GEOTECHNICAL

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TETRA TECH LIMITED

HARLESTONE INERT LANDFILL

ENVIRONMENTAL PERMIT APPLICATION

Stability Risk Assessment Report

GEC JOB NO: GE220041301

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1.0 INTRODUCTION

Report Context

1.1 The operator of the installation is Mick George Ltd. (MGL).

1.2 Tetra Tech Ltd. have instructed Geotechnical & Environmental Consulting Ltd. (GEC) to undertake a Stability Risk Assessment (SRA) to form part of an Environmental Permit Application for the Harlestone Inert Landfill.

1.3 This environmental permit application is for the permanent placement of inert material within the void formed by the former mineral extraction works.

1.4 The following documents and drawings have been supplied by the Client and referred to in the compilation of this Report:-

- Harlestone Environmental Permit Application Environmental Setting and Site Design. Tetra Tech Report No. B027237 – May 2024;
- Harlestone Environmental Permit Application Hydrogeological Risk Assessment. Tetra Tech Report No. 784- B027237 - May 2024;
- Harlestone Environmental Permit Application Operating Techniques. Tetra Tech Report No. B027237 – May 2024;and
- Harlestone Quarry – Restoration Masterplan, Drawing No. H40/2/22/04 Restoration Plan DHS3/10 - January 2023.

1.5 This Report has been completed in conjunction with the Environmental Setting and Site Design Report (ESSD) (May 2024). It is not a standalone document and factual data related to the site, its setting and receiving environment are located in the ESSD and referred to in this document. All drawings referred to in this SRA are to be found in the ESSD unless otherwise stated.

1.6 This document has been prepared in accordance with the Stability Risk Assessment Report Template (Version 1 – March 2010).

Conceptual Stability Site Model

Location

1.7 This Stability Risk Assessment refers to the area that is included within the Environmental Permit Application boundary shown on Drawing No. H40 2 22 02 and covers the area known as Harlestone Quarry.

1.8 Harlestone Quarry is located approximately 5.4km northeast from the city centre of Northampton and is centred at approximate National Grid Reference (NGR) SP 70652 63914.

1.9 Access to the site will be gained via an unnamed road off Harlestone Rd located to the south east of the site. The immediate surroundings of the site is predominantly agricultural with an area of deciduous woodland to the north and an inert landfill site to the south known as Harlestone Quarry which is currently regulated under an environmental permit (reference EPR/VP3592NN) that’s registered to Barton Plant Limited.

1.10 The south of the application site is located adjacent to an authorised inert landfill, Harlestone Quarry (Reference EPR /WP3235SN/A001). Furthermore, the site is adjacent to the south east of a historic quarry which was in operation from 1880-1990 and was deemed disused in the 1930s.

1.11 A volume of 530,000m^3 cubic metres of imported material (or 848,000 tonnes using a conversion factor of 1.6m^3/tonne) is required to restore the site and it is proposed that up to 200,000 tonnes of material would be brought to the site each year over a course of 4 years.

Solid Geology

1.12 With reference to British Geological Survey the Site is underlain by the Northampton Sand Formation consisting of sandstone, limestone and ironstone. The Northampton Sand Formation is generally underlain by mudstones of the Whitby Mudstone Formation. Boreholes drilled around the periphery of the Site proved the presence of both ironstone and sandstone beneath a weathered sandstone horizon.

Superficial Geology

1.13 The geological map does not record any superficial deposits at the site.

Structural Geology

1.14 There are no structural features that are likely to affect the stability of the site within 500m.

Local Geology

1.15 Six monitoring boreholes have been installed at the Site. Borehole locations and logs are included at Appendix A.

1.16 It is apparent from the geological boreholes That the geological sequence to the base of Boreholes 1-6 is dominated by ironstone with a thickness of 5.6 m to 11.5 m. The thickness of the underlying sandstone ranged from 1.3 m - 3.4 m. The base of mineral, defined as the base of the lower sandstone unit, is shown as base of mineral contours on application Drawing No. 204.

1.17 Superficial deposits are shown to be largely absent across the site and there is no evidence of any shallow mine activities beneath the site.

Hydrology

1.18 Within the wider site area, the following surface water features are located: a pond approximately 430m northwest of the site, the Day (Dumble) Brook approximately 800m east, the Lambley

Dumble located approximately 1.2km southeast and the Day Brook approximately 2.7km southwest.

1.19 According to the Flood Map for Planning Service (FMPS), the application site is not situated in an area at risk of flooding.

Hydrogeology

1.20 The Northampton Sand Formation is designated a Secondary A Aquifer by the Environment Agency. The absence of superficial cover leads to a high groundwater vulnerability classification.

1.21 Monitoring boreholes at the Site demonstrate the presence of groundwater towards the base of the Northampton Sand Formation. The depth of groundwater above the base of mineral is approximately 3 m at the southern Site boundary, reducing to 0.25 m at the northern Site boundary. Groundwater is therefore present in the lower sandstone unit and the base of the overlying ironstone.

1.22 Groundwater monitoring data demonstrates that, with the exception of Borehole BH6, groundwater levels across the Site have shown minimal seasonal variation during the monitoring period. BH6 which is located at the south eastern Site boundary, show more significant seasonal variability with a range of up to 3 m.

1.23 Groundwater level data from October 2022 has been used to construct groundwater contours for the Site. Groundwater contours are shown on application Drawing No. 204. Groundwater monitoring results demonstrate a groundwater flow direction to the north north-east with a hydraulic gradient that reduces in a down-gradient direction. In the southern part of the Site groundwater is flowing through the lower sandstone unit and the lower section of the overlying ironstone. In the northern part of the Site groundwater flow is primarily occurring through the lower sandstone as groundwater levels are close to the base of mineral.

1.24 Comparison of Site groundwater levels with other local groundwater level indicators results in confirmation of a north easterly hydraulic gradient, as shown on Drawing 203/09/01, which accompanies this report. Available evidence indicates that groundwater flowing through the lower sections of the Northampton Sand Formation beneath the application Site discharges as baseflow to Harlestone Brook.

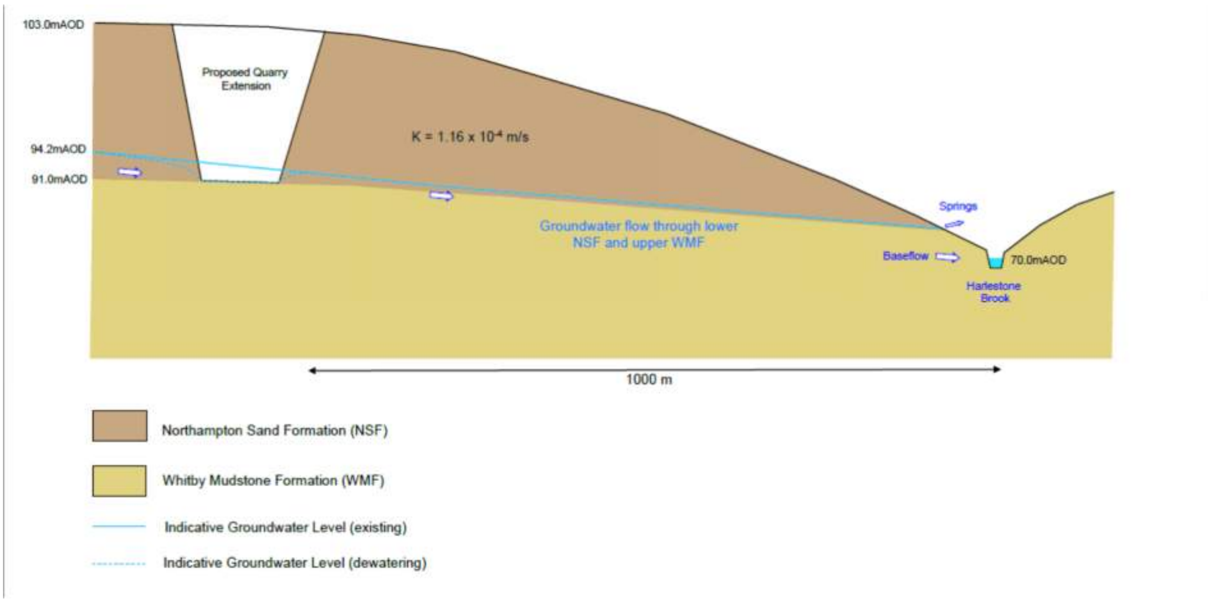


Figure SRA1 – Geological Cross Sections showing proposed finished elevations (Drawing No. 203/09/02)

Basal Subgrade Model

1.25 The existing void will be created by the extraction of the Northampton Sand Formation and into the Whitby Mudstone Formation.

1.26 The Northampton Sand Formation are described locally as interbedded ironstones and sandstones with lenses of limestone and mudstones. The Whitby Mudstone Formation is described as interbedded mudstones and siltstones.

1.27 All the individual lithologies making up these formations within the site area are considered to be of extremely low compressibility.

