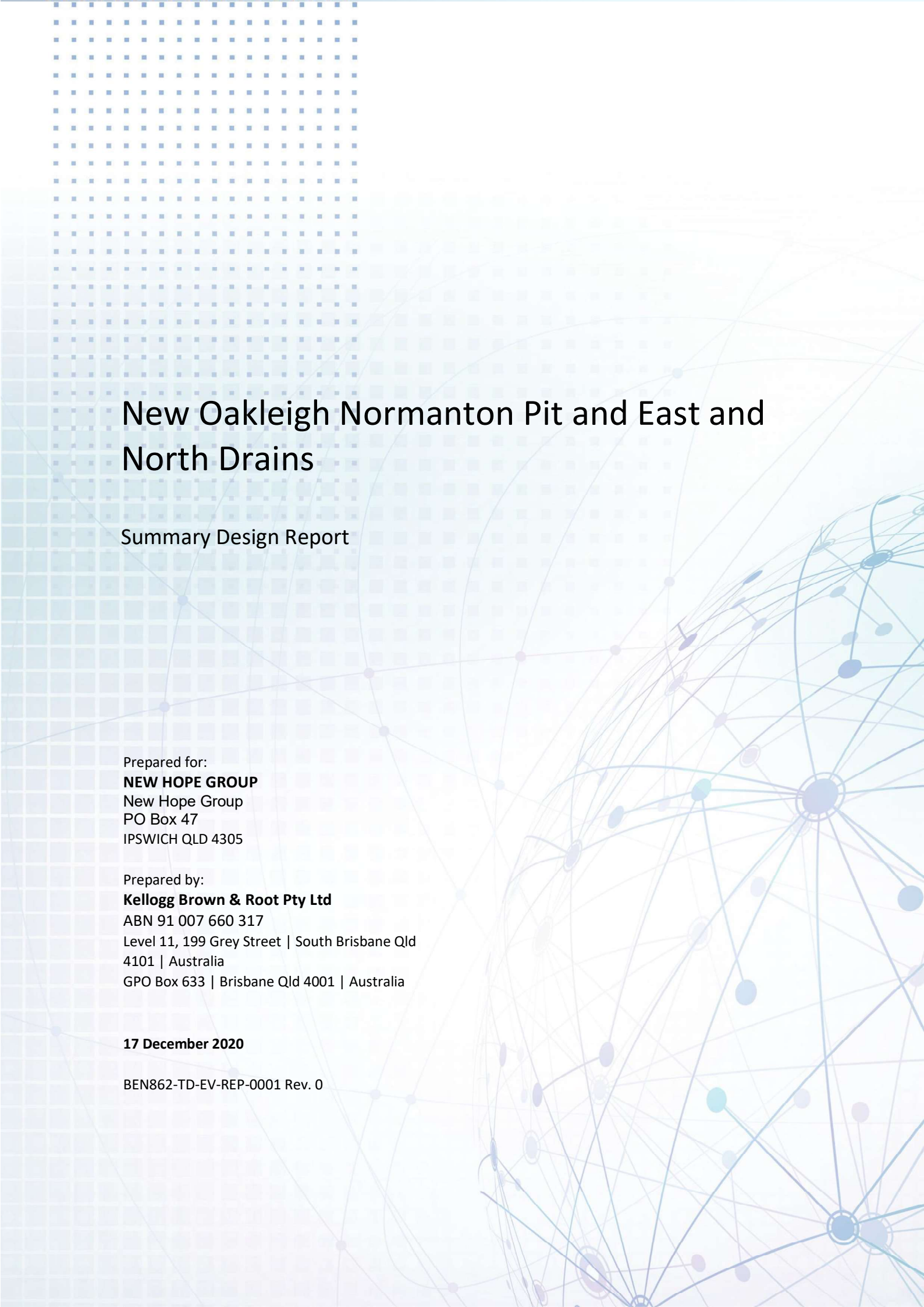




New Oakleigh Normanton Pit and East and North Drains

Summary Design Report



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KBR derived the data in this document primarily from data supplied by the Client, site inspection and discussion with the Client. The passage of time, manifestation of latent conditions or impacts of future events may require further exploration at the site and subsequent data analysis, and re-evaluation of the findings, observations and conclusions expressed in this document.

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List of abbreviations

AEP	Annual Exceedance Probability
BOD	Basis of Design
FOS	Factor of Safety
KP	Knight Piesold
ML	Mining Lease
NHG	New Hope Group
SGRS	Sherwood Geotechnical and Research Services
TSF	Tailing Storage Facility

1 Introduction

1.1 INTRODUCTION

This report looks at the detailed design of the rehabilitation of two parts of the New Oakleigh Mine site and builds on the work undertaken by Palaris in 2014. It provides final landform and drainage paths that can be developed to facilitate the rehabilitation of these areas.

The design focused on three main areas: the Northern Highwall and general drainage across the central region of Oakleigh East (particularly the Eastern main drain); and the Normanton Pit (including the cliff face backfilling and the surrounding drainage).

Design is limited to Oakleigh East and Normanton areas within surface rights and existing mining lease (ML) areas (known as the project area). Although the New Oakleigh site incorporates Oakleigh East and Normanton Pit areas as well as the Oakleigh West areas, design was not required outside the surface rights areas of Oakleigh East and Normanton Pit areas (as shown in shaded pink and blue areas in Figure 1.1).

The outcome of the design aims to allow the client to progress successful rehabilitation of the site.

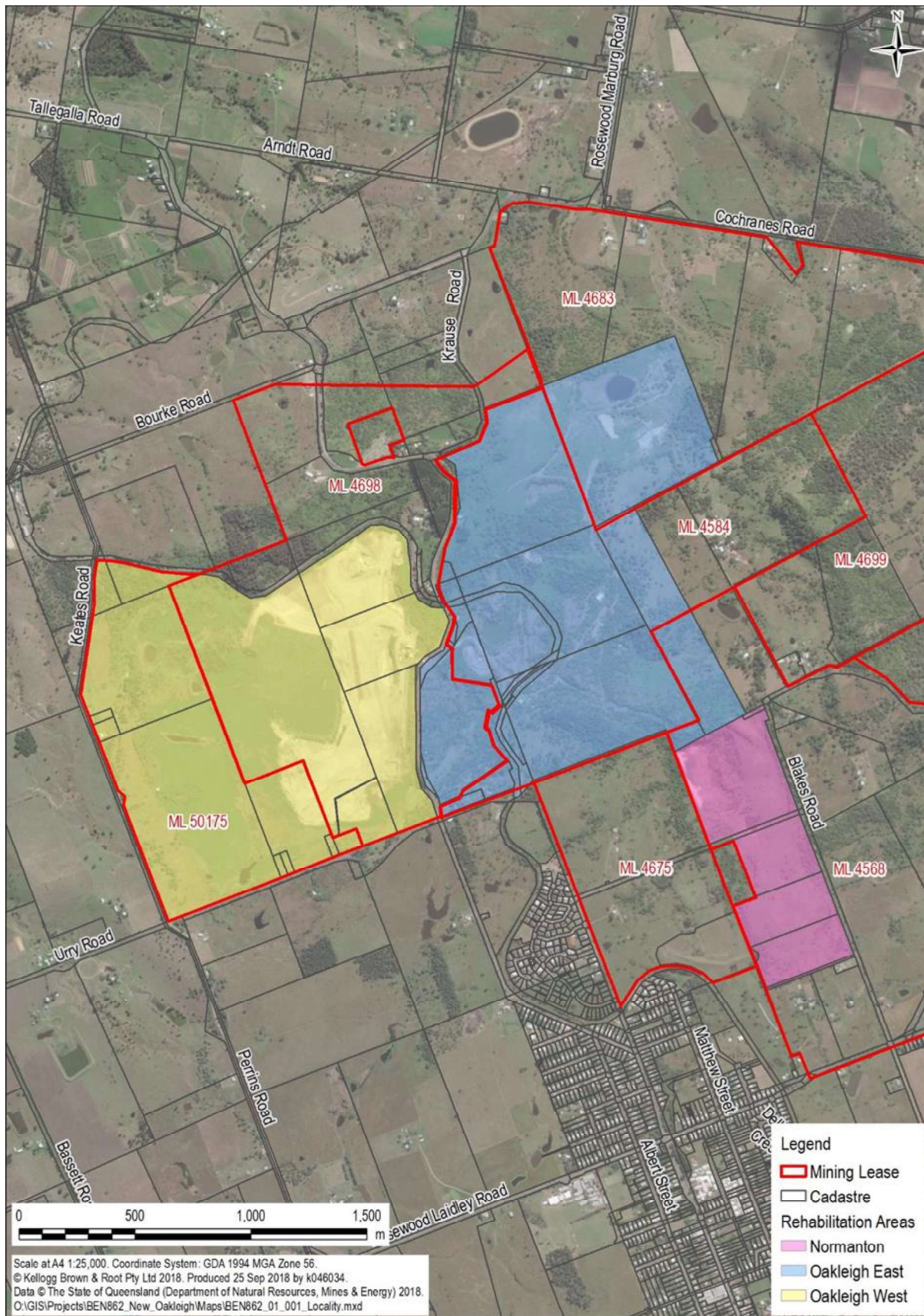


Figure 1.1 Oakleigh East and Normanton Battery Limits

1.2 BACKGROUND

This report builds on the work that has previously been undertaken by Palaris in developing an initial design report *Rehabilitation Design Report – Normanton Pit* (April 2014) and Concept Closure and Rehabilitation Plan – Oakleigh East (September 2014), copied in Appendix B. As part of this report the whole New Oakleigh East and Normanton Pit site was reviewed and it was identified that certain areas had been either fully or partially rehabilitated in the past.

It should be noted that all mining work within the New Oakleigh site has now ceased. Some rehabilitation work has continued since 2014, when the Palaris reports were published, including recent work that has involving the backfilling of the tailings dam at the north of the site using locally sourced materials from within the site.

To assist with the development of the detailed design, a high-level geotechnical investigation and design review was completed by Knight Piesold (Appendix A) and a soil stability report was undertaken for the Northern Highwall by Houghton’s Environmental (Appendix C) . A more detailed visual and geotechnical investigation of the Northern Highwall area has also been undertaken by SGRS at the request of the client (Appendix A).

The outcomes of these investigations which were used to develop the final landform and design approach applied in the designs by KBR are summarised later in this report.

2 Project overview

2.1 OVERVIEW OF SLOPE STABILITY AND GEOTECHNICAL CONSIDERATIONS

The LiDAR surface provided by NHG represented the current surveyed topography across the existing project areas.

Knight Piesold (KP) undertook a geotechnical investigation of the site focussing on the key areas around the Northern Highwall and Normanton Pit. The key findings were that the site consisted of a number of areas of unconsolidated material, which appeared to be stable at 1:5 to 1:6 slope. Though the results did not preclude the steepening of slopes to less than 1:5, it was seen that the material was variable across the site and without significant additional testing, grading and sorting it would be difficult to guarantee slope stability.

The client was considering a construction approach to rehabilitation which consisted of a general bulk-push and mass haul (cut to fill) method. The geotechnical overview and advice from KP was to use a grade of typically 1:5 as a minimum for bulk push operations, to help ensure that long term structural stability was maintained.

The full geotechnical report is included in Appendix A, but the key points which were used in the detailed design are outlined below:

- Slopes constructed from unconsolidated material will not exceed 1 in 5 slopes (to retain erosional and geotechnical stability), although 1 in 6 slopes are preferred and will be incorporated where possible.
- Landforms designed for closure are generally considered acceptable with a factor of safety (FOS) of 1.3 to 1.5 (static) and 1.05 to 1.1 (post seismic). The detailed design FOS is as follows:
 - 1.3 to 1.5 long term drained
 - 1.3 to 1.5 short term undrained
 - 1.05 to 1.1 post seismic.
- Slopes have been designed to meet the required FOS.

2.2 OVERVIEW OF SLOPE STABILITY AND SOIL EROSION CONSIDERATIONS

Long term soil erosion is a prime consideration in the rehabilitation works and three of the key design considerations were that:

- landform design requires long term stability 100+ years (i.e. long term closure planning timeframe)
- required service life of the drainage structures is 100+ years
- all current voids will be free draining.

The material that is to be used for the rehabilitation will be material sourced locally within the site and shaped and compacted using a bulk push approach. There will be no specific compaction of the slopes other than through gravity and construction machinery. Therefore, to avoid any significant scour, the slopes will need to be of a flatter grade and provision be made for draining to dedicated and protected main drains.

Long term stability and rehabilitation will depend on vegetation regrowth and, as the slope gradient increases, the opportunities for regrowth of native plants reduces. Relatively flat ground

conditions can support trees, bushes and shrubs. As slopes increase to 15 to 20 degrees (1:4 or 1:3) these moderate slopes can still support some vegetation whereas when the slope angles increase above 30–45 degrees (1:2 or 1:1) then this is likely lead to severe erosion and poor revegetation success.

Based on the likely material and overview of the geotechnical report and soil erosion data plus information gained from the site visits it was generally accepted that having slopes greater (no steeper) than 1:5 or 1:6 should be used as a general guide to help ensure long term stability. This was seen as a conservative solution that met both geotechnical stability and erosion control criteria without the need for significant site wide materials testing.

A specific report relating to the Northern Highwall was commissioned by the client to assess specific soil erosion risks in this location. The report *New Oakleigh Coal Mine – North Highwall Erosion and Rehabilitation* (June 2020) by Houghton Environmental Management (see Appendix C) identified that erosion of the currently bare area is relatively inactive/slow, and that erosional stability is likely to be achievable at the existing gradient provided specific surface treatments are implemented. The identified treatments are summarised later in this report.

2.3 PRIORITY AREAS - DESCRIPTION

The three primary areas of interest identified as requiring rehabilitation in Palaris (2014) were:

- Northern Highwall
- Eastern Drain
- Normanton Pit (refer Figure 2.1)

It should be noted here that there are a number of other areas within the New Oakleigh site boundary where slopes are steeper than 1:5. However, in discussion with the client many of these areas are identified as previously rehabilitated areas, where significant revegetation has taken place. Therefore, a decision was taken that to disturb areas outside the three main areas identified in the Palaris Report was not likely to result in significant improvement in overall rehabilitation of the site when the whole was considered.

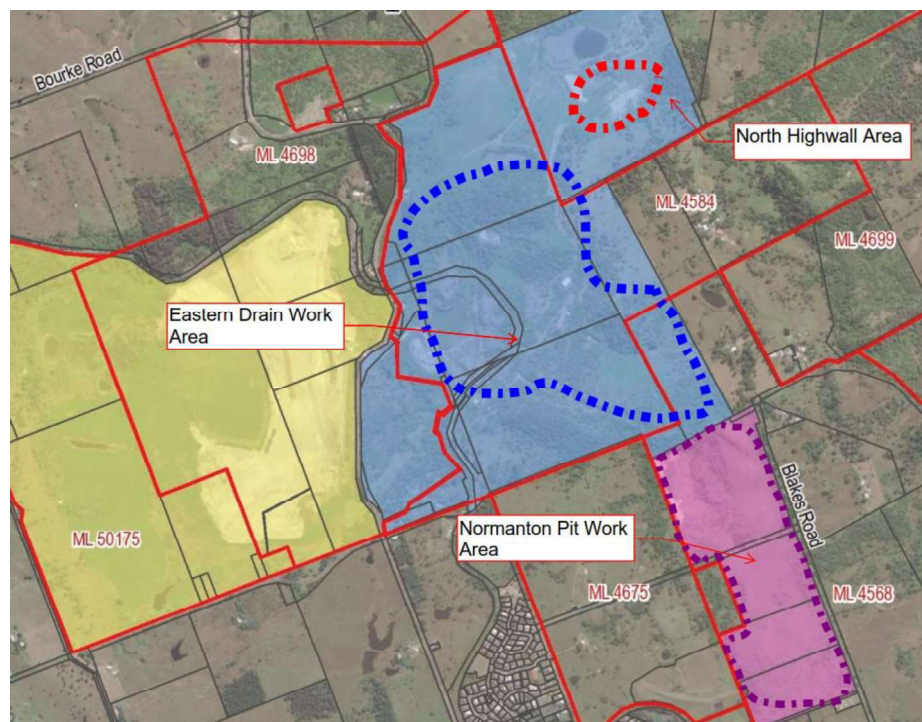


Figure 2.1 Priority areas

2.3.1 Northern Highwall

- **Northern Highwall** shown in Figure 2.1:
 - Northern Highwall and surrounding area.

2.3.2 Eastern Drain

- **Eastern Drain** shown in, Figure 2.1:
 - reshaping landform and central drainage area
 - capping ROM pad and miscellaneous historic coal stockpile locations
 - redesigning wash plant dam inflow/outflow
 - designing drainage structures as required to manage offsite release.

2.3.3 Normanton Pit

- **Normanton Pit** shown in, Figure 2.1:
 - backfilling and reshaping Normanton Pit
 - relocating and improving the drainage line that currently exists alongside Blake's Road, known as 'Blake's Gully'
 - designing drainage structures as required to manage offsite release.

2.4 HYDRAULIC DESIGN

2.4.1 External drainage

Oakleigh East contains two post-mining catchment areas: a large central catchment and a small north-eastern catchment. Only the large central catchment will be reinstated following optimisation design as the work required to re-install the northern catchment is excessive as vegetation in this area is considered to be advancing well. The drains designed for the large central catchment are referred to in this report and the design drawings as the 'East and North Drains'.

Normanton Pit also has two catchment areas – one large catchment that drains from the northeast to the central west; and a smaller catchment that starts in the southeast of the project area and continues southeast outside the project area boundary. Both catchments will discharge to the same locations that currently exist.

2.4.2 Internal Drainage of Constructed Slopes

Hydraulic analysis for Northern Highwall and Eastern Drain was initially conducted to size rock protection of adequate size and depth to prevent erosion and scour of the proposed chutes for events up to the 1% annual exceedance probability (AEP).

After discussions with the client on 6 October 2020 it was requested that KBR explore the use of Geofabrics Australasia Pty Ltd propriety products to reduce the amount of rock due to large sizes (>650 mm d50) and volumes while providing a more sustainable vegetative outcome. The client understands they will need to monitor and maintain vegetation establishment during the remaining 10+ years of site maintenance.

Through communication with Geofabrics by KBR it was established their Grassroots™ product would be a preferable option given durability and performance in a similar environment (Grassroots Technical Note 1 – Outdoor Durability and Performance v2).

Information provided by Geofabrics had shown that for hour long drainage scenarios the following was observed with well established, dense vegetation:

- Where velocities and bed shear stresses did not exceed 2.2 m/s and 140 Pa there was a cumulative soil loss of 0.5 mm
- Where velocities and bed shear stresses did not exceed 3.9 m/s and 250 Pa there was a cumulative soil loss of 1.0 mm
- Where velocities and bed shear stresses did not exceed 5.7 m/s and 390 Pa there was a cumulative soil loss of 1.8 mm
- Where velocities and bed shear stresses did not exceed 7.5 m/s and 510 Pa there was a cumulative soil loss of 2.8 mm.

In order to adequately for the 1% AEP, the following approach was taken:

- A 2d TUFLOW direct rainfall model was prepared running an ensemble of temporal patterns per duration up to 1 hour storm duration as per Australian Rainfall and Runoff (2016–19).
- Flows were validated by comparing to a DRAINS and XPRAFTS model at various points of interest for each chute.
- Velocities, depths and bed shear stresses in the TUFLOW model were validated at each chute by comparing to KBR internal spreadsheets of channel hydraulics, design guidelines by Catchments and Creeks Pty Ltd, IECA Best Practice Erosion & Sediment Control Guidelines and other industry appropriate guidelines and approaches.
- Velocities and bed shear stresses.

All drains and chutes have been designed as follows meeting the following criteria:

- Drains containment:
 - drains will be designed to an overall longitudinal gradient of ≤ 1 in 9 (~12%)
 - drains will typically comprise V-shaped or trapezoidal channels with nominal 1 in 5 side slopes
 - base width will vary 0.0 m to 20.0 m dependent upon flow rates expected
 - general overall channel/flow depth will aim to be shallow flow less than 0.5 m (incorporating 0.3 m freeboard) in areas where cut depths are not significant with larger cut depths expected through spoil material where channel slope and flow connectivity dictates the depth.
- Design standard for all drains and flow paths for internally draining structures – containment and stability is 1% AEP (1 in 100 year).
- Chutes incorporating Grassroots™ and revegetation generally limited to velocities and bed shear stresses to keep cumulative soil loss less than 1.8 mm for the 1% AEP.

2.5 GROWTH MEDIA AND REVEGETATION

Topsoil availability is in deficit across the project site. It is assumed that the growth media to be used is a combination of:

- topsoil material made available through the clearing process in advance of the landform reconstruction works
- incorporation of biosolids and gypsum into spoil material

Where topsoil material is made available, it will be placed on benches to promote early vegetation growth to minimise erosion.

3 Northern Highwall area

3.1 BACKGROUND

This area was identified in the Palaris report as an area that was in need of rehabilitation. The backfilling of the tailings dam in the north-east corner of the site was a key requirement and it was considered that locally sourced material could be used for this task. Sourcing material from the Northern Highwall was seen as an opportunity to address potential soil erosion issues on the highwall face by trimming the top of the wall and thus reduce the likelihood of future failure.

The new landform would then drain south and join the existing watercourse that discharges through the outlet at the former ROM pad to the west of the site.

3.2 BULK EARTHWORKS

In February 2019, KP was requested to perform initial modelling to assess the stability of the Northern Highwall. Although never formally reported, the stability results indicated the factors of safety for the current slope condition to be below acceptable levels and, as such additional runs were conducted on a conceptual rehabilitation profile which would involve minor reshaping to form a reduced slope profile and additional buttressing of the toe. The stability outputs were provided in draft form with a recommendation that further investigations be conducted.

However, the assessment was not formally concluded by KP. The original proposal was to reduce the slope and height of the highwall area to a typical 1:5 grade. This would address both the long term slope stability and soil erosion issues and was in line with the general guidelines that had been developed for the rehabilitation of the site as a whole. However, when these general principles were applied to the specific area it was found that they were unworkable and likely to lead to further on-going rehabilitation issues.

A part of the area behind the highwall was already well established and rehabilitated to a relatively stable condition. The flattening of the top of the highwall (to reduce overall height) and introducing the typical 1:5 slope would have actually resulted in significant clearing of the already rehabilitated and revegetated area and actually spilled outside the lot boundary. Therefore the client, in discussion with KBR, made the decision to do further targeted investigation work for the northern highwall area.

A more in-depth analysis of the geotechnical results obtained by KP was undertaken by Sherwood Geotechnical and Research Services (SGRS, 2020) who reported that their analysis and the local topography indicated that the slope would be likely to remain relatively stable. The SGRS report identified that both the rock formation and profile as well as the vegetation patterns, indicated a relatively good level of stability. This in-depth analysis also used a more localised FOS based on local knowledge and experience of the geotechnical team, which concluded that slip failure was unlikely.

There remained the issue of the top section of the highwall being significantly steeper than the 'global' 1:5 nominal design criteria for long term erosion and soil stabilisation. A report was commissioned by the client to look at the specific location requirements *New Oakleigh Coal Mine – North Highwall Erosion and Rehabilitation* (September 2020) by Houghton Environmental Management.

Their brief was to undertake the assessment of erosion control and associated rehabilitation requirements associated with the currently bare northern highwall area.

The report highlighted that this area had remained largely bare since rehabilitation had taken place in part of the area over twenty years previously. Extensive vegetative rehabilitation had been carried out on adjacent areas which left the face of the north wall the only area where vegetation has not been established.

On undertaking a focussed site visit Houghton (2020) found that the prevailing slopes of the northern highwall area were a fairly consistent 1:4 but with some localised slopes were up to 1:3. Houghton then compared aerial photography from 2003, when mining was active and no rehabilitation had yet taken place with 2009, 2014 and 2020 photos and found the following:

- substantial colonisation and pasture across the site
- the severity of erosion in the worst affected areas and adjacent areas showed minimal change over time.

As a result of this further investigation the client was mindful to avoid the need for a bulk earthworks approach to the landform and wished to follow the advice and findings of the Houghton report.

The key findings of the Houghton (2020) report were:

- Based on the geotechnical assessments and site inspection findings, geotechnical factors are unlikely to cause significant failure of the existing slopes. The focus should thus be on implementing surface erosion protection measures combined with vegetative rehabilitation
- While the existing erosion within the bare area initially appeared significant and unacceptable, it is believed that the existing extent and severity will show only minor change in the medium to long term. Nevertheless, natural vegetative colonisation will continue to be slow to non-existent due to the soil conditions unless remedy treatments are applied. In terms of gaining regulatory approval, the rehabilitation standard for this area as it currently stands would be likely to be regarded as unacceptable.
- Significant erosion is evident in a substantial area to the immediate north of the bare area, however the erosion scars have been naturally colonised and stabilised by pastures. While it is not recommended to undertake ground disturbance of this area in the short term, this area will need on-going monitoring in the short to medium term to ensure that stability is being maintained. This area should be fenced to prevent stock access.
- While the slopes within and adjacent to Area A (as shown in Houghton, 2020, see Appendix C) are steep, they are not so steep that vegetative stabilisation could not be successfully achieved. Flattening the affected bare area and lands upslope to (say) a 1:5 slope is considered inappropriate and will likely exacerbate erosion levels over a broader area in the short to medium term.
- The existing soil quality conditions and landform within the bare Area A make it highly unsuited to planting of cover species and natural colonisation is unlikely to occur in the absence of further treatment. Treatment of the *in-situ* soils within the bare area e.g. by heavy applications of gypsum (rates of up to 20 t/ha may be necessary to go some way to reduce the very high levels of exchangeable sodium), lime and fertiliser, would improve soil conditions. However the application and incorporation of such treatments onto the steep slopes (following levelling and track-rolling) could be difficult and the practicality and methodology for doing so would need to be confirmed by experienced earthworks machinery operators. It will be important that this area is ripped, graded and track rolled to create as even a final contour as possible, recognising that slope constraints may mean that machinery may only be able to safely work up and down the slope
- Given the above, the most appropriate solution would be to cover the Area A with a suitable depth of soil/weathered material (a minimum depth of 30 cm is recommended). The source

and suitability of such material (possibly 3,000 m³+ of material may be required) and means to cart and place it onto the eroded area should be the subject of further assessment.

- The application of surface stabilisation measures would then need to be undertaken using one or more of the measures described in the Houghton's report. The means to undertake this should be the subject of further assessment, particularly in regard to access constraints and placement/spraying of material onto the bare area
- If it is not practical to place a depth of imported cover over the bare area (once ripped and graded), then other simple stabilisation methods should be implemented, including the use of hay bales and silt fences). Most importantly, there should be no structural erosion control earthworks established on the slope as these would have the potential to cause prolonged ponding and instigate tunnel erosion and potential geotechnical failure.

In light of the findings of this report no further bulk earthworks are planned for the Northern Highwall area, except in relation to those associated with establishing or re-establishing drainage paths for the run-off to the south and east.

3.3 DRAINAGE

The area currently drains to an existing pond adjacent to the tailings dam infill area which then discharges south into the East Drain works area. Refer to Figure 4.1 in Section 4.

However, with the exception of the filling of the tailings dam, minimal bulk earthworks are proposed for this area. Outflow from this area is through the existing connection drain to the central drainage area. Refer to Figure 4.2 (Section 4.3).

3.4 WORK COMPLETED

The client commenced filling of the tailings dam in 2019. Filling was carried out by means of a bulk push operation using material from an area slightly south and west of the tailings dam.

The final profile of the capping material was graded to push the run-off into an adjacent existing pond which will then discharge to the eastern drain work area to the south.

No further work has been undertaken at the time of writing this report.

3.5 WORK REMAINING

There is limited engineering work required if the rehabilitation approach proposed by Houghton (2020) for the Northern Highwall is adopted.

4 Eastern Drain

4.1 BACKGROUND

The Palaris Report identified that one key to rehabilitation of the central area of the site was to develop an east-west drainage system to link up with the run-off from the northern area. This included designing a system to avoid significant impact on the Rosewood-Marburg Road by maintaining the existing culverts on Cover's Gully as the primary point of discharge. An additional consideration was to try to minimise the impact on the rail corridor and leave the area undisturbed to the maximum extent.

The central area was characterised by a number of significant wash-outs and erosion locations, particularly near the railway, where a former bridge and a number of culverts had led to washout of the rail line, making it impassable.

Based on the findings of the soil and erosion characteristics from the geotechnical report, a maximum slope grading for any newly disturbed areas was set at 1:5.

4.2 BULK EARTHWORKS

In conjunction with the client, KBR undertook a review of the landform to reinstate and realign a new east-west drain that would discharge through the pool adjacent to the existing ROM pad at the Rosewood-Marburg Road. Following the approximate line of the Palaris design, the grade and depth of the drain were developed to ensure that discharge velocities did not lead to significant scour over time. The design was finessed, with the use of a proprietary 'Grass-Roots' product and rock pitching proposed along significant lengths, to avoid the need for drop structures.

Adopting the 1:5 side slope for the drain, to avoid long term erosion and enable revegetation for potential pasture, resulted in an excess cut volume of approximately 45,000 m³ from the drain itself. This excess material cannot be stockpiled long term so will need to be used around the site. An approach to dress and cover other affected areas to improve the final landform and allow for easier rehabilitation to pasture for these areas is proposed. The majority of the excess material will be deposited in three locations, namely:

- on the existing ROM pad, where capping of the significantly disturbed area, with a minimum of 1.0 m of material is being proposed
- on the Stone Pile (overburden rock piles) areas
- within to the railway reserve to help reinstate the existing railway embankment, that has been badly eroded. This will assist in the re-establishment of the rail line should this occur.

The final landform design is presented in the detail design drawings in Appendix G.

4.3 DRAINAGE

A number of iterations of the drainage design in this area have been undertaken to reduce the need for drop structures and minimise disturbance to the adjacent land, especially in those areas where rehabilitation and regrowth has already been established. A detailed layout of the proposed drainage layout for the eastern and northern sub-catchments (referred to as the East and North Drains) is detailed in drawing BEN862-DW-CV-GAR-2001, Appendix G and detail in Figure 4.14.1.

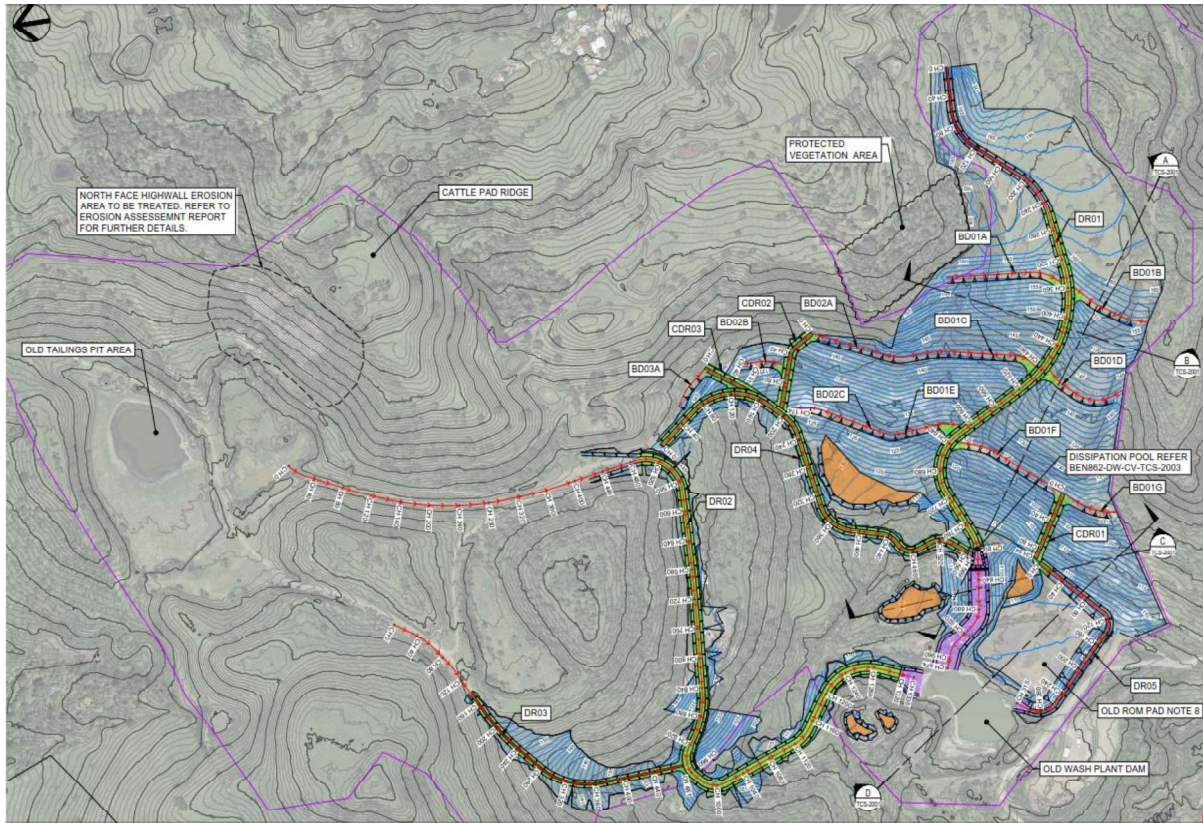


Figure 4.1 Eastern Drain Area (East and North Drains) General Arrangement

The drainage strategy has two main trunk drains, eastern drain DR01 and northern drain DR02 that outflow into the existing wash plant dam which will act as a settling pond. Minor branch drains DR03, DR04 and DR05 along with Chute and berm drains are used to further manage the natural runoff of the site and control erosion in accordance with the BOD parameters.

To control velocities and erosion within the main drains the proprietary Grass-Roots product (Refer Appendix H) has been utilised in the design for majority of areas along with rock armouring at the downstream ends. The use of the two materials have been based on maintaining flow velocities and bed shear stresses of less than 5.7 m/s and 390 Pa to keep cumulative soil losses to less than 1.8 mm for the 1% AEP.

At drain/chute outlets, rock has been adequately sized reduce velocities as they approach Old Wash Plant Dam. A dissipation pool was required (refer to drawing TCS-2003) to prevent erosion at the junction of DR01 and DR04. The dissipation pool and outlet rock was sized in accordance with guidelines described in Section 2.4.2. Shown in Figure 4.2 is flood depths outputted from the TUFLOW model for the proposed works.

It is noted that no assessment of changes in flow to points of discharge or stakeholders outside the mine lease has been conducted as part of this drainage assessment. The Old Wash Plant Dam was considered mostly dry in the hydraulic assessment as this would create a 'worst case' scenario for bed shear stresses and velocities at the drains. Volumes and storage at Old Wash Plant Dam weren't considered as part of this assessment.

The revegetation of drains incorporating the Grass-Roots product are to be based on the preparations, planting and maintenance described in the revegetation specification provided in Appendix I.

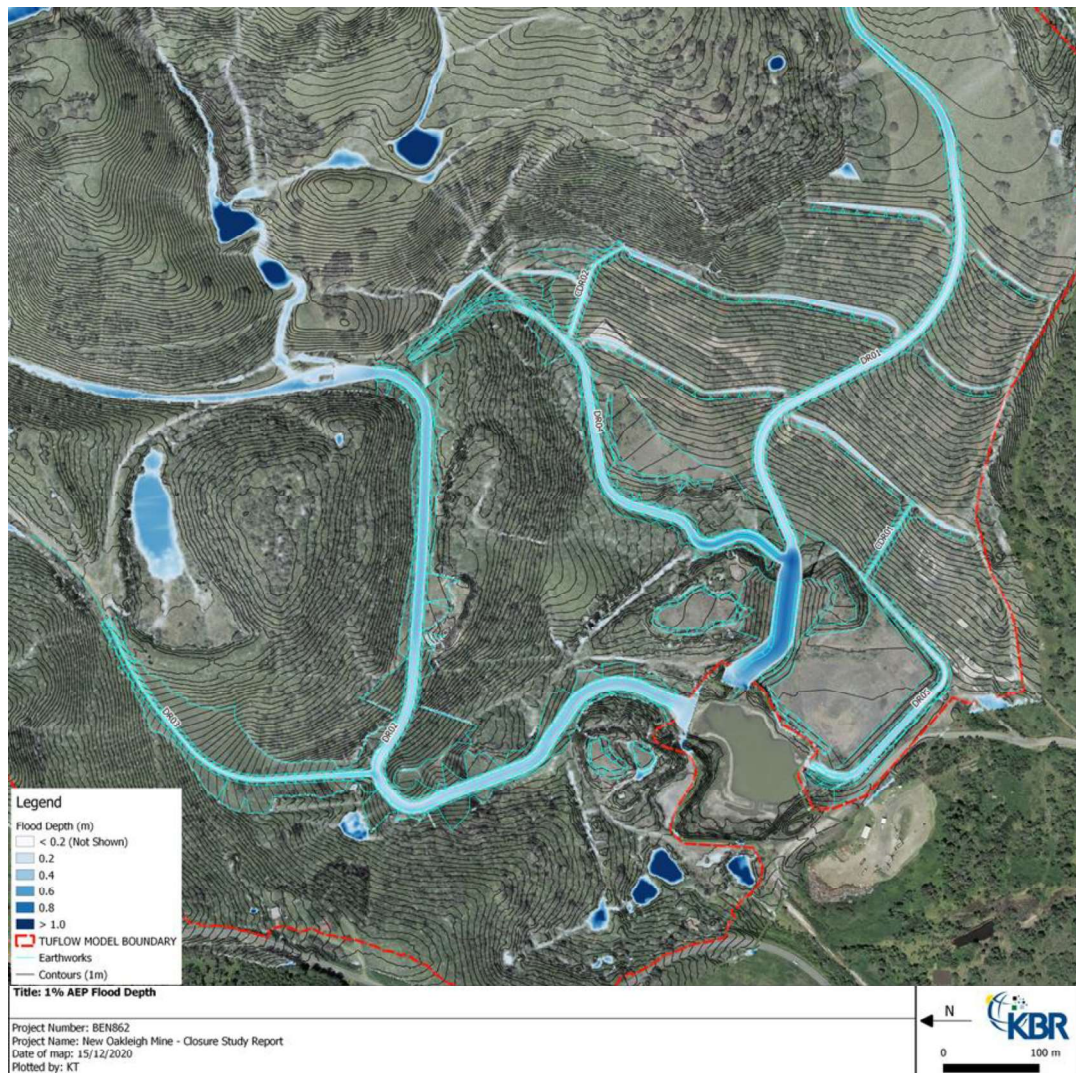


Figure 4.2 Modelled 1 in 100 year flood depths

The existing outlet from the washdown dam has not been assessed as part of this study and should be maintained and monitored, along with the establishment and/or maintenance of vegetation with the drainage channels.

4.4 WORK COMPLETED

At this stage, no work has yet begun on this element. The modelling and civil quantity take-off's are complete and are provided in Appendix D.

4.5 WORK REMAINING

With the completion and submission of this report and associated design KBR's design commission is complete. The information presented will be used by the client to arrange for a construction contractor to undertake the work on site.

5 Normanton Pit

5.1 INTRODUCTION

The Normanton Pit site includes a large vertical or near vertical cliff face and is located towards the southern end of the New Oakleigh mine site. Spoil and tailings have previously been deposited at the southern end of the pit excavation area. Both the pit cliff face and the base of the cliff are to be rehabilitated. An access road runs along the west side of the excavation rising from ground level to the top of the cliff. Along this access road there is evidence of significant erosion due to gradient issues and the quantity of run-off.

The top of the cliff area is generally flat and has previously been rehabilitated and shows significant tress, shrub and pasture growth—refer Figure 5.1.



Figure 5.1 Normanton Pit Cliff

The Palaris (2014) report recommends cutting back the top of the cliff face and backfilling in front of the wall, whilst reinstating the drainage along the edge of the access road. The vertical and horizontal dimensions of the site are such that a stable 1:5 slope can be developed using standard bulk push arrangements.

5.2 BULK EARTHWORKS

Approximately, 1.4 M m³ of material would need to be generated to fill the area and develop the stable 1:5 slope arrangement. Initially, the material was to be sourced from either cutting back the top of the cliff and battering this back to 1:5 and then using surplus material from the eastern drain to provide the remaining fill. This approach would see a large area of rehabilitated slope at the top of the cliff face being disturbed in order to provide the stable 1:5 final slope.

In consultation with the client, KBR developed an alternative solution which was to trim the eastern edge of the existing excavation and borrow material from the southern dump area to the south by reshaping it to generate the remaining fill. This allowed for the reinstatement of the drainage adjacent to the access road and development of drainage basins at the south of the site, which would ultimately feed into the existing drainage network.

5.3 DRAINAGE

Adoption of the 1:5 slope in the main area of the pit addresses the issue of long term erosion and scour of the main face of the cliff. By grading the slope to a channel on the eastern edge of the area the existing drainage channel can be reinstated and realigned to effectively convey existing runoff from the north and four existing road culvert crossings on Blakes Rd to the pond. Runoff from the surrounding bulk earthworks is managed via berm drains and chutes which ultimately discharge into a series of ponds before release into the existing downstream network at the western edge of the lease boundary. Rock armouring has been applied to chutes and the main drain to help control erosion. Refer to Figure 5.2 for the general layout.

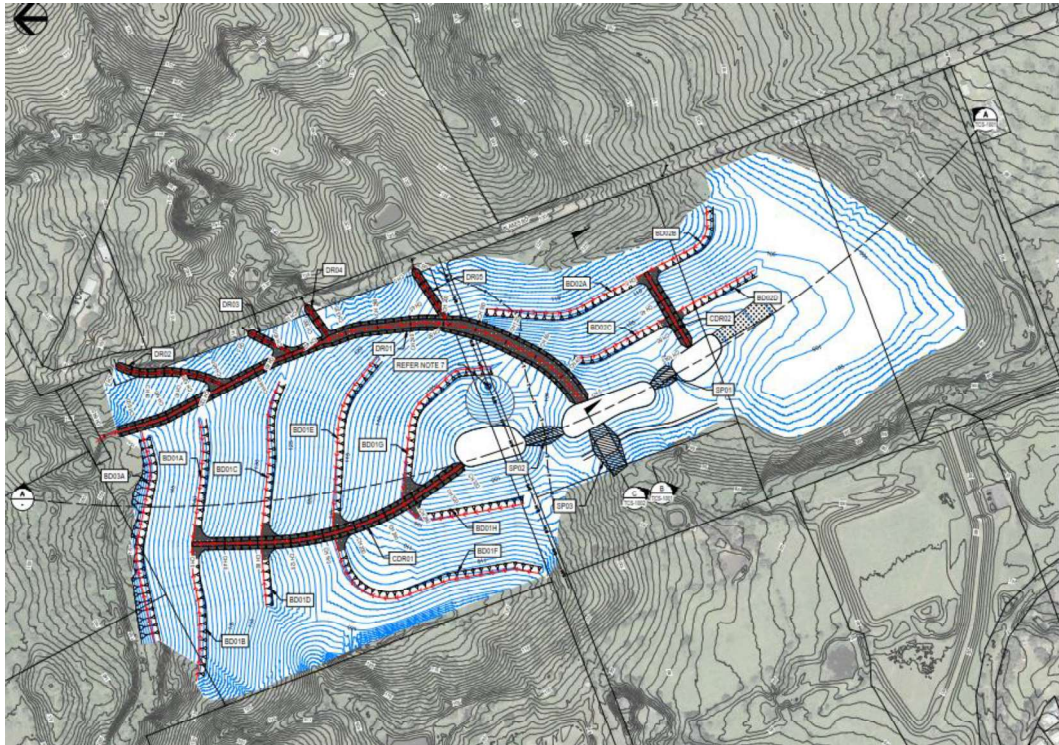


Figure 5.2 Normanton Pit General layout

5.4 WORK COMPLETED

The client commenced the bulk push operations on the Normanton Pit in 2019. The landform was based on the preliminary design provided by KBR and utilised only material from the side and base of the existing pit area.

The final approved design has been refined and has resulted in some minor changes to final levels. This information has been passed through to the client for inclusion in the final bulk earthworks and rehabilitation landform.

5.5 WORK REMAINING

The drains and rock pitching were still to be developed on site at the time of writing this report. KBR understands that this will be undertaken during the maintenance period.

All information has been provided to the client and work will proceed on the current basis until the client has determined that the final landform has been achieved. KBR's commission for this element of the works is complete with the submission of this report and associated final design.

6 Conclusion

This report covers the detailed design of the rehabilitation of New Oakleigh East and North Drains and Normanton Pit components of the New Oakleigh Mine site and builds on the work undertaken by Palaris in 2014. It provides final landform and drainage paths that have been developed to facilitate the rehabilitation of the site.

Focussing on the three key areas of the Northern Highwall, Eastern Drain and Normanton Pit, the report has detailed the engineering solutions and pulled together information on future management and maintenance to allow the client to progress rehabilitation of the site.

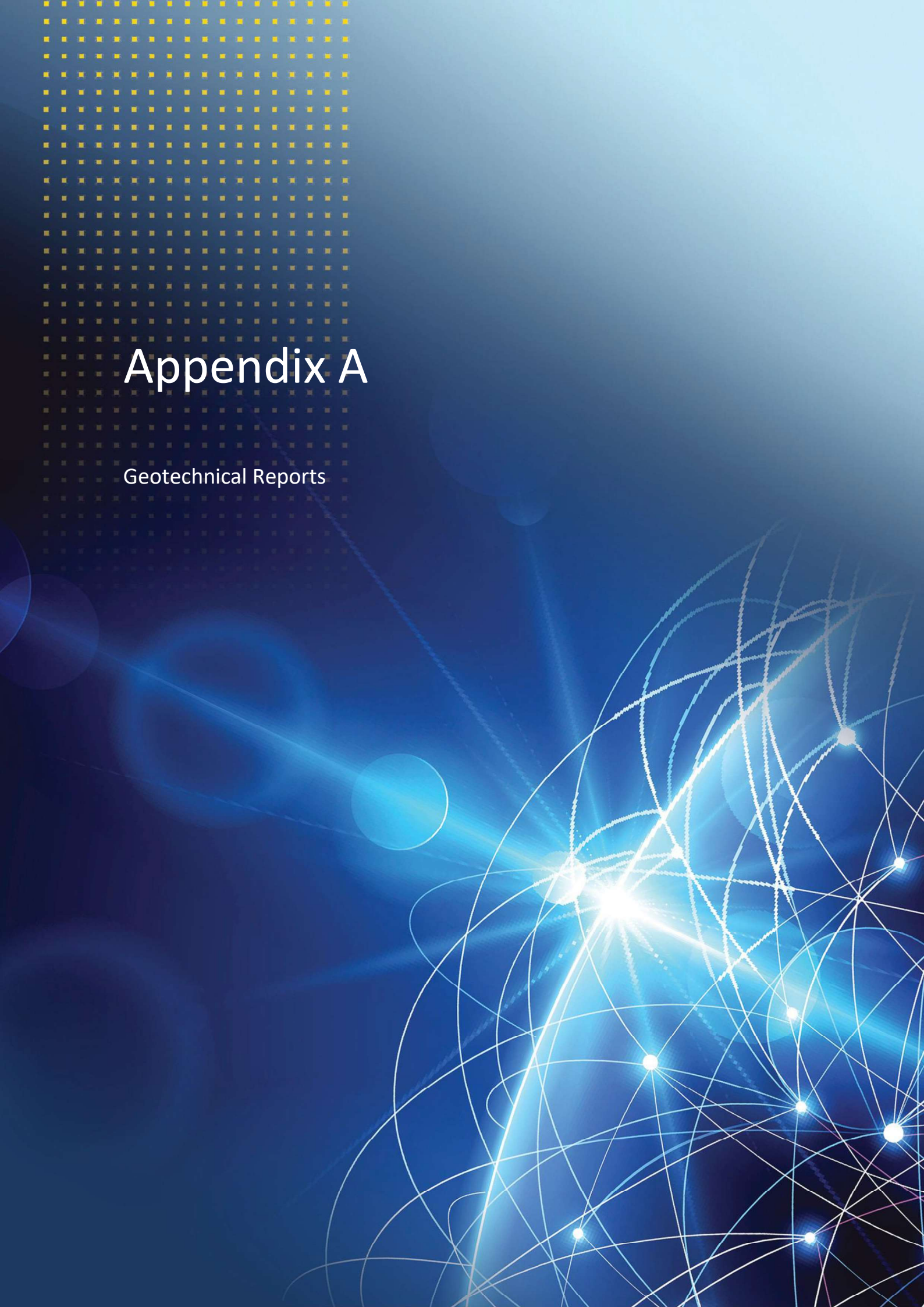
The Northern Highwall solution has focussed on localised rehabilitation of the existing landform as the area is identified as being relatively stable (Houghton 2020 and SCRS 2020) and adjacent areas have previously been rehabilitated. Therefore, the selected solution was to not disturb these areas. This solution was reached following reports from both geotechnical and erosion consultants and the identification of appropriate surface treatments to be installed as part of proposed rehabilitation and maintenance works.

The solution for the Eastern Drain is to pick up run-off from its eastern and northern sub-catchments and, using modification to existing and former creek and flow paths, discharge through the pool adjacent to the old ROM pad at the Rosewood-Marburg Road. Though there is a significant amount of bulk earthworks, the alignment still had a number of relatively steep areas. The potential run-off velocities in the peak storms would have potentially caused erosion within the drains if no protection measures were included. Therefore, a combination of rock pitching and soil erosion protection mats have been included at key locations in the design to mitigate this issue. No earthworks had been undertaken on the Eastern Drain area at the time of preparing this report.

The Normanton Pit area included of a sheer cliff face and a number of spoil areas at the southern end of the site. The solution was to fill in the pit and create gentle slopes with water runoff management using berm drains and armoured chute drains. The infill material was sourced from the existing stockpile material at the southern end of the site to create a balanced design. The bulk earthworks had already been completed for this element at the time of preparing this report but the drains and rock pitching are still to be developed on site. KBR understands that this will be undertaken during the maintenance period.

In summary, this report has described a potential solution for the client in each of the three main areas identified for rehabilitation in the Palaris report (2014). KBR believes these solutions will enable New Hope Group to achieve long term erosion control and stability of each of these sites. The solutions have been developed in consultation with the client to suit the client's program and budget. KBR recommends that consultation be undertaken with relevant Government Agencies in order to obtain their feedback on the proposed approaches.

New Hope Group have indicated that they will be proceeding on the basis of the information and reports currently available and plan to engage with the relevant Agencies once vegetation is adequately re-established. New Hope Group also plan to address and manage any issues that arise during the maintenance period.



Appendix A

Geotechnical Reports

MEMO

Date: 4 February 2020

Ref: 40004 / 4087-1

To: New Hope Group West Moreton Operations
Attention: Brad O'Reilly
Copy: Jim Thornton

From: John Simmons

Subject: **NEW OAKLEIGH NORTH CUT HIGHWALL
GEOTECHNICAL STABILITY REVIEW**

1. Introduction and Scope

Final post-mining landform and rehabilitation works are being undertaken for the New Oakleigh Colliery North Cut area located a few km to the north of Rosewood. **Figure 1** is an overall view of the North Cut site, with imagery from mid-2019 when capping of the tailings dam was in progress. Marked on this figure are the extent of the more detailed aerial view in **Figure 2** and the location and direction of view of the oblique view in **Figure 3**.

West Moreton Operations (WMO) commissioned civil design works for a final landform for the highwall. A geotechnical assessment (the "original assessment") was carried out by others to provide slope design parameters to satisfy the long-term stability criterion of a minimum computed Factor of Safety (FOS) of at least 1.5. For the current slope profile, the adopted geotechnical shear strength parameters resulted in FOS outcomes that did not meet the stability criterion.

John Simmons of Sherwood Geotechnical and Research Services (SGRS) was requested to review the geotechnical assessment, which appeared to be inconsistent with the observed condition of the slope and with long-term experience of stability for similar slopes involving the same sequence of coal measures rocks. This report provides the findings and recommendations of the SGRS review.

2. Findings and Recommendations

Shear strength parameters for the original assessment are considered by SGRS to be unrealistically low for the site materials. SGRS has not sighted the full report by others and therefore cannot provide an explanation for why their shear strength parameters are so low.

Based on shear strength parameters adopted by SGRS for geological materials equivalent to those present at the North Cut highwall, SGRS believes that the highwall is adequately stable. Suitable neutralisation and erosion-resisting treatments should be applied to manage risks associated with exposed carbonaceous materials at the current slope inclination.

SGRS has observed the North Cut highwall slope over a period of a few years and has not identified any evidence suggesting geotechnical instability. SGRS undertook stability assessments

for New Oakleigh Colliery Normanton Pit over two decades ago, and has undertaken several stability assessments for Jeebropilly Washplant and 7186 Pits since 2012. With this review report, SGRS has provided tabulations of recommended shear strength parameters for geological materials equivalent to those present at the North Cut highwall.

3. Information Reviewed

SGRS was provided with copies of email correspondence, proposed batter-flattening earthworks, and geotechnical stability assessment outcomes. This information was prepared for WMO by others, and SGRS was not provided with full details of investigations which contributed to the geotechnical stability assessment by others.

4. Methodology

The original assessment was based on a nominal highwall section. For the current slope condition, and considering long-term (drained) shear strength parameters, **Figure 4** shows an example of an original assessment critical potential instability mechanism involving sliding on a weak bedding-parallel tuffaceous clay band. SGRS adopted this nominal highwall section, which includes modelled geological layers, and applied shear strength parameters that SGRS has adopted for Jurassic coal measures rocks and related spoil materials at WMO sites.

All stability analyses, for the original assessment and the SGRS review, were carried out using 2D limit equilibrium methods based on vertical slices. The original assessment was carried out using the SLOPE/W code, with groundwater pressures calculated using an adopted phreatic surface, but with the analytical method not described. SGRS used the SLIDE code, with an adopted phreatic surface, and using the Spencer method for potential circular arc mechanisms and the GLE/Morgenstern-Price method for potential non-circular sliding. Both methodologies are considered by SGRS to be suitable and reliable for the analyses undertaken.

5. Stability Assessment

North Cut mining accessed coals of the Upper Jurassic Walloon Coal Measures. Stratigraphy comprises channel sandstones, finer-grained floodplain sediments, and mire facies comprising coals, carbonaceous siltstones, and some bentonite bands (Refs.1,2).

Unlike for the Permian coal measures rocks of central Queensland, there is no prevailing industry-wide consensus regarding shear strength parameters for the Jurassic Walloon Coal Measures. Over a period from the later 1980's to the mid 2000's Boyd Mining Services developed a set of shear strength parameters that were well proven in practice for Ebenezer and for WMO, and applied successfully by SGRS to New Oakleigh Normanton Pit. Shear strength and permeability parameters were further refined by SGRS by backanalysis of pit slope instabilities in 7186 and Washplant Pits (Refs.3-8).

The shear strength parameters tabulated in **Figure 4** are much lower than WMO parameters recognised by SGRS, and are considered to be unrealistically low given the observed condition of the rock materials exposed in **Figure 2** and **Figure 3**. For many of the materials described as rocks, the listed shear strengths are lower than the listed shear strengths for soil materials. Other analysis results, for undrained (short-term) conditions, utilised SHANSEP or $\Phi=0$ strength models which SGRS considers to be inappropriate for the conditions.

For all of the original assessment outcomes provided to SGRS the groundwater pressures within the slope were apparently (evidenced only from the graphics) modelled by a horizontal phreatic surface at the toe level of the slope. SGRS considers this to be unrealistic.

The geometry of **Figure 4** was scanned by SGRS and remodelled using a selection of material layers that SGRS considers reasonable for WMO materials generally and specifically the North Cut highwall. SGRS groundwater pressures were modelled using a phreatic surface commencing at ground level in the spoil at the slope toe and then rising to follow a contour about 15m below current ground surface. This is a guesstimate but considered to be reasonably cautious based on prior Normanton and Washplant conditions.

SGRS Check analyses were carried out for two potential mechanisms:

- (1) Circular arc sliding with stability controlled by rock mass strength: the minimum computed FOS was 2.15 within the spoil backfill in the lower part of the slope, and the minimum computed FOS was 2.28 for the highwall overall. **Figure 5** shows the SGRS analysis outcome and lists the applicable shear strength parameters on which it was based.
- (2) Block sliding along a weak tuffaceous clay band was also considered. In addition to the slope phreatic surface, potential tension cracking to a depth of 5m was also considered. For the tension crack completely filled with runoff water, an extreme case, the minimum computed FOS was 1.83 as shown in **Figure 6** along with the list of applicable shear strength parameters on which it was based.

6. Conclusions

The SGRS check calculations demonstrate acceptable highwall slope stability for the current geometry. SGRS did not carry out check calculations for other slope profile conditions because they were considered unnecessary and would not change the outcome in terms of acceptability.

Based on the above check calculations, no stabilisation of the highwall is required to achieve long-term slope profile stability. Suitable neutralisation and erosion-resisting treatments should be applied to manage risks associated with exposed carbonaceous materials at the current slope inclination.

Please contact me to discuss any aspect of this report in further detail.

