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Engineering, Environmental & Planning
Consultancy Services

Bryn Posteg Landfill Site

Sundorne Products (Llanidloes) Ltd

Stability Risk Assessment

Addendum No.5

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APPROVAL RECORD

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Project Titles: Bryn Posteg Permit – Regulation 61(1) Notice Response

Bryn Posteg – NRW Permit Variation Application Ref; BU7766IC/V009

Bryn Posteg – Powys County Council Planning Application for Retention of over tipped material.

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APPENDICES

1. INTRODUCTION

1.1 The Site

1.1.1 Bryn Posteg Landfill Site in Llanidloes, Powys is operated by Sundorne Products (Llanidloes) Ltd Trading as Potters Waste Management (Potters) under Environmental Permit EPR/BU7766IC.

1.1.2 Bryn Posteg Landfill Site (the Site) is situated approximately 2.8km south-east of Llanidloes, Powys and is centred at National Grid Reference SN 971 822.

1.1.3 The Site has been developed in the surface void associated with an old lead mine. The Site was operated by Montgomery County Council, later Powys County Council, from 1982 until April 1997, when it was taken over by Evans Logistics, now Potters Waste Management.

1.1.4 The Site previously operated under a Waste Management Licence and was issued with a PPC permit in 2004 (now transferred to Environmental Permit). It is currently operating under Environmental Permit EPR/BU7766IC.

1.2 Report Context

1.2.1 This document has been prepared in support of three submissions which include;

- Bryn Posteg Permit – NRW Regulation 61(1) Notice Response,
- Bryn Posteg – Powys County Council Planning Application for Retention of over tipped material.
- Bryn Posteg – NRW Permit Variation Application Ref; BU7766IC/V009, and

<u>NRW Regulation 61(1) Notice Response</u>

1.2.2 On the 18th January 2018 Natural Resources Wales (NRW) issued a Regulation 61(1) Information Notice pertaining to the Site. Under Schedule 1 NRW requested that that specific information was provided in connection with risks associated with stability of the over tipped landform.

1.2.3 Under Schedule 1 NRW requested that that the following information was presented to NRW by the 18th April 2018;

Submit to Natural Resources Wales a revised Stability Risk Assessment (SRA) that assess the risk(s) on the long-term stability of the land form because of the overtipping. This must also consider the impact of the period of non-compliance with permitted leachate head limits recorded between January 2016 and April 2017.

1.2.4 This Stability Risk Assessment (SRA Addendum No.5) presents details of the over-tipping, the current stability of the resultant landform and assesses the long-term stability of the current landform. The impact of the period of non-compliance with permitted leachate head limits recorded between January 2016 and April 2017 is also considered herein.

Powys County Council Planning Application for Retention of over tipped material.

1.2.5 A Planning Application has been made to Powys County Council for the retention of the over tipped material at the Site and includes for the infilling of areas that are currently low in level to the south of the Site to form an appropriate final profile. The Planning Application also includes for the importation and placement of further soils to restore the Site.

1.2.6 The proposed pre settlement restoration contours and sections through the site showing details of the proposals are shown on Drawing No's 3456-CAU-XX-XX-DR-G-1808.P1and 3456-CAU-XX-XX-DR-G-1813. P3

1.2.7 This Stability Risk Assessment (SRA Addendum No.5) is presented in support of the Planning Application and includes details of the proposed final profile for the Site landform and assesses the long-term stability of the proposed landform.

NRW Permit Variation Application Ref; BU7766IC/V009

1.2.8 Permit Variation Application Ref; BU7766IC/V009 has been submitted to coincide with the above Planning Application in connection with retention of the over tipped material and the development of a final restoration profile.

1.2.9 This Stability Risk Assessment (SRA Addendum No.5) is presented in support of the Permit Variation Application and includes details of the proposed final profile for the Site landform and assesses the long-term stability of the proposed landform.

1.3 Extent of the Over-tipping (NRW Regulation 61(1) Notice Response)

1.3.1 The over-tipping assessed herein and as referenced by NRW in their Schedule 1 pertains to the difference in surface elevation between the survey dated 24th January 2018 (Drawing No. 3456-CAU-XX-XX-DR-G-1808.P1) and the currently approved pre-settlement restoration profile referenced as Drawing No DRWG9.

1.3.2 On the basis of the above survey and pre-settlement restoration profile an isopachyte representation of the difference in levels between the two profiles has been prepared and is presented as Drawing No. 3456-CAU-XX-XX-DR-G-1806 P2.

1.3.3 For ease of reference the area where the levels exceed the pre-settlement profile is shown by the red isopachytes on Drawing No. 3456-CAU-XX-XX-DR-G-1806 P2. The over-tip area is located in the central part of the Site and overlays parts of Phases 3, 4, 5, 7 and 9. The over-tip at its highest exceeds the pre-settlement profile of Drawing No. DRWG9 by circa 12.5m in the central part of the Site.

1.3.4 The impact of the over-tip on the geometry of the landform to January 2018 has been to increase the maximum elevation of the landform to levels in excess of the pre-settlement profile and to form a single mound, whilst increasing the length of the external slopes and steepening the slope gradients to Phases 3 and 9 to the northern and eastern boundaries of the over-tip area.

1.4 Landform Stability

1.4.1 The landform resultant from landfilling and including the over-tip at January 24th 2018 is shown on Drawing No. 3428.CAU.XX.XX.DR.S.1801 P2. Sections through the existing slopes as well as the proposed pre settlement landform are presented on Drawing No's 3428.BP.SRA.5.01.P1, 3428.BP.SRA.5.02.P2, 3428.BP.SRA.5.04.P1, 3428.BP.SRA.5.05.P2 and 3456-CAU-XX-XX-DR-G-1808.P1.

