E3P
Taylor Road
Trafford Park
Urmston
Manchester
M41 7JQ

Manchester | London | Edinburgh

info@E3P.co.uk
www.E3P.co.uk

Ref: 14-244-L1-RevB
Date: 5th May 2022

C/O Ruttle Plant Hire Ltd

Mineral Planning Group
Oakdene House
Cottingley Business Park
Bingley
BD16 1PE

Dear Sirs,

ANALYSIS OF SLOPE STABILITY GALE MOSS, CHORLEY

1. BACKGROUND

E3P Understands that the Mineral Planning Group (MPG) are assisting their client (Ruttle Plant Hire) who intend to win minerals through excavation and backfill with imported arisings to later prepare and divest the site for development. The site is located to the north of Chorley and the north of the A674 known as Gale Moss.

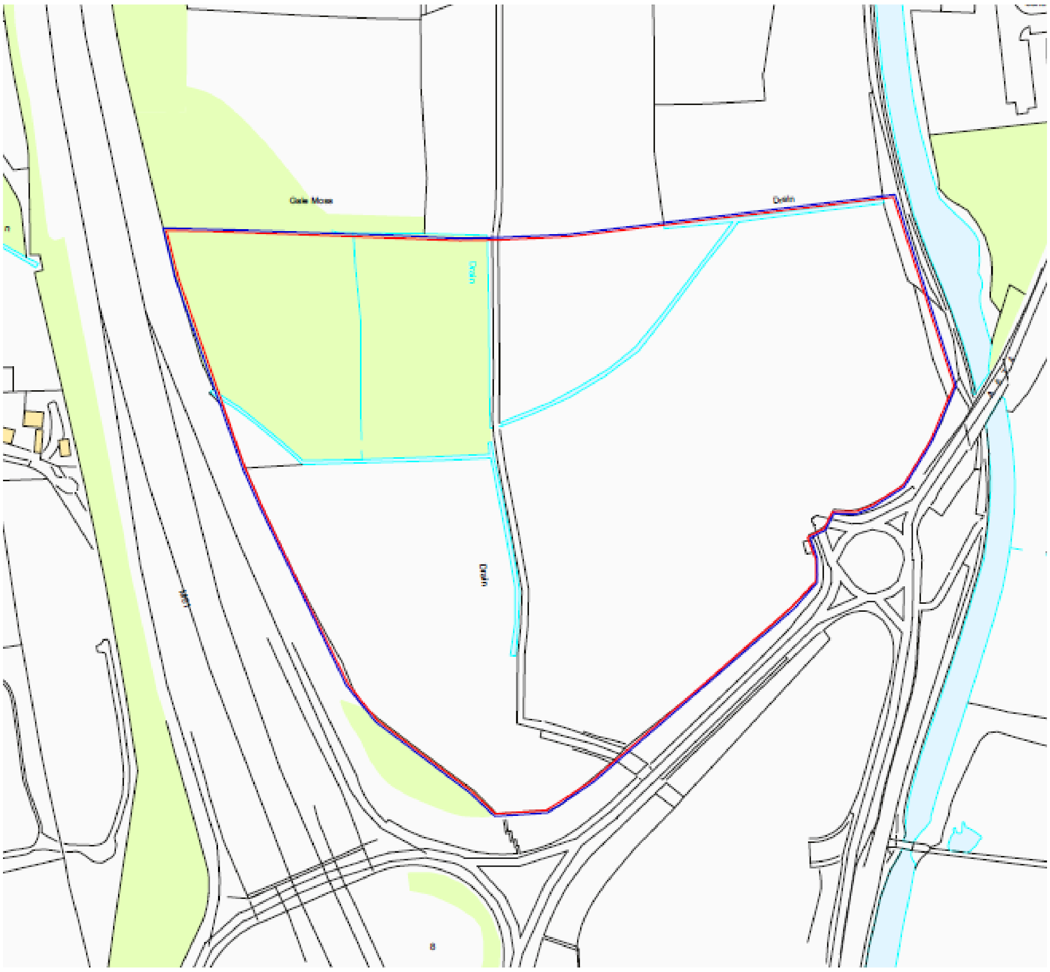
The site is currently agricultural land utilised for livestock grazing and is occasionally utilised as the location of a car boot sale during preferable summer months. The site is lined by the M61 motorway to the west.

To the periphery of the site there are a number of existing slopes but also following excavation there will be a high wall formed that also has the potential for slope failure and to induce failure in existing slopes. Furthermore, the Leeds-Liverpool Canal is present along the eastern boundary and the risk to infrastructure from any slope failure must be considered.

It is understood that the depth of excavation through the site will be limited to 3.00m, as such this value has been used to establish parameters for the model. In addition, E3P has been supplied with a topographical survey (Gale moss June 2020 survey) to provide existing levels and slope details to utilise in the model. E3P has also been provided with a plan showing the total excavation depths proposed, keeping 1.00m above the detected water table (MPG/GM/22-03 dated January 2022).

A location plan is presented within figure 1.1.

FIGURE 1.1 LOCATION PLAN



2. OBJECTIVES

The proposed site excavation and regrading will result in a significant alteration to the current topography with the subsequent formation of high walls along the boundaries of the site as well as then the current slopes at the boundary edges.

In light of the identified potential mechanism for slope failure to be induced by the proposed 3m deep excavation throughout the site, E3P has been commissioned to undertake further detailed slope stability analysis to assess the pertinent / relevant factor of Safety and potential failure mechanism in its current state and also the suitable distance from the boundary slope up to which any excavation can safely be advanced.

3. GEOMORPHOLOGY AND TOPOGRAPHY

The site is located within an area of natural and Man Made undulating landforms, with the site falling in topographical height from south east to north by circa 7 m down toward the drains through this area. In the south west of the site an artificially raised embankment is present that facilitates the M61 – Junction 8 slip road and the main A674 highway to the south of the site. To the east of the site the Leeds-Liverpool canal is present and an artificial build up is expected in the vegetation between the back of towpath and the site boundary.

3.1. GROUND CONDITIONS

Ruttle Group have previously completed a series of trial pits through the site and have provided the logs to assist in the completion of the slope stability assessment. During the intrusive investigation undertaken by Ruttle Group one location (BHE) identified peat (0.50-1.50m bgl) over clay (1.50m-3.50m bgl) though this is outside of the extraction area. Those completed through the remainder of the site identified sand and gravel with occasional sandy clay bands.

Ongoing groundwater monitoring has revealed a shallower water table than originally encountered, which has subsequently lead to the revised extraction profile to ensure a stand-off from groundwater.

4. GEOTECHNICAL SLIP CIRCLE ANALYSIS

Based on our review of the proposed works, the primary risk associated with future instability within the embankment would be associated with the effective removal of the toe of the slope during excavation of minerals and introducing a failure through the above ground slopes and or failure in the canal which could be located within a 'Slip Circle' mode of failure or slip surface along two material boundaries.

Given that the slopes are formed from predominantly granular soils the potential for future failure associated with rotational slip is relatively high. Therefore, to ensure the potential risk is accurately appraised, E3P has developed a detailed slope stability model with induced loadings to assess any potential degree of risk.

To ensure the perceived risk is fully appraised, E3P have created a slope stability model to assess the perceived location of all slip circles, their zone of influence, Factor of Safety and thus the potential of negative impact on the proposed works following removal of materials.

This slope stability analyses involves Limit Equilibrium (LE) analysis due to its simplicity and accuracy. This method consists of cutting the slope into fine slices and applying appropriate equilibrium equations (equilibrium of the forces and/or moments). According to the assumptions made on the efforts between the slices and the equilibrium equations considered, many alternatives were proposed, such as the Bishop and Fellenius methods. In most cases, they are shown to give similar results. For this study, Oasys Slope, EC7 Ultimate Limit State (ULS) scenario slope stability analysis program has been used.

4.1. LIMITATIONS OF THE STUDY

The comments made and conclusions drawn concerning the proposed earthworks associated with existing slopes within the subject site are appropriate at this point in time only and are based on the information available to E3P at the time of writing. If more information becomes available or the site conditions alter then the aforementioned comments and conclusions may have to be re-assessed. If any ambiguity exists concerning any point, for the avoidance of doubt guidance should be sought from E3P, in all instances.

4.2. INPUT PARAMETERS & DATA

Appropriate soil mechanics parameters derived from site investigation & data obtained during the Ground Investigations were analysed and interpreted in the Oasys Slope software.

Detailed proposed levels for the proposed excavation have been provided by the client within the Linear surveys Drawing (Ref: MPG/GM/22-03, dated Jan 2022) and the detailed excavation depths have been modelled accordingly.

For this assessment the Bishops method has been utilised.

An assessment of the slope has been undertaken at 10 critical sections as detailed within the E3P Drawing (ref: 14-244-001-RevC). The locations of for the slope assessment have been chosen along areas that are at a higher risk, such as steeper slopes, those that are close to roadways and/ or the canal in close proximity to the crest of the slope. It is understood that sections 1,2 and 6 are no longer within the 3 phase excavation approach but have been retained to show change and potential for future works/justification for excluding this area.

