Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Donnybrook Mine Shaft Remediation Methodology
Lot F27 Goodwood Road, Upper Capel

Prepared for
Department of Mines, Industry Regulation & Safety

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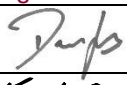
Author		18 June 2021
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1. Introduction

This report presents recommendations by Douglas Partners for the remediation of ten mine features investigated as part of the Donnybrook Mine Shaft Remediation Methodology project. The purpose of this report is to detail the recommended methods for remediation and attribute budget cost estimates to carry out the recommended remediation.

The investigation was commissioned in a letter dated 14 September 2020 from the Department of Mines, Industry Regulation & Safety (DMIRS) and was undertaken in accordance with Douglas Partners' proposal PER200261 dated 7 August 2020.

The ten features were identified by DMIRS as priority for remediation due to the high risk to persons within the forest (either for recreational or professional reasons).

Based on the results of the investigation undertaken in February and March 2021 (findings detailed in report reference 96721.00.R.002.Rev0), this report provides a recommended remediation methodology for the ten features including comment on:

- detailed description and rationale;
- quality control process for material specifications and backfill methodology;
- plant and equipment requirements;
- personnel and specific technical expertise required;
- timing and/or sequencing requirements;
- remediation schematics;
- disturbance area;
- potential risks to effective implementation including any impact from groundwater or unfavourable geochemistry, where applicable;
- budget costing for the recommended remediation options; and
- post remediation monitoring requirements.

To assess the most suitable remediation methodology, the following items were considered:

- long-term suitability of the solution to mitigate safety risks;
- technical feasibility and cost-effectiveness;
- minimising ongoing monitoring or maintenance;
- minimising disturbance to the surrounding forest area; and
- minimising risk to personnel involved in providing the remediation works.

2. Identified Risks

The geotechnical investigation undertaken in two phases during February and March 2021,. Phase 1 generally assessed the ten identified features to understand the risks associated with each feature whether there were any lateral workings passing beneath the adjacent access track. Where horizontal workings were detected within Phase 1, Phase 2 of the investigation assessed the characteristics of the workings below the track to better understand the risk the lateral workings posed to the stability of the ground underlying the track.

The risks the features pose to personnel within the forest includes:

- Falls into the features; and
- Surface collapse above lateral workings, particularly along the access track where heavy equipment such as firefighting trucks, may travel.

In summary, the investigation concluded that the stability of the ten identified features was sound considering their age with no evidence of any features being collapsed and plugged shafts which would form deeper features than they appeared. Three locations where lateral working passing below the adjacent access track were identified and all assessed to be very low risk of collapse, owing to their small dimensions, depth below the ground surface and apparent stability from observations made during this study, together with competent ground conditions. Some waste that included some potentially asbestos containing materials (PACM) was identified into Feature 6.

As such, the primary goal of the remediation option is to provide a solution which prevents personnel or equipment falling into the features.

3. Remediation Options

Possible options to remediate the features to reduce the risk to personnel and equipment include:

1. filling the features with stabilised fill or slurry type product;
2. capping or plugging the features;
3. covering the features with a grate;
4. fencing the features; or
5. filling the features with soil.

The above options are discussed in further detail in the following sections.

3.1 Filling Features with Stabilised Fill or Slurry

This method is considered to produce a suitable end result with very low ongoing maintenance requirements however the equipment required to provide this option is somewhat specialised, therefore is anticipated to unnecessarily increase the remediation costs compared to some other options. Providing access to the equipment to provide this solution may also require adjustment to the existing access track, thereby increasing impact on the forest.

3.2 Capping or Plugging the Features

This solution is typically more suited to deep shafts which are uneconomical to backfill to the base. Most features at the site are shallow and the deepest feature amongst the 10 features is approximately 17 m, with a total combined volume of the 10 features in the order of 300 m^3 which is considered to form a relatively small volume. The construction would also be significantly more complex, present greater risks to personnel during construction, be more expensive, result in greater impact on the forest than other simpler solutions (eg backfilling with soil) that would achieve similar results. Therefore, the features are not considered suited to a solution by capping or plugging.