Best wishes



John V Simmons
BE MSc PhD MIEAust CPEng NER RPEQ
Principal

Sherwood Geotechnical and Research Services

Appended: *References*
Figures 1 – 6

References

- (1) Fielding C R, 1993. The Middle Jurassic Walloon Coal Measures in the type area, the Rosewood-Walloon Coalfield, SE Queensland. Australian Coal Geology, Volume 9, pp 4-15.
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- (3) Sherwood Geotechnical and Research Services. 7186 Pit East Endwall Initial Geotechnical Recommendations. Memo to New Hope Group West Moreton Operations, Ref. 32031 / 259, 25 April 2012.
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- (5) Sherwood Geotechnical and Research Services. 7186 Pit East Endwall Geotech Recommendations Part (C): Option of Full Cutback to Old Void (D4) Floor. Memo to New Hope Group West Moreton Operations, Ref. 32031 / 337, 23 May 2012.
- (6) Sherwood Geotechnical and Research Services. Washplant Pit Strip 26 Spoil Cutback Wall Slump Updated Assessment and Treatment Recommendations. Memo to New Hope Group West Moreton Operations, Ref. 36004 / 187-1, 2 April 2016.
- (7) Sherwood Geotechnical and Research Services. Washplant Pit South Endwall Strip 26 Cutback Geotechnical Stability Assessment Update & Recommendations. Memo to New Hope Group West Moreton Operations, Ref. 38004 / 7584-1, 26 September 2018.
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Figure 1 New Oakleigh North Cut overall aerial view of site with inset showing exposed highwall strata [QldGlobe imagery, accessed 3/02/2020]



Figure 2 New Oakleigh North Cut exposed highwall strata aerial view [QldGlobe imagery, accessed 3/02/2020]



Figure 3 North Cut exposed strata on old highwall, viewed towards east-southeast

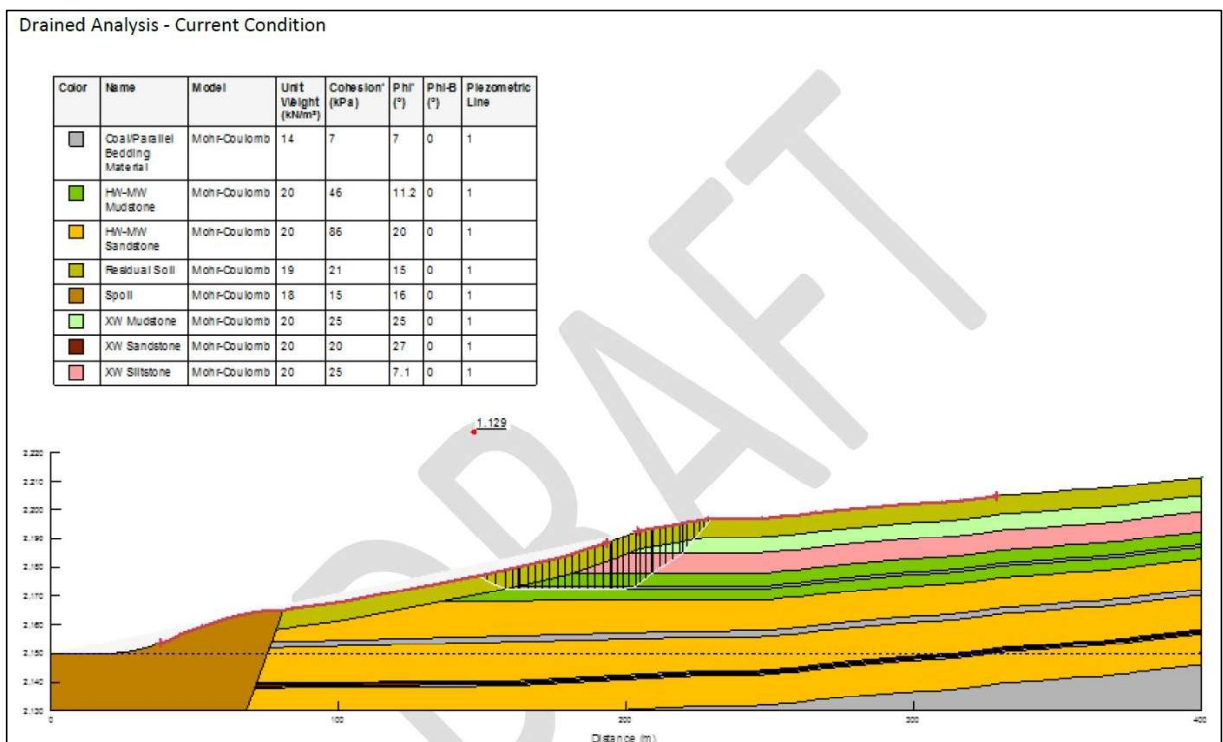


Figure 4 Example current highwall profile stability analysis provided for review with tabulation of shear strength parameters for drained strength mobilisation condition

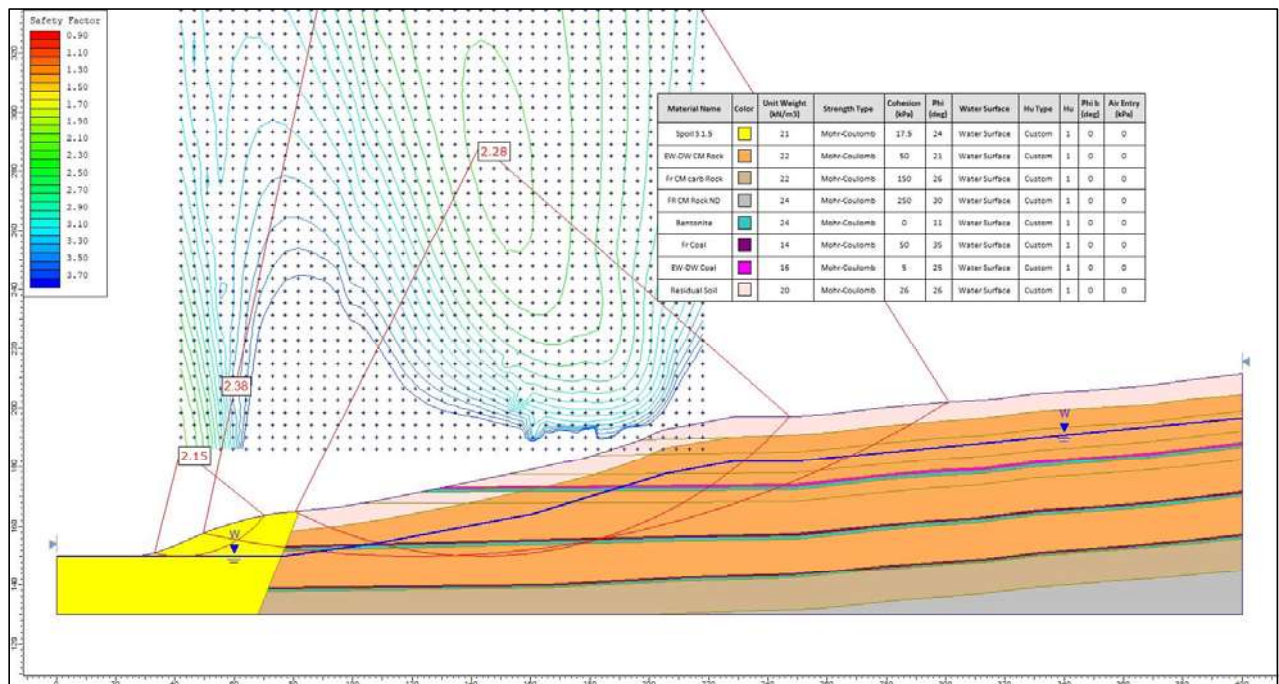


Figure 5 Adapted current highwall profile analysis for potential rock mass strength-controlled instability, with tabulation of drained strength mobilisation parameters adopted by SGRS for West Moreton Operations

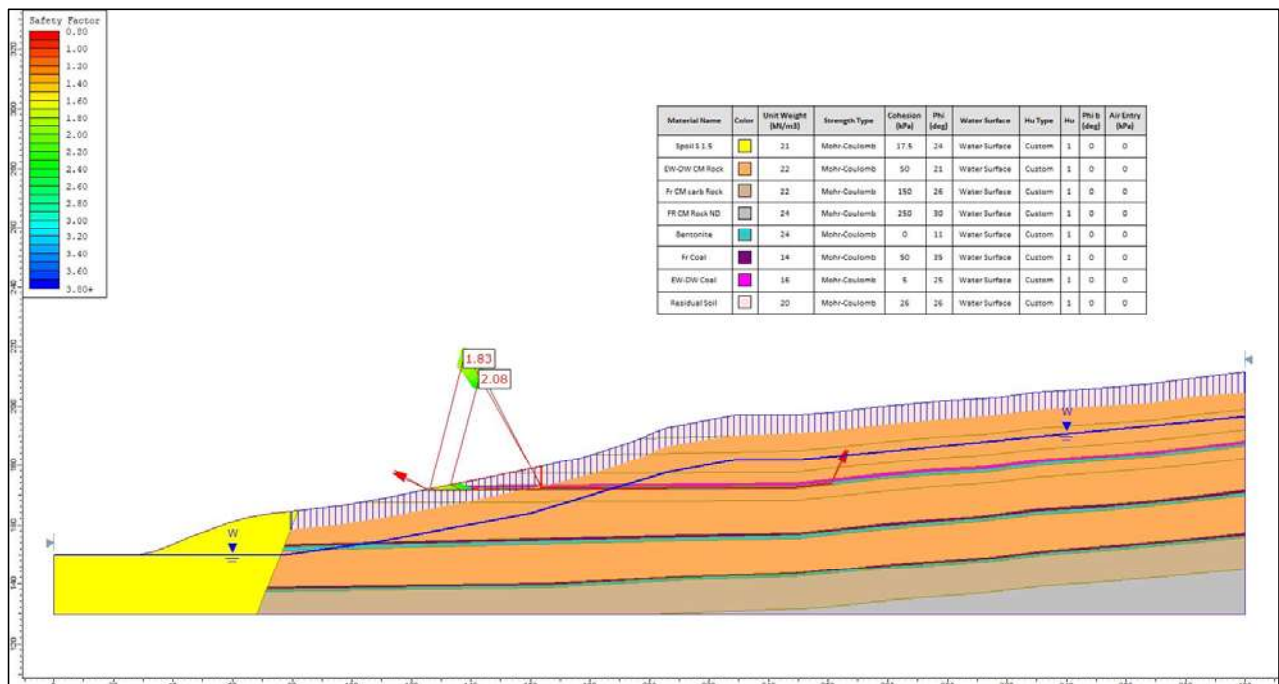


Figure 6 Adapted current highwall profile analysis for potential block sliding instability including water-filled tension crack loading, with tabulation of drained strength mobilisation parameters adopted by SGRS for West Moreton Operations

MEMORANDUM

To: KBR	Date: 07 October 2020
Attn: Steve Fox	KP File Ref.: BR801-00353 EJT M20001 Rev.0)
cc:	From: Ed Tuplin

RE: NEW OAKLEIGH – GEOTECHNICAL REVIEW OF KBR DESIGNS

Knight Piésold Ltd (KP) was engaged by KBR to provide geotechnical input to rehabilitation and closure landform designs for New Oakleigh, specifically with regard to the partially backfilled highwall of the Oakleigh East North Cut (which was subsequently informally referred to as the “Northern Highwall”) and the Normanton Pit. KBR’s design brief included drain structures which KP has provided informal guidance on, although was not specifically part of their scope. This memorandum discusses the findings of KP’s review of KBR’s designs.

1. NORTHERN HIGHWALL

In February 2019 KP were requested to perform initial modelling to assess the stability of the northern highwall. Although never formally reported, the stability results indicated the factors of safety for the current slope condition to be below acceptable levels and, as such additional runs were conducted on a conceptual rehabilitation profile which would involve minor reshaping to form a reduced slope profile and additional buttressing of the toe. The stability outputs were provided in draft form via email to KBR for review/comment, with a recommendation that further investigations be conducted. However, the assessment was not formally concluded by KP.

2. EAST AND NORTH DRAINS

The drainage design was specifically part of KP’s scope of work, however, informal discussions were held regarding appropriate slope angles. KP received a copy of KBR’s drainage layout on 6th July 2020 (Ref. 1) and has conducted a check on the design slope angles, which indicated that cut/fill design slopes were typically in the range of 1V:5H to 1V:7H (approximately 15% to 20%) and drain side slopes set to 1V:5H (18%). However, the bed slopes of the main drains generally follow the natural / existing topography and are, therefore, typically much steeper.

It is understood that the maximum design slope angles were based on an erosion study by KBR and previous work by Landloch. It is KP’s opinion that slope angles which are resistant to erosion would likely be geotechnically stable. In addition, the proposed side slopes are consistent with previous studies conducted by KP for coal mine sites in Queensland using similar construction materials and methods. As such, formal checks on the stability of the drains were not considered to be warranted.

3. NORMANTON PIT

A high level stability review has been conducted for the Normanton Pit backfill design provided by KBR on 22nd July 2020 (Ref. 2). The backfill design comprises a 1V:5.5H typical slope profile with 8 m wide bench drains at a vertical spacing of approximately 10 m to 15 m. The backfill extends up to the crest of the highwall and comprises spoil

reworked from the waste dump to the south of the pit. Previous examination of the spoil by KP during backfilling of the tailings dam adjacent to the Oakleigh East North Cut Highwall ("Northern Highwall") indicated the material to be variable consisting of reworked coal measures strata (i.e. sandstone, mudstone, siltstone and occasional coal). From discussions with New Hope it was understood that the backfill would be traffic compacted during construction but the moisture content would not be modified other than any water added for dust suppression or through rainfall.

An overview of the basis of the stability review and assumptions are as follows:

- The high wall stratigraphy was based on two borehole logs from 1985.
- Weathering details were not recorded in the logs. As such the materials were conservatively assumed to be highly to moderately weathered based on the site visit conducted by KP and photographic record.
- The shear strength of residual soil was based on back analysis of the current highwall condition (i.e. conservatively assuming marginal stability with a factor of safety of 1).
- The strength of in-situ basalt, sandstone and mudstone were based on previous testing by Golder Associates (Ref. 3) and/or using RocLab software.
- Coal and thinly interbedded layers were modelled as a single material type with shear strength parameters derived from back analysis of the current highwall (i.e. conservatively assuming marginal stability with factor of safety of 1).
- The shear strength of the backfill was conservatively estimated based on classification tests on spoil material obtained during a site visit by KP and experience with similar materials.
- The groundwater level was conservatively assumed to be 5 m below ground level (i.e. ground profile prior to backfilling). The groundwater level was not increased following backfilling as it was assumed the drains will be fully (or predominantly) operational and successful in preventing large scale infiltration.

The material parameters adopted for the stability review are provided in Tables 3.1 and 3.2, with the estimated factors of safety provided in Table 3.3.

Table 3.1: Geotechnical Shear Strength Parameters (Static Condition)

Material Type	Y _{sat} (kN/m ³)	C' (kPa)	φ' (°)	Su, min. (kPa)	Su Ratio	Remarks
Residual Soil (Sandy Clay)	19	20	22	15	0.25	Back analysis of stability of current highwall under undrained and drained conditions
HW-MW Basalt	24	120	25	-	-	Calculated using assumed UCS of 20 MPa in RocLab
HW-MW Mudstone	22	35	25	-	-	Calculated using Golder Associates (Ref.5) testing and RocLab
HW-MW Sandstone	22	100	28	-	-	Calculated using Golder Associates (Ref.5) testing and RocLab
Coal / Interbedded Mudstone	17.5	40	24	-	-	Back analysis of stability of current highwall under undrained and drained conditions
Backfill	18.5	16	23	20	0.27	KP estimate / assumed

Table 3.2: Geotechnical Shear Strength Parameters (Post Seismic Condition)

Material Type	Ysat (kN/m ³)	C' (kPa)	φ' (°)	Su, min. (kPa)	Su Ratio	Remarks
Residual Soil (Sandy Clay)	19	-	-	12	0.2	Back analysis of stability of current highwall under undrained and drained conditions
HW-MW Basalt	24	120	25	-	-	Calculated using assumed UCS of 20 MPa in RocLab
HW-MW Mudstone	22	35	25	-	-	Calculated using Golder Associates (Ref.5) testing and RocLab
HW-MW Sandstone	22	100	28	-	-	Calculated using Golder Associates (Ref.5) testing and RocLab
Coal / Interbedded Mudstone	17.5	40	24	-	-	Back analysis of stability of current highwall under undrained and drained conditions
Backfill	18.5	-	-	16	0.216	KP estimate / assumed

Table 3.3: Estimated Factors of Safety

Condition	FoS	Figure
Drained	2.8	3.1
Undrained	1.8	3.2
Post-Seismic	1.4	3.3

As shown in Table 3.3 and Figures 3.1 to 3.3, the backfill design is considered to have acceptable factors of safety under drained, undrained and post seismic conditions. As such, the final landform design is not expected to experience a deep seated failure. However, erosion may occur from overtopping or failure of the drains and minor surface slumping may occur due to variability in the composition and compaction of the surface materials.

We trust the information provided herein is sufficient for your current requirements. However, should you require further details, please do not hesitate to contact the undersigned.

Yours sincerely,

KNIGHT PIÉSOLD PTY LTD



ED TUPLIN

Senior Project Engineer



TIM ROWLES

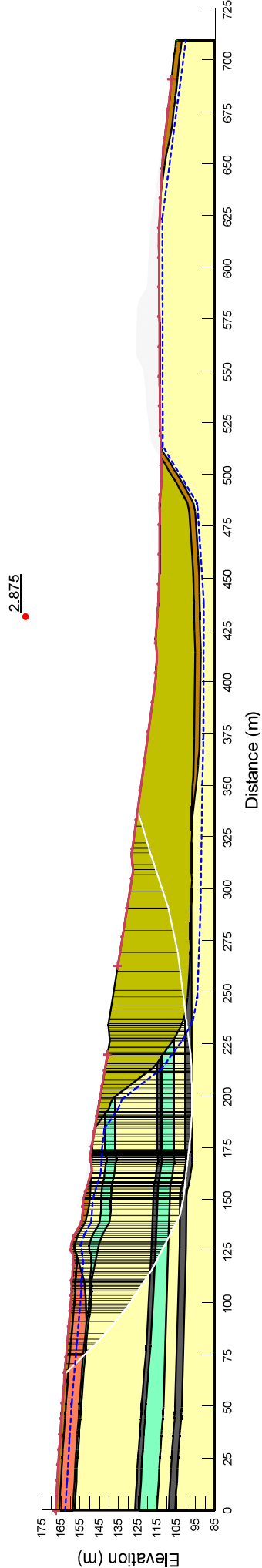
Regional Manager, QLD

REFERENCES

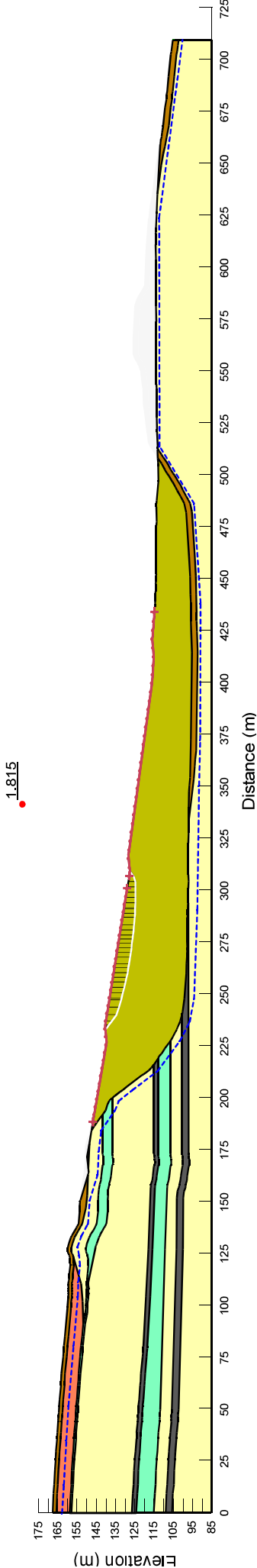
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2. KBR (2020). *"New Oakleigh Coal Mine Rehabilitation Plan, Recovery Pit"*. Issued for Construction 11th November 2019.
3. Golder Associates (2001). *"Oakleigh Coal Project: Geotechnical Evaluation"*. Report ID 01631002(I), September 2001.

FIGURES

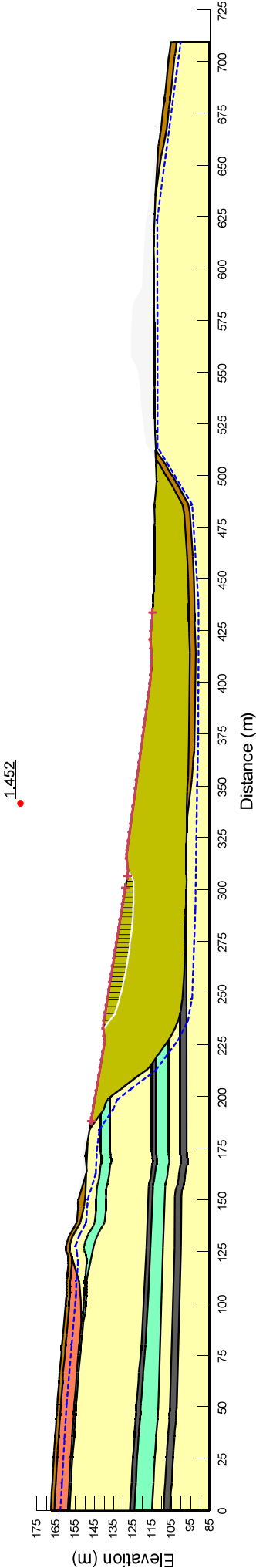
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Backfill Materials	Mohr-Coulomb	18.5	16	23	0	1
	Coal & Interbedded Mudstone	Mohr-Coulomb	17.5	40	24	0	1
	HW-MW Basalt	Mohr-Coulomb	24	120	25	0	1
	HW-MW Mudstone	Mohr-Coulomb	22	35	25	0	1
	HW-MW Sandstone	Mohr-Coulomb	22	100	28	0	1
	Residual Soil (Sandy Clay)	Mohr-Coulomb	19	20	22	0	1

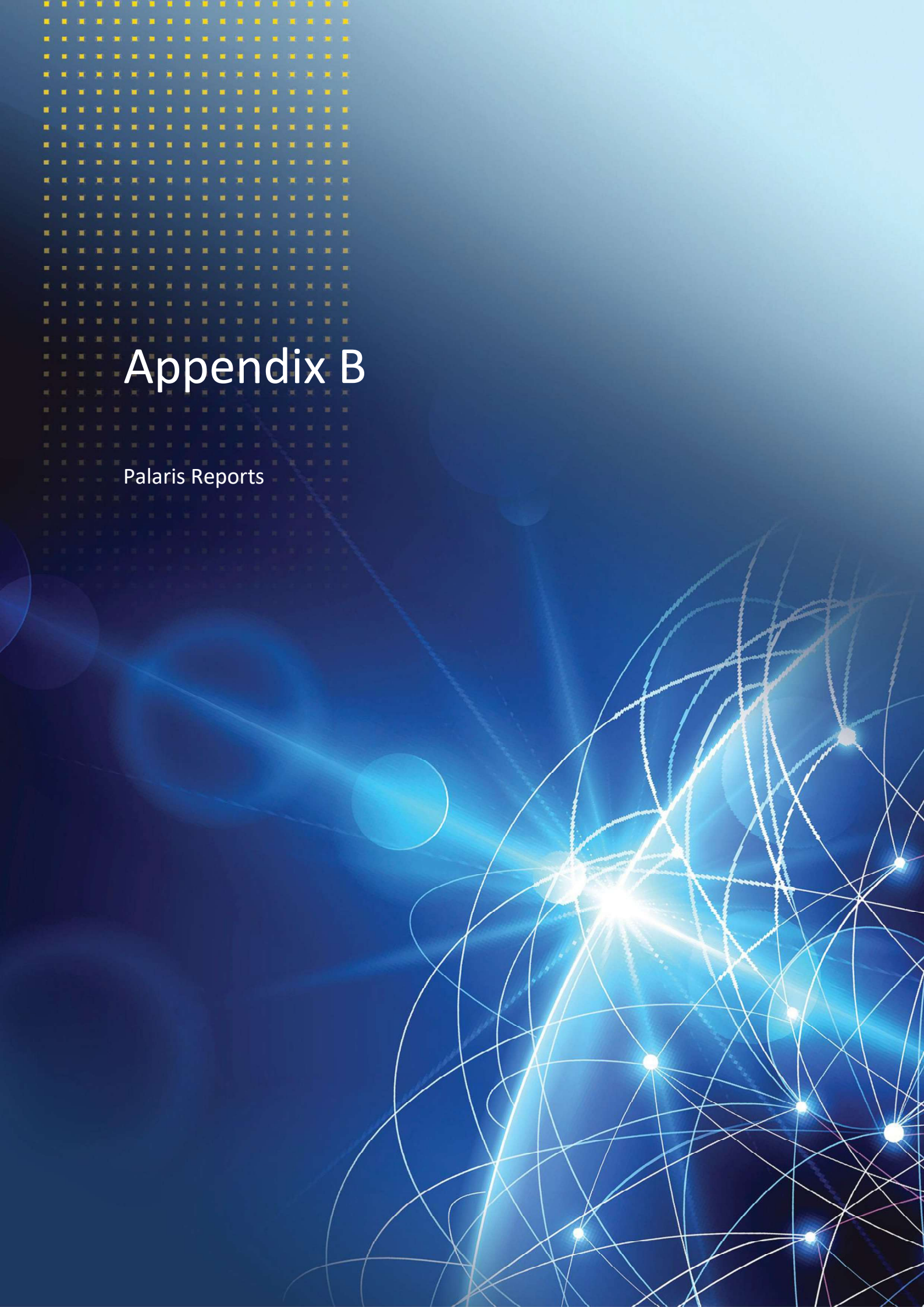


Color	Name	Model	Unit Weight (kN/m ³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Minimum Strength (kPa)	Tau/Sigma Ratio	Piezometric Line
	Backfill Materials	SHANSEP	18.5				20	0.27	1
	Coal & Interbedded Mudstone	Mohr-Coulomb	17.5	40	24	0			1
	HW-MW Basalt	Mohr-Coulomb	24	120	25	0			1
	HW-MW Mudstone	Mohr-Coulomb	22	35	25	0			1
	HW-MW Sandstone	Mohr-Coulomb	22	100	28	0			1
	Residual Soil (Sandy Clay)	SHANSEP	19				15	0.25	1



Color	Name	Model	Unit Weight (kN/m ³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Minimum Strength (kPa)	Tau/Sigma Ratio	Piezometric Line
	Backfill Materials	SHANSEP	18.5				16	0.216	1
	Coal & Interbedded Mudstone	Mohr-Coulomb	17.5	40	24	0			1
	HW-MW Basalt	Mohr-Coulomb	24	120	25	0			1
	HW-MW Mudstone	Mohr-Coulomb	22	35	25	0			1
	HW-MW Sandstone	Mohr-Coulomb	22	100	28	0			1
	Residual Soil (Sandy Clay)	SHANSEP	19				12	0.2	1





Appendix B

Palaris Reports



Report

Rehabilitation Design Report – Normanton Pit

Company	New Hope Group
Site	Normanton Pit, Rosewood
Date	April 2014
Doc No.	NHG1804-02

Report To	Ross Bennett		
Project No.	NHG1804		
Doc No.	NHG1804-021		
Document History	Name	Date	Version
Author	Stuart Macnish Bob Reid Heath Chapman	April 2014	01
Peer Review By	Toby Grogan		
Draft Issued To	Ross Bennett		
Amendments	Stuart Macnish/Anne Schneider	28 March 2014	02
Final Review By	Toby Grogan	2 April 2014	02
Final Issued To	Ross Bennett	4 April 2014	02

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- availability of funding to the operation
- availability and reliability of supporting infrastructure and services
- efficiency considerations
- variations in cost elements
- market conditions and global demand
- industry development
- regulatory and policy changes

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Executive Summary

New Oakleigh Mine consists of three workings, namely Normanton Pit, North Pit and West Pit. All mining has now ceased and the last coal was extracted from West Pit in February 2013. Both Normanton and North Pits have been rehabilitated to varying degrees and West Pit is currently being backfilled and shaped to a final landform. Normanton Pit occupies part of ML4568 (Figure 1.1 MLs constituting the New Oakleigh mine site showing location of Normanton Pit) and was mined in two separate stages – 1973 to 1979 and then 1997 to 2000.

The current landform of Normanton Pit does not achieve acceptable surface water management and the high wall in the north-west of the site remains exposed and unstable. Additional work is required to resolve all aspects related to high wall stability, erosion and runoff management so that the site can be relinquished.

Investigations Undertaken

Two site visits were undertaken, the first in late 2013 to assess the site issues and develop a scope of works that would meet the needs of New Hope Group (NHG) in seeking ultimate relinquishment. The second visit, following agreement on the scope of works, was on 16 January 2014 during which a detailed evaluation was undertaken of the various site constraints to achieving effective water management while working within the defined framework of limited materials availability.

Modelling of Final Landform

A series of model scenarios was run using LiDAR data for the site captured in 2010 and including spot height levels for the beds of the gullies that were not captured in the earlier LiDAR survey. The models were based on achieving the lowest possible grade for the drainage (generally <1% based on experience with similar materials and landscapes elsewhere), removal of all residual voids on the site and sourcing all fill material from the site only.

Following these runs, the preferred model was presented to NHG for approval to proceed to final concept design stage. During the presentation, the following design constraints were agreed.

Outcomes

A final concept design has been prepared with the following features:

- all unprotected stream grades less than 1% wherever possible (based on experiences with similar materials elsewhere) and maximum land slopes at 17% (based on recommendations by Landloch, 2013)
- all backfill material is sourced from site with the exception of materials for the drop structures
- a small self-draining void remains at the out-of-pit dump area (necessary so as not to have a deficit in backfill material)
- a series of gabion (suggested style or similar) weirs/drop structures is required to achieve mean stream grade (gabion fill to be sourced commercially)
- design should have no impact on the powerline across the site
- there is a need to investigate and potentially relocate a telecommunications cable if it is still active

- there is a need to coordinate with Ipswich City Council regarding upgrade of culverts that direct external catchments across Blakes Road onto the site
- coordination is required with the landholder where discharge leaves the site along the western boundary to ensure that the active gully is not subject to increased rates of headcutting from the managed discharge

The final concept design (Figure 4.2 Internal drainage schematic) takes account of NHG's need to minimise expenditure on this pit area where the company has not been involved in mining but has acquired a responsibility to ensure long-term safety and landform stability prior to relinquishment. It also recognises the limited equipment that is likely to be available to carry out the work. The work envisaged involves:

- progressive stripping of the surface to 0.3 m depth (difficulty of maintaining accurate stripping depth is accepted) on currently rehabilitated areas that will need to be disturbed and stockpiling this for reuse as 'topsoil' when landforming is complete or immediately using it on reformed areas
- salvaging the underlying material to a depth of approximately 1 m on currently rehabilitated areas wherever practical for reuse as subsoil where landforming is complete
- using doze and/or doze, load and cart techniques to bring material from the east and south, including from the spoil mound in the south of the site, as necessary to complete the proposed landforming to slopes of 17% or less
- re-grading Blakes Gully as a series of flat based, grassed channels on a grade of approximately 1% with a series of six gabion-protected drop structures to carry runoff from the east of the site, including runoff from two gullies from the east of Blakes Road to a shock dam in the approximate centre of the site
- constructing a shock dam in the approximate centre of the site to calm flows emanating from Blakes Gully
- constructing a flat based, grassed overflow channel on a grade of approximately 1% to the north-west from the shock dam into the present pit area after landforming there is complete (this maximises channel length, reducing the need for additional drop structures)
- constructing a gabion mattress-protected section of higher grade channel from the north-west, downstream end of the channel above, to the south-south-east towards a grassed channel on a grade of approximately 1% to the top of two gabion-protected drop structures
- constructing two gabion-protected drop structures to bring the main drainage channel to the approximate level of the current flow discharge from the site where flows from the borrow area in the south will intersect the main drain
- constructing a broad based, low gradient channel from the foot of the drop structures to the site boundary to a level crest discharge
- covering the reformed land surface with subsoil material stripped from the 0.3 to 1 m zone of currently rehabilitated areas or using benign spoil (from deeper in the stockpile) as subsoil where it is not practical to reuse subsurface material to approximately 1 m – if all subsoil to 1 m from the currently rehabilitated area is salvaged, depth of subsoil cover could be approximately 0.43 m but minimum depth of subsoil or similar material should be 0.4 m
- contouring all areas of slope greater than approximately 10% that are more than 10 m high

- ripping subsoil material to a depth of at least 0.3 m where required to reduce compaction caused during landforming and smoothing the surface (contour banks not to be ripped) prior to topsoiling
- covering the reformed land surface with topsoil material stripped from the 0 to 0.3 m zone of currently rehabilitated areas – if all topsoil from the currently rehabilitated area is salvaged, depth of topsoil cover could be approximately 0.18 m settled but minimum cover should be 0.2 m in constructed drainage and contour channels and 0.15 m on remaining areas (Note: depth of cover should be actual and not statistically derived)
- fertilising, and ensuring successful establishment of a grass and legume surface cover over all disturbed areas as soon as possible – progressive inputs required where the whole site is not landformed as a single continuous exercise
- maintaining the area by filling any rills or other erosion sites that develop and re-seeding until stable vegetation cover is achieved

Liaison with Ipswich City Council and the landholder to the west of the site will be required to coordinate the handling of incoming and exiting flows.

Implementation of the concept design will involve movement of approximately 1,202,660 bank cubic metres (BCM) of material comprising:

- 51,900 BCM of topsoil material comprising the 0 to 0.3 m zone from under currently rehabilitated areas that are to be disturbed (calculated as 0.3 m depth)
- 121,100 BCM of subsoil material comprising the 0.3 to 1.0 m zone from currently rehabilitated areas that are to be disturbed (calculated as 0.7 m depth)
- 1,029,660 BCM of spoil (or underlying rock depending on depth of spoil in the mound to the south of the site, part of which is an out-of-pit dump)

The total area to be disturbed by the rehabilitation works (as opposed to the total area disturbed by the earlier mining activity) is approximately 27.6 ha comprising approximately 17.3 ha of currently rehabilitated land and 10.3 ha of abandoned pit and associated areas.

This report presents the findings of the investigation and a concept design to manage the surface water runoff from the site in a safe and sustainable manner. The designs provided should not be used for construction as more detailed design is required, particularly for the drop structures and the shock dam.

1 Introduction

New Oakleigh Mine consists of three workings; namely Normanton Pit, North Pit and West Pit. All mining has now ceased and the last coal was extracted from West Pit in February 2013. Both Normanton and North Pits have been rehabilitated to varying degrees and West Pit is currently being backfilled and shaped to a final landform. Normanton Pit occupies part of ML4568 (Figure 1.1) and was mined in two separate stages – 1973 to 1979 and then 1997 to 2000. The mining to the east of Blakes Road was all underground. This area has long since ceased operation and does not constitute any part of the proposed rehabilitation program for Normanton Pit.

The current landform of Normanton Pit does not achieve acceptable surface water management and the high walls in the north-west of the site are still exposed and unstable. Early proposals for developing a final landform and effective drainage management do not fully address all risks. Additional work is required to resolve all aspects related to erosion and runoff management so that the site can be relinquished. Palaris understands that there are no regulatory conditions pertaining to relinquishment of Normanton Pit attached to the Environmental Authority for the site. Nevertheless, New Hope Group (NHG) intends to ensure long-term stability of the site and negligible impacts on downstream areas prior to seeking relinquishment.

Palaris was commissioned to finalise a scope of works and develop a concept final landform design to progress planning for effective rehabilitation of the Normanton Pit.

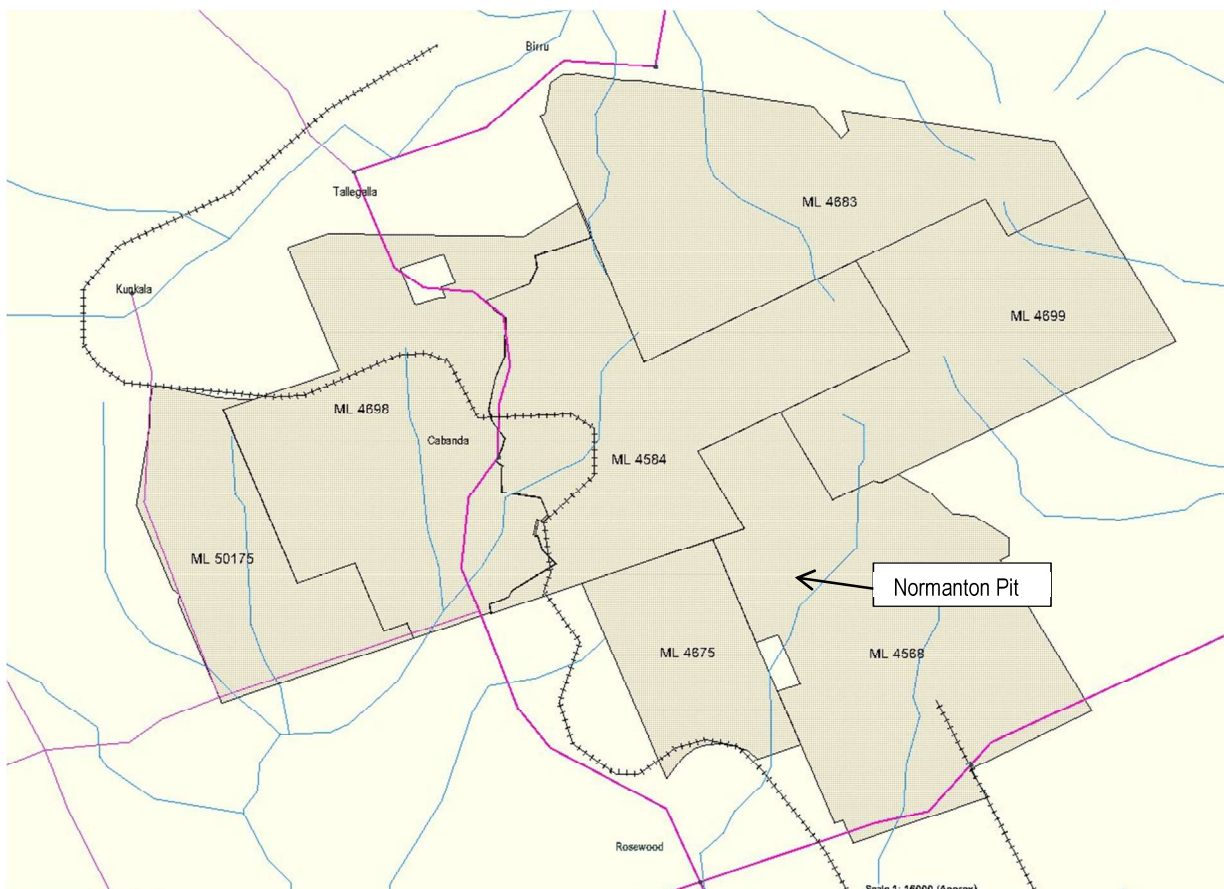


Figure 1.1 MLs constituting the New Oakleigh mine site showing location of Normanton Pit

1.1 Objectives

The principal objective of the study is to develop a concept design for site rehabilitation that will satisfy the regulator and permit ultimate relinquishment of the site. Key aspects to be addressed include:

- stabilising the northern high wall and western end wall of the residual void
- eliminating standing waterbodies within the rehabilitated area and developing a free draining site
- preparing a design that addresses both site-generated runoff as well as accounting for significant inflows to the site from unnamed tributary streams to the east and north-east of Blakes Road

As the final land use is likely to be low intensity grazing, there may be some value in incorporating a small farm dam for stockwater or designing a temporary detention basin to manage high energy runoff from the steeper upper sections of the newly created landform and external catchment.

1.2 Understanding of Scope of Work

There are two main components to the scope of works for the study, namely:

Final landform design

- provide a safe and stable solution for the northern and western high walls (Figure 2.9)
- design a final landform that will meet the needs of the end land use of low intensity grazing
- design a final landform with no standing waterbodies, unless these provide a net positive outcome for the end land use or function as runoff, sediment and erosion management structures
- recommend an effective rehabilitation approach that will achieve a sustainable groundcover and support the desired end land use for the long-term
- ensure that the concept plan produced complies with New Hope Group's closure strategies and is appropriate to satisfy the regulator's expectations

Material sourcing

- estimate the amount of material required to achieve the desired final landform
- identify areas from where suitable materials can be sourced and moved most efficiently within the Normanton Pit as the project does not anticipate having to source fill externally

Consideration will also be given to other issues such as temporary stripping and stockpiling of the existing surface soil and grass cover for re-use in topdressing the rehabilitated area. This material, though not strictly topsoil, appears to be eminently suitable for topdressing as it has accumulated considerable organic matter and seed stock over the last several years from the dense grass and legume cover present. Provided this is only stored for a short period during the landforming activity, it is likely that the seed will remain viable and support a quick recovery of vegetation over the site. To prolong its biological life if longer periods of storage are needed, it should be stockpiled in paddock-dump form, only one dump high.

2 Key Features of the Site

The Normanton Pit section of ML 4568 west of Blakes Road was operated as an open cut until closure in 2000. The earlier underground workings to the east of this area were not intercepted by the open cut operations and do not constitute part of the proposed rehabilitation requirements. The extent of Normanton Pit is shown in Figure 2.1.

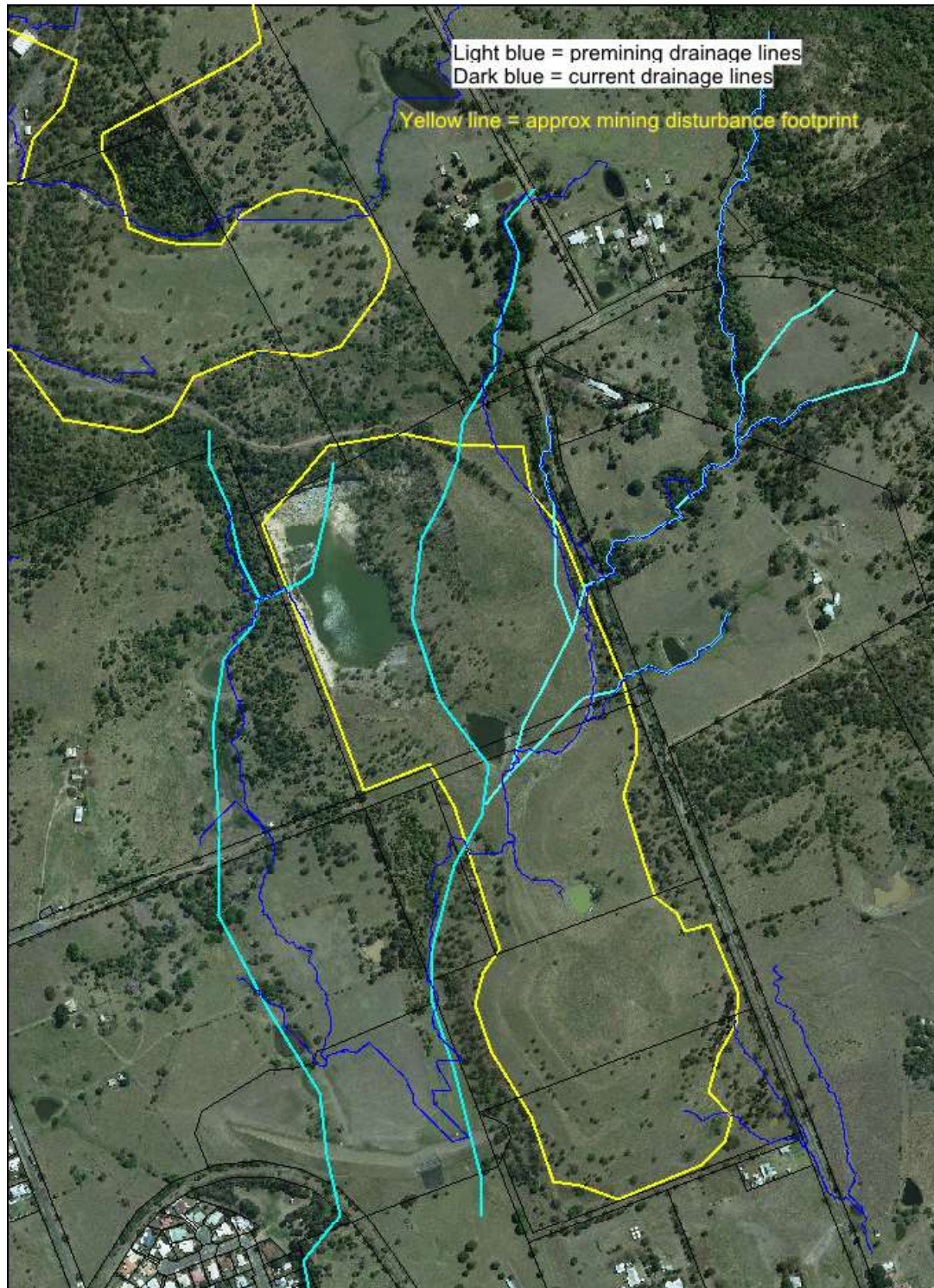


Figure 2.1 Normanton Pit (bottom area outlined in yellow) showing pre and post mining drainage. Residual void is in north-west corner of pit

The pre-mining and post-mining drainage are also shown in Figure 2.1 Normanton Pit (bottom area outlined in yellow) showing pre and post mining drainage. Residual void is in north-west corner of pit. A significant part of the catchment of what eventually becomes Masons Gully that runs through Rosewood township, is external to the Normanton Pit and drains across Blakes Road (road along the eastern side of the mine site) where it discharges into a gully that has formed along the eastern boundary of the mine site. All drainage on the former mine is now artificial and bears no relationship to the pre-mining drainage until it exits the site along the central western boundary at the original discharge point. From this point downstream to the Council-constructed bund wall, the gully is incised and has at least two significant active headcuts. To some extent, past mining and stockpiling now dictate the general drainage layout to be established by this rehabilitation process.

Key features of the site to be addressed in planning the final landform design include:

- a partially backfilled, open cut mine with a residual void in the north-west corner of the ML
- an out-of-pit dump in the south of the ML (extent to which this is an out-of-pit dump is unknown as at least a portion is assumed to be over the original spoil)
- the final void is not self-draining and seasonally holds both site runoff and incident rain
- three waterbodies within the ML, one of which is a small stock water dam on the out-of-pit dump, and the other two appear to be unintentional depressions left following abandonment of the site – none of these waterbodies appear to have been specifically designed/constructed for function
- a small, opportunistic, detention basin along the central western boundary where almost all site drainage ultimately leaves the ML – this storage was not designed or constructed properly and has failed (Figure 2.2 Failed detention dam discharging offsite), generating a significant source of sediment from an expanded catchment due to capturing runoff from the out-of-pit dump as well
- severely gullied artificial drainage lines that do not reflect the pre-existing drainage pattern and receive concentrated flows that have resulted in significant erosion
- a small topsoil dump south of the final void
- the far south-eastern corner, that was not disturbed by mining, drains off-site to the south-east and receives minor runoff from the out-of-pit dump

Gullying along the eastern side of the ML is particularly unstable and is characterised by a series of headcuts (also known as knickpoints (Figure 2.3 Headcut advancing upstream into fill) and intervening deposition sites that are progressively moving sediment downslope. This drainage is incised into fill. For the purposes of this report, this is referred to as Blakes Gully (Figure 2.4). The two confluences with the main drainage lines that cross Blakes Road are seriously unstable with the gully at the confluences >4 m deep (Figure 2.5). There is evidence of the inflows overtopping Blakes Road as the under-capacity culverts are silted up (Figure 2.6) and upstream inlets to the culverts are higher than the road invert. Managing these external catchment inflows (Figure 2.7) is a major component of the final landform planning as shown looking towards Normanton Pit where discharge joins Blakes Gully.

The majority of the site is well-vegetated and good groundcover prevents erosion except in the gullied areas (Figure 2.8). Some minor rilling occurs on the longer and steeper slopes in the north-east.

The Normanton Pit area is presently used for casual cattle grazing under low management inputs. An alternative site will have to be found for these cattle during any works on site and at least

initially during the re-establishment period until sufficient ground cover is restored. Management of the site during rehabilitation to avoid over-grazing and disturbance to the flow paths is discussed later in this report. It is also likely that temporary fencing will be required to protect key vulnerable areas of the rehabilitation during re-establishment of ground cover.



Figure 2.2 Failed detention dam discharging offsite



Figure 2.3 Headcut advancing upstream into fill



Figure 2.4 Blakes Gully looking upstream



Figure 2.5 Confluence of cross-road drainage with Blakes Gully



Figure 2.6 Silted up culvert on Blakes Road



Figure 2.7 Downstream view from Blakes Road of gully confluence with Normanton Pit in background



Figure 2.8 Good groundcover on backfilled area



Figure 2.9 Unstable highwalls in north-western corner of site

At some point, large basalt rocks were placed in the gully, presumably to dissipate energy and avoid the gully enlarging. This has not worked due to the nature of the fill and its highly dispersive qualities. The treatment proposed for this gully relies on stabilised areas where gabion drop structures and mattresses (or similar) are laid over geofabric so that water flows are kept away from the fill in high energy sites and energy dissipation is managed by other means.

3 Site Constraints

3.1 Known Landform Planning Constraints

Planning for the final landform to meet all objectives has required consideration of the following constraints:

- though the boundary of the pit is shown in Figure 2.1, it is uncertain if the spoil dump in the south of the site is all an out-of-pit dump or is partially lying over the backfilled void – this becomes an issue when sourcing spoil for shaping the final landform as it may require excavation of *in situ* material
- it is unknown exactly what the nature of the spoil is but it is assumed to be highly weathered sandstone and mudstone similar to that currently being worked at West Oakleigh – this should not limit recovery of the spoil for removal and relocation by the limited capacity excavation machinery expected to be available so no constraints have been placed on spoil recovery
- there are a number of large basalt boulders, some around 2 m in long dimension, that are found in Blakes Gully and lying on the surface of the spoil mound – the source of these is unknown and the extent to which similar material may be found within the backfilled area is unknown – these should be incorporated in the fill of the main void as they are too large for use in the gabion baskets and provide no rehabilitation value on the surface (though they may provide some specialist habitat value)
- there is minor to very low potential for buried extraneous materials to be found in the backfill – these should be dealt with as and if they occur
- Dial Before You Dig (DBYD) searches indicate a buried telecommunications cable crossing the site within the internal unopened road easement that also includes two loops that are outside the easement boundaries – it is unclear if this is an active or redundant line as at least some connections shown do not remain (Appendix A).
- a power pole is located in this easement also – the wires appear sufficiently high not to be a hazard to the equipment proposed for the spoil reworking and this alignment will not impact on the proposed landforming to be undertaken though care will be required during earthworks

3.2 Material Characterisation and Handling Characteristics

3.2.1 Background

The Normanton Pit area was evaluated as part of a study of the Oakleigh North, Normanton, and Oakleigh West areas by Landloch (2013) to define key soil characteristics and design rules for reshaping landforms and to develop strategies for effective rehabilitation. The study involved:

- assessing landform stability and revegetation success
- strategic sampling of surface and shallow subsurface materials for laboratory analysis
- subjecting bulk sampled materials to laboratory rainfall simulation and overland flow tests
- measuring *in situ* infiltration under simulated rainfall
- assessing erodibility using the Water Erosion Prediction Project (WEPP) model

- developing landform design rules for final landform design
- using the SIBERIA model to validate the landform design proposed by New Hope's planners (Oakleigh North and Oakleigh West only)
- providing general recommendations on rehabilitation strategies, topsoil management, fertiliser and soil amendments

3.2.2 Surface and subsurface materials

Landloch (2013) sampled surface (0 to 0.1 m) materials at 12 sites across the three pit areas. Subsurface materials were sampled (at approximately 1 m depth unless rock prevented sampling at this depth) at 13 sites including a gully wall and gully floor.

The surface materials from the three mine areas had some similarities and some important attributes were:

- low electrical conductivity and neutral to moderately alkaline pH
- effective cation exchange capacity (ECEC) between 26 and 84 meq/100 g of soil
- calcium as the dominant exchangeable cation (though exchangeable calcium and magnesium were similar at two sites) and exchangeable sodium below 6% (non sodic)
- clay percentages from 27.7 to 34.4%
- total nitrogen levels from 1162 to 6682 mg/kg with two sites noted as 'probably of concern' (Oakleigh North) and two noted as 'definitely of concern' (Oakleigh West)
- available (Colwell) phosphorus from 8.7 to 276 mg/kg with only the lowest level site (Oakleigh North) being noted as 'definitely of concern'
- labile sulfur levels that were noted as 'probably of concern' at most sites and a gypsum application was suggested
- available potassium was adequate at all sites
- available manganese was noted as 'probably of concern' at three sites (one in Normanton).

Some important subsurface material attributes were:

- low electrical conductivity and moderately to very strongly alkaline pH with two sites noted as 'probably of concern' (Normanton) and two as 'definitely of concern' (Oakleigh North)
- effective cation exchange capacity between 25 and 67 meq/100 g
- magnesium as the dominant cation at a number of sites (Oakleigh North and West) with calcium dominant at the others
- exchangeable sodium percentages up to 16.3% and noted as 'probably of concern' at two sites (Oakleigh North) and 'definitely of concern' at six sites (Oakleigh North and West, and both Normanton sites)
- clay percentages from 25.6 to 33.5%, a similar range to the surface materials.

The Oakleigh North and Normanton surface samples had a moderately high ECEC, indicating that a proportion of the soil clay was smectite (swelling) clay, which could result in higher fertility and is often associated with higher erodibility (Landloch, 2013). As ECEC levels are similar in the subsurface materials they almost certainly contain appreciable smectite clay as well.

Landloch note that, overall, it appears most 'soils' have been formed from relatively deep layers of reasonably uniform material placed during initial site rehabilitation. With time and with development

of (largely) vigorous plant growth and accumulating organic matter, there has been some leaching of soluble salts and sodium to depth.

Also, it is apparent that the generally vigorous plant growth with little removal of surface material by grazing animals has resulted in appreciable accumulation of organic matter in the surface few centimetres.

During our inspection of the Normanton Pit area on 16 January 2014, it was noted that plant growth was quite vigorous, with a higher proportion of legumes generally south of the road reserve running generally east/west through the Normanton Pit area. It is likely that, while this may be due to different seeding regimes, surface fertility may be better as a result of higher fertiliser applications and/or greater organic matter accumulation from longer residence time.

There is no information available on the nature and variability of deeper subsurface materials in the Normanton Pit area.

3.2.3 Palaris recommendations for surface and near-surface materials' management

The following recommendations for the handling of near-surface materials where they must be disturbed to restore landforms in the Normanton Pit area have been developed based on characterisation of surface and subsurface materials by Landloch as considered above and on our observations in the field.

- Surface material from rehabilitated areas should be stripped to a depth of approximately 0.3 m and stockpiled separately or, preferably, immediately placed on the surface of an area newly reformed to the planned final land surface. While this material may not be topsoil in the strict sense of the term, it has the attributes of reasonable fertility and a high seed store that justify its preservation and reuse at the final surface. The depth to which it is spread will depend on the ratio of the area from which it must be stripped to the total disturbed area and it appears that an average depth of approximately 0.18 m may be practical. Nevertheless, the minimum adequate depth would be approximately 0.15 m settled depth on the reshaped landform and 0.20 m settled depth in the constructed drainage. If this material cannot be re-used immediately, it should be stockpiled as paddock dumps no more than one dump high to maximise the retention of biological activity.
- The limited data available indicate high available phosphorus in the surface material in the Normanton Pit area. We recommend an application of approximately 30 kg/ha of phosphorus because of likely variability and because the near-surface material analysed will be diluted as a result of stripping to 0.3 m then spreading to a shallower depth. We support the Landloch (2013) recommendation of 1 tonne/ha of gypsum. As well as supplying sulfur, this will have a minor positive impact on surface soil structure.
- The stripped surface material can be supplemented by the material in the long-term stockpile of what is apparently topsoil just south of the present Normanton Pit. The bulk of this material is likely to have lower organic matter, lower biological activity, lower fertility, and poorer structure than newly-stripped surface material. Because of the lower surface area to volume, the seed store in this material will be low. The volume of this material in the stockpile appears to be limited so no account has been taken of it in estimating topsoil availability.

- If it is practical to mix material from the long-term topsoil stockpile with newly-stripped material in an approximately 50:50 ratio, the above recommendations for phosphorus and gypsum should be adequate. If such mixing is not practicable, then we recommend 50 kg/ha of phosphorus, 20 kg/ha of nitrogen and 2 to 3 tonnes/ha of gypsum for the currently stockpiled material based on our assessment of the likely nature of the material.

Note: The nature of the various subsurface materials underlying those parts of the Normanton Pit that have been rehabilitated and are carrying good grass and legume cover is unclear. Landloch (2013) suggest it was, or was part of, relatively thick layers of reasonably uniform material placed during initial site rehabilitation but it is not known whether it was selected as a subsurface material or whether it was unsorted bulk mine spoil.

Material below the surface stripped zone, from approximately 0.3 m to approximately 1 m in successfully rehabilitated areas, should be re-claimed separately and used at similar depths if it can be stripped, transported and placed without the additional handling and costs associated with loading and carting to temporary stockpiles. Where this material cannot be used directly, mine spoil placed below the immediate surface material should have the following attributes:

- pH <9.0
- salinity <4.5 dS/m
- texture - sandy clay loam or finer.

Given that some leaching of salt will occur under rainfall, these specifications should provide adequate soil water availability to support successful rehabilitation. Testing for pH and salinity at the time of removal and re-use should be conducted regularly.

3.2.4 Landform design recommendations based on WEPP modelling (Landloch, 2013)

These recommendations are based largely on the Water Erosion Prediction Program (WEPP) modelling (Landloch, 2013). Additionally, some general recommendations based on Landloch's experience with landform construction are also included.