As well as assessing the slope in its existing form we have also modelled scenarios for a maximum load to fail the slope, the closest a 3.00m excavation can be made at the toe of the slope before failure and then this scenario including a moving temporary load to allow for any heavy machinery such as excavators which may be used during works. Lastly, a scenario has been modelled to include the expected benching required to safely form the excavations at the site. In this revision of the assessment the proposals have been modified to include a mound of excavated materials to the south and eastern boundary. The load induced from this material has also been considered in the revision.

No true on-site data has been obtained therefore, to ensure a suitably robust assessment, conservative values of the soil material property parameters were utilised in the development of the Slope Modelling as detailed below.

TABLE 4.1 GEOTECHNICAL INPUT PARAMETERS

Material Type	**C' – Effective Cohesion (kPa)**	**ø' (°)** **Angle of Effective Friction**	**γ (kN/m2)** **Bulk Unit Weight**
SAND and GRAVELS	0.0	35*	18.0

*value derived from Unified Soil Classification System (USCS)

5. SLOPE ANALYSIS RESULTS

E3P have completed detailed analysis on the proposed slope sections in their current state, the results of each of the 10 proposed sections are detailed below in Table 5.1.

TABLE 5.1 SUMMARY OF RESULTS FOR THREE SCENARIOS

Section	**Factor of Safety (FOS)**			Can proposed excavation be moved closer to slope to maximise removal (Y/N)	Is bund position / height causing instability
	Existing Conditions (Topo Slope)	FOS w. proposed excavation levels (Incl. Bunds)	Maximum Load Failure (FoS/Max Load kN/m^2)		
1	1.800	1.40	1.072 / 600	N/A	N/A
2	1.707	1.374	1.072 / 300	N/A	N/A
3	1.665	0.662^	0.662 / 300*	Y	N/A
4	2.240	0.636$^+$	0.636 / 300*	N	Y
5	2.691	0.735$^+$	0.735 / 300*	Y	N/A
6	1.243	1.698	1.041 / 300	N/A	N/A
7	1.024	0.447$^+$	0.447 / 300*	N	Y
8	1.836	0.713$^+$	0.713 / 300*	N	Y
9	17.791	0.562$^+$	0.562 / 300*	N	Y
10	31.916	0.840$^+$	0.840 / 300*	N	Y

$^+$FOS less than 1 as the slope is safe however the bund design and/or excavation in the section hasn't been designed at 45°.
*FOS remains unchanged with load applied as the slope is stable yet the bund design and excavation is failing as the slope in section is not designed at 45°.
^Section 3 is unstable due to the angle on the excavation being over steepened – slight modification on design required.

Factory of Safety (FoS) as defined within EC7 ULS assessment suggests that all slopes below '1' demonstrate a failing slope. As such, scenarios that remain less than 1 are currently affected by the bund position/height or continuity with excavation slope that is causing instability. Where the bund design is altered by reducing the height or repositioning away from the excavation slope this will stabilise the section.

E3P has run the slope model with a 300kN load at the peak of the slope to gain an indication of how the slope would re-act to an excavator or mechanical plant at this position. In all cases the FOS remains unchanged which indicated the bund remains the key failure mechanism and not the new load applied.

In addition to the above the natural slope has been modelled including the designer's excavation of 3.00m depth. Detail in table 5.1 confirms where the excavation is not fully maximised and which sections would tolerate more excavation. Table 5.2 presents the distance the excavation could be moved towards the slope.

TABLE 5.2 SUMMARY OF RESULTS FOR A 3.00M EXCAVATION

Section	Current Easement	Possible Easement
1	N/A	N/A
2	N/A	N/A
3	9	6
4	0	+5
5	30	10
6	N/A	N/A
7	0	+8
8	0	+5
9	0	+10
10	0	+8

It should be noted that by design the newly formed slopes will need to be battered back to a maximum 45degree angle to reduce potential for instability.

To ensure the canal is not adversely affected by the works a 15m easement from the canal edge is recommended.

The calculus was performed following the Bishop's Method utilising the calculus for Design Approach 1 according to EN 1997:2004 Eurocode 7: Geotechnical Design which requires the compliance with the following partial FoS for a ULS analysis for DA1 to be >1.

6. CONCLUSIONS & RECOMMENDATIONS

6.1. EXISTING SLOPES

Based on the slopes in their existing manner it has been modelled that they are inherently stable and significant loadings can be applied without inducing slope failure issues.

However, the application of a bund of material to the existing slopes may induce instability and will need to be constructed in consideration of this. The slope created by extraction excavations is currently designed in a manner that interacts with the slope of the bund and therefore cumulates to instability. In most cases the bund will need to be repositioned or the height significantly reduced to ensure safety and stability. Alternatively, the excavation could be moved from the bund however this is likely to reduce extraction volumes.

6.2. EXCAVATION AT THE BASE OF SLOPES

When considering the pre-designed 3.00m excavation to the toe of the slope in order to replicate materials extraction, the slope is likely to be stable. Currently where 0 easement is identified adjacent bunds the new excavation is likely to interact and induce a failure mechanism.

Within sections 9 and 10 the original slope is not considered to be sufficiently steep to slip or slump when an excavation is advanced through it and so is not applicable in this regard. These sections are along the line of the canal however and so an easement is still recommended to ensure works do not impact the canal structure.

In this scenario no loading has been applied to the top of the slope however, the movement of mechanical excavators and plant has been modelled in the final scenario to include temporary works.

6.3. TEMPORARY WORKS LOADINGS

It is evident from the review of the proposed construction drawings, scaled cross sections and slope stability modelling that the slope has potential failure mechanisms where the FOS falls below 1 due to the bund within sections 3, 4, 5, 7, 8, 9 & 10. The 3.00m excavation without the bund is likely to support the application of a load up to 300kN at the top of the slope without failure.

6.4. RECOMMENDATIONS

It must be noted that detailed levels for the temporary or permanent future loadings have not been provided. Given that the slope from the highway toward the western and southern boundary of site appears to be fairly steep, in its current state this is modelled to be inherently stable though now considered outside of the phasing plan for excavation.

Following excavations slopes/bunds may require redesigning at the perimeter to ensure a safe angle is provided that would not impose any future geotechnical failures induced through slip circles; this includes the proposed excavations that may require benching and should be constructed using safe slope angles depending on the extraction depths at each and every location through the site.

It is recommended for design purposes that the base of the slope is mapped and sufficient easement placed around the periphery of the site to suitably manage the risk from slope instability and mark out the extents in order to calculate volumetrics for viability.

A suitably qualified supervising geotechnical engineer should be appointed for the duration of the land enabling works and as such weekly inspection of the embankment will be made to ensure that should any evidence of slope failure be observed, appropriate mitigation and corrective action can be agreed with the client.

I trust that the above information is sufficient at this time and if you require anything further please do not hesitate to contact me.

Yours sincerely,
For and on behalf of E3P Ltd

Roy Walker
Principal Geoenvironmental Consultant

Enclosed:

MPG Exploratory Borehole Logs; and,
MPG Exploratory Location Plan
E3P Slope Stability Cross Section Plan
E3P Slope Stability Cross Section and Easement Plan
E3P Slope Stability Analysis Output Plans

Legend

- Line of Cross Section
- Bottom of Slope

Notes:

Client: The Mineral Planning Group

Job No: 14-244

Date: 03.05.2022

Drawing No: 002

Scale: 1:2000 @ A3

Phase	Issue	Date	Drawn	Checked
P1	REVB	03.05.2022	CB	RJW
P1	REVA	24.09.2020	HM	RJW

Job Title: Gale Moss, Chorley

Drawing Title: Bottom of Slope Plan

e3p
Environmental Engineering Partnership Ltd
Taylor Road, Trafford Park
Urmston, Manchester, M41 7JQ
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk

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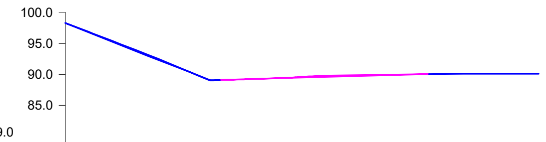
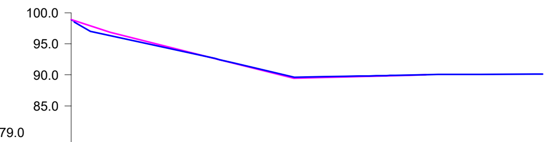
Section 1 - Datum 79.0



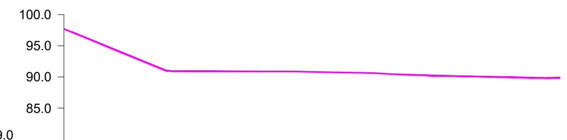
Excavation Level (mAOD)	98.284 96.133 94.132 92.169 90.212 89.060 89.089 89.246 89.422 89.559 89.692 89.825 89.957 90.051 90.073 90.062 90.069 90.088
Topographical Level (mAOD)	98.291 96.231 94.291 92.315 90.206 89.001 89.092 89.250 89.442 89.741 89.849 89.922 89.995 90.051 90.073 90.062 90.069 90.088

