GROUNDED EXPERTISE

Report on Shaft Rehabilitation Options

Geotechnical Engineering Services - Reids Ridge Abandoned Mine Site

Yalgoo-Ninghan Road, Paynes Find WA

Prepared for Department of Energy Mines Industry Regulation & Safety

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1. Introduction

This report presents several rehabilitation options for the main shaft, secondary shaft ('Rose Marie' shaft) and their vicinities at the abandoned Reids Ridge mine site located within the dead mining tenement M59/117, 55 km west of Paynes Find in the Karara Rangelands Park.

The investigation was commissioned in a letter from the Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) (letter Ref: DMIRS23250) and was undertaken in accordance with Douglas' proposal dated 21 September 2023 and the conditions outlined in the acceptance letter.

Following a Subsidence Risk Report (*ref: 224768.00.R.001.Rev1*) and Shaft Assessment Report (*ref: 224768.00.R.002.Rev0*) prepared by Douglas, this report outlines several rehabilitation options, assess the suitability of those options, and ultimately recommends a preferred option. 'Rehabilitation' in this context refers to the reinstatement of disturbed land, associated with a mine feature, to be safe, stable, and non-polluting. The following items are discussed for each option presented:

- description and rationale of rehabilitation solutions;
- schematics/drawings showing the process/arrangement/design;
- plant and equipment requirements;
- material specifications (where relevant) and volumes of material/s;
- potential or likely sources of material;
- timing/sequencing requirements;
- personnel and specific technical expertise required;
- potential risks to effective implementation including any impact from groundwater or unfavourable geochemistry, where applicable; and
- post rehabilitation monitoring requirements.

To assess the most suitable rehabilitation methodology, the main following criteria were considered:

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

This report must be read in conjunction with all appendices including the notes provided in Appendix A.

2. Identified Risks

From a geotechnical risk perspective, 'Reids Ridge abandoned mine' is considered to comprise the following features (listed in order of locations from south to north):

1. Southern Stope – a stope that has been backfilled, currently with an uncertain level of stability.
2. Main shaft – vertical open shaft with a concrete collar, flooded from 50 m depth, likely about 170 m total depth.
3. Northern Stope – an open stope that has visible debris/refuse within the open excavation. A shallow, lateral working is visible on the northern side.
4. Grizzly Shaft – a roughly square depression at ground surface that is interpreted to possibly be a relatively shallow former exploration shaft, now backfilled.
5. Rose Marie Shaft – a shaft that is vertical to approximately 20 m depth, before dipping at 45° to the south, and likely linking the Reids Ridge underground mine. It is understood to be an historical shaft that later became a ventilation shaft for the Reids Ridge mine.

Each of these features are discussed in detail in the Condition Report (*ref: 224768.00.R.002.Rev0).*

Natural ground conditions comprise relatively shallow (e.g. generally anticipated within 2 m of the surface) bedrock. Owing to the competent ground conditions, geotechnical risks in the surrounding area of the mine are considered to include:

- Instability of the ground in close proximity to existing excavations and shafts (e.g. Northern Stope and Rose Marie Shaft);
- Collapse of ground or sudden subsidence of shallow voids or lateral workings with insufficient thickness and strength of overlying ground (e.g. north of Northern Stope); and
- Collapse or sudden subsidence of backfill historically placed within mine voids intersecting ground surface (e.g. Southern Stope and Grizzly Shaft).

In addition to the above, mitigating the risk of falls into features is also a primary objective of rehabilitation.

3. Rehabilitation Options

3.1 Preliminary Selection of Rehabilitation Options

Although the five mining features under consideration for rehabilitation, presented in Section 2, are located close to each other, their significant differences in forms (shaft, stope...) and conditions (open, backfilled...) requires that a range of rehabilitation options be considered, both considering the suitability of options for each feature individually, but also considering all features and site context (remoteness, site access, access to materials...).

Table 1 below summarises a preliminary assessment, or first screening, of the suitability of various rehabilitation solutions for individual feature, noting however that, for practicability of construction, it might be preferable to adopt a commonly suitable approach for all or a group of features.

Table 1: Preliminary Suitability of Rehabilitation Options

Rehabilitation Option	Southern Stope	Main Shaft	Northern Stope	Grizzly Shaft	Rose Marie Shaft
Backfilling	N	Y	Y	N	Y
Structural Cover	Y	Y	Y	Y	Y
Pedestrian Grate/Grid and Perimeter Bunding	Y	Y	Y	Y	Y
Reinforced Ground	Y	N	N	Y	N
Fencing	Y	Y	Y	Y	Y
Concrete Plug or Cap	Y	N	Y	Y	Y

Some of the generic rehabilitations listed in Table 1 might take different forms between features to make them suitable to individual feature specificities. The options identified as potentially suitable are discussed in the next sections considering their specificities to individual features and prior to ranking them for the Reids Ridge site.

3.2 Backfilling

3.2.1 Estimated Volumes of Underground Voids Requiring Backfilling

Rehabilitation by backfilling is considered to form a potential approach for the three open features, namely the Main Shaft, Northern Stope and Rose Marie Shaft, out of the five features to rehabilitate at Reids Ridge.

The volume of material required for backfill can only be estimated with a large degree of uncertainty, owing to the conditions of the features that precluded direct measurement of the underground voids during the geotechnical field work, from the following main obstructions:

- the majority of the main shaft depth being below water (water at approximately 50 m depth and shaft likely 170 m deep);
- some obstructions within the Northern Stope significantly limiting observation of this void; and
- some limited information visible beyond a 45° bend within Rose Marie shaft.

Therefore, some large reliance on the desktop information available was made to derive the volume that would require backfilling listed in Table 2 below.

