured around the wells to offer further mitigation against escape of landfill gases and ingress of water. The placement of capping materials in the immediate vicinity to the gas wells will be carried out by hand to reduce any risk of damaging the infrastructure.

7 Restoration Layer

Lisbane Landfill site has been originally designed to be filled to the restoration levels i.e. top of quarry wall with non-hazardous waste. Due to early closure, and following the installation of a permanent cap, the remaining void shall be filled with restoration materials as agreed with NIEA.

The restoration soils are to be placed directly onto the permanent cap, with the initial layers placed with a digger bucket to prevent any damage to the cap. The initial layers of restoration material shall be free of large stones or objects that could cause damage to the capping layer.

The exposed quarry faces above the cap will be lined with a 1m thick soil barrier with a maximum permeability of $1x10^{-7}$m/s. This soil bund shall be installed in 3 metre layers using the "Christmas tree" effect as shown on Drawings 15047-503 and 15047-504. The top of the bund will have a maximum width of 1m with the bunds installed progressively as the restoration materials are placed.

The restoration materials shall continue to be placed until the agreed pre-settlement contours are reached. In restoring the site the final surface shall be restored with shallow rooted native species and allowed to return to scrub vegetation.

Lifting and transporting of the pozidrain materials shall be by appropriate machinery with the use of slings and core bars. The pozidrain is not to be handled with the blades of a forklift machine, bucket of excavator, or any similar equipment that my cause it damage.

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

6.2.2 Manufacturer's Quality Control

Quality control certificates for each roll of material to be used will be provided to the CQA supervisor. The certificates will contain quality control data and shall be a guarantee from the supplier that the product meets the properties outlined.

The CQA Supervisor will inspect all surface water geocomposite manufacturing Quality Control Certificates issued by the Contractor and inspect all materials prior to deployment.

6.2.3 Installation

The CQA Supervisor will ensure that the surface water geocomposite installation is in accordance with the CQA Plan and the Manufacturer's guidelines.

The geocomposite will be placed with a minimum of 300mm overlap and be tack welded or heat bonded together to prevent adjacent panels from moving apart. At the end of the working day, all exposed edges will be anchored down to ensure no damage will occur to the materials. The CQA Supervisor will inspect for any damage.

Any repairs necessary will be overlain with a single piece of pozidrain with a minimum overlap of 300mm in all directions. These will be tack welded or heat bonded in place to prevent the repair panel moving apart.

The CQA Supervisor will witness the deployment of the surface water geocomposite and inspect the works. If any of the works inspected do not comply with this CQA Plan, the CQA Supervisor will record this and the Contractor will make good any non-compliance.

The CQA Supervisor will witness the deployment of the GCL and record details of the panel number, roller number, deployed length, visual observations, and overlap lengths. If any of the GCL works inspected by the CQA Supervisor do not comply with this CQA Plan, the CQA Supervisor will record this and the Contractor will make good any non-compliance. Once repairs have been undertaken, these will be inspected and approved by the CQA Supervisor. Details of the deployment of all panels will be recorded on a GCL Panel Layout Drawing and submitted along with the CQA Validation Report.

6.2 Surface Water Geocomposite

The surface water drainage geocomposite layer is designed to prevent the ingress of surface water into the waste body and direct it towards the surface water drains along the perimeter of the landfill area. The surface water geocomposite shall be placed directly over the top of the GCL and shall also provide protection to the GCL.

The material to be used is Pozidrain 6S250D/NW8 or similar and approved. Only materials approved by the CQA Supervisor shall be utilised. The material properties for the surface water geocomposite to be used can be found in Appendix C and will conform to the minimum requirements as provided in table 6.2.

