



Russell Green Quarry

**Stability Risk Assessment and Restoration Design
(September 2022)**

Prepared for: Land Logical Ltd



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Land Logical Limited

Russell Green Quarry

Stability Risk Assessment and Restoration Design

(September 2022)

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8198-001-001	Existing Site Conditions
8198-001-002	Proposed Restoration Scheme
8198-001-003	Cross Sections

1.0 INTRODUCTION

Key GeoSolutions Ltd (KGS) have been commissioned by Land Logical Limited to undertake a stability assessment of the former sand and gravel quarry, Russell Green Quarry, which is understood to have been extracted and partially restored in the 1980's.

A site inspection was undertaken by KGS on 7th June 2022, the purpose of the inspection was to understand the ground conditions present and to assess the stability of the side slopes of the restoration.

The north-eastern and eastern quarry faces have been previously backfilled to form restoration slopes with a maximum inclination of 1v:4h. The existing former quarry faces to the west and southwest of the site are approximately 12m high and have an average slope angle of 1v:1.2h (40° from horizontal). Planning permission was granted in 2013 to allow the importation of inert waste to the site to be used to complete restoration works to the south-western side of the quarry. These proposed works were never undertaken, and the planning permission has now lapsed, however instability of the south-western excavation slopes has continued.

2.0 SITE DESCRIPTION

The quarry, National Grid Reference 574600mE N 212600mN, is located to the northeast of Chelmsford and approximately 1.6 miles northwest of Boreham village. The site is adjacent to Boreham Road with Grade II listed buildings Brent Hall and Ginn House located c. 320m to the east. The closest residential properties, Russell Green Cottages lie approximately 130m to the north of the site.

The boundary to the site includes agricultural land and Bulls Lodge Quarry to south-west. Access to the site is via a gated concrete-surfaced entrance off Boreham Road.

KGS have been informed of the following relevant planning history:

- CHL/1673/82 – Extraction of sand and gravel, with restoration to farmland and a small, landscaped lake. Approved 12 September 1983.
- CHL/1673/82/3 – Revised restoration scheme for amenity after use. Approved 16 January 1992.
- ESS/08/13/CHL – Importation of approximately 85,000 tonnes of inert waste material (excavation soils) to stabilise former quarry face and satisfactorily restore former mineral site to landscape grassland and ponds, and associated improvements to existing site access to facilitate delivery of waste material. Approved 29 January 2014.

Sand and gravel mineral extraction and restoration operations are understood to have taken place throughout the 1980's, being completed in the early 1990's. The originally permitted restoration scheme has not been completed following extraction of the sand and gravel and overly steep slopes have been left along the whole of the south-western margin of the site.

The planning permission (Ref. ESS/08/13/CHL) was granted in 2014 to allow the site to be restored with inert waste to landscaped grassland and ponds was never implemented and has now lapsed. The planning officer's report from the 2014 application has noted that the *'site has previously been poorly restored leaving a steep bank which looks unnatural within the context of the surrounding landscape'* and that *'the application seeks to create a comprehensive contoured topography that as well as stabilising the steep embankments found on the site, would also provide a more acceptable visual aesthetic across the former mineral working site'*.

3.0 GROUND CONDITIONS

The BGS Geindex Onshore and published geological map for the area (1: 50,000 Geological Survey of Scotland Sheet No. 241, Chelmsford) indicates that Russell Green Quarry extracted sand and gravel (alluvium and head deposits) of Holocene Epoch age. The sand gravel mineral is underlain by London Clay at the site.

On inspection of the site, in particular the south-western slopes where the natural ground is exposed, the general sequence was found to consist of 1-2m of overburden, which consists of a clay bound sand and gravel, this is underlain by c. 10m of sand and gravel.

Areas of previous sand and gravel extraction exist to the north-west and south-east of the site, these areas have predominantly been restored to lake features. The water levels in these lakes appear to be coincident with the water levels in the ponds in the site, i.e. approximately 38.5mAOD and it is considered that this level will be representative of the groundwater level.

4.0 SLOPE STABILITY ASSESSMENT

4.1 Findings and Recommendations of Inspection

An inspection of the south-western slopes of the site was undertaken by Key GeoSolutions Ltd (KGS) on 7th June 2022. Localised progressive failures were observed during the inspection and near vertical quarry faces at the upper slope have been noted (Photo 1 and 2).

The progressive slope failures have taken the crest of the slope closer to the site boundary, these failures can be expected to continue to occur whilst the near vertical sections of slope exist, at least until a slope with natural angle of repose of c. 35° from horizontal is ultimately established over the full height of the slope. This process could ultimately take the crest of the slope beyond the site ownership boundary if left unchecked.

It is therefore recommended that an appropriate restoration of the south-western slope should be undertaken in order to;

- Provide long-term stability, and
- Provide a more acceptable visual aesthetic across the site.

