The Geo-Environmental Service Provider

STABILITY RISK ASSESSMENT
TONG QUARRY, BACUP

Prepared for: Bacup Clay Company Limited

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1 INTRODUCTION

In August 2021, ASL was instructed by AA Environmental Limited (AAe) on behalf of Bacup Clay Company Limited to undertake a Stability Risk Assessment in support of the Permit application to dispose of inert waste.

The scope of works for this project was set out in ASL proposal reference 114-21-610.elo.3787 dated 29th July 2021 which was formerly accepted by AAe in their email dated 11th August 2021.

The purpose of the Stability Risk Assessment (SRA) is to support a permit application for the extension and restoration using inert waste. The current proposals comprise the placement of inert waste to restore the quarry following extraction in a controlled operation in accordance with the findings of the hydrogeological risk assessment for the project. The SRA presents the methodology adopted, sources of information used and the results of the stability analyses undertaken.

The methodology adopted for this SRA generally follows the principles outlined in the Environment Agency R&D Technical Report P1-385, volumes TR1 and TR2 together with additional analytical techniques as appropriate.

This report has been prepared for the sole benefit of the Client, Bacup Clay Company Limited and their representatives and agents. The report has been written based on the results of data searches and site conditions encountered at the time of the assessment. Future changes in legislation and advances in current best practises or provision of more detailed design proposals will result in this report requiring review and possible further assessment after the date of issue. The general notes section within this report should be noted in relation to the limitations of this assessment.

2 SITE DESCRIPTION

Tong Quarry is located approximately 1km to the south-east of Bacup in Lancashire and can be located approximately by National Grid Reference SD 880 220. The site is located approximately 600m to the south-east of Tong Farm. The quarry is established on former agricultural land in an area that is predominantly rural. Tong Lane runs south-east to north-west approximately 300m to the south-west of the existing quarry site. The only other access routes in the area are the quarry access track and agricultural access tracks. The location of the site is indicated in Figure 1.

The proposed extension is located to the north of the existing quarry. The site is set within moorland and currently comprises three large fields. The site slopes gently down from east to northwest.

The proposals comprise extending the existing quarrying works into the extension area and following the extraction, restoration of the site by backfilling with inert waste and restoration of the surface.

3 GEOLOGICAL SETTING

The British Geological Survey (BGS) Sheet No. 76 – Rochdale (Solid and Drift) and the BGS Geoindex indicates the site to be devoid of drift deposits and directly underlain by solid geology comprising the Pennine Lower Coal Measures Formation. The Pennine Lower Coal Measures Formation is described as 'Interbedded grey mudstone, siltstone and pale grey sandstone, commonly with mudstones containing marine fossils in the lower part, and more numerous and thicker coal seams in the upper part' by the BGS.

The BGS information indicates the underlying strata to comprise mudstones, siltstones, sandstone and coal, with the Great Arc Sandstone indicated to be outcropping in the east of the site. The Great Arc Sandstone and the central and western portions of the site are indicated to be underlain by mudstone, siltstone, sandstone and coal of the Pennine Lower Coal Measures Formation with the Woodhead Hill Rock (sandstone and mudstone) present to the west of the site, which is anticipated to be present at depth beneath the site.

4 STABILITY RISK ASSESSMENT

4.1 Report Context

Relevant background information describing the site is detailed in 'Hydrogeological Risk Assessment for Tong Quarry, Bacup, Lancashire', Report Reference 1762/HRA, dated July 2021 produced by McDonnell Cole. The HRA includes site specific information from site investigations completed at the site.

4.2 Conceptual Stability Site Model

A Conceptual Site Model has been produced by AAe showing the typical materials forming the proposed landfill. Drawings showing the Conceptual Site Model at the various stages of the development, including following construction of the first, second and third lifts of the liner together with associated infilling and also following construction of the completed side wall liner are included in Appendix II.

The ground conditions for the study area have been confirmed based on data included in HRA comprising a summary of the ground conditions encountered in three boreholes drilled at the main site. All of the boreholes indicate a thickness of Made Ground, up to 6.1m thickness, overlying Pennine Lower Coal Measures Strata to proven depths of 33m to 60m bgl. The Pennine Lower Coal Measures comprised various horizons of mudstone, sandstone and limited thicknesses of coal.

Coal workings have been encountered in the base of the existing quarry, however based on the base level of the extension these should not be encountered during the quarrying process.

The site has been quarried for sandstone and coal and associated strata and the proposed extension will continue the process of extraction of these materials. The proposed quarrying activities will extend to a depth of around 329m AOD, which is above the level of the previous mining activities. The side slopes of the quarry will be cut at an angle of approximately 2(v):1(h). It is assumed that this is as steep an angle that could be cut to maximise extraction without compromising the stability of the cut faces.

The proposals for the site post-quarrying comprise restoration for agriculture use in accordance with the moorland location. The levels in the quarry will be reinstated to the former ground level, in accordance with the relevant restoration plans by infilling with inert waste. As part of the infilling process the quarry floor will be regulated to provide a suitable engineered base. Additionally, any previous mining features will be remediated, although these are not expected in the extension area due to the depth of the proposed works.

Selected processed arisings, referred to a Fire Clay and Fines, resulting from the fines belt during grading of the aggregates, will also be used to produce a suitable lining material, which can be engineered to provide a low permeability liner in accordance with the requirements of the HRA. The materials recovered during the grading process comprise mixed materials with typically 30% to 40% fines (clay and silt), 20% to 40% sand and 20% to 30% fine and medium gravel. The assessment of these materials has concluded that they could provide a suitable low permeability liner material. Alternatively, any suitable fine grained material could be used as the lining material, following appropriate testing to demonstrate it can be engineered to provide a suitable low permeability liner.

Prior to placement of the liner a layer of free draining material will be placed against the quarry face to provide a drainage layer to control water levels behind the liner and regulated by the placement of attenuation fill to ensure the drainage layer is not impacted by the placement of the clay liner. The low permeability clay liner will be placed against the attenuation fill in compacted layers in accordance with an engineering specification developed in conjunction with the CQA Strategy to provide a material which will achieve a minimum undrained shear strength of 50kN/m^2 and a permeability of no more than 1 x 10^{-7}m/s. The earthworks specification and CQA Strategy will be implemented prior to operations. Each lift of the low permeability liner will be 2m high and extend at least 3m from the attenuation fill and will be constructed with a front slope at 1(v):3(h). Additionally a general fill will be placed above front slope of the clay liner to support the lift above and ensure stability during the filling operations.

4.2.1 Basal Sub-Grade Model

The basal subgrade will be formed from in-situ rock comprising mudstone following extraction to the design depth of between 329m and 335m AOD. The formation will be prepared by rolling the subgrade and excavating and replacing any unsuitable materials.

4.2.2 Side Slopes Sub-Grade Model

The side slopes are formed by the process of the quarry excavation of the rock comprising predominantly sandstone, which has left the pit side slopes at a comparatively steep angle. Based on the information available it is understood that the side slopes are to be cut with gradients at up to 2(v):1.1(h) to a typical maximum height of 15m to 20m across the quarry extension. The side slopes of the existing quarry have generally remained stable post quarrying, with no reports of significant instability. It is assumed that this will be the case for the proposed quarry extension. Any areas of instability will be addressed as part of the placement of a side slope drainage and attenuation layers.

The side slope drainage layer and attenuation layer will comprise suitable quarry arisings, placed and compacted against the quarry face using an appropriate methodology to meet the specification. The attenuation fill will form a suitable formation on which to place the side wall liner.

4.2.3 Basal Lining System Model

The basal lining will be provided by the basal sub-grade materials, reworked as necessary in advance of the infilling. Any areas of unsuitable materials will be excavated and replaced with suitable low permeability materials placed and compacted in accordance with a suitable methodology. The basal liner will have a hydraulic permeability of no more than 1 x 10^{-7}m/s.

4.2.4 Side Slope Lining System Model

The side slope geological barrier system will be composed of the site derived materials consisting of fire clay and fines.

Groundwater has been recorded below the level of the base of the quarry, although for the purpose of this assessment a groundwater level within the quarry walls and controlled by the drainage layer has been assumed.

The geological barrier will be placed against the drainage and attenuation fills with a minimum thickness of 3.0m in lifts of 2m height. Each lift of the geological barrier profile has been designed at a maximum gradient of 1(v):3(h) prior to backfilling. The finished liner will be at a gradient of 2(v):1(h) matching the quarry face profile, although slopes at this angle will be fully supported by the backfilled waste materials. The finished liner will have a minimum thickness of 3m. Any limited settlement of the front face of the liner will not impact on the minimum thickness of the finished liner.

4.2.5 Waste Mass Model

The waste will comprise inert materials typically comprising general cohesive and granular fills in accordance with Class 1 and Class 2 fills in accordance with Specification for Highway Works Series 600 – Earthworks. We have assumed conservative shear strength parameters to allow for a wide range of materials to be accepted.

4.2.6 Capping System Model

The site will not require a specific capping layer and the finished level will be formed by the placement of a restoration layer comprising topsoil and subsoil placed above the waste to prepare the site for agricultural use.

The general and maximum slopes of the finished restoration profile will comprise very flat slopes.

Gas pressure is not anticipated due to the nature of the waste accepted and the waste acceptance controls operated on site.

5 STABILITY RISK ASSESSMENT

Each of the six principal components of the conceptual stability site model have been considered and the various elements of that component have been assessed with regard to stability.

The principal components considered are:

- The basal subgrade
- The side slope subgrade
- The side slope geological barrier
- The inert waste material

The components not included in the design and therefore not considered are:

- The basal liner
- The capping system

5.1 Risk Screening

Potential stability and integrity issues relating to each component of the proposed landfill have been reviewed to determine the requirements for further detailed geotechnical analyses. The findings of the preliminary risk screening are presented in the following sections.

5.1.2 Basal Sub-Grade Screening

The material at the base of the quarry comprises Pennine Lower Coal Measures (in-situ mudstone), each aspect of the stability and deformability of the basal subgrade identified within the guidance is discussed below in Table 1.

Table 1 Stability Components for Basal Subgrade

Excessive Deformation	Compressible Subgrade	The basal subgrade is formed in Lower Pennine Coal Measures (insitu mudstone and sandstone) which is considered to be practically incompressible under the low loading imposed by the proposed waste height.
	Cavities within the subgrade	Previous mine workings have been identified under the original quarry area. Any cavities, shafts or adits at subgrade level will be appropriately treated and stabilised before infilling works. No further assessment is required.
	Basal Heave	The water table is located within the underlying Pennine Lower Coal Measures and in-situ mudstone and sandstone are at very low risk of heave and therefore basal heave is not considered to require further assessment.
Filling on Waste	The scheme does not involve any filling on Waste.	

The design does not include a specific basal liner as the low permeability layer will be formed of insitu materials. Therefore no further assessment is required.

5.1.3 Side Slopes Sub-Grade Screening

The controlling factors that will affect the stability and the deformability of the subgrade are included in Table 2.

Table 2 Stability/Integrity Components of Side Slope Subgrade

Cut Slope	Rock	Stability	The quarry side slopes are cut at a working face at a gradient of 2(v):1(h) to maintain a stable profile during extraction and therefore will require further stability assessment.
		Deformability	The side slope subgrade will be formed in in-situ sandstone or mudstone which is considered to be effectively incompressible under the limited stresses imposed by the waste height proposed. This component does not require further consideration.
		Groundwater	The water table is located beneath the base of the landfill and therefore is not considered to require further assessment.
	Cohesive Soils	The Conceptual Site Model does not include cut slopes in cohesive soils.	
	Granular Soils	The Conceptual Site Model does not include cut slopes in granular soils.	
Fill Slope	The Conceptual Site Model does not include filled slopes.		

5.1.4 Side Slope Lining System Screening

The controlling factors that influence the stability and integrity of the side slope geological barrier system are given below in Table 4.