- With respect to batter gradient, the maximum gradient applied should not exceed 20% slope (11.3 degrees), with 17-18% (9.6 degrees) being preferred.
- With respect to slope height, there is no restriction for the landforms likely to be obtained within the site, as erosion is not greatly responsive to slope length once rills establish.
- It is essential that areas discharging runoff onto batter slopes be avoided, either by avoiding construction of flat-topped landforms, or by installation of perimeter bunding.
- In plan, considerable care should be taken to avoid forming flow-concentrating slopes. As well, all corners formed on landforms should have a radius of curvature no smaller than 100 m

The proposed final landform considers all these recommendations as far as is possible within the constraints of the site.

4 Landform Modelling and Design

Multiple scenarios were run initially to assess the potential for achieving the design objectives without the need to source backfill material from off-site. Initially, it appeared that there would be a significant shortfall in backfill availability if the design objectives were strictly met. As a result, the following design criteria were selected for subsequent modelling:

- all slopes designed to 9° (approximately 17%) in line with the Landloch (2013) study
- all unprotected drains to have grades between 0.5 and 1% (Note: 'Unprotected' means grassed but no geofabric or gabions involved)
- long drains are trapezoidal channels with a base of 10 m minimum
- drop structure drains have minimum base width of channel at 10 m and are protected by gabion (or similar) mattresses

4.1 Modelling Software

The Minex package, developed by Geovia and Dassault Systemes, was used for the following processes to:

- import LiDAR data
- develop three-dimensional surfaces for visualisation and volumetric calculations
- develop three-dimensional drainage and landform models
- export design information to DWG/DXF format

4.2 Drainage System

Six-metre drop structures were used in the Blake's Gully channel design to manage runoff at a suitable grade to reduce risk of erosion. The channel design uses 50 m sections of drainage channel falling at 1% and incorporating 6 m drop structures. Six drop structures are required for the length of channel from the most upslope headcut to below the second and most southerly creek that crosses Blakes Road delivering flows from outside the ML. This includes one drop structure for the inflow channel from Blakes Road. The channel was designed to have a base width of 7 m for this inflow structure.

A 6 m drop structure will require at least 7 m (high) of gabions (or similar structures) for construction. A gabion is required to be keyed on both abutments and into the gully floor into the surrounding fill material to develop a rigid base for the structure to be developed and reduce the risk of flows bypassing the structure. Geofabric is also required on the upstream and abutment sides, as well as under the downstream apron, to prevent the ingress of fines in seepage that will restrict the permeability of the structure and impede its long-term effectiveness (Figure 4.1). This figure does not show the upstream and downstream gabion mattress components of the proposed design. Details on the use of gabions are presented in Appendix B Gabion drop structure information.

4.3 Drop Structure Designs

The drop structures recommended are based on the use of gabions (or similar) rather than mass concrete or other alternatives. This is mainly due to:

- relative ease of construction and cost
- long-term stability
- potential over time to blend in with the environment and become less obtrusive as vegetation establishes without loss of function
- ability to maintain functionality while compensating for differential subsidence
- benefits of permeability to manage hydraulic pressures
- rock for filling baskets readily available from nearby quarries

The gabion designs for the construction of the site drains have been estimated as requiring approximately (**Note:** to be re-estimated following detailed design)

- 315 (2 m x 1 m x 1 m) gabions for drop structures
- 85 (2 m x 1.5 m x 1 m) gabions for drop structures
- 20 (6 m x 2 m x 0.5 m) gabion mattresses for drop structures
- 800 m³ of suitable rip-rap material (approximate size – 0.2 - 0.5 m long dimension) for the drop structures
- 300 m² (estimate) of geofabric for lining gabion baskets and mattresses
- 340 gabion mattresses for internal collecting drain
- 800 – 1,000 m³ rip rap for the gabion mattresses for the long final channel section
- potentially some half pipes to create level spillways at entrance to internal drain and exit point from site as well as for overflows on the contoured reformed slopes

In the absence of a final design it is not possible to provide a realistic estimate of costs. Instead, unit costs are provided in Appendix B Gabion drop structure information along with an overview of the type of structures to be used. Costs are provided for both traditional gabion baskets/mattresses as well as for pre-formed permeable concrete gabions that can be placed directly on site with geofabric backing. No costs are provided for the labour components of construction or earthworks associated with the structures or for necessary rock fill.

Gabion mattresses (or similar) are proposed for both the crest and toe of the drop structures as well as for the long channel (internal drain) from the contour drain to avoid erosion and undermining that may occur behind or underneath the drop structure. Rip-rap material is also required to provide energy dissipation on the abutments and prevent vortex attack of the abutments under high flows in the channel. Additionally, it is essential in constructing all these drainage structures and channels that adequate compaction is achieved and that suitable topsoil is used where unprotected, grassed channels are involved.

A shock dam/detention basin has been incorporated into the channel design as the landform grades are too steep to reduce runoff to suitable velocities in the constrained length of the Blakes Gully channel. Multiple flows from the upper catchment outside of the mine site on the eastern side of Blakes Road also feed into Blake's Gully. These inflows have appreciable overfalls due to the fixed base level of the road inverts and culverts, leading to >4 m falls into the present gully. The shock dam has been incorporated into the water management design to hold peak inflows and allow progressive discharge via the internal drainage structure and ultimately discharge off-site. The shock dam construction will not interfere with the power pole and power lines that suspend over the mining lease but will impact the telecommunications cable (assumed from DBYD report (Appendix A Dial Before You Dig Plans)).

4.4 Contour Banks

Contour banks have been incorporated into the final landform on all major slopes. These will drain surface runoff and direct water to overflow sections of the bank to progressively discharge water to internal drainage structures in a controlled manner. These contour banks have design gradients of 0.5 to 1% and trapezoidal cross-sections with a minimum 5 m base width.

The contour drains at the western boundary along the former western high wall are upturned slightly at the end to prevent discharge out of the channel into the adjacent land. This will ensure that all water is directed into the central collecting channel that drains to the final reach for discharge off-site.

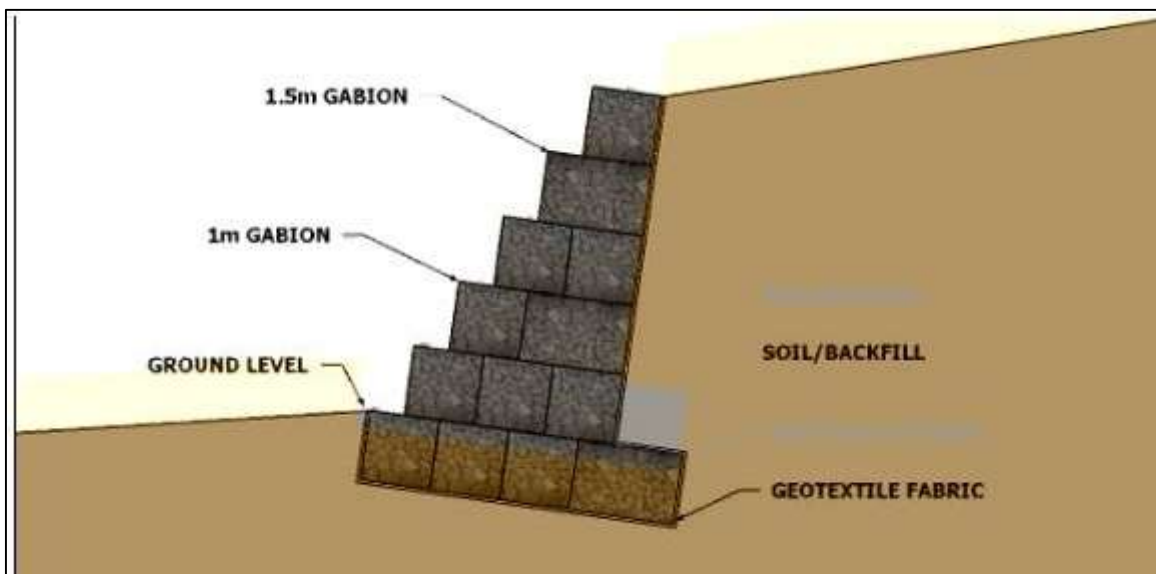


Figure 4.1 Schematic of design of gabion drop structures (not showing upstream and downstream gabion mattresses)

4.5 Internal Drainage Concepts

The layout of the drainage is shown in the concept plan (Figure 4.2). The following section discusses the function of the key reaches of the drainage layout and the way in which it replicates a normal drainage network in terms of stream order. In this instance though, the management of stream power has been achieved by the use of drop structures and grade control as the scheme will be constructed in unconsolidated backfill rather than over *in situ* rock and stream length cannot be extended due to site constrictions.

The major component is the reconfiguration of Blakes Gully (1a, 1b and 1c in Figure 4.2) to an engineered channel (equivalent to Stream Order 2) with broadly trapezoidal channel cross-section and a series of six drop structures (Figure 4.3) Note: drop structure for inflow channel not shown) This channel is to be grassed and, at least until stable flow conditions are achieved, regularly slashed to prevent excessive differential build-up of sediment, and loss of channel capacity and form. Two significant confluences occur due to drainage that rises on private land to the east of Blakes Road and over which NHG has no control (Figure 4.2; 1b and 1c). These streams both

have silted up culverts and inverters that are higher than the Blakes Gully bed. Both have overfalls of approximately 4 m that are very unstable and actively headcutting. Siting of the drop structures in the reconfigured Blakes Gully will account for stabilising these overfalls, though there still remains a need for liaison with Ipswich City Council to deal with the road culvert design to prevent re-initiation of the gully.

The next major drain (Figure 4.4 and 2 in Figure 4.2) is the spillway (contour drain) from the shock dam (this effectively becomes a new Stream Order 1 system). This flows to the north-west (generally) and roughly subtends the main zone of backfilling sloping down from the northern and north-eastern high walls. Maximum slope length on this infilled area from the high wall is 270 m, and this slope length is protected by a series of contour banks that ultimately discharge to the contour drain. This main channel is trapezoidal in cross-section with a 10 m grassed base and higher bund on the downslope side to prevent overflow at times of storm events causing bankfull flows in the channel. The low grade (<1%) is designed to slow water flows to non-erosive velocities before it discharges downslope into the final reach over a constructed drop structure. The small triangular area below this contour drain and downslope of the shock dam (Figure 4.2; 2a) will be filled and formed to drain to the next reach discussed.

The internal drain (Figure 4.5 and 3 in Figure 4.2) that receives flows via the contour drain from the spillway of the shock dam and combined overland flows from the constructed slopes overlying the present residual void is a key collection reach (Stream Order 2), which then discharges via a constructed drop structure to the final reach (north-west channel extremity to upstream of reach 5 in Figure 4.2, Figure 4.5). This drop structure is set at a grade of 2% unlike the near vertical drop structures in Blakes Gully. The channel is lined with gabion mattresses over geofabric, allowing for the management of progressive subsidence without loss of functionality. This reach is approximately 200 m long and 10 m wide and there is a grassed channel at a grade of 1% downstream of the gabion mattress-protected portion. Flows will then pass over two steep gabion-protected drop structures before leaving the site via the final reach (reach 5 in Figure 4.2, Figure 4.5).

The self-draining southern catchment (Figure 4.2; 4) (Stream Order 1) created by removal of spoil (and potentially excavation of unmined land under the out-of-pit dump) will drain at <1% to the north to a confluence with the discharge from the mattress-protected drop structure described above at the start of reach 5. This depression is designed to have slopes of <10% and will also receive flows via a diversion channel from the land above the shock dam on its southern side. The current plan for this borrow area is to leave a small, deeper, central depression that will temporarily hold some water for stock purposes. This may require a constructed grassed spillway to drain to the top of reach 5. The preferred option though is not to create any permanent waterbodies and rather to provide for a cattle trough to which water is piped from a domestic source (or bore) for stockwater supply. This trough can then be established in a site that will not impact the integrity of the constructed drainage and lead to future erosion risk.

The final reach (Reach 5) from the foot of the final drop structure is a grassed drain designed to have a 10 m base width to reduce erosion risk during peak flow. This drain flows at low grade (<1%) to the western boundary where it leaves the mine site. The discharge point to the adjacent land from the pit site will be constructed as a level crest to spread the water at a non-erosive velocity as it leaves the site.

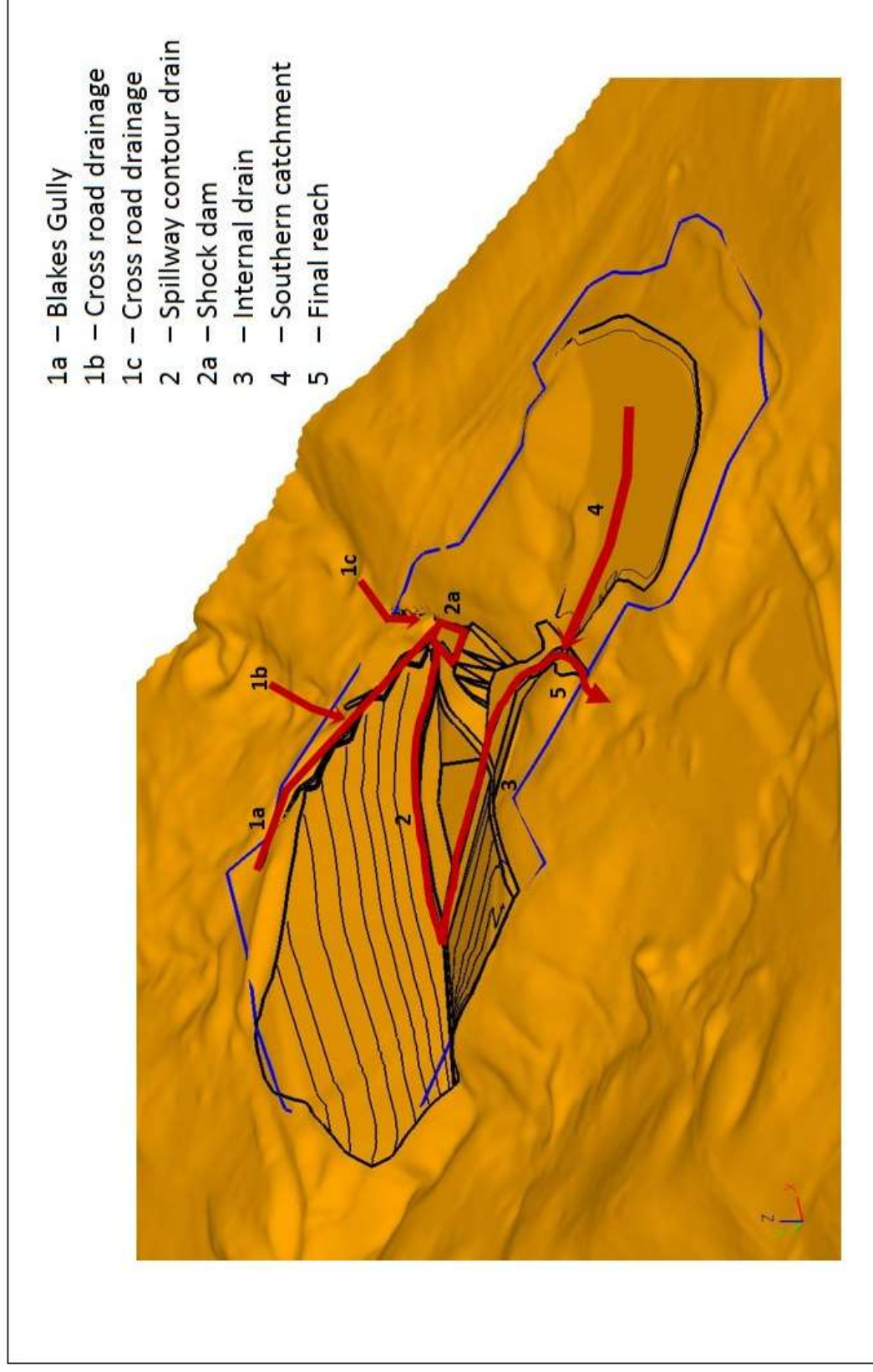


Figure 4.2 Internal drainage schematic

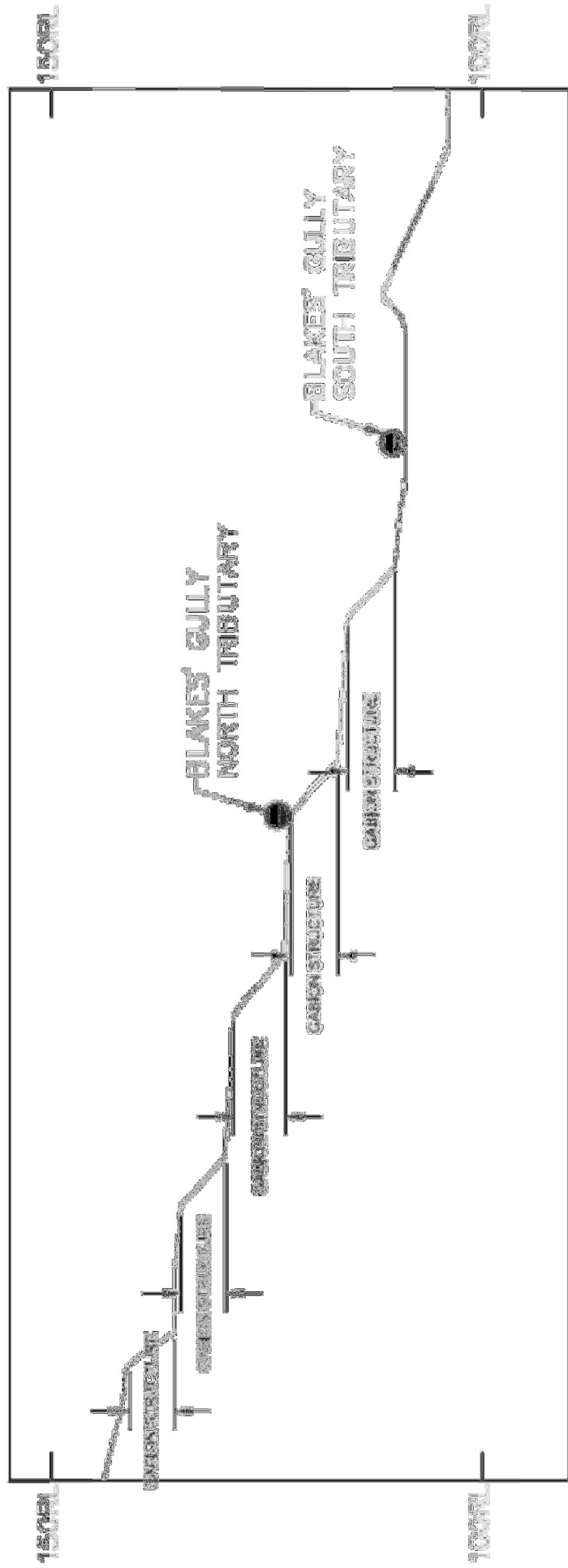


Figure 4.3 Long-section of re-formed Blakes Gully to shock dam

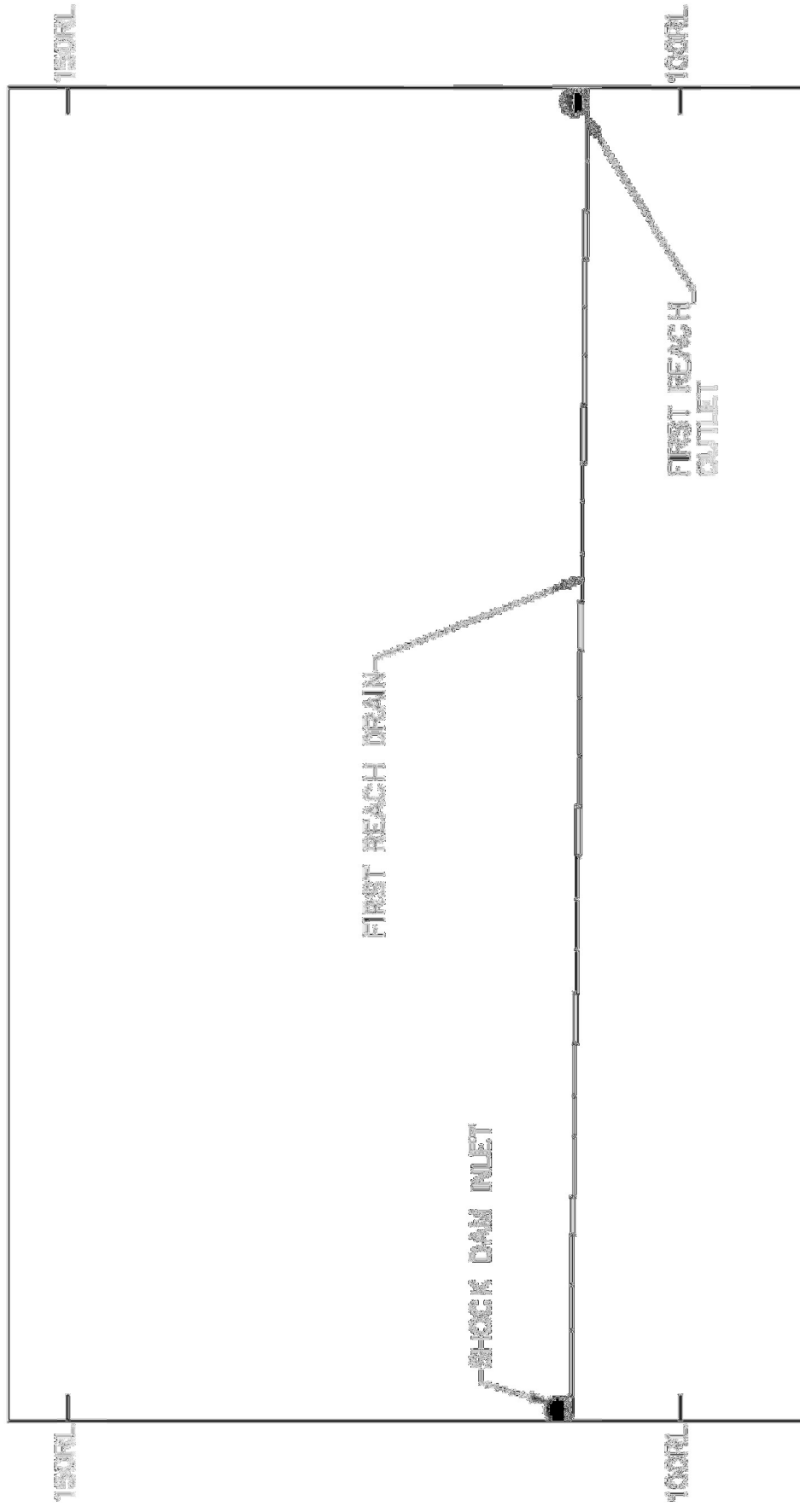


Figure 4.4 Long-section of drainage profile from shock dam to furthest north-west point

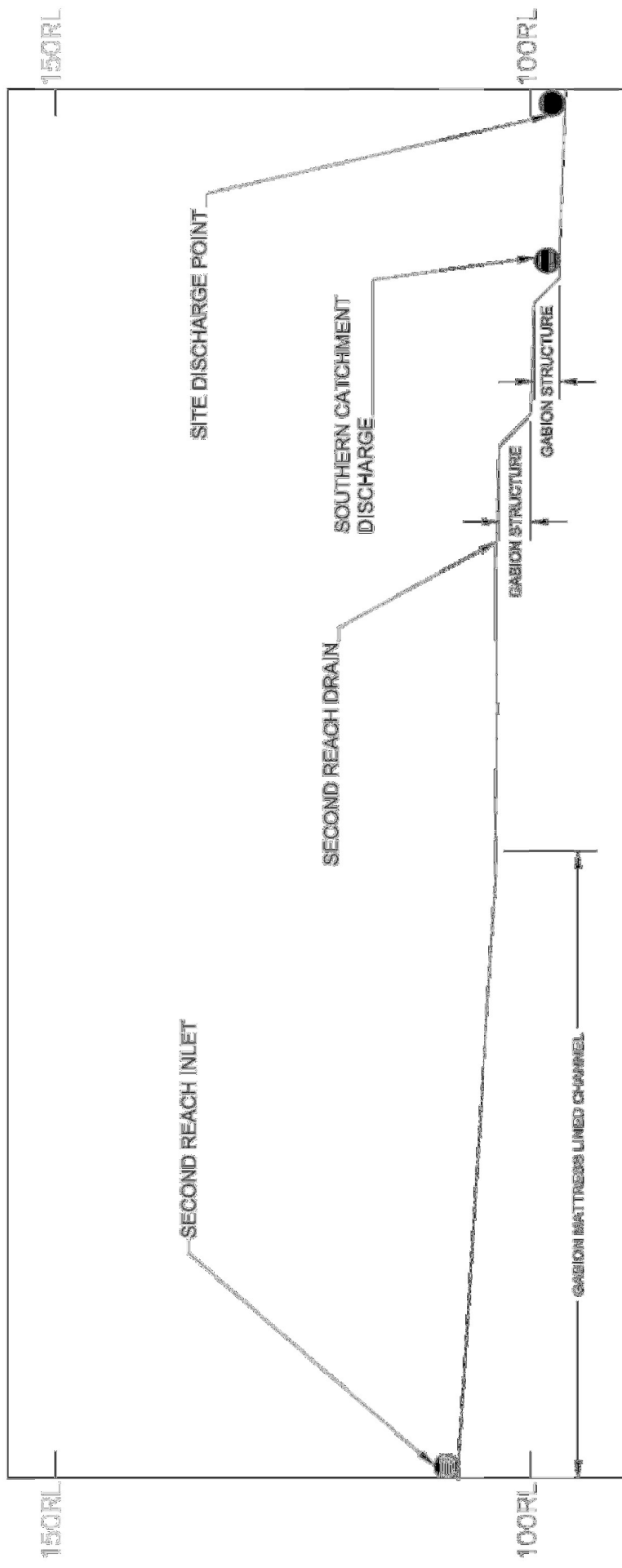


Figure 4.5 Long-section of drainage profile from furthest north-west point

Site inspection shows that this reach of the gully/creek on the neighbouring land (that ultimately becomes Masons Gully) is strongly incised from past events. This will continue to function as a defined channel and will continue to headcut back to the discharge point from the mine site unless treated. Any further headcutting would eventually threaten the integrity of the stormwater management design implemented on the mine site, negating the functionality of the structures and ultimately slope stability. The timeframe over which this would occur cannot be predicted as it is dependent on the time of the year at which landforming is undertaken, timing and frequency of erosive events, the time taken to re-establish effective groundcover and the level of groundcover at the time (e.g. drought conditions perhaps). Further, any lack of channel maintenance and management of riparian vegetation in this reach just upstream of the Council bund but downstream of the point of discharge from the mine site could also compromise the ability of the creek to operate at non-erosive velocities.

Discussions with the landholder and Council are recommended to coordinate efforts in this area to prevent the continuation of instability and active erosion of the channel leading into the bund. This would avoid maintenance costs for the removal of sediment from the bund and the discharge of sediment laden water through the town.

4.6 Landform Features

Key features of the landform proposed under this concept design are illustrated in Figure 4.6 and summarised as follows:

- northern and western highwalls filled to crest, graded to 17% approximately and drained internally across a contoured slope that covers the present final void
- the eastern batter cut back and formed to 17% slope approximately to just west of Blakes Gully and contoured
- Blakes Gully reshaped and six gabion (or similar) drop structures and discharge aprons constructed to reduce grade in this channel to a manageable and non-erosive state
- a shock dam constructed to intercept all flows from Blakes Gully, including flows entering the site from east of Blakes Road, to reduce energy from the steepest part of the internal catchment
- a spillway channel from the shock dam designed to take inflows at <1% grade back to the north-west before discharging south-eastwards via a gabion-lined and grassed drain that terminates with two drop structures in the centre of the pit site
- the area within the current pit that lies in the triangular area between the channels and the shock dam will be filled and shaped to drain directly to the channel segment leading to the last of the drop structures to avoid the need for additional banks and/or structures
- a drain from the southern borrow pit area that discharges at <1% to a point just below the last of these drop structures
- a final reach that discharges all site water into neighbouring land from where it flows to the Council constructed bund and ultimately discharges to Masons Gully

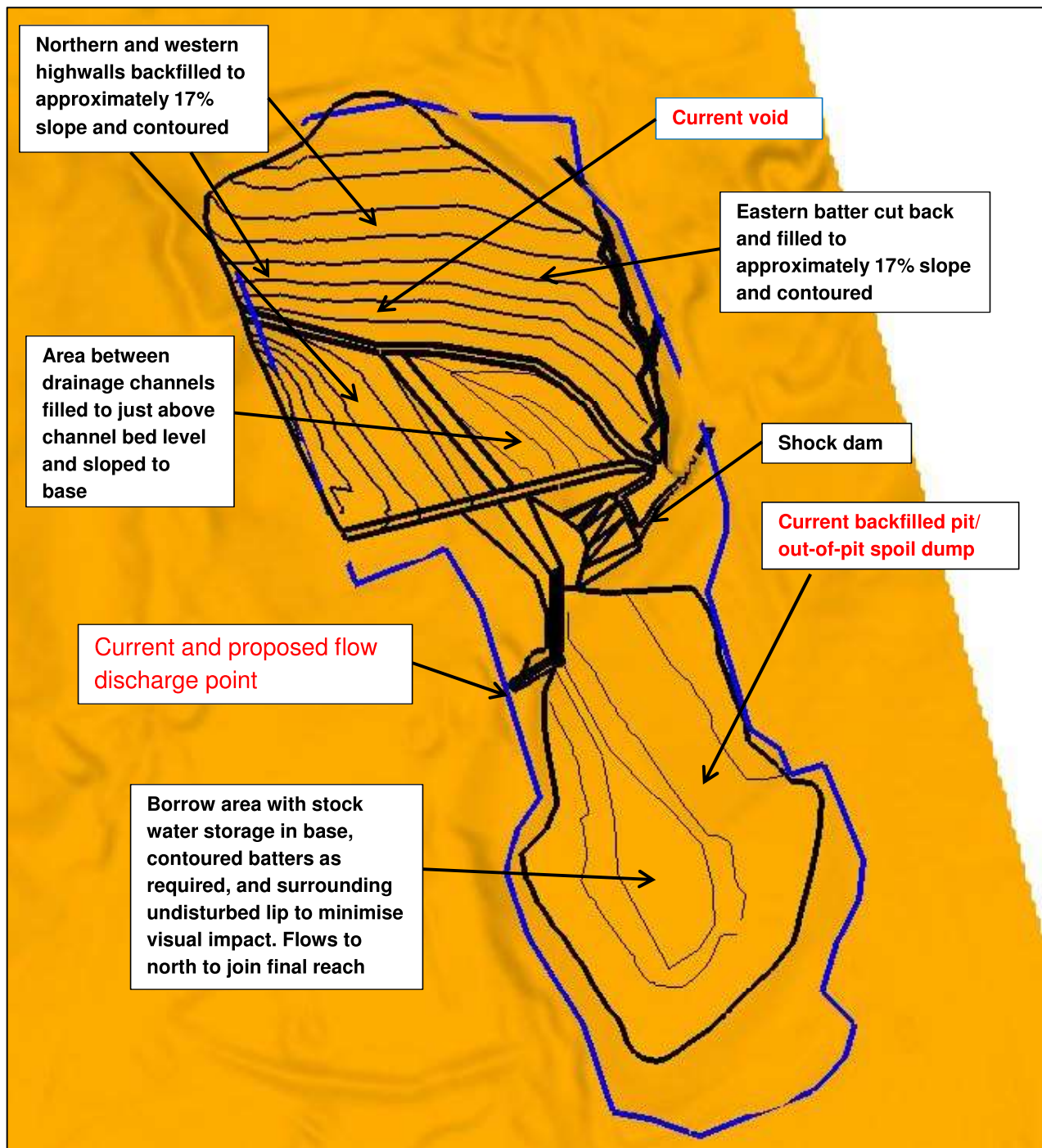


Figure 4.6 Key features of the landform under proposed concept design

4.7 Material Handling

Implementation of the concept design will involve movement of approximately 1,202,660 bank cubic metres (BCM) of material comprising:

- 59,900 BCM of topsoil material comprising the 0 to 0.3 m zone from under currently rehabilitated areas that are to be disturbed (calculated as 0.3 m depth)
- 121,100 BCM of subsoil material comprising the 0.3 to 1.0 m zone from currently rehabilitated areas that are to be disturbed (calculated as 0.7 m depth)
- 1,029,660 BCM of spoil (or underlying rock depending on depth of spoil in the mound to the south of the site part of which is an out-of-pit dump)

The total area to be disturbed by the rehabilitation works is approximately 27.6 ha comprising approximately 17.3 ha of currently rehabilitated land and 10.3 ha of abandoned pit and associated areas (Figure 4.7). This figure is for illustrative purposes only and is not a basis for calculations.

The material is likely to be handled by a combination of dozing, and dozing, loading and carting with some stockpiling of topsoil required. Work along the following lines is likely:

- progressive stripping of the surface 0 to 0.3 m (difficulty of maintaining accurate stripping depth is accepted) on currently rehabilitated areas that will need to be disturbed and stockpiling this for reuse as 'topsoil' when landforming is complete or immediately using it on reformed areas
- salvaging the underlying material to a depth of approximately 1 m (i.e. from 0.3 to 1.0 m depth) on currently rehabilitated areas wherever practical for reuse as subsoil where landforming is complete
- using doze and/or doze, load and cart techniques to bring material from the east and south, including from the spoil mound in the south of the site, as necessary to complete the proposed landforming to slopes of 17% or less
- re-grading Blakes Gully as a series of flat based, grassed channels on a grade of approximately 1% with a series of six gabion-protected drop structures to carry runoff from the east of the site, including runoff from two gullies from the east of Blakes Road to a shock dam in the approximate centre of the site
- constructing a shock dam in the approximate centre of the site to calm flows emanating from Blakes Gully
- constructing a flat based, grassed overflow channel on a grade of approximately 1% to the north-west from the shock dam into the present pit area after landforming there is complete (this maximises channel length, reducing the need for drop structures)
- constructing a gabion mattress-protected section of higher grade channel from the north-west, downstream end of the channel above to the south-south-east towards a grassed channel on a grade of approximately 1% to the top of gabion-protected drop structures
- constructing two gabion-protected drop structures to bring the main drainage channel to the approximate level of the current flow discharge from the site where flows from the borrow area in the south will intersect the main drain
- constructing a broad based, low gradient channel from the foot of the drop structures to the site boundary
- covering the reformed land surface with subsoil material stripped from the 0.3 to 1 m zone of currently rehabilitated areas or using benign spoil as subsoil where it is not practical to reuse subsurface material to approximately 1 m – if all subsoil to 1 m from the currently rehabilitated area is salvaged, depth of subsoil cover could be approximately 0.43 m but minimum depth of subsoil or similar material should be 0.4 m
- contouring all areas of slope greater than approximately 10% that are more than 10 m high
- ripping subsoil material to a depth of at least 0.3 m where required as a result of compaction during landforming and smoothing the surface (contour banks not to be ripped)
- covering the reformed land surface with topsoil material stripped from the 0 to 0.3 m zone of currently rehabilitated areas – if all topsoil from the currently rehabilitated area

is salvaged, depth of topsoil cover could be 0.18 m settled but minimum cover should be 0.2 m in constructed drainage and contour channels and 0.15 m on remaining areas

- fertilising, and ensuring successful establishment of a grass and legume surface cover over all disturbed areas
- maintaining the area by filling any rills or other erosion sites that may develop during the rehabilitation process and re-seeding until stable vegetation cover is achieved

Approximately 800 m³ of rock (125 – 250 mm), preferably basalt for its lasting qualities, will be required for gabion construction and riprap lining of the nominated channel sections. If an alternative to gabions is used such as pre-formed permeable concrete units, then riprap will be required only for the lined channels. The final lined channel would require a further 800 – 1,000 m³ for the gabion mattresses.

An overview of key components of the site redevelopment is provided in Figure 4.8.

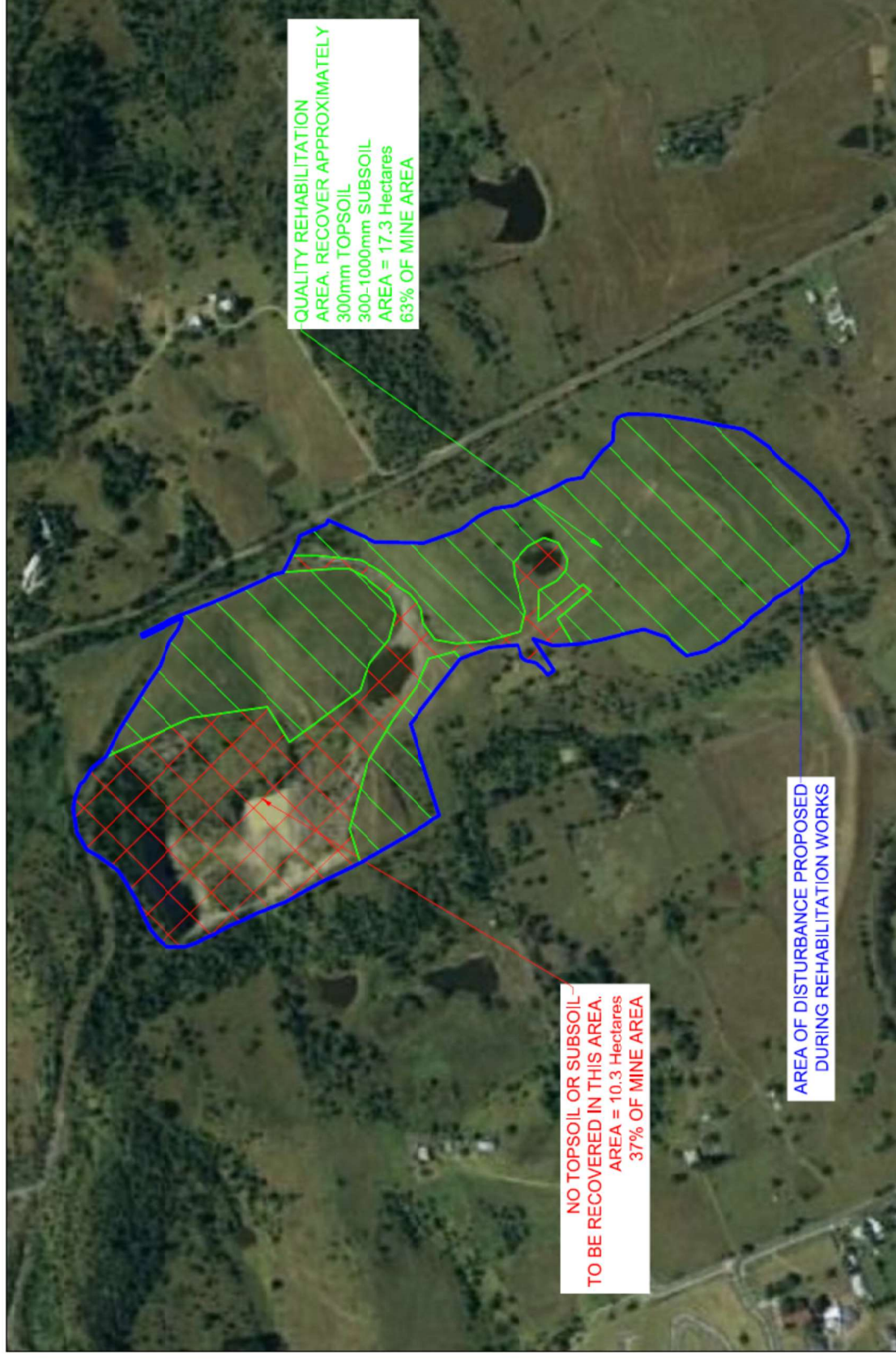


Figure 4.7 Disturbed area that will require rehabilitation and areas where soil material can be sourced

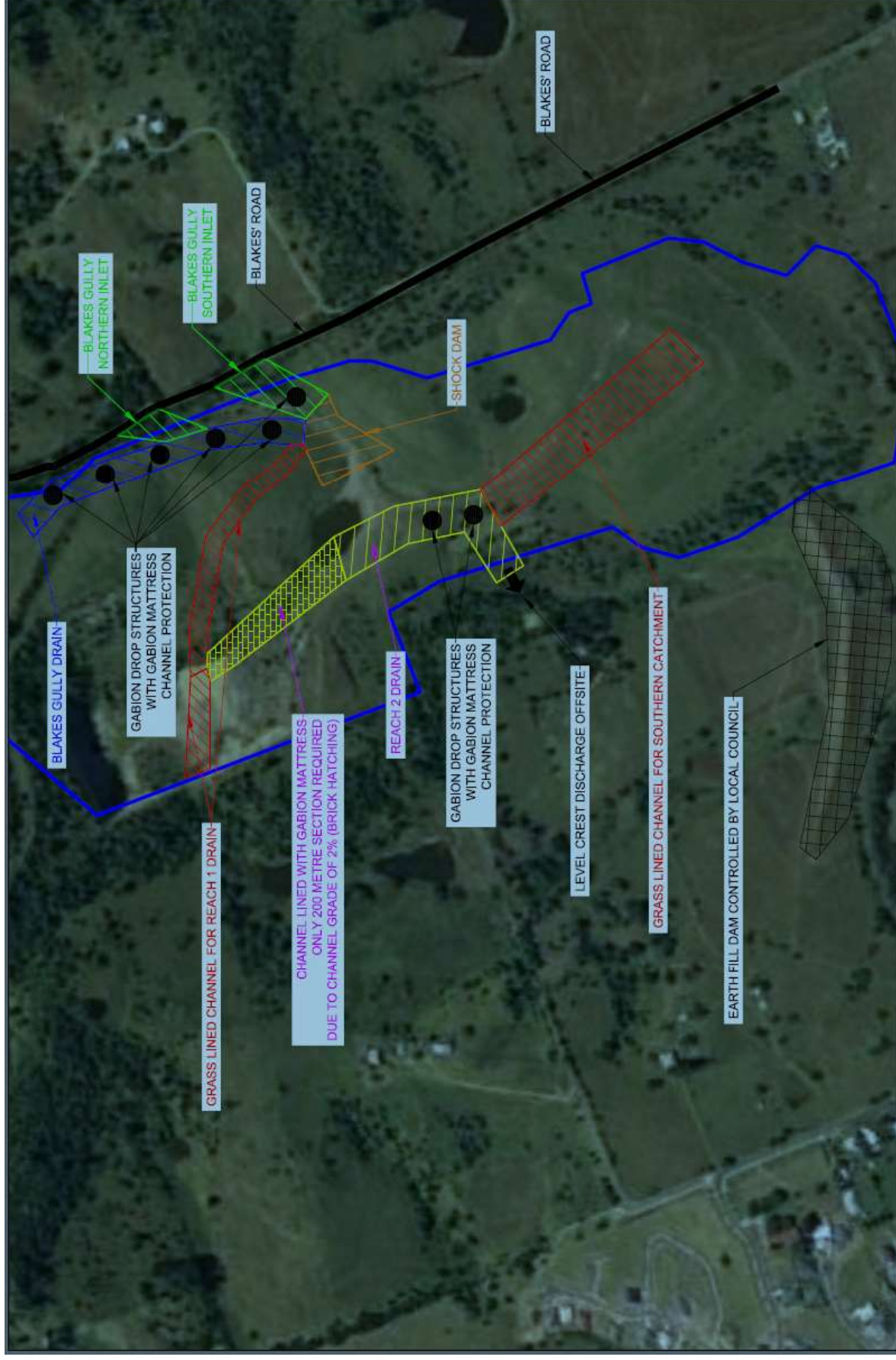


Figure 4.8 Overview of main drainage structures to be implemented (not to scale)

5 Proposed Rehabilitation Measures

5.1 Introduction

The success of the implementation of the proposed landform and drainage system is strongly dependent on achieving effective groundcover as quickly as possible. The construction of the final landform should preferably be undertaken during the Autumn-Winter months so that re-establishment of ground cover can begin and be well established before the likely onset of the heavy storm season in late Spring early Summer. It is likely though that the ideal timing will not be achieved for a range of reasons and a construction erosion and sediment control plan is likely to be required to manage incomplete or staged works.

5.2 Construction Issues

5.2.1 Soil handling

As indicated in Section 3.2.3, the surface 0.2 to 0.3 m of presently grassed areas is a valuable resource for use as topsoil when final landforming, including contour banking, is completed. Options for handling this surface material, from preferred to least preferred, include:

- Stripping, loading, carting, and placing on a re-formed surface immediately (preferred)
- Dozing into temporary stockpiles, loading, carting, and placing on a reformed surface
- Stripping, loading, carting to temporary stockpiles, re-loading, carting, and placing on a reformed surface

Provided that the resultant stockpiles can be re-used on part of the final landform within approximately six weeks of stripping they could remain as dozed or dumped with sediment control as required. Nevertheless, surface soil stockpiles should be restricted to 1.5 to 2.0 m height or paddock dumped and allowed to revegetate naturally if they are likely to remain undisturbed for more than six weeks.

Care will be needed to ensure that this surface material is spread evenly above contour banks on carting and final placement so that flow along the banks is not impeded. Rolling to establish a graded profile may be required. Minimum settled depth of this, or similar, material on the final landform should be 0.18 m.

It is estimated that approximately 17.3 ha of currently rehabilitated land will be disturbed in creating the final landform and that the total area disturbed and requiring revegetation will be approximately 27.6 ha. If the surface 0.2 m of currently rehabilitated land is stripped separately for spreading over the entire disturbed area, it will be possible to use a cover depth of approximately 0.12 m. If the surface 0.3 m is stripped separately, then the cover depth could be approximately 0.18 m. An approximate depth of topsoil stripping of 0.3 m has been assumed.

The Landloch (2013) study found that the subsurface soil material to approximately 1 m is of reasonable utility as a subsurface plant growth medium. As indicated in Section 3.2.3 it should be used as a 'subsoil' layer when it can be dozed, loaded and placed or dozed to one side left as a stockpile, loaded and placed. It is considered that its value as a subsurface material is not sufficient to justify the additional cost of loading, carting to a stockpile, reloading, carting and spreading as it is likely be required for some surface material. Nevertheless, the material placed

immediately below the surface soil where the current subsurface material is not available should be benign spoil.

5.2.2 Drop structures

It is recommended that drop structures, required to maintain grassed channel sections at grades likely to minimise erosion potential, be constructed of gabions or similar (Figure 4.3) with additional gabion mattresses upstream and downstream of those forming the near-vertical structures. In this context, gabions are rectangular woven wire mesh boxes, generally constructed of heavily zinc galvanised wire with or without additional coatings, and filled with competent rock. Galmac or galfan wire units are recommended as the coating is zinc and aluminium which has a much longer design life than zinc galvanising alone.

Gabion boxes are supplied as flat packs so that they are assembled, placed and fastened according to the final design, filled with rock, and closed with space behind backfilled and compacted progressively on site. Filling can be by machine or by hand but the rock needs to be tightly packed with the minimum of voids. Optimum rock size is 125 to 250 mm with a small percentage of smaller material allowable. Rock fill can be rounded or angular but angular rock that tends to fracture with flat sides, such as basalt or similar material has advantages because it can be packed with minimum voids and more readily be amenable to constructing flat faces within the baskets for optimum stacking of baskets. Alternative products such as permeable concrete modular units can also be used. Examples of the use of gabion baskets/mattresses are provided in Appendix B Gabion drop structure information.

Geofabric is required behind and below gabion structures to prevent erosion of backfill and underlying material flowing through and into the baskets silting up the voids and leading to eventual failure of the structure through loss of material behind/underneath the baskets.

The long-term intent of the gabions is that voids between the rock will fill with sediment from flows over the structure, vegetation will establish in this and the vegetation will be sufficient to maintain functionality of the rocks as drop structures on the eventual disintegration of the wire mesh boxes.

5.2.3 Contour banks and grassed channels

Contour banks are suggested for all major slopes in the disturbed area because of the lengths of slope at approximately 17%. The risk of significant erosion before good ground cover is established or if groundcover is reduced by fire or overgrazing is considered too great to leave slopes uncontroled. A vertical interval between contours of approximately 10 m is suggested with a gradient of 0.5 to 1% for the upslope channels.

It is recommended that the banks be trapezoidal in shape with at least a 5 m base or larger. Height should be approximately 1.2 m settled height. Banks should be constructed during spreading of the 0.2 – 0.3 to 1.0 m subsurface layer salvaged from currently rehabilitated areas where this is available. Benign spoil should be an acceptable alternative if salvaged subsurface material is not available but the bank and upslope channel area should be covered with at least 0.2 m of topsoil if spoil is used.

Contours should discharge from one to the next over stabilised spillways that are offset by at least 50 m from the contour discharge above so that flow velocity does not build up straight down slope

(Figure 5.1). One option to stabilise spillways would be to have discharge over a half section of almost-buried concrete pipe (concave side down).

Where contours are longer than approximately 250 m, consideration should be given to having two discharge paths, one towards each end.

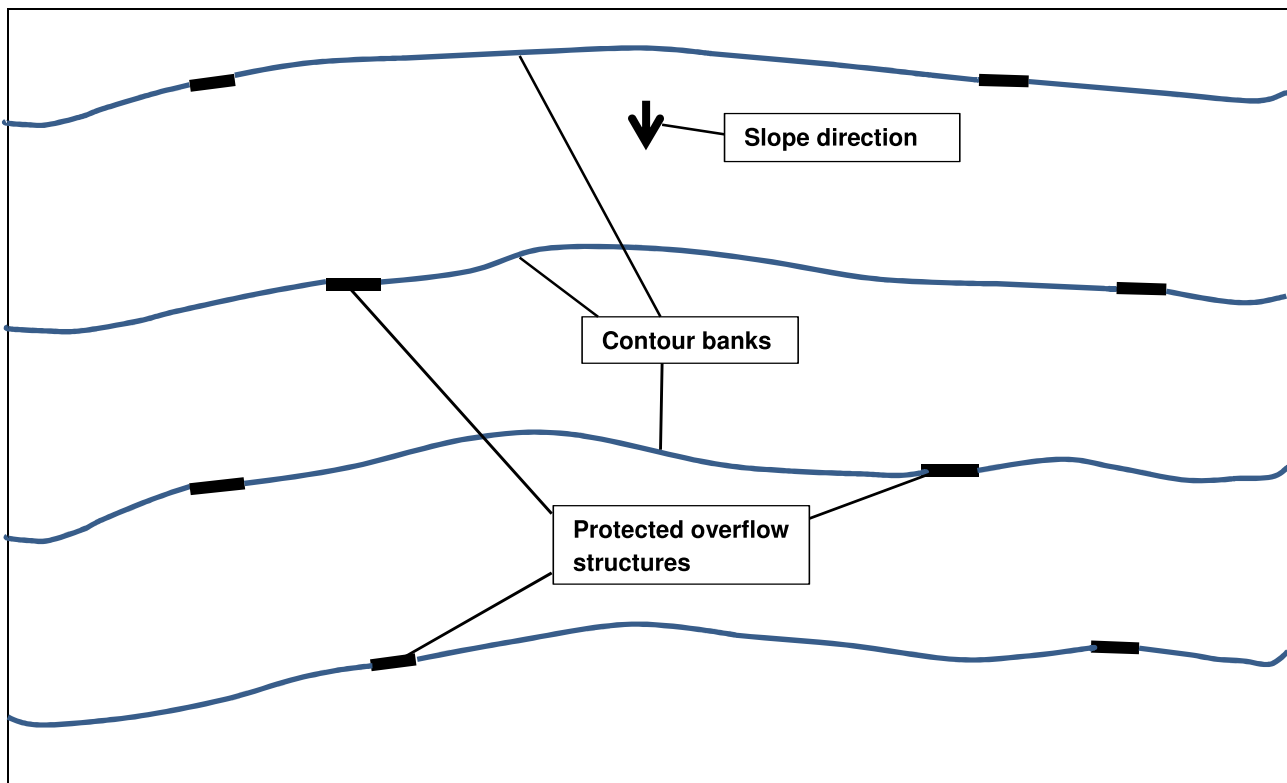


Figure 5.1 Schematic of contour discharge system with offset protected discharges downslope

5.2.4 Shock dam

The shock dam location is shown in Figure 4.2. It is designed to act as a buffer to accept flows from the re-built Blakes Gully. It is designed to form a shallow pond during runoff events and overflow via the drainage channel leading to the north-west, before changing direction to flow south-east down the channel to the last of the drop structures and then discharging from the Normanton Pit site on the western boundary. It provides a buffer for high flows, and an effective means of changing flow direction without a need for channel protection.

The dam will require design for a design storm (AEP to be determined in discussion with the owner based on risk assessment as no design parameters are set by the EA) and will need to be constructed with suitable materials. There may be a need to line the upstream face with geofabric and riprap to provide protection until site stability and effective ground cover have been achieved.

As protection of the spillway outlet is important to maintain the design crest level, it would be best to have the dam and the initial 10 m or so of the channel fenced off so that cattle cannot access the dam directly and trample the outlet. Regular maintenance of the spillway outlet in the initial years will be important.

5.2.5 External catchment aspects (inlet and outlet)

The principal external catchments that require consideration are those of the northern and southern gullies crossing Blakes Road. Drainage from these catchments enters the Normanton Pit area via two round pipe culverts that appear to be under-sized for the catchments they serve. Upstream approaches are silted up, probably as a result of entrapment of sediment by vegetation immediately upstream of the pipes.

NHG should liaise with Ipswich City Council to have the two culverts on Blakes Road upgraded to box culverts with appropriate capacity for the catchments served and flat concrete aprons upstream and downstream. Aprons will ensure vegetation does not block the inlets (and can be easily removed if it does), maximise flow dispersion downstream and provide for easier maintenance access. Council should create a broad grassed channel across the downstream side of the road reserve to direct shallow flows of runoff into the Normanton Pit just upstream of where it joins the reformed Blakes Gully.

It is proposed that the main drainage from the site will discharge at the present location by means of a broad, flat-bedded grassed channel downstream of the last drop structure. This will require removal of the present eroded structures and reshaping of the surrounding area. The stream is currently incised as a gully on the adjoining property below the Normanton Pit discharge point. It will be necessary to liaise with the landholder and possibly Ipswich City Council to ensure that this gully is stabilised and does not continue to erode headwards to threaten flow control works on the Normanton site.

5.2.6 Relocation of telecommunications

The location of telecommunications infrastructure on the site as indicated by DBYD is shown in Appendix A. It is understood that some, or all, of this infrastructure is non-functional but it will be necessary to liaise with Telstra to confirm status and any conditions for removal and disposal and relocation of the cables.

5.2.7 Electricity distribution network

There is an electricity distribution line crossing the Normanton Pit area on or immediately adjacent to, the road reserve shown in cadastral mapping as crossing the site. The concept design avoids the need to disturb the only pole in the area. It will be necessary to liaise with the power line owner (probably Energex) to determine the necessary clearances for work in the vicinity of the line and to maintain safe clearances at all times during site works.

5.2.8 Road reserve

It may be necessary to liaise with Queensland Government Department of Natural Resources and Mines concerning the status of the road reserve shown in cadastral mapping as crossing the Normanton Pit area and any restrictions on carrying out landforming and rehabilitation work on the reserve. Given the Mining Lease tenure, no problems are expected.

5.3 Revegetation

As indicated in Section 3.2.3, fertiliser application prior to re-seeding is suggested. Where the topsoil comprised the 0 to 0.3 m zone from currently rehabilitated areas, approximately 30 kg/ha of phosphorus and 1 t/ha of gypsum should suffice.

Applications of approximately 50 kg/ha of phosphorus, 20 kg/ha of nitrogen, and 2 to 3 t/ha of gypsum are recommended for any areas where topsoil is drawn predominantly from the small existing topsoil stockpile.

Species recommended for long-term are Rhodes grass, green panic, Setaria, and Siratro. Details of other species that might be considered and guidelines on planting may be obtained from O'Sullivan (2013).

It may be necessary to plant sterile millet over areas that will be exposed for some time during construction to temporarily provide erosion protection.

6 References

Landloch (2013) *Material Characterisation and Landform design for New Hope Coal's Oakleigh mine*. Landloch Pty Ltd Draft Report for New Hope Group.

O'Sullivan, D (2013) *Pasture management for South East Queensland*. SEQ Catchments and Queensland Government Department of Agriculture, Fisheries and Forestry.
<http://cdn.futurebeef.com.au/wp-content/uploads/SEQ-pasture-sml.pdf>

Appendix A Dial Before You Dig Plans

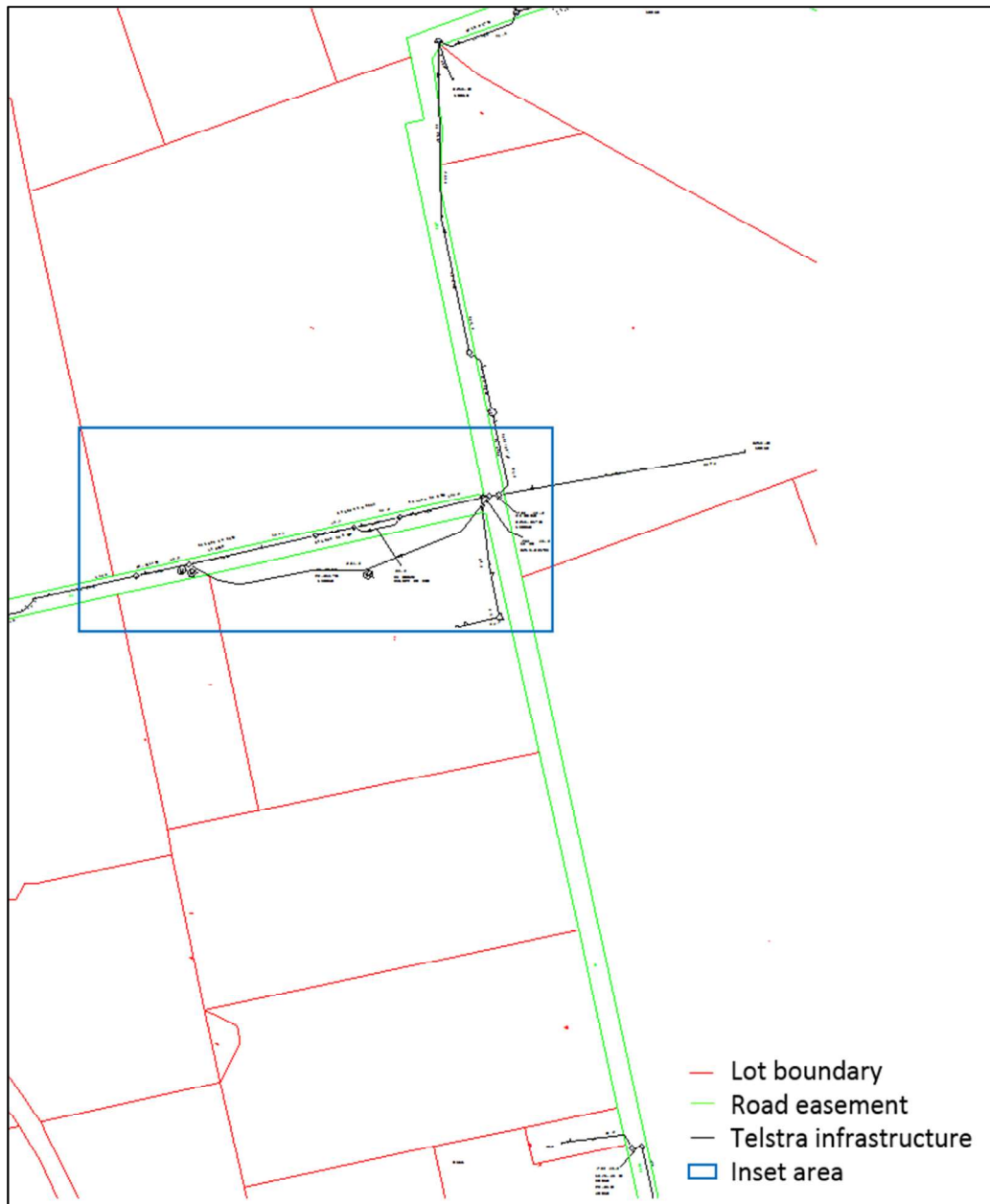
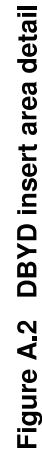


Figure A.1 DBYD overview



Appendix B Gabion drop structure information



Example of gabion (Reno) mattress for discharging water safely down long steep slopes such as the internal channel



Example of drop structure using gabion baskets and mattresses at top and base of structure. In the Blakes Road instance, the structure would be near-vertical and not be associated with a bridge, but in other aspects is similar.

Table B.1 Indicative costs for components of drop structures (excl labour and transport costs)

Type and size (mm)	Unit cost (\$)
Gabions (Maccaferri)	
Maccaferri Gabion Galmac 2 x 1 x 1m Mesh Type 8 2.7 mm Wire (each)	46.45
Maccaferri Gabion Galmac 2 x 1.5 x 1 m Mesh Type 8 2.7 mm Wire (each)	64.58
Geomac 330 Non-Woven Geotextile MRS/RTA Strength Class D 6 x 125 m (per roll)	900
Reno mattresses	
Reno® Mattress Galmac 6 x 2 x 0.3 m 5D B&L Mesh Type 6 2 mm Wire (each)	105.06
Gabi Block systems	
1200 x 600 x 600 (each)	171 (930 kg)
1200 x 600 x 900 (each)	240 (1,390 kg)
1200 x 600 x 1200 (each)	300 (1,850 kg)
1200 x 600 x 1500 (each)	378 (2,300 kg)
1200 x 600 x 1800 (each)	440 (2,800 kg)
1200 x 600 x 2400 (each)	570 (3,700 kg)
Gabi mattresses	
1200 x 1200 x 210 (each)	143 (650 kg)
1200 x 1200 x 260 (each)	161(800 kg)

Note:

- 1) unit costs only provided
- 2) no costs for rock fill material
- 3) freight to be estimated when total product requirement known
- 4) labour dependent on choice of product and construction method



Report

Concept Closure and Rehabilitation Plan - Oakleigh East

Company	New Hope Group
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Doc No.	NHG2041-01

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Project No.	NHG2041		
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Executive Summary

New Oakleigh Mine consists of three areas, namely Normanton Pit, Oakleigh East and Oakleigh West. All mining has now ceased and the last coal was extracted from Oakleigh West in February 2013. Both Oakleigh East and Normanton Pits have been rehabilitated to varying degrees and Oakleigh West is currently being backfilled and shaped to a final landform. The Oakleigh East area occupied parts of four MLs; namely ML4568, 4584, 4683 and 4698 as indicated in blue in Figure 1.1. The site to be investigated is known as the project area (see Figure 2.1) and occupies 175 ha approximately.

Currently, the Oakleigh East area does not meet acceptable rehabilitation objectives. Work is required to develop a final landform, suitable drainage management, manage the tailings dams, treat the contaminated and severely eroded sites, and to address all other issues of concern so that the site can be relinquished. Additional studies are being undertaken by ATC Williams for the rehabilitation of the large tailings dam in the north of the site.

Investigations Undertaken

An initial site inspection was undertaken on Wednesday, 16 April 2014 to identify the range of issues to be addressed in developing a concept closure and rehabilitation plan. This inspection determined the scope of works for this study and focused on:

- stabilising the eroding highwall in the north-east and other areas of severe erosion
- developing a surface water management plan that ensures a stable and sustainable drainage system for the site and will achieve relinquishment requirements
- developing a concept final landform design that meets the above objective and minimises the erosion risk

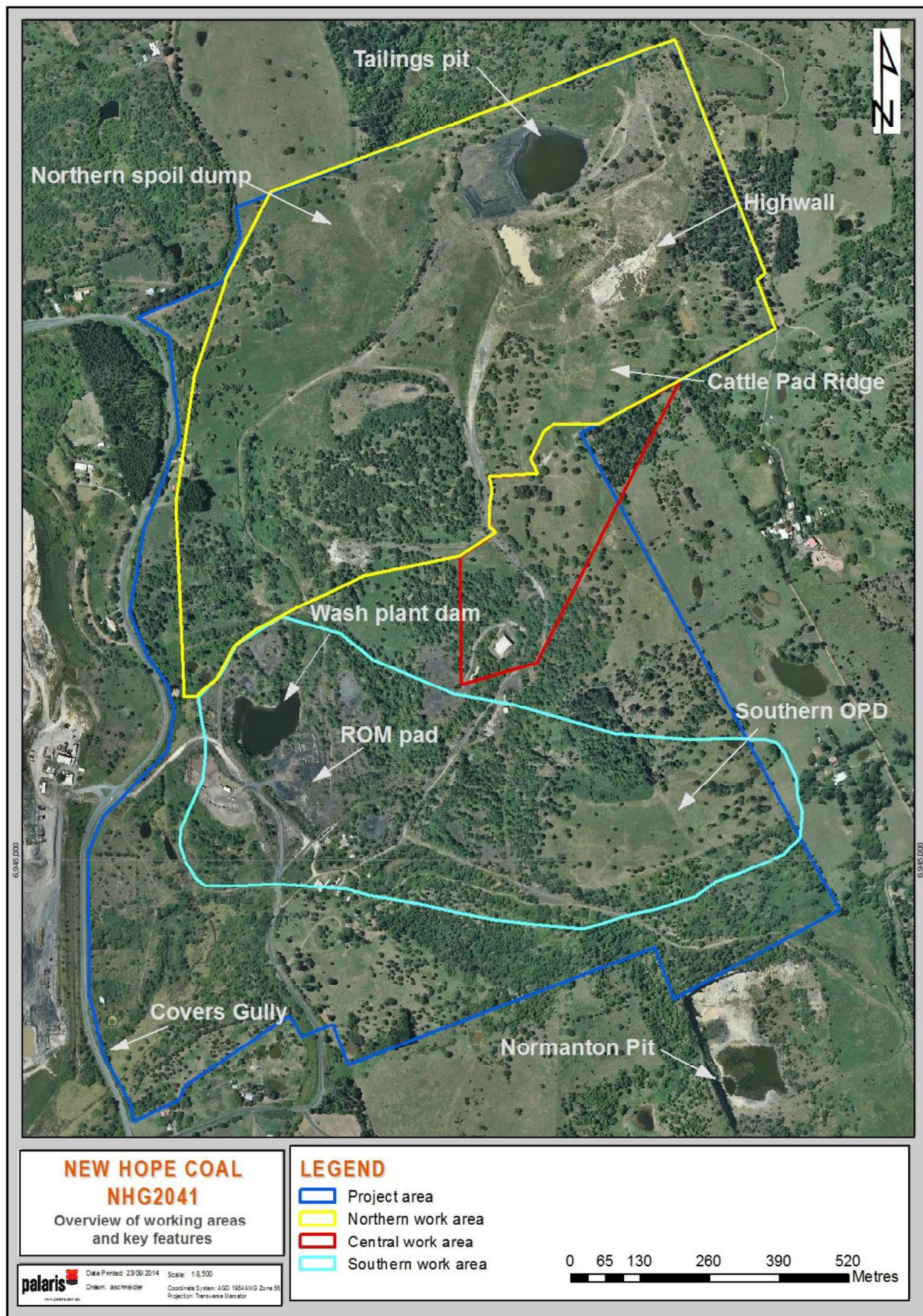
A second site inspection was made on 29 May to gain a better understanding of site conditions following agreement of the final scope of works. To aid in discussion and development of the final concept landform, the site was sub-divided into three drainage areas, namely:

- *Northern* – includes the highwall, tailings pit, north-western spoil dump
- *Central* – includes the central catchment from the eastern side of the lease that flows via two farm dams across the central tailings dam adjacent to the ROM pad and laydown area
- *Southern* – includes the southern out-of-pit dump, the catchment from east of the open cut area, the areas of most of the building infrastructure and the flow paths to the south of the ICC landfill

These drainage areas form the basis of the concept surface water management plan and constitute three staged work areas for implementation of the final landform. The three work areas effectively manage surface water runoff from three distinct natural catchments, though the contributory areas in the final landform are somewhat modified from the pre-mining drainage network. Subsequent discussions refer to these areas as 'work areas'.

In developing the concept final landform, the potential to use some of the existing spoil resource from Oakleigh East to meet landform requirements for the Normanton Pit rehabilitation to the south was considered. A further constraint in developing the plan was that the railway corridor is to be retained for possible future re-opening as part of the local Railway Museum activities.

The layout of the proposed work areas and naming conventions are given in the following figure:



Overview of work areas and naming conventions for on-site features

Modelling of Final Landform

Palaris utilised the Deswik CAD software package to complete the majority of detailed work for the Oakleigh East concept closure and rehabilitation design. In addition, some design work was completed in Dassault Systèmes Minex software; namely gridding of initial data sets to produce surfaces, comparing pre- and post-mining surfaces, and analysing catchments.

An understanding of areas within the former pit which differ from the original topography was determined using high resolution 2011 LiDAR point cloud, as well as less detailed 5 m 1974 contours. This technique was used to understand the footprint of the mined site, as well as the elevation changes from original topography to the current landform.

Working initially in the most complex and unstable final highwall area, various design attempts were made to rehabilitate the highwall to less than the target 17% slope, before a final design at ~20% was settled upon. This design balanced the need to keep the slope as shallow as possible, while facilitating the incorporation of a 1.5% drainage flow at the base of the highwall from the north-western corner of the mined area to connect into the pre-existing constructed drainage channel to the south of the highwall. In addition, this design also incorporates a good cover of the tailings pit which exists within the final highwall void. The design also relies upon the removal, primarily by dozer push, of the Cattle Pad Ridge into the existing highwall void.

Secondly, the drainage designs were completed to channel water from the rehabilitated highwall area down to near the current washplant dam, ensuring water from the central stream catchment that lies outside the mined area is managed in isolation to the water generated by the northern area of the final pit.

Most drains require a number of drop structures to be inserted to allow management of stream grade and velocity so as to mimic the original surface channel grades where practicable and to avoid the need for major earth movement. The use of shock dams remains an option to further assist in surface water management but has not been considered in any detail in this concept plan.

Also, drainage from the southern OPD was designed across the railway corridor and then around the western side of the railway corridor to discharge into Covers Gully. This drain flows east-west and under the access road to the ICC Transfer Station, and discharges on the western side of the transfer station access road, where a new channel has been designed to direct water away from the ICC transfer station. This new channel will alleviate continued erosion of the batter slopes at the south of the former landfill.

Next, various design iterations were completed to restore the southern OPD area to a stable drainage system. Five drop structures were required down the centre of this rehabilitated OPD area, which help limit the required movement of material as well as providing a stable flow of water to discharge at the washplant area. The new stable design requires the removal/relocation of ~1,470,000 bcm of material. NHG requested that 1,000,000 bcm of this area be kept for use at the nearby Normanton Pit rehabilitation program. This, along with the need to transport ~311,000 bcm of material to the final highwall area, and to keep ~260,000 bcm of material to complete all other drains, meant ~184,000 bcm of material were available to cap the washplant dam and pad area. This leaves approximately 690,000 bcm of spoil above the original surface in the southern OPD as shown in Figure 4.2, meaning that the new channel at the OPD is constructed almost entirely in fill.

Finally, the washplant dam area was designed, based on pushing down the existing dumps within this area, as well as incorporating the final ~184,000 bcm of material from the OPD to cap the dam. Drainage was directed to the south-eastern corner of the new dump, to flow into the new drainage channel that exits the OPD and then flowing to join Covers Gully in the south-west of the site.

The initial concept design was tested with NHG to determine if the general approach would be acceptable before the more detailed modelling was undertaken.

Key Features of Concept Design

The following key features of the concept design are based on treating the three work areas as separate stages in the construction program so that the whole site does not have to be in a bare condition at the same time.

Design parameters that were targeted as part of the design include:

- maximum slopes to be 17% (except where site constraints did not permit and/or existing steeper slopes were assessed as being stable and suitable for retention)
- target channel grade to be <1.5% and preferably <1% wherever practicable
- channel bottom width to be 10 m minimum with a flat bottom profile for major drains but final channel width to be validated by hydrology assessment prior to construction
- perched single-sided channels across slopes to have a trapezoidal cross-section with a bottom width of 10 m indicative
- downslope waterways to have flat bottomed cross-section with minimum bottom width of 5 m indicative
- diversion banks across slopes to target grades of <1.5% and preferably <1% where possible
- where grade control cannot be achieved within channel due to spatial constraints, use of gabion drop structures is recommended
- the removal/relocation of spoil was minimised in terms of volume and distance of transport by working within work areas as far as possible
- removal of approximately 1Mm³ of spoil from the southern out-of-pit (OPD) dump for use in Normanton Pit final landform was planned to minimise need for major earthworks at Normanton Pit
- all disturbed areas to be re-grassed as soon as possible after reworking using sward grasses and legumes in channel areas and avoiding use of tussock-forming species that disrupt smooth flow conditions
- remnant areas of Regional Ecosystems within the project area not to be adversely impacted by the final landform design
- need to retain as much of existing good regrowth on site to comply with EA condition for 30 ha of native ecosystem and minimise need for additional tree planting to achieve deficit

Key features of northern work area:

- four main channels (namely N1, N2, N3 and N4) with N1, N2 (in part) and N3 being flat bottomed channels and N2 (in part) and N4 being single sided perched channels
- diversion banks and waterways required in northern work area on reformed highwall/tailings pit and north-western spoil dump areas
- a series of six drop structures required in the lower section of N2

- batter geofab and riprap protection needed at both ends of N4 on outside curves to prevent erosion

Key features of central work area:

- the majority of this work area receives runoff from outside the open pit area that flows onto the project area via a series of small farm dams
- its flows have been kept separate from the northern work area discharge by extending an embankment from the existing drain from the final void that has now become N1
- two drop structures are used to discharge flows to the drain that flows over a former tailings dam to the north-east of the ROM pad before entering the channel that ultimately becomes Covers Gully

Key features of southern work area:

- to retain the RE remnant, the former drainage line has been reinstated centrally within the southern OPD
- the RE area now 'higher' in the landscape drains to the realigned channel and sheds runoff rather than having the channel attacking its southern margins and causing erosion as at present
- 1 Mm³ of spoil from this area, mainly from the eastern end, has been allocated for use at Normanton Pit for final landforming
- five drop structures are required to safely carry runoff the length of the southern OPD and discharge it to pass under the rail corridor at the ROM pad area
- spoil from the southern OPD is also relocated to fill the washplant dam and create a self-draining landform sloping to the east and south-east to join discharge from the southern work area and flow into Covers Gully

1 Introduction

New Oakleigh Mine consists of three areas, namely Normanton Pit, Oakleigh East and Oakleigh West. All mining has now ceased and the last coal was extracted from Oakleigh West in February 2013. Both Oakleigh East and Normanton Pits have been rehabilitated to varying degrees and Oakleigh West is currently being backfilled and shaped to a final landform. The Oakleigh East area occupied parts of four MLs; namely ML4568, 4584, 4683 and 4698 as indicated in blue in Figure 1.1. The site (referred to as the project area) to be investigated occupies 175 ha approximately.

Currently, the Oakleigh East area does not meet acceptable rehabilitation objectives. Work is required to develop a final landform, suitable drainage management, manage the tailings dams, treat the contaminated and severely eroded sites, and to address all other issues of concern so that the site can be relinquished. Additional studies are being undertaken by ATC Williams for the rehabilitation of the large tailings dam in the north of the site.

1.1 Objectives of Investigation

An initial site inspection was undertaken on Wednesday, 16 April 2014 to identify the range of issues to be addressed in developing a concept closure and rehabilitation plan. This inspection was used to define the scope of works for this study. Key issues to be resolved were identified as including:

- stabilising the eroding highwall in the north-east and other areas of severe erosion
- developing a surface water management plan that ensures a stable and sustainable drainage system for the site and will achieve relinquishment requirements
- developing a concept final landform design that meets the above objectives and minimises the erosion risk

When modelling the final landform, the potential to use some of the existing spoil resource from Oakleigh East to meet landform requirements for the Normanton Pit rehabilitation to the south should be considered. Achieving this outcome is not a requirement of the current proposal but would be a beneficial, unintended consequence of the final concept design.

A defined constraint in the development of the plan is that the railway corridor is to be retained for possible future re-opening as part of the local Railway Museum activities.

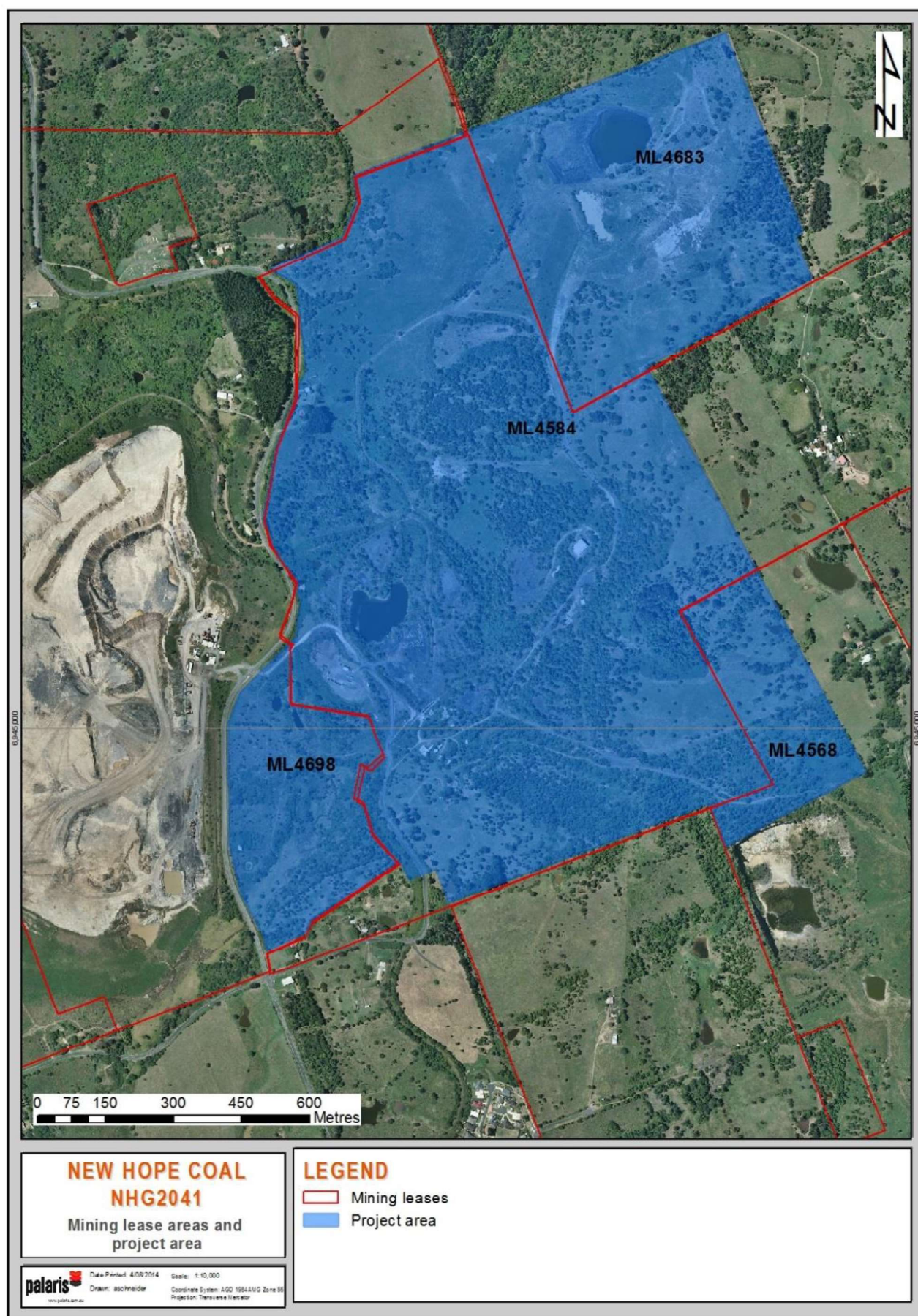


Figure 1.1 MLs constituting the Oakleigh East mine area

2 Background

The Oakleigh East area, highlighting key features of the site as shown in Figure 2.1, has been closed since mid-2000 when the last coal left the site. The open cut pit (Figure 2.1– orange outlined area) was referred to as the North Pit during those operations. Aspects requiring attention in developing the final landform and drainage system design as well as during rehabilitation include:

- an open tailings dam and multiple buried tailings dams (suspected)
- a washplant dam and building sites
- a potentially hydrocarbon-contaminated site
- a severely eroded residual high wall that has been modified post-mining to a lower grade
- several severely eroded sites associated with re-directed drainage from spoil dumps
- a rail corridor that remains across the site but has been damaged by flooding (bridges and line collapses) and is covered by sediment in places – line remains for most part
- a series of underground pit entrances and vent sites
- a stockpile of bentonite material that was sourced from the mine
- an active transfer station operated by Ipswich City Council (ICC) at a former council landfill site
- site administration office and sundry other infrastructure including inactive powerlines

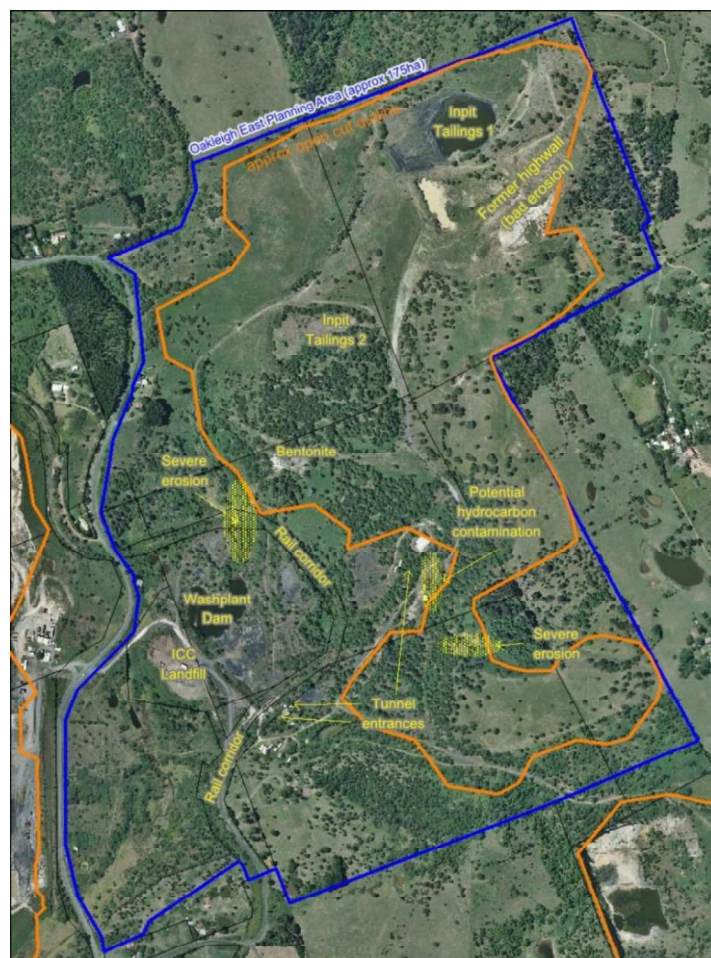


Figure 2.1 Oakleigh East area including North Pit outline and key site features of concern

2.1 Description of Site

The Oakleigh East area on the eastern side of the Rosewood-Marburg Road lies to the north and north-west of Normanton Pit and to the east of Oakleigh West. The study area covers approximately 175 ha within which lies the footprint of the North Pit open cut (90 ha) and the former washplant area. The ML area is presently used for casual cattle grazing under low management inputs. Incomplete records exist for the location of all activities associated with the various stages of mining from early underground mining to the present.

2.1.1 Current landform

The current landform reflects the multiple land uses across the site including:

- a railway corridor
- a railway siding area with sundry rolling stock and abandoned machinery and parts
- former ICC landfill now functioning as a Transfer Station
- a washplant dam
- a functioning but uncoordinated surface water management layout that is eroding in places
- a series of spoil heaps, covered tailings dams and an out-of-pit dump that do not conform to a planned final landform and some of which contain unknown material
- an in-pit tailings dam within a residual void
- a stockpile of bentonite clay that has been sourced from the mine workings
- abandoned underground mine entrances and access routes in disturbed areas but outside the area directly impacted as part of the open cut workings

The landscape has been strongly altered through mining activities and the subsequent rehabilitation to date. The change in elevation of the pre-mining landscape in 1974 relative to the mined and reshaped landscape of 2010 is shown in Figure 2.2. It is evident that the area around the tailings pit in the north has been lowered substantially compared to the pre-mined surface as is also shown in Figure 2.2. The areas south and south-west of the northern tailings pit have gained in elevation and the surfaces today are up to 30 m above the 1974 landscape. Both of the raised areas now have steeper slopes associated with them than were present in the initial landscape. In the south-east, a former valley has been backfilled with spoil as part of the out-of-pit dump, elevating the surface up to 30 m above the pre-mining landscape (Figure 2.2) and significantly altering the drainage in this area. This dump has diverted runoff (a portion of which is sourced from outside the project area from an unmined part of the catchment) to the north where it has resulted in a deep gully forming partly in fill and partly in a natural surface hard up against a remnant area of protected vegetation.

The current reshaped landscape for the area disturbed by the open cut mining, though it is sympathetic to the surrounding landscape (Figure 2.3), is unstable and showing extensive gullying on fill slopes (Figure 2.4). The final highwall in the north-east of the project area has been partially stabilised by grading the overlying slope to a gentler grade and pushing spoil against it to reduce erosion to a degree. This has been partly successful but the highwall remains unstable due to the exposure of sodic subsoil material during the reshaping of the land above the highwall. This exposure has affected vegetation establishment resulting in the formation of severe gullying (Figure 2.5 and Figure 2.6).

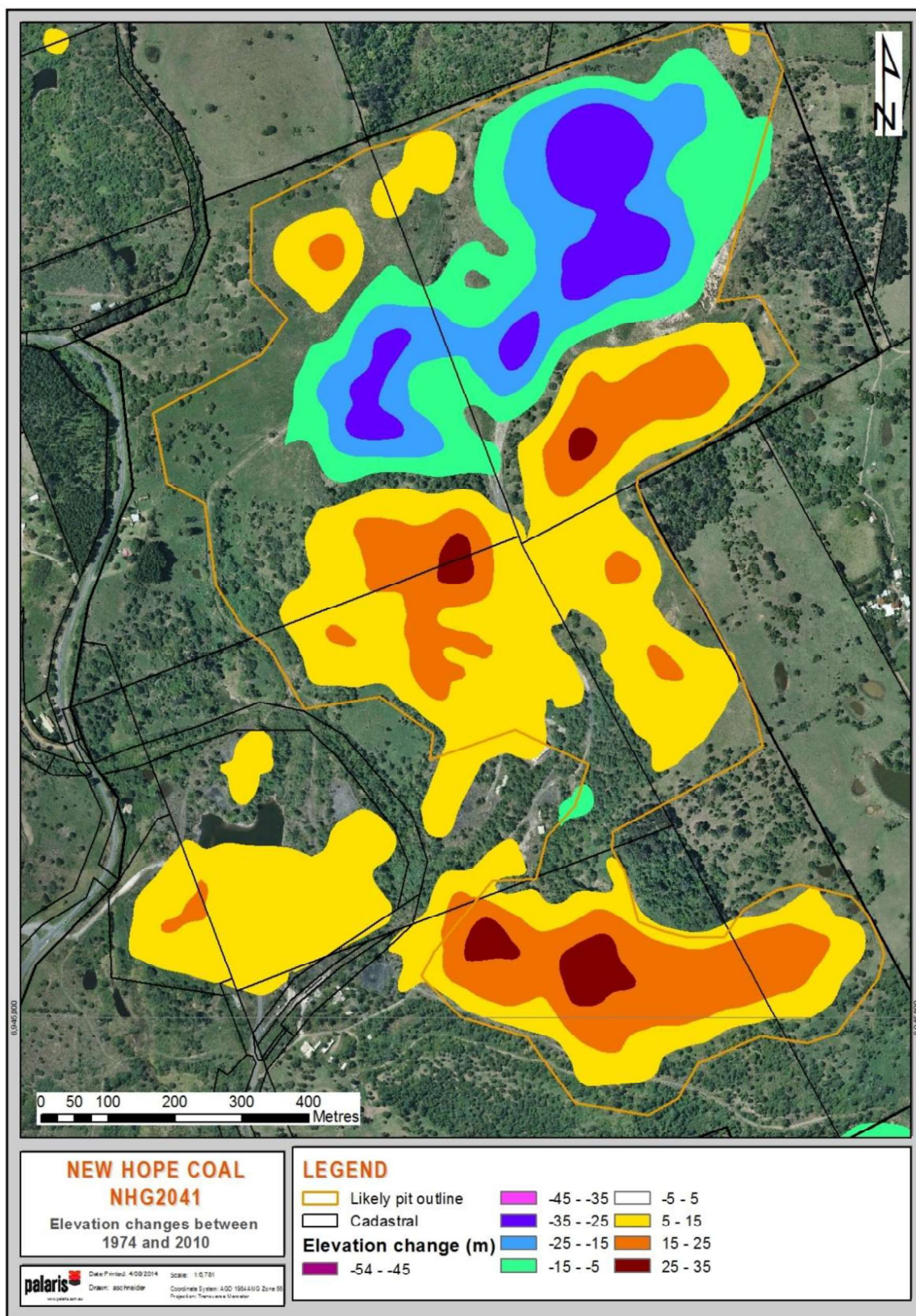


Figure 2.2 Elevation changes between the pre- and post-mining landscape



Figure 2.3 Reshaped landform looking north-east with tailings dam to the right and reshaped spoil to the left



Figure 2.4 Severe gullying close to the tailings dam in the north east



Figure 2.5 Sodic material exposed and resulting in severe gullying – looking south-west across highwall



Figure 2.6 Gullying in sodic subsoil material exposed above highwall during reshaping

2.1.2 Material characterisation

Chemistry

Spoil characterisation was undertaken for material in the north-western part of the project site (Landloch, 2013) but no investigations were undertaken on the out of pit dump materials in the south-eastern part of the site or on the steeply sloping spoil dump located to the immediate south of the remaining void (Figure 2.7). The latter area may be an important source of fill material for rehabilitation of the Normanton Pit, located to the south of the out of pit dump.

Samples from five sites were taken by Landloch to characterise the material in the shaded area in the north-west of Figure 2.7. The chemical properties of these samples as represented by analysis of the upper 10 cm did not show any values of concern for critical parameters. The pH of these samples ranged from 7.8 to 8.0 (slightly alkaline) and the electrical conductivity from 0.14 to 0.17 dS/m (low). Exchangeable potassium, calcium, and magnesium levels in this upper layer are acceptable. The effective cation exchange capacity (ECEC) was moderately high ranging from 28 to 31.3 meq/100g. This suggests a moderate presence of swelling clays (smectite clays) and the ability of the material to retain nutrients for rehabilitation. The total clay percentage ranged from 27% to 34%. The upper 10 cm of the sampled material is non-sodic (Landloch 2013) as exchangeable sodium percentage (ESP) was below 2% for all samples.

Two of the materials sampled below 10 cm depth showed moderately to very strongly alkaline pH with maximum values of 9.5 and 9.6 respectively, which may inhibit plant growth for some species. The electrical conductivities of some deeper samples were above the values of the upper 10 cm (0.13-0.85 dS/m), but not to the extent of concern for rehabilitation. Exchangeable potassium, calcium and magnesium values in these deeper samples are not of concern, but the ESP of two samples was marginally sodic to sodic (9.5% and 11.6% respectively) and one sample was strongly sodic with an ESP of 16.4%. The ECEC was high (suggesting again a high percentage of swelling clays) but the total clay content was similar to the upper 10 cm samples. The high ECEC could result in higher fertility but is often associated with higher erodibility (Landloch, 2013).

Landloch (2013) note that, overall, it appears most 'soils' have been formed from relatively deep layers of reasonably uniform material placed during initial site rehabilitation. With time, plant establishment and accumulating organic matter, some soluble salts and sodium have been leached into the lower parts of the profile. It is apparent that the generally vigorous plant growth with little removal of surface material by grazing animals has resulted in appreciable accumulation of organic matter in the surface few centimetres.

The chemical fertility of the upper 10 cm was variable, but all samples showed a generally low amount of labile sulfur (4.6 – 13.9 mg/kg). In general, total nitrogen and total phosphorus were low but not necessarily of concern (Landloch, 2013) as these elements can be easily applied as inorganic fertiliser. We support the Landloch recommendation of 1 tonne/ha of gypsum, which, as well as supplying sulfur, will have a minor beneficial impact on surface soil structure.

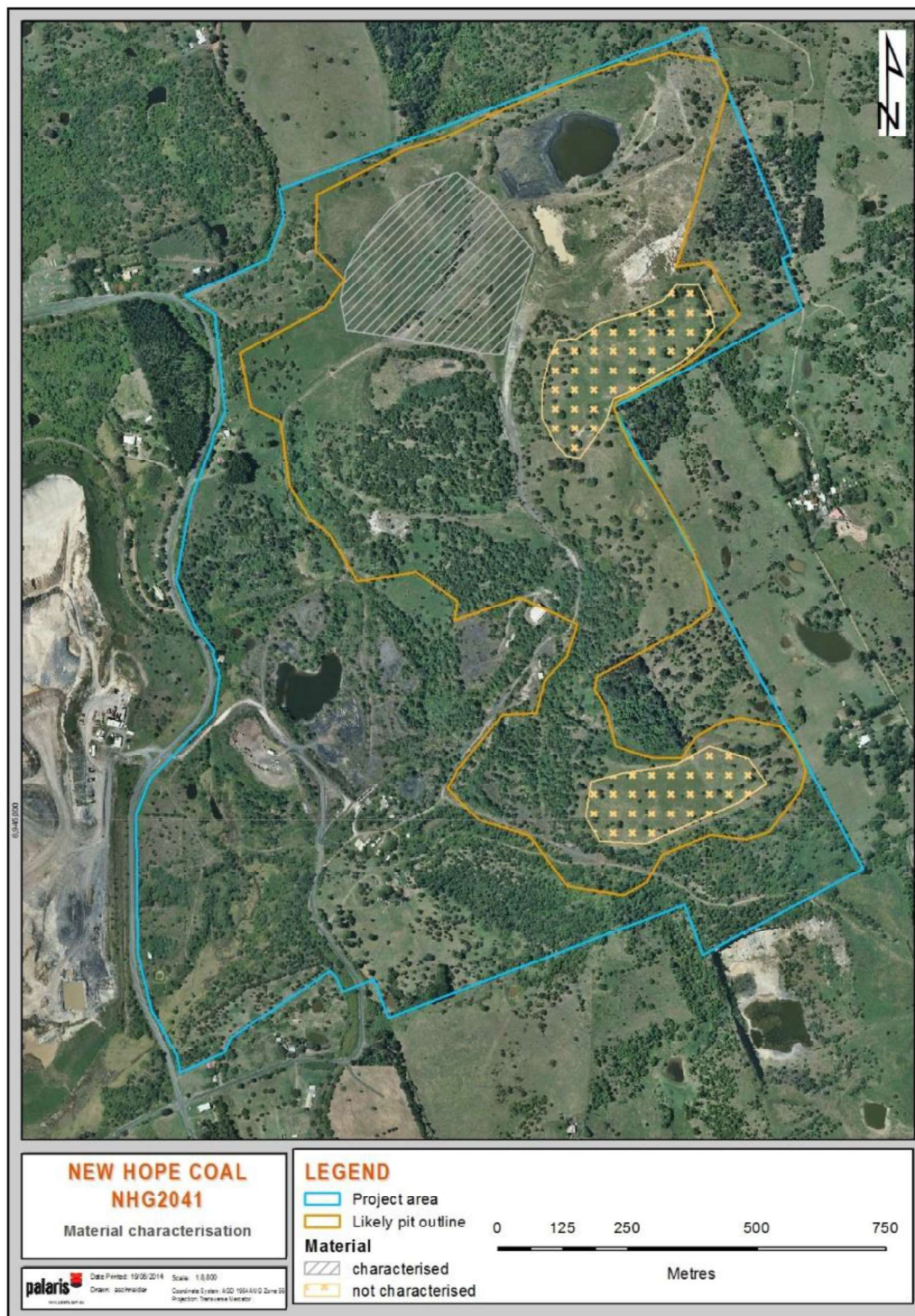


Figure 2.7 Areas of spoil characterisation

Erodibility

The project area has several erosion gullies of varying severity. Erosion studies by Landloch found that bare soil slopes are very susceptible to erosion but that erosion rates can be greatly reduced after vegetation establishment. The highest erosion potential for the project area occurs from September to March, i.e. in the wet season. Landloch (2013) recommends a preferred slope gradient of 17-18% and maximum slope gradient of 20% based on measured bare soil erosion losses and maximum acceptable initial soil loss (during vegetation re-establishment). This is accepted as a general objective for final landform design where material is to be moved and new

landforms developed. Where existing landforms are currently stable and may have steeper slopes that do not require earthworks to meet the final pit rehabilitation design, these may be retained if a detailed assessment indicates that they are likely to remain stable in the longer term. This assessment will depend on how well and to what extent these steeper areas remain intact and undisturbed following implementation of the proposed final landform.

2.1.3 Pre- and post-mining drainage

Pre-mining drainage of the site is no longer well-reflected in the post-mining landscape other than in the south-west and for the drainage from outside the project area in the central east of the lease area (Figure 2.8). Prior to mining activities, drainage from a small catchment in the north-east of the project site flowed north into the Blacksnake Creek system while the majority of drainage flowed to the south and south-west of the site. These southerly draining streams ultimately joined to one flow path, namely Covers Gully, which leaves the site in the south-west and flows under the Rosewood- Marburg Road (Figure 2.8), other than for a small catchment in the south-east of the mine site. This latter area originally drained via the Normanton Pit area in the north-west of Normanton Pit. It is now captured and re-directed by a bund above the residual high wall where it now flows into what has been called Blakes Gully along the eastern side of Normanton Pit.

The tailings pit in the north-east of the Oakleigh East site captures runoff both from above the former high wall area, as well as rainfall directly, but runoff does not exit the site from here. There is some evidence to suggest that the tailings pit also receives groundwater inflows, perhaps from the former underground workings. Observations indicate that this water level fluctuates over time possibly due to subsequent inflows/losses to groundwater as well as evaporation. Some fines have been extracted from the tailings pit and stockpiled in the south-west of the pit for the purpose of testing their suitability for brick-making. The future of this use is not yet determined and has not been considered in developing the landforming strategy.

A separate design for rehabilitation of the tailings pit is being undertaken independently of this report. Nevertheless, runoff from this general area will be accounted for in the surface water management plan being developed.

A small drainage line leaves the far north-eastern corner of the project site but does not contribute much flow to Blacksnake Creek to which it drains as most of the flow from its former upper catchment now enters the tailings pit first. A seepage area exists to the north of this tailings pit outside the mine site. Investigations to date have not identified the exact cause of the seepage nor tied it to losses from the tailings pit. Measurements of water quality show that the seepage is similar to other spring flows into Blacksnake Creek suggesting that it is more likely to be normal groundwater daylighting and not groundwater flows sourced directly from the mine.

There is also a small depression that captures water from the reshaped high wall in the south of the final void and overflows to the artificial channel that has been created through the spoil dumps. This water then flows westwards and ultimately delivers runoff south into Covers Gully. This detention area appears to be an isolated remnant of the final void and as far as can be identified does not contain tailings. Nevertheless, it has accumulated sediment from erosion of the high wall and may contain coal fines.

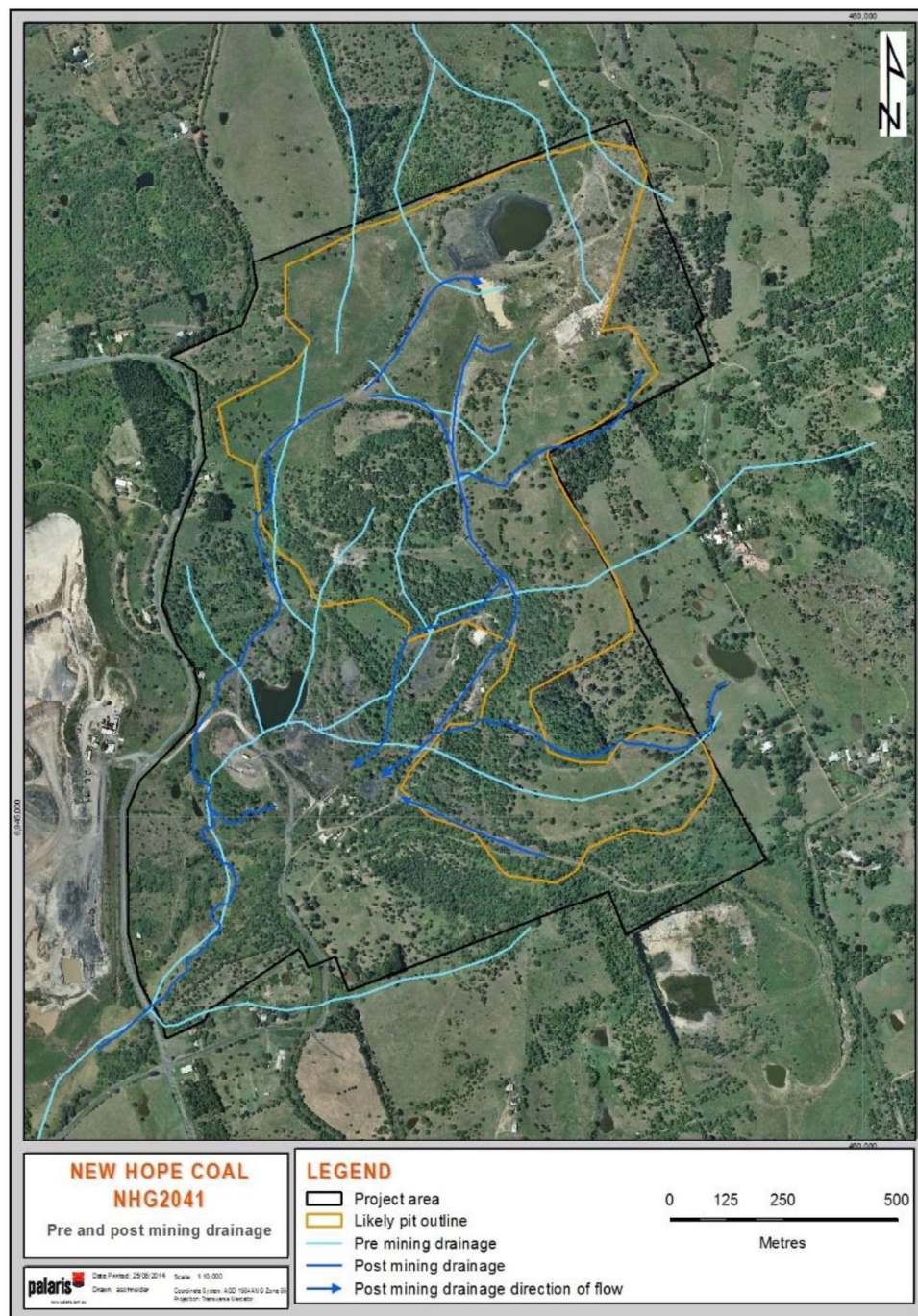


Figure 2.8 Pre and post-mining drainage

The majority of the site drainage now flows via two channels that ultimately join to form Covers Gully in the south-west of the site. One channel drains from the north generally paralleling the Rosewood-Marburg Road and the other from the north-east and the final void area. The channels diverge around the ICC landfill/transfer station. The north-eastern channel flows across the site upstream of the washplant dam as well as across the entrance road to the transfer station. The flow path across the rail siding and laydown area is not well defined (Figure 2.8) and may need to be contained more effectively as part of the final landform design. Initial investigations appear to show that this water enters a small void (possibly by seepage via fractures into remnant underground shafts although known nearby shafts only occur higher in the landscape) and seeps

under the laydown/ROM pad area before resurfacing just upstream of the gabion weir constructed on the access road to the transfer station.

From the laydown area, drainage to Covers Gully crosses the ICC Transfer Station access road, where a culvert has been instated as well as a gabion spillway and abutment, with riprap placed in the channel downstream. Previous flooding resulted in loss of the former access road to the landfill site in this section. Where water flows past the ICC site, high flows have eroded the steep embankment and at times exposed unconsolidated landfill material. Stabilisation of this reach of Covers Gully will be required. Beyond this section, Covers Gully then crosses the Rosewood-Marburg Road (Figure 2.8) before continuing southwards to eventually pass to the west of Rosewood Township.

The current drainage system reflects sequential site modifications and is not a fully planned, sustainable approach to coordinated surface water management. Accordingly, stream grades are too steep for stability in some sections and encourage sedimentation in others, making for an overall unstable system. Gullying on spoil stockpiles and associated with roads, cattle tracks and redirected drainage lines is common with some gullies being >1.5 m deep (Figure 2.4).

2.1.4 Vegetation

It is not clear just what areas have been planted and what is natural recruitment since mining ceased on site. Vegetative cover, particularly vigorous pasture growth, is not as well developed and stable as it is at Normanton Pit to the south and weed species form a significant part of the communities on site. Much of the site is covered with *Acacia* spp. regrowth, *Lantana camara* (lantana) and creeping vines (Figure 2.9). These weedy plants make access difficult and will need to be managed effectively to ensure that the final landform and rehabilitation inputs are successful and sustainable. The removal and control of these weeds are likely to pose problems for management during final landforming and subsequent rehabilitation due to the amount of seed material likely to be present in the selectively stripped 'topsoil'. A well implemented weed control plan will be essential until effective ground cover is re-established.



Figure 2.9 Vegetation overgrown with creeping vines

There are small areas of brigalow regrowth and other native species in the north of the former pit that are quite well established, though often with a *lantana* understorey. This brigalow regrowth will be targeted for retention wherever possible during the development of the final landform and drainage design. Similarly, there are approximately 25 ha of well advanced, mainly native tree species, in the central-south of the open cut workings which will be retained to the maximum extent possible to underpin expansion to achieve a requisite 30 ha of native ecosystem for mine closure (a condition of the Environmental Authority (EA) for the New Oakleigh operation).

A small remnant area of Regional Ecosystem (RE) (12.9-10.6/12.9-10.2) just to the north of the out-of-pit dump will not be disturbed by the implementation of the modified landform and drainage will be directed away from its southern margins to further encourage progressive expansion of the remnant. The same is true for the RE (12.8.23/12.8.13) to the east of the highwall (Figure 2.10).

The southern remnant (RE 12.9-10.6/12.9-10.2) comprises 90% of the 12.9-10.6 communities and 10% of 12.9-10.2 ecosystems. The former is classified as endangered and is described as *Acacia harpophylla* open forest on sedimentary rocks. The latter consists of *Corymbia citriodora* subsp. *variegata* with or without *Eucalyptus crebra* open forest on sedimentary rocks. This RE is of least concern.

The northern remnant (RE 12.8.23/12.8.13) comprises 60% of *Acacia harpophylla* open forest on Cainozoic igneous rocks (RE 12.8.23) and up to 40% *Araucaria* spp. complex microphyll vine forest on Cainozoic igneous rocks (RE 12.8.13). This latter RE is classified as of concern while RE 12.8.23 is classified as endangered.

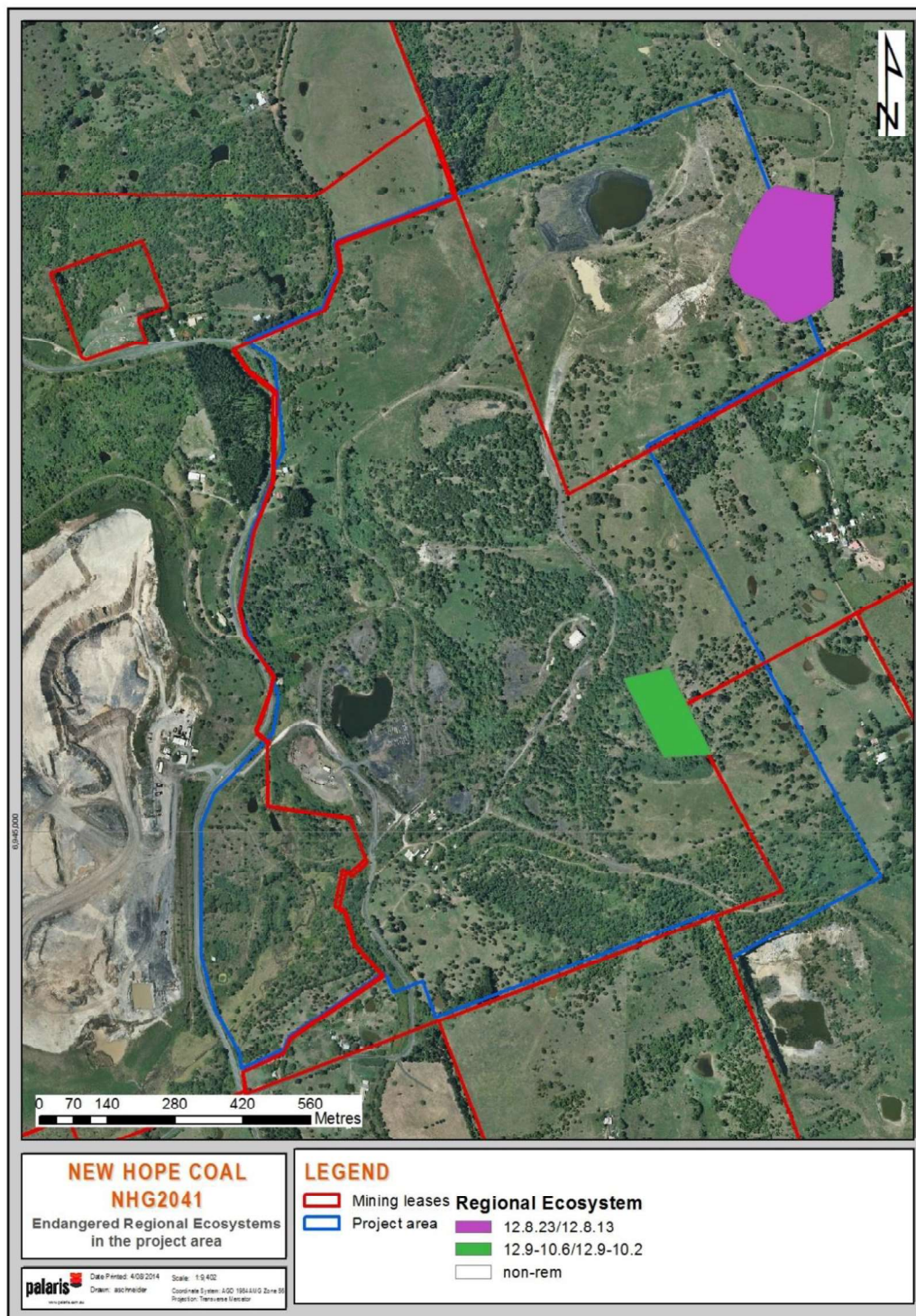


Figure 2.10 Endangered Regional Ecosystems in the project area

2.1.5 Railway

The railway corridor remains extant on the site but is no longer functional. Several bridges have been washed out (Figure 2.11) and the crossing at the Rosewood-Marburg Road is no longer operable. Mining activities have covered the track in places and the exact locations of cross-track drainage are not clear.

NHG has obligations to the Rosewood Railway Museum to maintain access to this corridor. There will be a need to resolve drainage locations/approaches across the corridor with respect to final landform design.

Disused and severely degraded rolling stock have been landlocked on the mine site by the severance of the rail line due to the washouts and their future is yet to be resolved (Figure 2.12). The final landform design is based on the retention of the railway corridor for its planned future use for local tourism purposes. The surface water management planning aims to establish drainage across the rail corridor at or close to where the original bridges were previously located though it is not always possible to accurately site these crossings in the disturbed landscape.



Figure 2.11 Washed out rail bridge



Figure 2.12 Deteriorated abandoned rail carriage

3 Scope of Work

3.1 Project Tasks

The main tasks of the study aimed at achieving ultimate relinquishment include:

- stabilising the high wall and all other areas of current severe erosion
- establishing an effective and sustainable surface water management system
- developing a concept final landform design that achieves the above needs (considering site constraints such as the railway corridor and ICC transfer station in the site plan)

As part of this design, the following issues need to be considered so that a coordinated approach to stabilising the site in preparation for relinquishment can be achieved:

- incorporating plans currently being developed separately for the tailings pit in the design
- decommissioning/closure of the underground mine entrances and vent sites so they can be covered by the final landform (**Note:** This does not include any inputs to stabilise the underground workings)
- not intercepting any underground mine workings in the final landform design when establishing a final drainage network
- recommending a rehabilitation strategy that will be compatible with grazing as a post-mining land use at the concept level
- avoiding any impacts on the Rosewood-Marburg Road by maintaining the existing culverts of Covers Gully as the primary point of drainage discharge from Oakleigh East pit
- minimising impacts on the railway corridor if possible and, if not possible, recommending alternative ways to manage this constraint in the final landform and drainage design
- leaving undisturbed to the maximum extent possible, all quality regrowth where this approach is compatible with achieving a stable final landform as part of the EA requirement to establish a minimum of 30 ha of native ecosystem
- not disturbing the remnant REs on site
- avoiding any design that leaves non-draining final voids or potentially exacerbates the known seepage to the north of the site
- in designing the surface water management plan, assess the potential for risk to the stability of the uncapped embankment of the ICC former landfill where Covers Gully passes to the south of the landfill site (identify the need for stabilisation inputs in this area)
- use the maximum slope grades in the final landform design that are recommended in Landloch report except where existing steeper slopes that can be retained are assessed to be effectively stabilised and not at risk of erosion

The potential to develop a final landform that will also permit the use of spoil from the Oakleigh East area for landforming in Normanton Pit to the immediate south is to be considered. If this is possible, the benefit would be that it would minimise the degree to which the Normanton out-of-pit dump would be removed thus reducing associated community noise, dust and visual impacts. This aspect is to be regarded as incidental to the Oakleigh East landform design and not a prime driver.

This current work assumes that all infrastructure, the bentonite dump, tailings pit, disused machinery and scrap materials, decommissioned powerlines, mine entrances/vent sites, buildings and other former mining activities will be removed from site or otherwise dealt with independently of the landform design process.

4 Methodology

4.1 Field Inspection

Two site visits were undertaken; the first on 16 April 2014 and the second on 29 May 2014. Based on the initial visit in April, the project scope was developed for approval by NHG. The latter visit served as a familiarisation with the site for all contributing Palaris team members as well as an opportunity to test out possible rehabilitation options for this quite complex site with NHG's Senior Planner, Mine Closure.

Three distinct areas as shown in Figure 4.1 have been identified as the basis for designing the surface water management systems as part of the final landforming. These areas have been treated separately to aid description, manage the complexity of the site and allow the progressive landforming of the area in stages that will permit instatement of the complete flow path of individual sub-catchments to account to some degree for weather events. They do not exactly reflect the original drainage system but will constitute the main drainage systems to be instated during final landforming. Managing the final landforming in this manner will avoid having the whole site in a bare surface condition at any one time and assist in planning and managing the staged earthworks. For discussion purposes these have been identified as:

- *northern*– includes the highwall, northern tailings pit and north-western spoil dump (this does not include the small residual areas that continue to drain off site to Blacksnake Creek)
- *central*– includes the central catchment that is external to the project area in the eastern side of the lease that flows via two farm dams across the central tailings dam adjacent to the ROM pad and laydown area
- *southern*– includes the southern out-of-pit dump, catchment external to the project site in the south-east and the sites of much of the building infrastructure; it ultimately flows to the south of the ICC landfill area and forms the main channel of Covers Gully

4.2 Concept Planning and Modelling of Landform Design

Extensive use has been made of the data provided by NHG showing the pre-mining DEM of the site to identify where spoil has been placed throughout the life of the mine and for which no mine plan was available (see Figure 2.2). This imagery was also useful in determining some locations of probable tailings dams and former drainage lines. It is clear from the DEM that at least two of the major prior drainage lines have been buried under more than 30 m of spoil and that this has caused the remaining residual catchments that are located above the dumps and outside the project site to find new pathways for discharge. This has resulted in severe erosion that now requires attention as part of the present concept planning.

An aim of the landform modelling has been to try to relocate drainage where possible close to the pre-mining configuration so as to regain or mimic at least some of the fluvial dynamics of the original drainage network and avoid significant changes to ultimate discharge patterns. It is important to remember that the reformed drainage is sited predominantly in disturbed fill rather than having developed naturally by incision into *in situ* rock over a long period of time and that such fill materials are far less stable than channels in a natural surface.

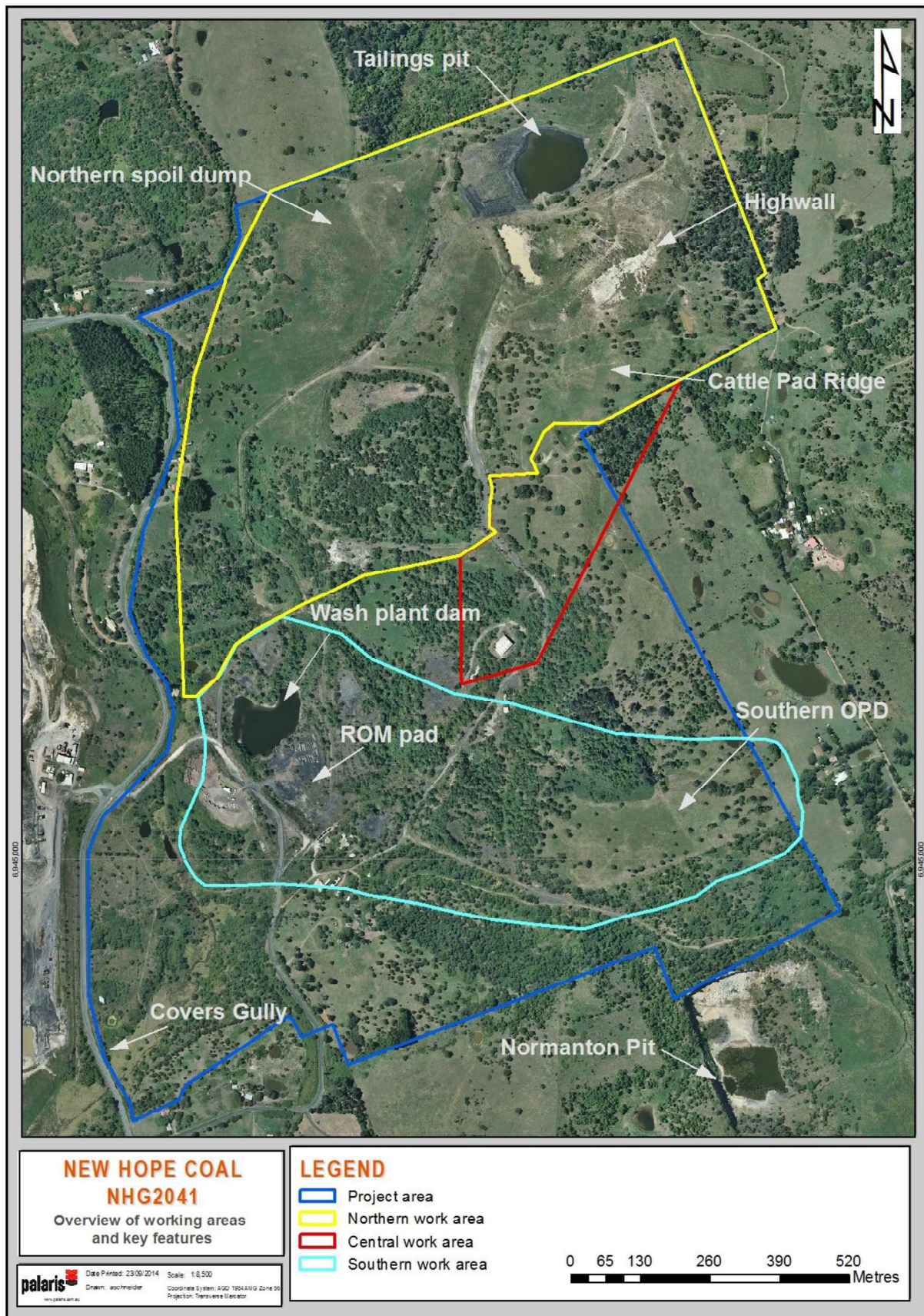


Figure 4.1 Work areas used in planning and discussing the final drainage system proposed and key locations

4.2.1 Modelling approach

Palaris utilised the Deswik CAD software package to complete the majority of detailed work for the Oakleigh East rehabilitation concept design. This software readily manages large volumes of data and is well suited to modern data file formats commonly encountered on mine sites. In addition, some design work was completed in Dassault Systèmes Minex software; namely gridding of initial data sets to produce surfaces, comparing pre- and post-mining surfaces, and analysing catchments.

Key data provided by NHG, which formed the basis of all designs included:

- high resolution LiDAR point clouds
- high resolution aerial photographs
- lower resolution historic aerial photographs
- 5 m contours of pre-mining 1974 surface
- boundaries
 - project area
 - pit disturbance (estimated)
 - an area where vegetation disturbance should be avoided if possible
 - cadastre, including a railway corridor

Firstly, to gain an understanding of areas within the pit which differ from the original topography, the high resolution 2011 LiDAR point cloud, as well as the less detailed 5 m 1974 contours, were utilised to create two surfaces that could be analysed for differences. Various maps were generated and highlighted areas which, while currently stable and well covered in grass or vegetation, are in fact elevated dumps. Two such areas are the Cattle Pad Ridge and the southern out-of-pit dump (OPD), and this technique was used to understand the footprint of these dumps, as well as the elevation changes from original topography to current landform.

Working initially in the most complex and unstable final highwall area, various design attempts were made to rehabilitate the highwall to less than the target 17% slope, before a final design at ~20% was settled upon. This design balanced the need to keep the slope as shallow as possible, while facilitating the incorporation of a 1.5% drainage flow at the base of the highwall from the north-western corner to connect into the pre-existing constructed drainage channel to the south of the highwall. In addition, this design also incorporates a good cover of the tailings dam which exists within the final highwall void. The design also relies upon the removal, primarily by dozer push, of the Cattle Pad Ridge into the existing highwall void, and will require trucking of a further ~311,000 bcm of material from the OPD to provide material to complete the design.

Secondly, the drainage designs were completed to channel water from the rehabilitated highwall area down to near the current washplant dam, ensuring water from the central stream is managed in isolation to the water generated by the northern area of the final pit.

Most drains require a number of drop structures to be inserted to allow management of stream grade and velocity to mimic the original surface channel grades and to avoid the need for major earth movements.

Also, drainage from the OPD was designed across the railway corridor and then around the western side of the railway corridor to discharge into Covers Gully. This drain flows east-west and under the access road to the ICC Transfer Station, and discharges on the western side of the transfer station access road, where a new channel has been designed to direct water away from

the ICC transfer station. This new channel will alleviate continued erosion of the batter slopes at the south of the former landfill.

Next, various design iterations were completed to restore the OPD area to a stable drainage system. Five drop structures were required down the centre of this rehabilitated OPD area, which help limit the required movement of material as well as providing a stable flow of water to discharge at the washplant area. The new stable design requires the removal of ~1,470,000 bcm of material. NHG requested that 1,000,000 bcm of this area be kept for use in the nearby Normanton Pit rehabilitation program. This, along with the need to transport ~311,000 bcm of material to the final highwall area to meet the deficit, and to keep ~260,000 bcm of material to complete all other drains, meant ~184,000 bcm of excess material were then available to cap the washplant dam and pad area. This leaves approximately 690,000 bcm of spoil above the original surface in the southern OPD as shown in Figure 4.2, meaning that the new channel at the OPD is constructed almost entirely in fill.

Finally, the washplant dam area was designed, based on pushing down the existing dumps within this ROM pad area, as well as incorporating the final ~184,000 bcm of material from the OPD to cap the dam. Drainage was directed to the south-eastern corner of the new dump, to flow into the new drainage channel that exits the OPD and then flowing to join Covers Gully in the south-west of the site.

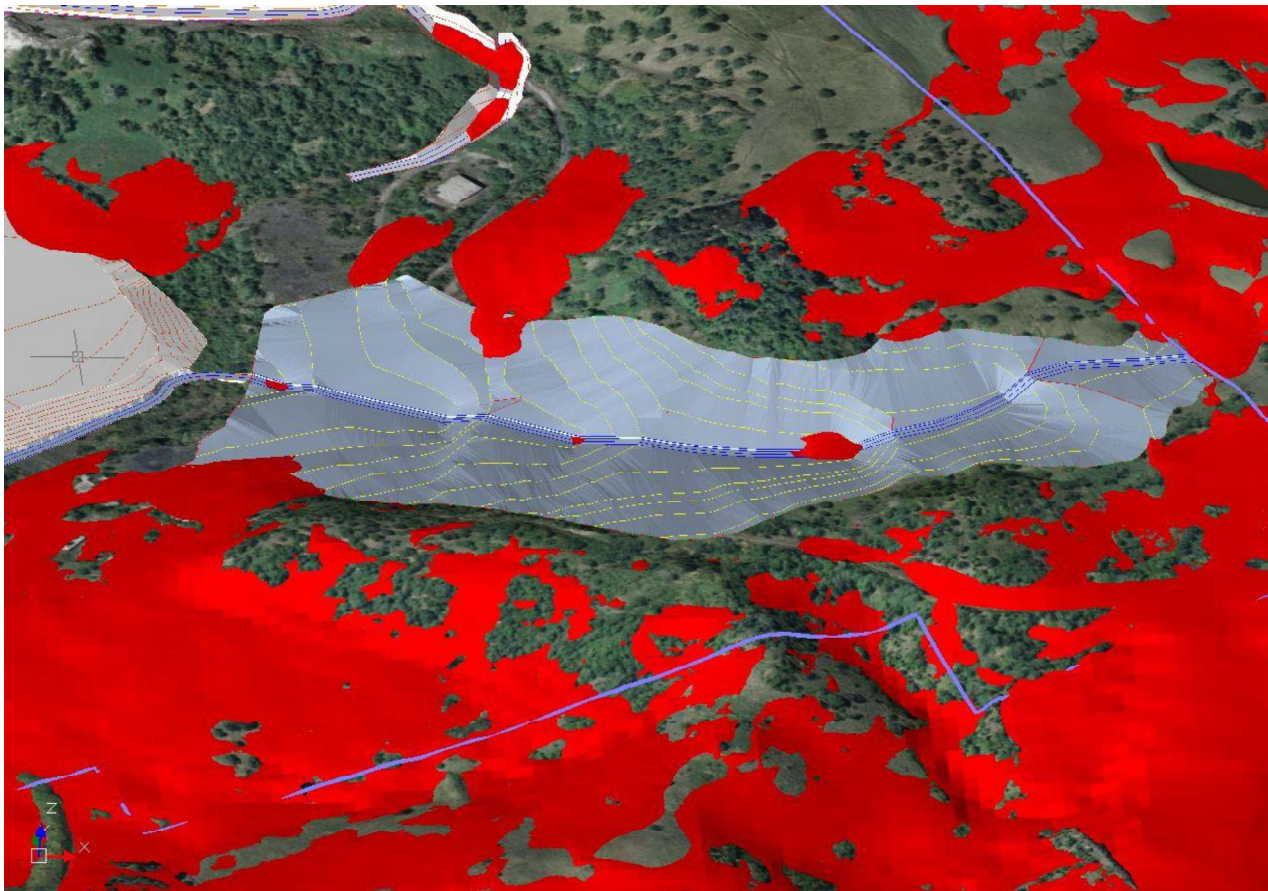


Figure 4.2 Red areas showing the pre-mining surface in relation to the out-of-pit dump (grey). Note: three small red areas intersected by drainage line to be re-established coincide with locations of gabion drop structures meaning that they can be located on *in situ* surface

5 Modelled Landform Design

5.1 Design Constraints/Parameters

The landform planning was based on:

- the removal of approximately 1 Mm³ of spoil from the southern out-of-pit dump for use in the Normanton Pit rehabilitation as this was the closest source of fill and would contain costs significantly prior to any allocation of the remaining stockpiled material
- minimising the need to move spoil large distances by firstly accessing adjacent stockpiles wherever possible
- causing least disturbance to good quality regrowth wherever possible and reshaping the new landform to protect vulnerable vegetation communities
- establishing 20% as a maximum land slope except where existing slopes that did not need to be reformed were stable even if they were steeper than this 20% limit
- developing a final landform that complements the surrounding non-mined areas and former pre-mining surface as far as is possible
- implementing drainage channels that are as low gradient as can be achieved, aiming for <1.5% wherever possible, and using gabion drop structures, contour/diversion banks on long slopes and energy dissipating surface protection at discharge points where channel slopes are steeper
- as drainage must exit the site into a stream that flows at or about the pre-mining surface elevation, all new drainage on the site will necessarily be implemented in fill as the base of the open cut was below the pre-mining surface
- designing a sequential approach to landform implementation that allows for effective staging and management of the extent of bare land exposed at any one time

5.2 Northern Work Area

The landform design process here assumes that the tailings area has been drained and capped according to a cover design prepared independently of this present study. The final land surface has then been built on top of this encapsulated material and shaped so as to capture and direct runoff to the centrally located channel that drains southwards. The main drainage has been based around retaining the existing artificial drainage from the residual void.

To fit in the upper reaches of the new channel at a suitable grade, it has been necessary to generate side slopes that are steeper (up to 20%) than the preferred 17% while working to the limit of available spoil. The spoil to be used for filling the final void is planned to come from the stockpile north of the central catchment from what is termed Cattle Pad Ridge that has more than 30 m of spoil thickness available. These steeper slopes require the use of contour banks discharging to a series of waterways on the side slopes that break up the long, directly downslope flow paths. These contour/diversion banks restrict both the length and volume of overland flow on the slope and the waterways incorporate drop structures in the design to stabilise the discharge point.

The design features for the northern work area are shown in Figure 5.1.

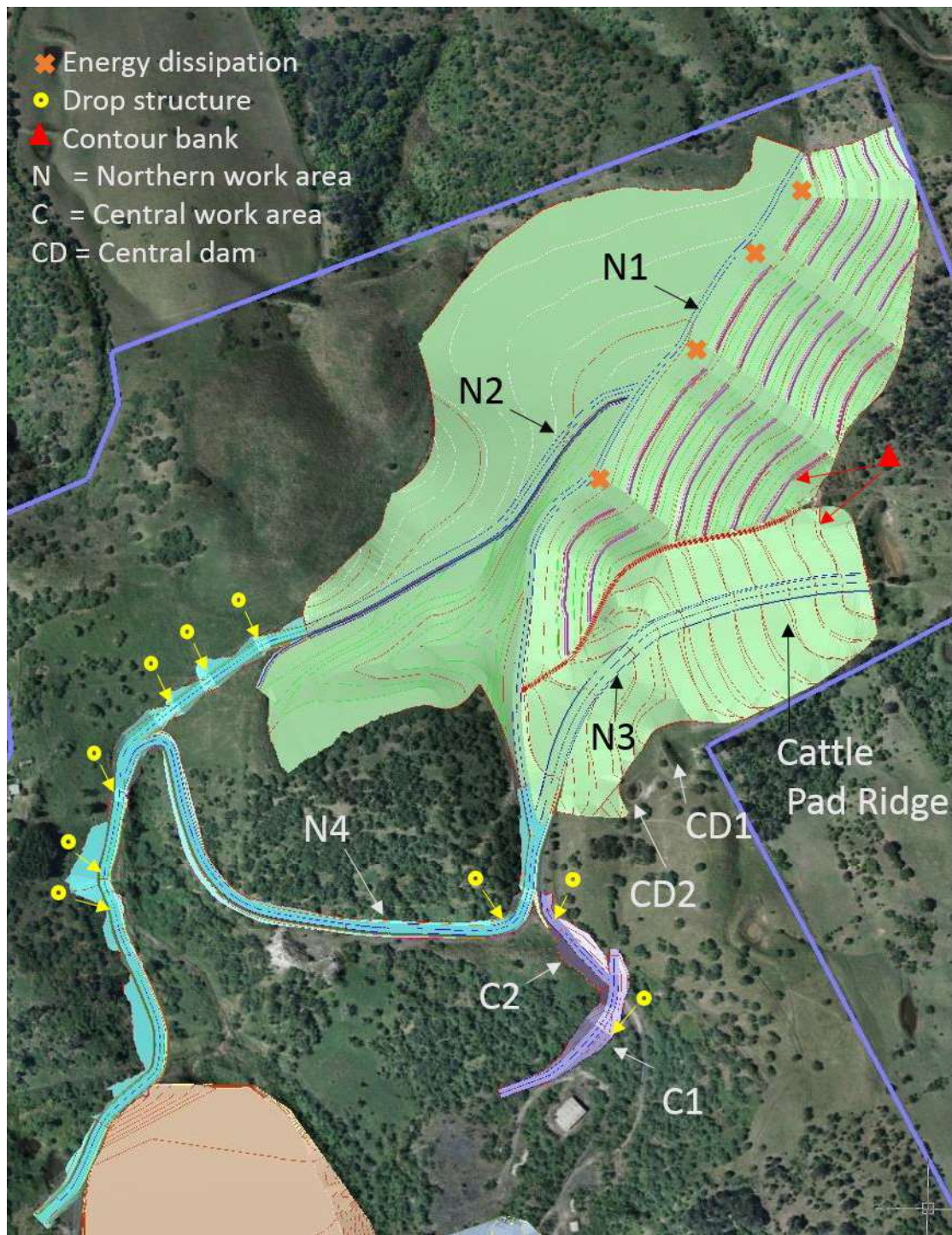


Figure 5.1 Detailed layout of northern and central work area showing key features of surface water management in relation to final proposed landform

5.2.1 Final proposed landform

The details for the landform for the northern work area are shown in Figure 5.1. A description of the individual features is provided as follows:

Drains

Key features are the main central drainage channel (N1), a secondary channel (N2) that drains the western spoil dump and a third channel (N3) that reinstates the former drainage under what is currently a spoil dump referred to as Cattle Pad Ridge. These channels have been designed to have as low a grade as possible within the constraints of the site, with an objective of less than 1.5% slope wherever possible. N3 is steeper than the other two channels but also has allowance for a broader channel base to spread flows and reduce velocity.

In its southern end, N1 generally follows the existing artificial drainage currently in place, while in its central and upper reaches it is a new construction sited over the tailings pit and draining from the catchment divide with Blacksnake Creek in the far north-east of the site. We have assumed that the tailings pit will be drained and that adequate compaction will be achieved during backfilling and emplacing the cover system. This should not impact on the drainage design if further minor subsidence occurs.

N2 is a significant diversion bank in fill for most of its upper and middle reaches and only becomes a more traditional channel where it has to traverse quite steep grades (junction of green and blue shading). The most northern end (solid dark blue line in the figure) is designed to drain north-east and discharge into N1 while the broad, light blue section functions as a channel flowing southwards. The light blue stream segment requires six drop structures as shown in Figure 5.1 that are necessary to manage the large difference in elevation to south of the junction with the cumulative drainage from the east via N4.

The final section of the N2 channel drains southwards towards the washplant dam, which is to be drained and filled (discussed later). This section of the drain has been sited on the slope to the west of an existing gully. The main reason for this is that additional drop structures would be required due to the steep gradient to be negotiated if all flows were discharged into the existing gully. This existing gully flows under the railway line at a point where the bridge has been washed away during a storm event. The proposed drain will also cross under the rail corridor at this point but no consideration has been given to what treatment may be required for the rail corridor. Drainage is then westwards around the washplant dam and down generally parallel to the Rosewood-Marburg Road into Covers Gully. It may be necessary to provide some abutment protection at the former bridge site to prevent further erosion of the rail track but access to this point to assess need has not been possible to date.

N3 is also constructed in fill and generally follows the former drainage location though at a slightly higher elevation. N3 and N1 join just below the point of spoil rework and are then channelled in a single-sided (downslope side) channel (N4) generally following the access road to the bentonite dump. This route allows for a low grade channel and causes minimal disturbance to the area of native vegetation to be retained as part of the EA requirements.

This channel (N4) eventually converges with N2 and flows down a constructed channel (largely a cut channel with only minor fill sections) located on the slope immediately to the west of an existing gully. This location has been chosen to minimise the need for the number of drop structures to negotiate the steep fall and to finally align with the bridged section of the rail corridor. N2 then flows to the western side of the rehabilitated washplant area and discharges into the northern tributary of Covers Gully between the Rosewood-Marburg Road and the transfer station site.

Only the lower sides of channels N2 (northern end) and N4 require constructed banks to contain water. All other drains should be constructed as broad-based flat bottom channels, well topsoiled and grassed with an effective low growing grass cover and not tussocky species that are likely to lead to channel instability in the medium-term.

Where channel N4 below its confluence with N3 turns westwards, there will be a need to line the bend with geofab and riprap to prevent scouring of the outside curve. It is not anticipated that the subsequent downstream curves at the western end would require similar protection as stream velocities here should be much lower. Nevertheless, monitoring of this western end during establishment will indicate whether attention needs to be paid to further stabilisation/modification in these sections or a risk averse approach would be to install protection initially.

There is an area sited between N2 and part of the retained vegetation to the west of N1 channel lower reaches. This has been planned without a constructed drainage channel with as low a slope profile as possible and a broadly dished flow path into N1. No contour banks are proposed in this area as when well-grassed, based on observations elsewhere on the present site, we believe that this will sustain non-erosive flows.

Contour banks/waterways

As the slopes from the highwall are of necessity steeper than the desired 17% (i.e. approximately 20%) to comply with site constraints, it is necessary to construct a series of contour/diversion banks on the slopes. These limit the overland downslope flow length to approximately 30 m. These banks flow at <1.5% grade then discharge into constructed waterways that deliver water to N1, N2 and N3. These are planned as broad, flat based channels approximately 5 m wide.

It will be critical that these channels are adequately topsoiled and well grassed to ensure stability. Though it will be difficult to manage in the long-term, it is also important that any cattle pads that may develop in the channels are removed to avoid gullies developing and causing failure of the scheme. These contour/diversion banks then discharge into downslope waterways with flat bottom, trapezoidal profiles to carry water down to N1. Each waterway is subtended by a 2 m high gabion structure as discussed later. These waterways need to be well-grassed with sward type grasses to provide stable flow conditions.

Energy dissipation

The base of each of the downslope waterways in the north-eastern section over the final highwall requires treatment with an energy dissipation measure (Figure 5.1) where the waterway channels meet N1. We propose that this be in the form of a two metre high gabion structure with an overfall mattress in the channel of N1 at each interception point.

Drop structures

A series of six drop structures are indicated for the final section of channel N2. These are required to manage the large elevation difference while still controlling channel grade to an acceptable non-erosive slope. The diversion channel (N4) from the bentonite dump section joins N2 just above the fourth drop structure so that the combined flows can be safely managed before flowing over the final two drop structures in the sequence and into the defined channel of the Covers Gully north of the washplant dam.

5.3 Central Work Area

The central work area features a stream that has the majority of its catchment outside the disturbed mined area. Pre-mining, this stream flowed roughly east-west some 250 m south of the current drainage line. That previous location has been mined and backfilled so that the stream now flows further to the north below a spoil stockpile that is south of the final void. The stream enters the mined area at a bend in the fence at the base of the stockpile and flows via two farm dams, discharging south-westwards across the washplant/ROM pad and ultimately into Covers Gully.

The stockpile lies over a mined area and, based on the floor level of the coal seam in the adjacent final void, it is likely that there is more than 60 m depth of spoil in parts of the stockpile. The extent of this stockpile (named Cattle Pad Ridge for discussion purposes) that lies above the original surface is shown in Figure 2.2 and Figure 4.1 with almost all lying between 5 and 35 m above the pre-mining surface. Thus, any redevelopment of drainage in this area will be established in fill material to a large extent and will require special treatment.

We understand that the majority of this spoil was probably sourced from the final mining area to the north and the landform plan has it being returned to that area to backfill the final void.

The design features for the central work area are shown in Figure 5.1.

5.3.1 Final proposed landform

There are two design features in the central work area. C1 is a constructed channel structure that starts just upstream of the existing access road, crosses the road and then discharges at grade into the existing drainage line that flows past a former tailings dam and into the channel that drains to the south and across the washplant/ROM pad into Covers Gully. Two drop structures are recommended here but this may depend on field inspection at the time as regrowth is too dense to determine the need for them confidently at present. This channel has been sited to avoid the need to clear good regrowth to the north that can be used towards the EA requirement.

The second feature of this area is C2, which is a low embankment. This is needed to prevent water from the catchment outside the project area joining up with flows from the northern area in N1/N3 as such a combined flow would exceed channel capacity in N4 and lead to significant erosion risk. This bank should be keyed into the existing low dump that is sited in this area below the current discharge point of the channel constructed to drain the final void which is to be diverted into N4.

5.4 Southern Work Area

The southern work area is nominally referred to as the out-of-pit dump but it actually lies in part over a former pit that was mined out early in the open cut sequence. It is likely that it was used for spoil from the central work area section of the pit as the mine moved progressively northwards. As shown in Figure 2.2, and similar to the central work area, the land surface now all lies between 5 and 35 m above the pre-mining surface.

The placement of the spoil is highest overlying the former position of the main drainage for this area and current drainage has now been pushed to the north. Here, it flows against an un-mined area and past a remnant of RE 12.9/10.6 and 12.9/10.2, which has been discussed in s 2.1.4. This relocation of the drainage has resulted in a confined flow path with a steeper grade than previously, leading to severe gullying along the north-west end of the dump.

This out-of-pit dump is targeted for sourcing the approximately 1 Mm³ of fill required to assist with landform development in the Normanton Pit, which abuts it immediately to the south. This approach has been adopted as by sourcing fill from the most easterly end of the OPD it means lowest costs for earthmoving. Nevertheless, this dump contains more spoil than is needed to reinstate a stable surface runoff management plan within the southern work area, and part of this excess will be used to cover the deficit in the northern work area and for disposal at the washplant dam and ROM pad site.

The plan focuses on moving only the optimum amount of material required to achieve a sustainable, functional surface drainage system that will meet regulator requirements for relinquishment rather than targeting something approaching the pre-mining condition. The design features for the southern work area are shown in Figure 5.2.



Figure 5.2 Detailed layout of southern work area showing key features of surface water management in relation to final proposed landform

5.4.1 Final proposed landform

Key features of this southern work area include a single main channel (S1) to be constructed approximately over the original location of drainage in this area. This channel will also receive inflows from outside the mined area including discharge from a large farm dam on the adjacent property. The drainage has been sited this way so as to allow for protection of the remnant RE by reinstating the final landscape so that it drains again to the channel rather than have drainage directed towards the remnant where undercutting and erosion have resulted. Thus, the spoil dump will now drain centrally again.

An allowance has been made for approximately 1 Mm³ to be removed from the upper (i.e. eastern) end of the spoil dump for rehabilitation in Normanton Pit, as this provides the shortest haul route. A further 300,000 m³ approximately is required from this dump to complete landforming in the northern work area. The final landform has then been configured to provide a stable drainage path

to manage the large elevation difference from the eastern boundary of the site to the discharge point just west of the internal access road near the rail corridor. To achieve this stability, grade is managed by instating five drop structures and minimising channel grade between structures. An alternative is possible whereby a shock dam(s) could be constructed instead of (or in addition to) the most upstream structure. The site selection would depend on the size of the dam to be built and acceptance by NHG of this as an alternative means to manage the inflows.

In creating this landform, approximately 180,000 m³ of spoil are then removed from the remainder of the out-of-pit dump to complete filling and reshaping of the washplant dam and ROM pad to achieve effective drainage into the channel alongside the rail line and into Covers Gully.

There are small stockpiles near to the washplant/ROM area that need to be reshaped in creating this landform. This area has been designed with a steep batter on the western and north-western sides to protect the ICC access road. The final landform will drain back towards the rail corridor and into the channel to be established along the western side of the rail line. This channel eventually drains into Covers Gully to the south of the former landfill site. A general location has been given for a crossing of the rail line. This may need to be relocated once the site is cleared somewhat as it is currently overgrown, making identification of such detail difficult. Further, a rail carriage also appears to be abandoned approximately where the crossing is proposed. It is not clear if a bridge exists in this general area but as drainage prior to mining used to flow under the line in this general area, it is likely that there is a culvert or bridge that may now be covered by spoil in this site.

5.5 Overview of Landform Proposed

An overall oblique view of the proposed landform showing the works areas for the complete site is provided in Figure 5.3 to give a general perspective of the proposed works. This plan is shown relative to the known area of disturbance associated with the open cut mining. All drainage will leave the site in the south-west corner of the mined area at the lower left of the image.

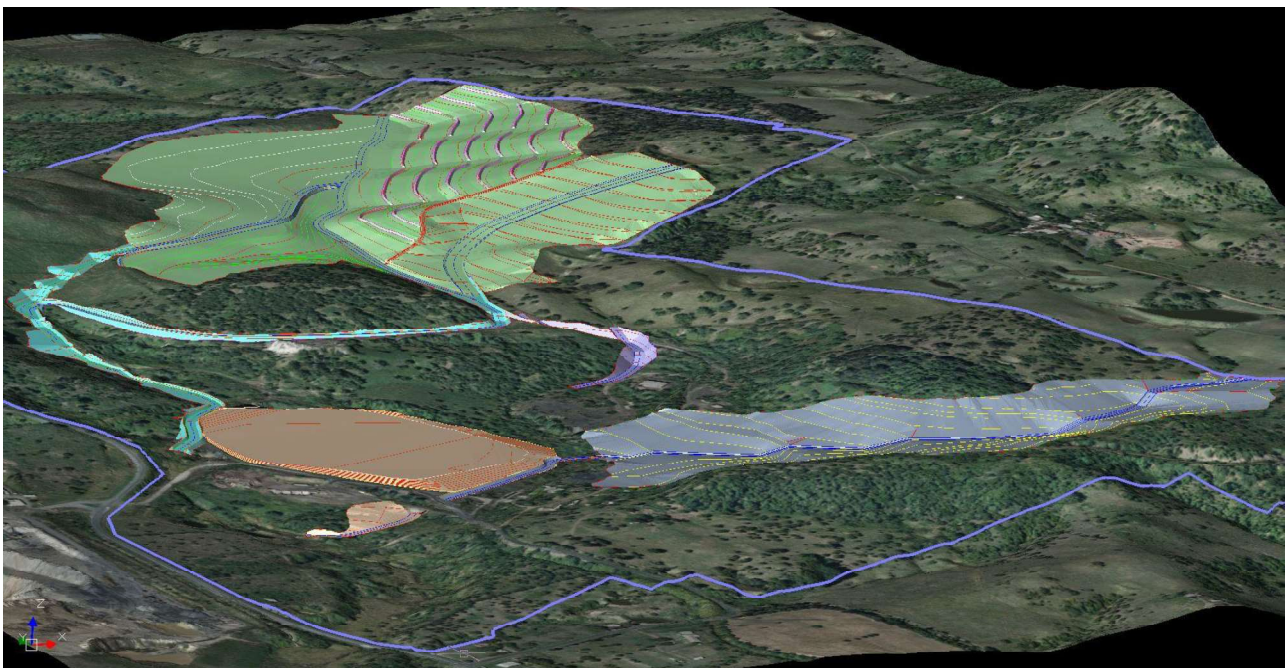


Figure 5.3 Oblique representation of final landform proposal looking from south-west

5.6 Summary of Estimated Earthworks

Only two main areas are seen as providing the required volumes of spoil to be moved the least possible distance for filling the voids and creating a final landform for the site. These are the areas identified as Cattle Pad Ridge and the out-of-pit dump in the south.

Other local sources will be reworked where they stand or can be moved short distances simply by dozer. These include small stockpiles on or near to the washplant/ROM area and the rehabilitated area in the north-west of the site that is to be reshaped to drain into N1 and N2 at a lower grade than presently.

Estimates have been made of the earthworks balance and these are presented in Table 5.1. Based on calculations made from the underlying data presented in Figure 4.2, it appears that there will be some 690,000 m³ of spoil that can be retained in the out-of-pit dump, thus reducing earthworks costs substantially.

Table 5.1 Volumes (estimated) of cut and fill required for proposed landform plan

Area	Cut (bcm)	Fill (bcm)	Balance (bcm)	Cumulative balance (bcm)
Out-of-pit dump	1,483,430	14,382	1,469,048	1,469,048
Normanton Pit	0	1,000,000	-1,000,000	469,048
Highwall	760,042	1,071,435	-311,393	157,655
Other drainage			26,639	184,294
Washplant and pad area	70,057	254,351	-184,294	0

Thus in summary:

- the highwall area will be largely filled with material gained from the Cattle Pad Ridge by dozer
- the deficit of approximately 300,000 bcm will be sourced from the southern OPD and will need to be trucked to site
- the slope on which N2 is located will largely be formed by reshaping the north-west spoil dump by dozer
- 1 Mm³ of spoil will be removed by truck and shovel from the southern OPD and transported to Normanton Pit
- the washplant dam and ROM pad will be filled and reformed by moving material locally and also by transporting some 180,000 bcm from the southern OPD to the site
- N2, N4 and C1 will be largely established by locally moving and reworking material
- N3 will be instated once Cattle Pad Ridge has been largely moved to fill the highwall area
- S1 will be formed by progressively reshaping the southern OPD during the process of removing material for Normanton Pit, the highwall area and the washplant/ROM site

6 Recommendations

6.1 Spoil

6.1.1 Stripping depth and stockpiling

The spoil characterisation by Landloch (2013) showed in general a distinct increase in pH and sodicity for spoil from depth compared to that from the upper 10 cm. Therefore, the upper layer should be stripped and stockpiled separately from deeper material and reapplied to the reshaped landforms as topsoil substitute.

Erosion gullies exposing currently rehabilitated spoil suggest that the better quality topdressing may be thicker than 10 cm in places (light brown material in Figure 6.1) though site observations did not indicate that this was a uniform characteristic across the site. Therefore, where there is a visual difference between the upper and lower spoil material suggesting an accumulation of organic matter, the complete upper layer should be stockpiled separately or at least a maximum thickness of 30 cm if deeper to the poorer quality spoil material. This will improve the potential to retain the partially leached top layer that contains a level of biological activity, seed sources and may be somewhat leached of salts for better outcomes. From the limited observations made, it does not appear that rehabilitation and ground cover responses have been as marked as at the Normanton Pit and this may reflect different species selection (e.g. an apparent lack of a legume species in the mix), fertiliser rates and different grazing pressures.



Figure 6.1 Topdressing on current rehabilitated landform

Nevertheless, ground cover establishment has been sufficiently effective in places to contain erosion on sometimes >20% convex slopes where runoff is not concentrated into defined drainage channels and contributing catchments are not too large.

Material below the surface stripped zone, from approximately 0.3 m to approximately 1 m deep in successfully rehabilitated areas, should be stripped separately and used at similar depths in the re-built surface if it can be stripped, transported and placed without the additional handling and costs associated with loading and carting to temporary stockpiles. Where this material cannot be used directly, mine spoil placed below the immediate surface material should have the following attributes:

- pH <9.0
- salinity <4.5 dS/m
- texture - sandy clay loam or finer

Given that some leaching of salt will occur under rainfall, these specifications should provide adequate soil water availability to support successful rehabilitation. Testing for pH and salinity (i.e. electrical conductivity by field meter) at the time of removal and re-use should be conducted regularly during stripping.

Stripped topdressing should be handled and stockpiled in accordance with best practice topsoil handling and stockpiling. Stripped material should be immediately respread onto already reshaped landforms wherever practicable. If the material cannot be reused immediately, stockpiles should not exceed 2 m in height and any material stockpiled for more than six months should be vegetated as an interim measure to retain/encourage biological activity.

If material from the southern out-of-pit dump is to be reclaimed for use at Normanton Pit, then staging of the rehabilitation and landforming design will be necessary in managing landforming in both Oakleigh East and Normanton Pit to avoid the risk of rework through secondary stockpiling of removed material. The removal of material in this area should be conducted with the final landform for this southern drainage in mind. In this way, the former drainage can be reinstated so that it also addresses the severe erosion problem, re-establishment of drainage gradients and the retention of the Regional Ecosystem remnant that lies just outside the pit wall in this area by selectively removing materials progressively closest to their final position. Design of an earthworks plan for scheduling material removal and transport will help in this aim.

The plan has been nominally based on removing spoil from the Cattle Pad Ridge immediately south of the residual void as the main source of fill for the void and high wall rehabilitation. Preliminary calculations indicate that there is still a deficit here and that spoil from the southern out-of-pit dump will also be needed.

6.1.2 Additional sampling

Maximum sampling depth in the Landloch study was 100 cm (Landloch, 2013). Thus, knowledge of the nature of the deeper materials is deficient and is of concern given the size/depth of the spoil dumps in the project area and the requirement for significant reshaping. However, due to the highly variable material and likely presence of large rocks/voids, challenges of sampling of spoil below 100 cm render further sampling for characterisation unlikely and potentially an issue to be managed during actual earthmoving should any unsuitable (e.g. dispersive) material be encountered.

Material below 2-3 m is expected to have lost most microbial activity since emplacement making the revegetation of this material more difficult. Consequently, material which is currently deeper than this should be replaced deeper than 2-3 m in the reshaped landform.

Mine spoil often shows a high spatial variability, in both chemical as well as physical properties, depending on bedrock geology and mining method (e.g. powder factor). Therefore an appreciable variability of mine spoil quality can be expected across the project area. To improve landform stability success, further material characterisation should be undertaken of the south-eastern out-of-pit dump and the Cattle Pad Ridge spoil dump adjacent to the final highwall.

6.2 Drainage Channel Establishment

Though drainage at a gross level will not be changed post-mining in that a small portion will still drain to Blacksnake Creek in the north and the rest of the site will continue to drain to Covers Gully other than for a minor drainage into Normanton Pit in the south-east, the drainage pattern and spatial arrangement of the sub-catchments will be quite different. Key differences include stream order, sub-catchment size, channel grade and cross-sectional area, all of which will result in different flow characteristics for the site. This means that streamflow patterns in terms of volumes, velocities and timing will be delivered to the exit points from the site somewhat differently to pre-mining. The landform modelling deals with this to the extent possible given the lack of streamflow data for the site and the absence of site hydrology. Nevertheless, there may be a period of dynamic instability in the channels as they adapt to the new flow regimes requiring some early modifications and maintenance inputs. At this stage, widths suggested for channels are only indicative and will need to be validated prior to construction through more detailed hydrology.

A consequence of this changed landform is that several drop structures and controls are required in the channels to manage the steeper stream grades that will be created as a consequence of the amount of spoil to be reshaped. These structures will control flow velocity/energy to avoid erosion on the steeper slopes in the spoil materials.

The use of small detention storages (i.e. shock dams) could be an alternative option to manage the higher velocity flows at or near a significant break in channel grade, with overflows being released at lower velocity into lower gradient, formed channels, particularly for Channel S1. No shock dams are currently planned but suitable sites could be considered in association with major flow paths such as N1 and S1. N3 already incorporates two farm dams that will fulfil this function.

6.3 Earthmoving Strategy

Though no detailed strategy is proposed in this report for creating the final landform for the site, our methodology is essentially based on:

- using all spoil from the Cattle Pad Ridge to fill the final void and reshape the green area as shown in Figure 5.1 and establish a landform to support N3
- moving approximately 311,393 m³ from the out-of-pit dump to the northern green area to satisfy the deficit in spoil required there
- the drainage lines are largely cut in either fill or un-mined land (minimal for the latter) and only minor fill is required to be moved for their construction
- approximately 184,294 m³ of spoil is removed from the out-of-pit dump and transported to the washplant dam and pad area

- approximately 1,000,000 m³ of spoil is taken from the out-of-pit dump and carted to Normanton Pit for landforming in that area

There will be a need for minor movement of fill during the construction of the nominated drop structures, at least some of which can be locally sourced.

This approach means that the landforming can be staged, largely minimising the total area being left bare during earthmoving at any one time and at risk of erosion. Thus, as a first stage, the northern catchment can be predominantly constructed by sourcing fill from the adjacent Cattle Pad Ridge using a combination of truck and dozer movement with the final material to come eventually from the out-of-pit dump after the majority of the landform has been created. No planning has been done as to how and where the topsoil and vegetative layer will be removed and temporarily stockpiled during this process in the northern area. Reshaping the northern area is by far the largest component of the final landform project in terms of area involved, volumes to be moved and design complexity.

Creation of the drainage lines and drop structures for both the northern and central work areas can be done concurrently with the above work or subsequently but it is important to time these works for the driest months to allow for effective completion prior to the likely onset of storm events.

The second stage would be the removal of spoil starting from the eastern end of the out-of-pit dump a short distance to Normanton Pit. This approach will facilitate progressive reshaping of the out-of-pit dump area from the top of the catchment downslope.

The final stage would be the removal of spoil from the out-of-pit dump across to the washplant dam and pad area with the reshaping and establishment of the new drainage system of the out-of-pit dump area being undertaken concurrently. Ancillary work such as revegetation of the completed areas and extension of the RE and retained timbered areas can be undertaken progressively as sections become available for access and do not impede further construction movements.

6.4 Drop Structures

A series of drop structures using such means as gabion baskets and mattresses is proposed at locations as shown in Figure 5.1 and Figure 5.2 for:

- slope drainage in the final highwall area
- along the drainage line in the north-west of the site (Chanel N2)
- in Channel C1
- in the southern out-of-pit dump area (Channel S1)

The use of drop structures provides two benefits in that they reduce the volume of spoil to be removed and translocated and they allow for managing channel flows where considerable elevation changes have to be managed as a consequence of the change in the post-mining landscape. A summary of the approximate heights of the drop structures for the main channels (identified by numbering from the most upstream to the most downstream drop structure) is provided in Table 6.1 to assist with preliminary cost planning. Indicative widths can be estimated from design information provided earlier.

A further five x two-metre high drop structures are required for the waterways that discharge into N1 in its upper reaches from the highwall slope. These are necessary to prevent head-cutting

developing and causing gullying to retreat upslope. Each drop structure will also require a mattress in the floor of N1 to deal with overfall turbulence.

No allowance has been made for estimating the mattress requirements, but similarly to those proposed for Normanton Pit treatment, they should be used both upstream and downstream of the gabion structures in the floor of the channel as well as for buttress protection. The general channel long-section profiles showing locations of the drop structures are given in Appendix A.

Table 6.1 Approximate heights (m) of drop structures for the main channels

Channel	DS1	DS1	DS1	DS1	DS1	DS1	Total
N2	4.5	5	10	5	9.5	5.5	39.5
N4	5.0	-	-	-	-	-	5.0
C1	10.0	9	-	-	-	-	19.0
S1	8.5	11	11.5	10	6.5	-	47.5
Waterways to N1 (x5)	10						10.0
Total							121.0

6.5 Revegetation Requirements

The concept plan was based on avoiding, to the maximum extent possible, any impacts on the area of well-established native vegetation located roughly centrally on site. This area will constitute a significant part of the requisite 30 ha of native ecosystem to be re-established under the EA for New Oakleigh mine. Retention of this area has been largely achieved and only minor impacts will occur along the access road to the bentonite dump where a constructed drain has been planned.

The remnant RE near the southern OPD has not been impacted by the design and the landform has been shaped to reinstate this remnant higher in the landscape so that runoff in this area drains similarly to in the pre-mining landscape. This remnant lies just upslope of the currently badly gullied drainage that has been initiated by imposition of the southern OPD in the former valley. By relocating the drainage closer to its original pre-mining position, there is an opportunity to extend this RE community by additional plantings of species represented in the remaining forest. This will not only assist in achieving the EA requirements for establishing the 30 ha of a native ecosystem, but target an endangered ecosystem, make it more likely to be sustainable by increasing its dimensions, and benefit the region by extending its coverage.

A large part of the site will be put to productive pasture so that the end land use of grazing will be achieved once ground cover is sufficient to reintroduce stock. Similar species to those used in the Normanton Pit rehabilitation would be appropriate. Recommendations have been provided in s 2.1.2 with respect to gypsum. General fertiliser recommendations should be assessed once topdressing is underway and a better understanding through analysis can be gained of the nature of the material available. A general dressing of a NPK fertiliser and inclusion of suitable legumes in the pasture mix should be considered.

6.6 Future Land Use and Access Issues

We understand that grazing is the proposed end land use once effective ground cover has been re-established and the surface drainage system has been demonstrated to be stable and functioning effectively.

The landform design does not include any provision for instatement of watering points, vehicle access tracks, yards, internal fencing or other infrastructure to manage livestock. These aspects can be planned and installed once the earthworks have settled and ground cover is considered sufficient to handle a grazing cycle.

Nevertheless, the siting of access tracks and infrastructure should consider the new landform, avoid crossings of the constructed drains at critical locations and avoid interference with structures such as gabion weirs and downstream mattresses within constructed channels. Any proposal to instate permanent access tracks should include crowning, grade control and the use of whoa boys on slopes as well as drainage to ensure that a new cycle of erosion is not initiated by the track design and usage. The constructed channels should never be used for vehicle access.

Grazing pressure should be well managed through stocking rates and use of watering points/fencing to ensure even grazing pressures across the site. A well maintained ground cover will perform better than overgrazed (susceptible to erosion risk) or under-grazed and rank pastures. Under-grazed pastures can be seen at Oakleigh West in the older rehabilitated area where Rhodes Grass and twining legumes are too tall for stock to graze and now present a severe fire risk unless slashed or crash c=grazed.

6.7 Further Work

To progress this concept design, several steps are indicated:

- proceed to detailed design once the concept plan has been accepted/amended (this should include hydrology assessments to validate the channel dimensions currently suggested)
- accurately identify the location of existing crossing points/culverts/bridges in the rail corridor so that drainage can be accurately aligned
- review tailings pit cover treatment to ensure compatibility with proposed design of N1 drainage
- confirm intent to remove material from southern OPD for use in Normanton Pit or it will be necessary to redesign landforming proposed for the southern OPD area
- determine preference/rejection for use of shock dams in conjunction with drop structures to control runoff flow (volume and velocity), particularly for S1
- plan for progressive monitoring/testing of stockpiled material being moved to prevent 'surfacing' of sodic or other unsuitable material
- assess impacts of using fill material from Oakleigh East in Normanton Pit rehabilitation on existing proposal for landforming in the southern part of Normanton Pit
- in discussions with NHG, select species to be used in rehabilitation (both grasses/legumes and trees) to best suit proposed end land use of grazing while meeting EA requirement for 30 ha of native ecosystem replacement
- plan for selective removal and replacement of near surface layer of soil material and grasses to improve success of revegetation program

6.8 Key Design Characteristics

Though the scope of works for this report does not specify the need for any detailed design inputs, the following have been provided as a guide to preliminary costing by NHG of likely commitments.

- Target grade for channels and diversion banks on slopes is <1.5% (and preferably <1% wherever practicable) but this is not always achievable. Where design constraints permit, grade has been managed by the insertion of drop structures and, potentially, shock dams where the final landform is amenable to construction of a storage (more investigation is required for this option if shock dams acceptable to NHG)
- Channel width for major channels (i.e. N1, N3 and S1) is minimum 10 m bottom width with a flat bottom profile though this needs to be validated by hydrological assessments during detailed design
- N2 is a perched, single sided channel in its upper reaches until below the confluence with N4. In the upper reaches where it drains to the north-east and into N1, it will be necessary to engineer and compact the diversion channel across the backfilled area as it is only a single sided channel with trapezoidal cross-section. Grade has been targeted at <1.5%. Below the confluence with N4 and through the drop structure zone that starts just upstream of this confluence, channel width is 10 m with a flat bottomed cross-section profile.
- Channel N4 is also a single sided trapezoidal channel with similar design characteristics to those of the upper reaches of N2. Additionally, in its major curves at both ends, there will be a need to hard-face the outside curve (i.e. downslope side) with geofab and riprap to protect against erosion under flow conditions
- Where the channel draining from the southern OPD passes to the south of the landfill site, the channel form has been curved away from the landfill batter so that any channel development that occurs over time will not attack the landfill batter. This outside curve will also require geofab and riprap protection. Batter protection may also be required following detailed site inspection to determine the extent of exposure (i.e. lack of vegetative cover) and presence of protruding undesirable materials/objects
- On the highwall backfill slope, the downslope waterways are proposed as 5 m wide (base width minimum) with a flat bottom channel profile and the contour/diversion banks enter the channel at floor level. Where these waterways join the main drain (i.e. N1) a 2 m drop structure with a gabion mattress in N1 on the downstream side is required to manage turbulence from the overfall
- All drop structures are based on a gabion type construction with mattress protection on both the upstream and downstream side to manage turbulence. Detailed construction design may be required for the larger structures (see Normanton Pit indicative designs)
- All channel floors are to be grassed as soon as possible following construction using suitable sward grasses such as creeping bluegrass (*Bothriochloa insculpta* var Bisset) or couch (*Digitaria didactyla* – more expensive but likely to be best performer in long-term due to drought resistance and tolerance of poor nutrition – may reserve its use for critical areas and can be undersown as seed into a sterile millet crop) and not tussock forming species. It can be sown together with medics and lucerne and generally will require a N:P:K mix at sowing. In the early years it is important that channel floors are slashed regularly to assist establishment of an effective ground cover and avoid loss of channel capacity. Trailing, climbing or twining legumes should not be used in channel plantings.

Rhodes grass (*Chloris gayana*) and green panic (*Panicum maximum*) are suitable grasses for the open areas to be grazed.

- Initiate review of final landform design for Normanton Pit to deal with implications of 1 Mm³ of backfill now to be sourced from the southern OPD at Oakleigh East
- In preparation for final land use of grazing, watering points should be located to preclude as far as is possible, the use by cattle of any channels/waterways for access to them

Appendix A Long-section profiles of constructed channels

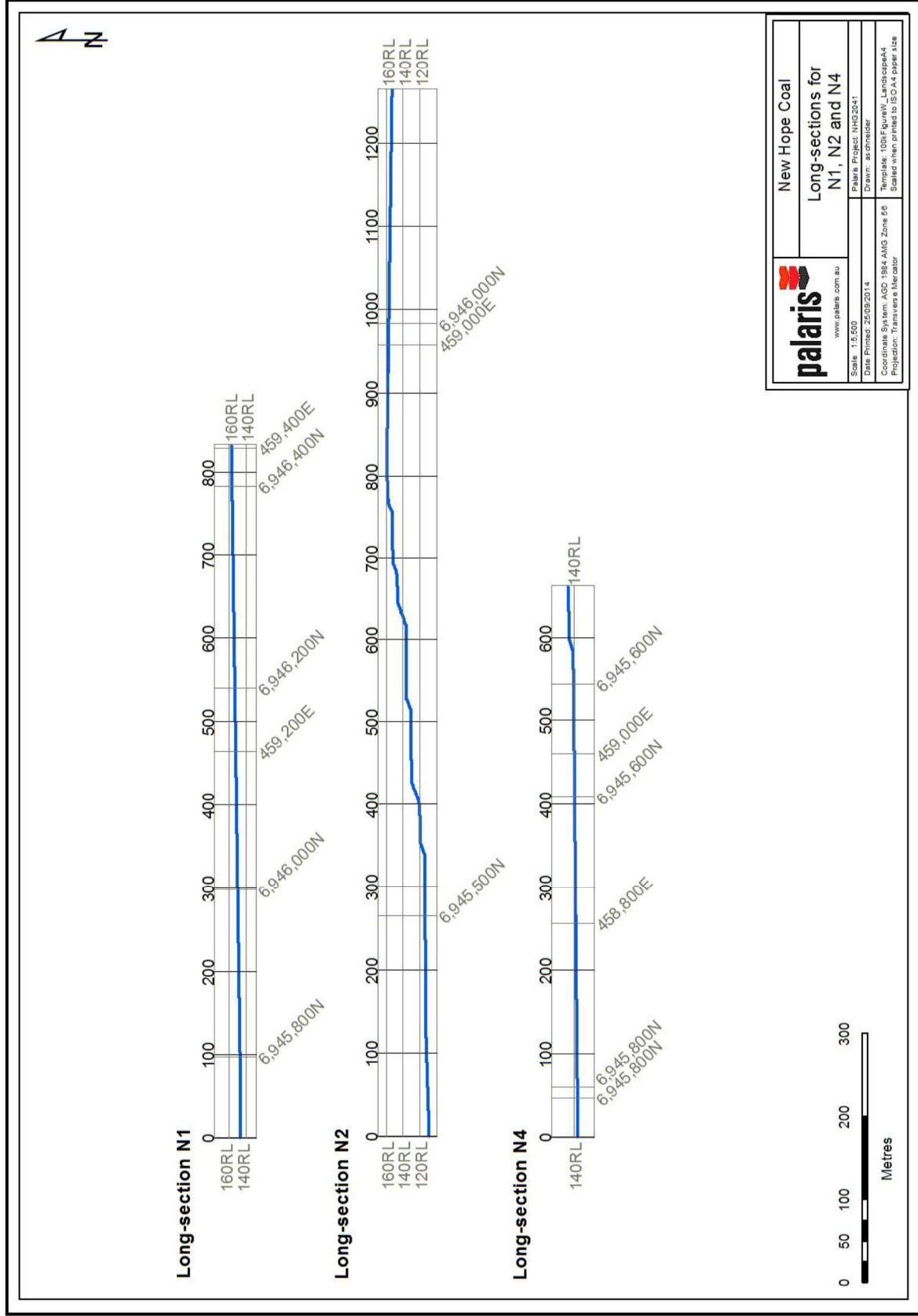
Long-section drawings

Long-sections for each of the main channels to be formed in the northern, central and southern work areas are provided in the following pages.

These long-sections show the proposed locations of the drop structures where they are required to manage grade and flow velocities in the channels at a concept level. Confirmation of the location and final heights of the various structures will only be available once a detailed hydrology and design for construction are undertaken. Thus, these profiles should be considered indicative only at this stage.

No drop structures are required in N1 and N3 and a long-section profile is not provided for N3.

For S1 in particular, there is potential to instate shock dams as an additional or alternative means of controlling runoff. The long-sections would assist in determining best locations but at this stage no attempt has been made to indicate positions in the absence of client agreement as to their interest in this approach.