A possible restoration topography is presented on drawing number 8198-001-002 which is included at the back of this report. It is proposed to form a 1 vertical in 4 horizontal slopes along the south-western boundary, which will tie in sympathetically with the restored slopes around the rest of the perimeter of the site. The 1 in 4 slopes will provide better amenity than the 1 in 3 slopes proposed in the 2013 application and will offer better habitat options around the margins of the proposed water body and it will be possible to maintain it.

4.2 Stability Analysis

Stability analyses have been undertaken on the existing south-western slope and the proposed restoration slope.

4.2.1 Assumptions

For the purposes of the stability assessment the following assumptions have been made:

Maximum slope height	13m
Angle of slopes	Range from 32° to 50°
Restoration slope angle	Maximum 1v:4h (14°)
Groundwater level	38.5 mAOD
Proposed pond water level	Maximum 45 mAOD

4.2.2 Cross Section

Stability analyses have been undertaken on a typical cross section that represents the typical ground conditions and slope profiles of the existing quarry faces and the proposed restoration profile. The locations and profiles of the cross sections are presented on Drawing Nos. 8198-001-001 and 003.

The height of the quarry face and the slope profile have been determined from the topographical survey provided by Land Logical Ltd (see Drawing No. 8198-001-001).

4.2.3 Parameters

The ground profile that will form the overall slope in the stability analysis is as follows;

- Overburden, thickness 1.7m
- Sand gravel, thickness 10m
- London Clay
- Restoration material

The parameters adopted for the slope stability assessment are listed in the table below, which are assumed based on the findings of the recent site inspection undertaken in June 2022, with reference to the published data for similar material.

Materials	Bulk Density γ (kN/m ³)	Effective Cohesion c' (kN/m ²)	Effective Friction Angle ϕ' (degrees)
Overburden	18	0	28
Sand Gravel	19	0	35
London Clay	20	0	25
Restoration Material	18	0	23

4.2.4 Method of Analysis

The stability analysis has been undertaken using the commercially available SLIDE 2 (Rocscience Inc.) slope stability software, which uses the limiting equilibrium theory to assess the stability of a slope. The theory calculates the resisting forces and disturbing forces within the slope and determines the ratio of the resisting over the disturbing forces. This ratio is known as the Factor of Safety (FoS), with a ratio greater than 1.0 indicating the slopes are stable and less than 1.0 indicating that the slopes are or could become unstable.

The quarry faces could have been generally stable or marginally stable during the mineral extraction and probably have remained stable for a short period of time following the completion of mineral extraction. However, localised progressive failures have occurred at the unrestored western quarry faces since 2013. This will continue to deteriorate in the long term and further slope failures would continue to occur until a slope profile with natural angle of repose will be ultimately formed from the failed material, by which point it will likely have breached the quarry boundary.

The current slope stability assessment has focused on the long-term stability condition of the quarry faces assuming the existing quarry faces would remain stable or marginally stable in the short term.

As part of the proposed restoration scheme, the current steeper quarry faces will be backfilled with inert waste material to form shallower and stabler fill slope. Given the existing eastern restoration has a maximum slope angle of 1v:4h (14° from horizontal), it is proposed to backfill the quarry faces with inert waste to create a landscape being consistent with the rest of the site.

Slope stability analyses have been undertaken on the existing quarry faces and the proposed 1v:4h restoration slopes.

The water level within the retained pond will vary from a minimal 36.5mAOD to a maximum pond water level of 45.0mAOD following the completion of restoration. Two water levels, current ground water level of 36.5mAOD and restored maximum water level of 45.0mAOD, are considered in the stability assessment. Copies of the analyses are included as Appendix 1 of this report.

4.2.5 Results of Analysis

The results of the slope stability analyses indicate that slope failures will ultimately occur at the steeper western quarry faces in the long term if the quarry faces are left unrestored. Localised slope failures have already occurred along the western quarry faces and further slope failures would likely continue to occur due to the progressive deterioration of the ground conditions.

The analysis results indicate that the proposed restoration slopes will be stable with a minimum factor of safety over 1.71 against any slope failures.

The results of the analysis indicate that the proposed restoration slopes will remain stable as the pond water level increase and the pond water level have minimal impact on the overall stability of the restoration slope.

5.0 RESTORATION DESIGN

The site inspection and the results of the slope stability analysis conclude that the quarry faces along the south-western boundary of Russell Green Quarry are not stable and the site should be restored to stabilise the steeper quarry faces and create a suitable landscape for the long-term benefit.

Given the quarry site has already been partially restored, the proposed restoration design aims to not only stabilise the quarry faces, but also create an overall landscape with minimal impact on or rather contribute to the existing restoration and surrounding landscape.

The proposed restoration design will create a landscape with a maximum slope gradient of 1v:4h and naturally merge more into the existing restoration scheme and surrounding landscape. The proposed restoration design is shown in Drawing No. 8198-001-002 and the existing site conditions are shown on Drawing No. 8198-001-001. The cross sections showing the existing and proposed restoration profiles are shown in Drawing No. 8198-001-003.