Section 6 - Datum 79.0



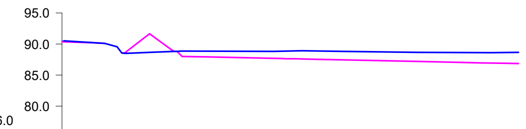
Excavation Level (mAOD)	98.160 96.595 95.342 94.090 92.837 91.584 90.332 89.473 89.510 89.628 89.746 89.864 90.033 90.064 90.085 90.113 90.123
Topographical Level (mAOD)	97.420 96.077 94.999 93.921 92.816 91.638 90.459 89.635 89.660 89.744 89.829 89.915 90.033 90.064 90.085 90.113 90.123

Section 2 - Datum 79.0



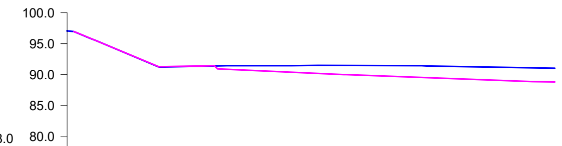
Excavation Level (mAOD)	97.682 95.155 93.116 91.077 90.911 90.884 90.862 90.890 90.788 90.679 90.532 90.335 90.194 90.044 89.987 89.898 89.831 89.870
Topographical Level (mAOD)	97.684 95.098 93.054 91.008 90.914 90.889 90.862 90.890 90.788 90.679 90.532 90.320 90.146 90.068 89.956 89.832 89.840

Section 7 - Datum 76.0



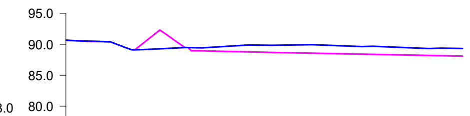
Excavation Level (mAOD)	90.321 90.096 89.585 88.553 89.989 91.646 88.810 88.021 87.965 87.857 87.749 87.641 87.532 87.423 87.314 87.205 87.097 86.989 86.846
Topographical Level (mAOD)	90.400 90.096 89.585 88.545 88.557 88.764 88.865 88.862 88.855 88.848 88.845 88.879 88.900 88.852 88.788 88.741 88.693 88.671 88.650 88.641 88.675

Section 3 - Datum 78.0



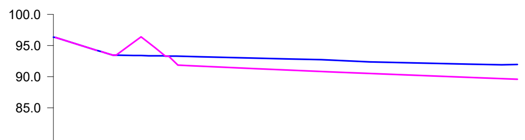
Excavation Level (mAOD)	96.990 95.343 93.247 91.284 91.374 91.436 90.929 90.668 90.444 90.219 89.996 89.813 89.629 89.445 89.261 89.077 88.896 88.819
Topographical Level (mAOD)	96.990 95.332 93.231 91.241 91.330 91.419 91.447 91.466 91.495 91.484 91.472 91.459 91.387 91.290 91.193 91.096 91.029

Section 8 - Datum 78.0



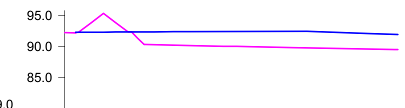
Excavation Level (mAOD)	90.496 90.405 89.118 89.134 92.302 89.499 88.995 88.917 88.813 88.709 88.604 88.500 88.396 88.292 88.187 88.083
Topographical Level (mAOD)	90.521 90.405 89.712 89.118 89.236 89.512 89.462 89.582 89.915 89.861 89.931 89.789 89.667 89.688 89.496 89.314 89.364 89.315

Section 4 - Datum 79.0



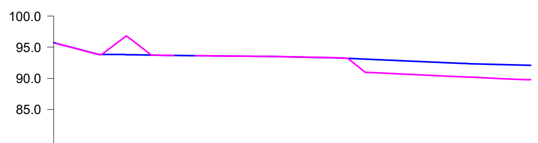
Excavation Level (mAOD)	96.323 94.098 93.478 93.467 95.217 96.378 93.291 91.848 91.744 91.532 91.320 91.106 90.891 90.683 90.486 90.289 90.092 89.895 89.629
Topographical Level (mAOD)	96.323 94.098 93.429 93.346 93.238 93.123 93.005 92.888 92.750 92.548 92.365 92.243 92.121 92.007 91.945 91.950

Section 9 - Datum 79.0



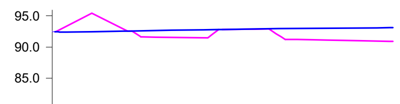
Excavation Level (mAOD)	92.171 92.281 95.308 92.334 92.338 90.314 90.254 90.148 90.048 89.953 89.855 89.763 89.672 89.580 89.523
Topographical Level (mAOD)	92.278 92.313 92.366 92.347 92.404 92.399 92.417 92.433 92.450 92.461 92.397 92.196 92.024 91.952

Section 5 - Datum 79.0



Excavation Level (mAOD)	94.971 93.849 93.852 96.807 93.730 93.692 93.638 93.577 93.543 93.462 93.354 93.215 90.950 90.825 90.600 90.375 90.148 89.923 89.754
Topographical Level (mAOD)	94.974 93.854 93.797 93.678 93.637 93.595 93.554 93.462 93.354 93.199 92.974 92.749 92.523 92.322 92.181 92.074

Section 10 - Datum 80.0



Excavation Level (mAOD)	92.452 94.413 95.457 93.935 92.563 91.630 91.544 91.450 92.807 92.835 92.900 91.241 91.205 91.110 91.018 90.921
Topographical Level (mAOD)	92.383 92.421 92.513 92.612 92.699 92.773 92.845 92.917 92.971 93.014 93.057 93.120

Legend

Excavation Level (mAOD)

Topographical Level (mAOD)

Notes:

P1	REVA	03.05.2022	CB	RJW
Phase	Issue	Date	Drawn	Checked

Client:

The Mineral Planning Group

Job Title:

Gale Moss, Chorley

Job No: 14-244

Date: 03.05.2022

Drawing No: 003

Scale: 1:1250 @ A3

Drawing Title:

Cross Sections (Sections 1 - 10)

e3p
Environmental Engineering Partnership Ltd
Taylor Road, Trafford Park
Urmston, Manchester, M41 7JQ
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk

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Legend

Line of Cross Section

Notes:

Phase	Issue	Date	Drawn	Checked
P1	REVC	03.05.2022	CB	RJW
P1	REVB	19.08.2020	CB	RJW
P1	REVA	23.07.2020	CB	RJW

Client: The Mineral Planning Group

Job Title: Gale Moss, Chorley

Job No: 14-244

Date: 03.05.2022

Drawing No: 001

Scale: 1:2000 @ A3

Drawing Title: Section Location Plan

e3p
Environmental Engineering Partnership Ltd
Taylor Road, Trafford Park
Urmston, Manchester, M41 7JQ
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk

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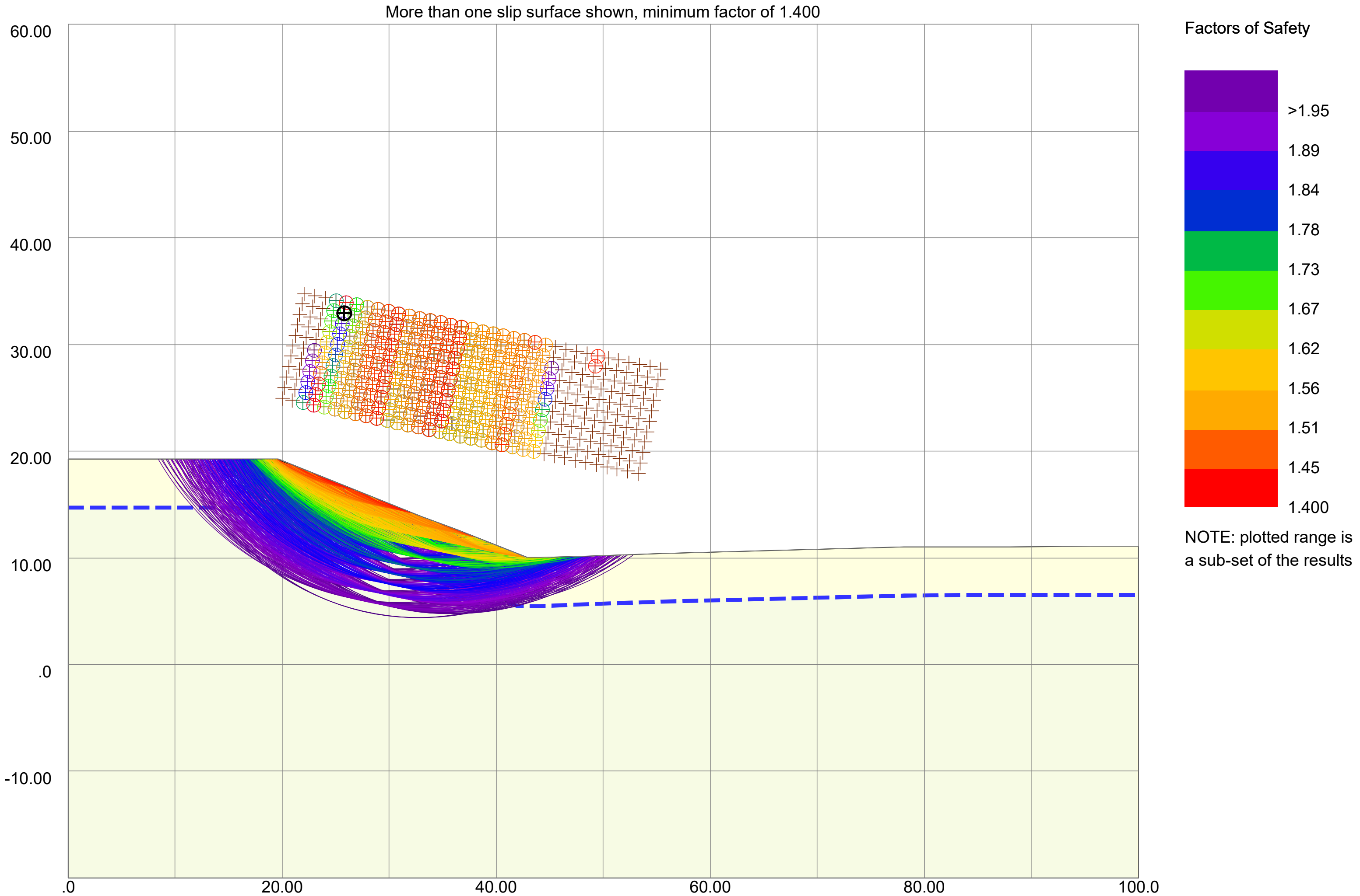
Gale Moss, Chorley
Slope Stability Assessment
Section 1