Basal Lining System

1.28 No mineral liner is required due to the presence of a natural geological barrier comprising units of the Whitby Mudstone Formation. Therefore, the geological barrier will be formed by leaving the existing mudstones in place.

Side Slope Subgrade Model

1.29 The side slope subgrade will be exposed during the mineral extraction works, which will be carried out by MGL and will comprise Northampton Sand Formation with imported CL:AIRE material acting as fill to create side slopes where necessary.

Side Slope Lining Model

1.30 The side slope liner will comprise a geological barrier 1m thick with a minimum hydraulic conductivity of less than 1.0 x 10m^{-7} m/s or its equivalent 0.5 m thick with a hydraulic conductivity of 5.0 x 10^{-8} m/s.

Inert Waste Mass Model

1.31 It is proposed that Harlestone Quarry will be used for the placement of inert materials only.

1.32 The inert material is liable to comprise locally derived arisings from earthworks, foundation construction works and demolition debris.

1.33 The geology of the local area is variable and comprises both coarse- and fine-grained materials. As most of the inert materials is likely to comprise locally derived materials. With respect to stability the worst case would be a waste mass comprised entirely of fine-grained materials. Therefore, the inert material model will comprise a generic fine-grained material and the characteristic geotechnical parameters attributed to this material will be based on a number of sources.

Table SRA1: Bibliography of Published Sources used in the Determination of the Characteristic Geotechnical Parameters of the Inert Waste

Author	Date	Title
Carter M., & Bentley S.P.	2016	Soil Properties and Correlations 2nd. Ed.
Look B.	2007	Handbook of Geotechnical Investigation and Design Tables
Duncan J.M., & Wright, S.G.	2005	Soil Strength & Slope Stability
CIRIA C583	2004	Engineering in the Lambeth Group[1]
Hight D.W., McMillan, F, Powell, J.J.M., Jardine, R.J., & Allenou, C.P.	2003	Some Characteristics of the London Clay: In Tan et al. (Eds.) Characterisation and Engineering Properties of Natural Soils.[1]

[1] *the inclusion of these two strata specific references should not be taken as a suggestion of the Inert Waste content.*

1.34 The maximum temporary waste slope during placement operations will be restricted to 1(v):3(h).

1.35 The waste will be compacted in horizontal layers across the base of the cell to the pre-settlement restoration level.

Capping System Model

1.36 On completion of filling to final levels, the site will be capped with 1.2m of restoration soils comprising not less than 0.3m of topsoil. In accordance with the requirements of the Landfill Directive, an engineered cap (clay or plastic) is not required.

2.0 STABILITY RISK ASSESSMENT

Risk Screening

Basal Subgrade Screening

2.1 The basal subgrade will be formed of the in-situ or redeposited mudstones of the Whitby Mudstone Formation. As the void has been and will continue to be formed by the excavation of material there will be a net unloading of the ground. The replacement of the excavated material with unwanted clays and inert waste will not fully reload the soil as there is a difference in the unit weight of the excavated material and the replaced inert waste.

2.2 No stability analysis of this component is considered necessary.

Basal Lining System Screening

2.3 The basal liner is to comprise the in-situ or redeposited mudstones of the Whitby Mudstone Formation. Therefore, no further analyses of the basal layer are considered necessary.

Side Slope Subgrade Screening

2.4 The side slopes will be formed as part of the extraction process which is being carried out by Mick George. These works and the redeposition of the unwanted clays are subject to geotechnical appraisal under Regulation 33 of the Quarries Regulations, part of which is to assess the stability of the side slope subgrade. Therefore, the side slope subgrade will be in a stable configuration at the onset of inert waste placement and there is no reason for this situation not to persist throughout waste placement operations.

2.5 As the side-slope subgrade would have undergone geotechnical appraisal during the mineral extraction works, no further stability analysis of the side-slope subgrade is considered necessary.

Side Slope Lining System Screening

2.6 An artificially established side-lining system, comprising a minimum of either 0.5m thick with a permeability of $5x10^{-8}$ m/s or its equivalent a 1m liner with a permeability of $1x10^{-7}$ m/s is to be placed on the side slopes of the landfill. Given the expected gradient of the side slopes subgrade it is probable that the side slope lining system will be placed in sections; such that the side slope liner will not achieve drained conditions prior to the placement of inert waste.

2.7 Analysis of this component is considered necessary to investigate the short-and long-term stability of this element prior to the placement of the inert waste.

Waste Mass Screening

2.8 This component is considered to be an issue that will require a detailed geotechnical analysis in order to assess the stability of the waste mass.

Capping System Screening

2.9 Based on the finished proposed finished contours a maximum gradient of 1(v):30 (h) will be created which will remain stable under all foreseeable ground conditions. Therefore, no stability analysis of the restoration soils is considered necessary.

Justification of Modelling Approach and Software

2.10 Two-dimensional limiting equilibrium stability analyses will be used in the assessment of the stability of the various components of the proposed site. The method of analysis used in each particular case was determined from an examination of the form of failure being considered.

2.11 The stability analyses were carried out using the Slope/W computer programme.

2.12 The Morgenstern and Price Method was used in the analyses to determine the factor of safety against instability for both total stress and effective stress conditions.

Justification of Geotechnical Parameters Selected for Analyses

Parameters Selected for Side Slopes Subgrade Analyses

2.13 Not a consideration at this site.

Parameters Selected for Side Slope Liner Analyses

2.14 The side slope liner is to be constructed using an appropriate fine-grained material. Typical values for clay materials have been used to define the characteristic geotechnical values of the side slope liner material (Table SRA2).

Table SRA2: Side Slopes Liner Stability – Summary of Characteristic Geotechnical Data

Material	Unit Weigh	Total Stress		Effective Stress	
	γ (kN/m^3)	c_{uk} (kN/m^2)	ϕ_{uk} (°)	c'_k (kN/m^2)	ϕ'_k (°)
Side Liner	19	50	0	2	25

Parameters Selected for Waste Analyses

2.15 The Parameters of the inert waste appropriate for this site were selected on the basis of the information presented in the various publications listed in Table SRA1. As stated previously the inclusion of stratum specific references should not be taken as guidance to what may be included within the Inert Waste but purely as another source to help define a generic fine-grained material.

2.16 In reality, it is likely to comprise a mixture of fine-and coarse-grained materials and demolition materials. Therefore, the treatment of the inert waste as fine-grained will be the worst-case as the inclusion of any coarse-grained material will increase its characteristic angle of shearing resistance.

Table SRA3: Waste Mass Stability - Summary of Characteristic Geotechnical Data

Material	Unit Weight	Total Stress		Effective Stress	
	γ_k (kN/m^3)	c_u (kN/m^2)	ϕ_{uk} (°)	c'_k (kN/m^2)	ϕ'_k (°)
Waste Mass	17	50	0	5	25

Selection of Appropriate Factors of Safety

2.17 The stability analyses have been carried out in accordance with EC7. The United Kingdom have adopted Design Approach 1 (DA1) Combination 1 & 2 (C 1 & 2) whereby partial factors are applied to either the actions or the material properties and a resultant factor of safety of 1.00 is required.

Table SRA4: Partial Factors used in Design in Accordance with the UK National Annex to EC7

Design Approach	Combination	Partial Factor Sets	Partial Factor Value			
1	1	A1 + M1 + R1	Actions A1			
			Permanent (G)	Unfavourable	$\gamma_{G;dst}$	1.35
				Favourable	$\gamma_{G;stb}$	1.00
			Variable (Q)	Unfavourable	$\gamma_{Q;dst}$	1.50
				Favourable	$\gamma_{G;dst}$	0
			Materials M1			
			Coefficient of shearing resistance (*tan*ϕ)		$\gamma_{\phi'}$	1.00
			Effective cohesion (*c'*)		$\gamma_{c'}$	1.00
			Undrained shear strength (c_u)		γ_{cu}	1.00
			Resistance R1			
			Resistance		$\gamma_{R;e}$	1.00
	2	A2 + M2 + R1	Actions A2			
			Permanent (G)	Unfavourable	$\gamma_{G;dst}$	1.00
				Favourable	$\gamma_{G;stb}$	1.00
			Variable (Q)	Unfavourable	$\gamma_{Q;dst}$	1.30
				Favourable	$\gamma_{G;dst}$	0
			Materials M2			
			Coefficient of shearing resistance (*tan*ϕ)		$\gamma_{\phi'}$	1.25
			Effective cohesion (*c'*)		$\gamma_{c'}$	1.25
			Undrained shear strength (c_u)		γ_{cu}	1.40
			Resistance R1			
			Resistance		$\gamma_{R;e}$	1.00

2.18 The values of the partial factors used are termed “nationally determined parameters” and EC7 (as published by CEN) allows these to be specified in National Annexes which recognise regional variations in design philosophy.

2.19 LFE4 – Earthworks in Landfill Engineering – Chapter 2 confirms the adoption of Design Approach 1 Combinations 1 and 2, and the nationally adopted partial factors.

Analyses

Side Slope Subgrade

2.20 The side slopes of the void will be formed during the mineral extraction phase of the works and will be subject to appraisal under Regulation 33 of the Quarries Regulations. Therefore, no further stability assessment is required. Although their stratigraphy and groundwater conditions will be considered in the side slope liner analysis.

