CQA Validation Report Reference: CE1013/03
December 2015

CONSTRUCTION QUALITY ASSURANCE VALIDATION REPORT

CONSTRUCTION OF CELL 4

HAFOD LANDFILL SITE

Prepared for
CORY ENVIRONMENTAL (CENTRAL) LIMITED

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Project Quality Assurance
Information Sheet

CQA Validation Report for the Construction of Cell

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1 INTRODUCTION

1.1.1 Stratus Environmental Limited (Stratus) were requested by Cory Environmental (Central) Limited (Cory) to carry out Construction Quality Assurance (CQA) supervision and testing during the initial phase of construction of Cell 4 at Hafod Quarry Landfill Site.

1.1.2 The construction works were carried out in accordance with the CQA Plan Version 2.0 dated July 2015.

1.1.3 The works were undertaken using plant and labour resources provided by Cory, who undertook the construction work during the period August to December 2015.

1.1.4 The construction works incorporated the following elements:

(i) clearance of vegetation and unsuitable materials from the cell footprint;
(ii) excavation of in-situ marl and made ground to achieve design formation levels;
(iii) installation of groundwater collection system, comprising a net-cored drainage geocomposite, with a collection drain at the base of the eastern side-slope;
(iv) installation of 1000mm minimum thickness engineered clay liner as an artificially established geological barrier (AEGB) to the eastern side-slope (made ground area); and
(v) installation of 1000mm minimum thickness engineered clay liner as an artificial sealing layer (ASL) to the northern and southern side-slopes and across the base (in-situ marl); and
(vi) installation of separation geotextile, gravel drainage blanket, preferential leachate collection pipework, target pad and monitoring/collection chambers as the leachate collection system.

1.1.5 The Stratus CQA Engineer who provided supervision and quality assurance for the works was Kay Adedotun.

1.1.6 Survey control and recording was provided throughout the project by StafSurv, an independent survey company appointed by Cory.

1.1.7 This CQA Validation Report represents a record of the site works undertaken at Hafod Quarry Landfill Site, and includes a record of all the in-situ and laboratory testing undertaken.

1.1.8 The extent of the cell is shown on the as-built drawing presented in Appendix 1.

2 THE SITE

2.1.1 Hafod Quarry Landfill Site is situated approximately 4km southwest of Wrexham, at National Grid Reference SJ309 455.

2.1.2 The site is operated by Cory Environmental (Central) Limited under the authorisation and control of PPC Permit Number PP3139GB.

3 PREPARATORY WORKS

3.1 Formation Works

3.1.1 The existing quarry face was cleared of vegetation and loose/unsuitable material prior to excavation to design formation levels. Proof-rolling of the cleared formation was undertaken to ensure a firm unyielding surface had been exposed. Once formation level had been achieved, installation of the groundwater collection system was undertaken.

3.2 Installation of Groundwater Drainage System

3.2.1 The groundwater drainage system comprised a drainage geocomposite laid across the prepared formation on the base and southern side-slope, and to a height of 3m above the base on the eastern side-slope, discharging to a collection drain at the base of the eastern side-slope. In addition, a single counterfort drain was installed on the eastern side-slope to intercept an historic surface water drain comprised of tile fragments, which was encountered during excavation works.

3.3 Drainage Geocomposite

3.3.1 The groundwater collection geocomposite comprised Terram 1B1, a net-type drainage geocomposite. A total of nine rolls of 1B1 were delivered to site, five in August and a further four in late September 2015. Each roll had dimensions of 4.0m x 100m, giving a delivered quantity of 3,600m^2.

3.3.2 The geocomposite was delivered to site and offloaded into storage on the concrete slab adjacent to the site weighbridge (the bypass lane). The CQA Engineer subsequently supervised handling and deployment of the geocomposite. The CQA Engineer inspected the rolls of geocomposite and confirmed that no damage had occurred to them during transportation to site and unloading/storage.

3.3.3 The CQA Engineer obtained the manufacturer's product data sheet and assessed these as acceptable against the requirements of Table 1 of the Specification. The data sheet and delivery note are presented in Appendix 2.

3.3.4 The sub-grade upon which the geocomposite was deployed was prepared using a hydraulic excavator fitted with a ditching bucket. The CQA Engineer inspected successive areas of the subgrade, to ensure that no potentially deleterious materials would be in contact with the geocomposite. Throughout the geocomposite installation, the surface was deemed to be satisfactory.