Table 6.2 Surface Water Geocomposite Minimum Requirements

Property	Minimum Requirements	Test
Mass per unit Area	760g/m²	BS EN ISO 9864
In Plane Water Flow	0.95 l/m/s (@20kPa)	BS EN ISO 12958
Minimum Thickness	5.8mm (@2kPa)	BS EN ISO 9863
Tensile Strength MD/CMD	22/19kN/m	BS EN ISO 10319
Minimum Residual Friction Angle with Restoration Soil Material	19°	ASTM D6243/5321
Minimum Residual Friction Angle with GCL Material	19°	ASTM D6243/5321

6.2.1 Transporting and Storage of Material

The material will be delivered, handled and stored in accordance with the manufacturer's recommendation. Each roll of the surface water pozidrain to be used will be identified with its product identification, type, batch and roll number.

maximum slope where possible. The CQA Supervisor will review the panel deployment progress of the installer and advise the Project Manger on the suitability to the actual field conditions. Once approved, any changes to the panel deployment procedure must be agreed with the Project Manager.

The GCL will not be deployed during any precipitation, areas of surface water, or in the presence of winds in excess of 20mph (32km/hr) in the working area. The CQA Supervisor will verify that site conditions are acceptable for deploying the GCL and will report to the Project Manager any weather related problems which affect the GCL deployment.

The GCL shall be installed in accordance with the manufacturer's installation guidelines. The GCL will be placed with a minimum of 300mm overlap of panels. Along the boundary of the works area the GCL shall be placed with a minimum of 300mm overlap with previously deployed GCL or finished within the anchor trench or beyond the lining system as appropriate. Any exposed edges will be anchored down to ensure no damage. At all overlaps/joints a continuous bead of powdered bentonite will be applied to create a seal. The powdered bentonite will be used at a minimum rate of 0.4kg/m.

6.1.4 Construction Quality Assurance

The CQA Supervisor shall ensure the Contractor:

- Avoids damage to the GCL by equipment during handling, leakage of hydrocarbons, or other means;
- Uses a method to unroll the panels that does not cause damage to the GCL and does not damage the supporting soil;
- Uses a method to place the panels that does not result in wrinkling/folding of the GCL material;
- Uses temporary anchoring (e.g. sandbags) to prevent the GCL uplifting due to wind but not damage the GCL;
- Places the Surface Water Geocomposite on the same working day as the GCL and weighed down using appropriate means; and
- Doesn't allow the GCL to become hydrated during or before the installation.

All seam and non-seam areas of the GCL will be examined by the CQA Supervisor for defects and any sign of contamination by foreign matter. Any repairs necessary will be overlain with a single piece of GCL with a minimum overlap of 300mm in all directions and bentonite powder applied. The GCL shall be installed around gas wells and other appurtenances with a minimum overlap of 300mm in all directions and bentonite powder applied.

Property	Minimum Requirements	Test Method
Montmorillonite content	≥300mg/g	VDG P69
Minimum Residual Friction Angle with Surface Water Geocomposite	19°	ASTM D6243/5321
Minimum Residual Friction Angle with Geohess	19°	ASTM D6243/5321

6.1.1 Transporting and Storage of Material

The material will be delivered, handled and stored in accordance with the manufacturer's recommendation. Each roll of the GCL to be used will be identified with its product identification, type, batch and roll number.

Lifting and transporting of the GCL materials shall be by appropriate machinery with the use of slings and core bars. The GCL is not to be handled with the blades of a forklift machine, bucket of excavator, or any similar equipment that would cause damage to the GCL. In accordance with the accepted practice, the Contractor shall at all times ensure that:

- Smoking is prohibited on or in the surrounding area of the GCL;
- No items will be dragged across the GCL;
- Only suitable footwear is permitted on the GCL; and
- Operation of construction plant directly on the GCL is not permitted.

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

6.1.2 Quality Control

Quality control certificates for each roll of material to be used will be provided to the CQA supervisor. The certificates will contain quality control data in accordance with the test methods and requirements provided by the manufacturer and shall be a guarantee from the supplier that the product meets the properties outlined.

The CQA Supervisor will inspect all GCL manufacturing Quality Control Certificates issued by the Contractor and inspect all materials prior to deployment.