Side Slope Liner Analyses

2.21 A side slope liner will be placed against the side slope subgrade. Given the lithified nature of the side slope subgrade it is likely that side slopes will be stable at near vertical gradients. For the side slope liner stability assessment, it is assumed that the side slopes are at 80°.

2.22 Although no groundwater outflows have been reported during the mineral extraction works for completeness the volume required to resist sliding initiated by horizontal piezometric pressures has been determined for the stratigraphy and groundwater conditions present in the East Face of Phase B which represents the worst case.

2.23 The results of the sliding analyses are presented in Appendix 2 and indicate that a 4m high section of liner with a face angle of 1(V) to 2 (H) will have sufficient weight to resist the horizontal piezometric forces and achieve horizontal equilibrium.

2.24 The results of the side slope liner stability analyses are shown in Table SRA5 and the SlopeW worksheets presented in Appendix 3.

Table SRA5: Side Slope Liner Stability – Summary of Results

Run	File Name	Shear Strength		Factor of Safety		Notes
		c	ϕ	C1	C2	
Side Slope Gradient up to 80 °						
01	SLINER1	50	0	6.04		Total Stress
02	SLINER2	36	0		5.94	
03	SLINER3	2	25	0.48		long term exposure – Full effective stress conditions
04	SLINER4	1.6	20		0.69	
05	SLINER5	1.6	20	1.16	1.07	Gradient slackened to 1(v) : 2 (h)

Waste Mass Analyses

2.25 The post extraction void may be up to 12m deep. However, although it is unlikely that a 12m high waste face would be created given the phasing and placement of the inert waste in layers. However, for risk assessment purposes a 12m high slope will be considered and the waste during placement operations will be restricted to 1(v) : 3(h).

2.26 Leachate pore fluid pressures may develop in the waste mass during filling due to infiltration. It is noteworthy that the term leachate as applied refers to direct precipitation or groundwater present within the inert waste at time of placement.

2.27 Given the composition (inert materials), landfill gas pressures are unlikely to develop within the waste mass.

2.28 Waste stability must be assessed as part of the design process for the temporary waste slope configuration. A Stability assessment is required for failure modes wholly within the waste body. The analyses of the failures wholly within the waste were based on Table 3.43 “Failure Wholly within the Waste” of the Environmental Agency R&D Technical Report P1-385/TR2.

2.29 Slope/W has been used to undertake the investigation into failures wholly within the waste mass for both total and effective stress conditions.

2.30 The effects of variations in leachate pressure were modelled by investigating the effects of increased leachate levels on the factor of safety against instability within the waste body.

2.31 Results of the analyses are presented in Appendix 1 and can be summarised as follows:

Table SRA6: Waste Mass Stability – Summary of Results

Run	File Name	Waste Strength	Leachate Level	Degree of Utilisation		Notes
				C1	C2	
1	WMass1	Total	Dry	0.59		Short term waste mass parameters
2	WMass2				0.54	
3	WMass3	Effective	1.00m	0.63		Increasing leachate level measured from base of waste mass
4	WMass4				0.72	
5	WMass5		4.00	0.71		
6	WMass6				0.80	
07	WMass7		8.00	0.70		
08	WMass8				0.76	
09	WMass9		Not Present	1.39 (FoS)		Cohesion = 0kN/m^2

Assessment

Basal Subgrade

2.32 The basal subgrade is to comprise the in-situ Whitby Mudstone Formation which is considered competent and with no net increase in stress at basal subgrade level predicted, no settlement other than short term elastic recompression is expected. Therefore, the basal subgrade is considered appropriate without any significant re-engineering.

Basal Liner

2.33 The basal liner is to comprise the in-situ or redeposited mudstones of the Whitby Mudstone Formation. Basal heave is not a consideration at the site.

Side Slope Sub-Grade

2.34 The side slopes of the void will be formed as part of the mineral extraction works which is to be carried out by MGL. It is appropriate to assume that the extraction works will be subject to Geotechnical Appraisal under Regulation 33 of the Quarries Regulations and as part of that appraisal it will be demonstrated that the side slope subgrade is stable at the planned angle of excavation. The lithologies forming the side slope subgrade are unlikely to degrade over the time in which the void will be open. Given this and the design and appraisal under the mineral extraction phase of the works, the void must be considered as being stable at the angle at which the mineral extraction works are undertaken and the inert waste placement commences.

Side Slope Liner

2.35 Given the lithified nature of the side slope subgrade it is probable that the side slope liner will be placed in lifts to avoid long term exposure without support.

2.36 A 4m high lift of side slope liner has been analysed and is shown to be stable in the short term under total stress conditions with a minimum factor of safety of 5.94 being returned under Design Approach 1 Combination 2 factoring.

2.37 However, if left unsupported in the long-term such that fully drained effective stress conditions are achieved the liner becomes unstable. To achieve long term stability the side slope liner gradient needs to be slackened to 2(h) : 1(v) which then returns a factor of safety of 1.07 under the more onerous Combination 2 factoring.

2.38 Although no groundwater inflows from the Whitby Mudstone Formation are likely, an assessment of horizontal sliding of the liner indicates that under drained conditions a 4m high section of liner with a face gradient of 2(h) : 1(v) has sufficient weight to achieve horizontal equilibrium.

2.39 It can be concluded that placement of the side slope liner in lifts ahead of the waste placement will be stable in the short term. However, if the liner material is to be left unsupported for an extended period of time then it should be either buttressed by inert waste or placed with a minimum face gradient of 1(v) : 2(h).

Waste Mass

2.40 The stability of the temporary waste face was analysed using the computer programme SLOPE/W to calculate the factor of safety against failure through the waste body for a range of circular failure surfaces using Morgenstern and Price’s method.

2.41 The importance of different leachate levels within the waste and their effect on overall stability were assessed. The effect of reduction of shear strength from peak to residual values has also been investigated.

2.42 The waste slope has a degree of utilisation < 1 for all leachate levels up to 6.00m from the base of the waste body. As the thickness of the unbuttressed inert waste is 12.00m a leachate level of 8.00m is extremely unlikely to occur under normal operating conditions.

2.43 The waste slope has a factor of safety of 1.39 even if the value of the cohesion intercept of the waste reduces from 5kN/m^2 to 0kN/m^2.

2.44 It is concluded that a 1(v) : 3(h) waste slope will be stable for the range of leachate levels anticipated.

Capping System

2.45 Not a consideration at this site.

3.0 MONITORING

The Risk-Based Monitoring Scheme

3.1 Monitoring of the stability of the site is proposed in the form set out below. The objectives are to identify any instances of overall settlement of the structure, identify instability of the waste mass itself and instability of the side slope subgrade and lining system at the earliest possible juncture.

Basal Subgrade Monitoring

3.2 Prior to the placement of the waste, it is recommended that the basal subgrade is carefully inspected to identify any areas where the Whitby Mudstone Formation has been exposed at the surface as a result of local faulting. If such area areas are identified it is recommended that localised placement of locally derived fine-grained material (the same as that used in the side liner construction) is placed to ensure the integrity of basal subgrade. If the basal subgrade is to be left exposed for any length of time a programme of routine monitoring should be undertaken to identify any soft spots that may develop as a result of exposure to inclement weather.

Side Slope Subgrade + Lining Monitoring

3.3 The side slopes should be visually monitored for instability during the waste placement operations. In the event of any instances of instability appropriate action should be taken which may include buttressing the toe of the slope using inert waste material.

Basal Lining System Monitoring

3.4 The basal liner is to comprise the in-situ or redeposited mudstones of the Whitby Mudstone Formation.

Waste Mass Monitoring

3.5 The temporary slopes in the waste should be visually monitored and appropriate actions taken on any sign of instability. This would typically include a reduction in slope angle of the temporary waste slopes.