Job No.	Sheet No.	Rev.
14-244		
Drg. Ref.		
Made by CB	Date 03-May-2022	Checked



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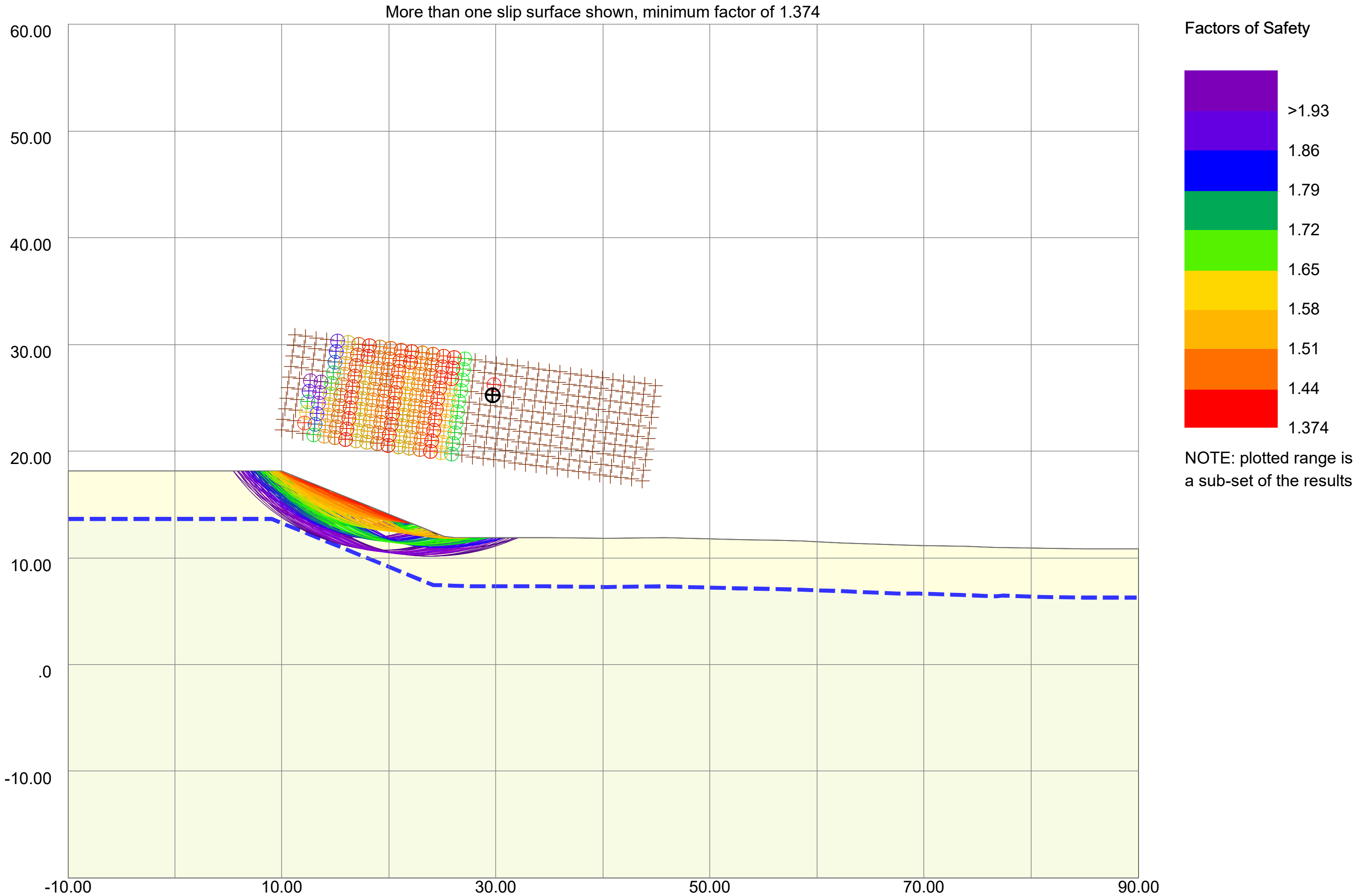
Oasys E3P

Gale Moss, Chorley
Slope Stability Assessment
Section 2

Job No.	Sheet No.	Rev.
14-244		
Drg. Ref.		
Made by CB	Date 03-May-2022	Checked



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Gale Moss, Chorley

Slope Stability Assessment

Section 3

Job No.	Sheet No.	Rev.
14-244		
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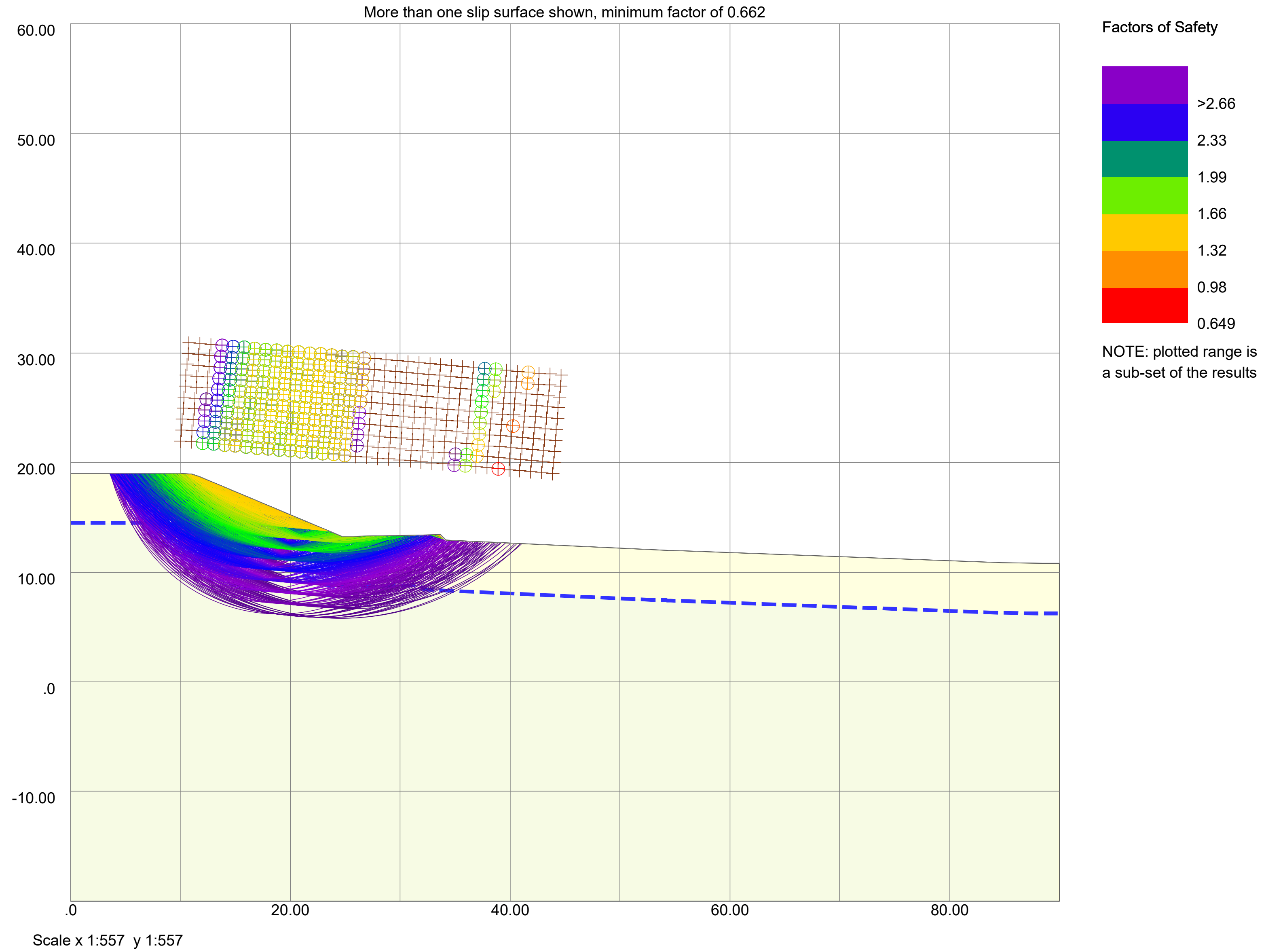
Made by CB	Date 03-May-2022	Checked