1.4.2 From a landform perspective stability has been assessed in connection with the following areas; the Western perimeter slopes; the Southern Phase 9 slopes, the Northern capped and restored slopes and the Eastern capped but not restored slopes. The location of these slopes is shown on Drawing No. 3428.BPSRA.5.03.P2 with the individual lines of section shown on Drawing No's 3428.BPSRA.5.02.P2 and 3428.BPSRA.5.05.P2.

The Western Perimeter Slopes

1.4.3 The Western perimeter slopes of the Site have been capped and restored in accordance with the SRA Addenda pertinent at the time. It is noted that slip did occur to the western flank more than 10 years ago, but this was caused by a water body at the crest of the slope and was not a result of waste slope or cap instability. The slip was subsequently remediated in an approved manner.

1.4.4 This area is outside the over-tip area has been inspected and no signs of instability were identified. In the light of the above information the capped and restored slopes to the Western boundary are therefore considered to be stable.

1.4.5 The western perimeter slopes are therefore not considered further in this report.

The Southern Phase 9 Slopes

1.4.6 Three types of slopes currently exist in Southern Part of the Site in proximity to Phase 9. These include the long and steep southerly facing waste slopes which have been covered with a temporary geomembrane cap (within what was the operational tipping area); short slopes of exposed waste and around the perimeter to Phase 9 short sections of slope which have been capped with an LLDPE geomembrane (textured) and covered with a protection geotextile. Each of these slope types are discussed separately below.

1.4.7 The long and steep southerly facing waste slopes have occurred as a result of the cessation of the landfilling activities. These slopes bound the former active landfilling area at the Site in Phase 9. These steep slopes would formerly have been considered to temporary slopes which would have been filled against over time to achieve the final pre settlement restoration profile. The covered waste slopes are typically in the order of 100m long at gradients predominantly in the order of 1 in 2 to 1 in 2.3 with localised areas as steep as 1 in 1.8. These slopes are steeper than the 1 in 2.5 gradient detailed in the SRA Addendum 4 and their stability has therefore been assessed herein.

Plate 1; the long and steep southerly facing waste slopes in Phase 9 with the pumped sump at the toe.

1.4.8 The short sections of waste slopes to the southern side of the former operational landfill area have been inspected and are shallower than the 1 in 2.5 gradient detailed in the SRA Addendum 4. On this basis the short sections of waste slopes waste slopes considered to be stable; their stability has therefore not been assessed further herein.

1.4.9 Around the perimeter to Phase 9 short sections of slope were capped in 2017 with an LLDPE geomembrane (textured) and covered with a protection geotextile. These slopes are generally in the order of 30m long and have gradients up to 1 in 2.7 in places which is considerably steeper than the 1 in 6.5 gradient which was detailed as a minimum gradient criteria in SRA Addendum 4 for a stable slope capped with a textured LLDPE geomembrane and a protection geotextile. To accord with the SRA Addendum 4 the steepest slope should be shallower than 1 in 5 and incorporate a Geocomposite Drainage Layer (GDL) on slopes steeper than 1 in 6.5.

Plate 2; Capped Slope to the Phase 9 Southern Boundary.

1.4.10 The stability of these slopes has therefore been assessed within this document.

1.4.11 During the inspection of the Site soil materials were identified which had been placed at the toe of the capped sections of the slopes. These had been placed on the capped slope as a temporary ballast over the anchor trenches and lower slope areas. Since they had not been placed or compacted to a specification these loose materials show some signs of localised instability (see Plate 2) as a result of runoff softening the soils and resulting in the localised sliding of the soils. This localised pockets of soil instability will be addressed as part of the restoration works when they are carried out.

1.4.12 Due to their gradient these short perimeter slopes have been assessed herein.

1.4.13 It is noted that the slopes which have been capped with the LLDPE geomembrane in 2017 have been covered with a Geofabrics HPS3 protection geotextile. This protection material does not comply with the requirements of SRA Addendum A. For steeper slopes a GDL should be installed. The stability of these slopes has therefore been assessed within this document with regards to the existing protection geotextile and a GDL.

The Eastern Capped Slopes

1.4.14 The perimeter slopes (along with a section of the crest of the Site) were capped in 2017 with an LLDPE geomembrane (textured) and covered with a protection geotextile. These slopes are generally in the order of up to 100m long and have gradients up to 1 in 3.5 in places which is considerably steeper than the 1 in 6.5 gradient which was detailed as a minimum gradient criteria in SRA Addendum 4 for a stable slope capped with a textured LLDPE geomembrane and a protection geotextile. To accord with the SRA Addendum 4 the steepest slope should be shallower than 1 in 5 and incorporate a Geocomposite Drainage Layer (GDL) on slopes steeper than 1 in 6.5.

Plate 3; the capped slope to the Eastern boundary of the site covered with the protection geotextile.

1.4.15 The stability of these slopes has therefore been assessed within this document.

1.4.16 During the inspection of the Site soil materials were identified which had been placed at the toe of the capped sections of the slopes. These had been placed on the capped slope as a temporary ballast over the anchor trenches and lower slope areas. Since they had not been placed or compacted to a specification, these loose materials show some signs of localised instability (see Plate 3) as a result of runoff softening the soils and resulting in the localised sliding of the soils. This localised pockets of soil instability will be addressed as part of the restoration works when they are carried out.

1.4.17 Due to their gradient these Eastern perimeter slopes have been assessed herein.

1.4.18 It is noted that the slopes which have been capped with the LLDPE geomembrane in 2017 have been covered with a Geofabrics HPS3 protection geotextile. This protection material does not comply with the requirements of SRA Addendum A. For steeper slopes a GDL should be installed. The stability of these slopes has therefore been assessed within this document with regards to the existing protection geotextile and a GDL.