Table 2: Estimated Volumes of Underground Voids Requiring Backfilling

Feature	Volume of Void (m^3)
Main Shaft, above water (49.2 m of shaft length)	409
Main Shaft below water (~120 m of shaft length)	~430
Rose Marie	64 [1]
Northern Stope	250 to 400 [2]
Estimated Total	1,200 to 1,600 [3]

Note [1]: Volume of section visible to LiDAR equipment. This figure is considered suitable to assume following blocking Rose Marie shaft near its 45 degree bend, resulting in a likely significant reduction in backfill requirement and to increase confidence in the long-term stability of the backfill rehabilitation.
[2]: This estimate is associated with a low to moderate level of confidence: 65m^3 of volume were visible to LiDAR equipment within the Northern Stope to about 20 m depth. The greater values in the table were estimated from available mine plans indicating that the base of the northern stope is at 36 m depth and connects to lateral workings, and assuming an average working width of 2 m for the workings in Reids Ridge.
[3]: Including some allowance for additional material required from partial filling of horizontal workings.

The volume of tailings and mined waste rock stockpiled in the vicinity of the Reids Ridge Main Shaft were estimated from field observations (for the rock waste) and lidar data (for the tailings), as follows :

- 1000 m^3 to 1,500 m^3 of stockpiled rock waste, generally comprising gravelly COBBLES, trace boulders, sand and silt.
- 5,000 to 5,500 m^3 of tailings, generally a material primarily comprising silt sizes particles, trace fine-grained sand (based on a preliminary visual-tactile assessment only).

It is highlighted that the above values are approximation only at this stage based on assumptions such as a flat ground surface beneath the tailings, which is likely inaccurate to some extent, and specific surveys would be required to refine those estimates. These estimates however provide a suitable order of magnitude of material availability to facilitate their considerations and discussions in this report.

3.2.2 Suitability of Various Backfill Materials

Tailings

It is estimated from visual-tactile assessment that the tailings likely predominately comprise silt sized inorganic particles with possibly a small fraction (less than 20%-30%) of fine-grained sand. Laboratory testing would be required to accurately assess the tailings grading. Various foreign items such as plastic sheets, pipes, steel, wood and other items were noted in relatively small quantity within the tailings stockpiled at Reids Ridge.

It is noted that the estimated volume of tailings are approximately 3.5 times the estimated volume of the targeted voids to backfill within the Reids Ridge mine, including the main shaft, the northern stope and upper part of the Rose Marie shaft (down to its 45^o bend).

However, the tailings comprise some major geotechnical limitations for reuse as backfill, mostly owing to its fine grading, as detailed below:

- For the northern stope and the Rose Marie shaft, a backfill comprising predominately silt dumped within these dry voids would be anticipated to densify under its own weight, over time, following placement, resulting in settlement of the constructed backfill surface by likely several metres occurring relatively quickly over several years then more slowly over decades.

It is noted that compaction of the backfill during placement, for instance using a weight dropped from a crane positioned at ground surface, was considered to minimise post construction settlement of the silty backfill surface but would unlikely be unsuitable at this site owing to the non-verticality of the stope, and to a lesser instant the difficulty and cost effectiveness to source some specialised equipment to this relatively remote site.

Water conditioning the silt prior to its placement in the feature would decrease its post placement consolidation but not to a suitable level (without accompanying compaction) to consider post construction settlement to be entirely mitigated. Water conditioning would also require sourcing some water, which might be difficult at this site, as discussed in the discussion about cement paste backfill in a following paragraph.

Also, the Rose Marie shaft would require to be blocked at its bend to preclude the backfill to access deeper large and flooded underground voids of the Reids Ridge mine.

Backfilling would not address a subsidence risk zone from a relatively shallow horizontal working identified between the northern stope and the Grizzly Feature (refer to Subsidence Risk Report 224768.00.R.001.Rev1 dated June 2024).

- <u>For the Main Shaft</u>, the silty tailings placed into the mostly flooded shaft would not form a suitable backfill material due to long sedimentation and consolidation times of this type of soils below water, that would detrimentally impact both the backfilling operations during construction and the performance of the backfill over decades, resulting in an unstable and unsafe backfill surface not meeting the objectives of the rehabilitation.

  Consideration was given to the suitability to dewater the main shaft (and by extension the entire Reids Ridge underground development) to provide a potentially dry environment and assist the placement of the tailings, however, this option would also include some major constraints:

  - It bears its own constraints, such as feasibility, containment and disposal of the water pumped from the underground mine; and
  - It does not address all aforementioned constraints related to the use of tailings as backfill, and in particular a residual long-term instability of the backfill that would require some complementing structural provisions near surface (e.g. capping).

The above limitations are considered to preclude the use of the readily accessible tailings in their current form for a backfilling rehabilitation solution, because the safety risk associated with ongoing settlement of the backfill surface over years to decades together with some residual subsidence risk post construction would require that the backfill be complemented by another, more robust, rehabilitation solution, likely structural, such as discussed hereafter in this report. Therefore, placing tailings into the existing voids, if considered (subject to environmental suitability outside the scope of this report and thus not considered herein) would be considered disposal option of the tailings rather than a rehabilitation option, and would require to be complemented by a robust geotechnical rehabilitation solution.

<u>Cemented Paste Backfill</u>

Consideration was given to use the available tailings within a cemented paste backfill (CPB) following mixture with a cementitious binder and water. Although considered to be the lowest risk method to dispose the available mine tailings into the Reids Ridge Mine and form a geotechnically suitable rehabilitation method, the following major constraints and risks would apply:

- Suitability of the tailings for this approach would need to be further assessed by additional testing, and to select suitable binder type and quantities.
- Placement of CPB below water will require the use of a tremie pipe lowered to the base of the shaft, with some significant risk of tremie obstruction from unknown items in the shaft, particularly along its flooded 120 m bottom section.
- There is limited knowledge of the geometry of total mine development (that would allow suitable planning of CPB.
- The undertaking is logistically large (e.g. cement batch plant to be constructed on site and import of cement in remote environment).
- A suitable water source would need to be identified and might not be available in a practical distance of this site that is located in a semi-arid region. Water accumulated in the mine could be considered (assuming its chemical suitability) but would require further assessment of its suitability and practicality for reuse, because it occupies the voids to fill.
- Specialised contractor and possibly limited availability of the required technology for this site.