3.3.5 The geocomposite was deployed using the hydraulic excavator. The CQA Engineer oversaw placement of the drainage geocomposite and ensured that the edges were correctly butted together. Panels were installed with no significant wrinkles.

3.3.6 Two samples of the geocomposite were taken from randomly-selected rolls during deployment and despatched for testing at BICS Laboratory in Huddersfield. Testing was undertaken to confirm:

(i) tensile strength;
(ii) CBR puncture resistance;
(iii) in-plane water flow;
(iv) thickness; and
(v) geotextile permeability.

3.3.7 The laboratory testing was undertaken with UKAS accreditation for all the tests carried out. The laboratory results are presented in Appendix 11, and confirm that both samples of geocomposite were in accordance with the specified values; the results are summarised in Appendix 4.

3.4 Collection Drain

3.4.1 The panels of geocomposite discharged to a collection drain excavated at the base of the eastern side-slope, comprising a 150mm ID twinwall pipe installed in a 600mm wide x 550mm deep trench. The pipework was connected using push-fit collars. The collection drain flows southwards, and discharges to a permanent groundwater sump located in the south-eastern corner of the cell.

3.4.2 Terram 1000 filtration geotextile was used to line the collection ditch to prevent fines ingress and clogging. The CQA Engineer took a sample of this material and submitted it to the laboratory for testing in accordance with the requirements of Table 2 of the Specification.

3.4.3 The geotextile test certificate is presented in Appendix 11 and summarised in Appendix 4. For all tested parameters of puncture resistance, pore size tensile strength, the material was found to be in accordance with the specified requirements.

3.4.4 The grading and strength of the drainage gravel used within the collection drain was not specified, nor was testing required under the CQA Plan. The CQA Engineer and Quality Engineer discussed the material during a site visit on mobilisation (3 August 2015), and agreed that as it was the same material/source as that being proposed for the leachate drainage blanket, and that visually the material was a single-sized coarse limestone gravel of ~50mm average size, it would be suitable for use in the drain.

3.5 Groundwater Sideslope Riser

3.5.1 To remove collected groundwater from within the south-east sump, a 450mm diameter SDR17.6 side-riser was installed up the crease-line between the eastern and southern side-slopes. To provide redundancy within the design, two side-risers were installed in the trench, which was backfilled with 10-20mm gravel.

3.5.2 The side-riser pipework was delivered in 6m sections, welded into strings using butt-fusion techniques. One string was welded at full length, whilst the other, for ease of handling, comprised two parts which were subsequently joined using an electro-fusion coupler. Welding logs for the various joints are presented in Appendix 15, together with deflection calculations for the 450mm diameter side-riser pipework; the welder's training certificate is presented in Appendix 13.

3.5.3 The basal 3m section of each of the side-risers was formed from perforated casing, the remainder being formed from plain casing. The perforated basal sections were surrounded by 10-20mm gravel, wrapped in a layer of the Terram 1000 filtration geotextile.

3.5.4 Duty and stand-by electric submersible groundwater pumps are being installed by Cory within the side-risers.

4 ENGINEERED CLAY LINER (ECL)

4.1 Acceptance Criteria

4.1.1 The acceptance criteria were derived from laboratory test results undertaken prior to commencement of the works as part of the source evaluation prepared by Egniol Limited in 2008. The acceptance criteria are essentially an envelope within which the field dry density and moisture content results should fall in order to achieve the desired in-situ permeability. The boundaries of the envelope for the acceptance criteria are above the 5% air voids line, and between the upper and lower moisture content limits. The lower moisture content limit was set at 12% and the upper moisture content was set at 20%. The 5% air voids line was calculated using the average particle density derived from the laboratory results (2.75 Mg/m^3). The minimum clay content was set at 10%, with a maximum particle size of 125mm.

4.2 Field Trial

4.2.1 As part of the construction of the previous section of engineered clay liner, a compaction trial had been carried out on 18 February 2015 with the Stratus CQA Engineer in attendance, in accordance with the Specification for Highway Works Tables 6/1 – 6/4, to confirm that the proposed construction methodology would achieve the required specification. As the same make/model of padfoot roller and the same source of engineered clay material would be used for the current works, it was decided to adopt the previous compaction methodology (eight passes at a finished thickness of 250mm) without undertaking construction of the trial pad.

4.3 Compacted Mineral Liner Construction

4.3.1 The mineral lining works were undertaken by placing and compacting selected suitable cohesive material in a progressive manner. A self-propelled pad-foot roller (Hamm 3412) was used for compaction of the engineered clay; the pad-foot shells were removed for final compaction of the completed liner surface. This roller has a mass per unit width of 3180kg.