The Northern Restored Slopes

1.4.19 The Northern slopes referred to herein are shown in 'Red' on Drawing No.3428.BP.SRA.5.03.P2. These slopes were capped and restored from approximately 2009 using an LLDPE textured geomembrane and a GDL (ABG Pozidrain 6S250D).

1.4.20 The northern and slopes to Phases 3 and 9 are shown on Drawing No. 3428.BP.SRA.5.01.P1. They are typically 100m in length with gradients ranging from approximately 1 in 2.7 to 1 in 4.5 over the majority of the area.

1.4.21 These slopes are generally steeper than the gradient for the waste profile detailed in the SRA Addendum 4 and are steeper than the 1 in 5 to 1 in 15 gradients of the pre-settlement profile of Drawing No. DRWG9.

Plate 4; the Northern capped and restored slope.

1.4.22 The extent of the capped and restored northern slope is seen as green to the right side of the landform on Plate 5 below.

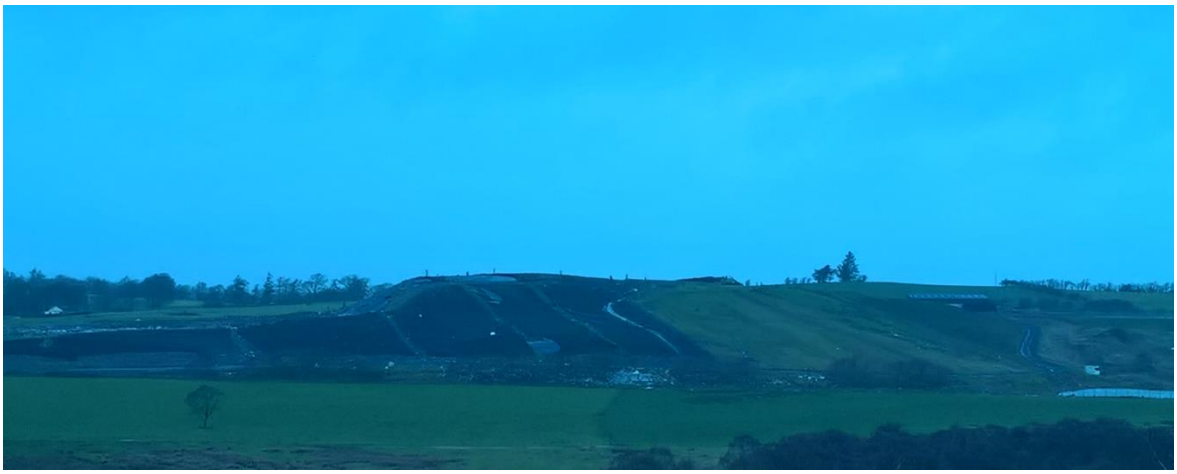

Plate 5; Eastern and Northern Slopes.

1.4.23 During the inspection of the Site no signs of instability were observed in connection with the northern slopes, however they are steeper than the criteria stated in SRA Addendum 5. The long term stability of the northern slopes are therefore assessed in this report below.

Drainage from Capped Areas to the Northern, Eastern and Southern slopes

1.4.24 On the basis of the inspection and discussions with the Site operator it is apparent that the GDL to the Northern slope and the protection geotextile to the Eastern and Southern slopes terminate in the capping anchor trench which does not include a drain for the collected water at the soils / LLDPE capping geomembrane interface.

1.4.25 Consequently any water percolating through the restoration soils will become trapped at the interface resulting in saturation of the overlying soils and the potential for instability. Whilst it is noted that the clay restoration material used at the Site will exhibit a permeability in the order of 10^{-10} m/sec (based on the results of the clay used for lining the landfill cells), water will percolate and collect in the anchor trench and along the upper surface of the capping geomembrane.

1.4.26 In order to provide long term stability the capped slopes must drain: a collection drain will therefore need to be installed at the toe of the capped slopes to collect and drain the water from the slopes. For the purposes of this SRA a saturated soil condition has been used to

reflect the current situation without drainage and further assessments carried out to reflect the situation once the drain has been installed.

1.5 The Impact of the Period of Non-Compliance with Permitted Leachate Head Limits

1.5.1 The period of non-compliance with permitted leachate head limits was recorded between January 2016 and April 2017.

1.5.2 The 10m maximum leachate head associated with this period would have resulted in a level of approximately 317mAoD. The lowest point on the perimeter of the site is approximately 318.5mAoD providing a freeboard of approximately 1.5m. Whilst perched leachate is always a common feature associated with landfill due to the nature and thickness of temporary caps and cover materials; it is likely that the leachate mass associated with the period of non-compliance was contained at levels below the rim of the Site and therefore below surrounding ground level and the toe of the external slopes. As such these increased and non-compliant leachate levels would not have come into contact and would not have impacted on the capped and restored perimeter waste slopes.

1.5.3 To assess the potential impact of the non-compliant leachate levels (and specifically perched leachate) on the stability of the slope; each of the waste slope sections analysed in this assessment has been set up to include a range of piezometric leachate levels.

2. STABILITY RISK ASSESSMENT

2.1 Context

2.1.1 The Stability Risk Assessment included in the Permit Application for the Site allowed for two capping options. One option was a 1m thick clay liner covered by 1m of restoration soils and the other was a 1mm thick welded LLDPE geomembrane.

2.1.2 In April 2005 Sundorne Products (Llanidloes) Ltd, the Permit holder, appointed Egniol Ltd to re-assess the stability calculations for the LLDPE option and to assess the stability of the mineral option but with the clay replaced by a geosynthetic clay liner (GCL). This assessment was presented in their report titled, 'Stability Risk Assessment – Capping; Addendum 4'; hereafter referred to as 'SRA Addendum 4'.