Dewatering the mine would somewhat reduce the technical constraints of CPB operations by allowing placement to be undertaken from surface (rather than using a tremie). This option however introduces other difficulties associated with dewatering, which would require further considerations such as water testing, required treatment, disposal areas at ground surface and suitability for reuse in CPB.

It is also noted that owing to the impossibility to create underground barricades within the mine to contain the CPB within targeted underground voids during CPB pouring, the volume of underground mine void is estimated to be significantly larger than the volumes indicated in Table 2 and therefore CPB option placed directly into accessible voids does not solve an anticipated void to tailings volume deficit.

In summary, CPB is a highly specialised technology associated with high construction constraints, risks, and costs and therefore it is not considered to form a suitable rehabilitation approach at this site.

<u>Mine Rock Waste</u>

The volume of mine rock waste within the vicinity of the Main shaft is estimated to be 1,000 m^3 to 1,500 m^3. This volume is relatively close to the estimated combined void volume of the main shaft, northern stope and targeted upper void within Rose Marie shaft (i.e. after choking Rose Marie shaft at its 45 degree bend). As such, it is considered that the existing mine waste is a viable option to utilise as backfill, possibly complemented by in-situ gravelly soils sourced from site.

The mine waste primarily comprises gravel and cobble sized rock particles and therefore, should be generally suitable for placement into the voids from surface, without any complex transformation before placement (eg no screening, blending, slurrying or other requirements).

The Rose Maire shaft will require choking with suitably sized boulders, which have not been observed to exist within the mine waste material. The objective of blocking the shaft (near its bend at 45°) is to minimise the backfill volume requirement by blocking access to deeper, larger and flooded underground voids and to ensure the long-term stability of the proposed granular backfill by mitigating the risk of migration of the backfill into these deeper voids. It is considered that suitable boulders could likely be readily sourced and excavated from site owing to the shallow bedrock observed at numerous locations near Reids Ridge, using a powerful excavator equipped with a rock breaker. To reduce the risk of future settlement, attention to the particle sizing specification of backfill material placed within approximately 5 m of the choking boulders would be required.

Debris (mostly disused mining equipment) blocking the northern stope would require removal prior to commencing any backfill (possibly as part of the headframe demolition works, if convenient). Once the northern stope is as clear as practicable, backfill could be undertaken from surface, however it is suggested that rock waste material with generally smaller particles (maximum cobble size of 200 mm) are selected for backfill of the northern stope. It is suggested that the larger particles within the mine waste are reserved for the main shaft with the largest of the particles being placed first within the main shaft, followed by the more cobbly and gravelly material. Placement of gravelly backfill into the main shaft would require to be undertaken from a safe distance, using a conveyor or a large excavator with suitable reach, owing to the risk to compromise the timbering reinforcement and stability of the shaft during placement, possibly impacting the immediate stability of the shaft at ground surface) noting this stability will be reestablished once backfilling is complete.

As noted in Table 2, estimated volumes of waste rock stockpiled on site appears to approximately equal estimated volumes of voids targeted to be backfilled. Provision should be made for sourcing additional gravelly material from nearby areas around the mine, to mitigate the risk of a shortfall of rock waste. It is noted that bedrock was observed to sporadically outcrop around the main shaft and therefore, the availability of gravelly soils in the immediate vicinity of the main shaft is possibly limited (other than a thin layer of mining waste rock locally spread as trafficking surface) and material from other parts of the mining tenement M59/117 may be more suitable for sourcing fill. Areas preferably already cleared of vegetation are suggested, such as the old airstrip to the northeast of the main shaft or disturbed areas near Commodore. If this option is considered, some targeted investigation using test pits across the site is recommended to identify suitable borrow areas, in particular to allow for both an assessment of the near surface material and to assess depth to rock, so that a suitable depth of soil can be retained above rock after borrowing to allow regrowth of vegetation. Also, a dedicated survey to derive a more accurate estimate of available rock waste volumes than currently available in Table 2 could also be considered at that time.

It is noted that a backfilling option would not address a subsidence risk zone caused by a horizontal working heading north at relatively shallow depth from the northern stope towards the Grizzly feature. A backfilling option for the northern stope would require that this feature be exposed by excavation using powerful plant (excavator equipped with rock breaker) owing to bedrock (apparently weathered from observation within the face of the northern stope) observed above the feature, prior to be backfilled.

Rock Waste from Nearby Mines

The suitability to source rock waste from other active mines in the area (eg Golden Grove, Mt Mulgine, Rothsay, Blue Hills Mungana, Mid West, Mount Gibson) for reuse as backfill at Reids Ridge could be considered, noting however the following possible constraints that would require further assessment:

- Possible conflict of interest for an active mine operation to deliver services or products on a DEMIRS project;
- Transport cost will likely be critical in the financial viability of this option and would likely limit the number of potential sources to the nearest mines (indicatively say within 20 to 40 km -to be confirmed- from the site).
- Availability of suitable material from mine sites
- Possible environmental impact of the waste.

Compared to sourcing rock backfill from site, importing materials from nearby mines would mostly minimise possible site disturbances associated with the backfilling of feature, whose site impact might form a small component or is included within site disturbances associated with the entire rehabilitation programme across the Reids Ridge site.