Capping System Monitoring

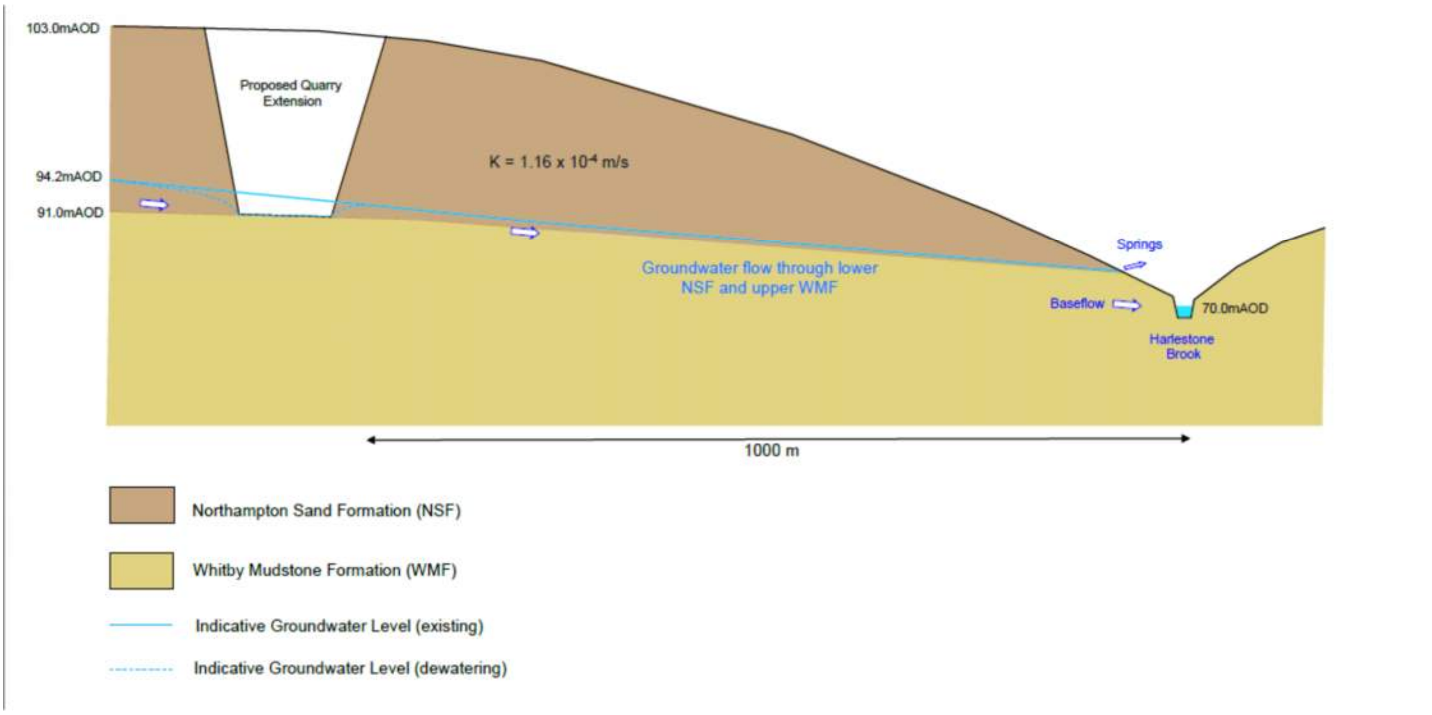
3.6 The condition of the surface of all restored areas will be monitored on a regular basis as part of the site inspection regime.

3.7 The surface will be checked for incipient signs of failure that might result from the occurrence of differential settlement within these deposits. These would include cracking, development of depressions or ponding and seepage of water. In the event that any symptom of incipient failure is detected the Environment Agency will be informed and a site action plan for remediation agreed.

3.8 The Surface of the restored areas will be monitored by land survey techniques on a regular basis. These checks will be on an annual basis for the first two years and then on every other year until the fifth year after restoration, when the periodicity reviewed with the Environment Agency.

Appendix 1

Conceptual Site Model Cross Section

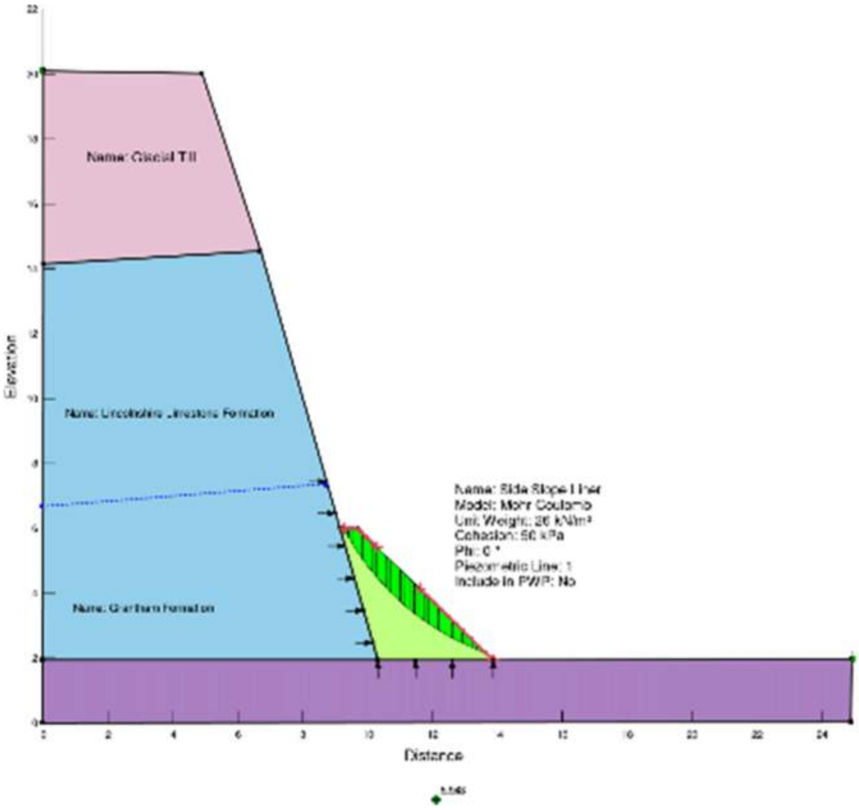

103.0mAOD
Proposed Quarry Extension
K = 1.16 x 10-4 m/s
94.2mAOD
91.0mAOD
Groundwater flow through lower NSF and upper WMF
Springs
Baseflow
70.0mAOD
Harlestone Brook
1000 m
Northampton Sand Formation (NSF)
Whitby Mudstone Formation (WMF)
Indicative Groundwater Level (existing)
Indicative Groundwater Level (dewatering)