The proposed restoration scheme as shown in Drawing No. 8198-001-002 requires approximately 63,450m³ fill material (114,210 tonnes assuming an average density of 1.8t/m³), of which 5,940 tonnes (3,300m³) of soils can be sourced on site and the rest 108,270 tonnes (60,150m³) materials need to be imported. The restoration material can be any cohesive or granular inert waste material, which should be placed and compacted in a controlled manner.

The total required 108,270 tonnes imported material include 85,000 tonnes of inert waste to form the proposed restoration profile and 23,270 tonnes soils to provide a suitable growing medium for vegetation.

6.0 CONCLUSIONS

A site inspection and a slope stability assessment have been undertaken for the existing quarry faces and the proposed restoration design at Russell Green Quarry.

Slope failures have been observed during the recent inspection undertaken in June 2022. Localised near vertical slope sections have been formed from historical slope failures and these over-steepen slopes will ultimately collapse in the long term.

Slope stability analyses have been undertaken on the western quarry faces and the results of the analyses indicate that slope failures will occur at the western quarry faces in the long term. Hence, the quarry faces must be stabilised or restored to prevent further slope failures.

Historical restoration has been partially undertaken to restore the eastern quarry faces to a landscape with a maximum slope angle of 1v:4h. The recent inspection indicates that the existing restoration area are overall stable.

For the purpose of the slope stabilisation and creating a landscape that is consistent with the existing restoration and surrounding landscape, it is proposed to stabilise the quarry faces and restore the site with inert waste to form a landscape with a maximum slope angle of 1v:4h. The proposed restoration slope will ensure long term stability.

In conclusion, the quarry faces within Russell Green Quarry are not stable if left unrestored and could potentially regress beyond the site boundary. The proposed restoration scheme will require to import approximately 85,000t inert waste material and 23,270t soils, which will create a suitable landscape that will stabilise the quarry faces and achieve long-term benefits.