3.3 Structural Cover and Pedestrian Grid

Structural covers, either steel or reinforced concrete covers, and pedestrian grids are discussed together in this section because their implementation and risks are considered similar.

3.3.1 Main Shaft

For the main shaft, a structural option such as a heavy-duty steel plate permanently bolted or welded to the main shaft collar is considered a safe, stable and non-polluting option. The plate thickness and corrosion treatment should be tailored to meet the target design life and should not be airtight. This option is considered suitable considering the assessed stable condition of the existing mine shaft and collar, and its suitability to support an engineered cover (steel or concrete), to exceed a design life of 100 years. This option can be considered to form either a permanent (>100 years) or a semi-permanent rehabilitation solution (i.e. allowing future access) that preserves the shaft for possible future mining activities if required.

A reinforced concrete slab used as cover (rather than a steel cover), permanently fixed onto the existing shaft collar, would also form a technically suitable solution for the main shaft. For this option, importing a pre-cast concrete cover subsequently fixed onto the shaft collar on site would probably form a practical approach for this relatively remote site, rather than in situ formed and poured concrete slab. However, it is considered that a concrete cover would not add significant advantages over a more easy-to-construct heavy-duty steel cover other than possibly adding some minor vandalism mitigation, which is likely already addressed by a steel cover because of the requirement to import specialised tools to vandalise the cover. Hence the ranking in suitability as rehabilitation option (discussed hereafter in the report) will be similar between a steel cover and a concrete cover.

It is suggested that including a small opening (small enough to fully mitigate any risk of fall or any entry attempt) could further mitigate a risk of vandalism over a full cover, by allowing some observation into the shaft to address any curiosity of future visitors.

3.3.2 Southern stope, Northern stope, Grizzly Shaft and Rose Marie Shaft

For the southern stope, northern stope, grizzly shaft and Rose Marie shaft, engineered steel covers of suitable rigidity over the voids to span, permanently founded on or bolted to shallow footings constructed on the perimeter of the remaining features, would technically form a feasible option.

It is considered however that a pedestrian grid style of structural solution could be more suited for these features, with vehicular access being restricted by other cost-effective measures. It is recommended that the footings are founded within competent natural ground, ideally rock or hard clayey soils anticipated around the features, at least 2 m from the edge of any feature.

For the open features (Northern Stope and Rose Marie Shaft), an engineered designed grid suitable for pedestrians would be considered preferable to solid steel cover because:

- Grids would allow for observation of the features below, therefore:
  - increasing safety mitigation by not masking the feature.
  - reducing the likelihood of vandalism (as previously discussed).
  - retaining possible touristic value at this site in the Karara Rangelands Park.
- Grids targeted to pedestrians (with other cost effective controls to restrict vehicle access) would reduce the engineering requirements (size and costs) of the cover owing to the void span to cover that would otherwise require to effectively form a vehicular bridge.

The construction of a bund or other non-trafficable feature should complement any form of structural cover or grid around the perimeter of features to prevent vehicles from traversing capped features.

The zone of subsidence risk (not visible from ground surface) identified heading north from the Northern Stope should also be protected (refer to Subsidence Risk Report 224768.00.R.001.Rev1 dated June 2024).

Railing should be installed where any differences in ground level will remain and there is an unacceptable risk of falls, such as along the perimeter of the existing mine shaft collar and surrounding ground.

The topography surrounding the mine features is favourable in current site conditions to minimise any concentred flow of water runoff towards the features. Also, the vehicle prevention bunds proposed around the rehabilitated features will also form a barrier against surface water entering rehabilitated areas. Some cut-off drains constructed on the upslope side of the features (i.e. to the west) would be good practice from geotechnical considerations to control surface run-off flowing from upslope, however, considering the favourable conditions noted above, such drains are likely not warranted and can be omitted providing care is given during construction to shape (if required) the ground surface upslope of the proposed bunds to preclude any accumulation of future run-off against the vehicular prevention bund, and to allow such water to flow downslope of the features.

3.4 Reinforced Ground Capping

A variation of a plate or grid solution that could be considered for the Southern Stope, Grizzly Shaft (which are existing backfilled features) and the zone of subsidence risk north of the Northern tope (which is a buried feature), could comprise a cap constructed of steel beams placed at, or near the surface covered with a material of suitable particle sizes to rest above the beams. Practically, this solution would likely comprise selected boulders and cobbly materials selected from existing mine rock waste stockpiles placed above parallel beams spanning across the feature and placed with a spacing of about 0.2 m (or possibly more depending on the grading of the available selected overlying backfill). Douglas refers to this concept as 'reinforced ground'. The objective of this solution is to mitigate a residual risk to safety posed by these three backfilled or buried features whose performance over more than 20 years could be assessed today. The material placed above the beams should be of sufficient thickness and footprint to completely cover the beams and be mounded over surrounding ground level to preclude vehicular access, discourage efforts to interfere with or to vandalise the cap. One main advantage of this solution at this relatively remote site is its simplicity and low logistic (other than importing steel beams), noting however this advantage might no longer prevails considering the other forms of rehabilitation solutions required for the other features.

3.5 Below-ground Concrete Cap

A below-ground reinforced concrete slab could be utilised to effectively cap the voids and form a low-risk rehabilitation solution during and following construction. The capping is recommended to be complemented with some minor earthworks undertaken above the slab to tie into the surrounding ground with very low to no visual evidence of the mine features, minimising risk of interference.

Precast concrete slabs imported to site rather than slabs formed and poured in-situ are suggested owing to the remoteness of the site and to increase safety during construction.