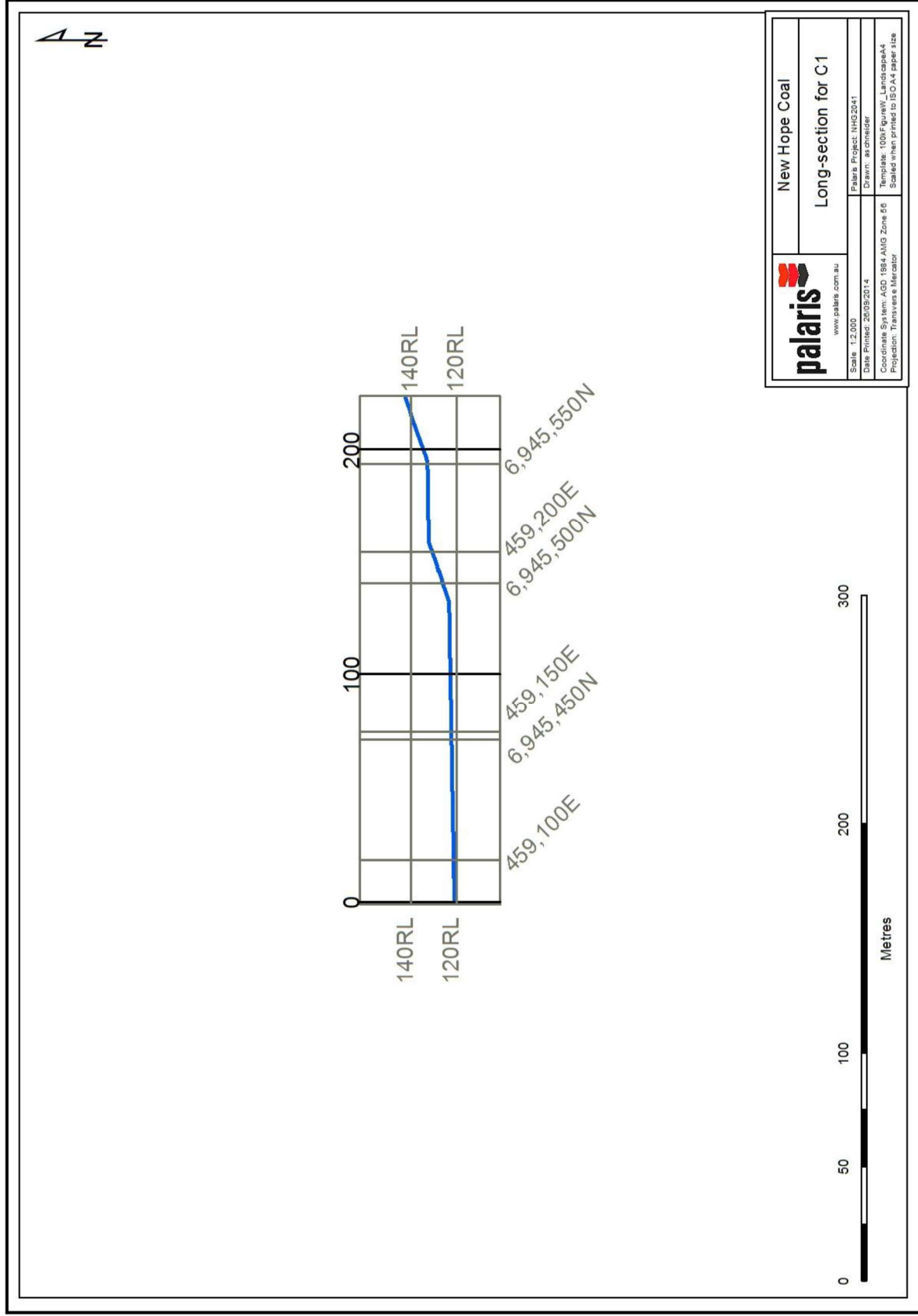


Figure A2 Long-section for stream with drop structures in the central work area (C1)

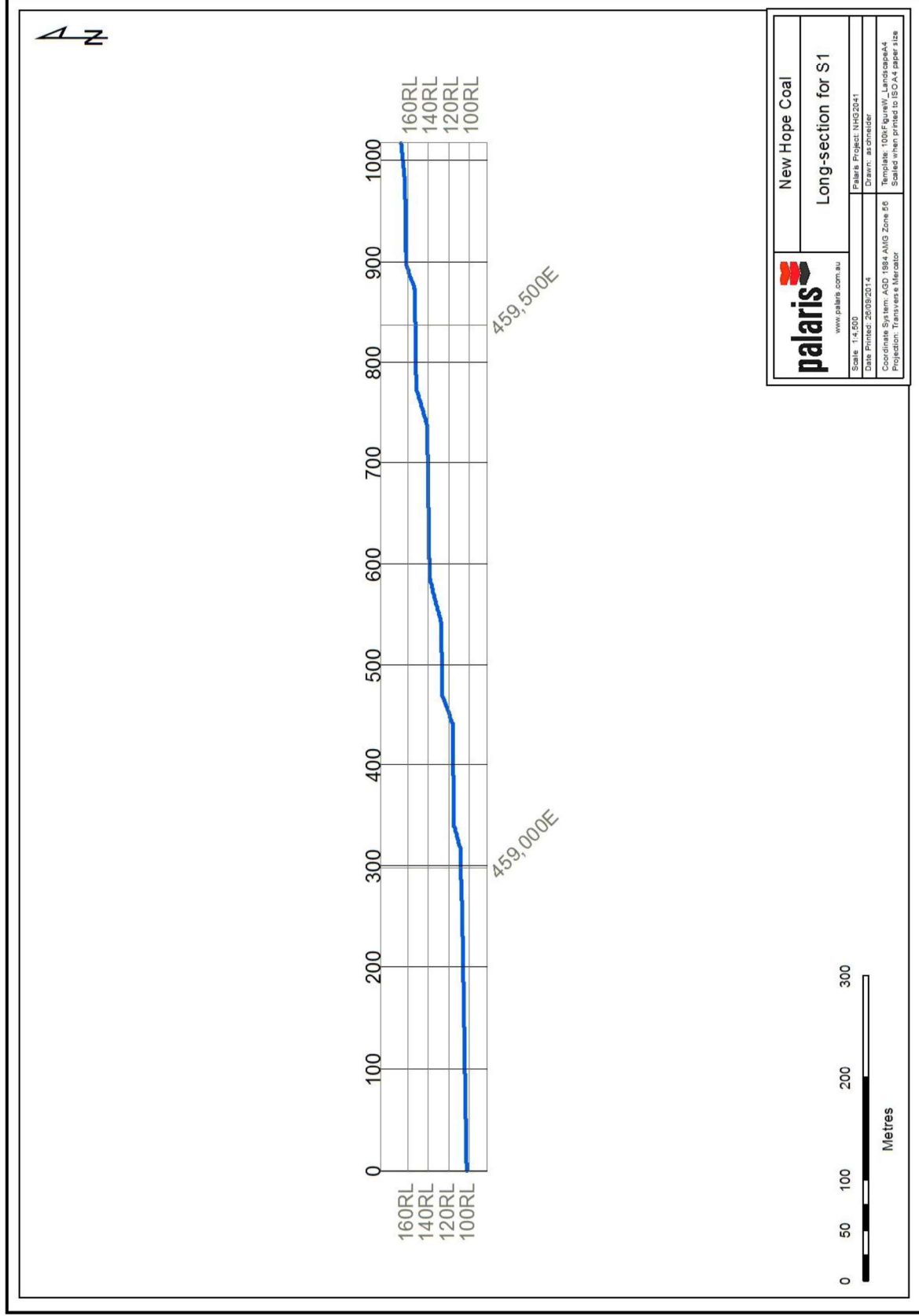
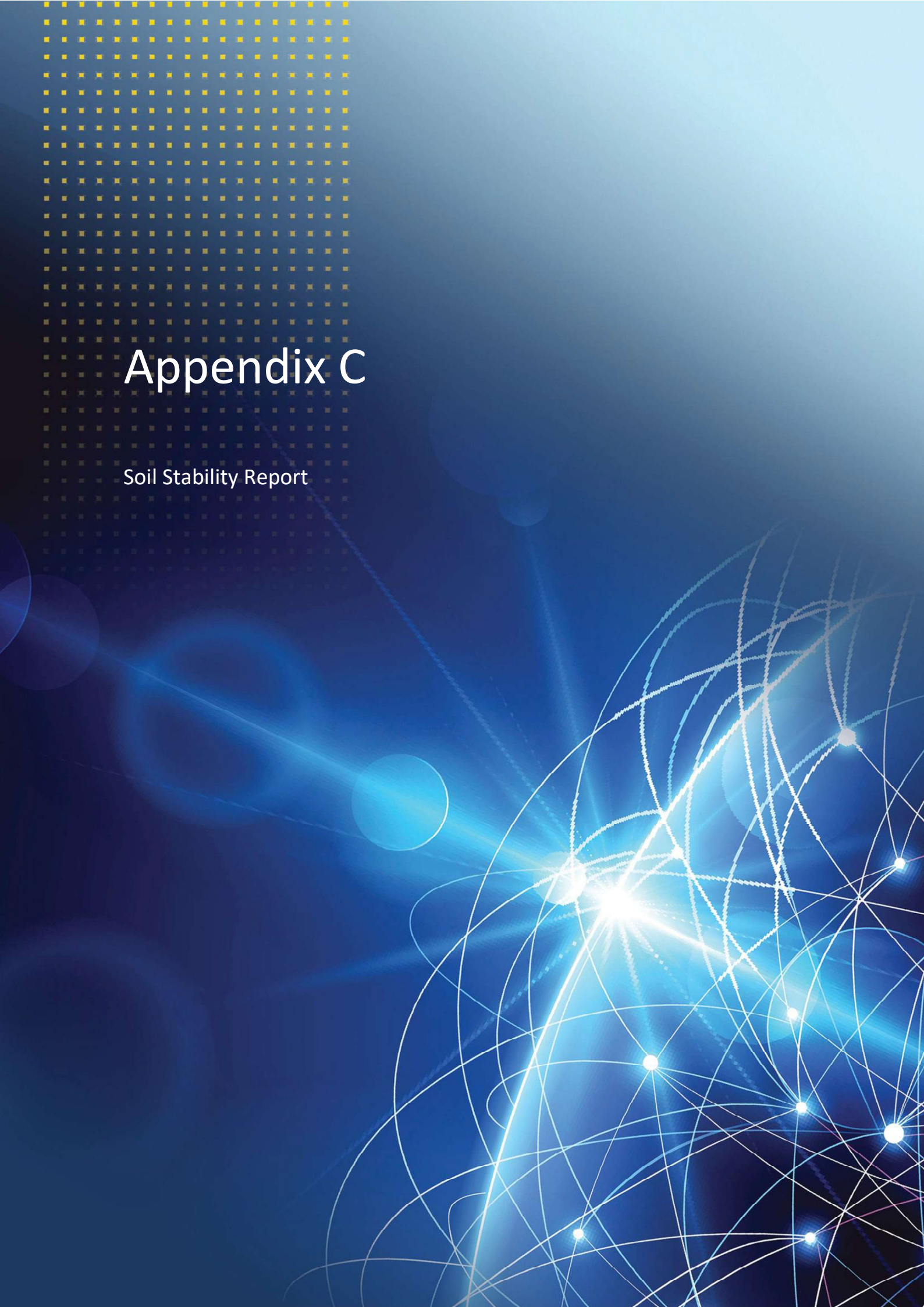


Figure A3 Long-section for stream with drop structures in the southern work area (S1)



Appendix C

Soil Stability Report



NEW OAKLEIGH COAL MINE NORTH HIGHWALL EROSION AND REHABILITATION ASSESSMENT

Final Report

28 September 2020

Prepared for:
New Hope Group - West Moreton Operations

Prepared by:
Houghton Environmental Management Pty Ltd

NEW OAKLEIGH COAL MINE NORTH HIGHWALL EROSION AND REHABILITATION ASSESSMENT

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1 INTRODUCTION

Houghton Environmental Management Pty Ltd (HEM) has been commissioned by the New Hope Group – West Moreton Operations (WMO) to undertake the assessment of erosion control and associated rehabilitation requirements associated with an eroded site within the New Oakleigh Colliery North Cut area.

KBR have been engaged by WMO to carry out post-mining rehabilitation design and closure planning for the New Oakleigh mine area. As part of this rehabilitation planning, KBR had previously commissioned geotechnical investigations associated with an area of the Northern Highwall which has remained largely bare and exposed to erosive forces since rehabilitation works were undertaken around the North Cut area in the last twenty years. The geotechnical investigation indicated some uncertainty regarding the geotechnical factors affecting the slope stability (refer Section 3.2.1) however it was considered that runoff and associated erosion of the surface and near surface exposures was a critical factor for control prior to implementing rehabilitation measures.

Accordingly, this report has assessed:

- The historic and current erosional severity and stability of the area in question
- The prospect of achieving erosional stability at the site to the extent that the slope can be suitably rehabilitated and be sustainable in the longer term
- The options available for stabilising and rehabilitating the site and determination of the most appropriate methods.

2 METHODOLOGY

The work conducted for this report comprised the following:

1. A detailed review of existing information and site aerial photography and mapping (including historic aerial photography)
2. A site visit to the New Oakleigh mine site and Northern Highwall area and a site walkover. Shallow hand auger soil sampling of the highwall area in question was undertaken and samples collected.
3. Soil samples were then laboratory tested for key physical parameters including dispersion rating, EC and sodicity plus pH, Cl, and Ca/Mg ratio and various other parameters. Overall rehabilitation commitments were discussed on site.
4. Review laboratory results and the outcomes of the site visit and consider the various erosion control/rehabilitation options for the area in question and their practicality and potential effectiveness
5. Provide recommendations for the preferred erosion control treatment of the bare part of the high wall. This will provide confirmation that the recommended treatment is suitable, based on the existing slope gradient and erosion/physical characteristics of the soil. It was noted that it may be the case that the erosion cannot be suitably brought under control at the existing gradient and significant reprofiling/earthworks may be required.
6. Erosion treatment notes (for the specific erosion area) were then to be added to KBR's detailed design drawings for the larger site.

3 SITE REHABILITATION FACTORS

3.1 Historic and Current Status of Site Rehabilitation

Figure 3.1 presents an aerial view of the site and surrounding former mine area as at 2020.

Rehabilitation works have been active in lands in proximity to the Northern Highwall for the last two years (capping of residual tailings dams). Prior to this, substantial earthworks including spoil placement and battering had been carried out in and around the former tailings dam to the north of the Northern Highwall over twenty years earlier. Extensive vegetative rehabilitation has been carried out to the extent that the subject portion of the Northern Highwall presents the main area where rehabilitation works have not been carried out to any significant extent and vegetation has not become established.

From discussions with WMO personnel (Brad O'Reilly, pers comm), rehabilitation works have included the placement of biosolids in certain areas adjoining the Northern Highwall area. The majority of the rehabilitated area is proposed to be used for grazing on improved pastures. It is also planned to establish an area of native tree species as a copse within the local landscape and at an area yet to be determined.

At the time of the site inspection (1 April 2020), a heavy grass and legume cover was evident over most of the rehabilitated landscape. The predominantly bare area of the Northern Highwall (herein Area A - an approximate area of 1ha) is in stark contrast to the surrounding vegetated area (see **Plate 1**). Indeed, the standard of vegetative cover in surrounding lands at the time of inspection was considered to be very good. This includes the steeply sloping spoil placement area to the immediate west of the Northern Highwall (see **Plate 2**).

3.2 Northern Highwall Site Conditions and Limitations

3.2.1 Geotechnical assessment and implications

As noted earlier, two geotechnical investigations have assessed the potential for the Northern Highwall area to be subject to slope failure due to geotechnical properties associated with the cut batter slopes.

Figure 3.2 (from Knight Piesold 2020) presents a diagrammatic cross-sectional representation of the geology of the batter in question.

The Knight Piesold (KP-2020) preliminary stability assessment summarised that the current slope profile did not meet the acceptance criteria for geotechnical stability. Under drained conditions, the failure was indicated as being mobilised through the coal layer, which is largely due to low shear strength parameters indicated by previous testing. In the undrained and post seismic conditions, the instability is characterised by shallow surface slipping, which was considered to be reflective of the current eroded slope condition.

A further geotechnical assessment was conducted by Sherwood Geotechnical and Research Services (SGRS). Based on shear strength parameters adopted by SGRS for geological materials equivalent to those present at the Northern Highwall, they reported that the highwall is adequately stable geotechnically and that suitable neutralisation and erosion-resisting treatments should be applied to manage risks associated with exposed carbonaceous materials at the current slope inclination. In support of this conclusion, SGRS noted that they had



Figure 3.1 Site Aerial (@2020)

Color	Name	Model	Unit Weight (kN/m ³)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Signa Ratio	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Coal/Paolite Bedding Material	Mohr-Coulomb	14				7	7	0	1
	HWMW Mudstone	Mohr-Coulomb	20				46	11.2	0	1
	HWMW Sandstone	Mohr-Coulomb	20				86	20	0	1
	Residual Soil	SHANSEP	19		0	0.25				1
	Soil	SHANSEP	19		0	0.25				1
	XW Mudstone	Undrained (Phi=0)	20	77.9						1
	XW Sandstone	Undrained (Phi=0)	20	90						1
	XW Siltstone	SHANSEP	20		0	0.27				1

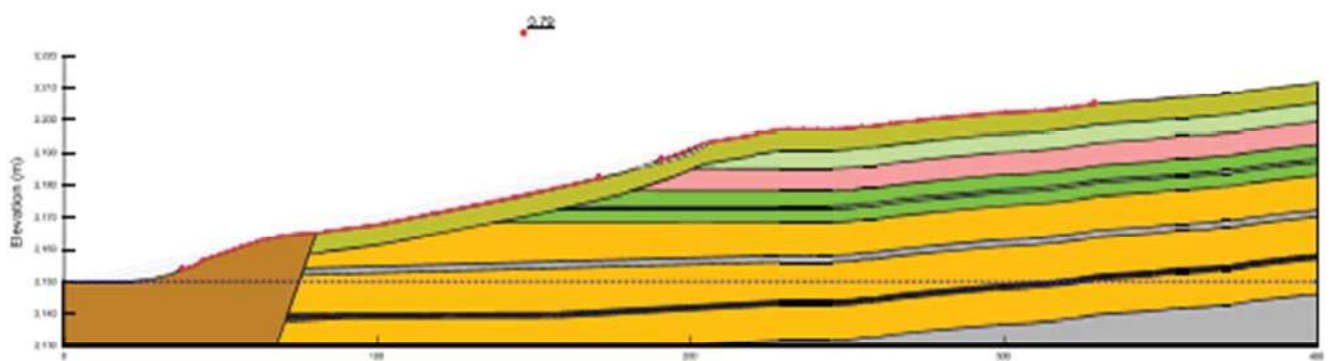


Figure 3.2 Geological X-section (from Knight Piesold)



Plate 1 View to site

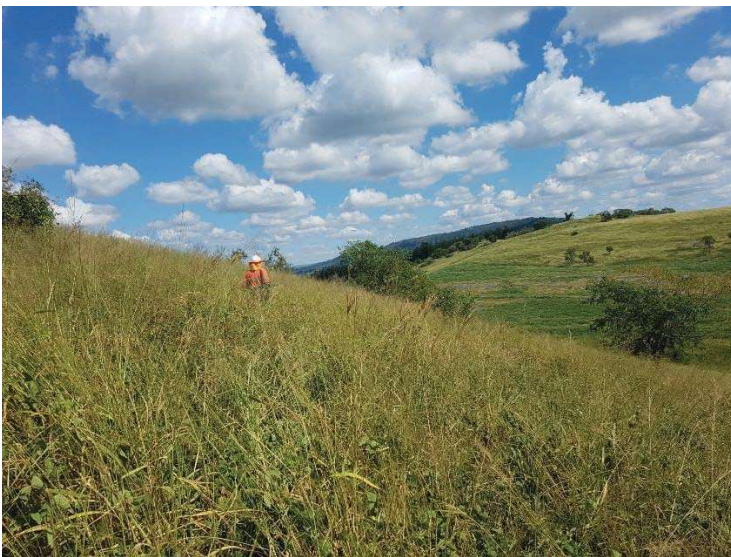


Plate 2 Rehabilitated slope within Area A



Plate 3 Gully erosion within Area A

observed the Northern Highwall slope over a period of a number of years and had not identified any evidence suggesting geotechnical instability.

3.2.2 Extent and severity of existing erosion of the Northern Highwall

Figure 3.3 presents the general boundary of the Northern Highwall area that has been previously assessed as in need of erosion stability treatment. This figure also indicates the existing 1m contour interval for the site and surrounds.

The prevailing slope of the general site is a relatively consistent 23 to 25% gradient throughout the bare area and adjacent vegetated land *i.e.* approximately 1V:4H or approximately 14°. Some localised short slopes may however exceed 33% gradient.

The following comments are made in regard to the existing extent and severity of the exposed and highly eroded area (Area A) of the Northern Highwall:

- Approximately 1.04ha of the Northern Highwall is essentially bare and exposed to erosive forces (Area A – see **Figure 3.3**). Only isolated tussocks of Rhodes grass are present in places. This erosion comprises extensive sheet and rill erosion with intermittent gullying up to 1.5m deep (see **Plate 3**)
- An additional area of approximately 0.8ha (mainly downslope and to the immediate north of the bare area – Area B) has suffered extensive erosion in the past but at the time of inspection had a heavy grass/legume cover. It is possible that during extended dry periods, this cover could significantly reduce particularly under heavy grazing pressure thus increasing the susceptibility to erosion
- Land to the immediate west of Area A (Area C – refer **Figure 3.3**) is stable with good cover and limited evidence of extensive erosion
- There is minimal lateral extension of the rills and gullies. Erosion caused by runoff from areas upslope of the bare Area A has thus been predominantly due to sheet flow erosive effects. The catchment area above the slope contributing runoff is relatively small with good vegetative cover and the length of overland flow relatively short (generally 50 to 80m)
- A minor gully/depression is located upslope and traverses the bare area. Under current conditions, discharge flows down this gully would be expected to be minor
- No visible evidence of active tunnel erosion but it is probable that this has occurred in the past and the tunnels (albeit shallow) have subsequently collapsed
- There was no significant visible evidence of active geotechnical instability *eg.* slumping, rotational slides, solifluction (small circular failures), etc confirming the assessment of SGRS.

3.2.3 Assessment of changes to erosion over time

In addition to the assessment of current site conditions, an assessment of changes to the extent of erosion over time has been conducted. This has been based on aerial photography available from 2003 (see **Figure 3.4 (a)**) when mining activities were active and rehabilitation works, including placement and backfilling of spoil over much of the site, had yet to be undertaken.

Figures 3.4 (b) to (d) indicate the changes that have occurred since that time for the years 2009, 2014 and 2020.

These figures indicate that:

- There has been substantial colonisation of pasture over much of the site (*eg* Area C)
- the most severely eroded area (Area A) has shown little change in aerial extent
- The severity of erosion with Area A and adjacent land has shown minor change over time.

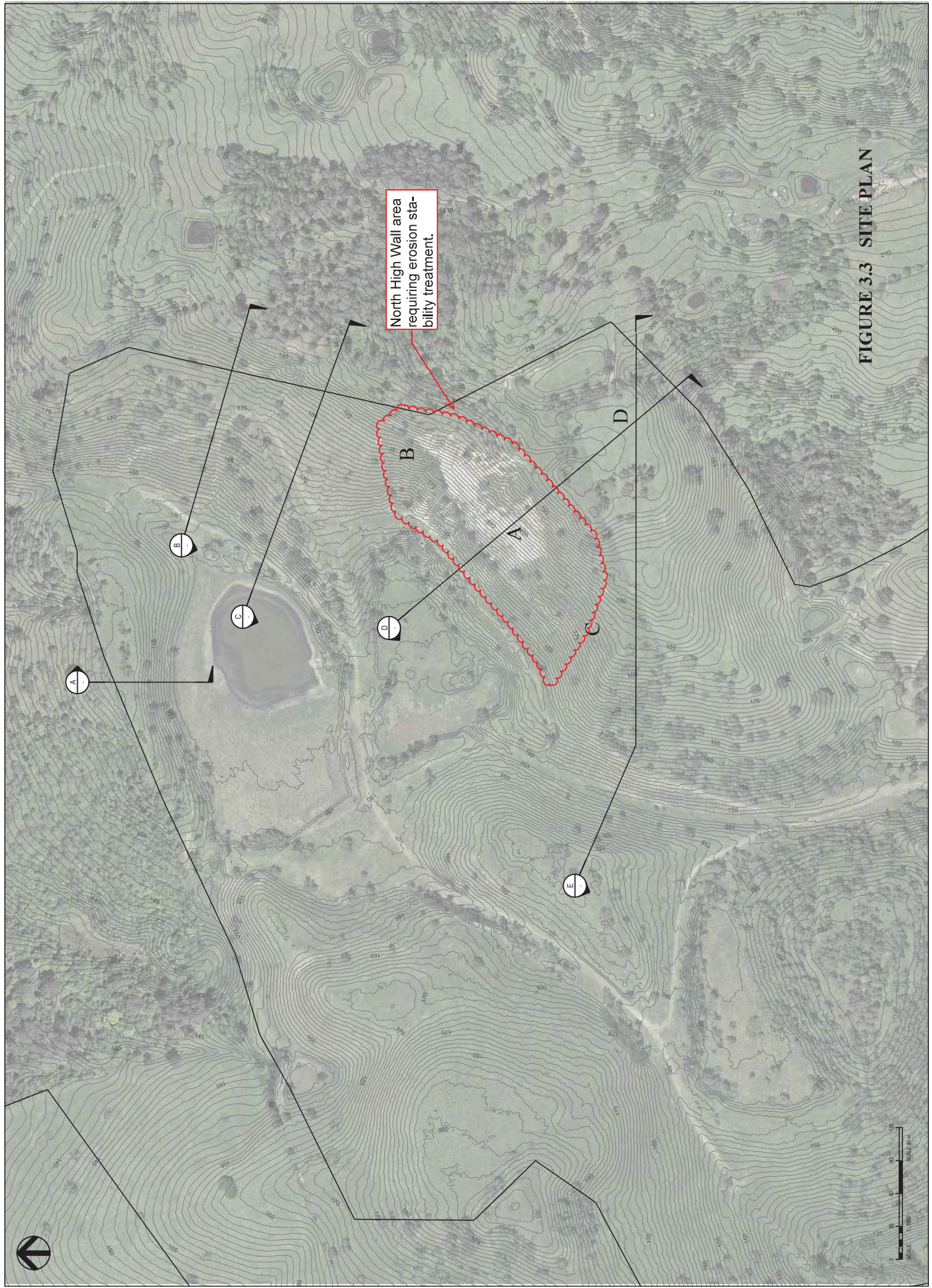


FIGURE 3.3 SITE PLAN

Figure 3.4 (a to d) Aerial sequence of changes to rehabilitation and erosion (2003-2020)





3.3 Characterisation of site soils

3.3.1 Overview

All exposed soils in the Northern Highwall cut batter slope (focussing on Area A) are essentially moderately to strongly weathered subsoils/'C' horizon material derived at the varying depths from the different sedimentary strata associated with the Jurassic Walloon Coal Measures. Stratigraphy comprises channel sandstones, finer-grained floodplain sediments and facies comprising coals, carbonaceous siltstones and some bentonite bands (Fielding 1993, in SGRS, 2020). Exposed horizontal bands of mudstone and siltstone at varying elevations downslope were evident during the site inspection as was a thin coal seam at mid-slope. No seepages were evident however only a portion of the eroded area was inspected.

Given the differences in the structure and depths of the banded layers, there is also a significant difference in the appearance, structure and textural qualities of soil in the various layers. The site investigation indicated the following physical characteristics of the exposed soils:

- No 'topsoil' or material that could potentially be used as a suitable alternative surface or near surface growth medium was evident
- Colours of exposures varied from light grey /light brown through to dark grey reflecting the substantial differences in the sedimentary rock strata and associated weathering
- Organic material was essentially absent reflecting the predominantly subsoil weathering processes
- Texture varied markedly from light sandy loose clays to medium stiff very hardsetting clays and commonly blocky in structure but with pockets of weak apedal conditions.

Sampling of the subsoils was undertaken at five locations within the bare eroded area (Area A) with the aim to gather a representation of the differing physical and chemical properties within the overall site. **Attachment One** presents the results of the laboratory analyses while **Attachment Two** presents the interpretation for each of the analytes presented in the laboratory data. Samples taken were material composites and were collected from a shallow depth only (~10cm).

3.3.2 Soil sample results and discussion

The following is a summary of the five sites sampled, focussing on those parameters that present particular issues and/or management constraints for erosion control and rehabilitation. Photos from each sample site are presented in **Attachment Three**.

- Site 1 (1): grey medium clay; high sodicity offset by elevated salinity (EC) levels; chloride (Cl) levels extremely high; SAR levels are acceptable; Ca/Mg ratio low; Dispersion low but probably suppressed by elevated salinity ; highly problematic for vegetative rehabilitation; no trace element deficiency or toxicity.
- Site 1(2): brown medium clay with some sand; highly elevated salinity; Cl levels extreme; SAR marginal; Ca/Mg ratio acceptable; Dispersion low but probably suppressed by elevated salinity; highly problematic for vegetative rehabilitation; no trace element deficiency or significant toxicity (Zn is very high but probably not toxic).
- Site 2(1): dark grey blocky medium to heavy clay (near coal seam?); extreme hardsetting, salinity acceptable and moderate sodicity; low Cl; dispersion level high (reflecting lower sodicity); no trace element deficiency or toxicity; strongly acid requiring rectification; other chemical parameters indicate no major constraints to revegetation.
- Site 2(2): light grey sandy medium clay; salinity low (possibly from leaching effects); generally acceptable chemical parameters; highly dispersive, likely very low plant available water holding capacity (PAWC), otherwise no major constraints to revegetation.

- Site 3(1): light brown loose sandy medium clay; salinity low (possibly from leaching effects); generally acceptable chemical parameters; highly dispersive, likely very low plant available water holding capacity (PAWC), otherwise no major constraints to revegetation.

In summary:

- Three of the five soil samples (Sites 1(1), 1(2) and 2(1)) have severe physico-chemical constraints to use for vegetative rehabilitation. While the application of treatments such as gypsum (or lime in the case of Site 2(1)) may ameliorate these constraints to some extent, dose levels would need to be high and the placement and incorporation of the treatments on site may be difficult due to the slope (refer Section 4.1)
- The two other samples (Sites 2(2) and 3(1)) are generally acceptable chemically however dispersion levels are high but not unusual. Soils would dry out rapidly so any grass cover established may be ephemeral at best.

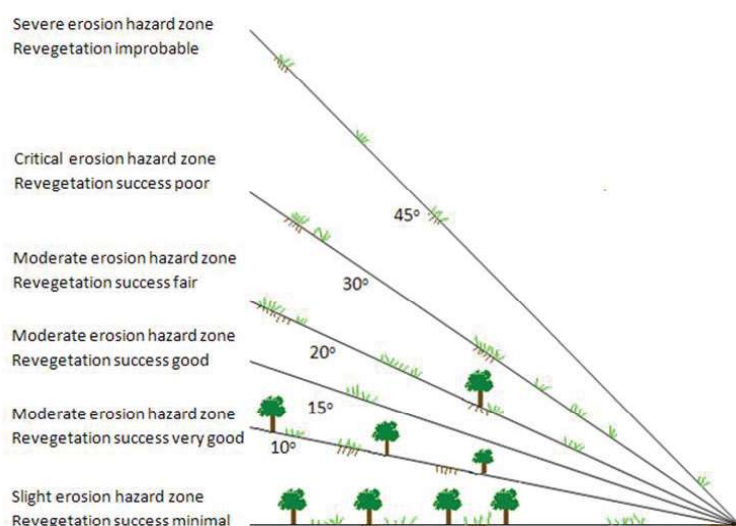
Based on the above assessment, due to the significant to severe material quality deficiencies and treatment constraints, it is considered that the exposed Area A will desirably need to be covered by a suitable depth of relatively well-structured weathered material in order to achieve sustainable vegetative rehabilitation for long-term erosion control. This matter is addressed in Section 4.1.

3.4 Considerations for determining erosion and rehabilitation options

3.4.1 Slope factors

In terms of undertaking material cover placement, it is desirable that the existing eroded landform be ripped and graded to an even contour prior to material placement. Ideally this working should be across the slope to obliterate erosion scars however most of the existing slope is likely to be too steep for earth-moving machinery (typically a large dozer) to traverse safely across the slope. The actual limits will depend on machinery being used however 20-25% is often regarded as the upper side slope safe working limit. This matter would need to be confirmed by site OHS personnel.

Irrespective of slope working limits for machinery, it is generally accepted that 20° (~34%) is the upper slope limit suitable for successful vegetative rehabilitation (see below).



Slopes within the bare area are below this figure whilst existing rehabilitation standard of cover of nearby steep spoil slopes demonstrate that suitable vegetative rehabilitation is achievable.

Machinery would thus need to work up and down the slope, typically starting with ripping and filling the gullies and then track-rolling with the aim to create as even a slope as is practical (refer **Section 4.1**).

3.4.2 Cover material and placement

As noted above, it is considered desirable to initially place a cover of weathered material with acceptable physical and chemical properties over the graded bare area. The source of this material has not been investigated for this report and potential supplies (other than from external commercial suppliers) are unknown. An option previously considered is to push *in-situ* material from land above the eroded area over the area in question thus flattening the overall slope down to a buttress at the base to the slope (the KP geotechnical report recommended a final 1V:5H slope). This has the advantage of ready access for earthmoving machinery between the source and placement area, as opposed to significant machinery access constraints to the bare area from other areas. Constraints to this approach are considered to be as follows:

- The unknown physico-chemical properties of weathered subsoil material from the area to be pushed. It is possible that properties at depth could be similar to those of the exposed material within the bare Area A
- A significant increase in the area of disturbance. A new and presently very stable area of land would then be prone to erosion and consequent rehabilitation requirements
- Gaining statutory approval to disturb a new area of previously undisturbed landscape and timing implications thereof. The extended timing and other logistical constraints may prevent adoption of this measure.
- Substantial costs associated with moving significant volumes of material.

There may however be the option of sourcing a significantly smaller volume of material from this area sufficient to cover the bare Area A but retaining the overall gradient for rehabilitation.

3.4.3 Structural control options (primary and/or supplementary)

Whilst it has been noted that the existing slopes of the bare area are of sufficiently low gradient to be conducive to vegetative rehabilitation, consideration needs to be given to alternative or supplementary measures to achieve runoff and erosion control on the bare area. However, as noted in **Section 3.2.2**, runoff from catchment areas above the bare area will essentially occur as a sheet flow based on the pattern of erosion downslope. Structural earthworks across the slope, whether they be by diversion or pondage banks, contour banks or other runoff control measures, would have the potential to concentrate flows and increase the potential for gullying downslope as well as increasing the seepage of ponded waters to subsurface layers thereby increasing the potential for tunnel erosion downslope (refer ACMER 2004). This may also increase the potential for geotechnical failure of the slope. An overall objective for grading and rehabilitation of the eroded slope is to avoid concentrating runoff flows. Structural controls are thus not recommended for erosion control of the slope.

3.4.4 Erosion control /stabilisation techniques and products

There are a range of stabilisation techniques (commonly associated with commercial products and/or suppliers) that could be placed on the graded bare area and provide suitable protection over a varying timeframe. These include:

- Soil binder/bitumen emulsion or tackifier
- Hydroseeding

- Straw mulching
- Hydromulching – includes use of a bonded fibre matrix and hydrocomposting
- Erosion control blankets – using synthetic or organic fibres (includes compost blanket)
- Cellular confinement systems (probably inappropriate for the site)
- Placed soils/turf (including turf reinforcement mats) or soils alternatives such as council-sourced biosolids. Note that WMO is understood to have used biosolids with success in the recent past for rehabilitation near the subject site.

The report by the NSW RTA (2015) provides coverage of the different options for steep batter slopes. While this report has primarily been prepared for road batter slope stabilisation, many of the measures discussed are applicable to the stabilisation of Area A.

This report has not assessed the relative advantages of each of the above techniques. A key issue (apart from matters such as the period of protection provided prior to a permanent vegetation cover being established, costs, etc) will be ease of access to the area to be rehabilitated. At present, there is no suitable means of access for machinery to Area A and a temporary track would need to be established at least to the toe of Northern Highwall. The maximum handling/'throw' distance for commercial spray operations using hydroseeding/emulsions etc. would also be an important access consideration.

In the eventuality that suitable machinery access arrangements cannot be made to the subject area, then it is possible that specialised handling arrangements using small machinery and/or manual labour may need to be employed.

3.4.5 Vegetation for slope stabilisation

Revegetation species presently used in adjacent lands to the site would appear to be appropriate to the rehabilitation of Area A (following treatment) with the following qualifications:

- Rhodes grass should remain the dominant pasture species for rehabilitation plantings however the Pioneer variety may be preferable to Katambora Rhodes grass in this situation due to a better adaptation to drier and less fertile conditions. However the recent 'Reclaimer' type of Katambora variety has a higher tolerance of saline conditions and may be a suitable alternative
- If a quick temporary cover is planned, seeding with barley may be better than millet as it is more salt tolerant, drought hardy and deep rooted
- Should it be proposed to plant native trees in the site, then *Acacia spp* may be more suitable than eucalypts due to the sodic ground and soil conditions.

4 OPTIONS FOR REHABILITATION AND PREFERRED STRATEGY

4.1 Erosion control and rehabilitation options

Based on the preceding assessment, there are considered to be a number of important factors in determining the most appropriate option/s for site erosion control and revegetation.

In summary:

- Based on the geotechnical assessments and site inspection findings, geotechnical factors are unlikely to cause significant failure of the existing slopes. The focus should thus be on implementing surface erosion protection measures combined with vegetative rehabilitation
- While the existing erosion within the bare Area A appears significant and unacceptable, it is believed that the existing extent and severity will show only minor change in the medium to long term. Nevertheless, natural vegetative colonisation will continue to be slow to non-existent due to the soil conditions. In terms of gaining regulatory approval, the rehabilitation standard for this area would be likely to be regarded as unacceptable.
- Significant erosion is evident in a substantial area to the immediate north of the bare area (Area B) however the erosion scars have been naturally colonised and stabilised by pastures. While it is not recommended to undertake ground disturbance of this area in the short term, this area will need on-going monitoring in the short to medium term to ensure that stability is being maintained. This area should be fenced to prevent stock access.
- While the slopes within and adjacent to Area A are steep, they are not so steep that vegetative stabilisation could not be successfully achieved, subject to the approach described later in **Section 4.2**. Flattening the affected Area A and lands upslope to (say) a 1V:5H slope is considered inappropriate and will be likely to exacerbate erosion levels over a broader area in the short to medium term.
- The existing soil quality conditions and landform within the bare Area A make it highly unsuited to planting of cover species and natural colonisation is unlikely to occur. Treatment of the *in-situ* soils within Area A eg. by heavy applications of gypsum (rates of up to 20t/ha may be necessary to go some way to reduce the very high levels of exchangeable sodium), lime and fertiliser, would improve soil conditions however the application and incorporation of such treatments onto the steep slopes (following levelling and track-rolling) could be difficult. This would need to be confirmed with experienced earthworks machinery operators. Certainly it is important that this area be ripped, graded and track rolled to create as even a final contour as possible, recognising that slope constraints may mean that machinery may only be able to safely work up and down the slope
- Given the above, the most appropriate solution would be to cover the Area A with a suitable depth of soil/weathered material (a minimum depth of 30cm is recommended). The source and suitability of such material (possibly 3,000m³+ of material may be required) and means to cart and place it onto the eroded area should be the subject of further assessment. The establishment of a borrow pit to provide some of this material in the general location of D shown on **Figure 3.3** was previously identified as an option however subsequent advice from WMP has indicated that they would be reluctant to disturb this area. WMO have indicated a preference for importing suitable material or spoil that has been ameliorated to create a suitable growth medium.
- The application of surface stabilisation measures would then need to be undertaken using one or more of the measures described in **Section 3.4.4**. The means to undertake this should be the subject of further assessment, particularly in regard to access constraints and placement/spraying of material onto the bare area

- If it is not practical to place a depth of imported cover over Area A (once ripped and graded), then other simple stabilisation methods should be implemented, including the use of hay bales and silt fences (as outlined below). Most importantly, there should be no structural erosion control earthworks established on the slope as these would have the potential to cause prolonged ponding and instigate tunnel erosion and potential geotechnical failure.

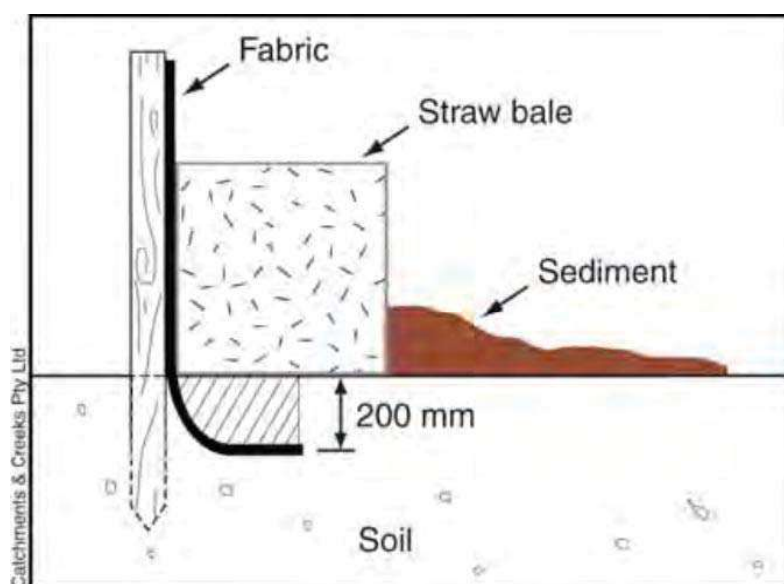
4.2 Recommended strategy

4.2.1 Option 1- No cover capping

This option is recommended should it not be practical to source a volume of suitable cover material and place it to an even grade over Area A.

This option would involve:

1. Ripping, grading and track-rolling and other earth-moving techniques that will result in the bared area having as even a final contour as is practical to ensure that sheet flow runoff conditions over the bare area are maximised.
2. During this grading, applications of gypsum (up to 20t/ha if possible) and lime (possibly up to 5t/ha) would desirably be undertaken and incorporated into surface and near-surface material
3. Apply surface stabilisation measures such as outlined in **Section 3.4.4** if practical
4. Establish a combination sediment fence/hay bale barrier along the contour as shown below thus maintaining sheet flow conditions across the fence barrier. Bales are to be placed lengthwise. The fence/hay bale barrier needs to be installed with regular 'returns' to avoid water concentrating along the fence. Based on the prevailing slope (approx. 25%), parallel barrier rows should be spaced at approximately 8m apart downslope.
5. The initial barrier should be established immediately below the grassed area above the eroded batter slope.
6. An alternative to the above would be to just use hay bales on the contour with returns every 10m across the slope and each bale driven into the earth with a picket. Bales of Rhodes grass with an abundance of seed heads should be chosen together with some seeding of couch grass seed at the base of the bale
7. The rehabilitated area should then be fenced and be subject to ongoing monitoring, particularly after significant rainfall events.



4.2.2 Option 2 - Cover placement

Should it be practical to do so (as outlined in the preceding text), this option would involve:

1. Grading etc as for Points 1. and 2. in **Section 4.2.1**
2. Source a suitable volume and quality of weathered material for placement as a cover over Area A. Some analysis of the quality of the source material should desirably be undertaken, particularly in regard to exchangeable sodium and electrical conductivity
3. Apply surface measures such as outlined in **Section 3.4.4** if practical
4. Establishment of sediment fencing/hay bales across the slope as outlined for Option 1 could be considered however spacing between the rows could be increased to 16m apart. Should tree planting be envisaged as part of the final cover rehabilitated condition for Area A, then plantings of seedlings immediately downslope of each of the rows/bales may be appropriate.
5. The area should then be fenced and be subject to ongoing monitoring, particularly after significant rainfall events.

5 REFERENCES

Australian Centre for Mining Environmental Research (ACMER- 2004) The Identification and Management of Dispersive Mine Spoils

Knight Piesold Consulting (2020) Geotechnical Stability of the Northern Highwall. Memo to KBR

Roads and Maritime NSW (2015) Guidelines for Batter Surface Stabilisation using Vegetation

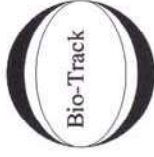
Sherwood Geotechnical and Research Services (2020) New Oakleigh North Cut Highwall Geotechnical Stability Review. Memo to NHG-WMO.

ATTACHMENTS

ATTACHMENT ONE

Laboratory test results

CERTIFICATE OF ANALYSIS



Analysis By: Bio-Track Pty Ltd
ABN 91 056 237 275
Mt. Glorious Road
Highvale, Brisbane, Australia, 4520
Ph. 07 3289 7179 Fx. 07 3289 7155

DATE OF REPORT
CLIENT NAME
CLIENT ADDRESS
PROJECT NAME
SAMPLING DATE
PACKAGING
DATE RECEIVED

03 APRIL 2020
David Houghton c/o Houghton Environmental Management
11 Lookout Court Camp Mountain Brisbane 4520
Oakleigh
NUMBER OF SAMPLES 5 SAMPLE TYPE: Soil/Solid
Plastic Bag ** SAMPLES DISPOSED ON 31/05/2020
1/04/2020 2:58:40 PM LAB REF. LR010420.626

Page 1 of 1 Report Pages.

YOUR PROJECT/JOB REFERENCE 232

METHODOLOGY: EC pH Cl as 1:5 air dried soil in water, 30 minute rolling shake, Cl by ion selective electrode. Na K Mg Ca Fe Al S as 1:20 soil dried soil in 1 N NH₄Cl, 60 minute rolling shake, Na K Mg Ca Fe Al S measured by ICP OES CEC (cation exchange capacity) as the sum of extracted cations (no pretreatment for soluble salts), SAR (sodium adsorption ratio) as Na/((Ca+Mg)/2) 0.5, %Na as Na% of CEC. (meg/100 =milli-equivalents/100 g soil)

SAMPLE ID	EC ds/m	pH	Na meg/100	K meg/100	Ca meg/100	Mg meg/100	Fe mg/kg	Al mg/kg	Cl mg/kg	S mg/kg	ECEC meg/100	SAR ratio	%Na ratio	Ca:Mg ratio
Site101-(1) -	2.82	6.2	6.9	<0.1	2.0	6.5	4	<1	3448	6	15.4	3.36	44.9	0.3
Site101-(2) -	9.57	6.2	23.9	<0.1	11.1	17.5	2	3	11022	28	52.6	6.32	45.4	0.6
Site202-(1) -	0.96	5.2	13.1	0.2	17.2	30.8	2	<1	1002	40	61.3	2.67	21.4	0.6
Site202-(2) -	0.24	7.5	13.0	0.3	14.7	37.2	4	<1	170	<1	65.2	2.55	19.9	0.4
Site303-(1) -	0.58	8.6	7.9	0.5	25.7	31.7	1	<1	60	281	65.8	1.48	12.1	0.8

Signatory

P. Solomon

For and behalf of Bio-Track Pty Ltd

Determination of Trace Elements in Soil



CERTIFICATE OF ANALYSIS

Analysis By: Bio-Track Pty Ltd ABN 91 056 237 275781 Mt. Glorious Road Highvale, Brisbane, Australia, 4520 Ph. 07 3289 7179 Fx. 07 3289 7155

DATE OF REPORT 06 APRIL 2020
CLIENT NAME David Houghton c/o Houghton Environmental Management
CLIENT ADDRESS 11 Lookout Court Camp Mountain Brisbane 4520
PROJECT NAME Oakleigh
SAMPLING DATE NUMBER OF SAMPLES 5
PACKAGING Plastic Bag
DISPOSAL SAMPLES DISPOSED ON 2/06/2020
LOG-IN DATE 3/04/2020 9:44:03 AM LAB REF. LR030420.426
METHOD As per Aust Lab Handbook of Soil & Water Chemical Methods Method 12A1, 12C1
METHOD Results gravimetric, oven dry

SAMPLE ID		B	Cu	Fe	Mn	Zn
SAMPLE ID		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Site 1	01 - (1)	0.3	0.5	7	2	0.9
Site 1	01 - (2)	0.7	7.4	130	8	120.0
Site 2	02 - (1)	0.4	0.7	11	10	1.1
Site 2	02 - (2)	0.1	3.4	16	2	7.2
Site 3	03 - (1)	0.3	1.1	20	< 1	0.8

Signatory

For and behalf of Bio-Track Pty Ltd

Site	BH	Depth Increment	Al	Ca	Cr	Cu	Fe	Mg	Mn	Na	Ni	P	S	Zn
			mg/kg Water Soluble Element											
1	1	1	4.2	700	0.46	<0.1	2.2	488	0.72	2020	0.04	0.36	4.6	0.08
1	1	2	12.6	2160	0.4	<0.1	3.6	1864	2.8	6860	0.52	0.72	40	0.1
2	2	1	26	144	0.26	<0.1	7.8	208	0.4	1882	0.6	1.06	88	1.06
2	2	2	3.6	50	0.2	0.26	2	68	0.14	1404	0.2	0.56	14	0.12
2	3	1	3	260	0.16	<0.1	1.68	228	0.12	1304	0.1	0.66	412	0.1

Analysis by Bio-Track Pty Ltd. Report date April 6/2020



Certificate of Analysis

Signatory:

Phone: +617 3289 7179 Bio-Track Pty Ltd ABN 91 056 237 275

Test Code/Name		[179] Phosphorus Olsen 1:20	
Lab Reference (LR)	030420.658	Client Name	Houghton Environmental Management
SampleID	All Samples	Client Contact	David Houghton
		Project Name	Oakleigh
Report Date	8/04/2020	Job Number	232
Sample Received Date	1/04/2020	Order Number	
Sample Disposal Date	2/06/2020	Chain of Custody	
Sample Packaging	Plastic Bag	Client Email	
Temperature	Ambient	Client Address	11 Lookout Court Camp Mountain Brisbane Queensland 4520

Analytical Method: As per Olsen-P (9C) Soil Chemical Methods - Australasia, Raymont & Lyons, 2001.

S#	SampleID	Olsen P mg P/kg
1	Site 1 01 - (1)	12
2	Site 1 01 - (2)	10
3	Site 2 02 - (1)	1
4	Site 2 02 - (2)	5
5	Site 3 03 - (1)	3



Certificate of Analysis

Signatory:

Phone: +617 3289 7179 Bio-Track Pty Ltd ABN 91 056 237 275

Test Code/Name	[34] Emerson Class		
Lab Reference (LR)	010420.627	Client Name	Houghton Environmental Management
SampleID	All Samples	Client Contact	David Houghton
		Project Name	Oakleigh
Report Date	6/04/2020	Job Number	232
Sample Received Date	1/04/2020	Order Number	
Sample Disposal Date	31/05/2020	Chain of Custody	
Sample Packaging	Plastic Bag	Client Email	
Temperature	Ambient	Client Address	11 Lookout Court Camp Mountain Brisbane Queensland 4520

Analytical Method: As per Emerson, WW 1967, A classification of soil aggregates based on their coherence in water.
Australian Journal of Soil Research, 5: 47-57.

S#	SampleID	Emerson Class
1	Site 1 01 - (1)	6
2	Site 1 01 - (2)	6
3	Site 2 02 - (1)	2
4	Site 2 02 - (2)	2
5	Site 3 03 - (1)	2

ATTACHMENT TWO

Soil Assessment parameters

ATTACHMENT TWO

SOIL ASSESSMENT PARAMETERS – NEW OAKLEIGH NORTHERN HIGHWALL REHABILITATION

The following is a list of the various parameters/ analytes presented in the laboratory results section of the report and the significance of these.

1. **Dispersion test:** The Emerson dispersion test (refer Australian Standard AS1289) relates to the Modified Emerson Crumb Test and Seedsman (undated). This method is commonly used to determine the dispersive nature of soils on mining and construction sites. It is based on a hierarchical class based system with Classes 1 through to 8 representing different dispersive natures (Class 1 having the highest dispersion). Classes 1 and 2 will provide problems while care should be exercised with Class 3 materials.

Classes 4 to 7 are considered to have slight to no dispersion characteristics, whilst 8 is considered to be inherently non-dispersive. Because the Emerson class test deals with soil aggregates as a whole, it provides a good estimate of the likely soil behaviour upon wetting for each soil facie. Therefore the test relates to the susceptibility of a soil to disperse.

Dispersion is the tendency for the clay fraction of a soil to enter into colloidal suspension, where unlimited swelling and disintegration of some of the clay particles forms a colloidal cloud around the sample. These attributes provide an indication of the soils erosion potential with a dispersive soil being (obviously) more susceptible to erosion.