APPENDIX 1

Results of Slope Stability Analyses

APPENDIX 2

Photographs

DRAWINGS

APPENDIX 1

Results of Slope Stability Analyses

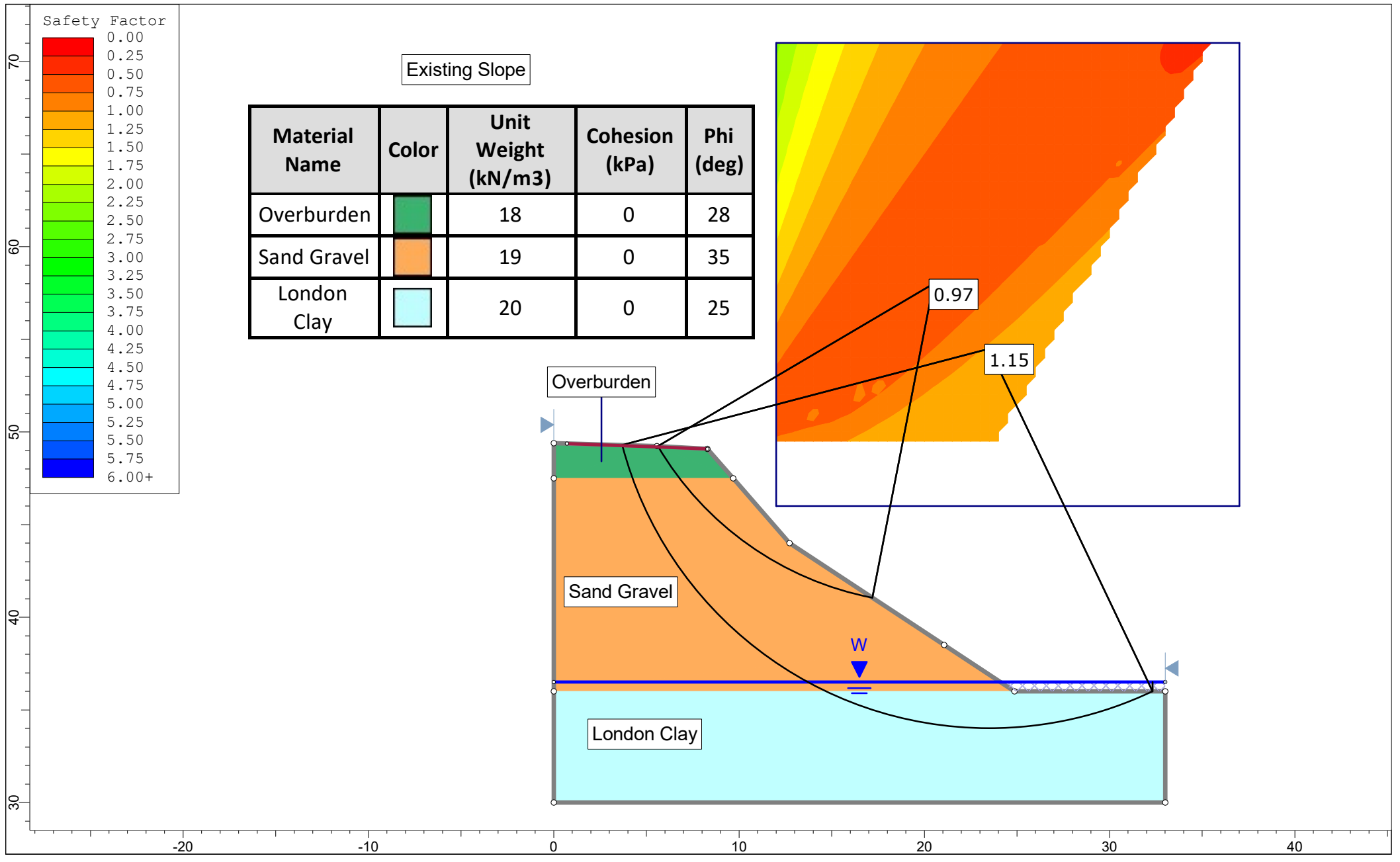


Figure 1 - Existing quarry face/slope

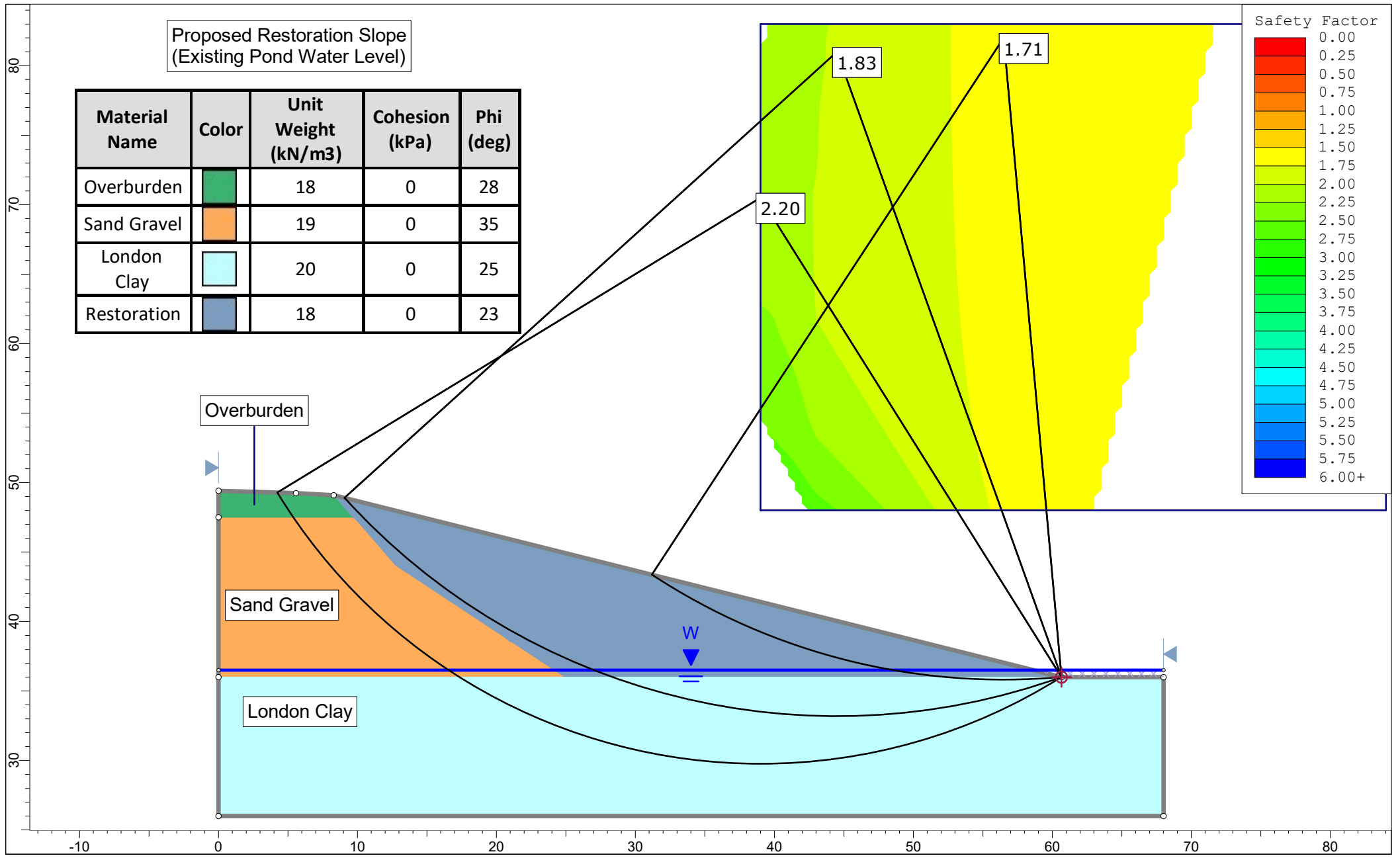


Figure 2 - Proposed restoration slope (minimum pond water level)