Precast concrete slabs should be founded on competent, natural ground (e.g. low strength rock or hard clayey soil) at a level that would allow approximately 0.5 m to 1 m of soil cover above the slab. Competent ground for supporting the slabs is considered to generally exist approximately 0.5 m to 1 m depth and therefore, site preparation for this option is anticipated to comprise to box-out natural soil/rock material around the perimeter of the features to, say roughly 0.7 m depth, the placement of slabs (lifted into place and positioned adjacent to each other), sealing any gaps between slabs or the placement of a geofabric across the top of the slabs and then backfilling over the slabs to levels to tie into surrounding levels.

Vehicular access across the rehabilitated features envelopes should be precluded by the construction of granular bunds around the rehabilitated features, using available mine rock waste or granular soils sourced from site.

The zone of subsidence risk identified from a buried feature heading north from the Northern Stope should also be protected (refer to Subsidence Risk Report 224768.00.R.001.Rev1 dated June 2024).

This approach can be combined with backfill of the features if required, noting the stability of the backfill not being relied upon, the material can be placed within the voids with a lower level of control.

3.6 Fencing

Perimeter fencing is a final consideration for rehabilitation of Reids Ridge features.

This option is simple, low cost and low environmental impact and has been adopted to address various dangerous voids (eg caves, wells, abandoned mine shafts) in national parks across Western Australia, however it is the most susceptible to vandalism or damage and would require some ongoing monitoring and possible maintenance. Perimeter fencing would be considered a warning measure that would not preclude voluntary attempts by public to either approach features within their hazardous zones of instable ground, trip and fall, and would not preclude attempts to enter features.

4. Preferable Rehabilitation Options

It is considered possible that different rehabilitation options between features will be preferable at the Reids Ridge Mine. As such, for clarity in assessment, the criteria listed in Section 1 of the report has been rated against a selection of rehabilitation options applicable to each feature. The assessment is summarised in Table 3 to Table 7 below.

Table 3: Southern Stope - Rehabilitation Option Suitability

Rehabilitation Option	Rehabilitation Solution Considerations				
	Long-term suitability	Risk to personnel providing solution	Monitoring and Maintenance Requirements	Technical Feasibility and Cost Effectiveness	Disturbance to the Environment
Backfill	-	-	-	-	-
Structural Cover	**	**	**	**	***
Pedestrian Grate/Grid and Perimeter Bunding	**	**	**	**	***
Reinforced Ground	**	**	**	***	***
Fencing	*	***	*	***	***
Concrete Cap	***	**	***	**	***

Table 4: Main Shaft - Rehabilitation Option Suitability

Rehabilitation Option	Rehabilitation Solution Considerations				
	Long-term suitability	Risk to personnel providing solution	Monitoring and Maintenance Requirements	Technical Feasibility and Cost Effectiveness	Disturbance to the Environment
Backfill – Rock Waste and On-Site Material	***	**	***	**	**
Backfill – Imported Material	***	**	***	*	***
Structural Cap	**	**	**	***	***
Pedestrian Grate/Grid and Perimeter Bunding	**	**	**	***	***
Fencing	*	***	*	***	***
Concrete Plug/Cap	-	-	-	-	-

Table 5: Northern Stope - Rehabilitation Option Suitability

Rehabilitation Option	Rehabilitation Solution Considerations				
	Long-term suitability	Risk to personnel providing solution	Monitoring and Maintenance Requirements	Technical Feasibility and Cost Effectiveness	Disturbance to the Environment
Backfill – Mine Waste and On-Site Material	***	**	***	**	**
Backfill – Imported Material	***	**	***	*	***
Structural Cap	**	**	**	**	***
Pedestrian Grate/Grid and Perimeter Bunding	**	**	**	**	***
Fencing	*	***	*	***	***
Concrete Plug/Cap	***	**	***	**	***

Table 6: Grizzly Shaft - Rehabilitation Option Suitability

Rehabilitation Option	Rehabilitation Solution Considerations				
	Long-term suitability	Risk to personnel providing solution	Monitoring and Maintenance Requirements	Technical Feasibility and Cost Effectiveness	Disturbance to the Environment
Backfill	-	-	-	-	-
Structural Cap	**	**	***	***	***
Pedestrian Grate/Grid and Perimeter Bunding	**	**	***	***	***
Reinforced Ground	**	**	**	***	***
Fencing	*	***	*	***	***
Concrete Plug/Cap	***	**	***	***	***

Table 7: Rose Marie Shaft - Rehabilitation Option Suitability

Rehabilitation Option	Rehabilitation Solution Considerations				
	Long-term suitability	Risk to personnel providing solution	Monitoring and Maintenance Requirements	Technical Feasibility and Cost Effectiveness	Disturbance to the Environment
Backfill – Mine Waste and On-Site Material	***	**	***	**	**
Backfill – Imported Material	***	**	***	*	***
Structural Cap	**	**	**	***	***
Pedestrian Grate/Grid and Perimeter Bunding	**	**	**	***	***
Reinforced Ground	**	**	**	**	***
Fencing	*	***	*	***	***
Concrete Plug/Cap	***	**	***	**	***

The highest rated options from Table 3 to Table 7 are summarised in the Table below.

Table 8: Summary of Highest Rated Rehabilitation Options

Feature	Recommended Rehabilitation Option
Southern Stope	Concrete Cap
Main Shaft	Structural Cover/Pedestrian Grid
Northern Stope	Concrete Cap
Grizzly Shaft	Concrete Cap
Rose Marie Shaft	Concrete Cap

The suitability of reinforced ground and concrete cap is considered relatively even for both the Southern Stope and Grizzly Shaft however for consistency and efficiency between features during and post construction, it is recommended that a concrete cap solution is adopted.

It is highlighted that the above assessment in Table 8 was derived using similar weighting between the considered criteria.