3.3 Covering the Features with a Grate

A grate is considered to be a suitable solution to prevent personnel and equipment from accidental falling into the features. It is typically more suited to ground conditions where strong rock is located at or near the surface (which is not the case at this site), however construction of a suitable founding system such as a strip footing around the perimeter of the feature would provide a suitable founding system to anchor the grate onto. Structural resistance of the grate during a bushfire, when risk of fall to firefighting personnel and vehicle would be the greatest, would need to be considered. Ongoing maintenance is likely to be low, however the system can be vandalised or damaged, thereby requiring periodic visual checks and associated repairs to ensure the grates are in good condition.

Grate would not be suitable at Feature 5, owing to the geometry of the feature.

3.4 Fencing the Features

A fence is considered to be a suitable solution to reduce the risk of accidental falling into the features. The solution however is unlikely to prevent accidental access for heavy equipment such as a firefighting truck, or voluntary access by the public. Fencing is anticipated to have similar ongoing monitoring and maintenance requirements as a grate solution, however its construction would have a lower impact to the forest and be cheaper than other solutions.

3.5 Filling the Features with Soil

This method is considered to produce a suitable remediation option with very low ongoing maintenance requirements, and likely no maintenance in the long term. Unlike the stabilised material or slurry option, granular soil, suitable for fill is locally available and does not require specialised equipment or expertise to handle and place. This solution is considered to have a low impact on the environment as the imported material comprises soils (rather than say concrete products). Ongoing maintenance should be minimal, and likely not required in the long term, once the suitability of the solution is confirmed by some monitoring in the short term.

The matrix below, provides a rating for of the above discussed options with respect to the project considerations listed in Section 1.

Table 1: Rating Remediation Solution Considerations

Remediation Option	Remediation Solution Considerations				
	Long-term suitability	Feasibility and cost-effectiveness	Monitoring and Maintenance Requirements	Impact on Surrounding Forest	Risk to personnel providing/constructing solution
Fill with Stabilised Material or Slurry	***	*	***	*	***
Capping or Plugging	***	*	**	*	*
Covering with a Grate	**	***	**	**	**
Fencing	*	***	**	***	**
Filling with soil	***	***	***	***	***

Notes: * : suitability of solution is low
** : suitability of solution is moderate
*** : suitability of solution is high

Backfilling the features with soil is considered to be the most suitable solution for the features at this site. Further discussion of this remediation solution is provided in Section 4.

4. Recommended Remediation Option

4.1 Material Specifications

Specification for fill material should satisfy the following points:

- the fill should comprise a granular material (i.e. either sand or gravel);
- organic content should be less than 5% (when assessed in accordance with ASTM D2974-14 - Test Method C);
- fines content (i.e. passing 75 mm sieve size) should be less than 12% (when assessed in accordance with AS1289.3.6.1);
- no particle greater than 75 mm in size (when tested in accordance with AS 1289.3.6.1; and
- liquid limit of less than 15% (when tested in accordance with AS 1289.3.1.1).

Other materials that do not meet the above specification could possibly be suitable provided they are assessed and approved by a geotechnical engineer.

4.2 Recommended Process

Prior to any remediation, it is anticipated that some minor clearing for the widening of some tight bends in the existing access track will be required to allow access to the area to vehicles delivering the fill.

A remediation schematic is provided in Figure 1 below.