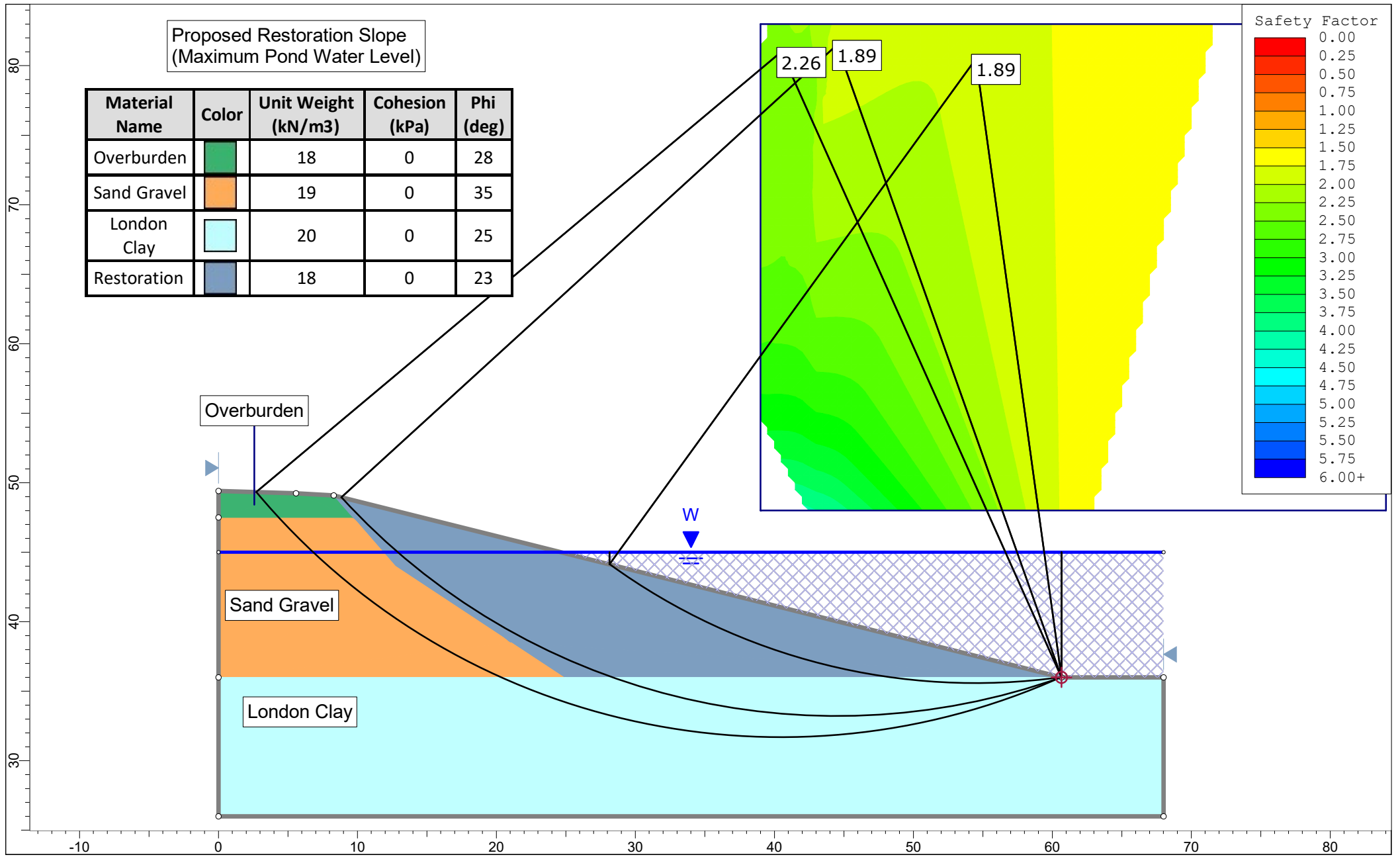


Figure 3 - Proposed restoration slope (maximum pond water level)

APPENDIX 2

Photographs



Photo 1 – instable ground approximately 3m behind the crest of the western quarry face (potential slope failure in the long term)

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By:

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Date:

Sep '22





Photo 2 near vertical quarry face/slope

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By:

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Date:

Sep '22





Photo 3 current pond water level

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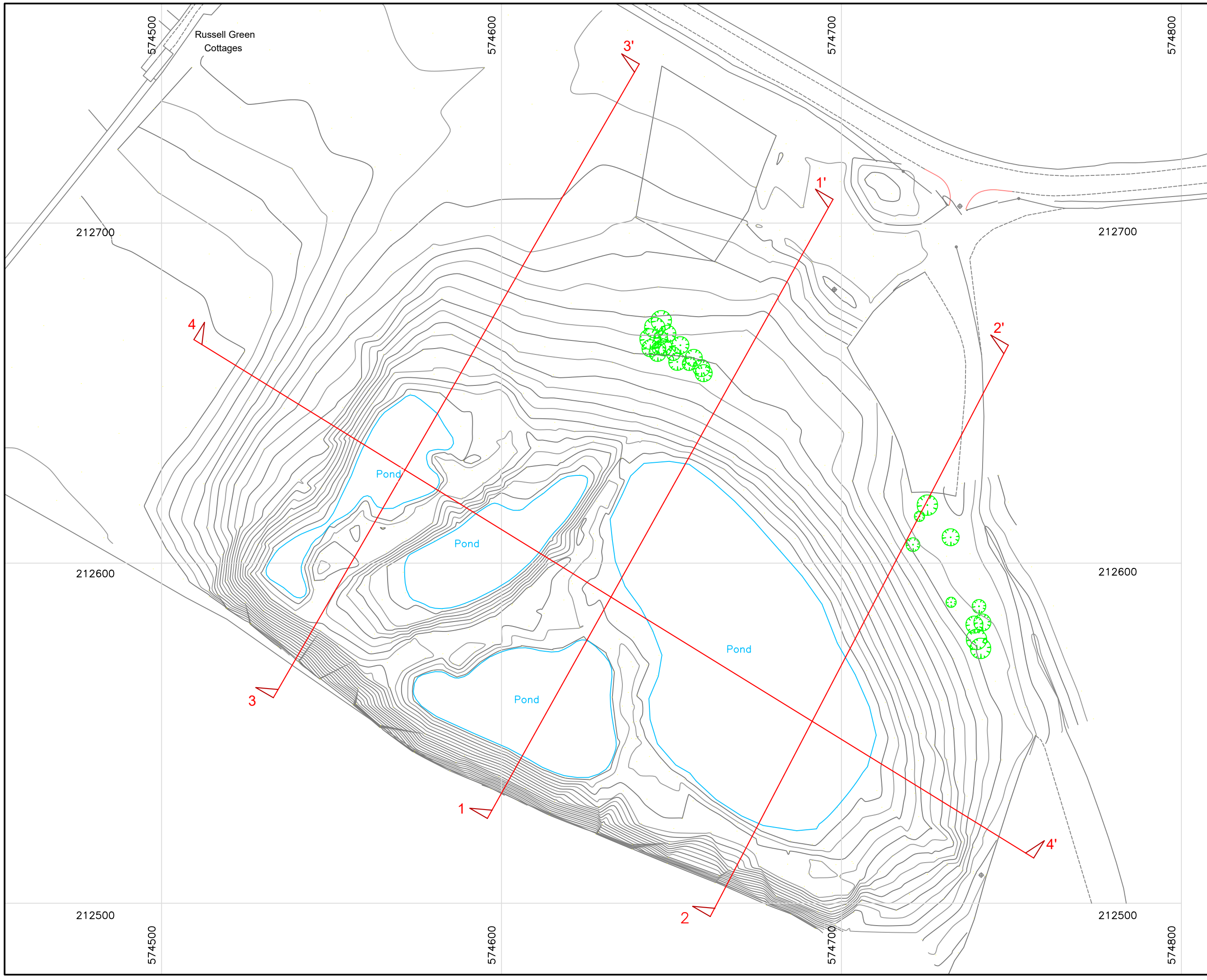
ZLu


Date:

Sep '22



DRAWINGS




 Cross Section Line

NOTES
 1. Cross sections 1-1' to 4-4' are shown in Drawing No. 8198-001-003.