Table 3 Stability/Integrity Components of Side Slope Geological Barrier System

Unconfined	Mineral only	Stability	The side slope geological barrier will comprise a granular drainage layer and attenuation fill in conjunction with an engineered low permeability material (site derived) placed to an engineered specification. Further assessment is necessary to assess the side slope and determine suitable gradient, typically 1(v):3(h).
		Integrity	The integrity of the side slope geological barrier will not be compromised in the unconfined condition providing the stability assessment returns a suitable factor of safety. Therefore, this aspect of the assessment does not require further consideration. The confined side slope geological barrier system stability is also considered as part of the Waste Mass Analysis.
Confined	Mineral only	Stability	If the stability in the unconfined condition is satisfactory, the stability of the side slope geological barrier system in the confined condition will be greater due to the buttressing effect of the waste.
		Integrity	If the integrity in the unconfined condition is satisfactory based on the factor of safety the integrity of the side slope geological barrier system in the confined condition will be greater due to the buttressing effect of the waste.

Based on the preliminary screening it is considered that the side slope geological barrier liner does require further assessment.

5.1.5 Waste Mass Screening

The controlling factors that influence the stability of the waste mass are presented below in Table 5.

Table 4 Stability/Integrity Components of Waste Mass

Failure wholly in waste	Stability	The waste will be placed in layers and compacted with a maximum slope of up to 1(v):4(h).
Failure involving Geological barrier and waste	Mineral Only	The development of progressive infilling will result in the generation of a single temporary waste slope in the short term. The proposed method of working is likely to generate a temporary waste slope parallel to the side slope geological barrier that has the potential to shear through the side or basal geological barriers.

Based on the preliminary screening it is considered that the waste mass requires further assessment.

Due to the nature of the waste to be deposited, a significant volume of leachate will not be generated and therefore a specific leachate collection system will not be installed.

Due to the nature of the waste to be deposited, a significant volume of landfill gas will not be generated. Therefore, a gas extraction system is not required and will not be installed.

5.2 Lifecycle Phases

This aspect of the assessment identifies the various critical phases during the development of the landfill. The side slope liner and inert waste will be filled in lifts as part of a single phase of infilling.

To ensure stability throughout the life of the landfill, the side slope subgrade, side slope geological barrier and temporary waste slope (short term) stability are all considered.

5.3 Data Summary

The following data is required as input for the analyses undertaken for this Stability Risk Assessment:-

- Material unit weight
- Drained and undrained shear strength of soils and waste

It should be noted that there is limited laboratory test data relating to the shear strength of the materials available on the site or those proposed for import to site.

The borehole logs and associated insitu testing has been used to determine the soil parameters for the purposes of modelling the slope stability. Where specific data is not available conservative parameters have been estimated based on material descriptions.

5.4 Justification for Modelling Approach and Software

To undertake the detailed Stability Risk Assessment, the various components of the landfill development have been considered not only individually but also in terms of the overall model. The assessment and analytical methods should adequately represent all of the considered scenarios, including the different modelled phases of the lifecycle, for both confined and unconfined conditions (where appropriate). The methodology and the software should also produce the required output results for the assessment, e.g. determination of limit equilibrium factor of safety within geological barrier components.

The analytical methods used in this Stability Risk Assessment include:

- Limit equilibrium stability analyses for the derivation of factors of safety for the unconfined subgrade, side slope liner, temporary waste slopes and final restoration profile.

The limit equilibrium analyses have been undertaken using the SlopeW (Geo Studio 2007) package utilising the Bishop simplified method of analysis.

5.5 Justification of Geotechnical Parameters Selected for Analyses

The following sections present a justification for the various parameters used in the stability analyses based on the following criteria:

- Site specific information;
- an assessment of the suitability of non-site specific data, where used;
- methods for the derivation of the parameters adopted.

A summary of the geotechnical parameters used in the design and analysis of the development are presented in tabular form for each component of the landfill in Table 7 below.

Table 5 Geotechnical Design Parameters

Material	Unit Weight γ (kN/m^3)	Effective cohesion c' (kPa)	Angle of Shearing Resistance Ø (°)	Description
Drainage layer	18	0	40	Granular Fill
Attenuation Fill	20	0	25	General Cohesive/Granular Fill
Side Wall Liner	20	0	25	Low Permeability site derived fill
General Fill	20	0	30	General Cohesive Fill
Rock	21	50	30	Insitu Sandstone/Mudstone
Inert Waste	20	0	20	Mixed Inert Waste

5.5.1 Parameters Selected for Basal Sub-Grade Analyses

The parameters for the basal sub-grade are provided within Table 7. The parameters have been based on visual descriptions of the insitu materials present in the quarry.

5.5.2 Parameters Selected for Side Slopes Sub-Grade Analyses

The side slope subgrade will be formed from the existing rock slopes with further cut where required. The parameters have been based on visual descriptions of the insitu materials present in the quarry.

Any small scale failures in the slope will be backfilled prior to construction of the drainage layer, attenuation fill and side slope liner.

The existing side slopes are up to 15m in height with the existing gradients being typically 2(v):1(h).

5.5.3 Parameters Selected for Basal Liner Analyses

There is no specific Basal Liner. The base of the landfill will be formed of insitu materials which will be re-worked as necessary.

5.5.4 Parameters Selected for Side Slope Liner Analyses

The parameters required for the side slope liner analysis are the typical angle of shearing resistance and effective cohesion of the side wall liner formed of processed fines and fire clay and the general fill (drainage layer and attenuation fill) comprising a general cohesive (Class 2) or granular fill (Class 1) in accordance with the DoT Specification for Highway Works. The assumed parameters are presented in Table 7 and are based on visual description and the assumption the materials will be placed in accordance with the engineering specification.

5.5.5 Parameters Selected for Waste Analyses

In order to provide a conservative representation of the stability of the waste mass, a weakly granular waste with the addition of cohesive clay bunds and daily cover has been considered. Assumed conservative values of effective shear strength and cohesion parameters for inert waste have been assumed to allow for variations in the waste accepted at the site. The assumed parameters are presented in Table 7 based on the expected nature of the waste.

5.5.6 Selection of Appropriate Factors of Safety

The factor of safety is the numerical expression of the degree of confidence that exists, for a given set of conditions, against a particular failure mechanism occurring. It is commonly expressed as the ratio of the load or action which would cause failure against the actual load or actions likely to be applied during service.

The factor of safety should be appropriate to the parameters selected and the quality of the site specific data. In this instance there is limited site specific data and therefore conservative parameters have been assumed where relevant together with an appropriate factor of safety.

The Factor of Safety adopted for each component of the model is related to the consequences of a failure.

Therefore, prior to determining appropriate factors of safety for the various components of the model, it is necessary to identify key 'receptors' and evaluate the consequences in the event of a failure (relating to both stability and integrity).

Consideration of the following receptors is required.

- Groundwater;
- Other environmental receptors;
- Property - relating to site infrastructure, third party property;
- Human beings (i.e. direct risk).

The factors of safety have been determined based on using a Traditional Approach to the stability assessment using material properties and loads in an unmodified state and then apply a factor of safety to the analysis to allow for uncertainty and consequence of failure.

5.5.7 Factor of Safety for Basal Sub-Grade

An assessment is not required for the Basal Sub-Grade as it has been screened out as detailed in section 5.1.2.

5.5.8 Factor of Safety for Side Slopes Sub-Grade

The side slope subgrade has been formed by excavation of the quarry at a side slope angle of approximately 2(v):1(h). Evidence of significant instability has not been observed within the side slopes.

An acceptable factor of safety is usually considered to be 1.3 for permanent excavated slopes of this nature. However, based on the consequence of failure, limited activity at the base of slope and the non-permanent nature of these features, a factor of safety of greater than 1.0 is considered acceptable. Any failures will be remediated as part of the placement of the regulatory layer and the placement of these materials together with the liner and the waste will provide a buttress to this slope and increase the factor of safety for the permanent situation.

5.5.9 Factor of Safety for Basal Lining System

An assessment is not required for the Basal Lining System as it has been screened out as detailed in section 5.1.2.

5.5.10 Factor of Safety for Side Slope Lining System

A factor of safety of 1.3 is considered appropriate when using conservative peak shear strength parameters as long term stability. Where reduced shear strength parameters are adopted (for example, for very long term conditions, involving the 'fully-softened' or residual shear strength of the side slope geological barrier), it is considered that the factor of safety could be reduced to a value greater than unity, in accordance with the advice given in the Guidance.

5.5.11 Factor of Safety for Waste Mass

In this case it is considered appropriate to adopt a factor of safety of 1.3.

5.6 Analyses

Details of the various Stability Risk Assessment analyses undertaken for the site are presented in the following sections.

5.6.1 Basal Sub-Grade Analyses

An assessment is not required for the Basal Sub-Grade as it has been screened out as detailed in section 5.1.2.

5.6.2 Side Slopes Sub-Grade Analyses

The stability analysis program SlopeW has been used to analyse the sections using the Bishop simplified method.

The stability analysis considered the worst case for the proposed side slopes. The worst case being considered is a 15m high slope with an existing gradient of 2(v):1(h).

The calculated factor safety is calculated as 1.7 for failure surfaces through the rock in the side wall of the quarry.

The output plot showing the failure surface in the side slope subgrade is shown on Output Plot 5 included in Appendix II.

The recorded factors of safety exceed the required factor of safety and are therefore considered acceptable. Additionally, as the infilling progresses the rock slope is further supported by buttressing of the slope increasing the factor of safety. In all of the other analyses undertaken the slip surface with the lowest factor of safety does not pass through the rock face indicating a Factor of Safety greater than the minimum.

5.6.3 Basal Liner Analyses

An assessment is not required for the Basal Sub-Grade as it has been screened out as detailed in section 5.1.2.

5.6.4 Side Slopes Liner Analyses

The side slope geological barrier which comprises the granular drainage layer, attenuation fill and low permeability liner will be placed onto the existing side slope sub grade in a series of lifts to provide the side slope liner. In total eight lifts of approximately 2m will be constructed. Between each lift waste will be placed against the liner.

Analyses have been carried out on the first, second and third lifts. The calculated factor of safety for failures through the side slope liner are 1.46, 1.69 and 1.65. The output plots showing these failures are included as Output Plots 6 to 8, included in Appendix II.

Additionally, an analysis was completed on the finished profile which indicated a minimum factor of safety of 1.95 for a failure through the waste indicating a higher factor of safety through the liner.

The recorded factors of safety exceed the required factor of safety and are therefore considered acceptable.

5.6.5 Waste Analyses

In considering the stability of the waste mass, the stability and integrity of the geological barrier system has been considered as they are intrinsically linked.

The stability analysis program SlopeW has been used to analyse the sections using the Bishop simplified method. The minimum factor of safety for any or a combined circular failure is 1.95 for the waste profile at 1(v):4(h). The output plot is shown as Output Plot 9, included in Appendix II.

Based on the required factor of safety this is considered acceptable.

5.7 Assessment

5.7.1 Basal Sub-Grade Assessment

Assessment of the basal subgrade is not required since it has been eliminated from consideration by the screening process detailed within section 5.1.3.

5.7.2 Side Slopes Sub-Grade Assessment

The assessment of this component indicated that the stability of the unsupported side slopes, comprising in-situ rock required further investigation. The analysis undertaken considers the short to medium term stability of the existing worst case side slope geometry prior to placement of the side slope geological barrier and waste.

Given the excavated side slopes existing stability and the low impact of slope failure, it is concluded that the existing slopes have an adequate factor of safety.

5.7.3 Side Slopes Liner Assessment

The assessment of the side slope geological barrier indicated that the unconfined side slope geological barrier requires further assessment. The assessment considers the medium term stability of designed 1(v):3(h) gradient slopes. In drained conditions the slope is considered to have an acceptable factor of safety.

The slope will be buttressed by the placement of waste. Based on phased filling the side slope geological barrier will remain unconfined for a relatively short time period and factor of safety will increase with the placement of the waste.

5.7.4 Waste Assessment

This Stability Risk Assessment incorporates analyses of side slope geological barrier stability since this component plays a role in waste mass stability. The assessment also considers temporary waste slopes within the inert waste.