2. **EC (Electrical conductivity).** A measure of soil salinity. Levels are becoming very significant above 0.5 (sand) to 1 (clay) dS/m although plant growth (for tolerant species) may generally not be significantly affected until levels exceed 1.5 to 2.0 dS/m in a clay. (note: 1mS/cm=1dS/m).
3. **Chloride:** chloride levels above 800mg/kg can have a significant effect on plant growth. Levels above 1,200mg/kg may cause a 50% reduction in crop yield (GRDC 2006).
4. **pH:** levels should desirably be between 5 and 7.0 for native plants and 6 and 8 for introduced plants (1:5 soil/water used) – specific plant requirements should be checked. Levels below 5.0 are very strongly acid while levels above 9.0 are very strongly alkaline.
5. **%OM:** Percent Organic Matter. Levels <1 are very low and >4 are high. Note that OM was not tested for Oakleigh soil samples as all samples were of subsoil material and would be expectedly have very low to negligible levels of OM.
6. **CEC (cation exchange capacity):** Indicates the soils ability to retain nutrients. Levels below 10 are low.
7. **Exchangeable Sodium Percentage (% Na):** Indicates the sodium % of CEC. Levels <6 are considered non-sodic. Levels >10% indicate significant levels of sodium with levels > 15 considered as strongly sodic and >25 very strongly sodic.
8. **SAR (Sodium adsorption ratio):** expresses the relative activity of sodium ions in the exchange reactions within the soil – measures the relative concentrations of Na versus Ca and Mg. If levels are greater than 8, then the use of gypsum may need to be considered.
9. **Ca:Mg ratio:** The ratio of exchangeable calcium to magnesium. A low ratio (<1) indicates a propensity to aggravate the dispersive effects of sodium and contribute to poor soil structure. Levels < 0.5 commonly cause dispersion
10. **P :** levels below 10 mg/kg are very low, 20-40 are medium and >100 very high

11. **S (%)**: <0.005 very low; 0.02-0.05 medium; 0.05-0.10 high; >10 very high
12. **Mn**: Levels below 1mg/kg are very low and >500 are very high
13. **Al**: levels above 15 mg/kg are high while above 50mg/kg may start to become toxic to plants
14. **Cu**: levels < 0.1 mg/kg are very low and > 15 are very high
15. **Na,K,Ca,Mg**: ranges are presented in the following table (ranges in meq/100g)

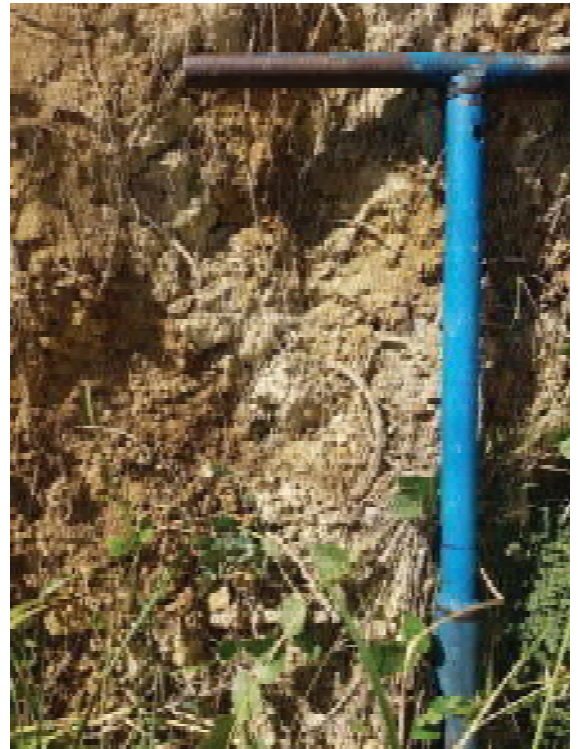
Parameter	VERY LOW	LOW	MEDIUM	HIGH
Na	0.2	0.4	0.7	1.8
K	<0.15	0.3	0.6	1.0
Mg	0.7	1	2	5
Ca	2	4	7.5	12.5

ATTACHMENT THREE

Sample site photos



Site 1 (1)



Site 1 (2)



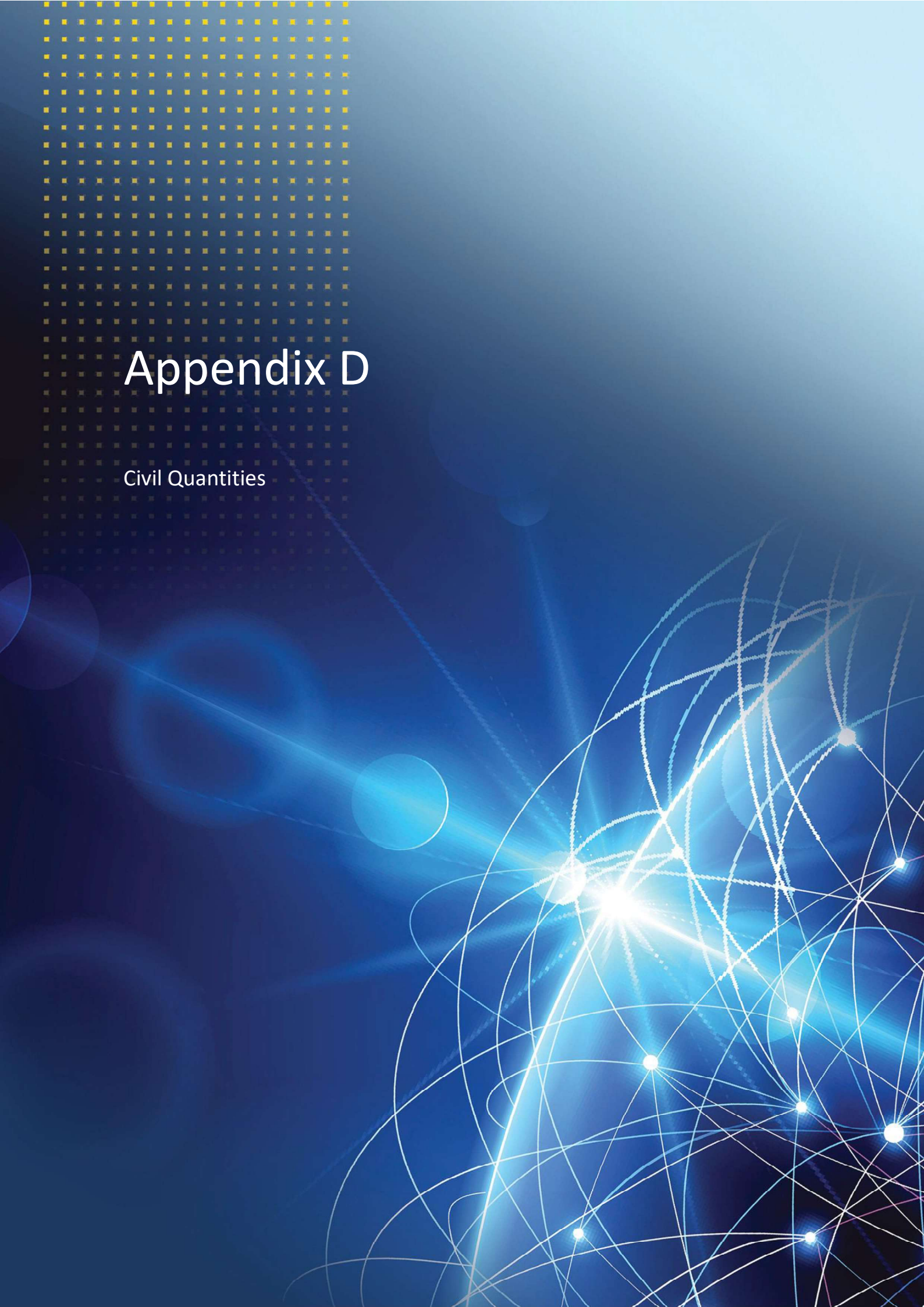
Site 2 (1)



Site 2 (2)



Site 3 (1)



Appendix D

Civil Quantities

NORMANTON PIT CIVIL QUANTITIES

Item No.	Description	Unit	Quantity
1.0	BULK EARTHWORKS		
	(Include bench(contour) and chute drains + box out for armouring)		
1.1	Cut to fill	m ³	1,360,000
1.2	Cut to spoil	m ³	24,600
1.3	Cut to spoil (armour box out within chutes)	m ³	15,100
2.0	MAIN DRAINS		
2.1	<u>Drain 01 (DR01)</u>		
2.1.1	Supply and installation of geotextile (Strength Class C, Filtration Class V)	m ²	10,810
2.1.2	Rock protection requirement (d50 rock size 450mm min)	m ³	8,620
2.2	<u>Side Drains (DR02-DR05)</u>		
2.2.1	Supply and installation of geotextile (Strength Class C, Filtration Class V)	m ²	3,150
2.2.2	Rock protection requirement (d50 rock size 350mm min)	m ³	1,880
3.0	CHUTE DRAINS		
3.1	<u>Chute 1 (CDR01)</u>		
3.1.1	Supply and installation of geotextile (Strength Class C, Filtration Class V)	m ²	3,200
3.1.2	Rock protection requirement (d50 rock size 300mm min)	m ³	1,920
3.2	<u>Chute 2 (CDR02)</u>		
3.2.1	Supply and installation of geotextile (Strength Class C, Filtration Class V)	m ²	1,040
3.2.2	Rock protection requirement (d50 rock size 300mm min)	m ³	630
4.0	SPILLWAYS		
4.1	<u>Spillway 01 (SP01)</u>		
4.1.1	Upstream batter crushed rock fill layer (250mm thick)	m ³	20
4.1.2	Supply and installation of geotextile (Strength Class C, Filtration Class V)	m ²	380
4.1.3	Rock protection requirement (d50 rock size 300mm min)	m ³	210
4.2	<u>Spillway 02 (SP02)</u>		
4.2.1	Upstream batter crushed rock fill layer (250mm thick)	m ³	40
4.2.2	Supply and installation of geotextile (Strength Class C, Filtration Class V)	m ²	480
4.2.3	Rock protection requirement (d50 rock size 300mm min)	m ³	270
4.3	<u>Spillway 03 (SP03)</u>		
4.3.1	Upstream batter crushed rock fill layer (250mm thick)	m ³	82
4.3.2	Supply and installation of geotextile (Strength Class C, Filtration Class V)	m ²	1,610
4.3.3	Rock protection requirement (d50 rock size 450mm min)	m ³	1,450
5.0	MISCELLANEOUS		
5.1	Rock Mulch	m ²	160
5.2	Bench Drains - Extra over for trim, shape and compact	ln.m	2,060

EAST DRAIN - CIVIL QUANTITIES

Item No.	Description	Unit	Quantity
1.0	BULK EARTHWORKS		
	(Include bench(contour) and chute drains + box out for armouring)		
1.1	Cut to fill	m ³	345,000
1.2	Cut to spoil	m ³	45,000
1.3	Cut to spoil (armooour box out within chutes)	m ³	
2.0	EROSION CONTROL		
	(10% allowance added to geotextile and Grassroot plan area to allow for anchoring)		
2.1	Supply and installation of geotextile 'Bidim A29'	m ²	7,194
2.2	Rock Protection (D50 = 350mm. 700mm depth)	m ³	560
2.3	Rock Protection (D50 = 450mm. 900mm depth)	m ³	5,166
2.4	<u>Non Rock Protection</u>		
2.5	Grassroots Erosion Matting	m ²	44,110
2.6	Topsoil - 150mm to 300mm fertilised topsoil	m ²	40,100
2.7	Plant seeditng	m ²	40,100
3.0	MISCELLANEOUS		
3.1	Bench Drains - Extra over for trim, shape and compact	ln.m	1,220



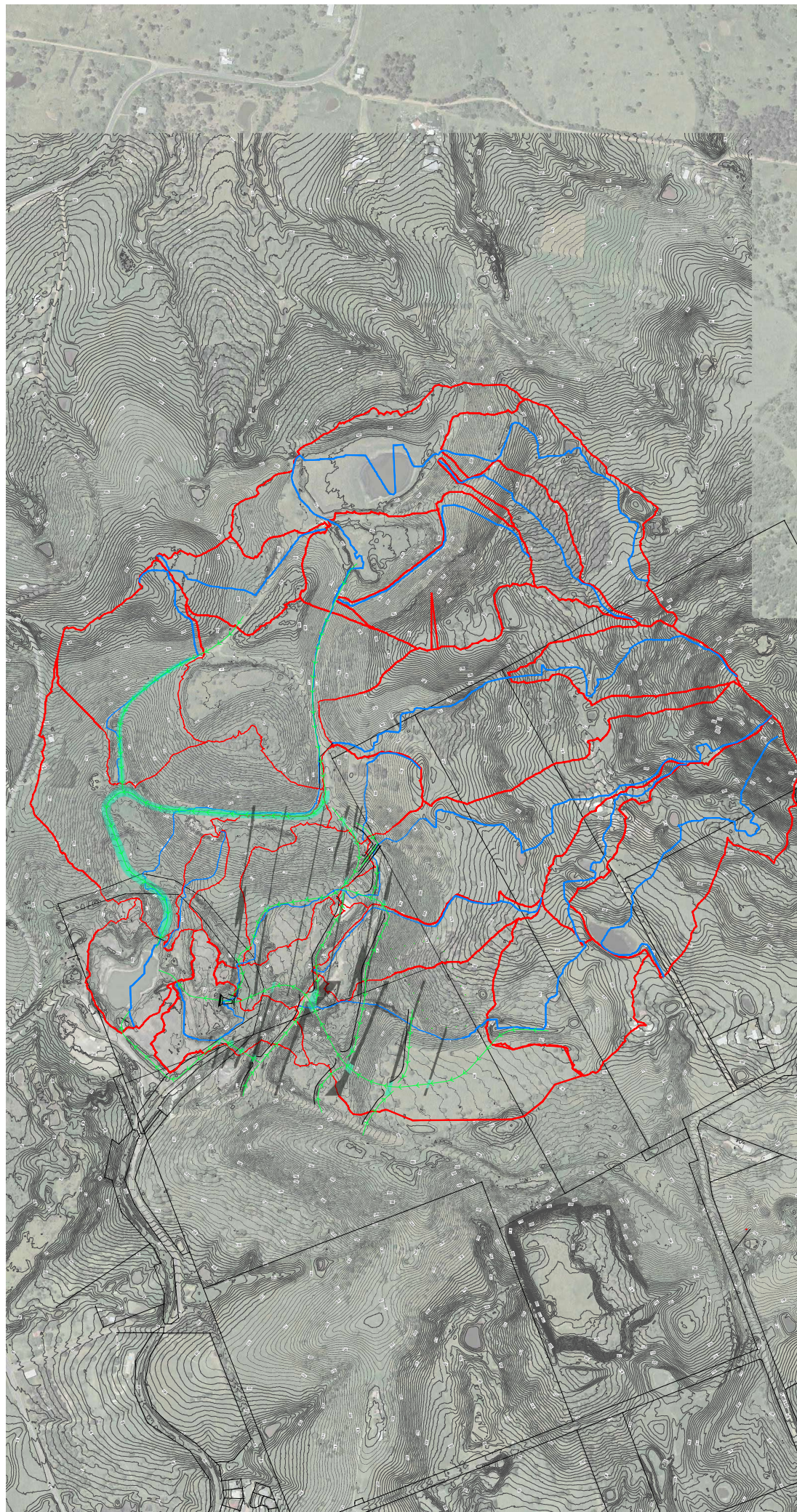
Appendix E

Catchment Plans



LEGEND

- CATCHMENT BOUNDARY
- STREAM
- EXISTING CONTOURS (1.0m INTERVAL)



PLAN
SCALE 1:4000 (A1)

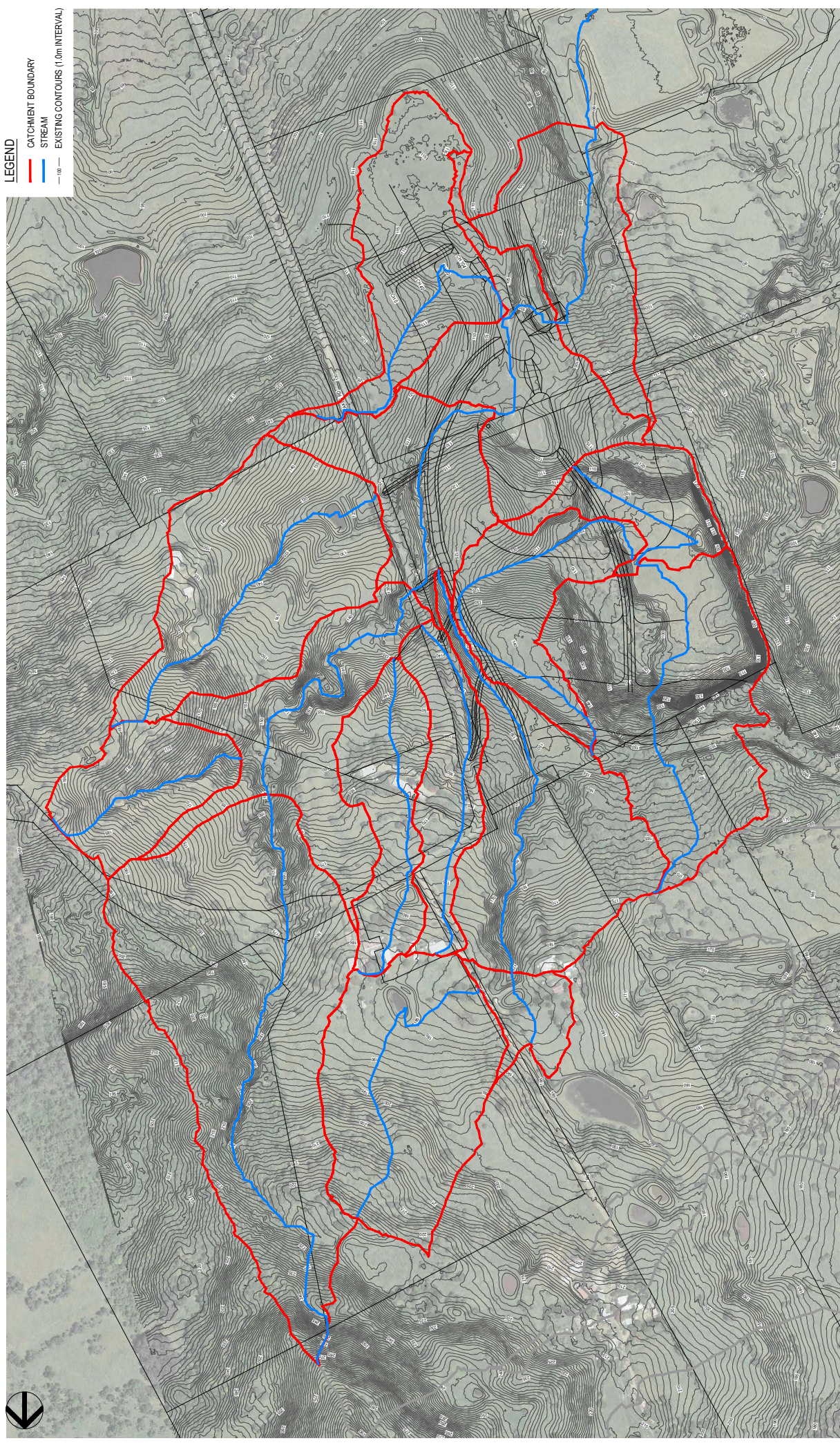


Kellogg Brown & Root Pty Ltd
ABN 97 007 663 317



NEW HOPE GROUP
REHABILITATION PLAN - NEW OAKLEIGH
EAST DRAIN
CATCHMENT PLAN

Thursday, 17 December 2020 7:46:03 AM



- LEGEND**
- CATCHMENT BOUNDARY
 - STREAM
 - EXISTING CONTOURS (1.0m INTERVAL)

PLAN
SCALE 1:2500



NEW HOPE GROUP
REHABILITATION PLAN - NEW OAKLEIGH
NORMANTON PIT
CATCHMENT PLAN

Kellogg Brown & Root Pty Ltd
ABN 59 007 663 317



Thursday, 17 December 2020 7:43:23 AM



Appendix F

Photos



Oakleigh East - North High Wall



Oakleigh East – Old Tailings Dam before infill





Oakleigh East – Tailings Dam Capping Operations





Oakleigh East - Washdown Dam



Oakleigh East - Washdown Dam Outlet



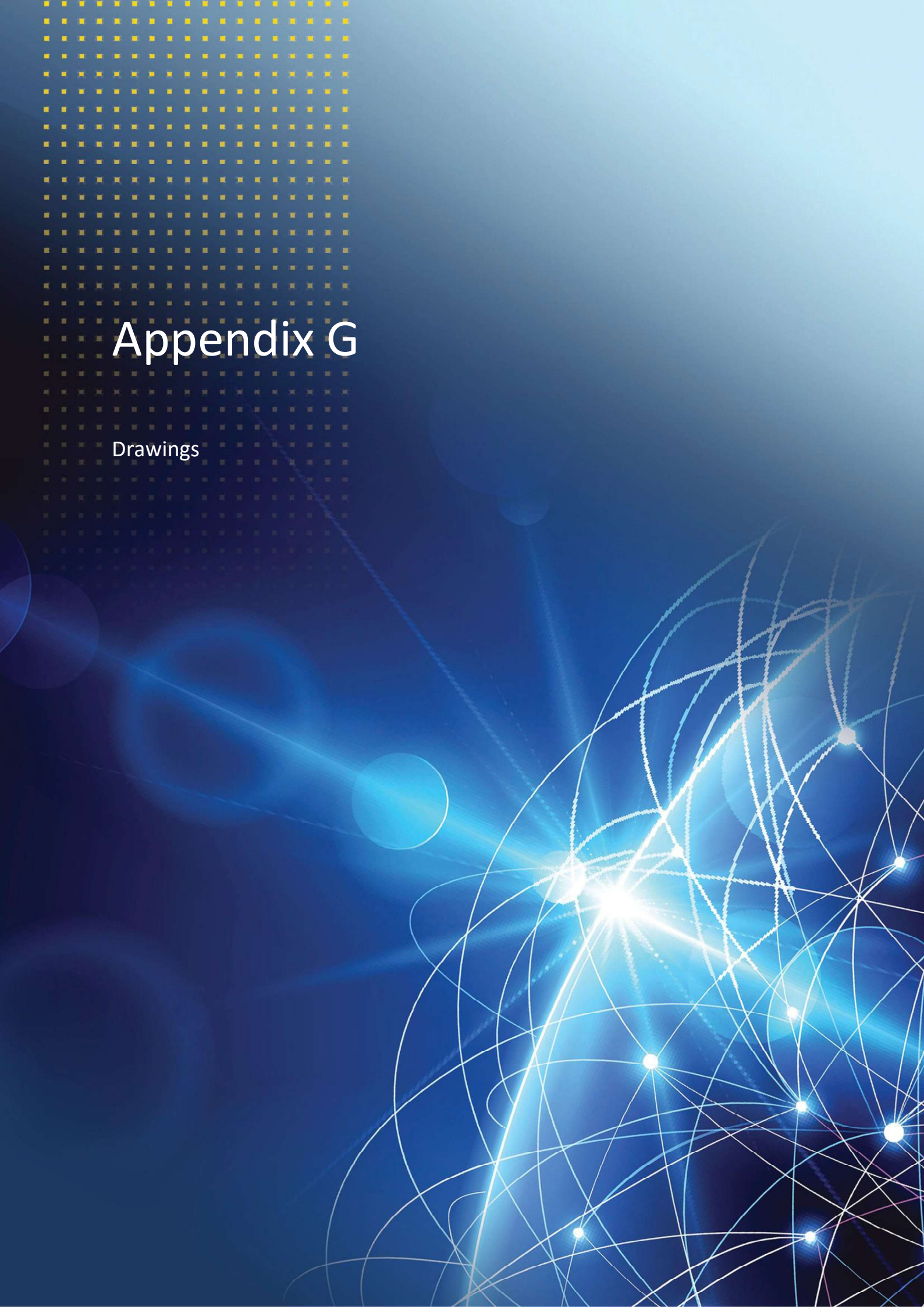
Normanton – Pit Cliff Face



Normanton – Blakes Road



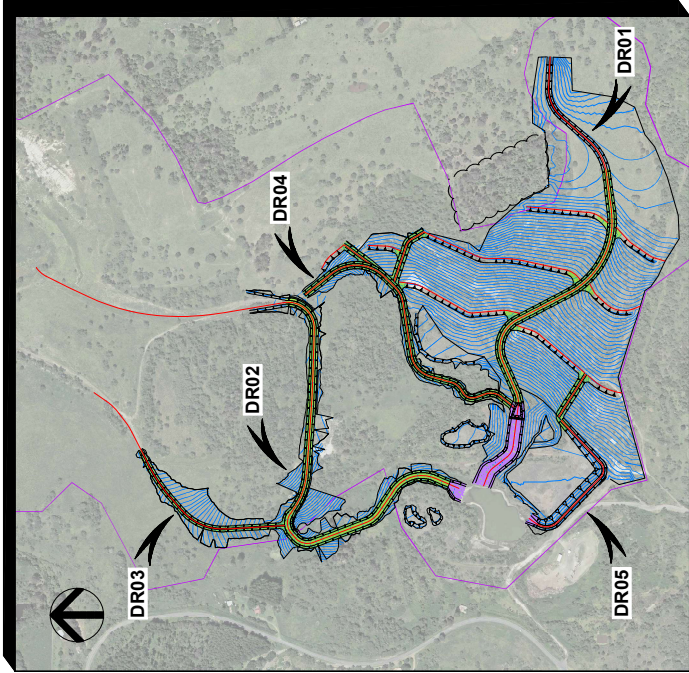
Normanton – Blakes Road Outlet



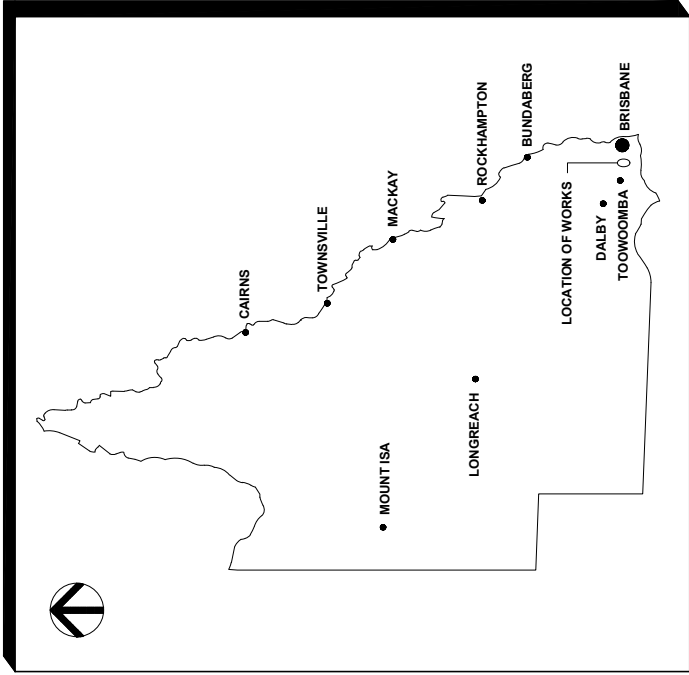
Appendix G

Drawings

NEW OAKLEIGH COAL MINE REHABILITATION DRAINAGE WORKS EAST AND NORTH DRAINS NEW HOPE GROUP



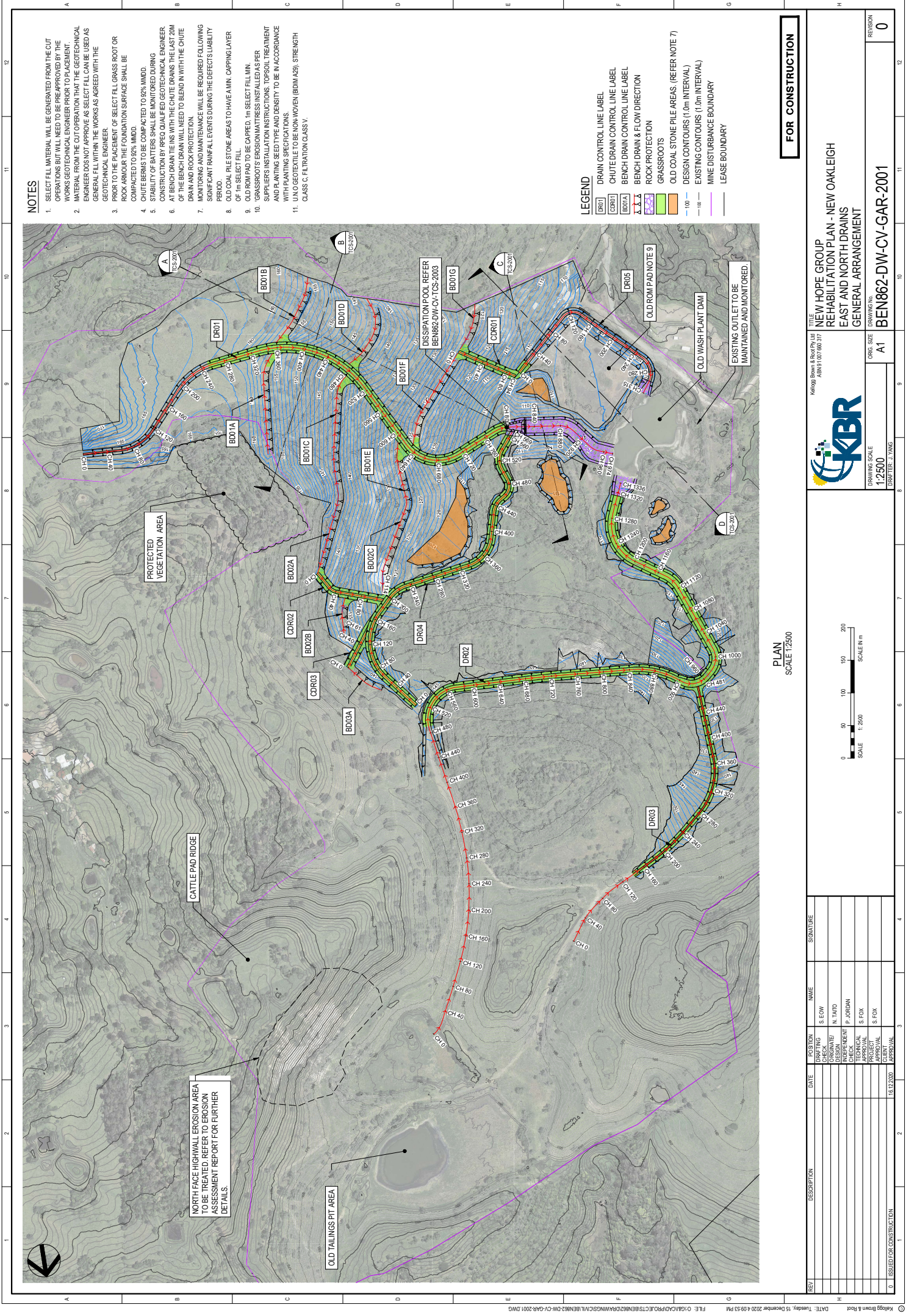
LAYOUT PLAN
N.T.S.



LOCALITY PLAN
N.T.S.

REV		DESCRIPTION	DATE	POSITION	NAME	SIGNATURE
		CHECK		DRAFTING	S. EOW	
		DESIGN		IN. TMD		
		INDEPENDENT		P. JORDAN		
		TECHNICAL		S. FOX		
		APPROVAL		S. FOX		
		CLIENT	15.12.2020	APPROVAL		
0		ISSUED FOR CONSTRUCTION				
KBR						
KBR 8000 Series 8 (Rev 01) 1/14 KBR 8107/800 317						
DRAWING SCALE N.T.S.						
DRAWING SIZE A1						
DRAWING NO. BEN862-DW-CV-PLK-2001						
REVISION 0						
TITLE NEW HOPE GROUP REHABILITATION PLAN - NEW OAKLEIGH EAST AND NORTH DRAINS LOCALITY PLAN						

FOR CONSTRUCTION



NOTES

1. SELECT FILL MATERIAL WILL BE GENERATED FROM THE CUT OPERATIONS BUT WILL NEED TO BE APPROVED BY THE WORKS GEOTECHNICAL ENGINEER PRIOR TO PLACEMENT.
2. MATERIAL FROM THE CUT OPERATIONS THAT THE GEOTECHNICAL ENGINEER DOES NOT APPROVE AS SELECT FILL CAN BE USED AS GENERAL FILL WITHIN THE WORKS AS AGREED WITH THE GEOTECHNICAL ENGINEER.
3. PRIOR TO THE PLACEMENT OF SELECT FILL GRASS ROOT OR ROCK AND/OR COAL STONE PILE AREAS SHALL BE CONSIDERED TO BE COMPACTED TO 95% MDD.
4. STABILITY OF SLOPES SHALL BE MONITORED DURING CONSTRUCTION BY A REG. QUALIFIED GEOTECHNICAL ENGINEER.
5. AT BENCH DRAIN LINES WITH THE CHUTE DRAINS THE LAST 20M OF THE BENCH DRAIN WILL NEED TO BLEND IN WITH THE CHUTE DRAIN AND ROCK PROTECTION.
6. MONITORING AND MAINTENANCE WILL BE REQUIRED FOLLOWING PERIOD.
7. SIGNIFICANT RAINFALL EVENTS DURING THE DEFECTS LIABILITY PERIOD.
8. OLD COAL PILE STONE AREAS TO HAVE A MIN. CAPPING LAYER OF 1m SELECT FILL.
9. OLD ROM PAD TO BE CAPPED, 1m SELECT FILL MIN.
10. GRASSROOT'S EROSION MATRESS INSTALLED AS PER SUPPLIERS INSTALLATION INSTRUCTIONS, TOPSOIL, TREATMENT AND PLANTING SEED TYPE AND DENSITY TO BE IN ACCORDANCE WITH PLANTING SPECIFICATIONS.
11. UNO GEOTEXTILE TO BE NON WOVEN (BDM A29), STRENGTH CLASS C, FILTRATION CLASS V.

LEGEND

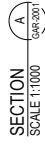
- DR01 DRAIN CONTROL LINE LABEL
- CHUTE DRAIN CONTROL LINE LABEL
- BD01A BENCH DRAIN CONTROL LINE LABEL
- BD01B BENCH DRAIN & FLOW DIRECTION
- ROCK PROTECTION
- GRASSROOTS
- OLD COAL STONE PILE AREAS (REFER NOTE 7)
- DESIGN CONTOURS (1.0m INTERVAL)
- EXISTING CONTOURS (1.0m INTERVAL)
- MINE DISTURBANCE BOUNDARY
- LEASE BOUNDARY

PLAN
SCALE 1:2500

FOR CONSTRUCTION

KBR		KBR Group Pty Ltd ABN 81 007 660 337		NEW HOPE GROUP REHABILITATION PLAN - NEW OAKLEIGH EAST AND NORTH DRAINS GENERAL ARRANGEMENT		DRAWING NO. BEN862-DW-CV-2001		REVISION 0	
DRAWING SCALE 1:2500		DRAWING SIZE A1		DRAWING DATE 15/12/2020		DRAWING BY J. YANG			
ISSUED FOR CONSTRUCTION		DATE 15/12/2020		APPROVAL CLIENT		APPROVAL DESIGN		APPROVAL CHECK	
DESCRIPTION		NAME		SIGNATURE					
		S. EOW							
		N. TATO							
		P. JORDAN							
		S. FOX							
		S. FOX							

1. FOR DR01 WITHIN THE OLD COAL STONE PILE AREA ENSURE ROCK ARMOUR SITS ON VIRGIN GROUND OR 1.0m OF COMPACTED SELECT FILL MATERIAL.



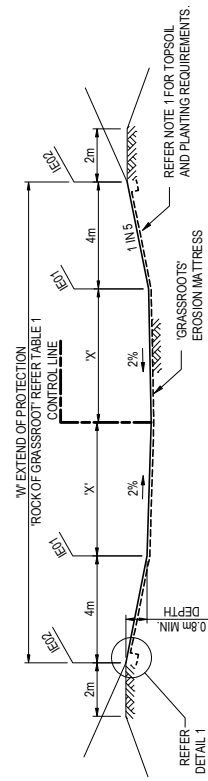
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REHABILITATION PLAN - NEW OAKLEIGH
EAST AND NORTH DRAINS
TYPICAL SECTIONS & DETAILS - SHEET 1



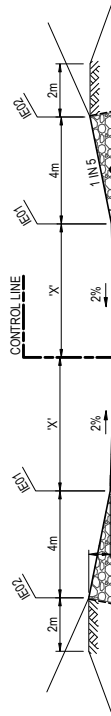
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BEN862-DW-CV-TCS-2001

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	CHECKED		S.GUMATE		N.T
	REVIEWED		N.TARD		P.J
	APPROVED		P.GORDAN		A.D
	PROJECT MANAGER		S.FOX		J.D
	PROJECT ENGINEER		S.FOX		
	CLIENT		CLIENT		

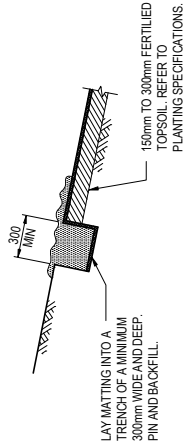
A	UNITED STATES GOVERNMENT



DRAIN TYPICAL SECTION (DR01 - DR04)
SCALE 1:100



DRAIN ROCK PROTECTION TYPICAL
SCALE 1:100

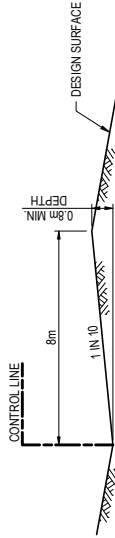


DETAIL 1
NTS

ROCK PROTECTION TO MAIN DRAIN
GEOTEXTILE UNDER ROCK PROTECTION
REFER TO NOTE 2 ON DRAWING
BEN862-DW-CV-GAR-1001 FOR SUBGRADE
PREPARATION AND TREATMENT

TABLE 1 - EROSION PROTECTION EXTENTS

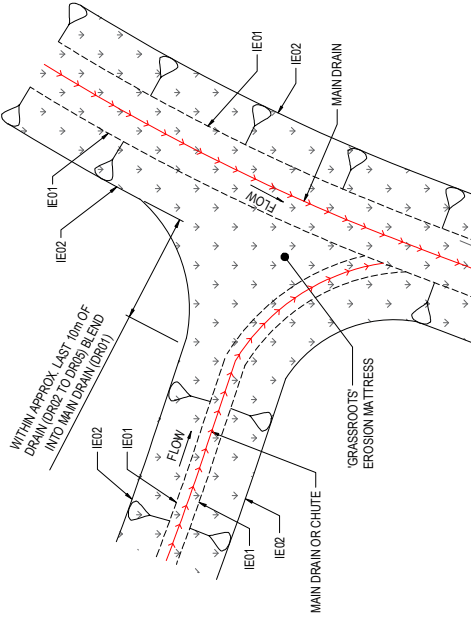
SECTION	CHAINAGE E START	CHAINAGE G END	BASE 'X' (m)	ARMOUR		EROSION MATRESS 'W' (m)
				D50 (mm)	T ¹	
DR01	1	START	350	3	nil	14
	2	350	800	4.25	nil	16.5
	3	800	850	10	350	700
	4	850	END	10	450	900
DR02	1	START	240	5.5	nil	19
	2	240	600	3.5	nil	15
	3	600	924	3.5	nil	15
	4	924	1310	5.5	nil	19
DR03	1	START	120	1.25	nil	10.5
	2	120	370	1.25	nil	10.5
	3	370	END	1.25	nil	10.5
	4	370	END	1.25	nil	10.5
DR04	1	START	550	5.75	nil	19.5
	2	550	END	2.75	450	900
DR05	1	START	20	2.5	nil	13
	2	20	295	2.5	nil	nil
DR06	1	START	20	2.5	nil	nil
	2	20	295	2.5	nil	nil



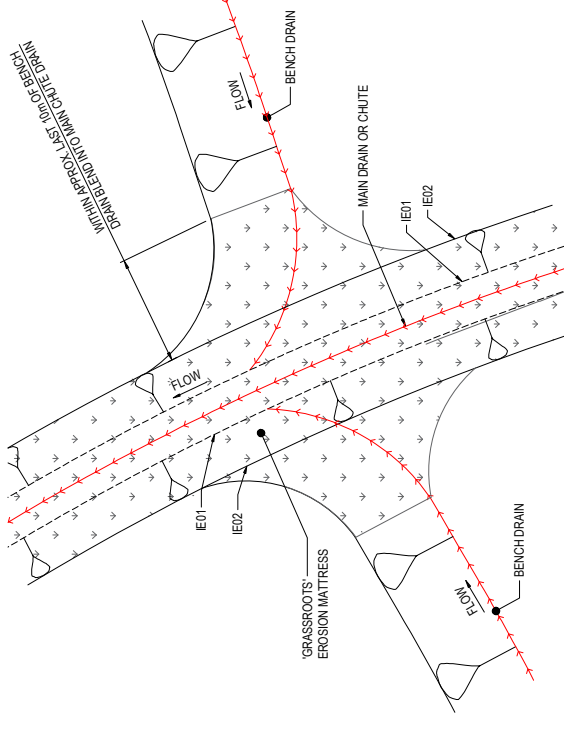
TYPICAL SECTION - BENCH DRAIN
SCALE 1:100

TOPSOIL & PLANTING NOTE:

1. EROSION MATRESS TO BE INSTALLED OVER 150mm TO 300mm OF FERTILIZED TOPSOIL
2. TOPSOIL TREATMENT AND PLANTING SEED TYPE AND DENSITY TO BE IN ACCORDANCE WITH PLANTING SPECIFICATIONS.



TYPICAL TIE DETAIL - MAIN DRAIN WITH MAIN DRAIN OR CHUTE
SCALE 1:250



TYPICAL TIE DETAIL - BENCH DRAIN WITH MAIN DRAIN OR CHUTE
SCALE 1:250

NOTE:

1. OVERALL CHANNEL DEPTH - 0.8m FOR FLOW CONTAINMENT.
2. ROCK DEPTH UP BATTERS TO 600mm FOR CHANNEL STABILITY.

OPTIONAL - CHUTE DRAIN ROCK PROTECTION TYPICAL
SCALE 1:100

FOR CONSTRUCTION



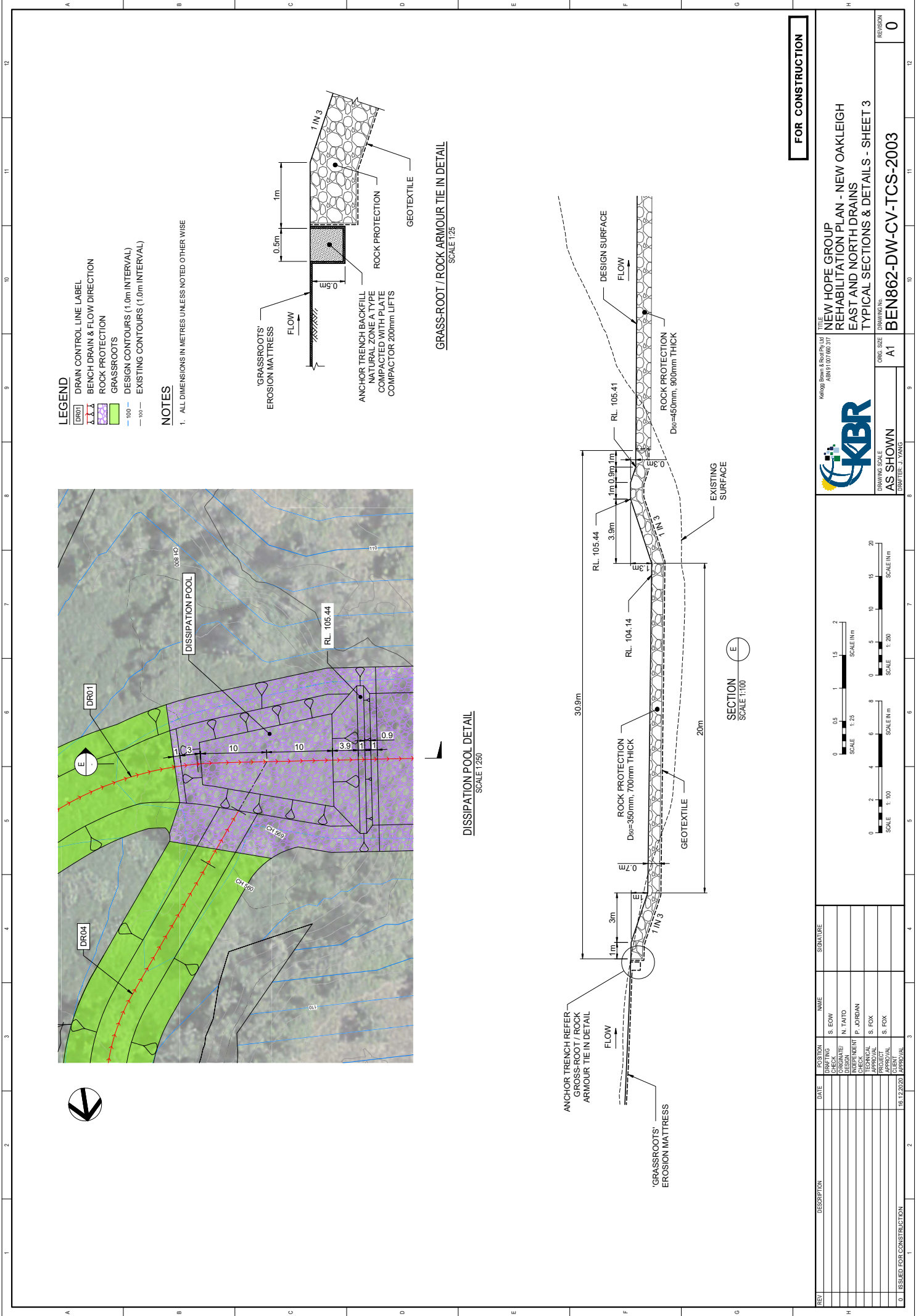
NEW HOPE GROUP
REHABILITATION PLAN - NEW OAKLEIGH
EAST AND NORTH DRAINS
TYPICAL SECTIONS & DETAILS - SHEET 2

AS SHOWN

A1

BEN862-DW-CV-TCS-2002

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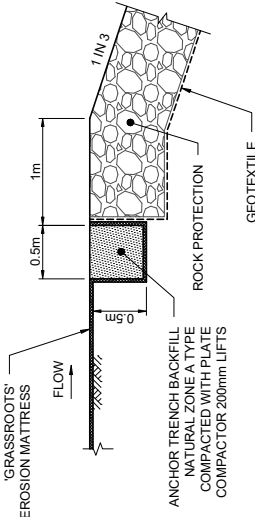


LEGEND

- DR01 DRAIN CONTROL LINE LABEL
- ANCHOR TRENCH BACKFILL
- ROCK PROTECTION
- GRASSROOTS
- DESIGN CONTOURS (1.0m INTERVAL)
- EXISTING CONTOURS (1.0m INTERVAL)

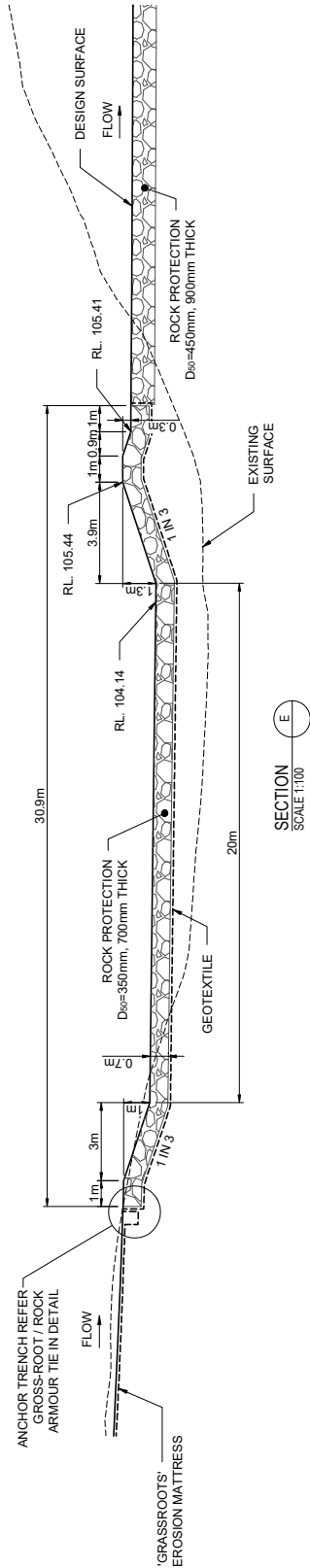
NOTES

- 1. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE



GRASS-ROOT / ROCK ARMOUR TIE IN DETAIL
SCALE 1:25

DISSIPATION POOL DETAIL
SCALE 1:250



SECTION
SCALE 1:100

FOR CONSTRUCTION



NEW HOPE GROUP
REHABILITATION PLAN - NEW OAKLEIGH
EAST AND NORTH DRAINS
TYPICAL SECTIONS & DETAILS - SHEET 3

AS SHOWN
DRAWN BY: J. YANG

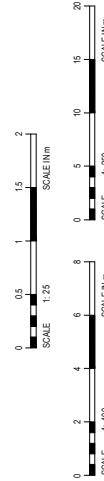
DATE

SCALE

REVISION

BEN862-DW-CV-TCS-2003
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2			APPROVAL	S. FOX	
3			TECHNICAL	S. FOX	
4			DESIGN	P. JORDAN	
5			INDEPENDENT	P. JORDAN	
6			DESIGN	N. TAITO	
7			CHECK	S. EOW	
8			DRAWING	S. EOW	



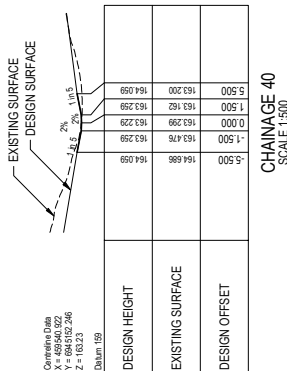
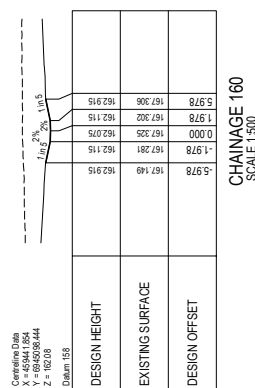
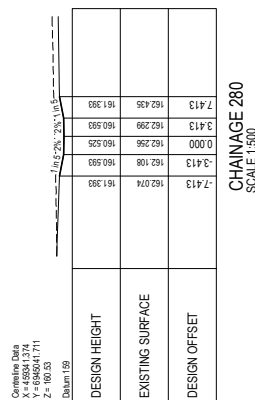
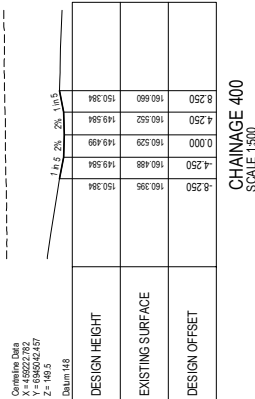
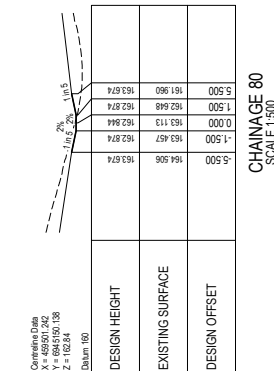
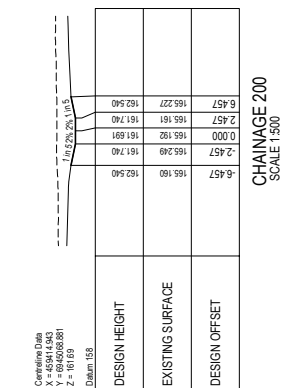
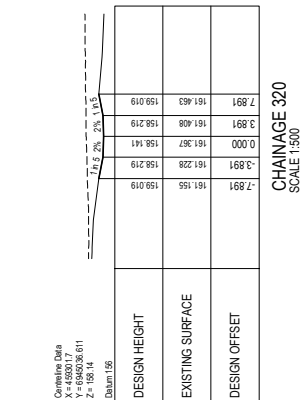
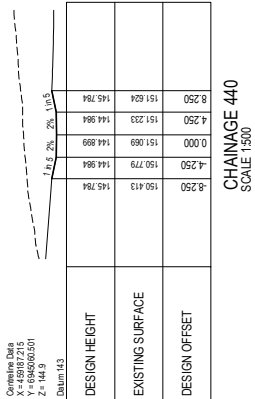
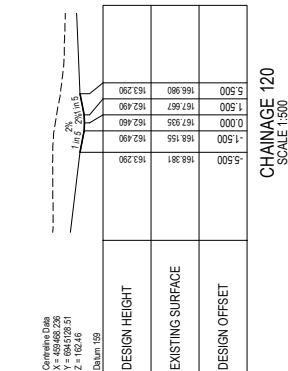
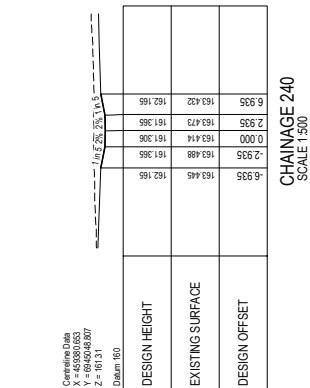
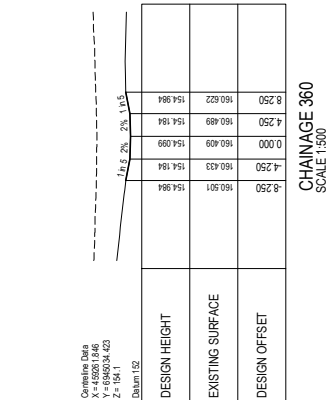
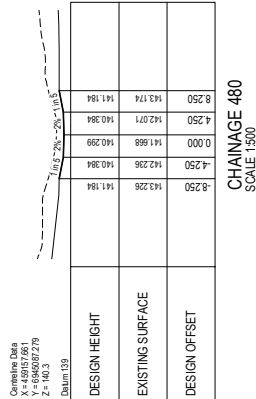
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	CHECK		S. EOW		
	ORGANISE/		N. TATO		
	RENDERING		P. JORDAN		
	CHECK		P. JORDAN		
	REVISION		S. FOX		
	APPROVAL		S. FOX		
	CLIENT		S. FOX		
	CLIENT		S. FOX		
	ISSUED FOR CONSTRUCTION	10.12.2003			

KBR

Kellogg Brown & Root Pty Ltd
KBR 91 007 660 317

NEW HOPE GROUP REHABILITATION PLAN - NEW OAKLEIGH EAST AND NORTH DRAINS CROSS SECTIONS DR01 - SHEET 1	TITLE Kellogg Brown & Root Pty Ltd KBR 91 007 660 317	DATE 15/02/2004 SCALE 1:500 FORWARDING A1 ISSUED FOR CONSTRUCTION BEN862-DW-CV-CSX-2001
		REVISION 0

FOR CONSTRUCTION



NOTES

1. PART SECTIONS SHOWN FOR CLARITY

DESIGN HEIGHT	Datum 104				
EXISTING SURFACE	-14.000	111.171	106.527	109.916	110.456
DESIGN OFFSET	-14.000	110.975	106.327	109.715	110.255

CHAINAGE 720
SCALE 1:500[illegible]CHAINAGE 680
SCALE 1:500

DESIGN HEIGHT		EXISTING SURFACE		DESIGN OFFSET	
8.250	106.292	4.250	106.468	8.250	106.292
4.250	106.640	0.000	107.097	4.250	107.158
0.000	108.112	0.000	108.197	0.000	108.197
0.000	108.997	0.000	109.997	0.000	109.997

Construction Data
 X = 459698.054
 Y = 696220.044
 Z = 108.11

Datum 004

CHAINAGE 640
SCALE 1:500

	KBR Kiewit Building Resources 10000 West 10th Avenue, Suite 100 Denver, CO 80231 Tel: 303.733.1100 Fax: 303.733.1101 Email: kbr@kbr.com		TITLE NEW HOPE GROUP REHABILITATION PLAN - NEW OAKLEIGH EAST AND NORTH DRAINS CROSS SECTIONS DR01 - SHEET 2	REVISION 0
	DRAWING SCALE 1:500 DRAWN BY: J. YANG	ONE SIZE A1	CONTRACT NO. BEN862-DW-CV-CSX-2002	

FOR CONSTRUCTION



TITLE
NEW HOPE GROUP
REHABILITATION PLAN - NEW OAKLEIGH
EAST AND NORTH DRAINS
CROSS SECTIONS DR01 - SHEET 2

DRAWING SCALE 1:500	ORIG. SIZE A1	DRAWING No. BEN862-DW-CV-CSX-2002	REVISION 0
DRAFTER: J. YANG			



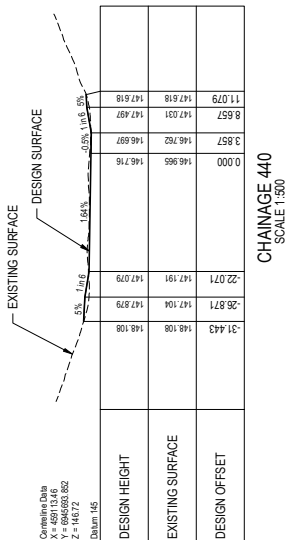
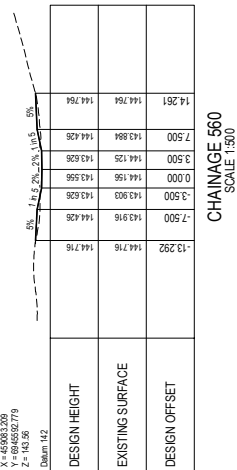
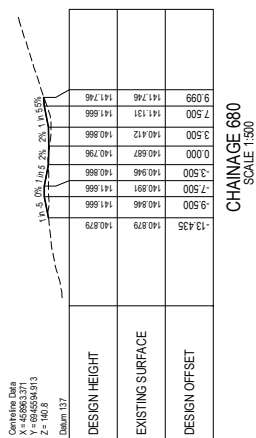
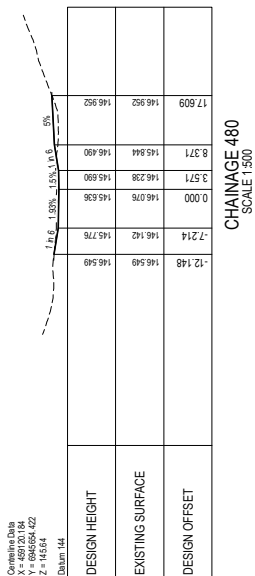
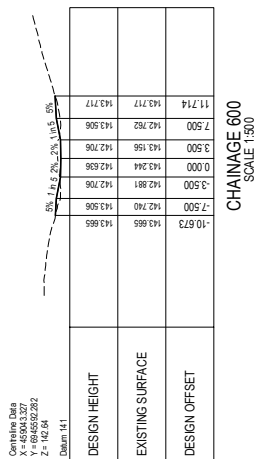
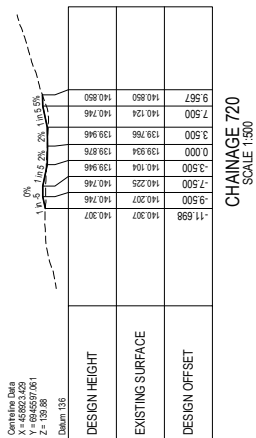
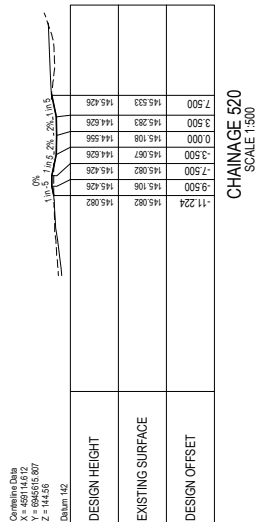
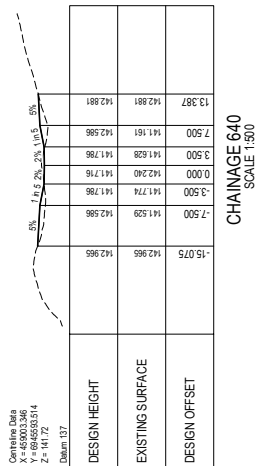
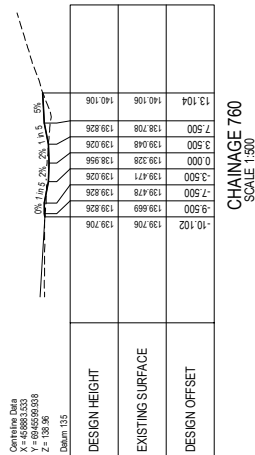
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	DESIGN/		DESIGNER/		
	CHECK		P. JORDAN		
	DESIGN/		S. FOX		
	APPROVAL				
	APPROVAL				
	CLIENT				
	APPROVAL				
	10.12.2003				

KBR

Kellogg Brown & Root Pty Ltd
ABN 91 007 660 317

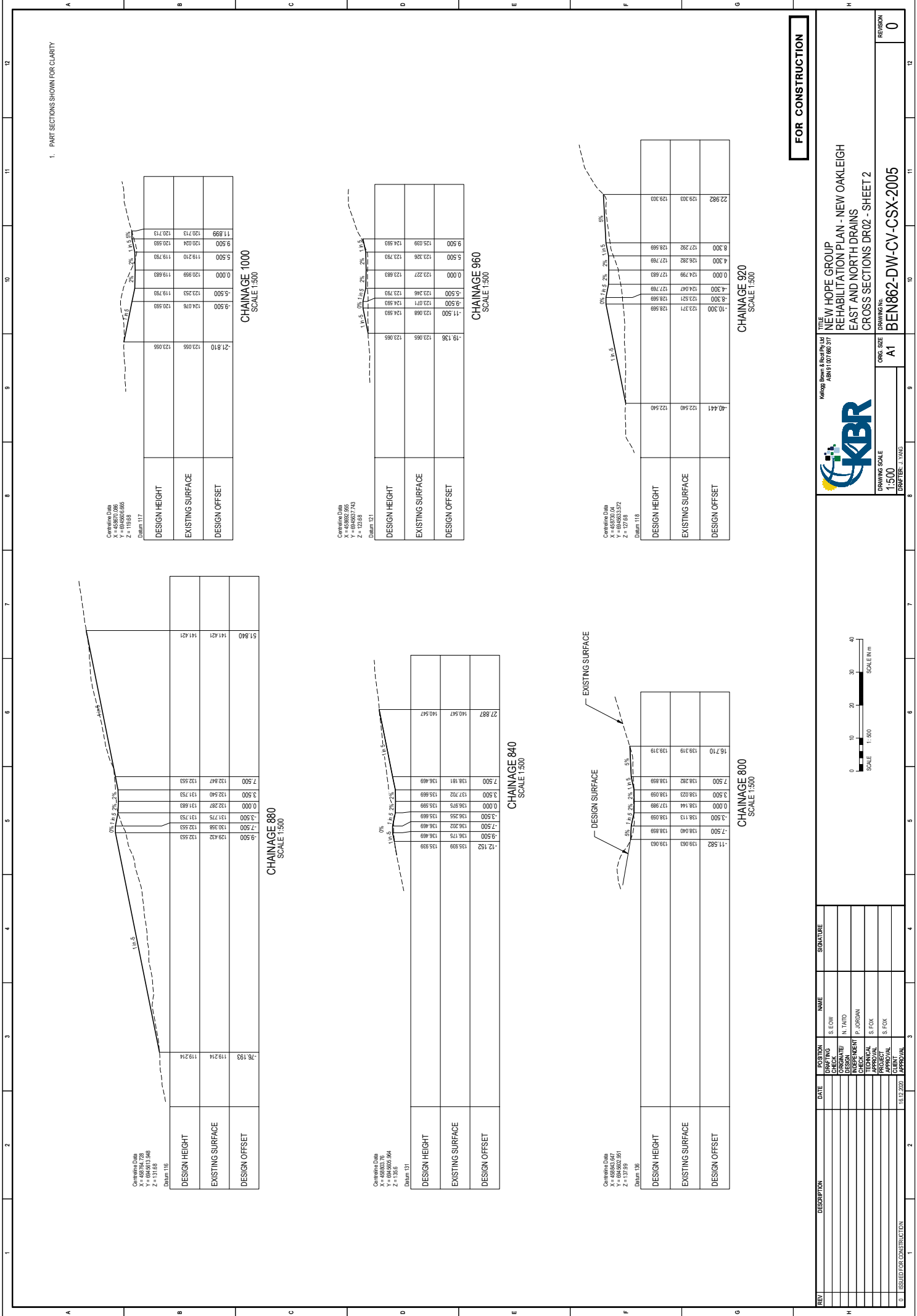
NEW HOPE GROUP REHABILITATION PLAN - NEW OAKLEIGH EAST AND NORTH DRAINS CROSS SECTIONS DR02 - SHEET 1	TITLE Kellogg Brown & Root Pty Ltd ABN 91 007 660 317	DRAWING SCALE 1:500 DATE: 10.12.2003 DRAWN BY: J. YANG SHEET NO. A1 PROJECT NO. BEN862-DW-CV-CSX-2004
FORWARDED:		REVISION 0

FOR CONSTRUCTION



NOTES

1. PART SECTIONS SHOWN FOR CLARITY



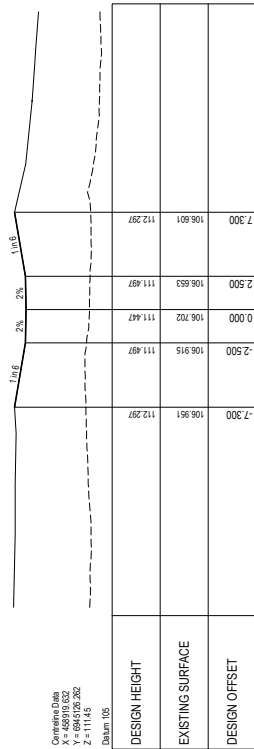
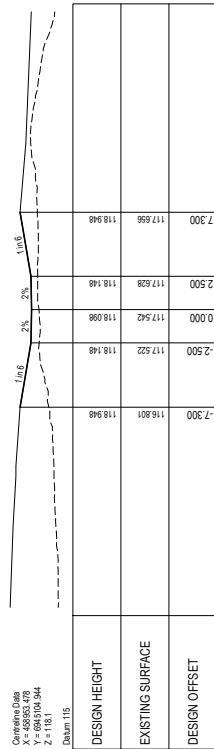
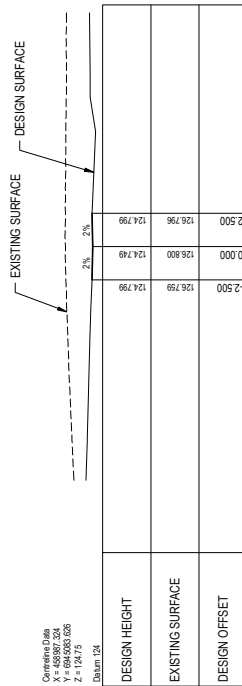
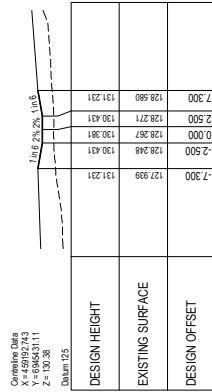
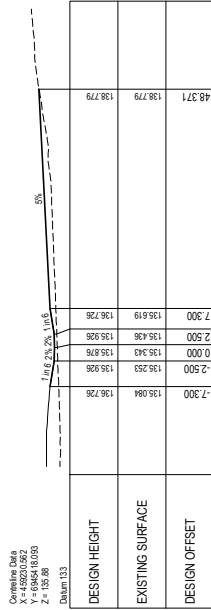
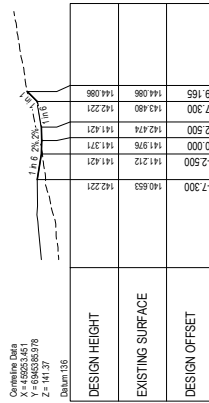
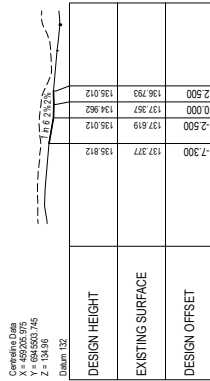
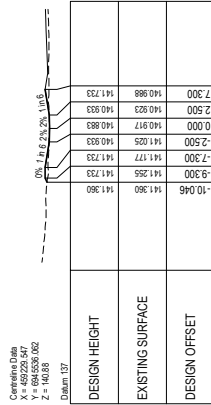
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			DESIGN	N. TAYLOR	
			ORGANIZER		
			INSPECTION	P. JORDAN	
			CHECK		
			APPROVAL	S. FOX	
			APPROVAL	S. FOX	
0	ISSUED FOR CONSTRUCTION	18.12.2020	CLIENT VAL		

	DRAWING SCALE		ORIG. SIZE
	1:500		A1
	DRAWN BY: J. YANG		

TITLE
NEW HOPE GROUP
REHABILITATION PLAN - NEW OAKLEIGH
EAST AND NORTH DRAINS
CROSS SECTIONS CDR01, CDR02 & CDR03

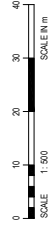
DRAWING No.
BEN862-DW-CV-CSX-2011

FOR CONSTRUCTION

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SCALE 1:200CHAINAGE 80
SCALE 1:500CHAINAGE 40
SCALE 1:500CHAINAGE 0
SCALE 1:500CHAINAGE 40
SCALE 1:500CHAINAGE 0
SCALE 1:500

CDR03

CDR02



NOTES

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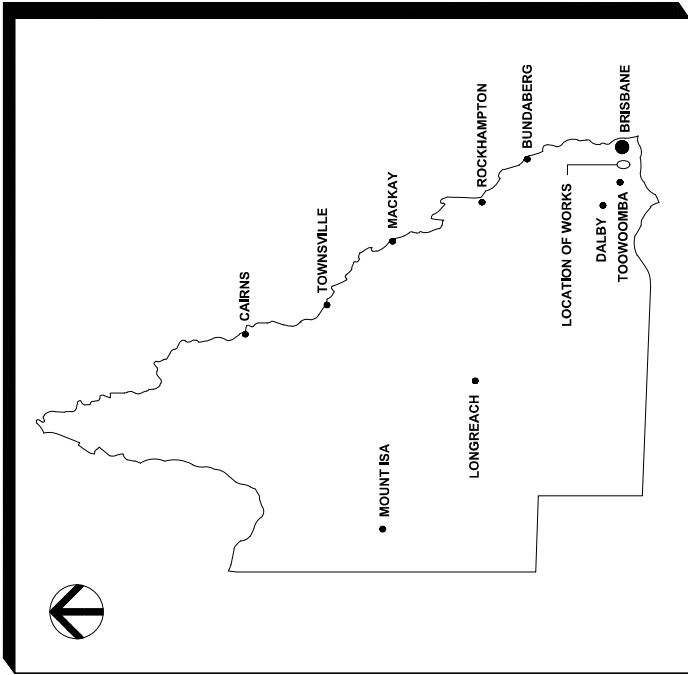
NEW OAKLEIGH COAL MINE REHABILITATION PLAN

RECOVERY PIT

NEW HOPE GROUP



LAYOUT PLAN
N.T.S.