2.1.3 Subsequent capping activities at the Site, and those specifically related to the over-tipped Northern, Eastern and Southern perimeter slopes, were carried out using the LLDPE option presented in SRA Addendum 4.

2.1.4 The capping and restoration works to the perimeter slopes of Phases 3 and 9 were carried out from 2009; on slopes steeper than 1 in 5 contrary to the criteria in SRA Addendum 4. Additionally the most recent capping works undertaken in 2017 included the use of a protection geotextile which in accordance with SRA Addendum 4 should only have been used on slopes shallower than 1 in 6.5.

2.1.5 Over the past 9 years these perimeter slopes have not shown signs of instability.

2.1.6 The over-tip has created longer and steeper slopes to Phases 3 and 9 than those assessed under SRA Addendum 4. The use of materials not in accordance with the requirements of SRA Addendum 4, the lack of drainage from the toe of the slopes and the impact of the cessation of landfilling activities have resulted in slopes which need to be assessed in order to determine their current and long term stability.

2.1.7 Additionally, it is considered that the assumed interface characteristics and material parameters used in the modelling to support the SRA Addendum 4 were extremely conservative.

2.1.8 To assess the stability of the current slopes and those proposed as part of the Planning Application, a number of sections have been identified for the relevant slopes which

represent the steepest sections. Using the January 24th 2018 survey the ground profile at these locations has been used to initially model the stability of the waste profile (under varying leachate head conditions) and subsequently to develop models for assessing the stability of the capping system (installed and / proposed). To thoroughly assess the stability of the slopes, shear box testing has been carried out using the materials installed as well as those proposed for future capping works.

2.1.9 The capping system to the capped and restored Northern slope comprised a textured LLDPE geomembrane overlain by a GDL (ABG Pozidrain 6S250D) and covered with restoration soils up to 1m thick.

2.1.10 The capping system to the capped Eastern and Southern perimeter slopes in 2017 (including the crest of the Site) comprised a textured LLDPE geomembrane overlain by a protection geotextile (Geofabrics HPS3) this has been supported at the toe by soils which will subsequently be reused in the restoration soil cover. It is proposed that the protection geotextile be removed and replaced by a GDL (an ABG Pozidrain G4SD product or similar) with enhanced stability characteristics (details of the G$SD product is provided in Appendix 12).

2.1.11 Subsequent capping works following the development of the proposed pre settlement restoration profile will be carried out using a textured LLDPE geomembrane overlain by a GDL (an ABG Pozidrain G4SD product or similar) with enhanced stability characteristics.

This report describes the derivation of the input parameters to the stability analyses, the method of analysis and discusses the results.

2.2 Risk Screening

Waste Mass Screening

2.2.1 The current waste mass profiles at each of the section lines has been assessed prior to assessing the stability of the capping system above.

Capping System Screening

The stability of the current LLDPE capping systems incorporating a protection geotextile (to the eastern and Southern slopes) will be assessed.

2.2.2 The stability of the current LLDPE capping systems incorporating a GDL (to the Northern slopes) will be assessed.

2.2.3 The stability of the proposed LLDPE capping systems incorporating a GDL (to the Eastern and Southern slopes) will be assessed.

Lifecycle Phases

2.2.4 No change

Data Summary

2.2.5 Site specific interface shear box test was carried out to determine the parameters used in the analysis. Where this information was not available test based values were provided by ABG from other landfill sites the details are presented in Appendices 1 and 11.

Justification of Modelling Approach and Software

2.2.6 To assess the stability of the current slopes and those proposed as part of the Planning Application, a number of sections have been identified for the relevant slopes which represent the steepest sections. Using the January 24th 2018 survey the ground profile at these locations has been used to initially model the stability of the waste profile (under varying leachate head conditions) and subsequently to develop models for assessing the stability of the capping system (installed and / proposed). To thoroughly assess the stability of the slopes, shear box testing has been carried out using the materials installed as well as those proposed for future capping works.

2.2.7 Waste slope models were developed and analysed using a recognised commercial software package – Slope/w, the capping system was analysed using veneer covered slope calculation sheets as used in SRA Addendum 4 (no change)

Justification of Geotechnical Parameters Selected for Analysis

2.2.8 Site specific interface shear box test was carried out to determine the parameters used in the analysis. Where this information was not available test based values were provided by ABG from other landfill sites the details are presented in Appendices 1 and 11.