The stability assessment demonstrates that temporary and permanent waste slopes at a gradient of 1(v):4(h) return an adequate factor of safety in all analysed conditions.

It is recommended that site tipping rules should be used in order to maintain safe working practices.

This should include presentation of the approach to and the results of the analyses undertaken for this component.

5.8 Monitoring

5.8.1 The Risk Based Monitoring Scheme

Based upon the results of the Stability Risk Assessment, a simple risk-based monitoring scheme is considered appropriate for the future development of the landfill. The monitoring is limited to ensuring compliance with the tipping rules and monitoring of groundwater levels.

5.8.2 Basal Sub-Grade Monitoring

Monitoring prior to filling will comprise visual inspection to determine any evidence of previous mining activity. If any signs of previous mining activity are highlighted this will need to be investigated, assessed and remediated prior to filling.

5.8.3 Side Slopes Sub-Grade Monitoring

Monitoring during construction will comprise visual inspection to determine any failed or weakened zones that may require removal.

No additional instrumentation is required during construction or post final landscape restoration.

5.8.4 Side Slope Lining System Monitoring

Monitoring during construction will comprise construction quality assurance (CQA) to ensure compliance with the construction specification.

No additional instrumentation is required during construction or post final landscape restoration.

5.8.5 Waste Mass Monitoring

During infilling tip faces and surrounding areas should be inspected daily for signs of failure.

No other specific monitoring is required for the waste other than to record waste elevations across the site.

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BS10175+A2:2017 "Code of Practice for the Investigation of Potentially Contaminated Sites"

GENERAL NOTES

The interpretation made in this report is based on the information obtained during the course of the desk study and ground investigation. It should be appreciated that any desk study information is not necessarily exhaustive and that further information relevant to the site and its proposed usage may be available. There may be conditions present on the site that have not been revealed by the ground investigation which as a result have not been addressed within this report.

The accuracy of any map extracts cannot be guaranteed and it should be recognised that different conditions on site may have existed between and subsequent to the various map surveys.

The qualitative assessment of risk presented in this report presents an assessment of potential pollutant linkages between sources, pathways and receptors. A level of risk is attributed to these linkages. However a low or insignificant risk does not imply that elevated concentrations of various determinants are not present on the site when compared to background or 'greenfield' conditions.

The level of risk attributed is based on a number of factors and the interpretation of this risk may be applied in a different manner for a different end use or environmental setting. The presence of contaminants may be assessed in alternative ways by institutional bodies regardless of whether an apparent risk is present based on the identified pollutant linkages in this assessment.

This report may express an opinion on possible configurations of strata underlying the site between or beyond the exploratory holes or on the possible presence of features based on either visual, verbal or published evidence, this is for guidance only and no liability can be accepted for its accuracy.

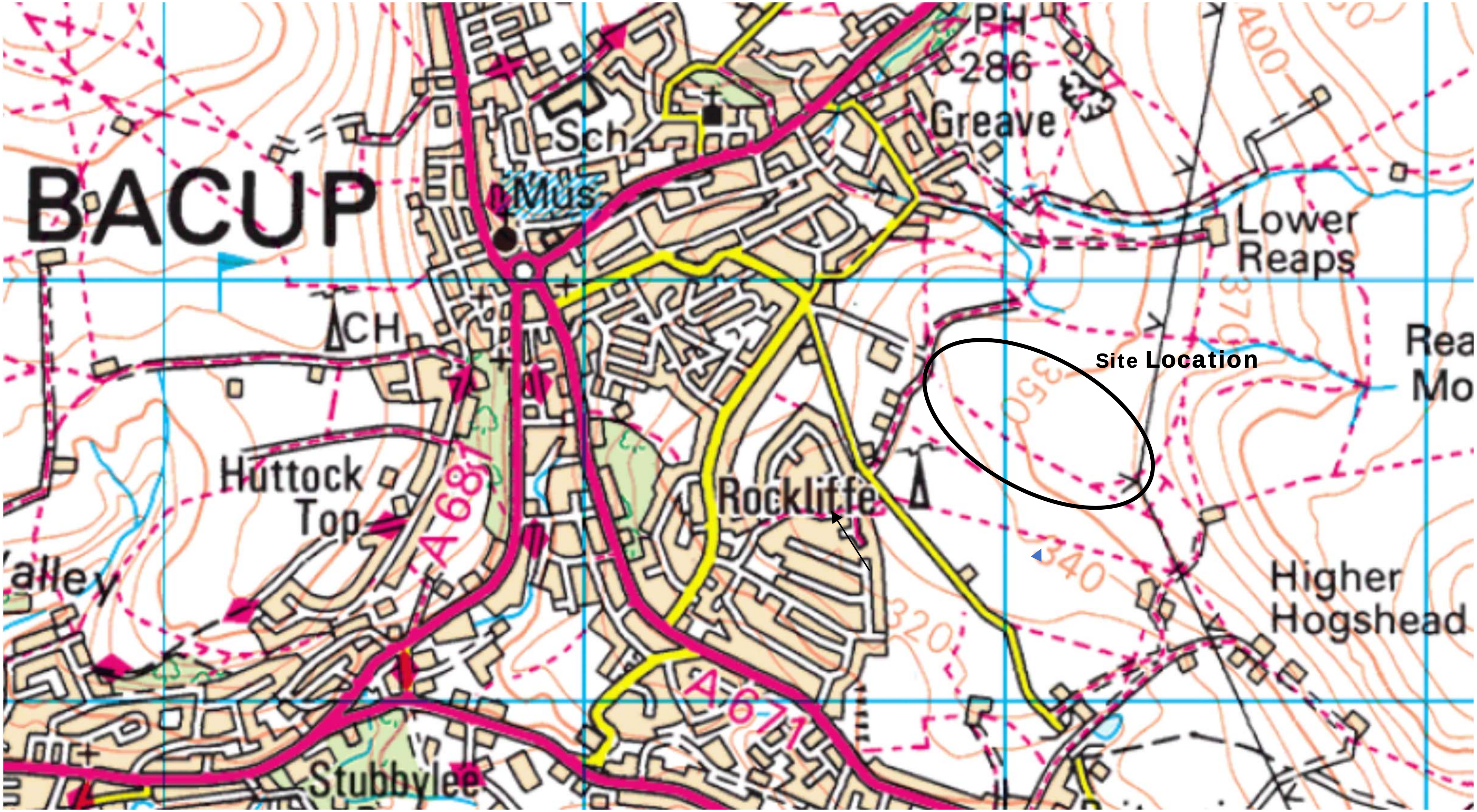
Comments made on ground conditions are based on the observations made at the time of the investigation works. It should be noted that groundwater levels may vary due to seasonal fluctuation or other factors. Observations made with respect to below ground gas concentrations may also vary due to seasonal factors and atmospheric conditions.

This report has been prepared in relation to the proposed development as detailed herein. Should the nature of the development change following the submission of this report a re-assessment of the conditions recorded on the site may be necessary.

This report may not be used in the assessment of the conditions at any site other than the site described herein

This report has been prepared for the sole use of the client and the client's agents and advisors in relation to the proposed development as detailed herein. The issue of this report to third parties not involved in the proposed development as described herein is not permitted without the prior permission being received in writing by ASL. Reproduction of this report to include all figures, drawings and appendices is prohibited without the prior written consent of ASL.

FIGURES



Drawing No.	**Figure 1**
Drawing Name	**Site Location Plan**
Project Name	**Tong Quarry**
Client Name	**Bacup Clay Company Limited**
Project No.	**114-21-610-13**

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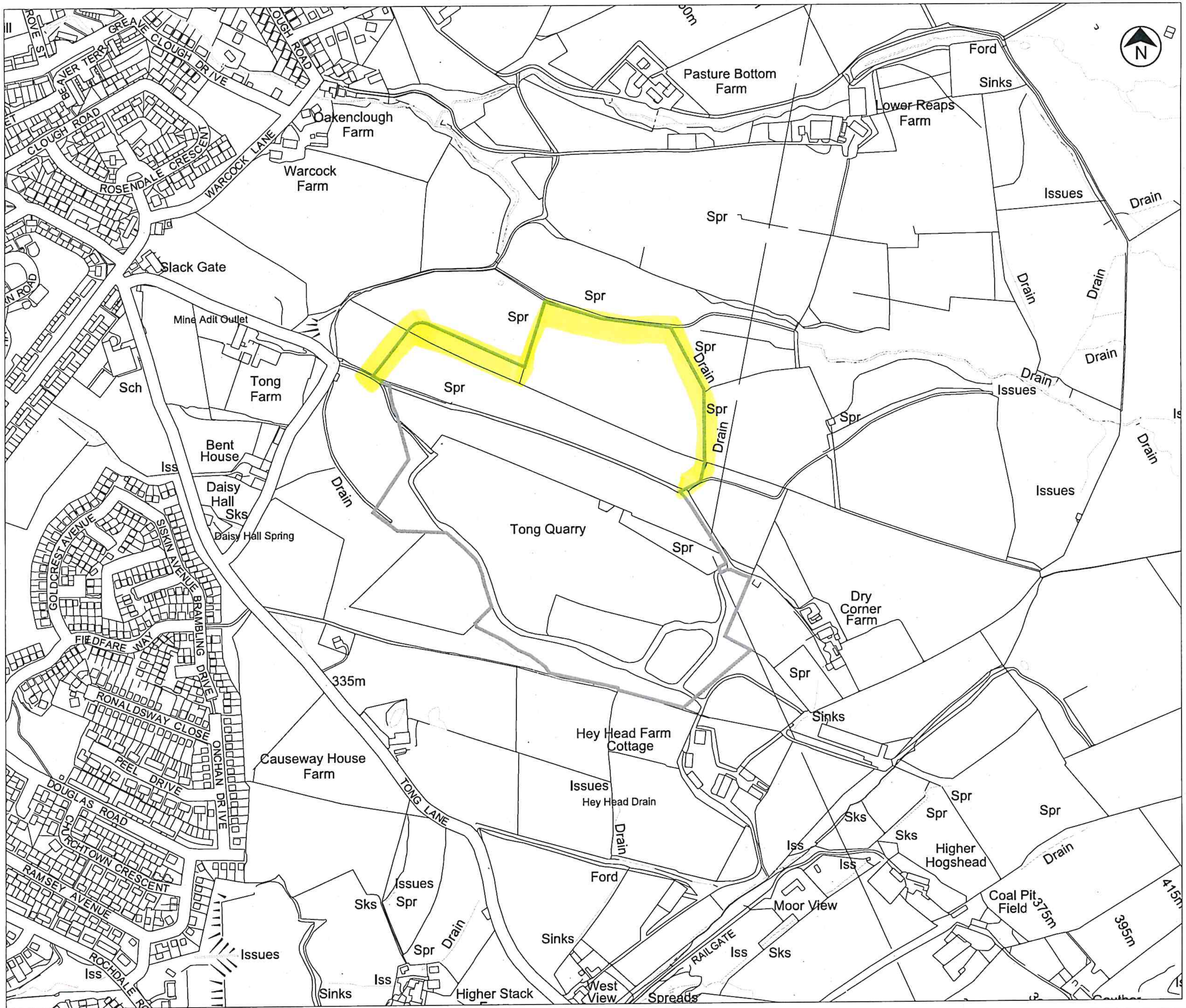
APPENDIX I

SITE LAYOUT PLAN



Key:

Site Boundary

Notes:

1. The site is centered at Grid Reference SD 68082 22704.

Rev.	Details	Drawn / Chkd.	Date

Project

213036
Tong Quarry

Title

Site Location Plan

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www.aae-ltd.co.uk

Scale	Date	Drg. No.	Rev.
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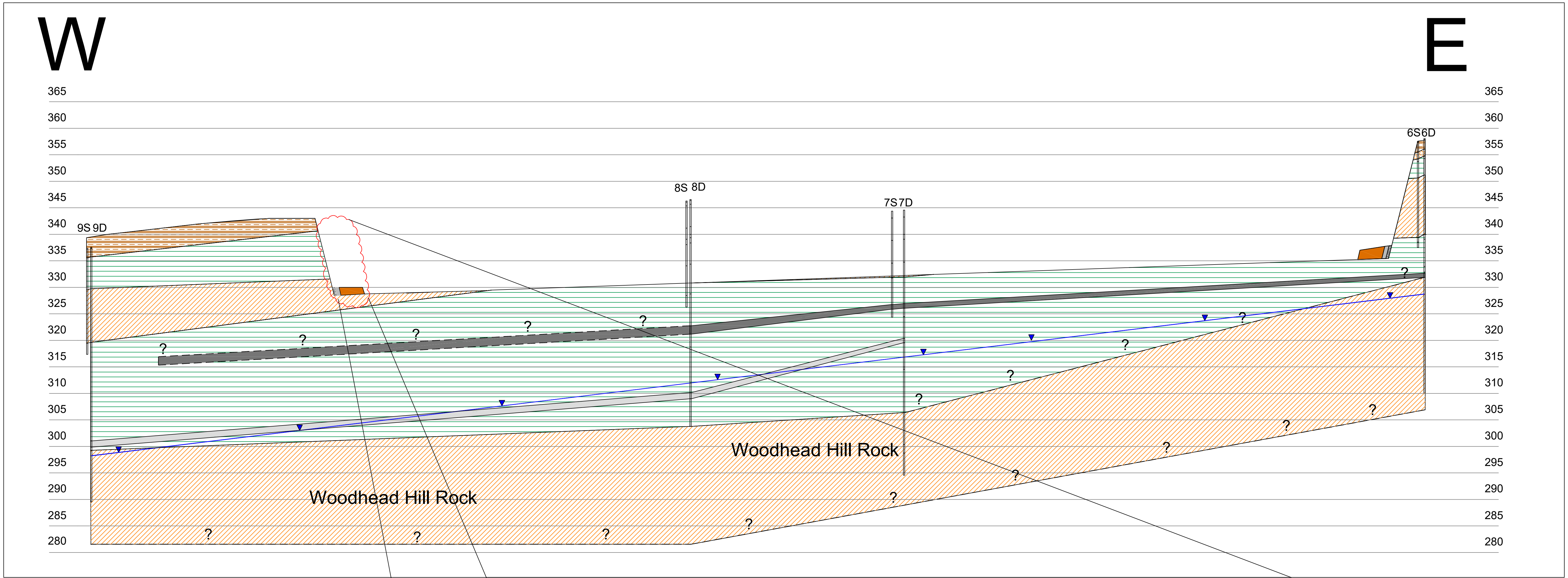
	Drawn: JM / Chkd.: ML		

APPENDIX II

CONCEPTUAL SITE MODEL

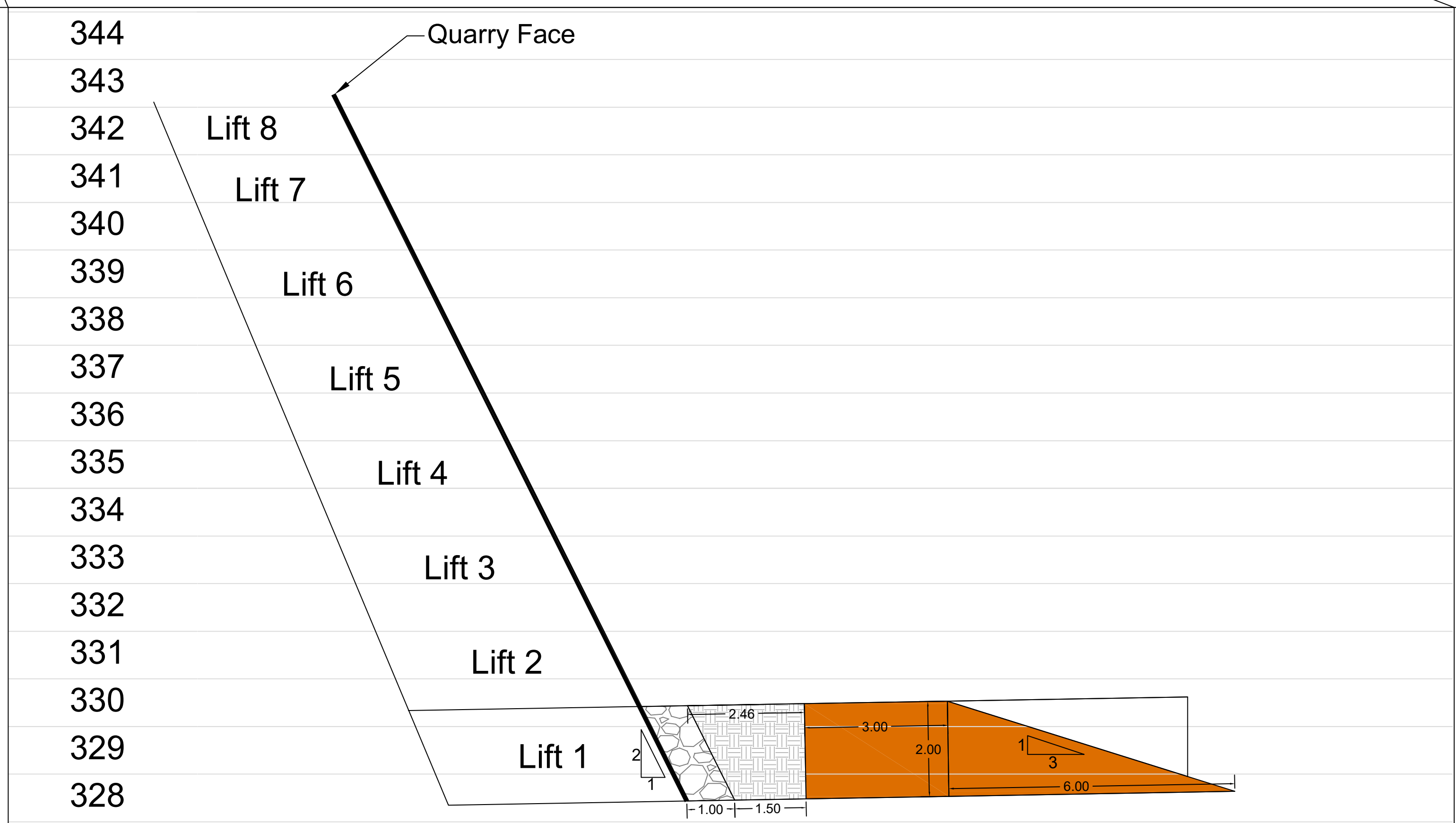


Key:

- Waste
- Compacted Clay Liner
- Granular Drainage
- Attenuation Fill
- General Fill Compacted to S.H.W Series 600
- Topsoil / Gravelly Clay
- Pennine Lower Coal Measures (Shale / Mudstone)
- Lower Foot Mine Coal Seam
- Lower Coal Seam
- Sandstone
- Deep Groundwater Level (06/02/2021)

Notes:

1. The Conceptual Site Model has a vertical exaggeration is 2:1 and a horizontal exaggeration of 1:1.
2. The engineered side wall diagram has a vertical and horizontal exaggeration of 1:1.



Scale: 1:150@A3

Rev.	Details	Drawn / Chkd.	Date

Project

213036
Tong Quarry

Title

Conceptual Site Model - First Lift Constructed

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Scale	Date	Drawn	Chkd.	Drg. No.	Rev.
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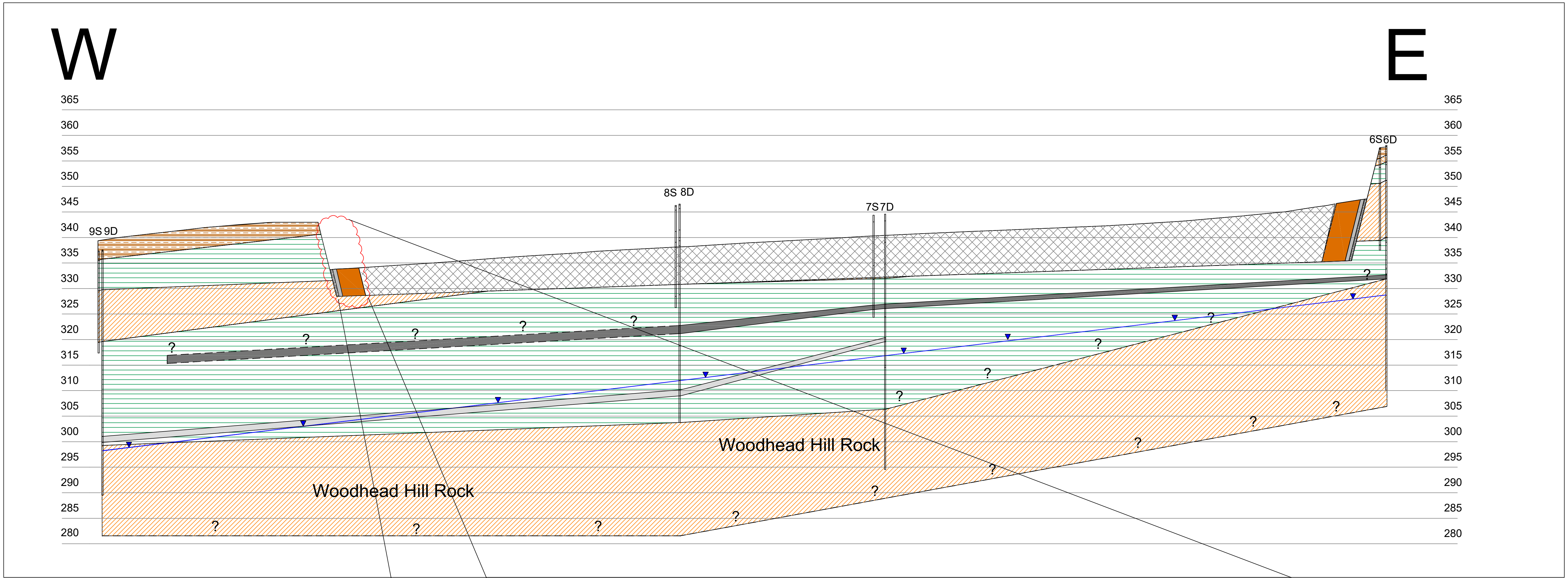