6.1.3 Placement and Installation

The Contractor will produce a proposed GCL panel layout in advance of the GCL works commencing on site with an orientation so that the panel seams are parallel to the line of

6 Geocomposite Cap

A geocomposite cap is designed to contain landfill gas within the landfill and mitigate against water ingress through the cap and create a self-sealing barrier. The geocomposite cap shall be installed directly on top of the existing geohess layer and consist of a GCL and surface water geocomposite.

Along the perimeter of the landfill, where possible, the geocomposite cap shall be terminated within the existing anchor trench on to the lining system to completely seal the landfill. Along the revetment system and quarry face the liner may not be able to be exposed. Where this is the case, the geocomposite cap will be terminated beyond the revetment system and anchored within the engineered fill. A clay bund will then be placed around the perimeter of the capping works.

6.1 GCL

The material to be provided for this project is Bentofix NSP 4000 or similar approved. Only materials free from damage and deemed fit for purpose by the CQA Supervisor shall be utilised. The material properties for the GCL to be used can be found in Appendix B and will confirm to the minimum requirements as provided in table 6.1.

Table 6.1 GCL Minimum Requirements

Property	Minimum Requirements	Test Method
Mass per unit area of GCL	3,670g/m²	EN 14196
Mass per unit area of clay component of GCL at manufacturers stated moisture content	4,000g/m²	EN 14196/ASTM D 5993
Thickness	6mm	EN ISO 9863-1
Peel Strength	N/m ≥ 360	EN ISO 13426-2/ASTM D6496
Moisture content of clay	Approx. 10%	DIN 18121/ASTM D 2216
Swell index/free swell of clay	≥24ml/2g	D 5890
Water Absorption	≥500%	DIN18132 Enslin Neff/ ASTM E946
Tensile Strength (MD only)	Length: 12kN/m Width:12kN/m	EN ISO 10319/ ASTM D4595
CBR/Puncture Resistance	2kN	EN 12236/ASTM D 6241
Mass/unit length of bentonite in overlaps	≥0.4kg/m	Visual Inspection
Index Flux	$5x10^{-9}$ $(m^3/m^2)/s$	ASTM D 5887
Montmorillonite content	>70%	XRD

the CQA Supervisor will be removed and labelled for conformance testing, ensuring that the material meets the relevant requirements.

The CQA Engineer shall witness and supervise all conformance testing carried out in accordance with Table 5.1 and 5.2 above and record all construction activities and results. The CQA Supervisor reserves the right to request further measurements to be made or tests carried out as necessary, to demonstrate the cap has been installed in accordance with this CQA Plan.

If any of the works inspected by the CQA Supervisor do not comply with this CQA plan, the CQA Supervisor will record this and the Contractor will make good any non-compliance. Solutions for non-compliance will be noted and included in the CQA Validation Report.

Table 5.2 In-situ Testing

Parameter	Test Method	Frequency
Density in-situ	In-situ Nuclear Density Gauge	1 / 2,500m³
Moisture Content in-situ	In-situ Nuclear Density Gauge	1 / 2,500m³
Density	Core Cutter Method- BS1377: Part 9: Method 2.4	1 / 5,000m³
Moisture Content	Core Cutter Method- BS1377: Part 2: Method 3.2	1 / 5,000m³
Particle Size Distribution	Sieve Analysis- BS 1377: Part 2: Method 9	1 / 5,000m³
Depth	Trial Pits	1 / 2,500m²
Permeability	Soak away test- See Section 5.4.1 below	1 / 5,000m³

5.4.1 Permeability Testing

Permeability testing of the cap shall be carried out in-situ as outlined below:

1. Scrape a smooth flat surface 50mm below the surface layer to be tested;
2. Drive a 100mm internal diameter U100 cutter and tube 15mm into the smoothed area of the geological barrier;
3. Fill the tube to a depth of 50mm with water, record the time and seal the tube to minimise evaporation;
4. After 24 hours remove the cover and measure the depth of any remaining water. The level shall be recorded along with the observations of ground conditions around the ring.