2.2.9 The parameters used are presented in Table 1.

Parameters Selected for Waste and Capping Analysis

2.2.10 The parameters selected for waste and capping analysis are presented below in Table 1.

2.2.11 To assess the potential effects of leachate head variations piezometric surfaces were used.

Interface	Interface Adhesion α(kN/m^2)	Interface Friction δ(˚)	Dry Density (kN/m^3)	Saturated Density (kN/m^3)	Location	Comments
Waste (Landfilled)			11.0		Present under the Green, Red, Blue and Yellow areas shown on Dwg No. 3428-BP-SRA-5-03 P2.	
Clay Formation			18.0	21.0	Present under the Green, Red and Blue areas shown on Dwg No. 3428-BP-SRA-5-03 P2.	Measured and as reported in Addenda 3 and 4
Clay Formation / LLDPE (Textured|)	0	30			Present over the Red and Blue areas shown on Dwg No. 3428-BP-SRA-5-03 P2	Measured and as reported in Addenda 3
Non woven Protector Geotextile (HPS3 / GPT3) / LLDPE (Textured|)	1	40			Currently installed over the Blue area shown on Dwg No. 3428-BP-SRA-5-03 P3; The Geotextile will be removed will be removed and replaced with a GDL (Pozidrain G4SD)	Measured (ABG) see Appendix 11
GDL (Pozidrain 6S250D) / LLDPE (Textured|)	4	27			Currently installed over the red area shown on Dwg No. 3428-BP-SRA-5-03 P3.	Measured (ABG) see Appendix 11
GDL (Pozidrain G4SD) / LLDPE (Textured|)	4	27			Proposed to be installed over the Blue and the Yellow (uncapped) areas shown on Dwg No. 3428-BP-SRA-5-03 P3.	Measured (ABG) see Appendix 11
Cover Soils / Non woven Protector Geotextile (HPS3)	1.9	42.7			Combination not currently installed at the site; The Geotextile has been installed over the Blue area as shown on Dwg No. 3428-BP-SRA-5-03 P3.	Measured see Appendix 1
Cover Soils / GDL (Pozidrain 6S250D)	10.4	36.5			Currently installed to the Green and Red areas shown on Dwg No. 3428-BP-SRA-5-03 P3.	Measured see Appendix 1
Cover Soils / GDL (Pozidrain G4SD)	23.1	35			Proposed to be installed over the Blue and the Yellow (uncapped) areas shown on Dwg No. 3428-	Measured see Appendix 1
Cover Soils	0	30	18		Currently installed to the Green and Red areas shown on Dwg No. 3428-BP-SRA-5-03 P3.	Measured see Appendix 1

Table 1; Parameters selected for waste and capping analysis

2.3 Analysis

Waste Analysis

2.3.1 The slope sections were analysed using slope/w

Phase 9 'Temporary' Waste Slopes

2.3.2 The results of the waste analysis for the temporary waste slopes are presented in Table 2 and the models in Appendices 2 and 3.

Table 2 Summary of the Waste Slope Modelling Details and Results — Sections T1 to T2

Model	Section	Assumed Cell Base (mAoD)	Toe of Slope (mAoD)	Assumed Leachate Location	Assumed Leachate Level	Leachate Head (m)	Slope FOS	Applicable FOS if Maximum Leachate Head Was 10m	Steepest Part of Slope	Shallowest Part of Slope	Most of Slope	Slope Gradient Used For Cap Stability Model
T 1.1	T1	307	323	None	n/a	0	1.480	1.480	>1 in 2.0	1 in 7.0	1 in 2.0	n/a Temporary Slope
				Toe -1m	322	15	1.446					
	Length (m)			Toe	323	16	1.333					
				Toe +1m	324	17	1.234					
	100			Toe +2m	325	18	1.172					
T 2.1	T2	307	322	None	n/a	0	1.389	1.389	1 in 2.3	1 in 5.0	1 in 2.3	n/a Temporary Slope
				Toe -1m	321	14	1.284					
	Length (m)			Toe	322	15	1.187					
				Toe +1m	323	16	1.147					
	120			Toe +2m	324	17	1.119					

2.3.3 A water body exists at the toe of these waste slopes. It is considered likely that this is a result of runoff into this low point in the former operational area. The water body is unlikely to be leachate as this would imply a leachate head of 16m at this location which is significantly in excess of the 10m reported and requiring assessment by NRW. Assuming worse case conditions with perched leachate at the toe of the slope the Factor of Safety (FOS) determined for the waste slope sections T1 and T2 was 1.33 for T1 and 1.187 for T2.

2.3.4 On the basis of the above results the current long and steep waste slopes (which face south) in Phase 9 are considered to be short term stable and will require to be filled against to create a stable profile.

2.3.5 The infilling of waste against these slopes as proposed in the Planning and Permit Variation applications will develop shallower and long term stable waste slopes of approximately 1 in 5 or shallower (in line with the analysis carried out in SRA Addendum 4).

Currently Capped Waste Slopes

Sections C1 and C2

2.3.6 Sections C1 and C2 are located on the steepest sections of the Northern slope which has been capped and restored.

2.3.7 The results of the analysis are presented in Table 3 and the models in Appendices 4 and 5.

2.3.8 Assuming a worst case scenario that there is perched leachate at the toe of each slope the FOS determined for Sections C1 and C2 were 1.459 and 1.948 respectively. On the basis of the results the current Northern waste slopes in Phase 3 and 9 exceed a FOS of 1.3 and are considered to be long term stable.

Section C3

2.3.9 Section C3 is located on the steepest sections of the Southern slope which has been capped and restored for more than 10 years. Due to the gradient of the profile a check of the waste slope stability was carried out using Section C3. The results of the analysis are presented in Table 3 and the models in Appendix 6.

2.3.10 Assuming a worst case scenario that there is perched leachate at the toe of the slope the FOS determined for Sections C1 was 1.948. On the basis of this result the currently capped and restored section of the south west boundary to Phase 9 exceeded the FOS of 1.3 and is considered to be long term stable.

Sections C4 and C5

2.3.11 Sections C4 and C5 are located on the steepest sections of the Southern and Eastern slopes which has been capped with LLDPE and covered with a protection geotextile but not covered with restoration soils.

2.3.12 The results of the analysis are presented in Table 3 and the models in Appendices 7 and 8.

2.3.13 Assuming a worst case scenario that there is perched leachate at the toe of each slope the FOS determined for Sections C4 and C5 were 2.184 and 1.949 respectively. On the basis of the results the current eastern and southern slopes in Phase 9 exceed a FOS of 1.3 and are considered to be long term stable.