4.3.2 All engineered clay liner construction work was carried out using the method previously confirmed by the field trial (i.e. a maximum compacted layer thickness of 250mm, achieved with a minimum of eight passes of the roller). The eastern side-slope liner, comprising a 2m perpendicular thickness of clay (AEGB + ECL) was constructed in horizontal lifts, as there was sufficient width to be able to undertake this safely; the other side-slopes, comprising just a 1m ECL, were constructed parallel to the slope in four discreet layers.

4.3.3 Before placement of a subsequent layer, the CQA Engineer ensured that the surface of the previous layer was suitably scarified, to provide adequate inter-bonding between the layers.

4.3.4 For construction of the tie-in to the existing sidewall liner, and where construction joints within the proposed liner were necessary, the CQA Engineer ensured that off-set (stepped) joints were employed.

4.3.5 Throughout the works the only unsuitable materials identified were occasional oversize materials (brickbats and tile fragments), and small quantities of material that became saturated due to heavy rain. All unsuitable materials were removed from the works to the satisfaction of the CQA Engineer.

4.4 Monitoring, Testing and Sampling

4.4.1 A programme of intensive monitoring, testing, and sampling was undertaken by the CQA Engineer during the construction period to check compliance with the requirements of the CQA Plan.

4.4.2 Quality control testing consisted of in-situ shear strength measurements recorded using a hand shear vane. Additionally, cores of compacted clay were taken and subjected to constant head permeability, moisture/dry density and undrained shear strength testing in the laboratory, while bulk samples were taken for classification testing.

4.4.3 The in-situ testing and sampling was undertaken at random locations (within a 20m x 20m reference grid) over the cell and are considered representative of the entire thickness and area of emplaced liner. The volume of clay placed to the engineered clay liner (AEGB + ASL) was approximately 19,234m^3. The in-situ testing and material sampling was undertaken in accordance with the testing and sampling frequencies stated in Table 1 of the CQA Plan.

TABLE 1 : ASSESSMENT OF CONFORMANCE TEST FREQUENCY ACHIEVED (FOR 20,000m^3)

Test Property	Test Frequency	Number of Tests Required	Number of Tests Undertaken
Liquid Limit	1/500 m^3	40	40
Plastic Limit			
Plasticity Index			
Particle Size Distribution			
Clay Content			
Compaction Core	1/250 m^3	80	80
Air Voids	1/250 m^3	80	80
Permeability	1/750 m^3	27	30
Hand Shear Vane	1/250 m^3	80	82

4.4.4 The CQA Engineer did not allow placement of subsequent layers of clay until the previously placed layer had demonstrated the requisite shear strength.

4.5 Assessment of Testing

4.5.1 Testing of the compaction core samples (site, laboratory and permeability core data combined) yielded dry density results of between 1.86 and 2.11 Mg/m^3, together with moisture contents between 10% and 16%. Air voids range from -0.7% to 6.91% (based on a particle density of 2.75 Mg/m^3). The moisture content and density results are summarised in Appendix 4 and presented in Appendix 6-8.

4.5.2 In the course of the previous side-liner construction works, Natural Resources Wales (NRW) suggested that permeability data be obtained for material possessing moisture contents lower than the 12% adopted as the lower moisture content for the engineered clay liner. Accordingly, bulk samples were submitted to the laboratory for permeability determination following remoulding at 10% and 11% moisture content (using the standard 2.5kg Proctor hammer). The results indicate that the Hafod clay is capable of maintaining its low permeability performance down to at least 10% moisture content, suggesting that the occurrence of a limited number of core samples whose moisture content is drier that the 12% lower limit, is acceptable. The data for the remoulded permeability cores are presented in Appendix 8, and summarised in Appendix 4.

4.5.3 Hand shear vane testing of the compacted clay gave results of between 66 kPa and 98 kPa. All the test results are greater than the specified minimum in-situ shear strength of 55 kPa, and were therefore deemed to be acceptable. Hand shear vane measurements are presented in Appendix 5.

4.5.4 Atterberg Limits testing demonstrated an average plasticity index of 14%, which is within the normally-specified range of >10% and <65%. The average liquid limit of 29% was also below the specified maximum of 90%. The range of plastic limits recorded by the laboratory testing is 14% to 16%.