If there is no water remaining the cap is too permeable. Observations and results of all in-situ permeability testing shall be included within the CQA Validation Reports.

5.5 Construction Quality Assurance

The objective of CQA Supervision is to confirm appropriate procedures are implemented at the site and to provide assurance that only suitable materials and construction methods are used.

The CQA Engineer shall instruct and train site staff on the procedures and requirements of the CQA Plan including all record keeping. Site staff shall be instructed to separately stockpile materials thought to be suitable for use in the cap. As soon as is reasonably practicable after the stockpiling of potential geological barrier materials, a quantity of material determined by

5.2 Field Trials

Before proceeding with the installation of a soil cap, the properties and suitability of the material shall be determined by laboratory testing. A field trial of the installed material shall then be conducted to evaluate the following aspects:

- Material handling and placement requirements;
- Compaction equipment and procedures;
- Number of passes of equipment necessary to achieve the specified relative compaction; and
- Field testing procedures for compaction.

The installation and testing of trial pads shall be witnessed by the CQA Supervisor on site. Sufficient information shall be obtained to demonstrate consistency across the site.

5.3 Placement and Compaction

The material to be used within the cap shall be placed and compacted in layers until the 1m depth is achieved. The level of compaction will be based on the completed field trials that will have determined the density levels required to achieve the desired permeability.

No placement or compaction of the capping material shall take place during inclement weather to include rain, snow and/or freezing conditions. Under no circumstances shall any frozen material be employed, be that from the stockpile of in-situ material or material which has been imported; neither shall the material be placed upon frozen subgrade. Any frozen material shall be placed to one side until thawed. If any placed capping material becomes frozen adjacent to a new placement area, then either the placement of the new section of cap shall be suspended until the existing material has thawed, or the frozen cap removed and replaced with non-frozen capping material. Any laid section which is damaged (including by weather) beyond its suitability for use, shall be removed and replaced as necessary.

The Contractor shall provide adequate and acceptable measures for protecting the material at all stages of the work from all sources of potential contamination until completion of the contract.

5.4 In-situ Testing

In-situ testing of the soil cap shall be carried out in accordance with Table 5.2 in order to demonstrate the compliance of the cap.

5 Soil Cap

If a natural material landfill cap is to be used it will be a minimum of 1 metre thick and provide a maximum permeability of 1 x 10^{-9} m/s.

Throughout the restoration of the landfill, the Operator may receive or import available materials suitable for use as a cap. These materials shall be stockpiled in suitable locations within the landfill and shall be subject to a quality control system. This system shall include the delivery documents including source and weight of loads. Any imported materials shall be subject to testing and soil analysis to determine its capability for use as a capping material.

5.1 Soil Testing and Requirements

Testing of soils and clays shall be carried out in accordance with Table 5.1 to determine the materials suitability for use as a soil cap. The results of all testing shall be provided within the CQA Validation Reports.

The general requirements of materials to be used as a cap may vary based on material availability and agreed use with NIEA.

Table 5.1 Soil Testing

Property		General Requirements	Lab Test Method	Minimum frequency of test
Permeability / Hydraulic conductivity		1x10^{-9} m/s	BS1377 : 1990 , Part 6 : Method 6	1 per 5,000m³
Remoulded undrained shear strength		≥ 50KN/m²	BS1377 : 1990 , Part 7 : Method 8	1 per 5,000m³
Plasticity index (I_p)		10% ≤ I_p ≤ 65%	BS1377 : 1990 , Part 2 : Method 4.3 and 5.3	1 per 5,000m³
Liquid Limit		≤ 90%	-	1 per 5,000m³
Particle Size Distribution	Percentage fines <0.063 mm (63 µm)	≥20%	BS1377 : 1990 , Part 2 : Method 9.2, 9.5	1 per 5,000m³
	Percentage gravel > 5mm	≤ 30%		
	Maximum particle (stone) size	150mm		
Minimum Residual Friction Angle with Geohess		19°	ASTM D6243/5321	1 per 5,000m³

4 Engineered Cap

The engineered cap is designed to mitigate water ingress and contain landfill gas until extracted by the gas management system. The cap will constitute a barrier providing a maximum permeability of $1x10^{-9}$m/s, and depending on material availability, will consist of either:

- A 1m thick soil/clay cap; or
- A geocomposite capping system.