Table 3	Summary of the Waste Slope Modelling Details and Results									Sections C1 to C5		
Model	**Section**	**Assumed Cell Base (mAoD)**	**Toe of Slope (mAoD)**	**Assumed Leachate Location**	**Assumed Leachate Level**	**Leachate Head (m)**	**Slope FOS**	**Applicable FOS if Maximum Leachate Head Was 10m**	**Steepest Part of Slope**	**Shallowest Part of Slope**	**Most of Slope**	**Slope Gradient Used For Cap Stability Model**
C 1.1	**C1**	310	322	None	n/a	0	1.874	1.874	1 in 2.7	1 in 4.0	1 in 3.1	1 in 3.0
				Toe -1m	321	11	1.582					
	Length (m)			Toe	322	12	1.459					
				Toe +1m	323	13	1.343					
	87			Toe +2m	324	14	1.229					
C 2.1	**C2**	310	323	None	n/a	0	2.262	2.262	1 in 3.5	1 in 4.7	1 in 3.5	1 in 3.0
				Toe -1m	322	12	1.836					
	Length (m)			Toe	323	13	1.745					
				Toe +1m	324	14	1.582					
	92			Toe +2m	325	15	1.446					
C 3.1	**C3**	310	323	None	n/a	0	2.248	2.248	1 in 2.1	1 in 2.3	1 in 2.1	N/A
				Toe -1m	322	12	2.248					
	Length (m)			Toe	323	13	1.948					
				Toe +1m	324	14	1.583					
	15			Toe +2m	325	15	1.283					
C 4.1	**C4**	307	325	None	n/a	0	2.328	2.328	1 in 3.5	1 in 4.7	1 in 3.5	1 in 3.5
				Toe -1m	324	17	2.269					
	Length (m)			Toe	325	18	2.184					
				Toe +1m	326	19	2.101					
	97			Toe +2m	327	20	2.012					
C 5.1	**C5**	307	326	None	n/a	0	2.640	2.64	1 in 2.7	1 in 4.4	1 in 4.3	1 in 2.7
				Toe -1m	325	18	2.278					
	Length (m)			Toe	326	19	1.949					
				Toe +1m	327	20	1.637					
	30			Toe +2m	328	21	1.371					

Sections F1 and F2

2.3.14 Sections F1 and F2 are located on the infilled Southern slope which will be created by waste inputs into phase 9 (and adjacent areas) to achieve the proposed pre settlement profile which will subsequently be capped with LLDPE and a GDL before being covered with restoration soils.

2.3.15 The results of the analysis are presented in Table 4 and the models in Appendices 9 and 10.

2.3.16 Assuming a worst case scenario that the slope profile is at a gradient of 1 in 5; slope the FOS determined for Sections F1 and F2 were 1.480 and 1.389 respectively. On the basis of the results the proposed slopes at a worst case gradient of 1 in 5 exceed a FOS of 1.3 and are therefore considered to be long term stable.

Table 4	Summary of the Waste Slope Modelling Details and Results								Sections F1 to F2			
Model	**Section**	**Assumed Cell Base (mAoD)**	**Toe of Slope (mAoD)**	**Assumed Leachate Location**	**Assumed Leachate Level**	**Leachate Head (m)**	**Slope FOS**	**Applicable FOS if Maximum Leachate Head Was 10m**	**Steepest Part of Slope**	**Shallowest Part of Slope**	**Most of Slope**	**Slope Gradient Used For Cap Stability Model**
F1.1	**F1**	307	330	None	n/a	0	1.480	1.480	1 in 5	1 in 14	1 in 6.5	1 in 5
				Toe -1m	329	22	n/a					
	Length (m)			Toe	330	23	n/a					
				Toe +1m	331	24	n/a					
	120			Toe +2m	332	25	n/a					
F2.1	**F2**	307	330	None	n/a	0	1.389	1.389	1 in 5	1 in 14	1 in 11.5	1 in 6
				Toe -1m	329	22	n/a					
	Length (m)			Toe	330	23	n/a					
				Toe +1m	331	24	n/a					
	227			Toe +2m	332	25	n/a					

Capping Analysis

Currently Capped and Restored Waste Slopes

Sections C1 and C2

2.3.17 Sections C1 and C2 are located on the steepest sections of the Northern slope which has been capped and restored but has not got a drain installed at the toe to serve the GDL.

2.3.18 The results of the analysis are presented in Table 5 and the models in Appendices 4 and 5.

2.3.19 To represent the current situation slope gradients of 1 in 2.7 and 1 in 3 have been analysed with saturation depths of the cover soils at 1.0m and 0.7m. For both sections C1 and C2 the critical plane of failure was at the LLDPE / GDL interface. The FOS for the current situation was the same for both sections with the lowest FOS being 1.28.

2.3.20 To represent the final situation after the toe drain has been installed saturation depths of the cover soils at 0.2m and 0.4m for the slope gradients of 1 in 2.7 and 1 in 3 have been analysed. For both sections C1 and C2 the critical plane of failure was at the Formation / LLDPE interface. The lowest FOS for the final situation after the toe drain has been installed was 1.57.

2.3.21 On the basis of the results of the analysis the capped and restored Northern slope will not achieve a FOS in excess of 1.3 and be long term stable unless a toe drain is installed to the slope to serve the GDL.