4.5.5 Particle density results ranged from 2.71 Mg/m^3 to 2.77 Mg/m^3.

4.5.6 Particle size distribution analyses indicated an average clay content of 19%, ranging from 11% to 28%. This is greater than the 10% minimum required, and is therefore deemed acceptable. No particles greater than 10.0 mm were recorded.

4.5.7 The laboratory results of the classification testing demonstrate that the material is of a consistent nature, and meets the requirements of the CQA Plan. The laboratory results for the classification testing are summarised in Appendix 4 and presented in Appendix 8.

4.5.8 The laboratory results of the constant head permeability tests from core samples taken from the emplaced clay at locations within a grid across and throughout the full depth of the liner, range between $k=4.50 \times 10^{-10}$ m/s and $k=2.7 \times 10^{-11}$ m/s, with an average permeability of 8.76×10^{-11} m/s. These results demonstrate that the target permeability of $k=1.0 \times 10^{-9}$ m/s was achieved in the field. The results of the constant head permeability testing are summarised in Appendix 4 and presented in Appendix 8.

4.6 Assessment of Procedures

4.6.1 The CQA Engineer monitored all lining material placement and compaction, and was satisfied with the placement methodology and the final quality of the engineered clay liner.

4.6.2 The working procedures adopted throughout the duration of the works, in terms of layer thickness and the numbers of passes of the compaction plant, were in accordance with the CQA Plan and the compaction field trial, and therefore were deemed satisfactory. All the clay material utilised in the construction of the engineered clay liner was placed satisfactorily. All the laboratory testing was undertaken at a laboratory with UKAS accreditation for the tests undertaken. The laboratory details are included with each result sheet presented in the respective appendices.

4.6.3 The CQA Engineer ensured that the engineered clay liner was constructed to the lines and levels shown on the design drawings in conjunction with Cory's appointed surveyor. A topographical survey of the works area was undertaken prior to, and following construction of the ECL. The surveys confirm that a minimum perpendicular thickness of 2000 mm of clay has been laid on the eastern side-slope, with a minimum perpendicular thickness of 1000mm on the other side slopes and basal area of the cell in accordance with the CQA Plan. The thickness of the clay is shown on the as-built drawing presented in Appendix 1.

5 LEACHATE COLLECTION SYSTEM

5.1 General

5.1.1 The leachate collection system for the cell comprised a drainage blanket of clean, hard gravel, supplemented by preferential collection pipework draining to a leachate collection chamber (sump). In addition, two monitoring chambers were constructed within the cell. To provide for replacement of the collection chamber by future retro-drilling, a concrete target pad was also constructed.

5.2 Drainage Blanket

5.2.1 The drainage blanket was sourced from Hendre Quarry in Mold, and comprised a nominal 50mm limestone. This product is coarser than the grading proposed in the CQA Plan (previously, a 30-70mm recycled rail ballast has been used); Cory proposed a modification to the Plan via email dated 8 October 2015; the coarser nature of this material will only assist leachate drainage within the cell, and as there is no geomembrane included with the containment design, there is no requirement to increase the grade of protection geotextile to accommodate the larger grain size.

5.2.2 Three samples of drainage gravel were taken for conformance testing. The ten percent fines content was reported in the range 140-150 kN (minimum 100kN required). The particle size distribution indicates the material is not compliant with the grading previously adopted, being significantly coarser, but is considered acceptable.

5.2.3 The CQA monitored deliveries to site, and supervised the initial placement within the cell. As reported in Section 6 below, the CQA Engineer was not able to undertake the full depth-profiling due to suspension of the works; this was undertaken by the

Quality Engineer during a subsequent visit. The drainage blanket was found to be at or greater than 300mm in thickness, and extended up the eastern side-slope as required.

5.3 Separation Geotextile

5.3.1 To provide a separation layer between the drainage gravel and the underlying clay lining system, a geotextile was installed across all areas of the liner receiving the drainage blanket. This was Terram 1000, a medium non-woven geotextile. It was installed on the prepared base and lower side-slopes of the cell. The CQA Engineer checked that adequate overlaps were achieved (>300mm), and that the geotextile was suitably restrained pending placement of the drainage gravel.

5.3.2 A sample of the geotextile was submitted for testing against the requirements of Table 2; the results confirmed that this material was in accordance with the specified requirements. The laboratory data is presented in Appendix 11, with a summary in Appendix 4.

5.4 Preferential Collection Pipework

5.4.1 A single string of preferential pipework was installed running north-south on the base of the cell. This comprised 180mm PE80 SDR11 perforated pipework, and was delivered in 6m lengths. The deflection calculations are presented in Appendix 15.