Rev.	Revision Detail	Drawn	Date
P01	First Issue	ZL	14/10/22

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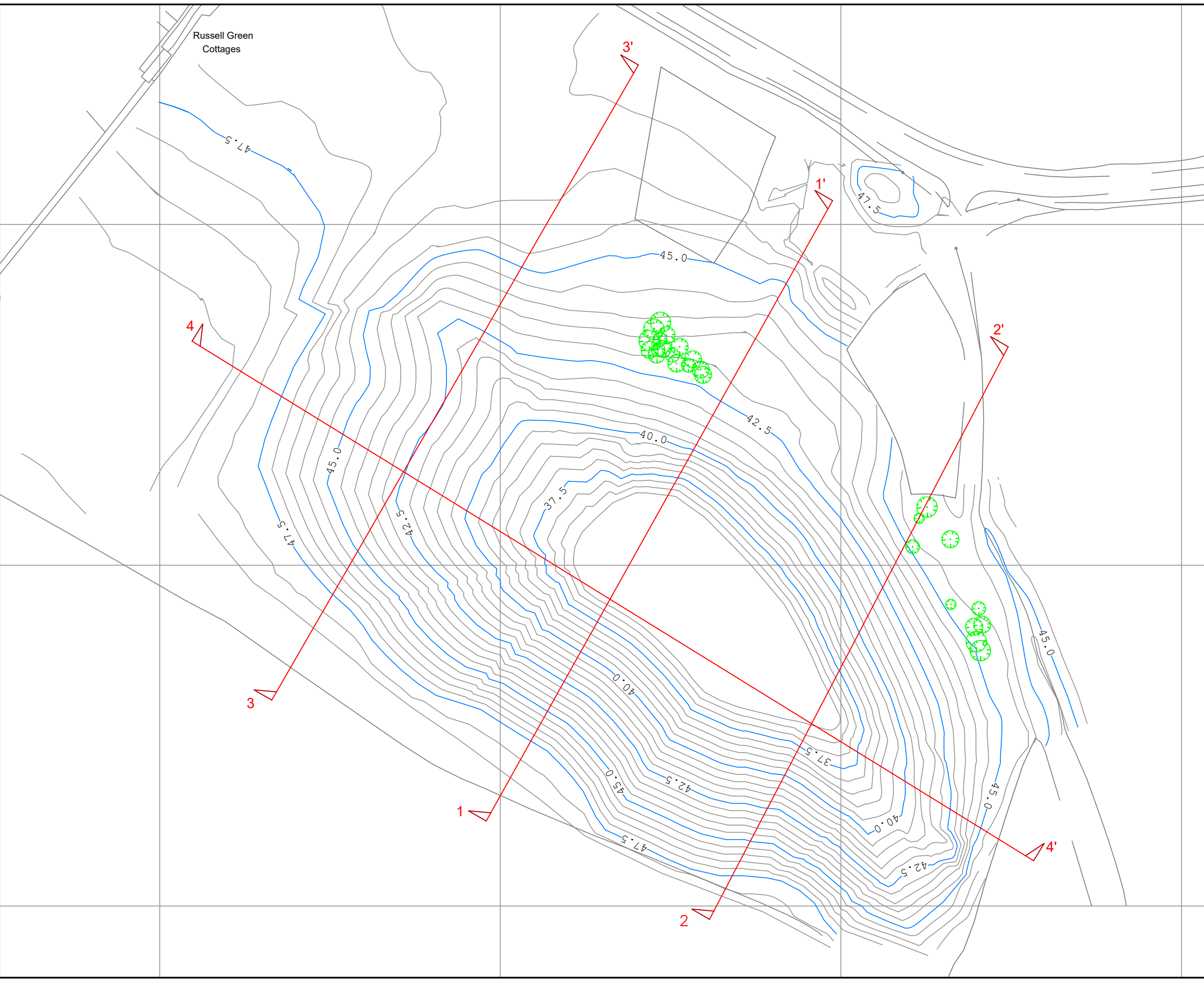
TITLE:
Existing Site Conditions

Drawn: ZL	Checked: BD	Date: Oct '22
Scale: 1:1000	Original Sheet Size: A3	Status: V01
Drawing No. 8198-001-001	Revision: P01	



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Russell Green Cottages


1' 1' Cross Section Line

NOTES
 1. Cross sections 1-1' to 4-4' are shown in Drawing No. 8198-001-003.

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P01	First Issue	ZL	14/10/22

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TITLE:
Proposed Restoration Design

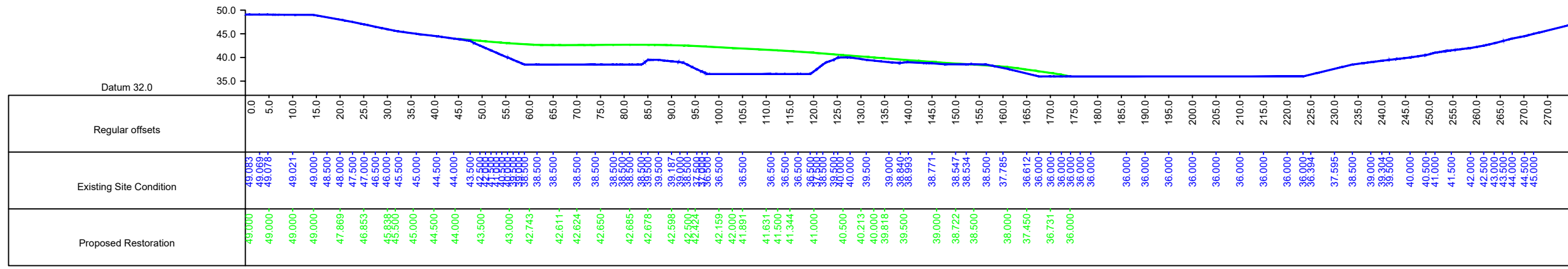
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Drawing No. 8198-001-002	Revision: P01	