Table 5	Summary of the Capped Slope Modelling Details and Results						
						Section C1	
Model	**Situation**	**Section**	**Slope Gradient Used For Cap Stability Model**	**Saturated Thickness (m)**	**Critical Interface**	**Critical Interface FOS**	**Soils / GDL Interface FOS**
C1.2a1	**Current**	C1	1 in 3	1.0	LLDPE/GDL	1.41	1.41
C1.2a2	**Current**		1 in 3	0.7	LLDPE/GDL	1.66	1.41
C1.2a1	**Post Drain & Final**		1 in 3	0.4	Formation / LLDPE	1.74	1.91
C1.2a2	**Post Drain & Final**		1 in 3	0.2	Formation / LLDPE	1.74	2.08
C1.2b1	**Current**		1 in 2.7	1.0	LLDPE/GDL	1.28	1.28
C1.2b2	**Current**		1 in 2.7	0.7	LLDPE/GDL	1.50	1.50
C1.2b1	**Post Drain & Final**		1 in 2.7	0.4	Formation / LLDPE	1.57	1.72
C1.2b2	**Post Drain & Final**		1 in 2.7	0.2	Formation / LLDPE	1.57	1.88
						Section C2	
Model	**Situation**	**Section**	**Slope Gradient Used For Cap Stability Model**	**Saturated Thickness (m)**	**Critical Interface**	**Critical Interface FOS**	**Soils / GDL Interface FOS**
C2.2a1	**Current**	C2	1 in 3	1.0	LLDPE/GDL	1.41	1.41
C2.2a2	**Current**		1 in 3	0.7	LLDPE/GDL	1.66	1.41
C2.2a1	**Post Drain & Final**		1 in 3	0.4	Formation / LLDPE	1.74	1.91
C2.2a2	**Post Drain & Final**		1 in 3	0.2	Formation / LLDPE	1.74	2.08
C2.2a1	**Current**		1 in 2.7	1.0	LLDPE/GDL	1.28	1.28
C2.2a2	**Current**		1 in 2.7	0.7	LLDPE/GDL	1.50	1.50
C2.2a1	**Post Drain & Final**		1 in 2.7	0.4	Formation / LLDPE	1.57	1.73
C2.2a2	**Post Drain & Final**		1 in 2.7	0.2	Formation / LLDPE	1.57	1.88

Currently Capped but Not Restored Waste Slopes

Section C4

2.3.22 Sections C4 is located on the steepest sections of the Eastern slope which has been capped (and covered with a protection geotextile) but not restored and has not got a drain installed at the toe to serve the GDL.

2.3.23 The results of the analysis are presented in Table 6 and the models in Appendix 7.

2.3.24 To represent the current situation slope gradients of 1 in 3.5 and 1 in 3 have been analysed with saturation depths of the cover soils at 1.0m and 0.7m. For section C4 the critical plane of failure was at the LLDPE / Geotextile interface with a saturation depth of 1.0m and at the same for both the LLDPE/Geotextile & Formation / LLDPE interfaces at a saturation depth

of 0.7m. The lowest FOS for the current situation was the same for both sections with the lowest FOS being 1.33.

2.3.25 If the geotextile was left in place the flow characteristics of the geotextile would not be sufficient to reduce the saturation depth in the cover soils significantly. Therefore the FOS of 1.33 would not only represent the current situation but also the final situation post drain installation if it was left in place.

2.3.26 On the basis of the results of the analysis the slope capped and covered with the geotextile will marginally achieve a FOS in excess of 1.3 and be long term stable if a toe drain is installed to the slope to serve the GDL.

2.3.27 To represent the final proposed situation after geotextile has been replaced with the GDL and the toe drain has been installed saturation depths of the cover soils at 0.2m and 0.4m for the slope gradients of 1 in 3.5 and 1 in 3 have been analysed. For both sections slope gradients the critical plane of failure was at the Formation / LLDPE interface. The lowest FOS for the final situation after the toe drain has been installed was 1.74.

2.3.28 On the basis of the results of the analysis the geotextile should be removed from the capped areas and a GDL installed together with a toe drain. The resultant capping system will then achieve a FOS in excess of 1.3 and be stable in the long term.

Table 6	Summary of the Capped Slope Modelling Details and Results						
						Section C4	
Model	**Situation**	**Section**	**Slope Gradient Used For Cap Stability Model**	**Saturated Thickness (m)**	**Critical Interface**	**Critical Interface FOS**	**Soils / Geotextile Interface FOS**
C4.2a1	**Current, Post Drain & Final if Geotextile Retained and Soils Placed on Top**	C4	1 in 3.5	1.0	LLDPE/Geotextile	1.55	1.55
C4.2a2			1 in 3.5	0.7	LLDPE/Geotextile & Formation / LLDPE	2.03	2.03
C4.2b1	**Current, Post Drain & Final if Geotextile Retained and Soils Placed on Top**		1 in 3.0	1.0	LLDPE/Geotextile	1.33	1.33
C4.2b2			1 in 3.0	0.7	LLDPE/Geotextile & Formation / LLDPE	1.74	1.74
						Section C4	
Model	**Situation**	**Section**	**Slope Gradient Used For Cap Stability Model**	**Saturated Thickness (m)**	**Critical Interface**	**Critical Interface FOS**	**Soils / GDL Interface FOS**
C4.2c1	**Post Drain & Final With GDL Installedand Soils Placed on Top**	C4	1 in 3.5	0.4	Formation / LLDPE	2.03	2.22
C4.2c2			1 in 3.5	0.2	Formation / LLDPE	2.03	2.41
C4.d1	**Post Drain & Final With GDL Installedand Soils Placed on Top**		1 in 3.0	0.4	Formation / LLDPE	1.74	1.91
C4.2d2			1 in 3.0	0.2	Formation / LLDPE	1.74	2.08

Section C5

2.3.29 Sections C5 is located on a section of the Southern slope which has been capped (and covered with a protection geotextile) but not restored and has not got a drain installed at the toe to serve the GDL.