If disposing of the existing tailings (or other material) is beneficial to the overall rehabilitation of the area, from a geotechnical standpoint (i.e. assuming the environmental suitability whose assessment was outside the scope of this report), the material can be placed into the Northern Stope and Rose Marie shaft as a disposal option before capping, the latter forming the geotechnical rehabilitation solution. Disposal of tailings (or other materials) into the main shaft is not considered suitable for the recommended rehabilitation option for this feature in Table 8 because it would present some significant risk of interfering with the internal timbering reinforcement and structural stability of both the shaft and shaft collar. If such tailings disposal is further considered into the main shaft, capping of the shaft with a reinforced concrete slab like the other features would be required for the main shaft, which would also require the demolition of the existing shaft collar to allow construction of the cap.

Further discussion for the concrete cap and structural cover options are discussed in the following sections.

5. Concrete Capping Solution

5.1 Personnel, Plant, Equipment and Timing

No specialist equipment or particular expertise would be required to build the concrete capping. The work could be undertaken by most capable civil contractors with access to earthmoving equipment and capable of arranging precast concrete slabs. It is considered that all of, or the majority of components required could be precast and transported to site.

The concrete slabs would require design by a structural engineer to account for the span of the feature (void for open structure and potential void for backfilled and buried features) and the load from soil and rock fill overlying the cap and potential vehicle loads. Design for accidental vehicular loading is recommended, noting restricting vehicular access over the capped features should also be implemented by the construction of granular bounds surrounding features.

The rehabilitation work could commence as soon as the area surrounding the features (say, a buffer of 5 m from the edge of the features) had been cleared back to natural levels.

It is anticipated that a work crew of less than five personnel with suitably sized plant (say 20 tonne excavator) could complete the rehabilitation work within 2 to 4 weeks.

It is noted that access to the site is currently available via a track (2WD suitable in dry weather) that will possibly require some upgrade, such as grading, to allow access for the proposed construction vehicles.

5.2 Schematic of Concept

Figure 1 on page 17 provides cross-section and plan view schematics for the Rose Marie Shaft. The concept for the northern stopes would be similar, just that more sections of concrete slabs would be placed adjacent to each other to cover the void, and its buried extension to the north of the opening (refer to Subsidence Risk Report 224768.00.R.001.Rev1 dated June 2024). Similar concept applies to the southern stope and grizzly feature, except that the exiting void beneath the cap shown in Figure 1 is backfilled.

5.3 Monitoring Requirements

Monitoring requirements for this solution are anticipated to be low. Competent natural ground is anticipated at shallow depth and no observable settlement is anticipated.

A monitoring programme that comprise a visit for visual inspection at the following frequency is suggested:

- 1 month;
- 6 months; and
- 12 months following completion of rehabilitation.

Provided no issues are observed within 12 months, it is suggested that ongoing monitoring requirements would be less rigorous than those for the Main Shaft rehabilitation solution and therefore, a visual check of the capped area could be undertaken in line with checks on the Main Shaft.

6. Structural Cover Solution

6.1 Personnel, Plant, Equipment and Timing

It is considered that the existing concrete and steel collar around the Main Shaft forms a stable structure to bolt or weld a robust structural cover or grid to. Following demolition and removal of items above collar level, ample space to bolt a cap or grid that spans the Main Shaft will be available. As such, the design and manufacture and installation of a cover or grid should be relatively straight forward. No specialist designer, manufacture or contractors are anticipated.

The cover or grid could be precast and transported to site. Its installation should be readily achieved within the space of a few days (say less than a week). Installation of railing where any level differences between the top of collar and the adjacent ground should be installable within a few days (say less than a week). The railing should be able to be bolted (or using another typical fastener type) to the collar.

The rehabilitation work could commence as soon as the concrete collar is clear and accessible, following demolition of the existing surrounding equipment.

6.2 Schematic of Concept

Figure 2 on page 18 provides cross-section and plan view schematics for the Main Shaft.

6.3 Monitoring Requirements

Provided the structural components are adequately designed for both strength and durability (resistance with weathering), monitoring of the structural cap is anticipated to largely be required for the purpose of assessing possible vandalism. While not a geotechnical issue, Douglas suggests that an annual monitoring interval should be sufficient, however this recommendation is not intended to override any policies that DEMIRS or DBCA (due to the site being within a Park) have in place for monitoring and maintenance of facilities.