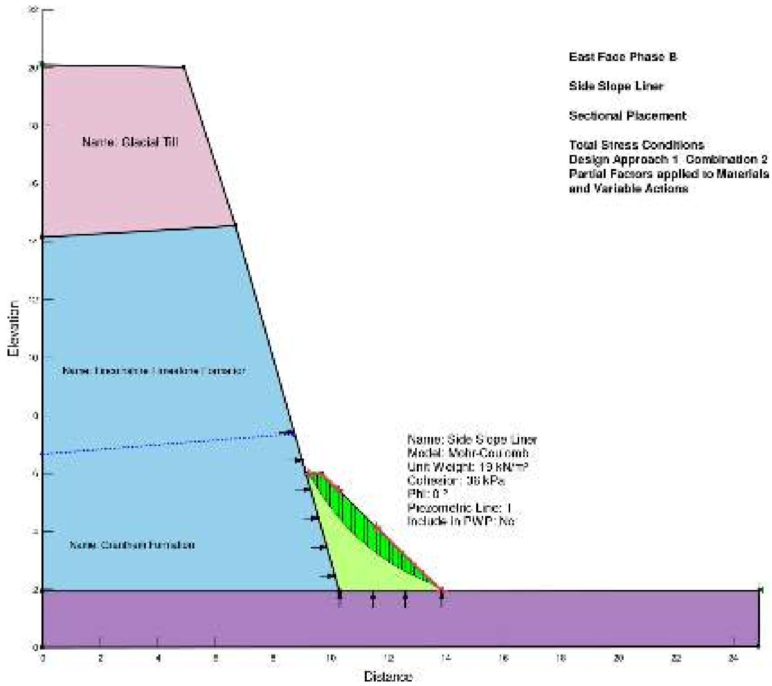
Appendix 2

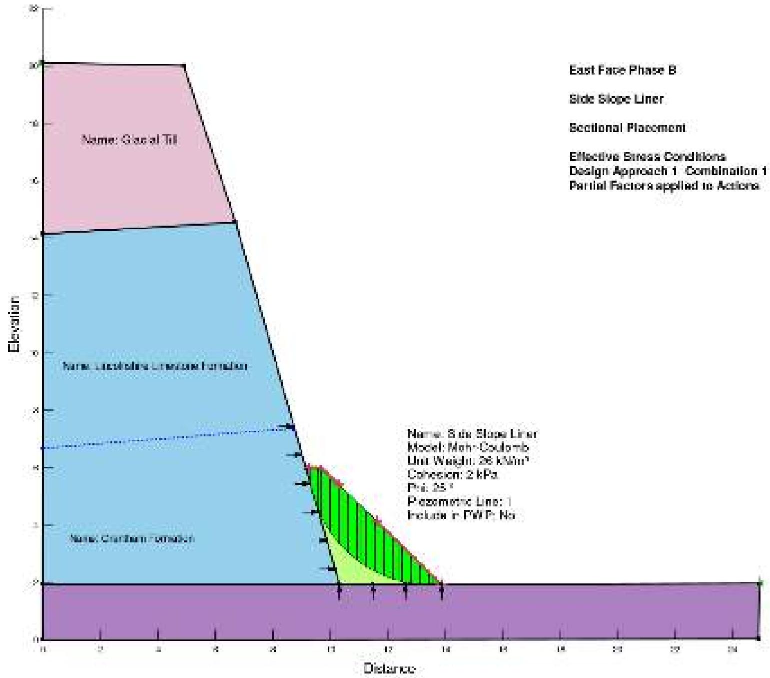
Liner Sliding Calculations

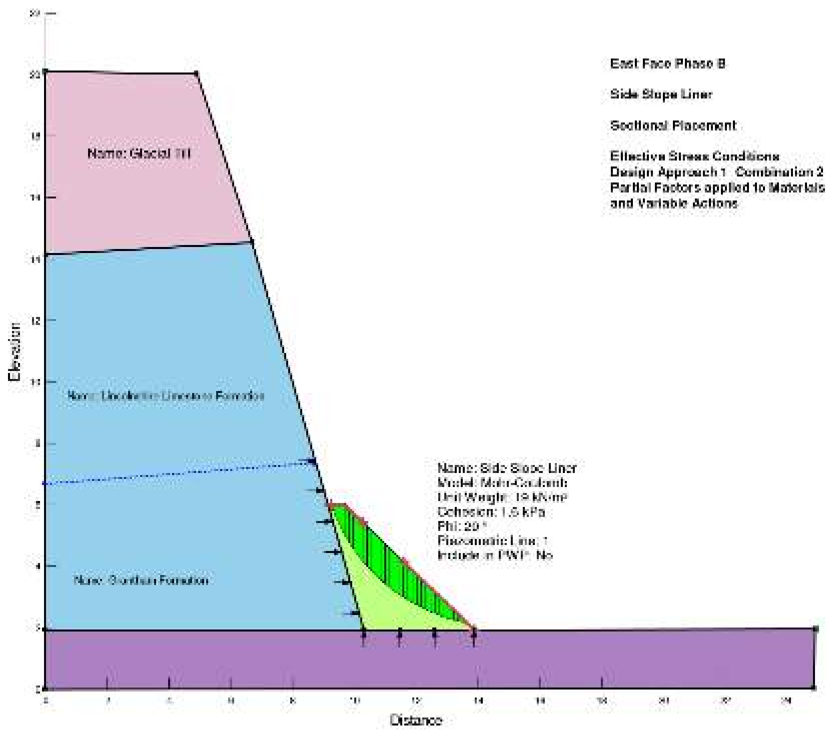
Appendix 3

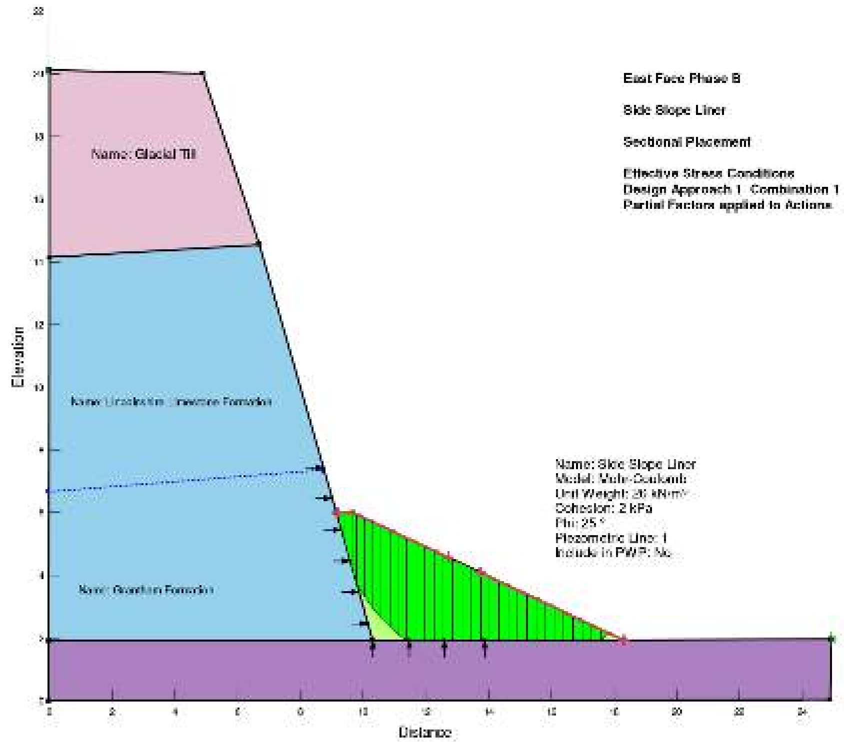
SlopeW Worksheets – Side Slope Liner

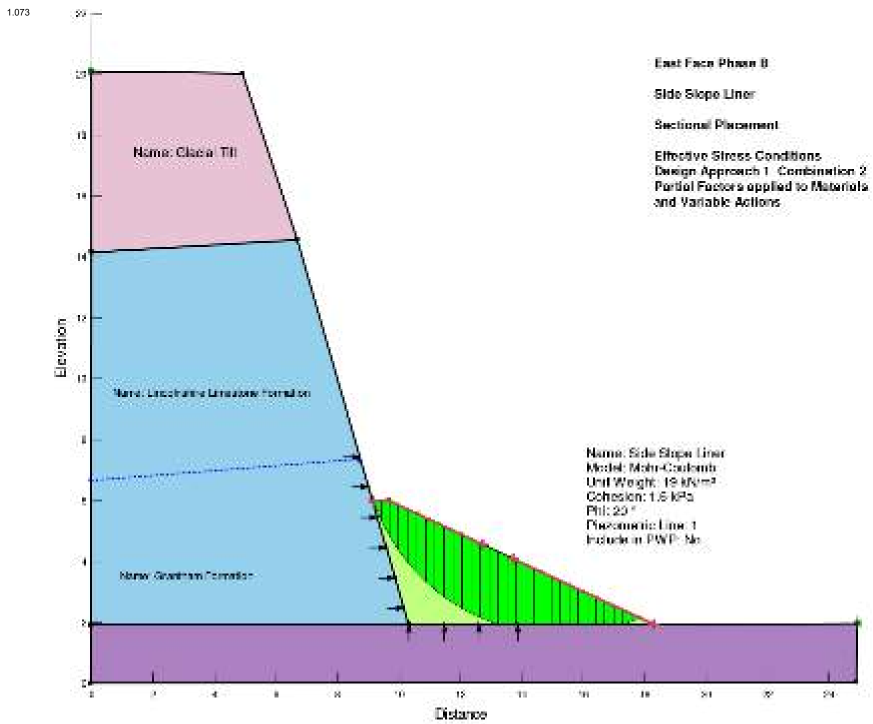

Name: Glacial Till
Name: Side Slope Liner
Model: Mohr Coulomb
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °
Piezometric Line: 1
Include in PWP: No
Elevation
Distance


East Face Phase B
Side Slope Liner
Sectional Placement
Total Stress Conditions
Design Approach 1 Combination 2
Partial Factors applied to Materials
and Variable Actions
Name: Glacial Till
Name: Side Slope Liner
Model: Mohr-Coulomb
Piezometric Line: 1
Include in PWP: No
Elevation
Distance


East Face Phase B
Side Slope Liner
Sectional Placement
Effective Stress Conditions
Design Approach 1 Combination 1
Partial Factors applied to Actions
Name: Glacial Till
Name: Grantham Formation
Name: Side Slope Liner
Model: Mohr-Coulomb
Unit Weight: 26 kN/m³
Cohesion: 2 kPa
Phi: 25 °
Piezometric Line: 1
Include in PWP: No
Elevation
Distance

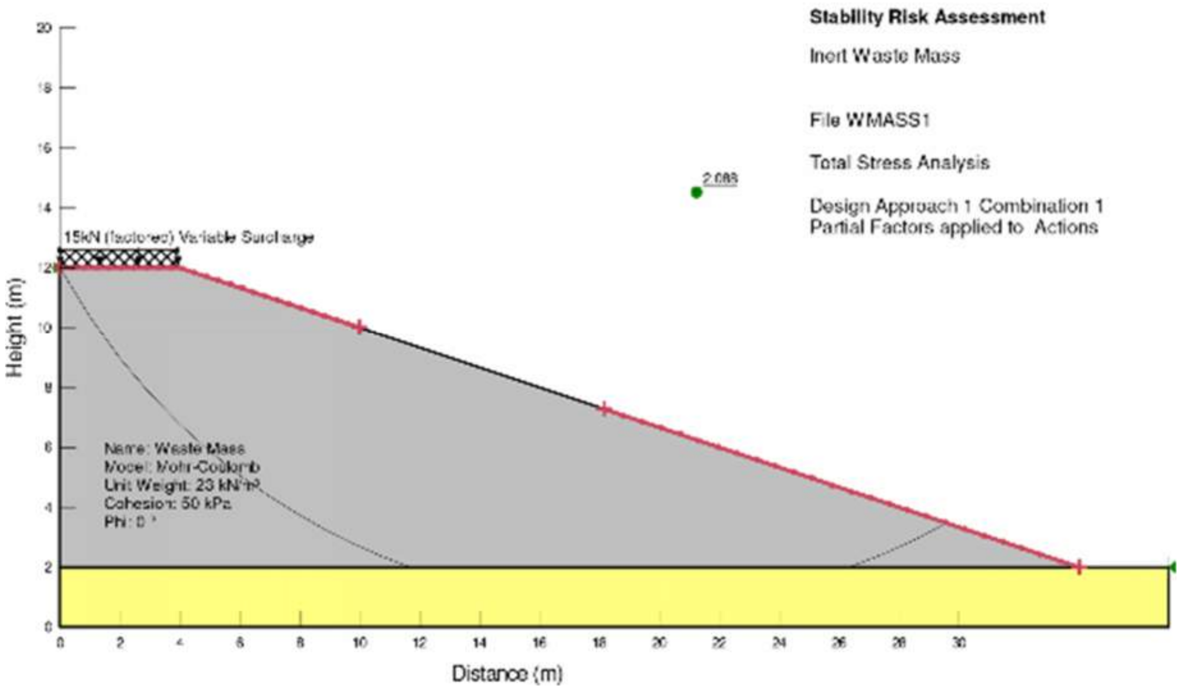

East Face Phase B
Side Slope Liner
Sectional Placement
Effective Stress Conditions
Design Approach 1 Combination 2
Partial Factors applied to Materials and Variable Actions
Name: Glacial Till
Name: Lincolnshire Limestone Formation
Name: Grantham Formation
Name: Side Slope Liner
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion: 1.6 kPa
Phi: 20 °
Piezometric Line: 1
Include in PWP: No
Elevation
Distance