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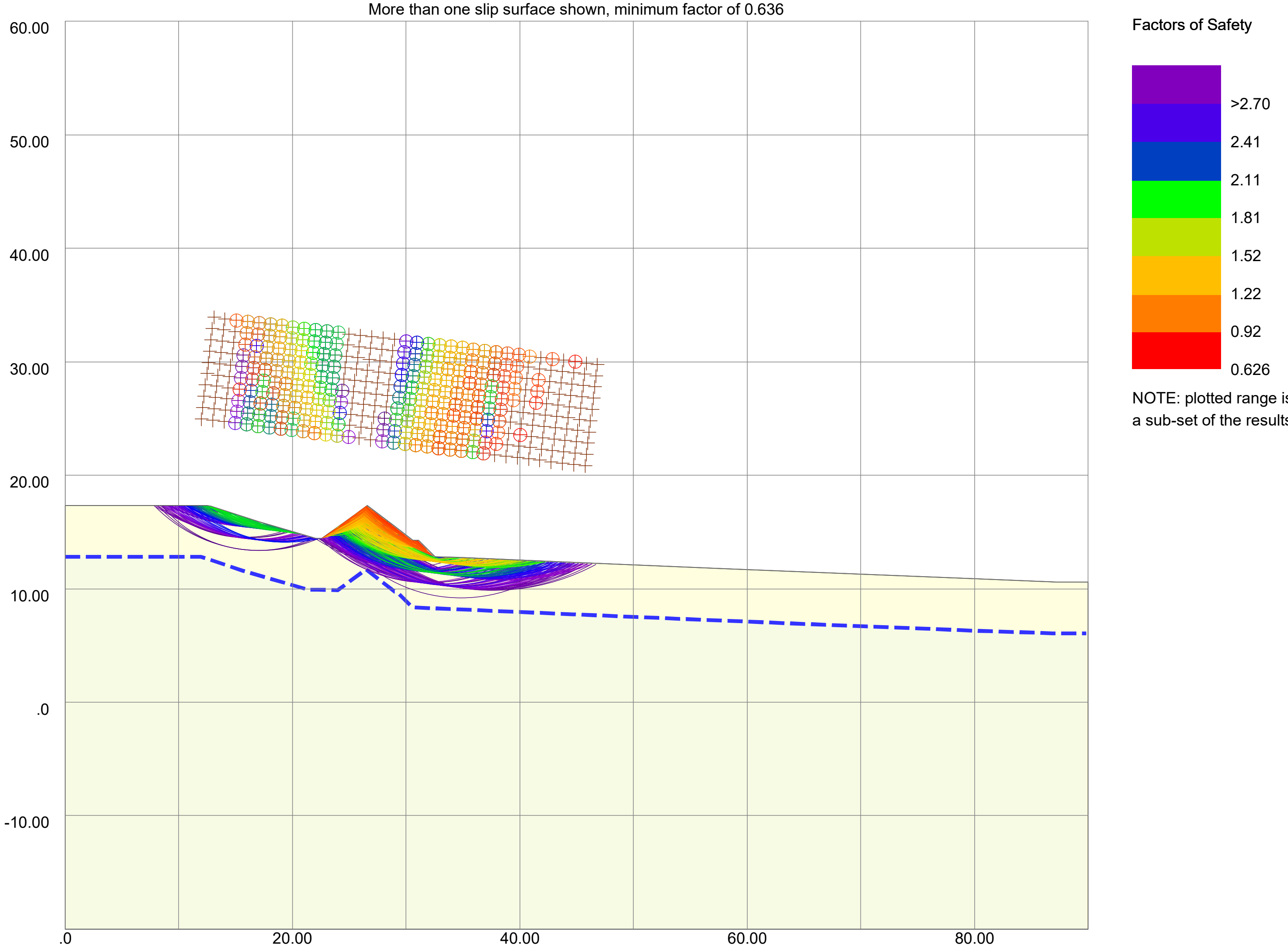
Gale Moss, Chorley
Slope Stability Assessment
Section 4

Job No.	Sheet No.	Rev.
14-244		
Drg. Ref.		
Made by CB	Date 03-May-2022	Checked

More than one slip surface shown, minimum factor of 0.636



NOTE: plotted range is a sub-set of the results

Scale x 1:557 y 1:557

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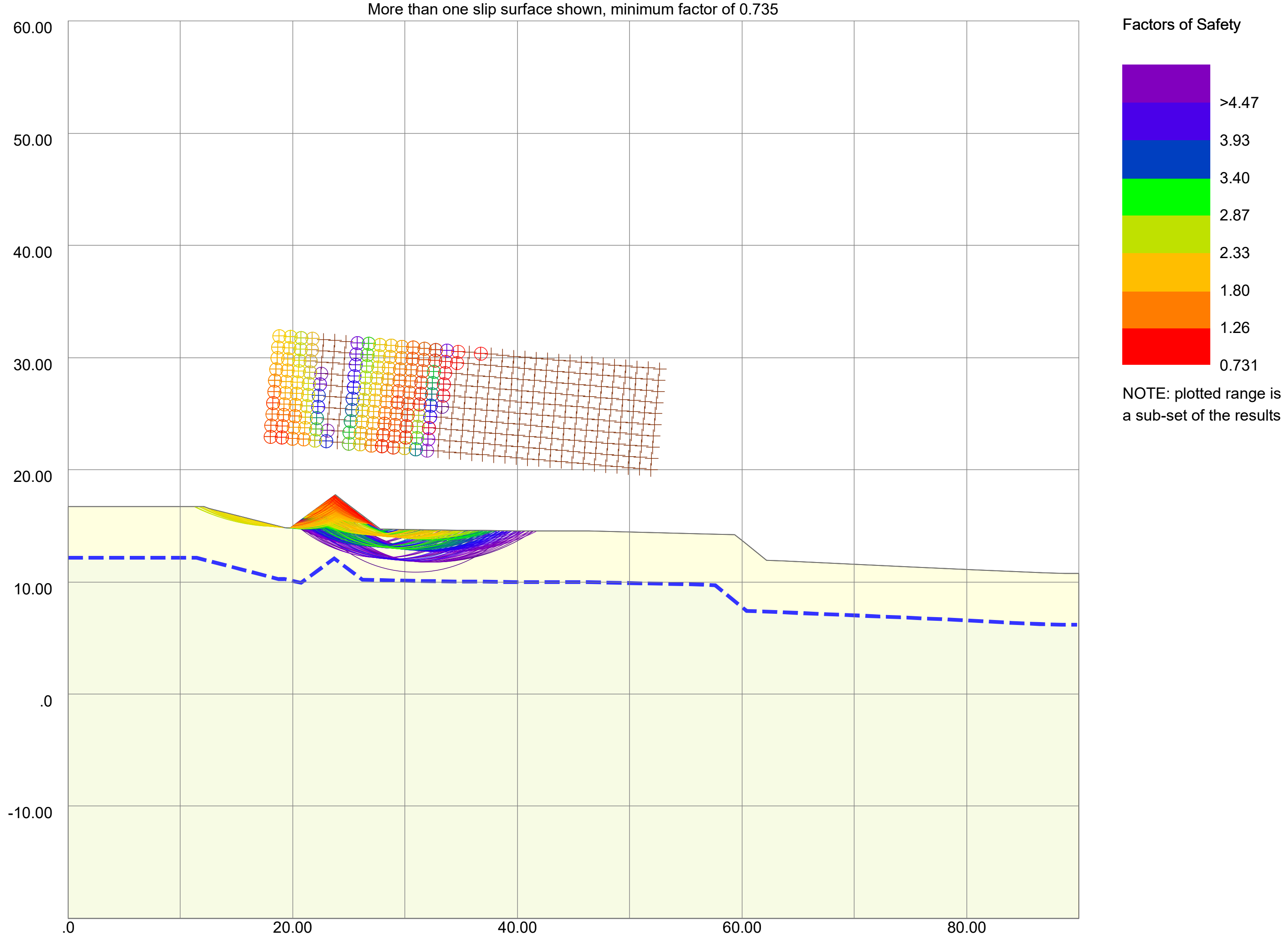
Gale Moss, Chorley
Slope Stability Assessment
Section 5