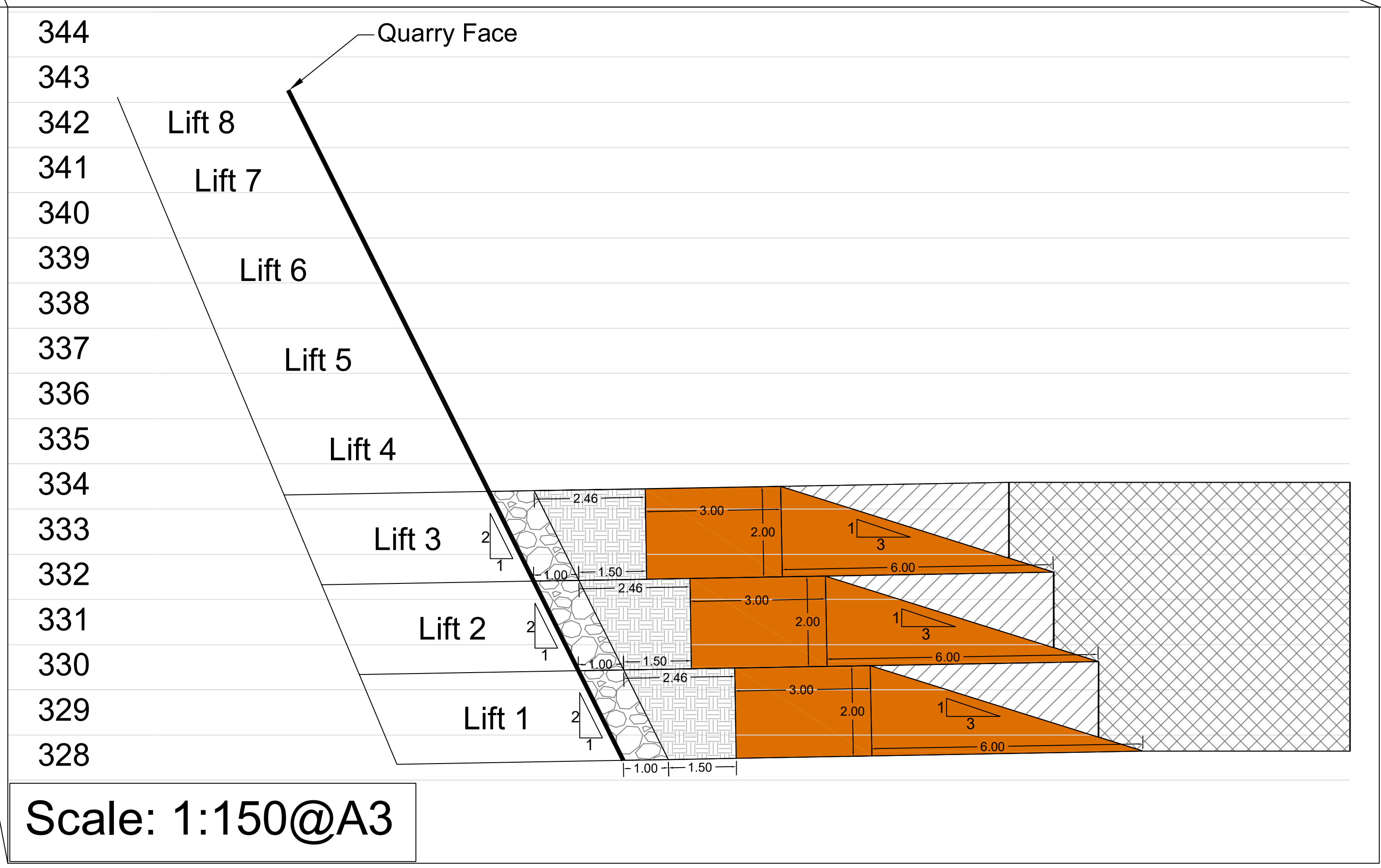

Key:

- Waste
- Compacted Clay Liner
- Granular Drainage
- Attenuation Fill
- General Fill Compacted to S.H.W Series 600
- Topsoil / Gravelly Clay
- Pennine Lower Coal Measures (Shale / Mudstone)
- Lower Foot Mine Coal Seam
- Lower Coal Seam
- Sandstone
- Deep Groundwater Level (06/02/2021)

Notes:

1. The Conceptual Site Model has a vertical exaggeration is 2:1 and a horizontal exaggeration of 1:1.
2. The engineered side wall diagram has a vertical and horizontal exaggeration of 1:1.

Rev.	Details	Drawn / Chkd.	Date

Project
213036
Tong Quarry

Title
Conceptual Site Model - Third Lift Constructed

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Scale	Date	Drawn	Chkd.	Drg. No.	Rev.
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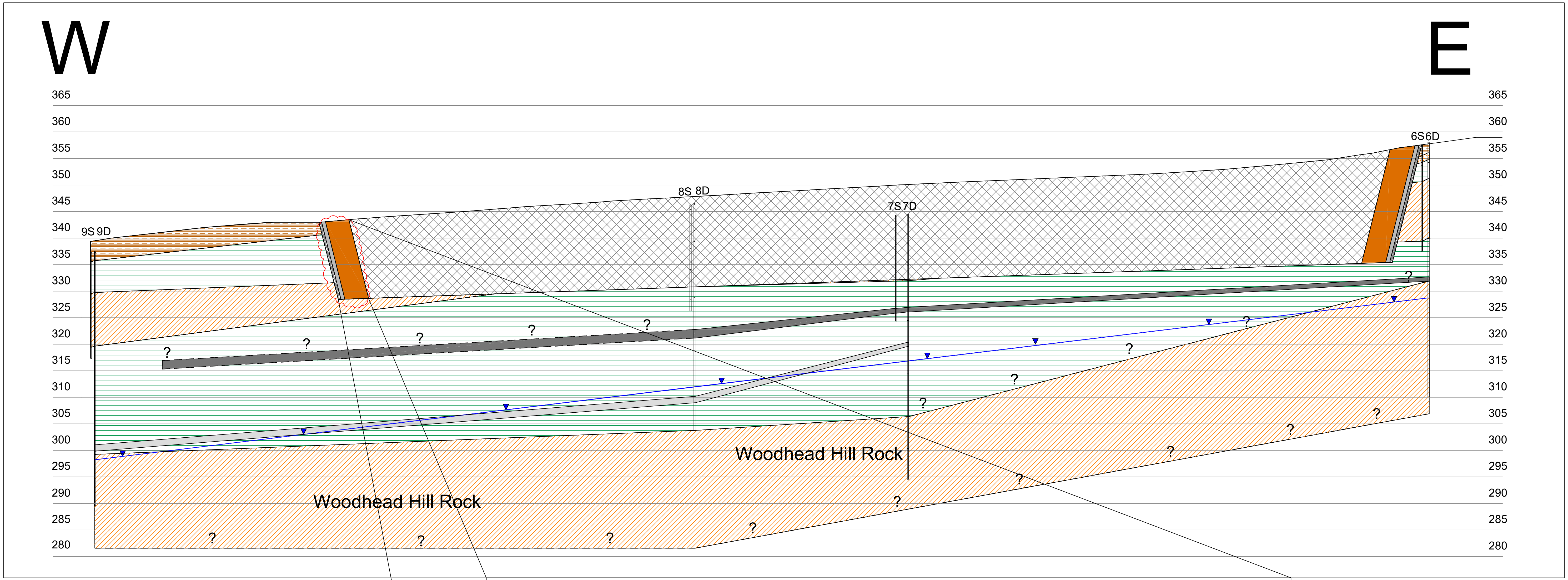

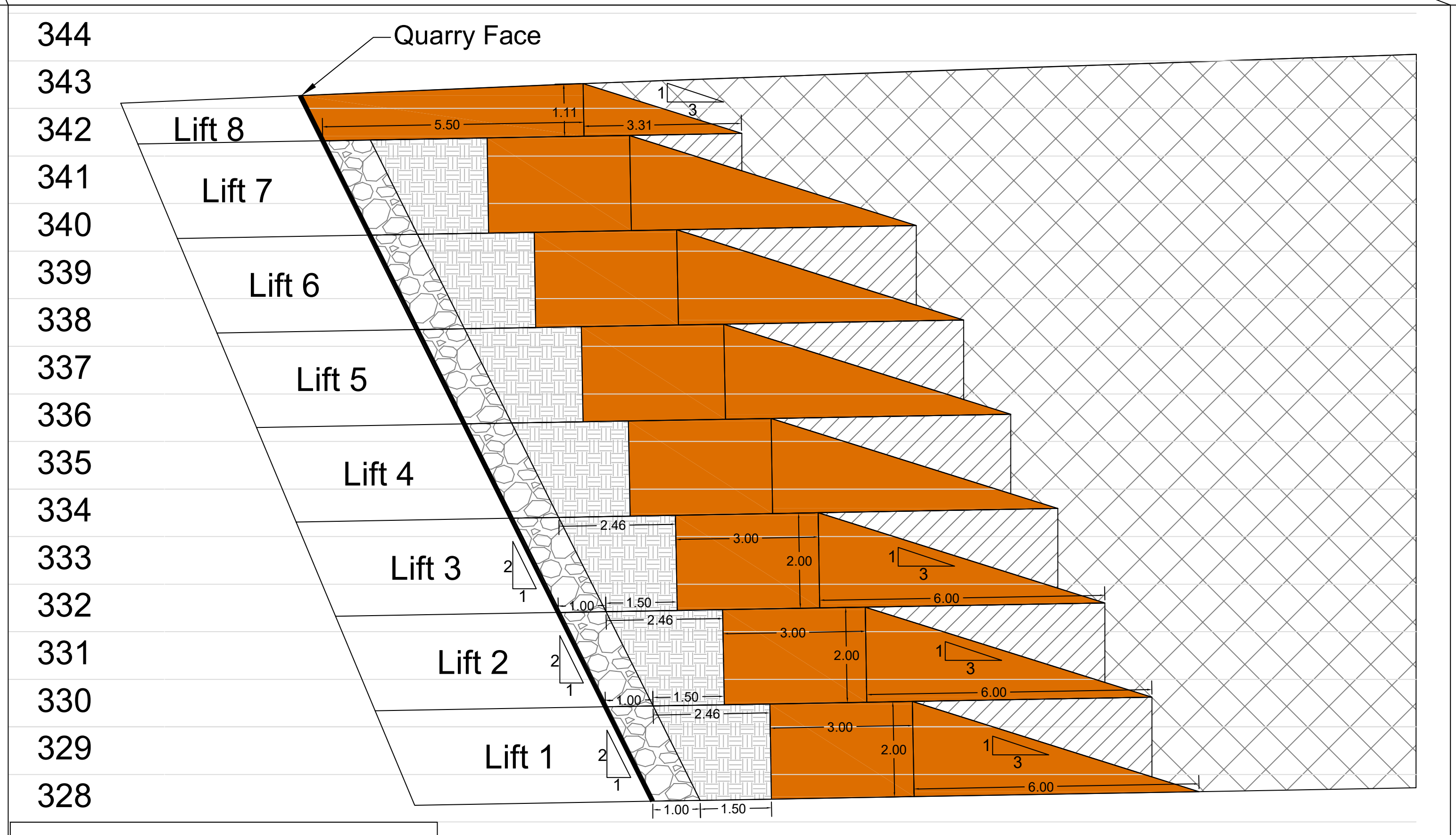

Scale: 1:150@A3

Key:

- Waste
- Compacted Clay Liner
- Granular Drainage
- Attenuation Fill
- General Fill Compacted to S.H.W Series 600
- Topsoil / Gravelly Clay
- Pennine Lower Coal Measures (Shale / Mudstone)
- Lower Foot Mine Coal Seam
- Lower Coal Seam
- Sandstone
- Deep Groundwater Level (06/02/2021)

Notes:

1. The Conceptual Site Model has a vertical exaggeration is 2:1 and a horizontal exaggeration of 1:1.
2. The engineered side wall diagram has a vertical and horizontal exaggeration of 1:1.