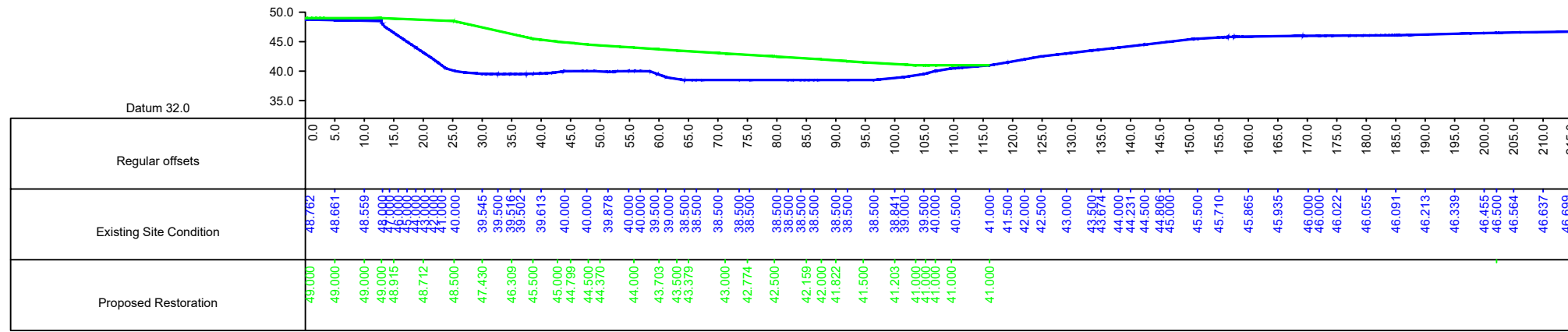
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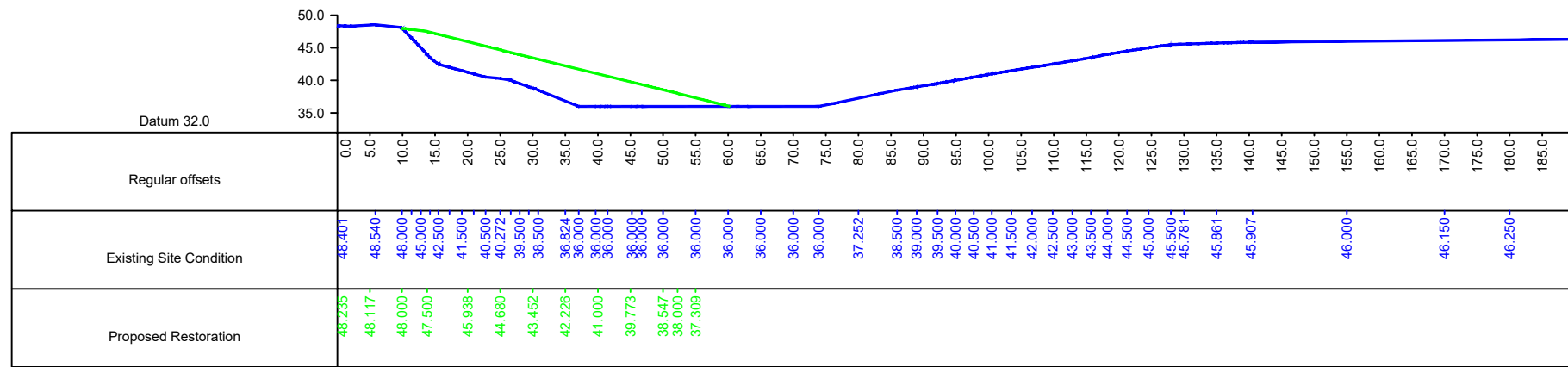
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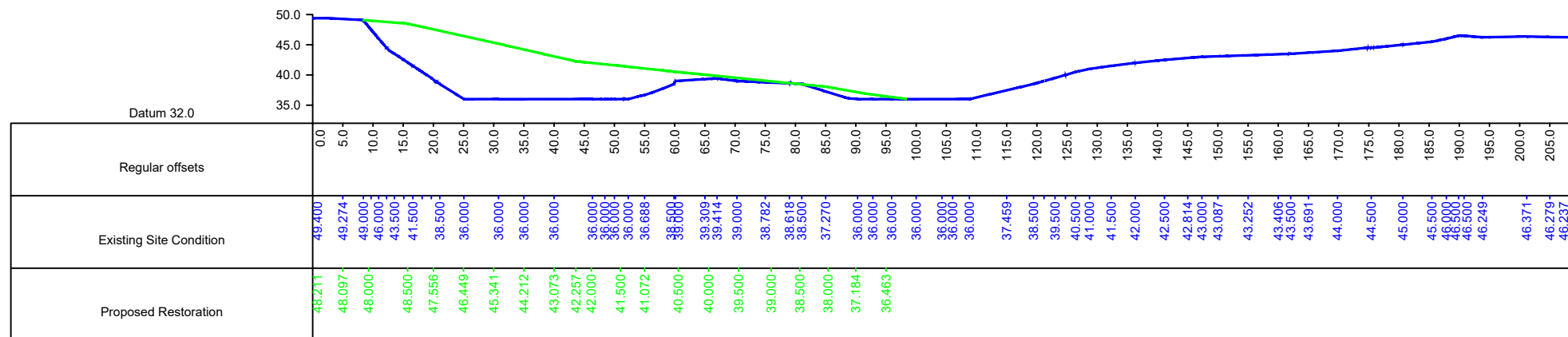
Section 4-4'



Section 3-3'



Section 2-2'



Section 1-1'

— Existing Site Condition
 — Proposed Restoration

NOTES
 1. Section lines location is shown in Drawing No. 8198-001-001.

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PROJECT:
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TITLE:
 Cross Sections

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ZL	BD	Oct '22
Scale:	Original Sheet Size:	Status:
1:1000	A3	V01

Drawing No. **8198-001-003** Revision: **P01**