Only material deemed fit for purpose by the CQA Supervisor shall be utilised.

The capping works will be carried out in a phased manner with a validation report for each phase submitted to NIEA for approval. The engineered cap shall be installed directly onto the temporary geohess cap currently installed on site that will provide further mitigation against the ingress of water and the collection of landfill gas. The temporary cap also provides a smooth surface for the placement of a GCL.

Details of the capping options are shown on Drawing 15047-502. The properties and quality assurance measures and requirements for each of the optional capping systems are provided in the subsequent sections of this report.

3 Responsibilities

The CQA Project Team will comprise of the following:

3.1 Project Manager

The project manager will be office based and will:

- Attend all progress or liaison meetings and be the key contact with regulatory officers;
- Review all designs, plans and specifications;
- Review other site-specific documentation, including proposed layout and Contractor's qualifications;
- Administer the CQA program; and
- Review all changes to the design, plans and specifications.

3.2 CQA Supervisor

The CQA supervisor will be located at the site and will:

- Manage the daily activities of the CQA regime;
- Attend all CQA related meetings (e.g. Pre-construction and Progress);
- Supervise the ongoing preparation of the as-built drawings;
- Assign locations for testing and sampling;
- Record any relevant observations in the daily report;
- Oversee the collection of all samples for laboratory testing;
- Report any unresolved deviations from this CQA Plan to the Project Manager;
- Provide all logs and relevant data to the Project Manager;
- Assist in the production of the CQA Validation Report; and
- Report to the Project Manager.

2 Definitions

For clarification, the following definitions are given:

Construction Quality Assurance (CQA) - A planned and systematic pattern of all means and actions designed to provide confidence that items or services meet contractual and regulatory requirements. Construction Quality Assurance refers to means and actions employed to assure conformity of the lining system, i.e. its preparation, production and installation, to this CQA Plan, the Contract Drawings and Specifications. CQA is provided by a party independent from production and installation.

Construction Quality Control (CQC) – Actions that provide a means of measure and regulation to characteristics of an item or service to contractual requirements. CQC refers to those actions taken by Manufacturers, Installers, Contractors, or the employer to ensure materials and workmanship meet the requirements of the plans and specifications.

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, Manufacturer. The Contractor will undertake the execution of the works under the terms of the Contract.

3. Placement of soils against cliff face in staged lifts.

4. Restoration layers – Appropriate materials as agreed with NIEA will be placed directly onto the cap as restoration materials.

5. Landfill gas extraction system – the current landfill gas extraction system will be maintained with all functioning gas wells appropriately extended through the restoration layers.

6. Leachate extraction system – the current leachate extraction wells will be extended through the restoration layers to maintain leachate extraction on site.

Table 1.1 Proposed Capping System

	Layer	Thickness (mm)	Properties	Purpose
Current temporary cap	Regulation layer of clay type material	150	Cohesive clay	Smooth surface for placement of Geohess
	Cover up 240 Geohess panels with stitched seems, 0.5m clay bunds around perimeter	0.4/500	1.6 x10^{-8}m/s	Temporary cap
Proposed final cap	Compacted Soil layer or geocomposite cap	1,000 100	To have permeability of 1x10^{-9}m/s	To provide a low permeability barrier to prevent infiltration of water into the landfill mass as required in the Permit conditions.
	Restoration layers	Varies max ~18,500	Materials as agreed with NIEA for acceptance	To allow the restoration of the site to the approved levels and the creation of a profile which will encourage surface water drainage.