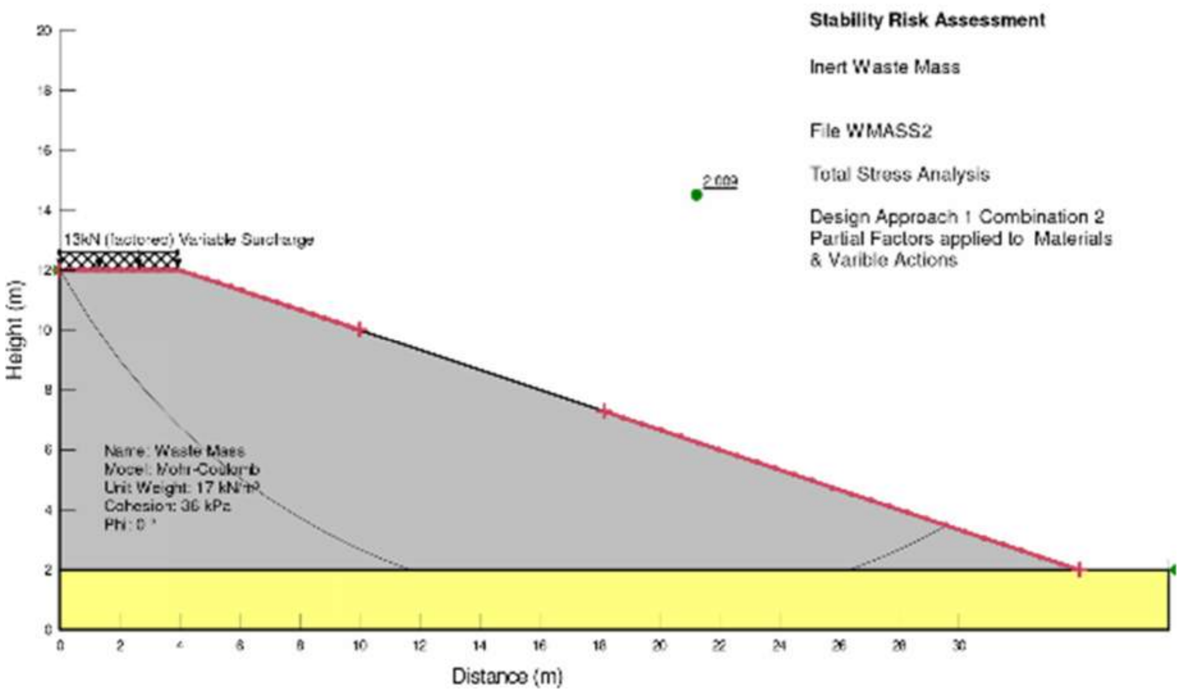

East Face Phase B
Side Slope Liner
Sectional Placement
Effective Stress Conditions
Design Approach 1 Combination 1
Partial Factors applied to Actions
Name: Glacial Till
Name: Lincolnshire Limestone Formation
Name: Grantham Formation
Name: Side Slope Liner
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion: 2 kPa
Phi: 25 °
Piezometric Line: 1
Include in PWP: No
Elevation
Distance

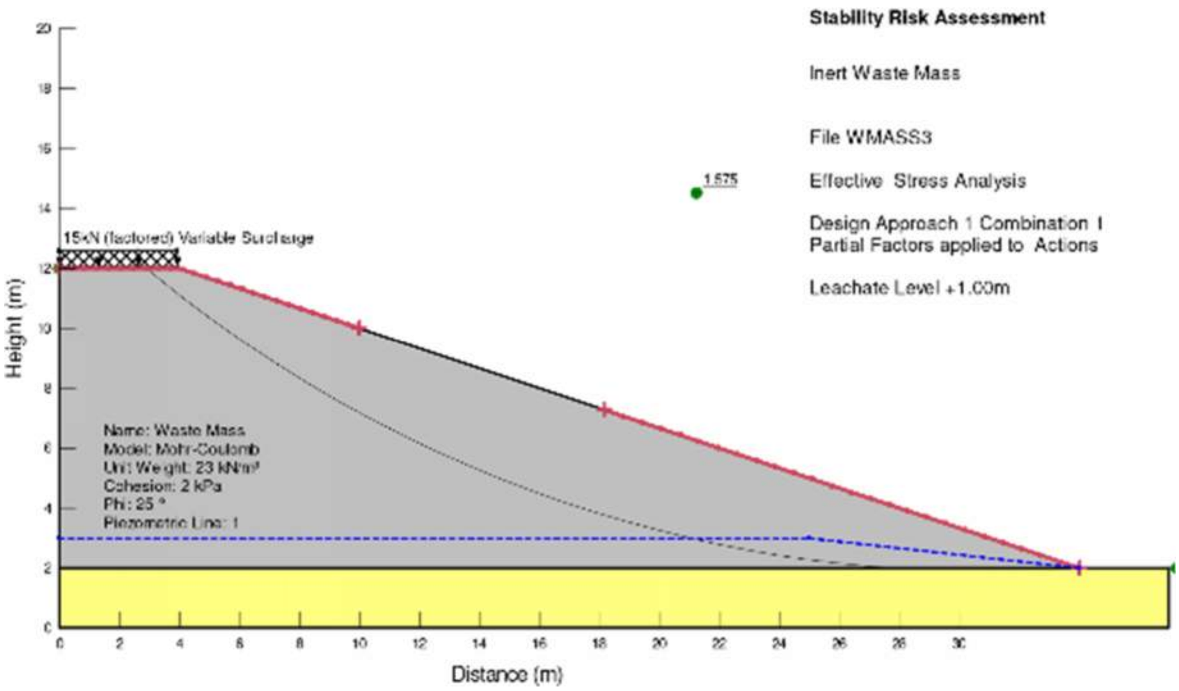

1.073
East Face Phase B
Side Slope Liner
Sectional Placement
Effective Stress Conditions
Design Approach 1 Combination 2
Partial Factors applied to Materials
and Variable Actions
Name: Glacial Till
Name: Lincolnshire Limestone Formation
Name: Grantham Formation
Name: Side Slope Liner
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion: 1.6 kPa
Phi: 20 °
Piezometric Line: 1
Include in PWP: No
Elevation
Distance