Job No.	Sheet No.	Rev.
14-244		
Drg. Ref.		
Made by CB	Date 03-May-2022	Checked

More than one slip surface shown, minimum factor of 0.735



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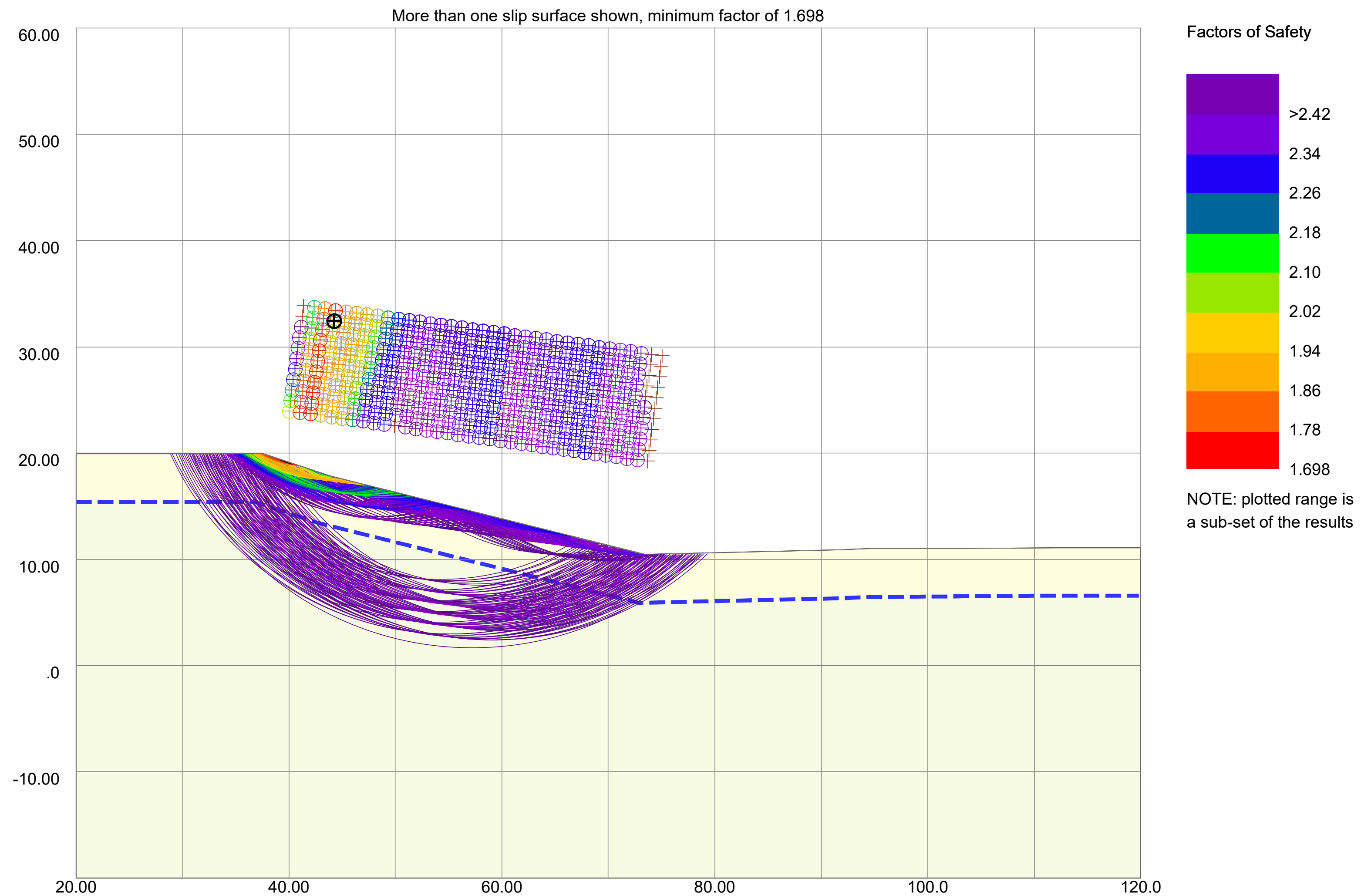
Slope Stability Assessment
Section 6