Rev.	Details	Drawn / Chkd.	Date

Project
213036
Tong Quarry

Title
Conceptual Site Model - Fully Restored

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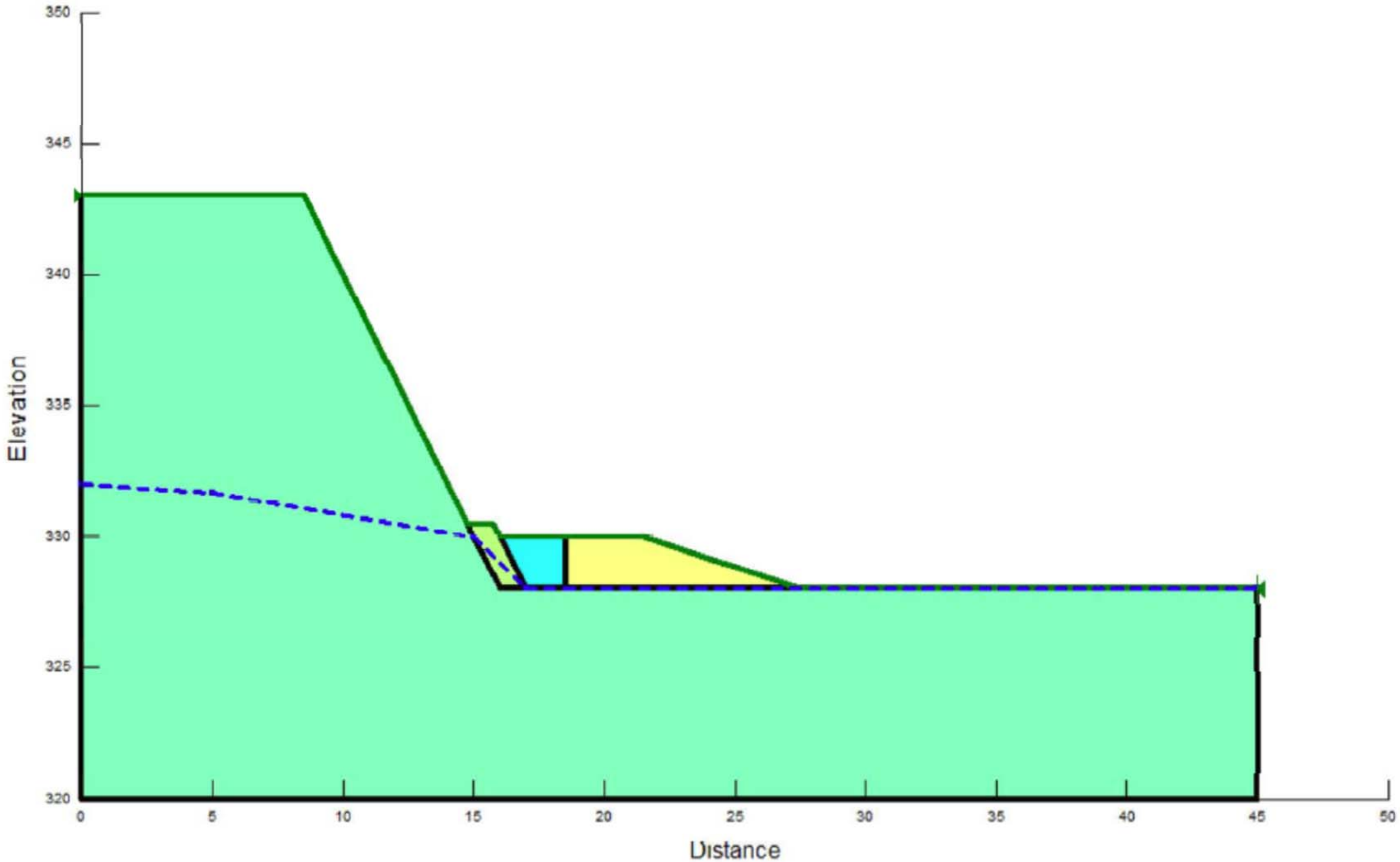
Scale	Date	Drawn	Chkd.	Drg. No.	Rev.
1:1,500@A3	Aug '21	JM	ML	213036/CSM/D/001C	

APPENDIX III

STABILITY ASSESSMENT OUTPUT PLOTS



Key

Drainage Layer
Density 18kN/m3 Cohesion 0 kN/m2
Friction Angle 40 deg

Attenuation Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

Side Wall Liner
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

General Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 30 deg

Rock
Density 21kN/m3 Cohesion 50 kN/m2
Friction Angle 30 deg

Inert Waste
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 20 deg

Drawing No.	**Output Plot 1**
Drawing Name	**Lift 1**
Project Name	**Tong Quarry**
Client Name	**Bacup Clay Company Limited**
Project No.	**114-21-610-13**

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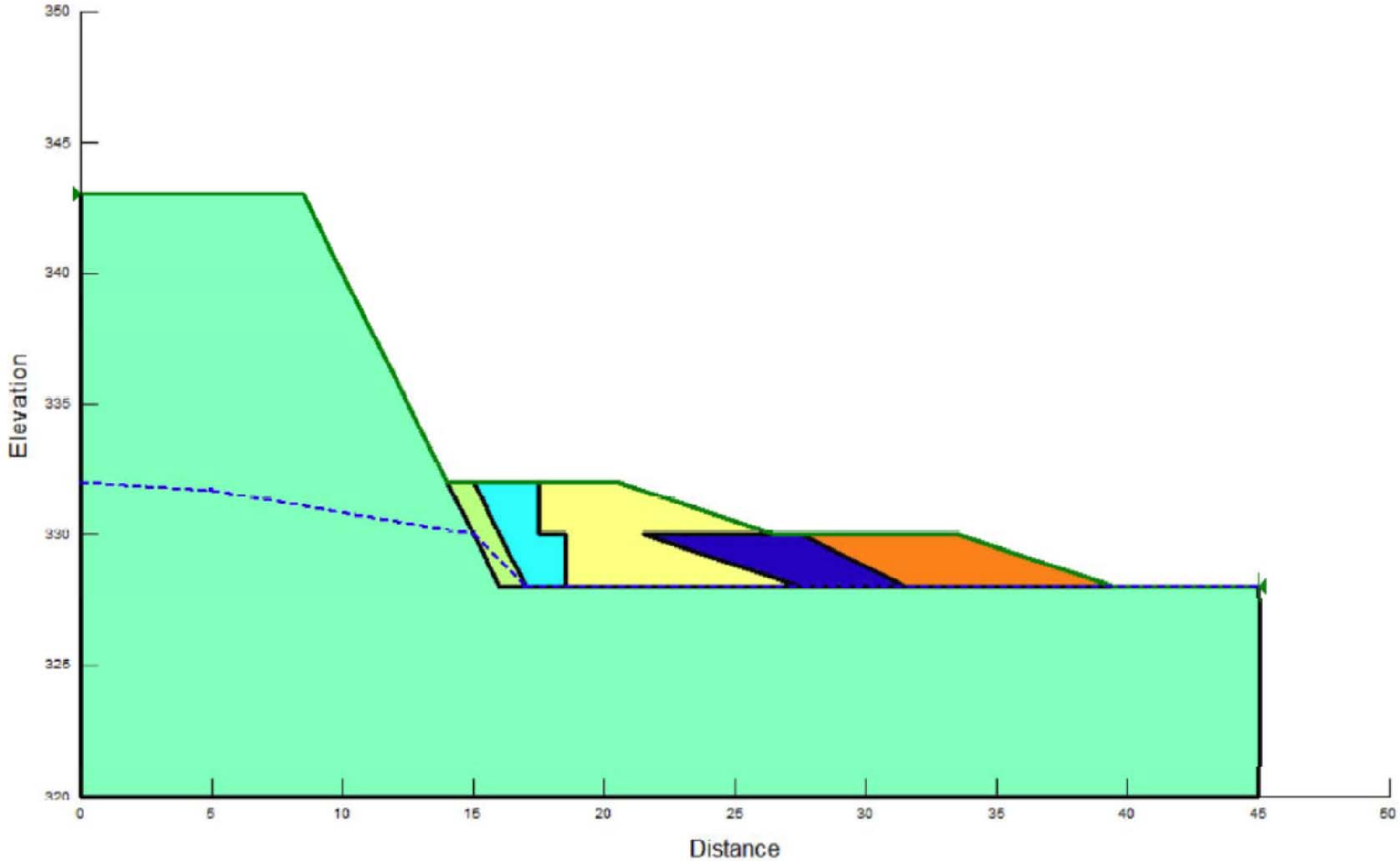

Key

- **Drainage Layer** — Density 18kN/m3 Cohesion 0 kN/m2, Friction Angle 40 deg
- **Attenuation Fill** — Density 20kN/m3 Cohesion 0 kN/m2, Friction Angle 25 deg
- **Side Wall Liner** — Density 20kN/m3 Cohesion 0 kN/m2, Friction Angle 25 deg
- **General Fill** — Density 20kN/m3 Cohesion 0 kN/m2, Friction Angle 30 deg
- **Rock** — Density 21kN/m3 Cohesion 50 kN/m2, Friction Angle 30 deg
- **Inert Waste** — Density 20kN/m3 Cohesion 0 kN/m2, Friction Angle 20 deg

Drawing No.	**Output Plot 2**
Drawing Name	**Second Lift**
Project Name	**Tong Quarry**
Client Name	**Bacup Clay Company Limited**
Project No.	**114-21-610-13**

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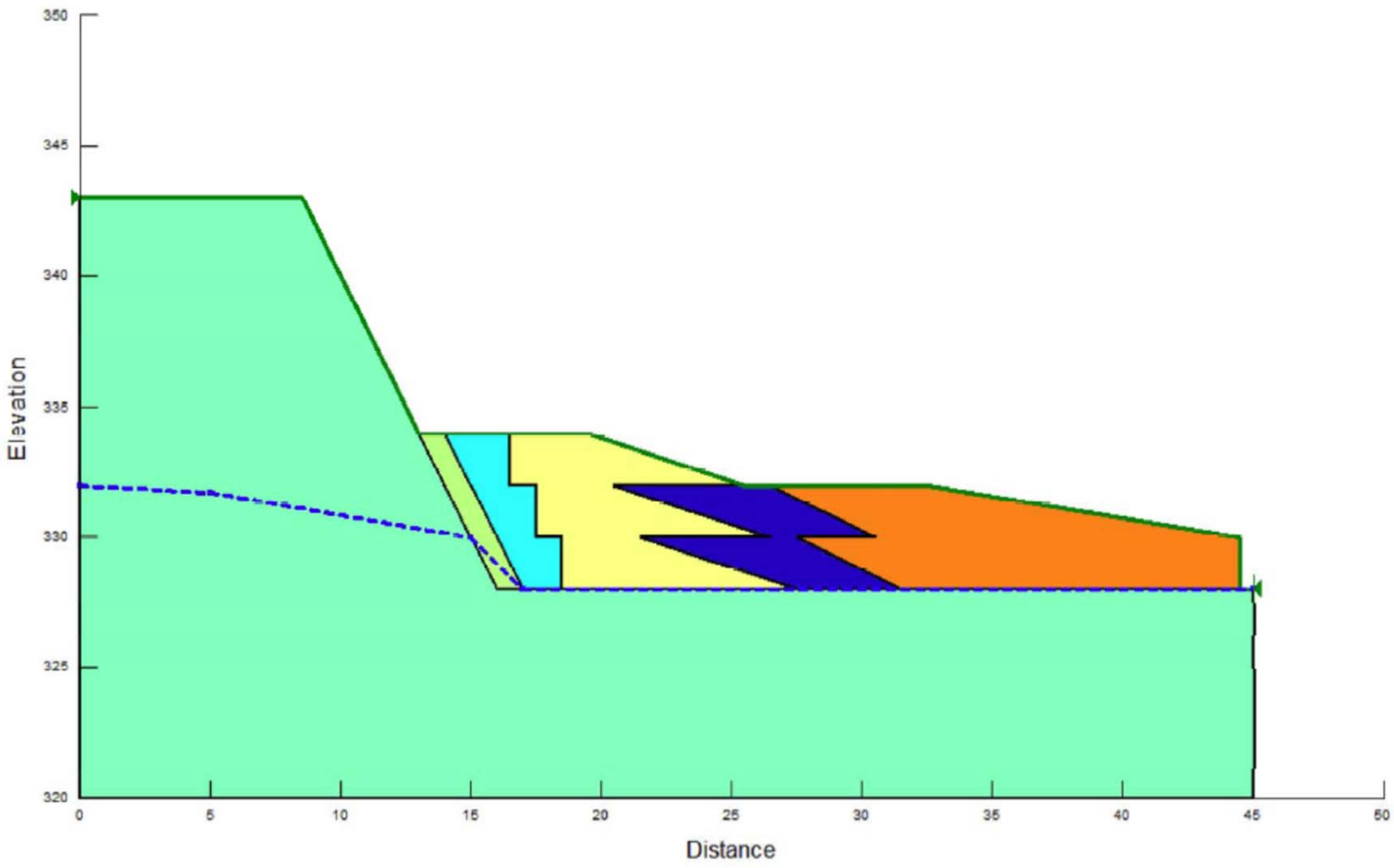

Key

Drainage Layer
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Friction Angle 40 deg

Attenuation Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

Side Wall Liner
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

General Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 30 deg

Rock
Density 21kN/m3 Cohesion 50 kN/m2
Friction Angle 30 deg

Inert Waste
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 20 deg

Drawing No.	**Output Plot 3**
Drawing Name	**Third Lift**
Project Name	**Tong Quarry**
Client Name	**Bacup Clay Company Limited**
Project No.	**114-21-610-13**