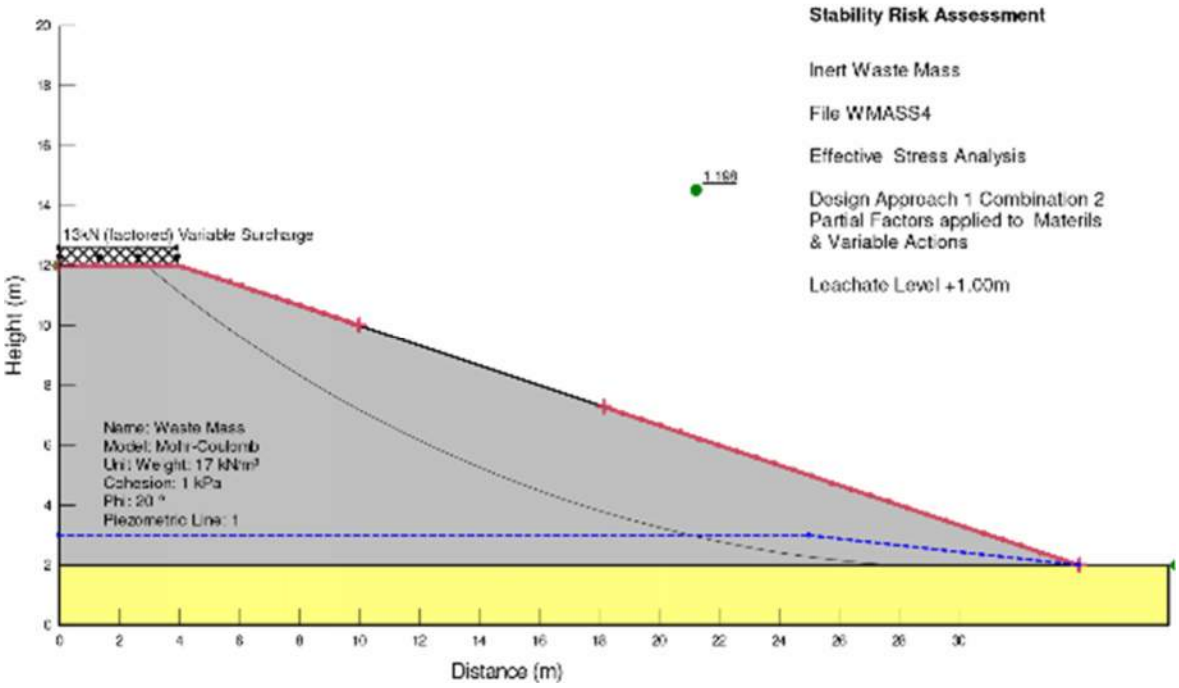
Appendix 4

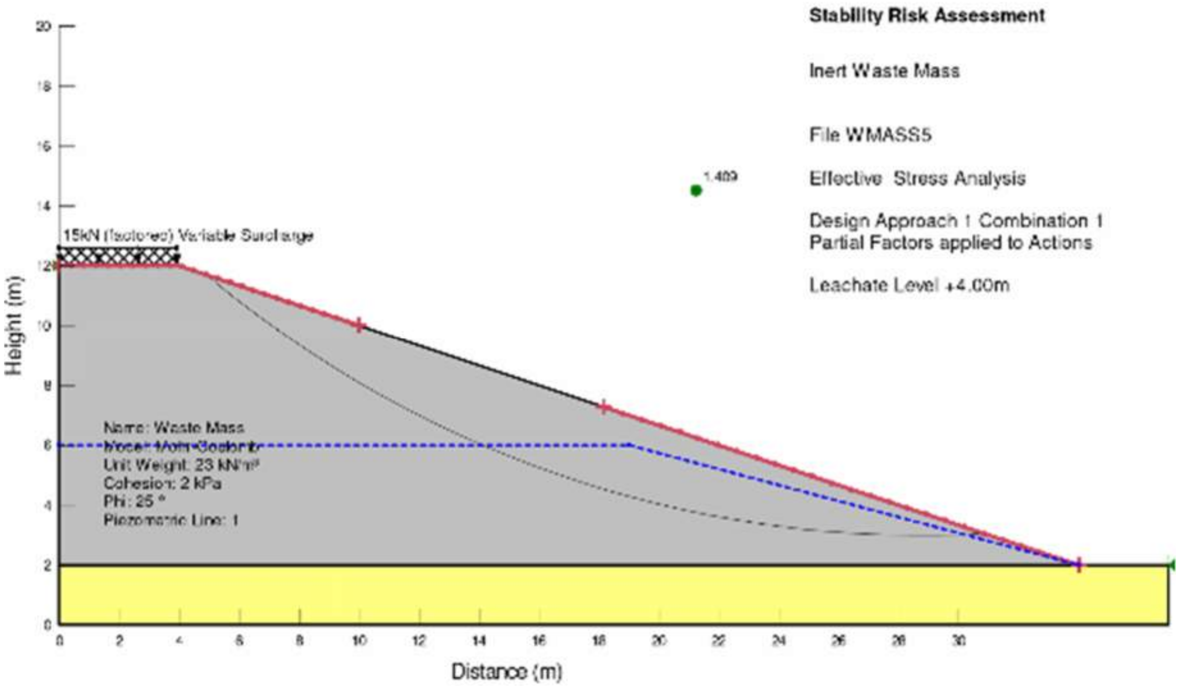
SlopeW Worksheets – Waste Mass

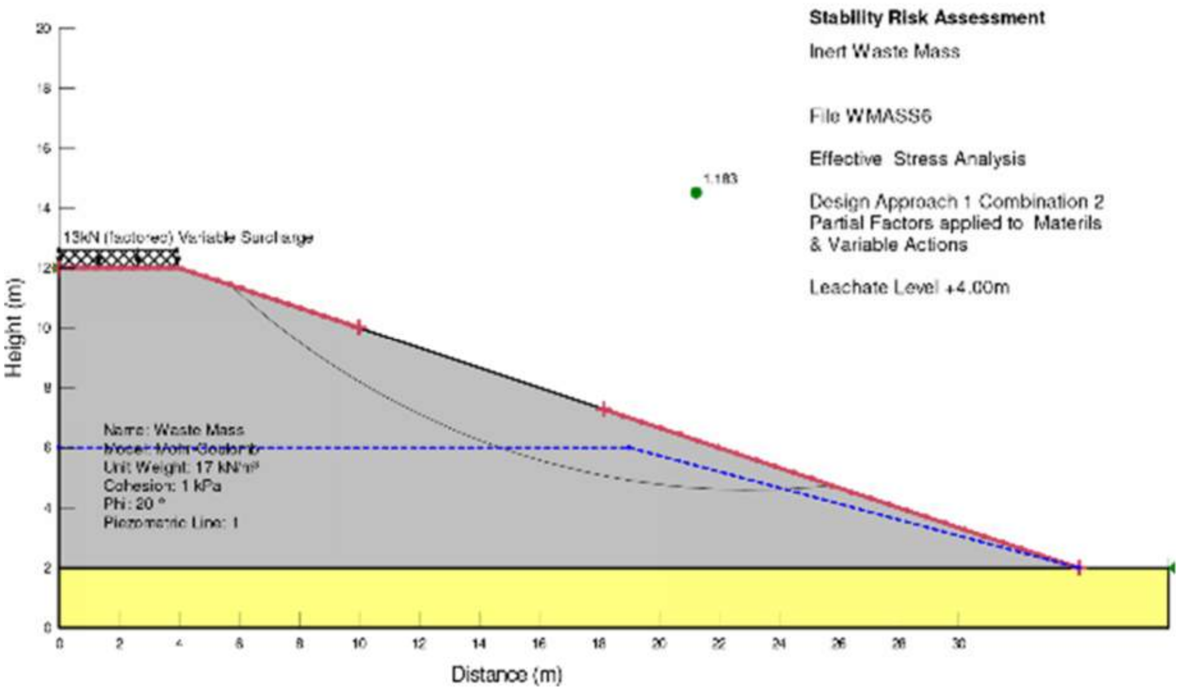

Stability Risk Assessment
Inert Waste Mass
File WMASS1
Total Stress Analysis
Design Approach 1 Combination 1
Partial Factors applied to Actions
2.088
15kN (factored) Variable Surcharge
Name: Waste Mass
Model: Mohr-Coulomb
Unit Weight: 23 kN/m³
Cohesion: 50 kPa
Phi: 0 °
Height (m)
Distance (m)

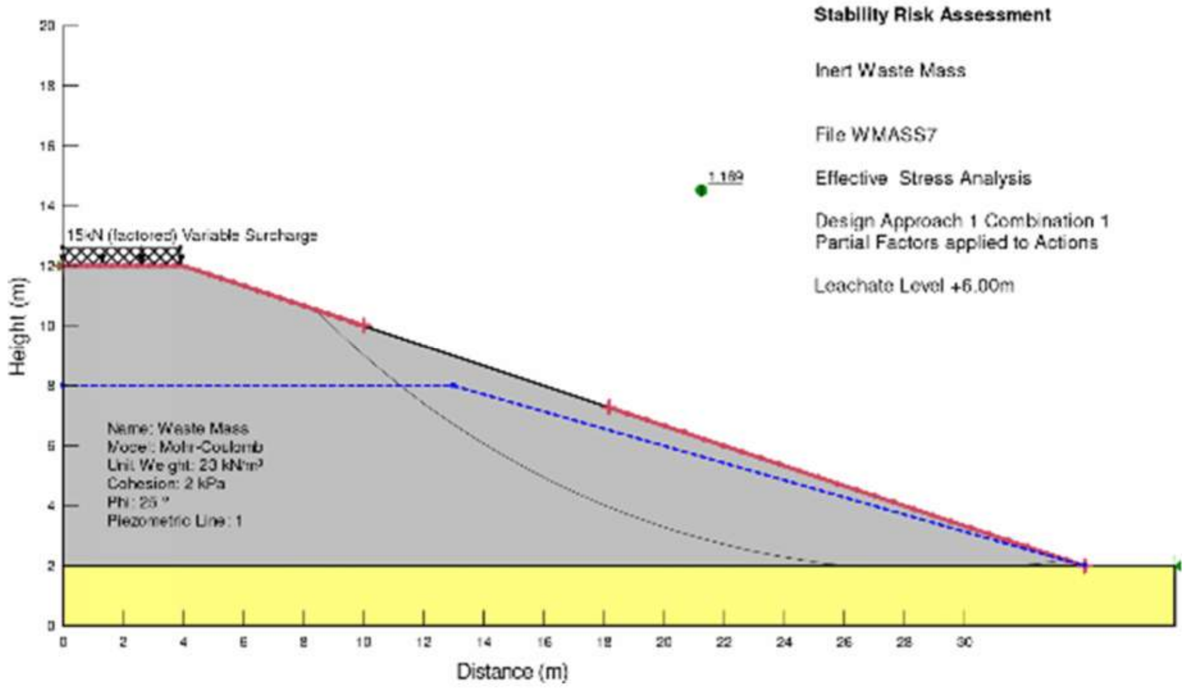

Stability Risk Assessment
Inert Waste Mass
File WMASS2
Total Stress Analysis
Design Approach 1 Combination 2
Partial Factors applied to Materials
& Varible Actions
2.009
13kN (factored) Variable Surcharge
Name: Waste Mass
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 36 kPa
Phi: 0 °
Height (m)
Distance (m)