LOCALITY PLAN
N.T.S.

REV	DESCRIPTION	DATE	POSITION	NAME	SIGNATURE
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3			APPROVAL	CLIENT	J.D.
4			APPROVAL	CLIENT	J.D.
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9			APPROVAL	CLIENT	J.D.
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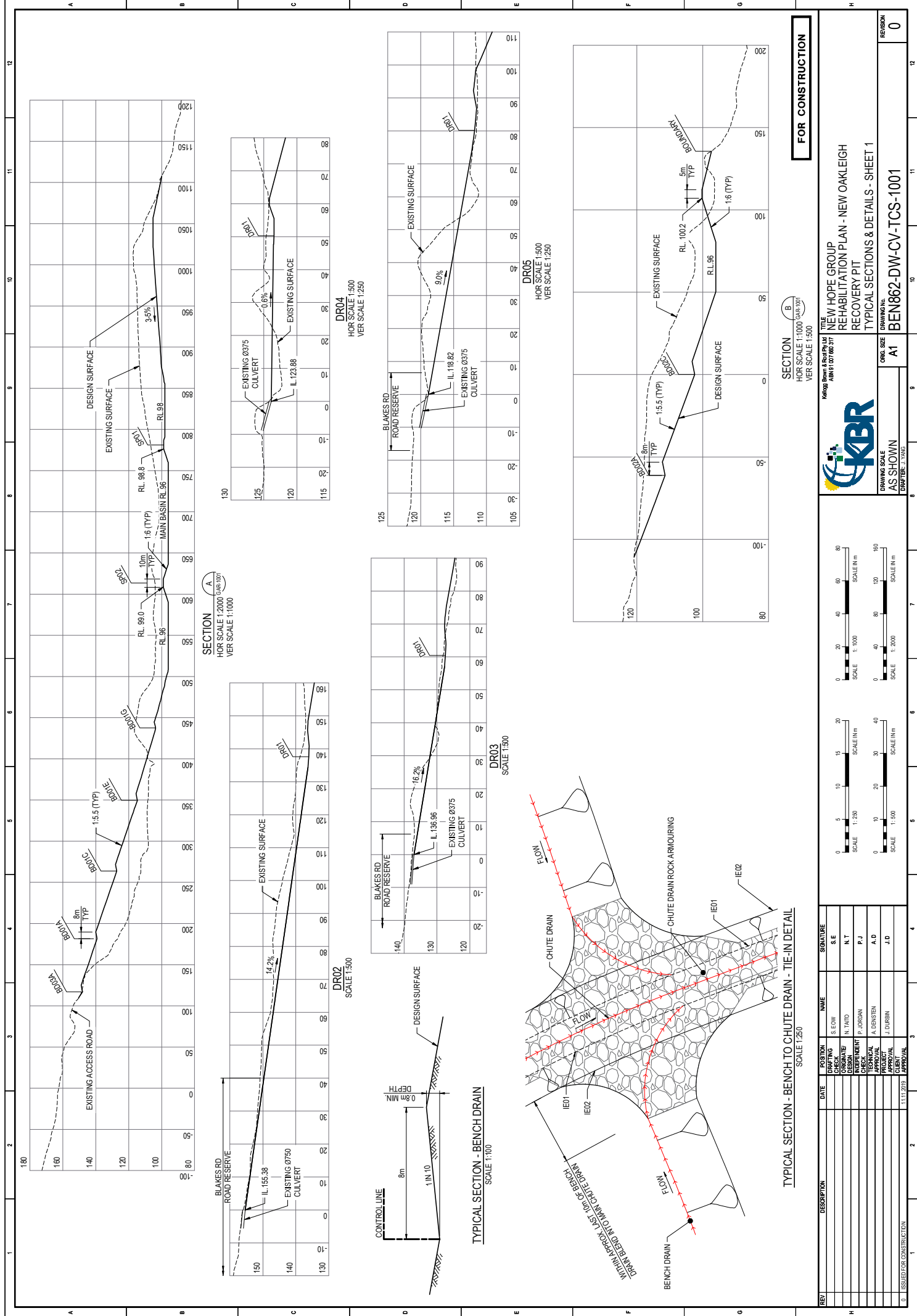


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DATE	11.11.2019	PROJECT	BEN862-DW-CV-PLK-1001
CLIENT	NEW HOPE GROUP	DESIGNER	BEN862-DW-CV-PLK-1001

NEW HOPE GROUP
REHABILITATION PLAN - NEW OAKLEIGH
RECOVERY PIT
LOCALITY PLAN

NOT FOR CONSTRUCTION

REVISION
0



NEW HOPE GROUP
REHABILITATION PLAN - NEW OAKLEIGH
RECOVERY PIT
TYPICAL SECTIONS & DETAILS - SHEET 1

DATE: 11/11/2018
DRAWN BY: J. DUBEN
CHECKED BY: A. DUBEN
APPROVED BY: J. DUBEN

PROJECT: NEW HOPE GROUP REHABILITATION PLAN - NEW OAKLEIGH RECOVERY PIT
DRAWING: TYPICAL SECTIONS & DETAILS - SHEET 1
SCALE: AS SHOWN
REVISION: 0

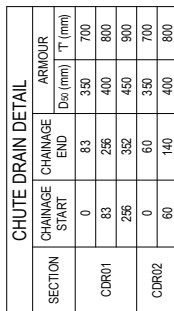


DR01 DETAILS				
SECTION	CHAINAGE START	CHAINAGE END	BASE 'X' (m)	ARMOUR
				Dco (mm) T' (mm)
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2	200	350	5.0	450 900
3	350	END	2.5	450 900

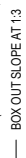
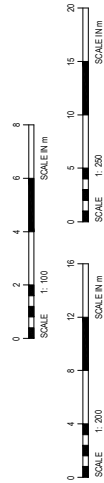


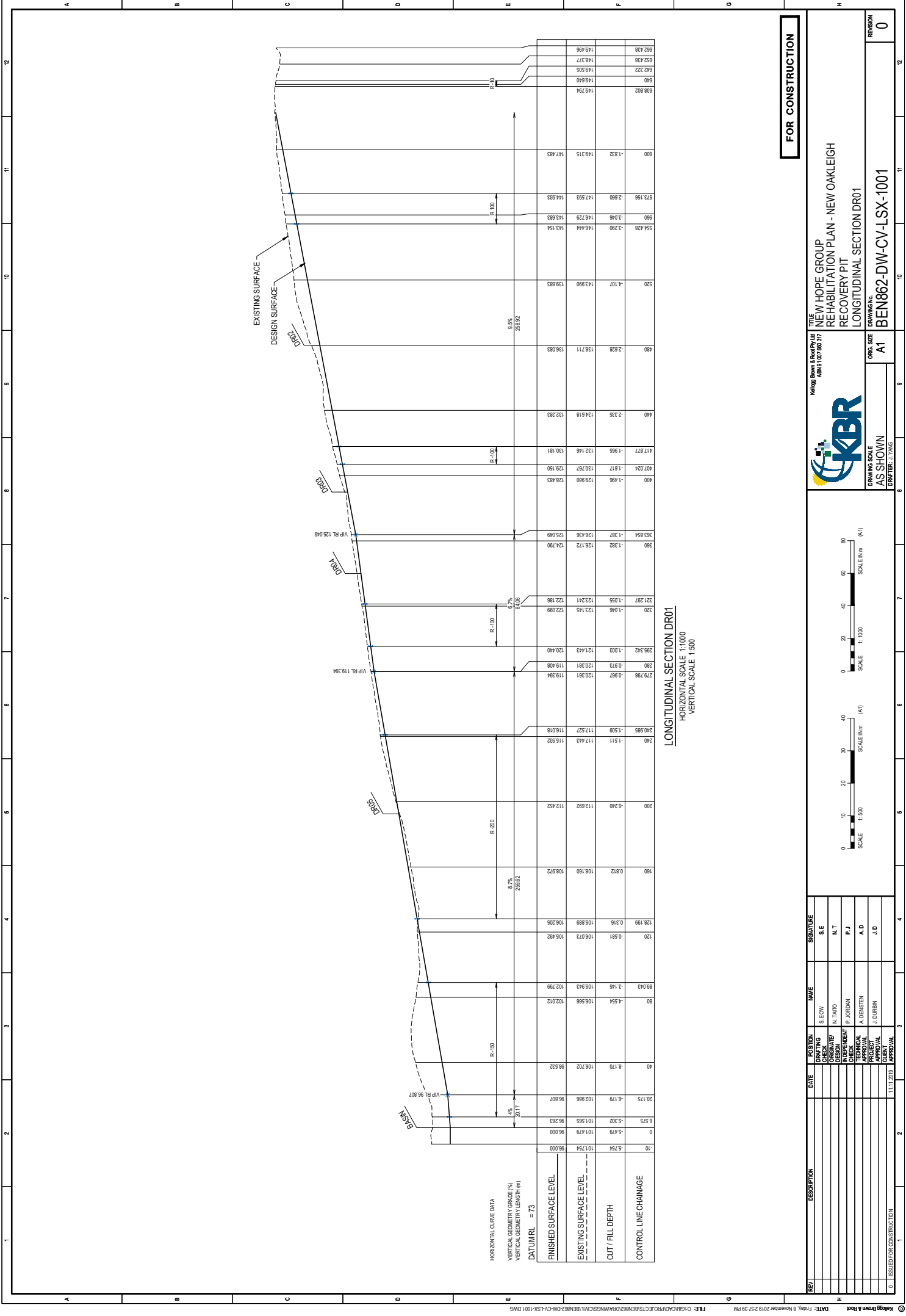
NOTE:

1. OVERALL CHANNEL DEPTH - 0.8m FOR FLOW CONTAINMENT.
2. ROCK DEPTH UP BATTERS TO 600mm FOR CHANNEL STABILITY.



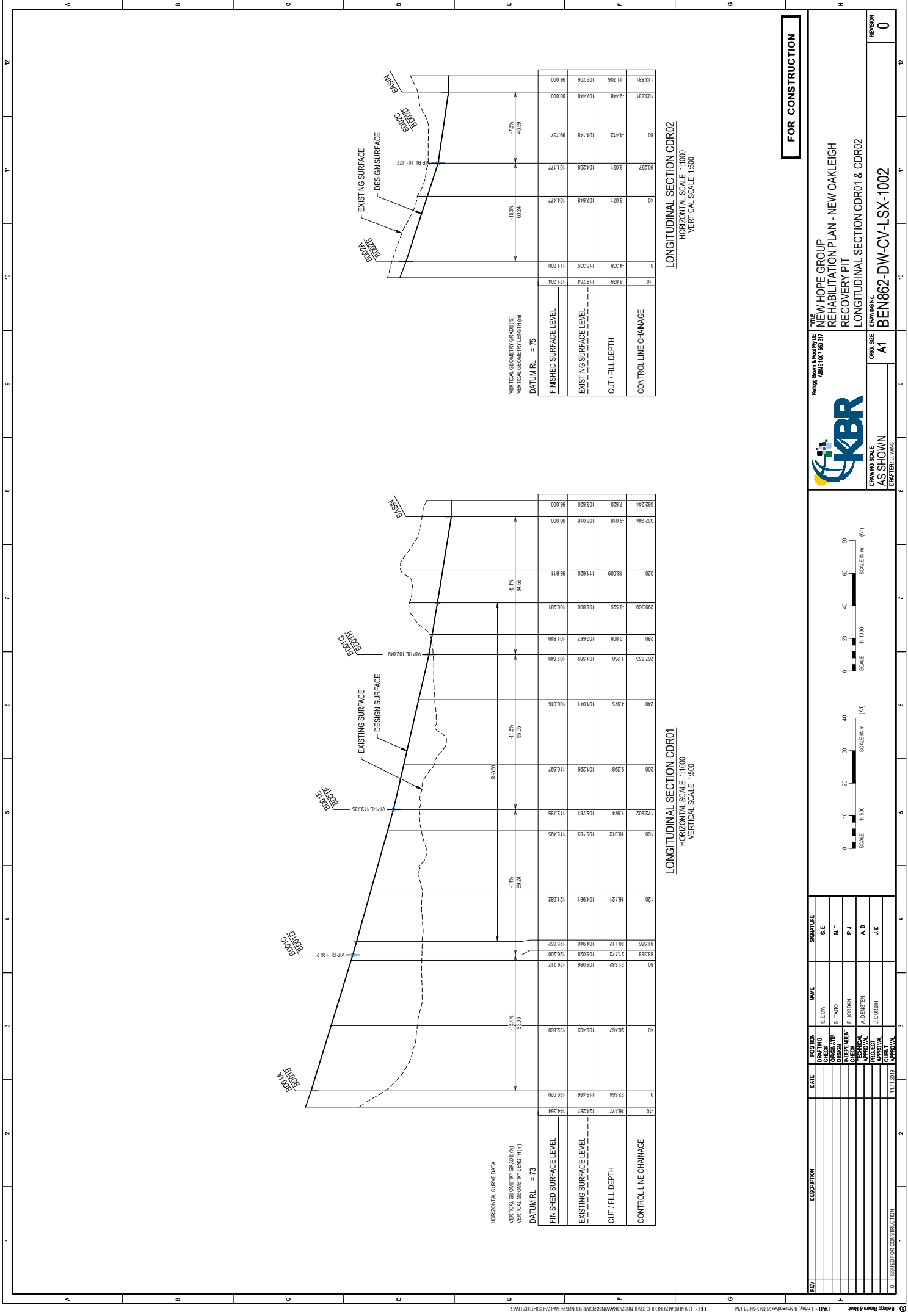
SPILLWAY DETAILS								
SPILLWAY	BASE 'X' (m)	SLOPE 'Y'	WIDTH 'Z' (m)	RL 'A' (m)	RL 'B' (m)	DEPTH 'H' (m)	ARMOUR	
							D ₅₀ (mm)	T ₁ (mm)
SP01	10	4	5	100.3	99.8	1.5	300	600
SP02	10	4	5	100.5	99.0	1.5	300	600





FOR CONSTRUCTION

KBR		KBR Group & Soil Pty Ltd KBR 81 007 800 377		NEW HOPE GROUP REHABILITATION PLAN - NEW OAKLEIGH RECOVERY PIT LONGITUDINAL SECTION DR01		REVISION 0	
DRAWING SCALE AS SHOWN		ORIG. SIZE A1		DRAWING NO. BEN862-DW-CV-LX-1001		REVISION 0	
DATE 11/11/2018		POSITION DRAFTING		NAME S. ECH		SIGNATURE S. E	
		DESIGN		N. T			
		INDEPENDENT		P. JORDAN			
		TECHNICAL		A. D			
		APPROVAL		J. DUBEN			
		CLIENT					
		APPROVAL					
		ISSUED FOR CONSTRUCTION					

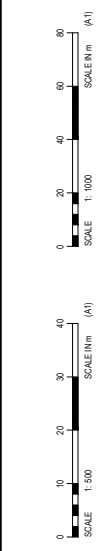


NEW HOPE GROUP
REHABILITATION PLAN - NEW OAKLEIGH
RECOVERY PIT
LONGITUDINAL SECTION CDR01 & CDR02

DATE: 11/1/2018
DRAWN BY: J. DUREN
CHECKED BY: J. DUREN
APPROVED BY: J. DUREN

SCALE: 1:500
SHEET: 1 OF 1

FOR CONSTRUCTION



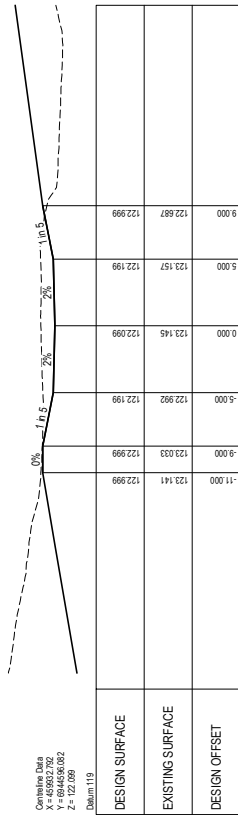
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3			APPROVAL	J. DUREN	J. DUREN
4			APPROVAL	J. DUREN	J. DUREN
5			APPROVAL	J. DUREN	J. DUREN
6			APPROVAL	J. DUREN	J. DUREN
7			APPROVAL	J. DUREN	J. DUREN
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10			APPROVAL	J. DUREN	J. DUREN
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12			APPROVAL	J. DUREN	J. DUREN

REV	DESCRIPTION	DATE	POSITION	NAME	SIGNATURE
	DRAFTING		SEOW		S.E
	DESIGN		ORGANATE		N.T
	IN TEND		N.TARD		P.J
	INSTRUMENT		P.JORDAN		A.D
	CHECK				A.DENISTEN
	APPROVAL				J.DURBIN
0	ISSUED FOR CONSTRUCTION	11/1/2019			

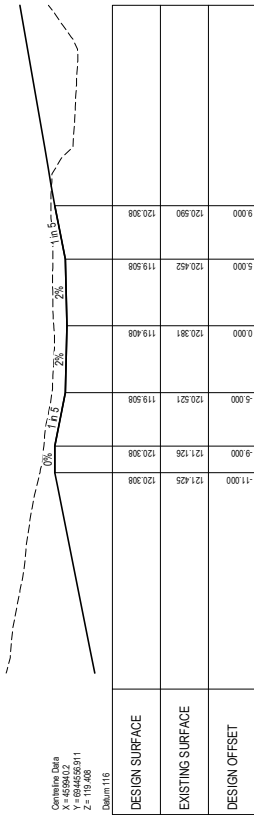
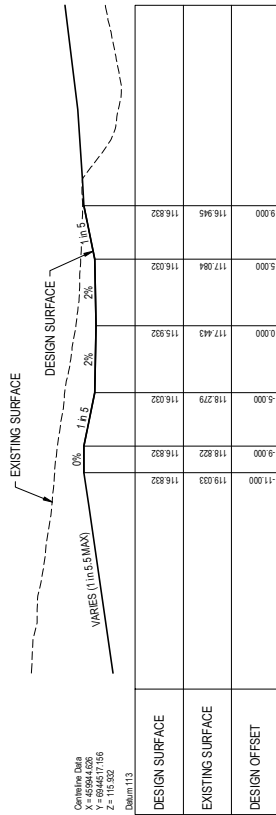
 KBR	Kollong Brown & Rod Pty Ltd ABN 9 1007 660 317	
	ORG. SIZE A1	DRAWING SCALE 1:200 DRAFTER: J. YANG

FOR CONSTRUCTION

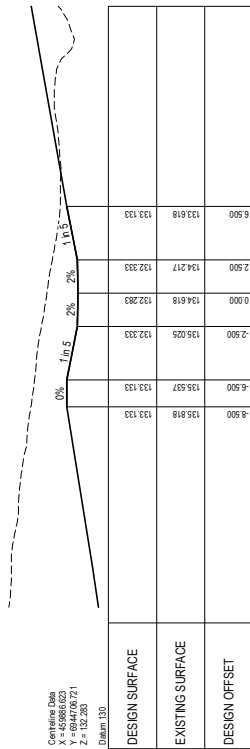
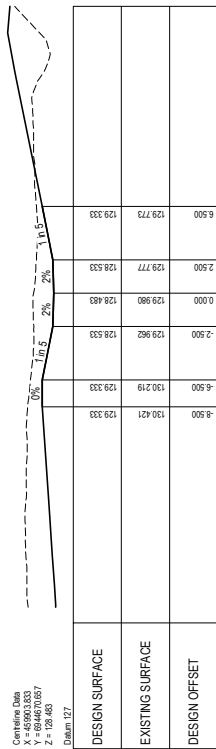
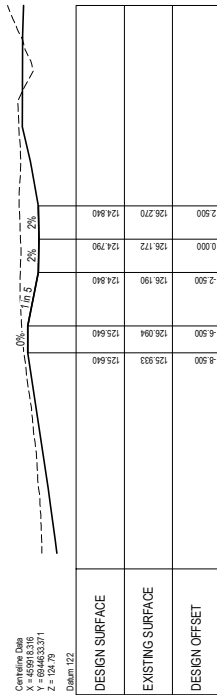
TITLE NEW HOPE GROUP REHABILITATION PLAN - NEW OAKLEIGH RECOVERY PIT CROSS SECTIONS DR01 - SHEET 2	DRAWING No. BEN862-DW-CV-CSX-1002



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SCALE 1:200

CHAINAGE 280
SCALE 1:200

CHAINAGE 240
SCALE 1:200

CHAINAGE 440
SCALE 1:200CHAINAGE 400
SCALE 1:200CHAINAGE 360
SCALE 1:200

NOTES

1. PART SECTIONS SHOWN FOR CLARITY



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	DRAWING SCALE 1:200 (AS SHOWN)	DATE 7/1/2003	



DRAWING SCALE 1:200	ORIG. SIZE A1	DRAWING No. BEN862-DW-CV-CSX-1003	REVISION 0
DRAFTER: J. YANG			

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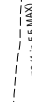
Defum 143

CHAINAGE 520
SCALE 1:200

Y = 69447.7

CHAINAGE 480
SCALE 1:200

Defum 134



CHAINAGE 600
SCALE 1:200

Datum 146



1. PART SECTIONS SHOWN FOR CLARITY

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APPROVAL		
PROJECT	J. DURBIN	J. D.
APPROVAL		
CLIENT		
APPROVAL		



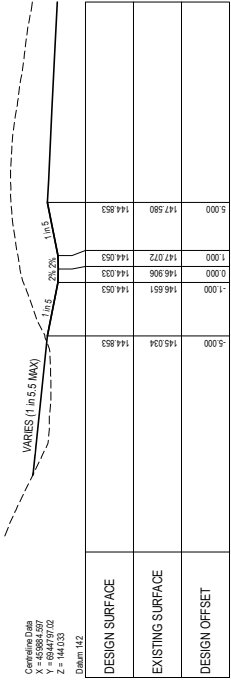
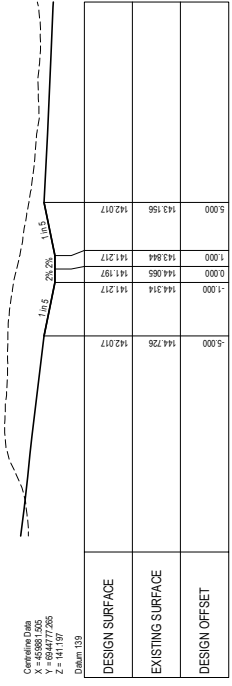
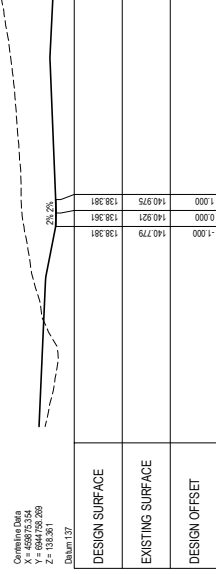
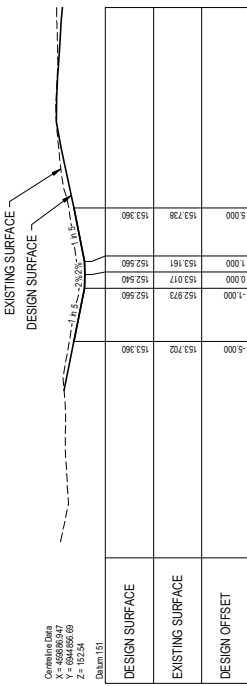
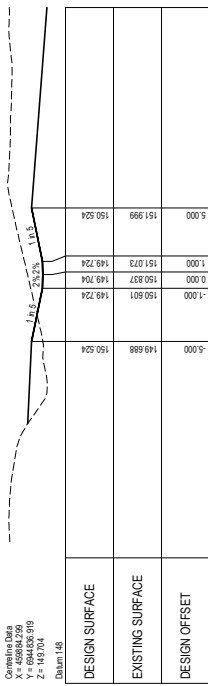
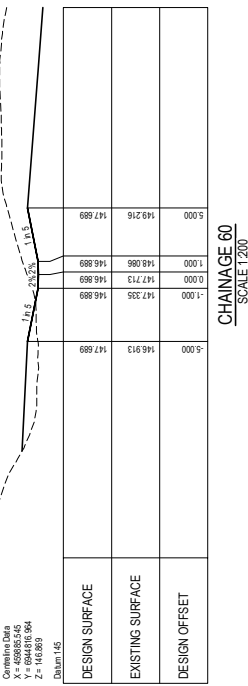
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DRAFTER: J. YANG	

FOR CONSTRUCTION

TITLE
NEW HOPE GROUP
REHABILITATION PLAN - NEW OAKLEIGH
RECOVERY PIT
CROSS SECTIONS DR02

DRAWING No.
BEN862-DW-CV-CSX-1004

REVA C



NOTES

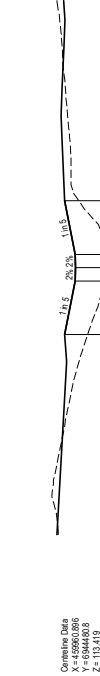
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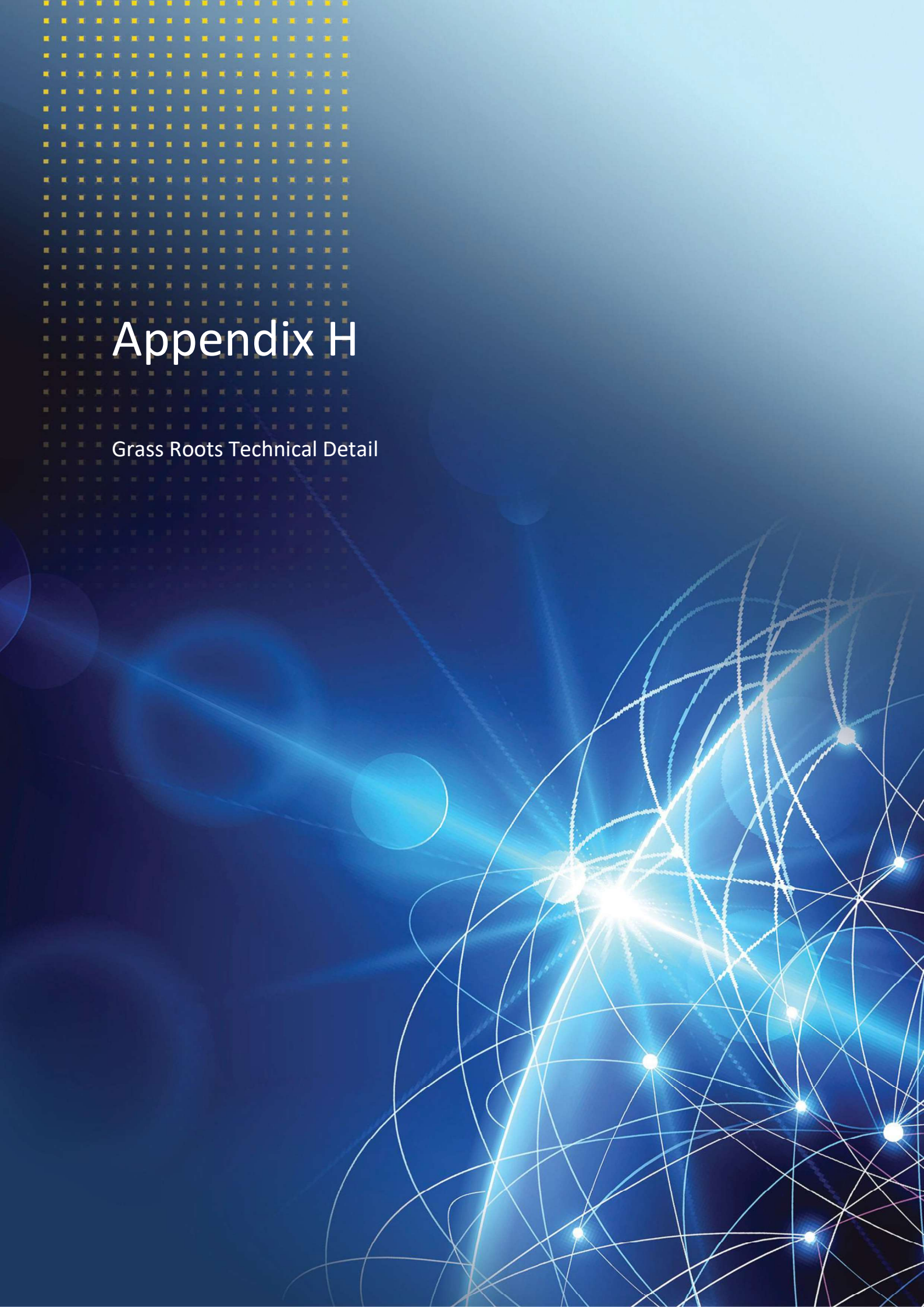
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DRAWING No.	BEN862-DW-CV-CSX-1006

FOR CONSTRUCTION

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DESIGN OFFSET	113.498	111.306	113.498	111.306	113.498	111.306
EXISTING OFFSET	112.757	110.565	112.757	110.565	112.757	110.565



1. PART SECTIONS SHOWN FOR CLARITY



Appendix H

Grass Roots Technical Detail

Outdoor Durability and Performance

Grassroots is an Australian-made permanent Rolled Erosion Control Product (RECP) made from heavy synthetic UV-stabilised fibres which are needle-punched together into an open weave synthetic scrim creating a three-dimensional structure. Grassroots has been designed to protect underlying soil in steep slopes and channels from moderate velocity water flows, rainsplash and other erosive conditions, while allowing seeds to germinate successfully and grow through the matting providing permanent vegetative reinforcement.



UV RESISTANCE – ASTM D4355 / D5970

In some applications, RECP's can be exposed to the elements for years at a time, requiring a high level of resistance from UV radiation. The fibres used in Grassroots contain high levels of stabilizers which help protect the polymer from photo-oxidative degradation. Samples of Grassroots have been tested for strength retained percentages after both outdoor and laboratory accelerated exposure. Samples removed from a site in QLD after 12 years in service on a fully exposed, unvegetated batter, had >50% strength retained. Additionally, samples of Grassroots exposed to xenon-arc light in an accelerated weatherometer for 1000h showed no loss in tensile strength.

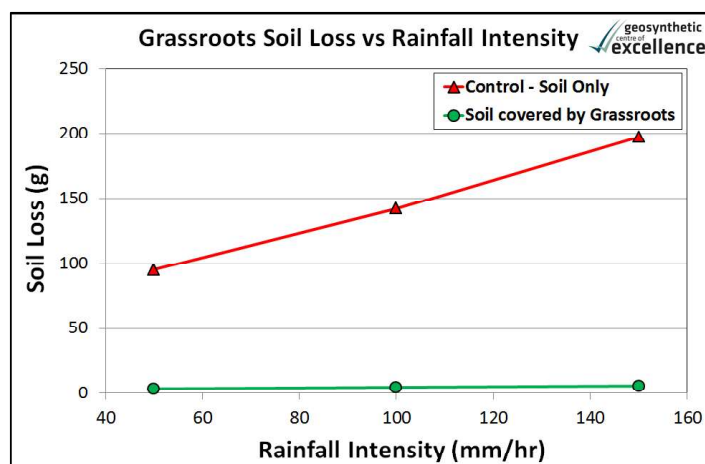


PERMISSIBLE SHEAR AND CHANNEL EROSION – ASTM D7207

Grassroots has been used successfully in many channel lining and road edge rehabilitation applications requiring increased resistance to soil loss as a result of hydraulically-induced shear stresses. Grassroots has been tested according to ASTM D7207 *Determination of Unvegetated Rolled Erosion Control Product (RECP) Ability to Protect Sand from Hydraulically-Induced Shear Stresses under Bench-Scale Conditions* which subjects containers with bare soil and containers with Grassroots-protected soil to shear stresses caused by the rotation of an impeller while fully immersed in water. Unvegetated tests show Grassroots is able to provide a reduction in soil loss to <13mm under shear stresses up to 180N/m².

RAIN SPLASH PROTECTION – ASTM D7101

One of the primary design characteristics of an RECP is to reduce the loss of soil during rainfall events. ASTM D7101 *Determination of Unvegetated Rolled Erosion Control Product (RECP) Ability to Protect Soil from Rain Splash and Associated Runoff under Bench-Scale Conditions* determines the soil loss ratio by comparing the loss of soil with and without an RECP using different rainfall intensities. As seen below, Grassroots provides an excellent barrier against soil loss even during heavy rainfall events.



GERMINATION ENHANCEMENT – ASTM D7322

Another important feature of RECP's is their ability to provide an enhanced long-term structure to assist with seed germination and reinforcement to the vegetation throughout maturation. Grassroots has been tested according to ASTM D7322 *Determination of Rolled Erosion Control Product (RECP) Ability to Encourage Seed Germination and Plant Growth under Bench-Scale Conditions* in which "containers containing soil are sown with seeds and then covered with an RECP. Additional containers of soil are sown with seed and left uncovered as controls. The light, temperature and humidity are maintained and documented. The amount of germination and growth is measured periodically throughout the test, and the mass of vegetation is calculated at the conclusion of the test" (ASTM D7322, Section 4.1). Using this method, Grassroots showed a 555% increase in biomass after 21 days when compared with the control pots.



Outdoor Durability and Performance

LARGE SCALE VEGETATED CHANNEL TESTING – ASTM D6460

ASTM D6460 Standard Test Method for Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Earthen Channels from Stormwater-Induced Erosion models and examines conditions typically found on construction sites involving earthwork activities, including: highways and roads; airports; residential, commercial and industrial developments; pipelines, mines, and landfills; golf courses; etc.

According to the method, the critical elements of this protection are the ability of the RECP to:

- Neutralize and absorb the hydraulic force of stormwater, thereby reducing soil particle loosening through “scour” mechanisms;
- Slow runoff and encourage sedimentation, thereby reducing soil particle transport downstream;
- Absorb shear forces of overland flow;
- Trap soil particles beneath; and
- Promote the establishment of vegetation.

A 300mm deep compacted soil bed was constructed in a 0.6m wide x 12.2m long flume on a 20% slope. Grass seed was sprinkled at a prescribed rate directly on top of the soil, followed by a sample of Grassroots, which was anchored at 0.3m intervals. The channel was then left for 6 months to allow the grass to establish through the sample.



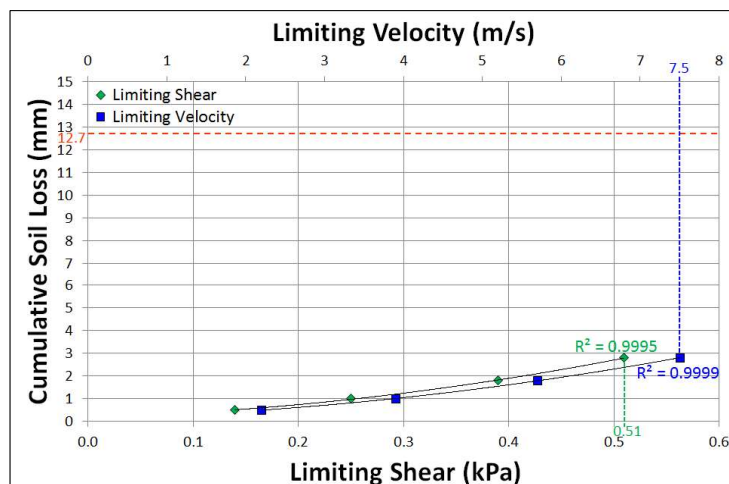
The analysis determines the maximum hydraulic forces that may be exerted on an RECP as a flexible channel liner in a vegetated condition. An RECP is considered to have failed once the average soil loss under the product has exceeded 12.7mm. During the execution of each test, flow velocity, flow depth and discharge are measured. At the conclusion of each test, the topography of the bed surface is quantified to determine the net erosion over the system. At the conclusion of the series of flows, shear stress (tractive force) is computed and compared to the soil loss measured. Evaluation of the data allows for a determination of the maximum shear stress and velocity achieved prior to 12.7mm of soil loss. Further, the resistance to flow (roughness, quantified as Manning's 'n') is computed from test data.

Four levels of flow were used in the analysis, each running for 60 minutes, up to flow velocities of 7.5 m/s. Even after subjecting the channel to increasing levels of flow, there was an insignificant loss of soil and vegetation.

Shear Level	Flow Depth (mm)	Flow Velocity (m/s)	Flow (L/s)	Manning's Roughness (n)	Max Bed Shear Stress (kPa)	Cumulative Soil Loss (mm)
1	73	2.2	96	0.036	0.14	0.5
2	142	3.9	336	0.030	0.25	1.0
3	216	5.7	751	0.027	0.39	1.8
4	305	7.5	1395	0.025	0.51	2.8



During LOW FLOW After During VERY HIGH FLOW After



If you have any questions regarding the information contained within this document, please contact Daniel Gibbs at the Geosynthetic Centre of Excellence at d.gibbs@geofabrics.com.au.

EROSION CONTROL

Matting Installation Guide

BEFORE YOU BEGIN

Storage

Mating rolls should be stored in their original, unopened packaging. The designated storage area should be level, dry, well-drained, stable, and should protect the product from:

- Precipitation;
- Chemicals;
- Standing water;
- Excessive heat;
- Ultraviolet radiation;
- Vandalism and animals.

Biodegradable matting such as jute should not be exposed to moisture prior to installation as this can cause premature degradation. Damaged wrappers should immediately be repaired with weather resistant tape. Wrapping should only be removed from rolls immediately prior to installation.

What You'll Need On Site

Prior to commencement of installation the following equipment will be required:

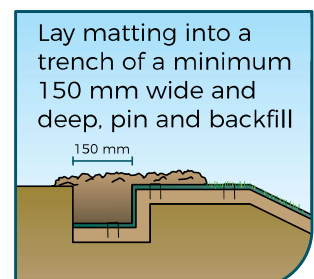
- Carpet knife, safety knife or scissors;
- Hammer or mallet;
- Spade or digger for trenching.

PREPARING THE SURFACE

- It is recommended that weed affected areas are sprayed with herbicide prior to mat installation.
- Excavate and trim slope to smooth profile, removing obstructions such as tree stumps or rubble and filling in any voids. The smoother the surface, the better contact between soil and matting.
- Excavate anchor trenches along the top edge as specified.
- Top soil is required to successfully grow grass and plants. Evenly spread top soil across the surface to required depth.
- All pre-seeding of the soil to be carried out prior to laying Grassroots and Biomac.

TRENCHING

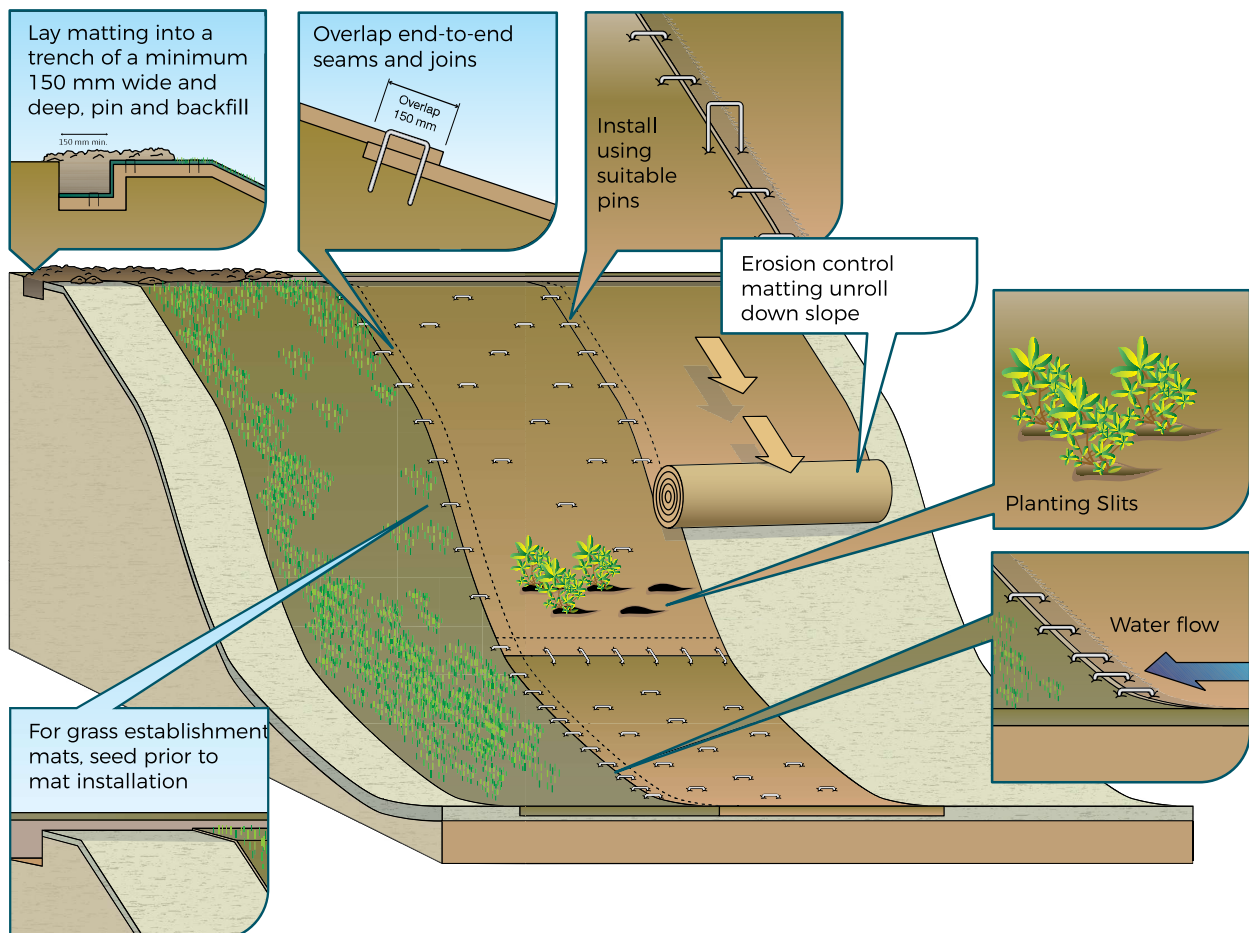
- A trench is necessary on gradients of 1:3 or steeper and in riparian or flood areas.
- Dig a trench at the top of the slope, minimum width and depth of 150 mm.
- Pin the end of the roll into the bottom of the trench at 300 mm intervals.
- Back-fill the trench and roll the matting down the slope with a minimum overlap of 150 mm.
- Pin material ensuring the overlaps are secured well.
- Trenches should be deeper for channels and slopes steeper than 1:1.



LAYING THE MATTING

The following instructions apply to all grades of Grassroots, Biomac and Jute.

- The material should be rolled from top to bottom of steep batters, as opposed to across the batter. The material may sag between fastening pins if laid across steep slopes.
- Minimum overlap of 150 mm is recommended. Overlaps should be pinned at 300 mm intervals.
- The matting should be laid down the flow line in swale drains. The leading edges should be trenched and overlaps must follow the flow line downstream.
- Sites subject to flooding require the laying pattern to mimic a fish-scale pattern. The material should be laid so that the leading edges are not exposed to water flow.
- Do not pull the material tightly across the soil surface. Allow it to contour to the soil profile and into undulations. This allows the material to settle and bond with the topsoil.
- If the site requires the matting to be laid across slopes, then the top edge should be trenched and pinned at a higher rate.



PLANTING

Grassroots & Biomac

Spread seed and fertiliser consistently over the topsoil prior to installation. Applying seed via a hydro-seeding machine is recommended for larger areas.

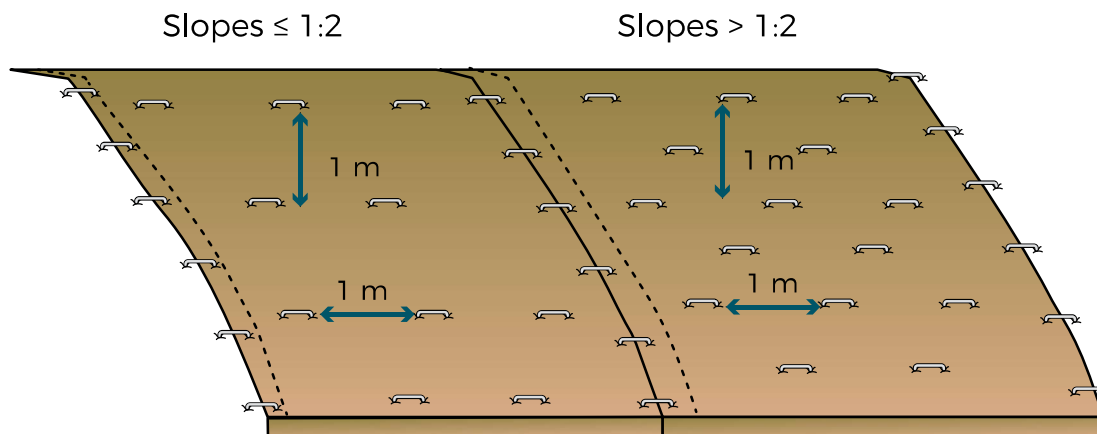
The material is designed to allow seeds to germinate successfully and grow through the matting providing permanent vegetative reinforcement.

Jute

- Planting into the mat requires a small slit to be cut (150 mm long) using a sharp blade or scissors. Do not cut a circular hole for your seedlings, as this may facilitate weed growth.
- Remove enough soil from under the material to plant the seedling. Ensure that excess soil does not come into contact with the top surface of the matting to reduce the spread of weed seed.

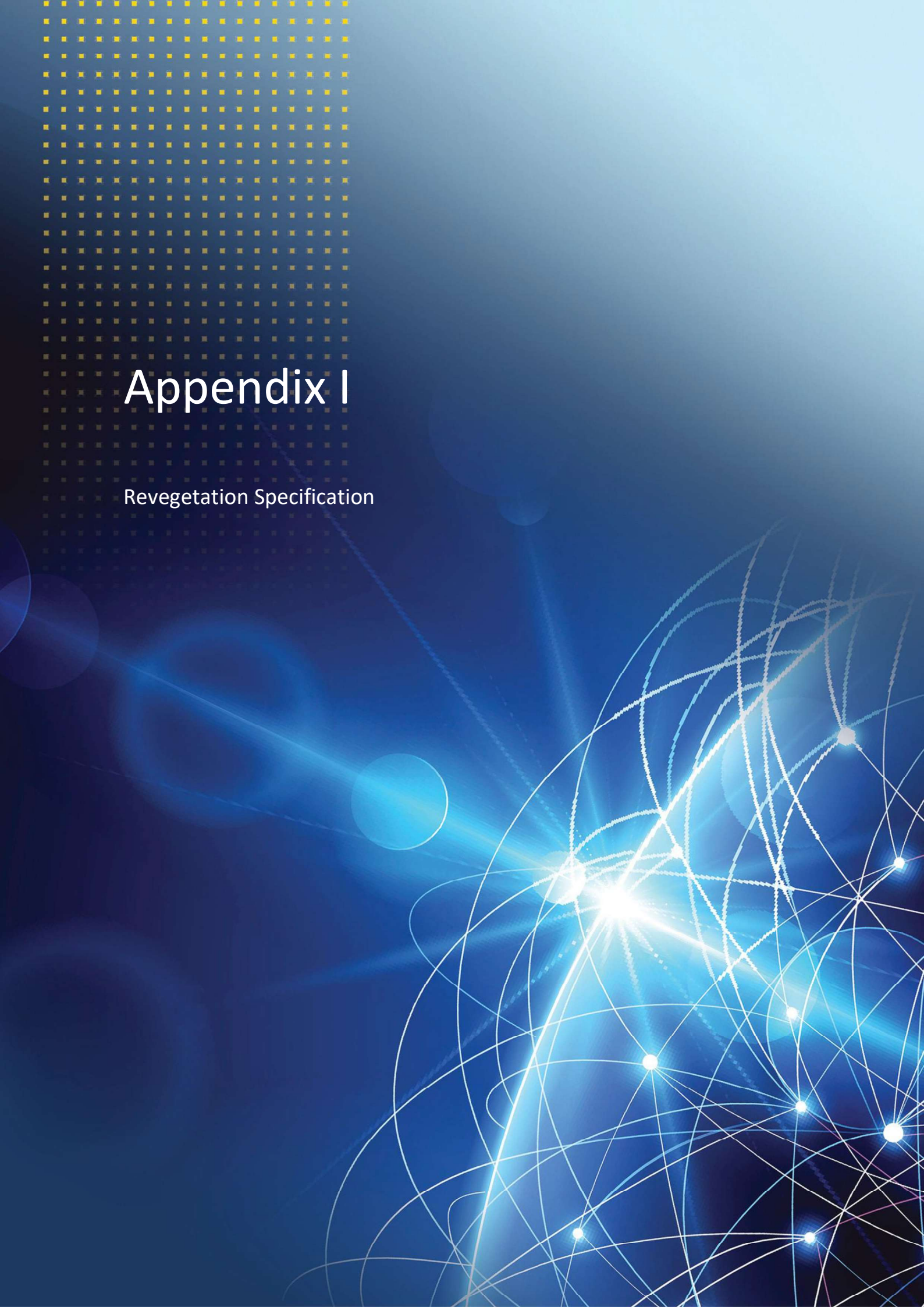
PINNING

- Minimum pinning frequency is shown in the figures below.
- Additional pinning may be required in undulating soil with low spots to ensure intimate contact between mat and soil.
- On steeper batters, flooding areas or areas prone to high wind and unstable subsoils, a higher pinning rate should be used.
- Pinning is extremely important to the long-term stability of the matting. Insufficient pinning may result in the material lifting in the wind or under water flow.
- Pin type and size will depend on site conditions, soil depth, compaction, wind and water flow. For suggested pins sizes, please refer to the designer. Contact Geofabrics for options available in your area.



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Appendix I

Revegetation Specification

PLANTING SPECIFICATIONS FOR GRASS-ROOTS AREAS

Planting medium and fertiliser:

- Gypsum (12 t/ha) and lime (3 t/ha) under or mixed with topsoil
- Superphosphate (200 kg/ha) mixed with topsoil
- Urea (100 kg/ha) mixed with topsoil
- 300 mm depth (if available) or minimum depth of 150 mm of topsoil
- Loosen and roughen topsoil surface prior to seeding if surface has 'set' since application

Seed with:

- Rhodes Grass (Pioneer variety 70-100% and (if available) 'Reclaimer' type of Katambora variety 0-30%) (5 kg/ha)
- Gatton Panic Grass (1 kg/ha)
- Barley (10 kg/ha)
- Aztec Siratro (0.5 kg/ha)
- Sally Wattle (*Acacia salicina*) (0.3 kg/ha)
- Black Wattle (*Acacia leiocalyx*) (0.3 kg/ha)

Water:

- 25mm every second day for first week
- 25mm twice a week for next three weeks
- 25mm weekly for a further two weeks.

Monitoring (vegetation establishment and weeds):

- Monthly for first year
- Then, quarterly until vegetation establishment is satisfactory in all areas (i.e. >70% cover)

Maintenance:

- Reseeding and / or additional application of fertiliser and / or water in poorly performing areas (e.g. <70% cover after 12 months) as required based on monitoring.
- Treatment of potentially dominating undesirable weed species (e.g. Castor Oil Bush, Groundsel, Lantana).