All works will be undertaken by a contractor with experience in landfill works, to be appointed by Armagh Power Generation Ltd. The works will be supervised by an independent CQA Supervisor.

The current site layout is shown on Drawing 15047-501.

1.4 Project Description

The works will comprise the construction and engineering of permanent capping works. The capping system has been designed to meet the requirements of the Landfill Regulations (Northern Ireland) 2003. The programme for capping and restoration works will be implemented in a phased manner.

A surface sealing layer will be installed over the current temporary capping layer. This cap will provide a maximum permeability of $1x10^{-9}$m/s and will comprise either a 1m deep soil layer or a geocomposite capping system. The installed cap will prevent the escape of landfill gases produced from degradable wastes and will mitigate the infiltration of surface water in to the waste body.

Geocomposite Installed

Subsequent to the installation of the cap, restoration layers shall be infilled to the agreed restoration levels as per the site closure plan. The restoration contours ensure that surface water drains to the discharge point at the site boundary and aims to restore the site to an appropriate landform.

As per the approved site closure plan the remaining slopes of the quarry will be lined with low permeability soils, with a maximum permeability of $1x10^{-7}$m/s. The side walls will be a minimum of 1m deep and will be constructed in stages as the restoration materials are placed.

In restoring the site, the final surface will be restored with shallow rooted native species and allowed to return to scrub vegetation.

A summary of the planned works is as follows:

1. The retention of the current temporary capping layers including the 150mm clay layer and the geohess liner. This will form part of the permanent cap reducing infiltration of water and the escape of landfill gas.

2. Capping of the site – The cap with a maximum permeability of $1x10^{-9}$m/s, will be determined by material availability and will be either:

    i. A geocomposite capping system consisting of a GCL and surface water drainage layer, or
    ii. A 1 meter deep layer of clay/soils compacted to achieve the required permeability.

1 Introduction

1.1 General

WDR and RT Taggart were commissioned by Armagh Power Generation Ltd. to prepare a Construction Quality Assurance (CQA) plan for the construction and engineering of capping works at Lisbane Landfill Site. The works will mainly consist of the installation of a capping system over an area of approximately 34,300m².

This subsequent CQA Plan details all the works and testing to be carried out and has been prepared in accordance with NIEA requirements and relevant guidance documents.

1.2 Location

Lisbane Landfill Site is located on Aughlish Road, approximately 2.5km to the south-east of Tandragee and 1.8km to the north-west of Scarva, Co. Armagh, centred on Irish Grid reference J 04822 344504. The site is accessed via secured gated access while the inactive landfill site is accessed via internal hard-core roads. The site location is shown on Drawing 15047-500.

1.3 Current Site

Lisbane landfill is an existing non-hazardous landfill situated in a former hard rock quarry (greywacke). The site previously accepted household, commercial and industrial wastes however no waste has been infilled at the site since July 2013. The site was temporarily capped with a 150mm regulation layer of clay type material which is overlaid by Cover up 240 Geohess panels in 2014. The temporary geohess cap is anchored around the perimeter of the site by 0.5m high clay bunds.

The quarry side wall of the landfill was lined with a GCL overlain by HDPE geomembrane, protection geotextile and Geogrid (Tensar 40RE). This lining system was attached to a polystyrene faced reinforced earth wall or by a revetment system which was bolted to the walls of the quarry. The top of revetment system is visible along the perimeter of the landfill.

Although the site no longer accepts waste the leachate and landfill gas produced on site continues to be managed. Leachate is extracted from sumps at the base of the landfill by two leachate extraction points and pumped to the on-site leachate treatment plant. Landfill gas is extracted via twenty-four gas wells across the landfill site and utilised within the on-site landfill gas plant.

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Appendices

Appendix A- Drawings

Appendix B- GCL

Appendix C- Surface Water Geocomposite

TITLE	LISBANE LANDFILL SITE - CAPPING WORKS- CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN
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Lisbane Landfill Site- Capping Works

Construction Quality Assurance Plan



5047- Lisbane Landfill Site

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