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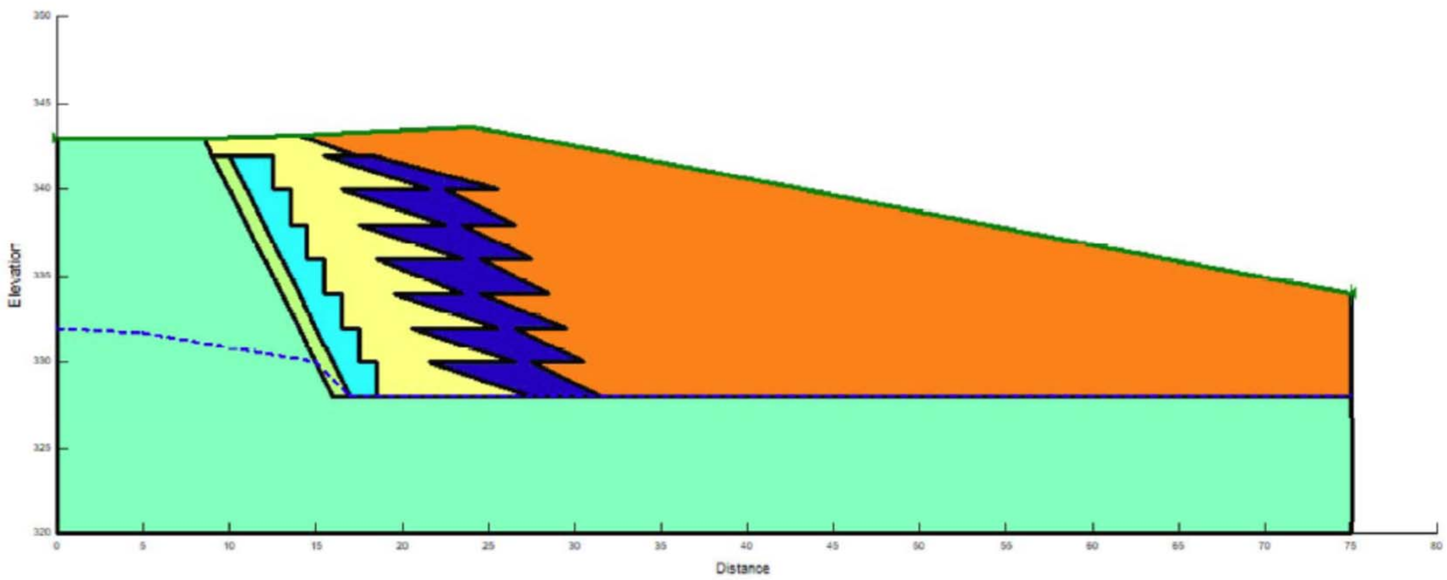

Key

Drainage Layer
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Friction Angle 40 deg

Attenuation Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

Side Wall Liner
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

General Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 30 deg

Rock
Density 21kN/m3 Cohesion 50 kN/m2
Friction Angle 30 deg

Inert Waste
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 20 deg

Drawing No.	**Output Plot 4**
Drawing Name	**Final Profile**
Project Name	**Tong Quarry**
Client Name	**Bacup Clay Company Limited**
Project No.	**114-21-610-13**

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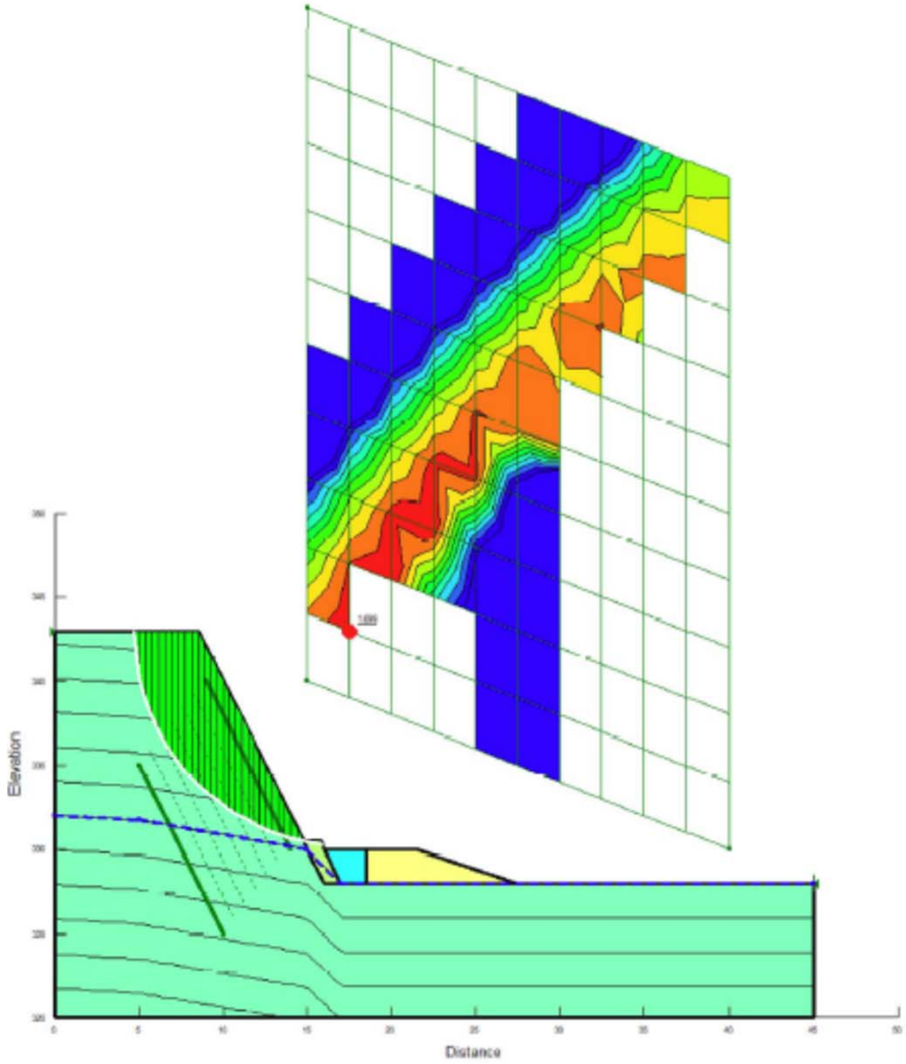

Minimum factor of Safety 1.70

Key

Drainage Layer
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Friction Angle 40 deg

Attenuation Fill
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Friction Angle 25 deg

Side Wall Liner
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

General Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 30 deg

Rock
Density 21kN/m3 Cohesion 50 kN/m2
Friction Angle 30 deg

Inert Waste
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 20 deg

Drawing No.	**Output Plot 5**
Drawing Name	**Lift 1 – Failure surface through quarry wall**
Project Name	**Tong Quarry**
Client Name	**Bacup Clay Company Limited**
Project No.	**114-21-610-13**

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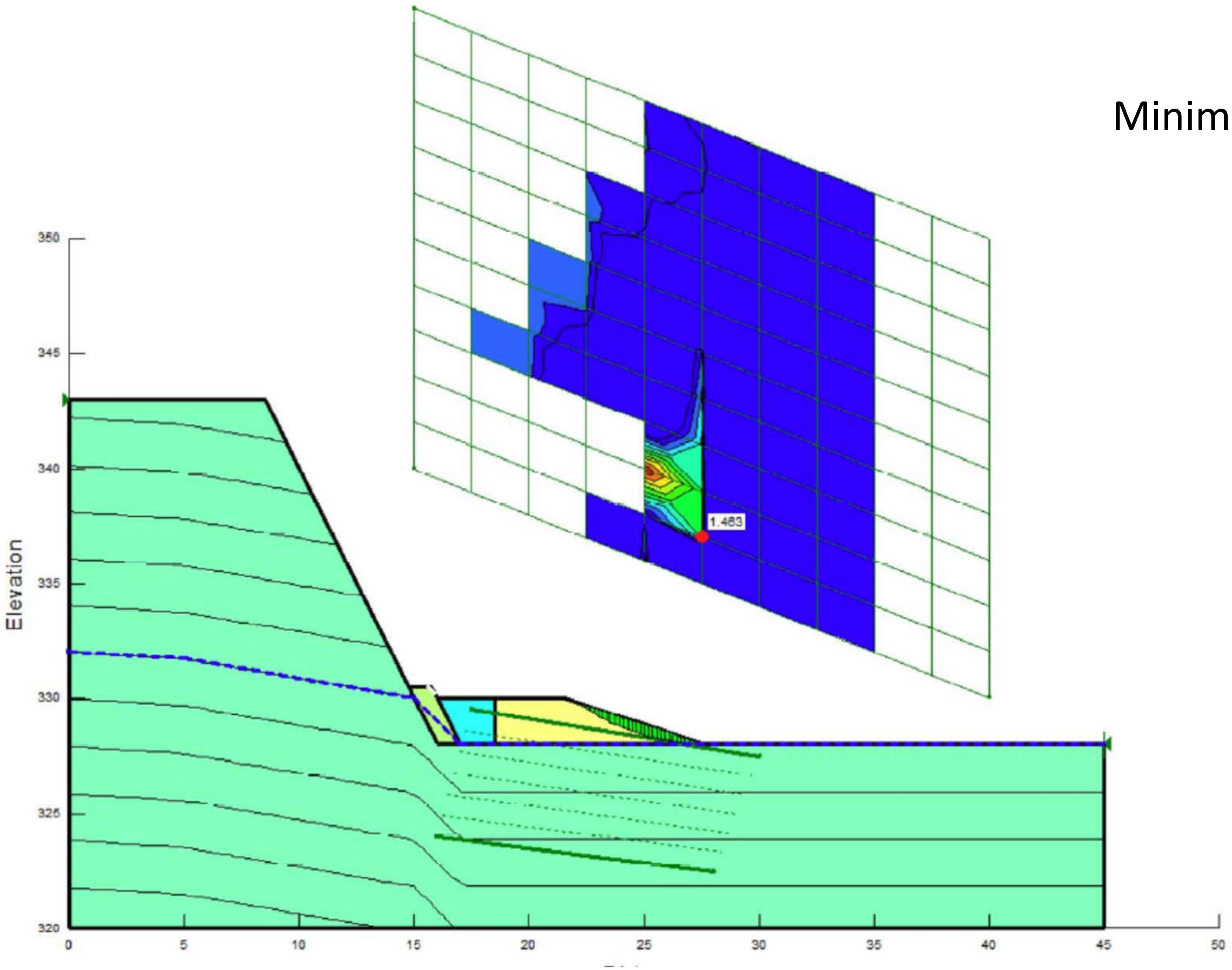
Minimum factor of Safety 1.46



Key

Drainage Layer
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Friction Angle 40 deg

Attenuation Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

Side Wall Liner
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

General Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 30 deg

Rock
Density 21kN/m3 Cohesion 50 kN/m2
Friction Angle 30 deg

Inert Waste
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 20 deg

Drawing No.	**Output Plot 6**
Drawing Name	**Lift 1 – Failure surface through liner**
Project Name	**Tong Quarry**
Client Name	**Bacup Clay Company Limited**
Project No.	**114-21-610-13**