Figure 1: Mine Feature Remediation Schematic

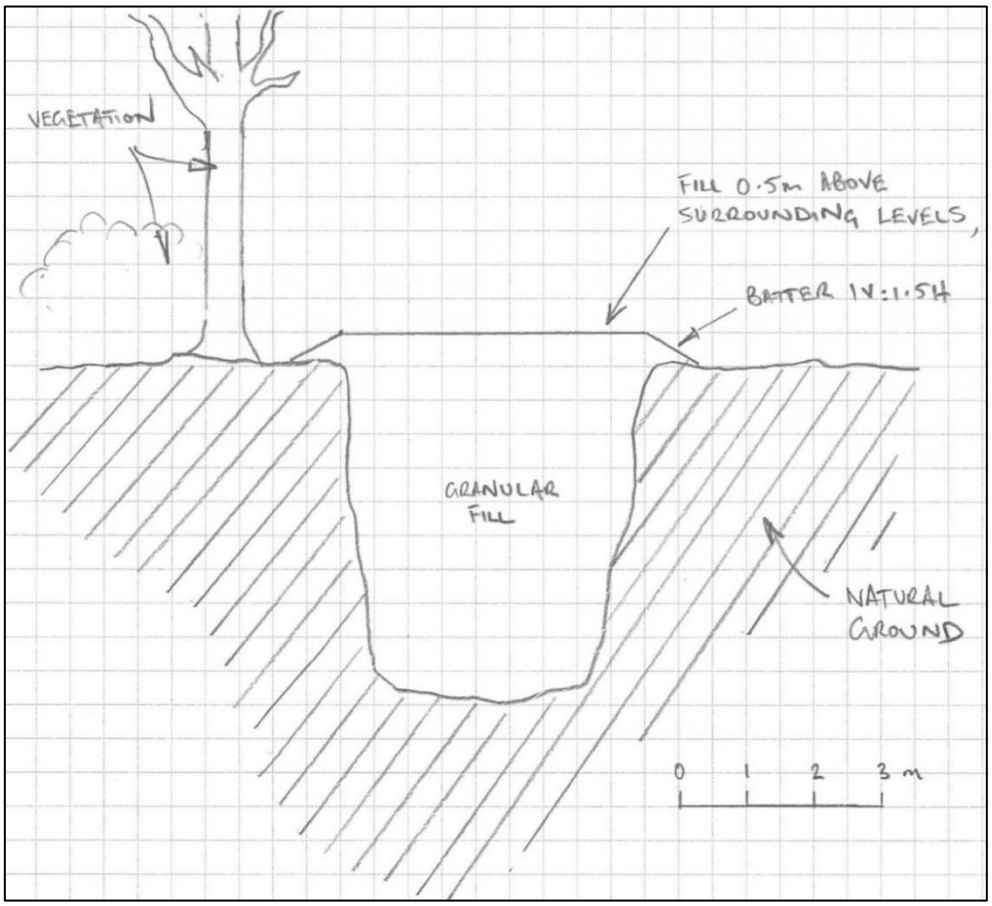

Table 2 next page provides an information on the feature volumed calculated from the data gathered during the geotechnical investigations and estimated fill material volumes.

Table 2: Estimated Fill Volumes

Feature	Volume of Feature (m^3)[1]	Fill Required to Surface (m^3)	Volume to Mound Above Feature (m^3) (to 0.5 m above surface)[3]	TOTAL (m^3)
1	51	51	14	65
2	12	12	2	14
3	<5	5	1	6
4	13	13	3	16
5	18	15[2]	2	17
6	<5	5	2	7
7	72	72	14	86
8	84	72[2]	4[3]	76
9	<5	5	2	7
10	25	25	6	31
TOTAL	**~290**	**275**	50	**325**

Notes: [1]: Derived from LiDAR data scans of the features undertaken in February 2021.
[2]: Fill volume less than feature volume due to partial removal of zones within lateral workings which will not be filled when placing fill in the features from the surface.
[3]: 1 m thick mounding (rather than 0.5 m) at Feature 8.

It is anticipated for the remediation work to take 10 to 20 working days.

4.2.1 Backfill of Features 1 to 4 and 7 to 10

The following process is recommended to backfill all features other than Features 5 and 6.

1. Deliver a fill to a suitable location at site.
2. Place fill into the feature, without compaction.
3. Continue to place fill until the surface of the fill is 0.5 m above the surrounding surface levels and batter the edges around the perimeter of the fill an angle of 1V:1.5H (therefore, at least 0.75 m beyond the edge of the feature).
4. Compact the surface of the fill.

In addition to the above comments, the following situation may apply to some features:

5. Where stockpiles of disturbed soils, free of significant vegetation are adjacent to features (i.e. material disturbed during the February 2021 field work), this material could be spread across the surface of the imported fill.