5.4.2 The sections of preferential pipework were joined together by butt-fusion techniques; the welding logs for this work are presented in Appendix 15. The welder's training certificate is presented in Appendix 13.

5.5 Target Pad

5.5.1 The target pad was cast in a recess formed in the basal liner, underneath which the liner had been deepened to ensure a minimum 1m thickness, and measured 3m x 3m x 0.3m. It was cast immediately adjacent to the leachate collection chamber slab, to ensure its location at the lowest point of the site.

5.5.2 Concrete was provided by Eco-readymix of Ruabon, and was C25/30 strength. Reinforcement was provided using a steel mesh to the base of the slab

5.6 Leachate Chamber

5.6.1 The three leachate chambers were constructed on basal concrete slabs cast in prepared recesses within the basal liner, underneath which the liner had been deepened to ensure a minimum thickness of 1m beneath the slabs. The slabs measured 3m x 3m x 0.5m.

5.6.2 Concrete was provided by Eco-readymix of Ruabon, and was C25/30 strength. Reinforcement was provided using 25mm steel bar at 200mm centres; these were spot-welded rather than tied; 8mm starter bars were then welded to the basal reinforcement prior to placement.

5.6.3 Once the basal slabs had cured, the preferential pipework was laid over the slab and 1050mm diameter precast concrete rings were placed to a height of 2m above the slab and pipework, with a 300mm diameter twin-wall HDPE core pipe inserted in the centre of the monitoring chambers. The annulus between the HDPE core and the outer precast concrete rings was then filled with concrete, in accordance with the design detail.

5.6.4 For the collection chamber, the 1050mm diameter precast chamber rings formed the inner core, with 1200mm diameter recast concrete chamber rings placed outside. The basal collection pipework was led into the chamber, and then the annulus between the precast rings was filled with concrete, in accordance with the design detail.

6 NON-CONFORMANCES AND THEIR TREATMENT

6.1 Demobilisation of CQA Engineer

6.1.1 At Cory's request, the CQA Engineer was demobilised from site on 21 October 2015, despite construction works being incomplete. The request was due to the wet weather having rendered access by wheeled plant to the cell all but impossible. Works were therefore suspended pending an improvement of ground conditions. At demobilisation, the works remaining to be completed were:

(i) The placement and final trimming of approximately 30% of the leachate drainage blanket; and

(ii) The placement of the pre-cast concrete chamber rings to the three monitoring/collection chambers.

6.1.2 The Quality Engineer attended site by arrangement on 10 December 2015, at which point the drainage blanket placement had been completed, and the chamber rings had been installed on the previously-cast basal slabs. Several trial pits were hand-dug within the drainage blanket, both on the basal area and to the haunching over the preferential pipework, in order to check its depth was satisfactory. All basal trial pits returned depths in excess of 300mm, and haunching depths were found to be in excess of 200mm above the crown of the pipe – all in accordance with the requirements of the CQA Plan.

7 LIAISON WITH AUTHORITIES AND REPORTING

7.1.1 Natural Resources Wales (NRW) was informed of the commencement of work on site and were given the opportunity to visit the site throughout the works to check any aspects of the works.

7.1.2 Informal progress meetings were held between Stratus and Cory site personnel, at which construction, design, and CQA issues were discussed.

7.1.3 As a visual record of the works, the CQA Engineer supervising the works kept on-going photographic records. Appendix 16 represents a selection of photographs showing different aspects of the construction works.

7.1.4 The CQA Engineer maintained daily records throughout the duration of the works. These daily records highlighted any problems encountered, the solutions adopted, and the detailed day-to-day site operations. The daily records are presented in Appendix 17.

8 CONCLUSIONS

8.1.1 PREPARATORY EARTHWORKS – The preparatory earthworks were carried out to the lines and levels indicated on the Design Drawings, and the formation was prepared in accordance with the CQA Plan.

8.1.2 GROUNDWATER COLLECTION SYSTEM – The groundwater collection system was installed in accordance with the Design Drawings. The results of laboratory testing show that the geocomposite incorporated into the works conforms to the requirements of the CQA Plan.

8.1.3 ENGINEERED CLAY LINER – The engineered clay liner has been placed and compacted in accordance with the CQA Plan. All compliance testing indicates that the emplaced clay liner achieves the values specified in the CQA Plan.

8.1.4 The construction of Cell 4 at Hafod Quarry Landfill Site has been carried out satisfactorily and in accordance with the approved CQA Plan.