2.3.30 The results of the analysis are presented in Table 7 and the models in Appendix 8.

2.3.31 To represent the current situation slope gradients of 1 in 2.7 and 1 in 3 have been analysed with saturation depths of the cover soils at 1.0m and 0.7m. For section C5 the critical plane

of failure was at the LLDPE / Geotextile interface with a saturation depth of 1.0m and at the same for both the LLDPE/Geotextile & Formation / LLDPE interfaces at a saturation depth of 0.7m. The lowest FOS for the current situation was the same for both slope sections with the lowest FOS being 1.35.

2.3.32 If the geotextile was left in place the flow characteristics of the geotextile would not be sufficient to reduce the saturation depth in the cover soils significantly. Therefore the FOS of 1.35 would not only represent the current situation but also the final situation post drain installation if it was left in place.

2.3.33 On the basis of the results of the analysis the slope capped and covered with the geotextile will marginally achieve a FOS in excess of 1.3 and be long term stable if a toe drain is installed to the slope to serve the GDL.

2.3.34 To represent the final proposed situation after geotextile has been replaced with the GDL and the toe drain has been installed saturation depths of the cover soils at 0.2m and 0.4m for the slope gradients of 1 in 2.7 and 1 in 3 have been analysed. For both sections slope gradients the critical plane of failure was at the Formation / LLDPE interface. The lowest FOS for the final situation after the toe drain has been installed was 1.59.

2.3.35 On the basis of the results of the analysis the geotextile should be removed from the capped areas and a GDL installed together with a toe drain. The resultant capping system will then achieve a FOS in excess of 1.3 and be stable in the long term.

Table 7	Summary of the Capped Slope Modelling Details and Results						
						Section C5	
Model	**Situation**	**Section**	**Slope Gradient Used For Cap Stability Model**	**Saturated Thickness (m)**	**Critical Interface**	**Critical Interface FOS**	**Soils / Geotextile Interface FOS**
C5.2a1	**Current, Post Drain & Final if Geotextile Retained and Soils Placed on Top**	C5	1 in 2.7	1.0	LLDPE/Geotextile	1.22	1.22
C5.2a2			1 in 2.7	0.7	LLDPE/Geotextile & Formation / LLDPE	1.59	1.59
C5.2b1	**Current, Post Drain & Final if Geotextile Retained and Soils Placed on Top**		1 in 3.0	1.0	LLDPE/Geotextile	1.35	1.35
C5.2b2			1 in 3.0	0.7	LLDPE/Geotextile & Formation / LLDPE	1.77	1.77
						Section C 5	
Model	**Situation**	**Section**	**Slope Gradient Used For Cap Stability Model**	**Saturated Thickness (m)**	**Critical Interface**	**Critical Interface FOS**	**Soils / GDL Interface FOS**
C5.2c1	**Post Drain & Final With GDL**	C5	1 in 2.7	0.4	Formation / LLDPE	1.59	2.24
C5.2c2			1 in 2.7	0.2	Formation / LLDPE	1.59	2.44
C5.d1	**Post Drain & Final With GDL**		1 in 3.0	0.4	Formation / LLDPE	1.77	1.93
C5.2d2			1 in 3.0	0.2	Formation / LLDPE	1.77	2.10

Future Capping Works

2.3.36 Future capping works will be carried out using LLDPE (textured) with a suitable GDL in accordance with the proposals detailed in the Application and to the pre settlement profile proposed.

3. ASSESSMENT

3.1 The installation of a toe drain to the currently capped and restored northern slope will result in a long term stable FOS in excess of 1.3.

3.2 The installation of a toe drain and the replacement of the protection geotextile with a GDL to the currently capped but not restored eastern and southern slopes will result in a long term stable FOS in excess of 1.3.

3.3 The support of waste is needed to the currently steep and uncapped 'temporary' slopes in Phase 9. The reprofiling of this slope by infilling waste against them will result in a long term stable FOS in excess of 1.3 and achieve the proposed pre settlement restoration profile.

3.4 The over-tip has therefore not resulted in an increased potential for the Site to pollute the environment on stability grounds.

Recommendations

3.5 A toe drain is installed to the northern, eastern and southern capped slopes.

3.6 The protection geotextile is removed from the LLDPE cap and replaced with a GDL.

3.7 The Phase 9 area is infilled with waste to achieve the proposed pre settlement profile.

DRAWINGS

3428.BP.SRA.5.01.P1	Site Survey of 24.01.2018 (with cross section lines)
3428.BP.SRA.5.02.P2	Proposed Restoration Contours (with cross section lines)
3428.BP.SRA.5.03.P2	Capping Areas at 24.01.2018 Survey
3428.BP.SRA.5.04.P1	Site Sections Drawing on 24.01.2018 Survey
3428.BP.SRA.5.05.P2	Site Sections Drawing on Proposed Restoration Contours
3456-CAU-XX-XX-DR-G-1806 P2	Survey and Drwg 9 of Isopachyte Between Jan2018 Planning Permission Ref M/2004/1362
3456-CAU-XX-XX-DR-G-1808.P1	Jan2018 Survey Sections Drawing
3456-CAU-XX-XX-DR-G-1813. P3	Proposed Restoration Contours
3428.CAU.XX.XX.DR.S.1801.P2	Site Survey at 24.01.2018

APPENDICES

Appendix 1	Shear Box Test Results
Appendix 2	Section T1; Slope Modelling Results
Appendix 3	Section T2; Slope Modelling Results
Appendix 4	Section C1; Slope Modelling Results
Appendix 5	Section C2; Slope Modelling Results
Appendix 6	Section C3; Slope Modelling Results
Appendix 7	Section C4; Slope Modelling Results
Appendix 8	Section C5; Slope Modelling Results
Appendix 9	Section F1; Slope Modelling Results
Appendix 10	Section F2; Slope Modelling Results
Appendix 11	ABG Infinite Slope Model Results
Appendix 12	Pozidrain G Specification and Technical Justification Details