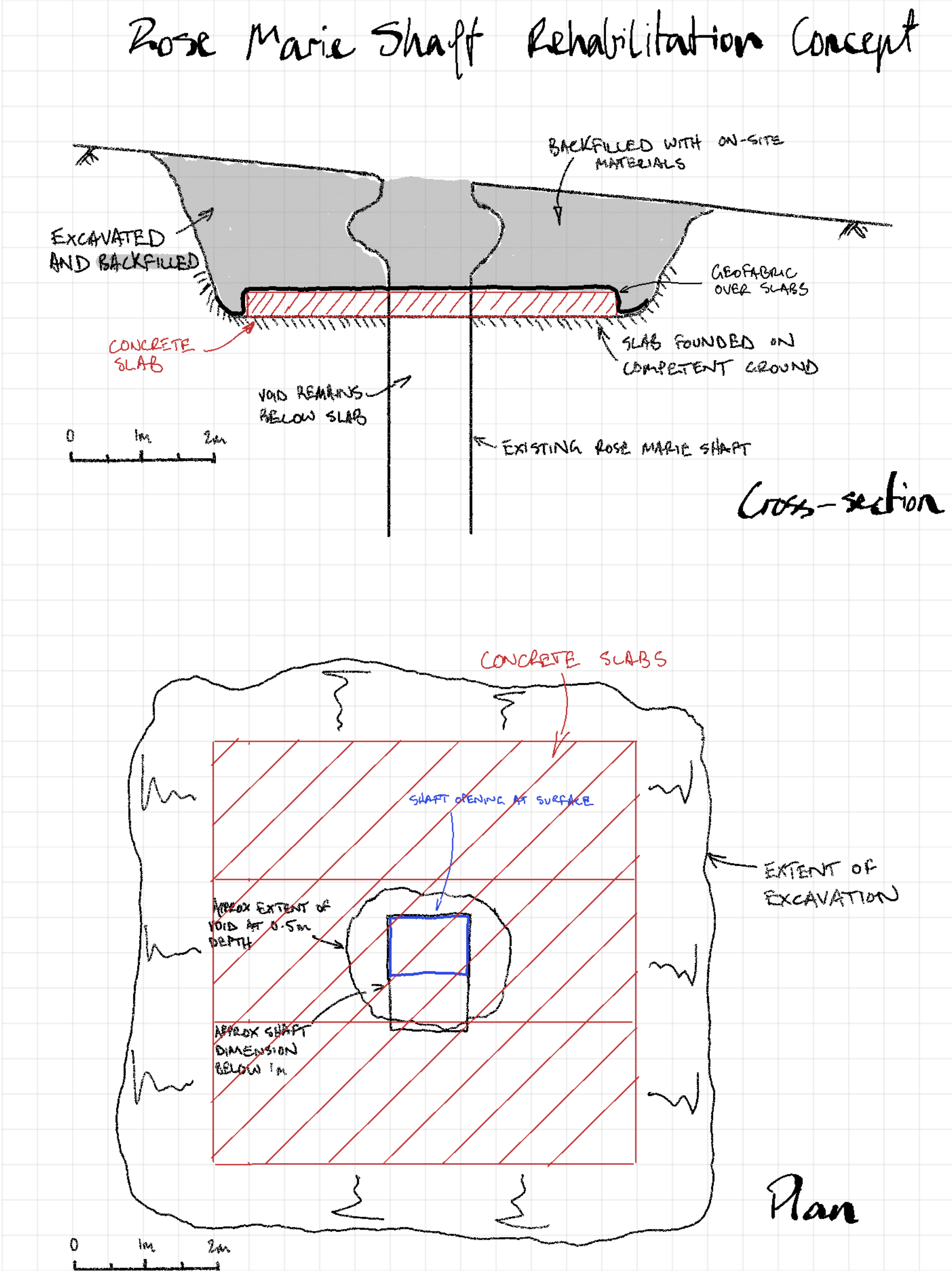

Figure 1: Concrete Cap Schematic

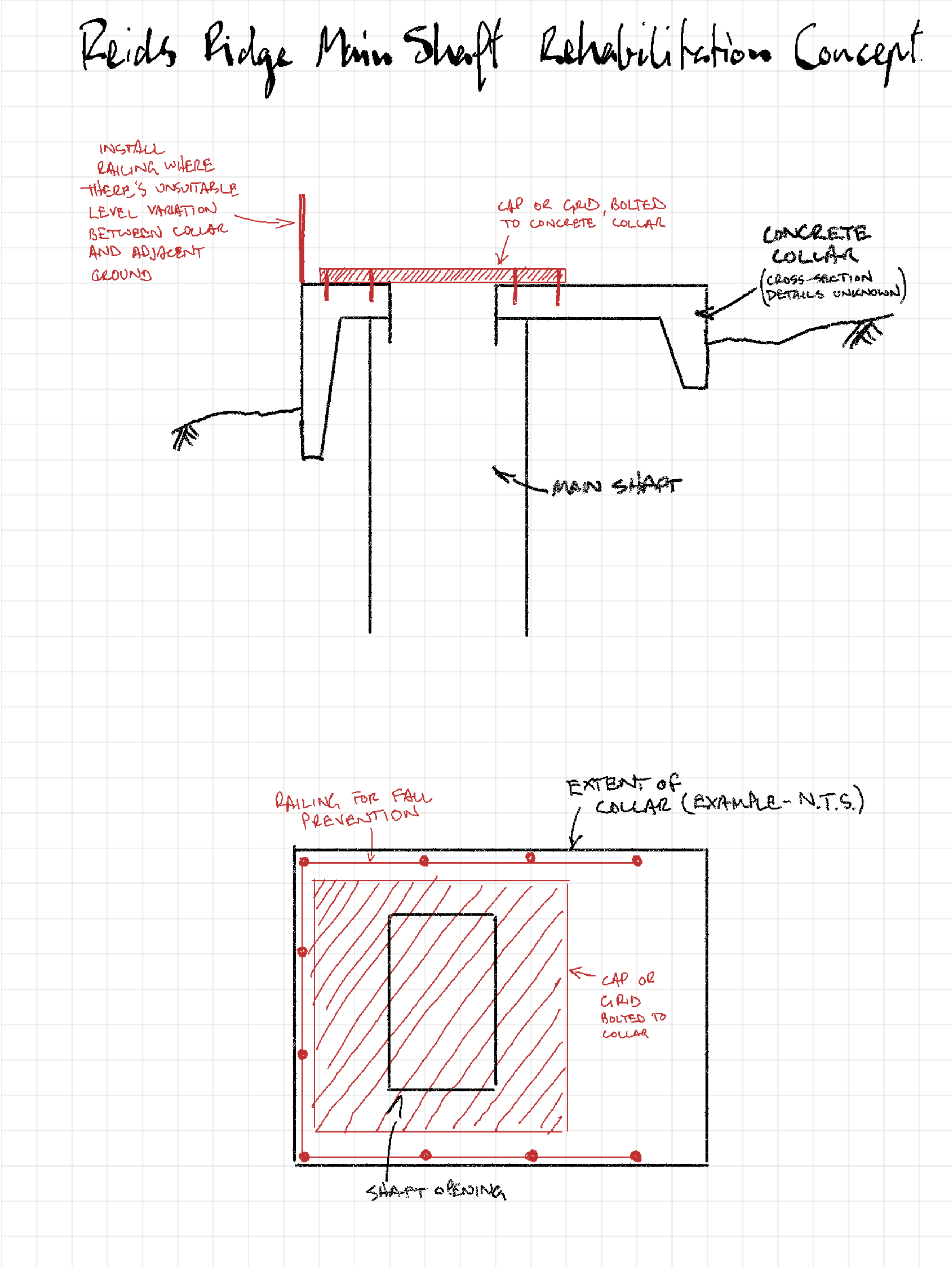

Figure 2: Schematic for Structural Cover or Grid

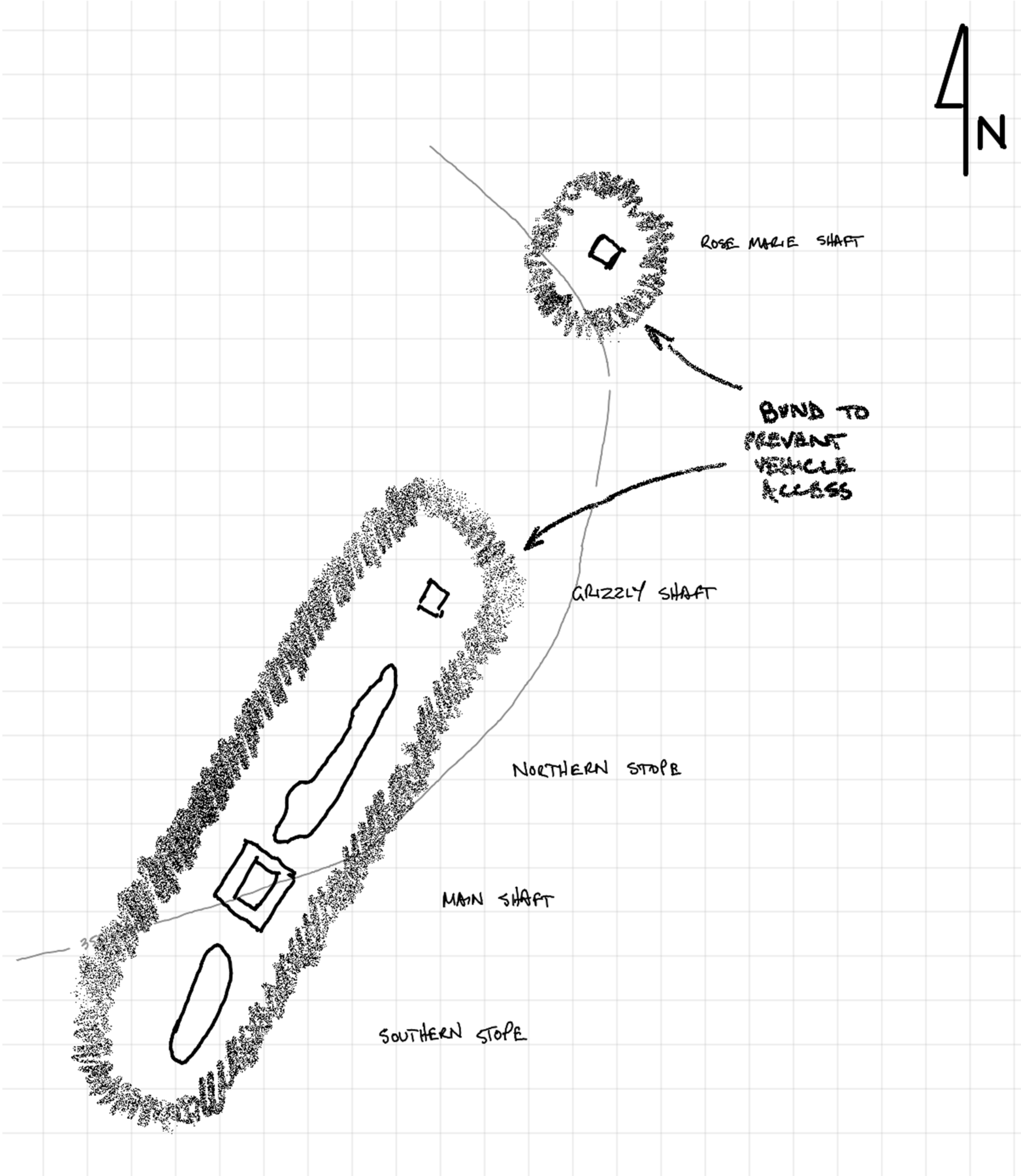

Figure 3: Vehicle Prevention Bund Concept Sketch

7. References

AS 1726. (2017). *Geotechnical Site Investigations.* Standards Australia.

Douglas Partners. (2024). *224768.00.D.001.Rev1.Subsidence Risk Report.*

Douglas Partners. (2024). *224768.00.R.002.Rev0.Reids Ridge Mine Condition Report.*

8. Limitations

Douglas Partners Pty Ltd (Douglas) has prepared this report for this project at Reids Ridge abandoned mine site in accordance with Douglas' proposal dated 21 September 2023 and acceptance received via letter from the Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) (letter Ref: DMIRS23250). This report is provided for the exclusive use of Department of Energy Mines Industry Regulation & Safety for this project only and for the purposes as described in the report. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of Douglas, does so entirely at its own risk and without recourse to Douglas for any loss or damage. In preparing this report Douglas 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 Douglas' field testing has been completed.

Douglas' advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by Douglas 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. Douglas 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 Douglas. This is because this report has been written as advice and opinion rather than instructions for construction.

Appendix A

Notes About This Report

About this Report

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

continued next page

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

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