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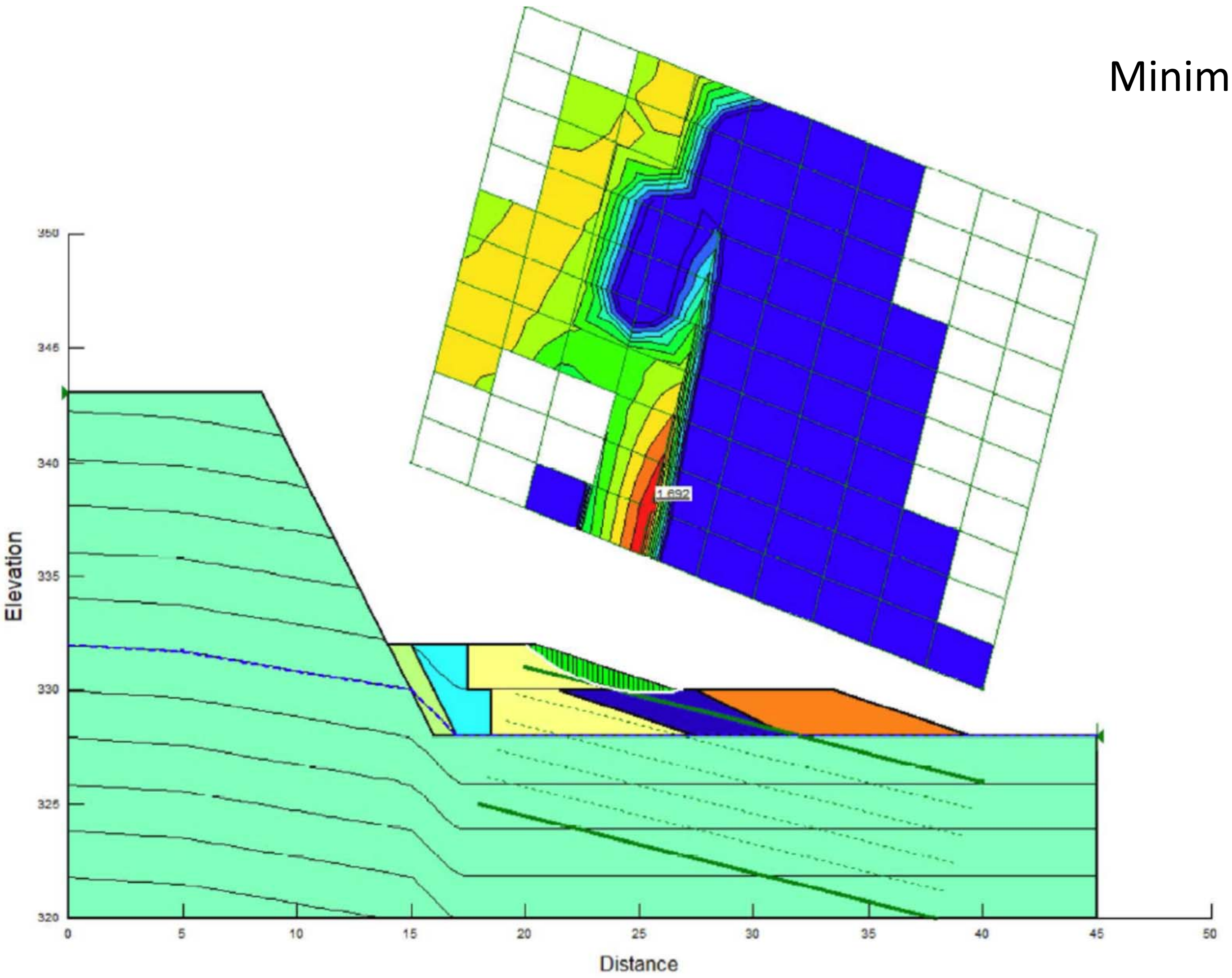
Minimum factor of Safety 1.69



Key

Drainage Layer
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Friction Angle 40 deg

Attenuation Fill
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Friction Angle 25 deg

Side Wall Liner
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

General Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 30 deg

Rock
Density 21kN/m3 Cohesion 50 kN/m2
Friction Angle 30 deg

Inert Waste
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 20 deg

Drawing No.	**Output Plot 7**
Drawing Name	**Lift 2 – Failure surface through liner**
Project Name	**Tong Quarry**
Client Name	**Bacup Clay Company Limited**
Project No.	**114-21-610-13**

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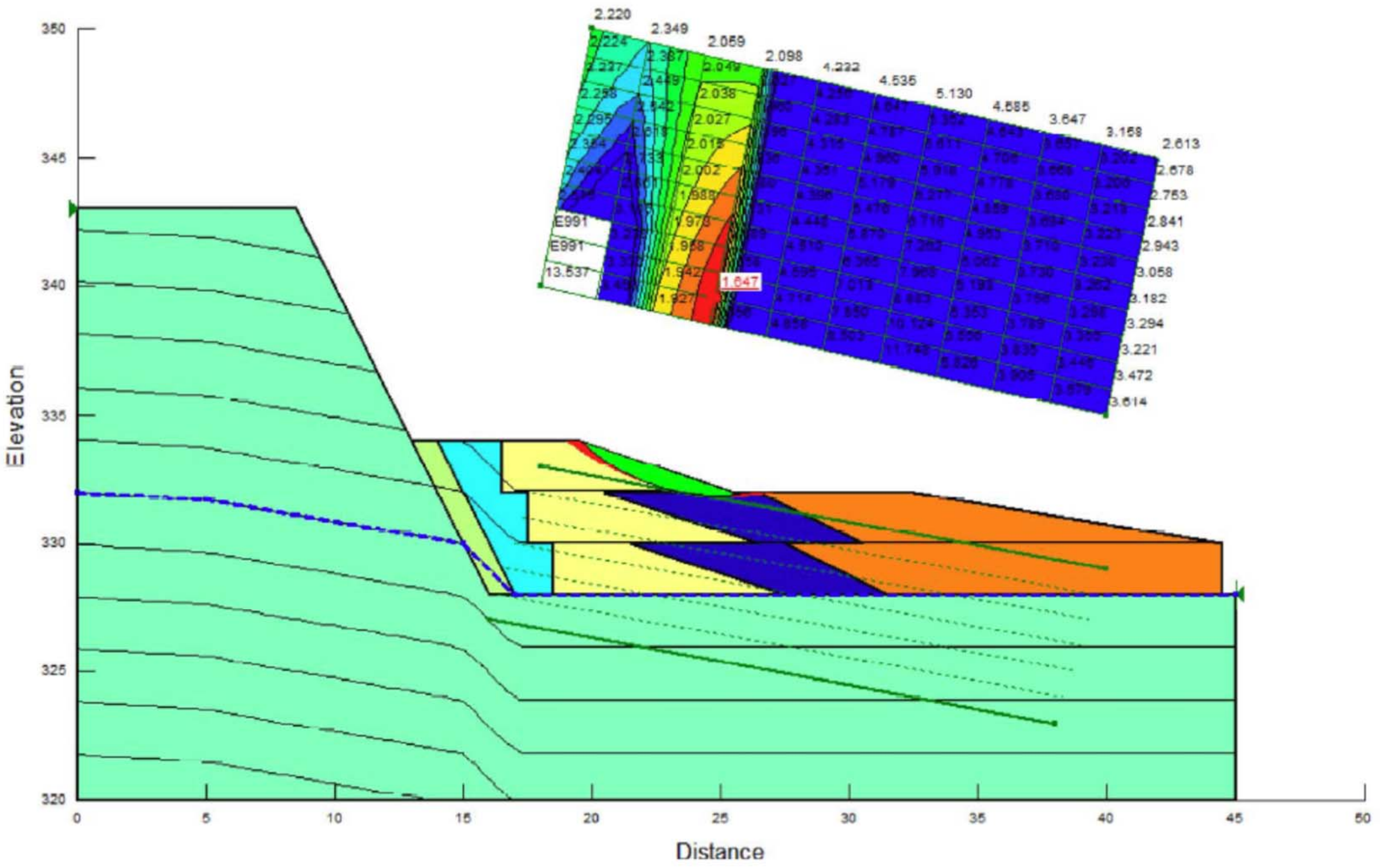
Minimum factor of Safety 1.65



Key

Drainage Layer
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Friction Angle 40 deg

Attenuation Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

Side Wall Liner
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

General Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 30 deg

Rock
Density 21kN/m3 Cohesion 50 kN/m2
Friction Angle 30 deg

Inert Waste
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 20 deg

Drawing No.	**Output Plot 8**
Drawing Name	**Lift 3 – Failure surface through liner**
Project Name	**Tong Quarry**
Client Name	**Bacup Clay Company Limited**
Project No.	**114-21-610-13**

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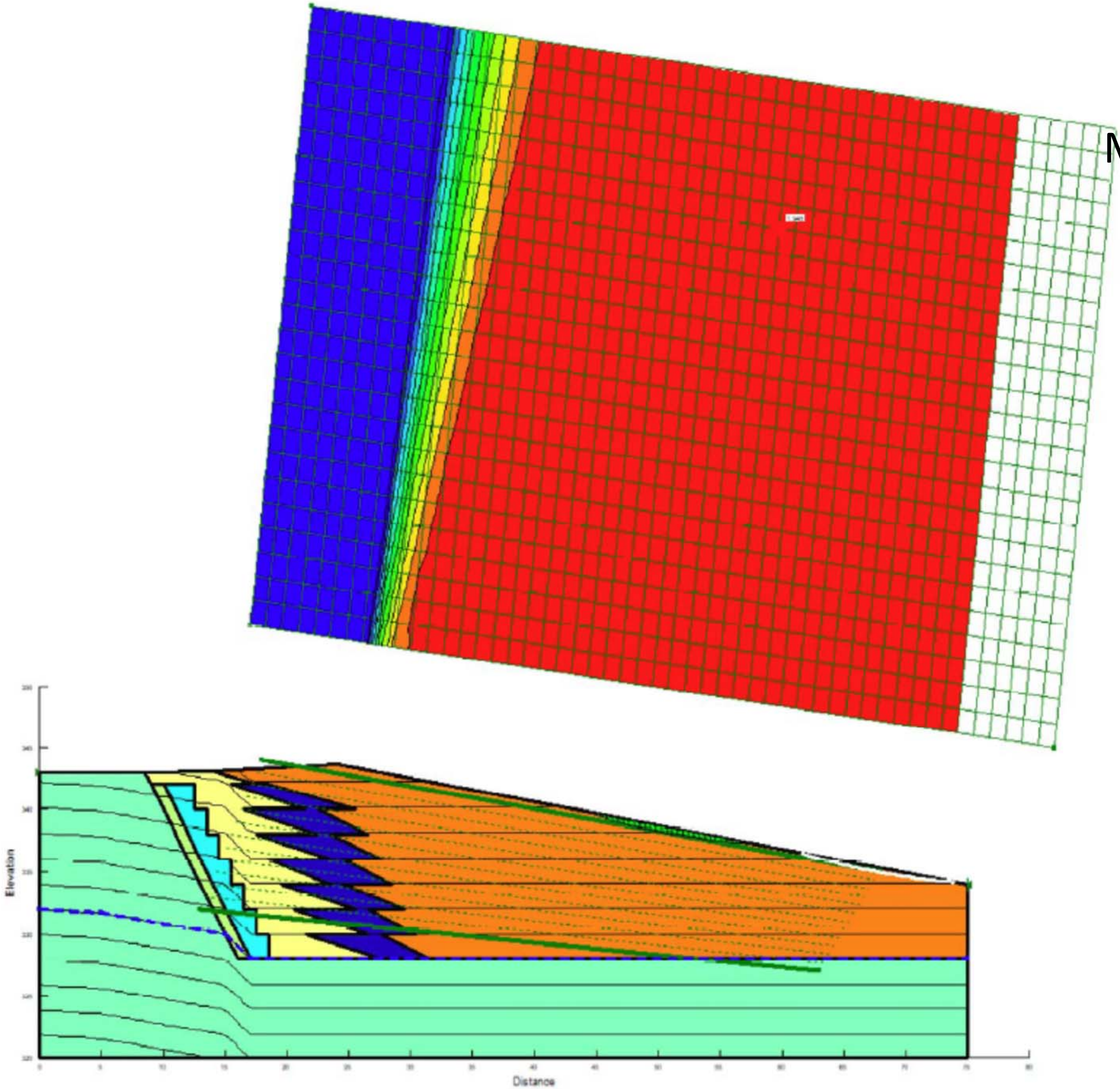
Minimum factor of Safety 1.95



Key

Drainage Layer
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Friction Angle 40 deg

Attenuation Fill
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Friction Angle 25 deg

Side Wall Liner
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 25 deg

General Fill
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 30 deg

Rock
Density 21kN/m3 Cohesion 50 kN/m2
Friction Angle 30 deg

Inert Waste
Density 20kN/m3 Cohesion 0 kN/m2
Friction Angle 20 deg

Drawing No.	**Output Plot 9**
Drawing Name	**Final Lift – Failure surface through inert waste**
Project Name	**Tong Quarry**
Client Name	**Bacup Clay Company Limited**
Project No.	**114-21-610-13**

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