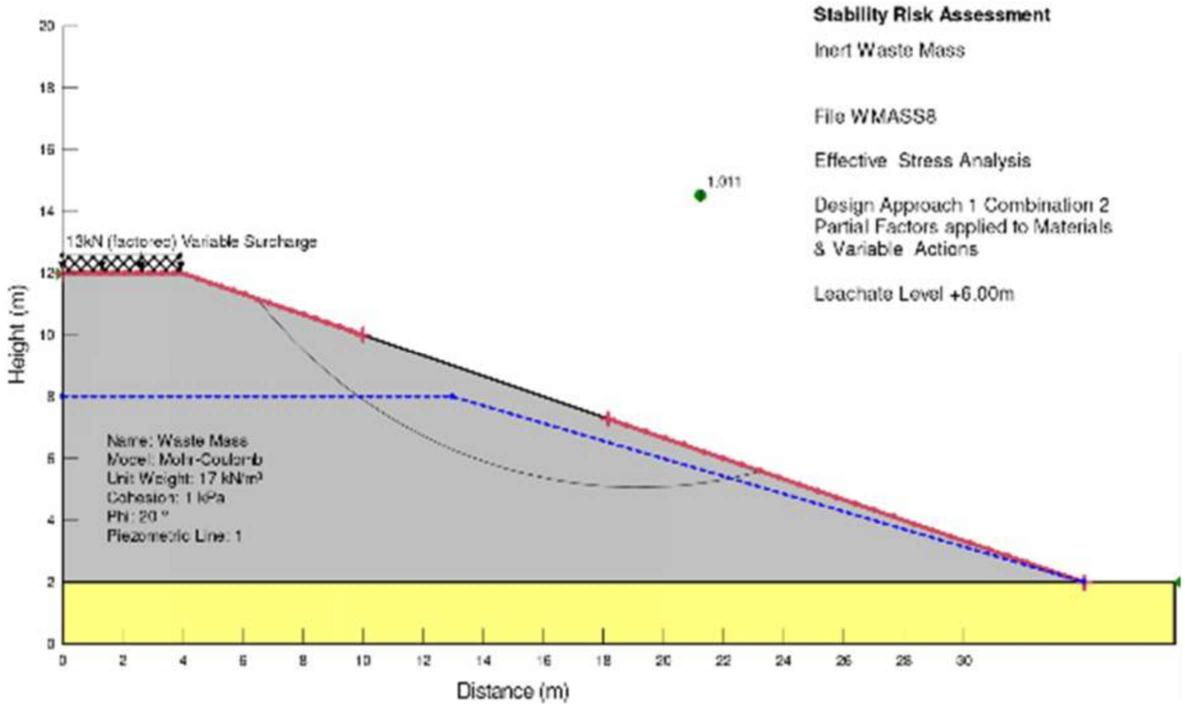

Stability Risk Assessment
Inert Waste Mass
File WMASS3
Effective Stress Analysis
Design Approach 1 Combination 1
Partial Factors applied to Actions
Leachate Level +1.00m
1.575
15kN (factored) Variable Surcharge
Name: Waste Mass
Model: Mohr-Coulomb
Unit Weight: 23 kN/m³
Cohesion: 2 kPa
Phi: 25 °
Piezometric Line: 1
Height (m)
Distance (m)

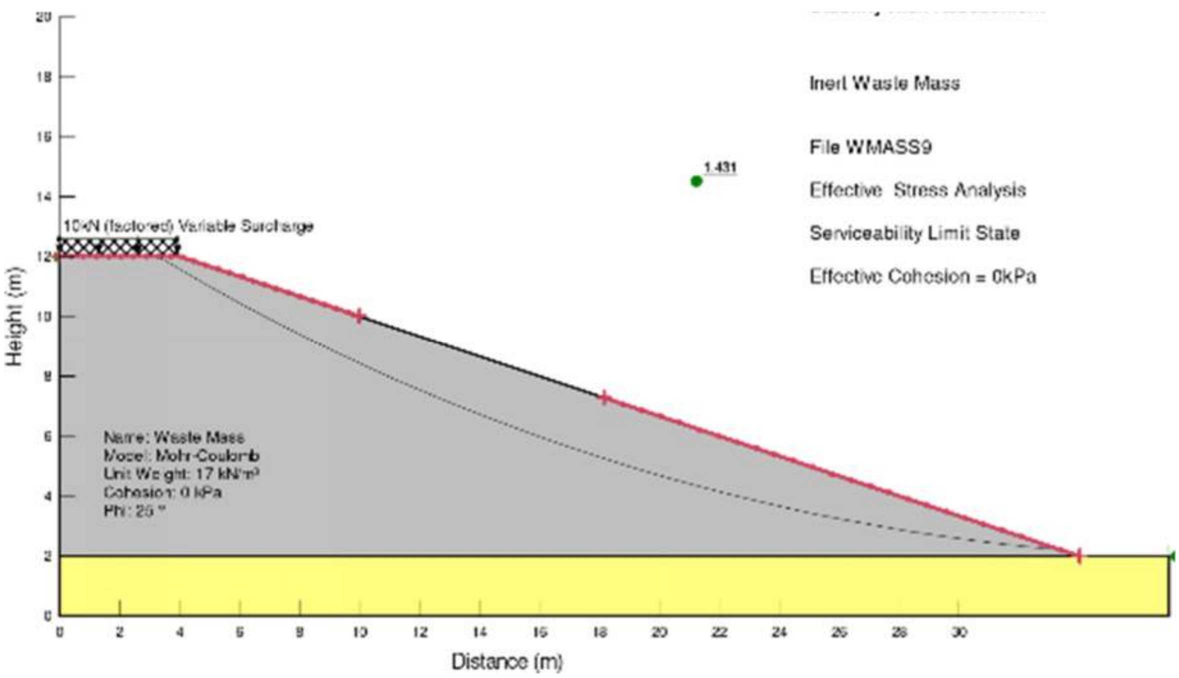

Stability Risk Assessment
Inert Waste Mass
File WMASS4
Effective Stress Analysis
Design Approach 1 Combination 2
Partial Factors applied to Materils
& Variable Actions
Leachate Level +1.00m
1.198
13kN (factored) Variable Surcharge
Name: Waste Mass
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 1 kPa
Phi: 20 °
Piezometric Line: 1
Height (m)
Distance (m)


Stability Risk Assessment
Inert Waste Mass
File WMASS5
Effective Stress Analysis
Design Approach 1 Combination 1
Partial Factors applied to Actions
Leachate Level +4.00m
1.409
15kN (factored) Variable Surcharge
Name: Waste Mass
Model: Mohr-Coulomb
Unit Weight: 23 kN/m³
Cohesion: 2 kPa
Phi: 25 °
Piezometric Line: 1
Height (m)
Distance (m)


Stability Risk Assessment
Inert Waste Mass
File WMASS6
Effective Stress Analysis
Design Approach 1 Combination 2
Partial Factors applied to Materils
& Variable Actions
Leachate Level +4.00m
1.183
13kN (factored) Variable Surcharge
Name: Waste Mass
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 1 kPa
Phi: 20 °
Piezometric Line: 1
Height (m)
Distance (m)


Stability Risk Assessment
Inert Waste Mass
File WMASS7
Effective Stress Analysis
Design Approach 1 Combination 1
Partial Factors applied to Actions
Leachate Level +6.00m
1.169
15kN (factored) Variable Surcharge
Name: Waste Mass
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion: 2 kPa
Phi: 25 °
Piezometric Line: 1
Height (m)
Distance (m)


Stability Risk Assessment
Inert Waste Mass
File WMASS8
Effective Stress Analysis
Design Approach 1 Combination 2
Partial Factors applied to Materials
& Variable Actions
Leachate Level +6.00m
1.011
13kN (factored) Variable Surcharge
Name: Waste Mass
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 1 kPa
Phi: 20 °
Piezometric Line: 1
Height (m)
Distance (m)


Inert Waste Mass
File WMASS9
Effective Stress Analysis
Serviceability Limit State
Effective Cohesion = 0kPa
1.431
10kN (factored) Variable Surcharge
Name: Waste Mass
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 0 kPa
Phi: 25 °
Height (m)
Distance (m)