To account for anticipated increased fill consolidation at Features 8 (the deepest feature), it is recommended to mound fill to 1 m above the surrounding surface levels at Feature 8 and batter the edges around the perimeter of the fill an angle not steeper than 1V:1.5H.

4.2.2 Backfill of Feature 5

The following process is recommended to backfill Feature 5.

1. Deliver a fill to a suitable location at site.

2. Place fill into the feature, as close as practicable to the lateral opening at the base of the feature.
3. Following the placement of each load of fill, direct water into the feature (for instance using a pump and hose), from the surface and with sufficient pressure to flush the fill through the opening. Avoid delivering more water than required to move the fill into the inclined lateral working.
4. Continue repeating steps 2 and 3 until the inclined lateral working has been filled.
5. Place fill into the feature, without compaction, until the surface of the fill is 0.5 m above the surrounding surface levels and batter the edges around the perimeter of the fill an angle not steeper than 1V:1.5H (therefore, at least 0.75 m beyond the edge of the feature).
6. Compact the surface of the fill.

It is recommended that this process is undertaken under the supervision of a geotechnical engineer. All personnel should keep a safe distance (2 m suggested) from the features unless wearing a fall arrestor harness.

4.2.3 Backfill of Feature 6

At the time of the investigation, Feature 6 contained potentially asbestos containing material (PACM). From a geotechnical perspective, it is considered that the backfill of Feature 6 could be done with the PACM left in place (effectively capping the PACM) or following the removal of the PACM. If the PACM is removed prior to backfill, the procedure outline in Section 4.2.1 is suitable for remediation.

If the PACM is left in place the following procedure is suggested:

1. Deliver a fill to a suitable location at site.
2. Wet the PACM with water, from the surface, enough to cover the surface of the PACM materials. Avoid over-wetting.
3. Tamp or compress the top of the PACM fill with an excavator bucket.
4. Place fill into the feature, in lifts of maximum 0.4 m thickness (loose lift thickness) and tamp with the excavator bucket until no notable compression at the surface of the fill is observed.
5. Repeat step 4 until the level of fill matches the surrounding surface level.
6. Place fill until the surface of the fill is 0.5 m above the surrounding surface levels and batter the edges around the perimeter of the fill an angle not steeper than 1V:1.5H (therefore, at least 0.75 m beyond the edge of the feature).
7. Compact the surface of the fill.

This operation would require a relatively small bucket or similar attachment to tamp the fill. Some geotechnical supervision is recommended at this feature if the rubbish is left in place prior to backfilling.

5. Site Management Considerations

5.1 Safe Working Recommendations

The primary risk to personnel and equipment involved with the remediation works are falls into the features. Therefore personnel should remain at least 2 m from the edges of the features unless a fall arrestor harness, anchored to a suitable point, is worn (or other safety devices suitable for the task to be undertaken).

Placement of fill into features should be done using an excavator, positioned at a safe distance (e.g. at least 1.5 m) from the feature.

5.2 Clearing and Equipment Access

It is anticipated that some minor clearing due to widening some bends in the existing access track will be required to allow access to the area to vehicles delivering the fill.

Additionally, depending on the size of the plants utilised by the contractor, some clearing may be required in the immediate vicinity of the features, however even if required, such clearing is anticipated to be minor.

Some gravelly material may be required to improve the trafficability of the existing access track for both earthmoving plant and plant delivering fill to site.

5.3 Geotechnical Engineer Supervision

It is anticipated that the majority of the work could be undertaken without any specialised supervision from a geotechnical engineer, however supervision during the backfill of Features 5 and 6 is considered prudent.

5.4 Material Testing

Quality control of the fill material need not be onerous given the primary focus is to backfill the features in such a way so that there is minimal movement of the fill following its placement.

A laboratory testing programme that comprises the assessment of the soil particle size distribution and Atterberg limits (liquid limit, plastic limit and plasticity index) on representative samples of the proposed fill is recommended. Three samples collected from the proposed fill source are suggested to be tested prior to import to site.

Some laboratory testing on samples of fill delivered to site is recommended to ensure consistency of the material delivered. The assessment of at least the soil particle size distribution is recommended. The assessment of the soil Atterberg limits can be requested either by default or at the discretion of the geotechnical engineer (who would indicate its requirement depending on previous information available about the fill material).