Job No.	Sheet No.	Rev.
14-244		
Drg. Ref.		
Made by CB	Date 03-May-2022	Checked

More than one slip surface shown, minimum factor of 1.698



Scale x 1:619 y 1:619

Oasys

E3P

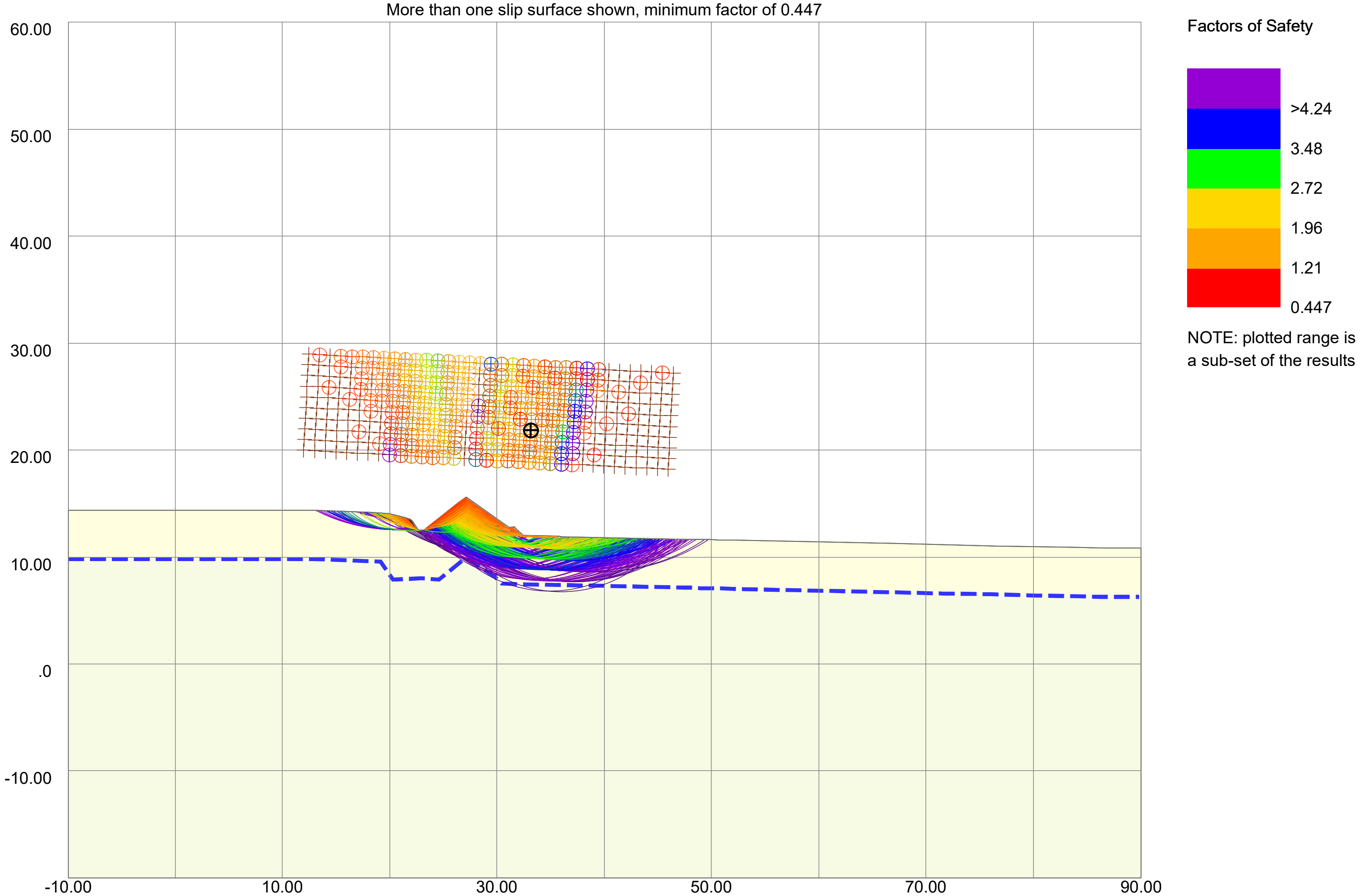
Gale Moss, Chorley

Slope Stability Assessment

Section 7

Job No.	Sheet No.	Rev.
14-244		
Drg. Ref.		
Made by CB	Date 03-May-2022	Checked

More than one slip surface shown, minimum factor of 0.447



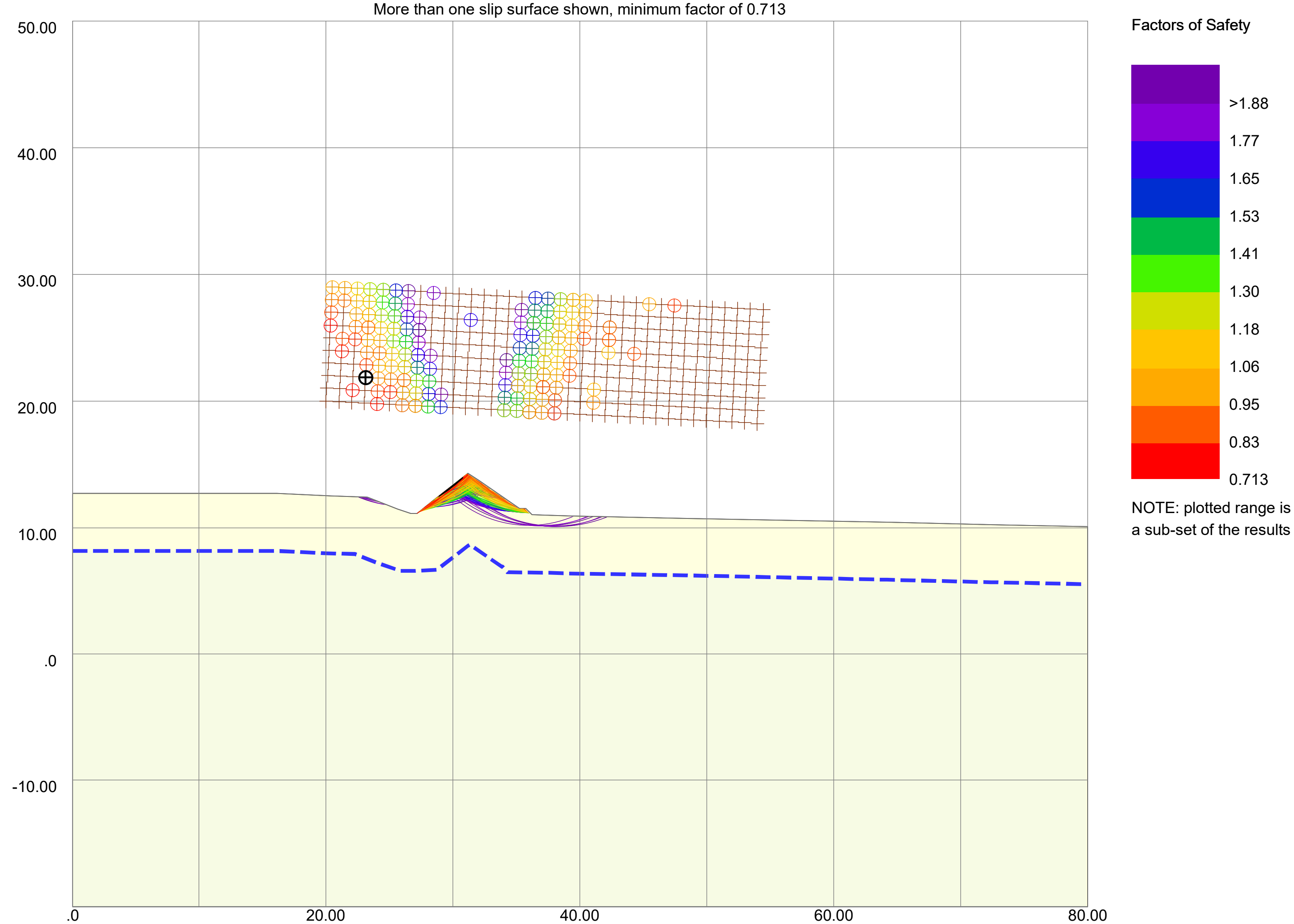
Scale x 1:619 y 1:619

Oasys **E3P**

Gale Moss, Chorley
Slope Stability Assessment
Section 8

Job No.	Sheet No.	Rev.
14-244		
Drg. Ref.		
Made by CB	Date 03-May-2022	Checked

More than one slip surface shown, minimum factor of 0.713



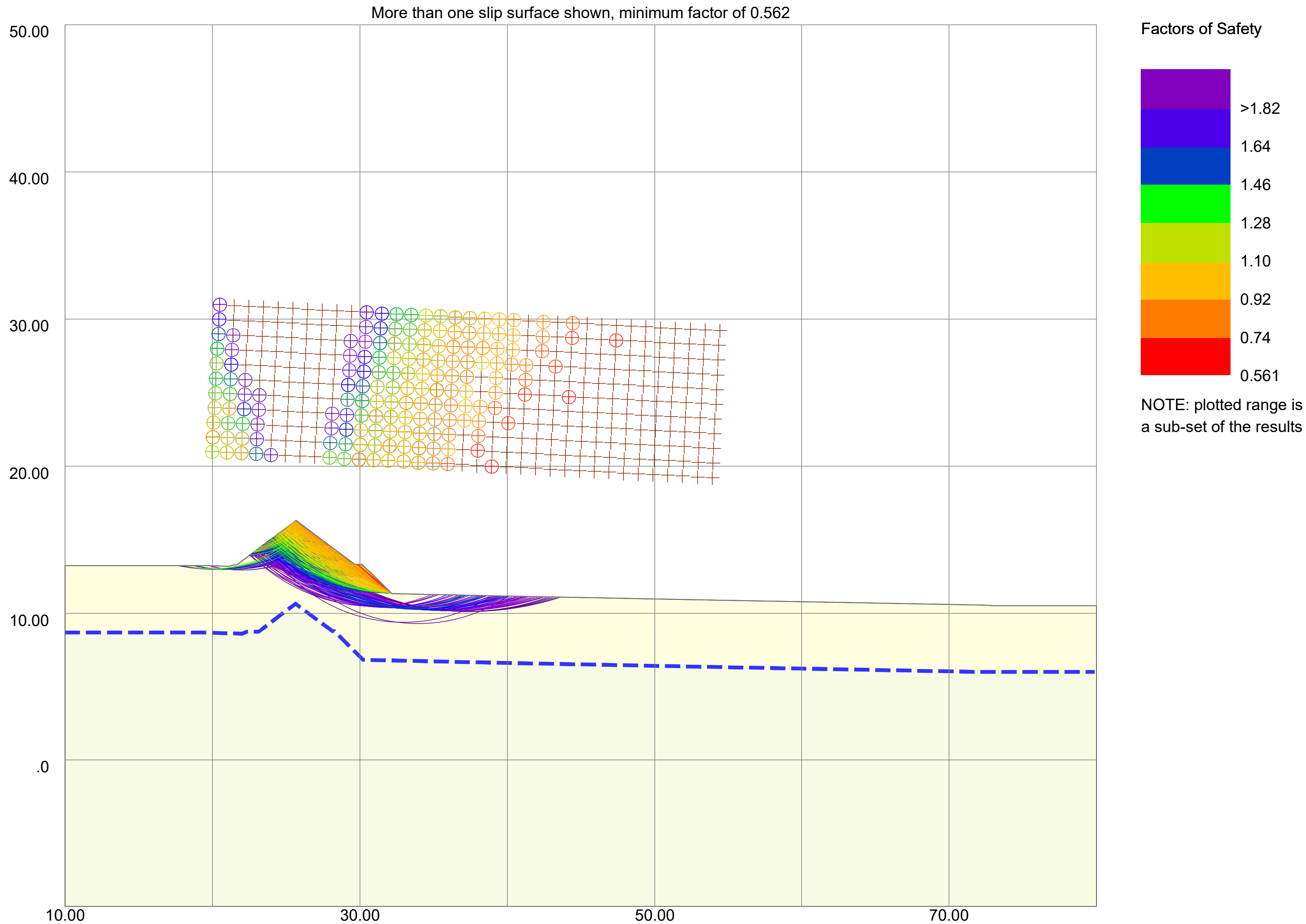
NOTE: plotted range is a sub-set of the results

Scale x 1:495 y 1:495

Oasys **E3P**

Gale Moss, Chorley
Slope Stability Assessment
Section 9

Job No.	Sheet No.	Rev.
14-244		
Drg. Ref.		
Made by CB	Date 03-May-2022	Checked



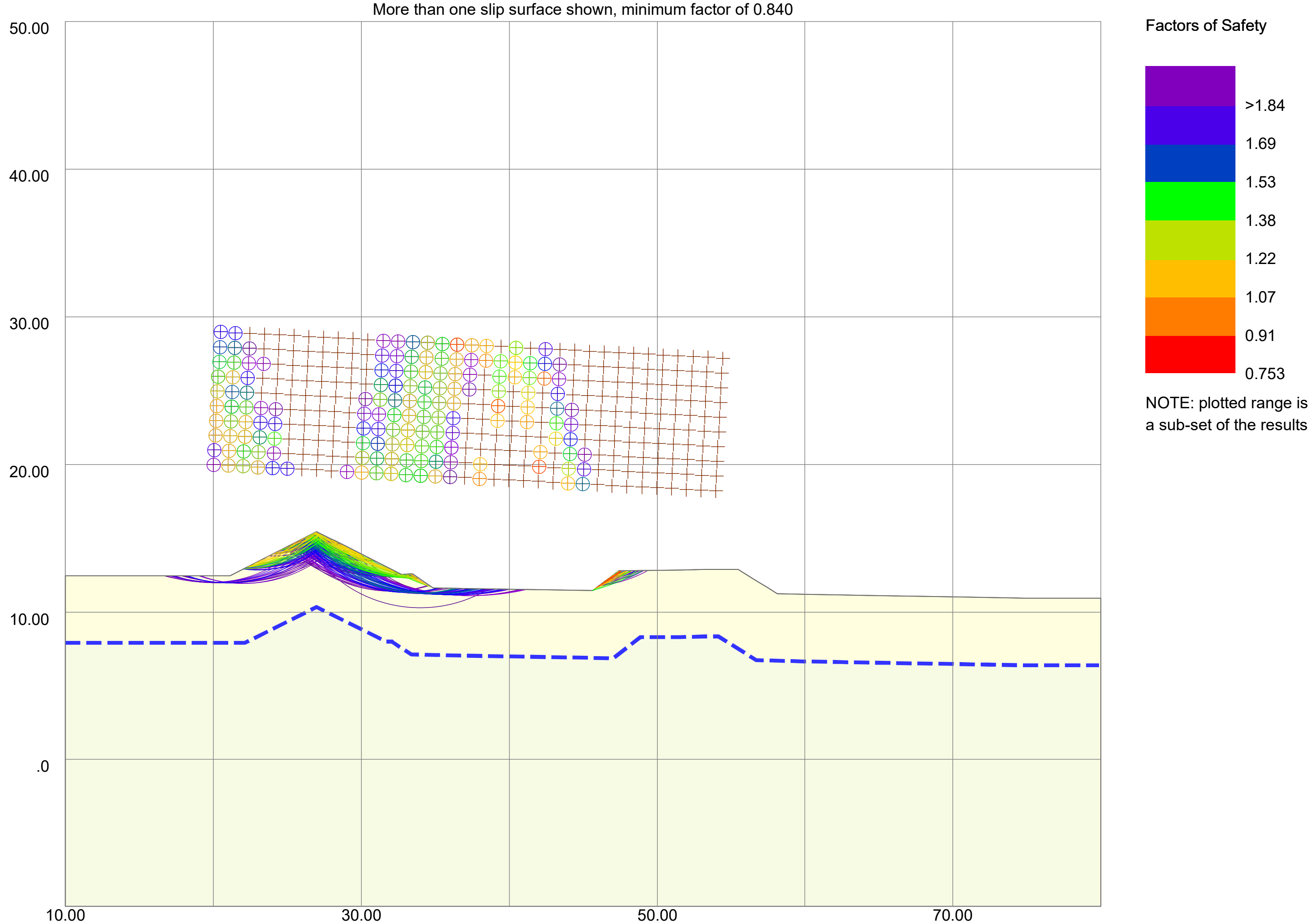
Scale x 1:433 y 1:433

Oasys E3P

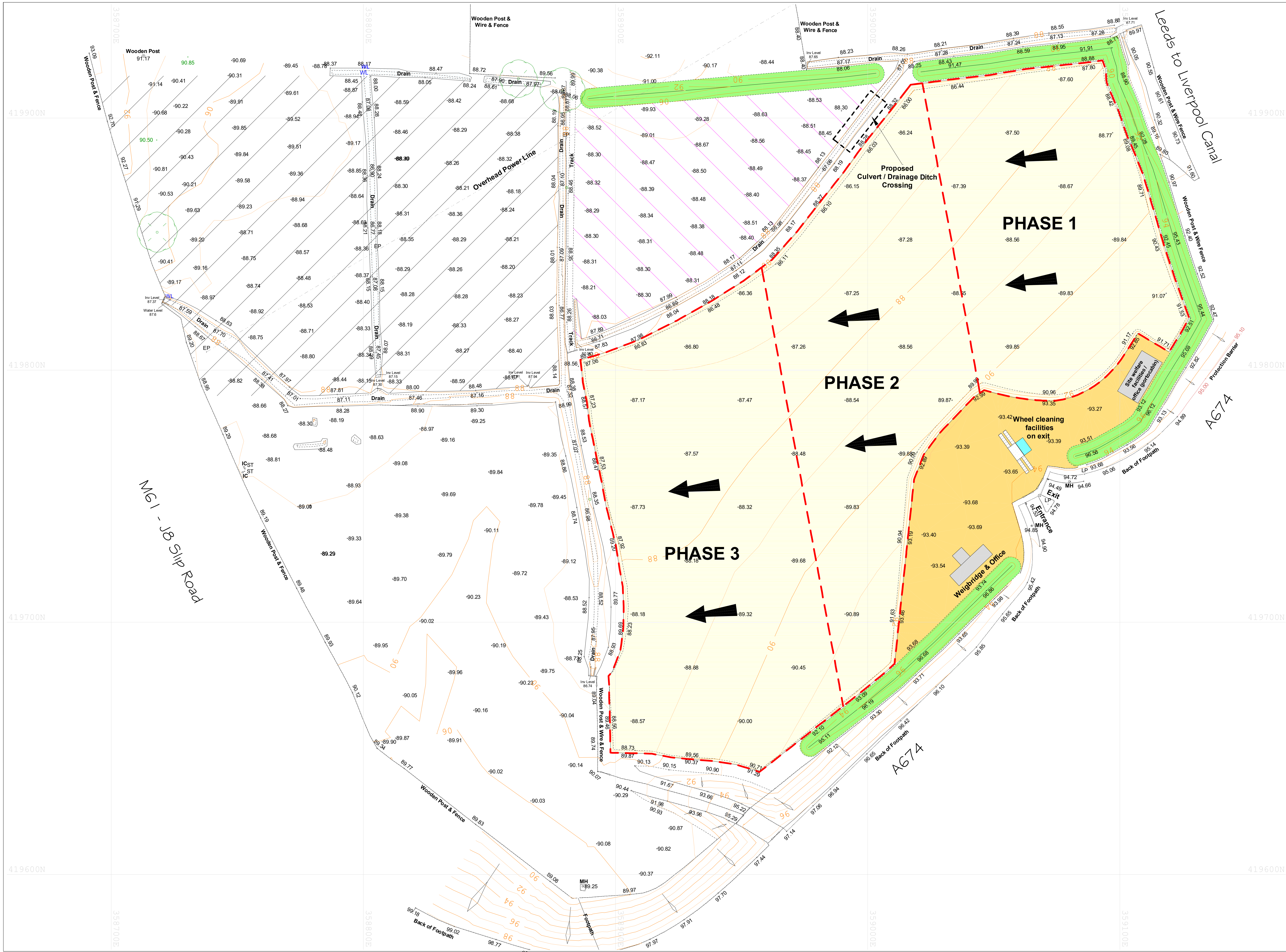
Gale Moss, Chorley
Slope Stability Assessment
Section 10

Job No.	Sheet No.	Rev.
14-244		
Drg. Ref.		
Made by CB	Date	Checked

More than one slip surface shown, minimum factor of 0.840



Scale x 1:433 y 1:433



REVISIONS

Date	Description	By
//	//	//
//	//	//
//	//	//
//	//	//

Legend:

- Proposed Mineral Extraction Area
- Approximate Compound Area
- Screening Bunds (Stripped Soils)
- Peaty Area
- Northern Area

Top of Banking	MH	Manhole
Bottom of Banking	IC	Inspection Cover
Kerb - Top	BT	British Telecom Cover
Kerb - Channel	G	Gully
Fence - Post & Wire	LP	Lamp Post
Fence - Secure	TP	Telegraph Pole
Gate	EP	Electric Pole
Track / Footpath	ST	Stop Tap
Wall	GV	Gas Valve
Edge of Waterline	WL	Water Level
Hedgeline	IL	Invert Level
Overhead Cable	CL	Cover Level
1m Contour Intervals	EL	Eave Level
OS Backcloth	RL	Ridge Level
Building/Structure	BH	Borehole / Trial Pit
Verge Line	133.92	Spot Level
Foliage Line		Trees
Top of Rock Face		Survey Control Station

Datum: Levels relative to Ordnance Survey by connection to OS Active Network by GPS

N

LINEAR surveys

LINEAR SURVEYS LIMITED
23 Knowler Way
Liversedge
West Yorkshire
WF15 6DG

Tel - 01274 878338
Mob - 07884434452

e-mail - linearsurveys@gmail.com

Client
Mineral Planning Group Ltd

Job Title
Gale Moss, Chorley

Project Title

Scale	Date	Drawn by	Surveyed By
1:1000@A2	JAN 2022	SW	PR

Dwg. title
Mineral extraction design to 1m above ground water table

DWG No.
MPG/GM/22-03