Review of the laboratory results by a geotechnical engineer is recommended. Considering the anticipated volume of fill, it is suggested that not less than six soil samples of fill delivered to site be tested, ensuring that at least one sample is collected from the fill proposed for Features 1, 7 and 8.

5.5 PACM

The handling or removal of any PACM during the remediation (i.e. from Feature 6), if required, should be done by a suitably qualified contractor.

5.6 Dieback Management

Dieback management will need to be considered and will possibly impact the scope and cost of the remediation at this site owing to specific constraints to access the features by the earthmoving plants. Detailed dieback management was outside the scope of this geotechnical study and it is generally understood that management requirements are derived on a case by case basis. However, it is suggested that the fill could be delivered to the access track no further south than the section of track adjacent to Feature 4 to avoid trucks moving into an area of dieback affected forest. This provision should simplify dieback management to the plant moving between features such as an excavator and front-end loader (if used to transport soils within the site).

It is recommended that work is undertaken in dry weather to aid dieback management and the placement of fill.

6. Recommended Plant

The plant listed in Table 3 below are anticipated, to complete the remediation works. This list should be considered indicative at this stage and advice from prospective earthworks contractors should be sought to recommend suitable plant based on their experience.

Table 3: Recommended Plant

Plant	Likely Role/s
Six-wheeler Truck	Delivery of fill to site.
Excavator (up to 8 tonne)	Placement of fill into features.
Front-end loader	Movement of fill on site.
Water Cart	Providing water for general earthworks requirements and water required for backfill of Feature 5.
Bob-cat/skid-steer	Movement of fill on site and shaping of finished surfaces.
Plate compactor	Compaction of surface of fill.

7. Local Fill Sources and Available Equipment

Douglas Partners is aware of at least two commercial sources of sand (borrow pits), within 6 km of the site, which should meet the criteria regarding fill discussed in Section 4.1, and therefore should be suitable for use as backfill material for the features. Other sources of suitable fill cannot be precluded.

The equipment listed in Section 6 is available locally and regionally.

8. Post Remediation Monitoring

Monitoring of the remediated features is recommended to assess the stability of the fill, at least in the short term as discussed below.

It is considered that monitoring could be undertaken by either a geotechnical engineer, a civil engineer, or other competent professional familiar with site conditions (for instance a representative from Department of Biodiversity, Conservation and Attractions). Monitoring by the same person between successive monitoring event would be preferred, if possible, in order to assist in identifying any evolution in site conditions.

Monitoring should comprise visual assessment as a minimum, with photographic records and written records of any notable observations. Consideration should be given to also include measurement of the fill surface levels (such as by a surveyor), at least within the first year, and for the deepest features (proven or possible) such as Feature 7 and 9, and for Feature 6 if the rubbish is left in place prior to backfilling.

Following completion of the remediation, monitoring should be undertaken at regular intervals, such as:

- Fortnightly for a period of one month (2 events);
- Once every two months for the first 6 months; then
- Annually thereafter.

The recommended frequency of surface level measurements should be assessed and adjusted following each survey event, depending on the measured rate of settlement.

As the fill will be placed with no compaction (albeit for some light compaction at the surface), some settlement at the fill surface, estimated to be likely less than 0.5 m, is anticipated due to densification of the backfill.

If either:

- total settlement is in excess of 0.5 m; or
- an accelerating settlement rate is recorded;
- any other abnormal feature is observed,

then further geotechnical assessment should be promptly undertaken, and it would be recommended to contact Douglas Partners office for further assistance.

9. Opinion of Probable Costs - Removed from Report

10. Limitations

Douglas Partners (DP) has prepared this report for this project at Lot F27 Goodwood Road, Upper Capel in accordance with DP's proposal dated 7 August 2020 and acceptance received from the Department of Mines, Industry Regulation and Safety (DMIRS) dated 14 September 2020. The work was carried out under DMIRS General Conditions of Contract dated August 2019.This report is provided for the exclusive use of Department of Mines, Industry Regulation & Safety for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the (geotechnical / environmental / groundwater) components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd