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EBA Engineering Consultants Ltd.
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Yellowknife, NWT
CANADA
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June 14, 2005

Attention: Kevin Jones

RE: REVIEW OF NANISIVIK MINE OPENINGS CLOSURE PLAN (JANUARY 27, 2005)

This is the third review of rock mechanics issues for the closure of the Nanisivik mine. The first review was addressed in a letter dated June 6, 2002. The second was issued April 15, 2004.

More work has been conducted, and additional information provided, as compared to the two previous reviews. This is by far the most comprehensive and best attempt to address the issue to date.

The concepts presented, while surficially sufficiently detailed for construction, do not address the core issues in a sufficiently comprehensive method to either insure permanence. In addition, it has not been demonstrated that the designer Bruce Geotechnical Engineering Inc. (BGC) utilized personnel with sufficient experience to analyze or appreciate the rock mechanics issues in question.

Both are troubling. The former as it may result in the problems being addressed adequately for appearance's sake in the short term, but requiring additional remediation efforts at some, unknown, time in the future. The latter as improper and incomplete analysis will result in improper and incomplete designs.

It must also be noted here that BGC did not conduct any analyses of their own regarding crown pillar stability. As quoted from page 15 of the BGC report, "It should also be noted that the Lauzier analysis has been used as a guide for the development of the closure designs and no additional analysis has been completed for this report." Yet, one of the primary stability concerns is, as quoted from the same page is, "The areas considered most vulnerable to instability are the areas proximal to the mine openings."

As for the previous review, the same issues exist and will be discussed:

- Where open pits exist, will they be left in a stable configuration?
- How will the entrances to the underground workings be sealed?
- Will the underground workings remain stable or fail, causing surface disturbance?

Open pits

The open pits are relatively small in size and are to be backfilled. In addition, the rock walls will likely remain stable due to the buttressing effect of the fill. However, that does not relieve the designer from providing adequate engineering analyses to confirm these likely results.

Oceanview highwall:

While this is a very shallow pit, as can be seen in Figure A, a potential structural failure geometry may exist in the benches. In addition, there is a lack of stability analyses addressing the stability of these slopes, including pore water pressure, ice, etc. This is a very minor wall. However, for completeness sake, the work should be conducted in a proper engineering manner. In other words: material properties should be listed for design purposes, design assumptions listed (including failure modes), and analytical methods and any computer codes utilized for analysis should be denoted.

East pit highwall

Here, a 25m high wall, apparently excavated as a single bench, is shown in section. This apparently faces somewhat to the northeast. If so, and if the structural mapping as obtained from Figure 28 is correct, then the bedding will be dipping out of the face in plane shear mode. Sub-vertical jointing would function as side and back releases for a kinematically viable failure. However, this is nowhere noted in the report nor addressed for closure. Does this jointing exist in this area? If so, does the sulphide zone shown on the highwall parallel bedding? What will occur if and when the sulphide decomposes, or will it? Will a step path be created by bedding in combination with the sub-vertical joints working back up the slope, driven by frost and water action? What engineering has been conducted to reach the design presented?

Surface openings to underground

While an attempt has been made to address methodologies for permanent closure of the surface openings, it is incomplete at best. The following comments are specific to the areas noted.

Pit wall and stope stability – East pit area

This area includes the East adit area, the 39 portal, and the Horseshoe blast area.

As can be seen in Figure B, the underground workings have apparently been daylighted under the highwall of the East pit (?). The exact geometry of the situation is difficult to discern from the mine plan (Figure B) and the limited number of sections provided. In fact, if one interprets the mine plan as shown on the upper center diagram, Figure B, then the Horseshoe blast did not even daylight the mined out area. However, photographs and descriptions elsewhere indicate that the underground workings were daylighted. Thus, a key question remaining is what is the exact geometry of the situation, including the remaining cover, included rock support, and geologic structure, both major and minor, in the area?

In addition, as is obvious from the photographs, a portion of the face is in plane shear on bedding joints. Whether this is blast related is irrelevant at this point, as the geometry obviously exists. How has this been addressed for closure design?

A complete engineering analysis is required here prior to determining remediation measures. This has not been conducted. As such, any remedial works proposed at this stage are premature and not verifiable.

Pit wall and stope stability – West adit area

This area is similar to the East adit area in that the stope was daylighted through into the West pit (?).

As for the East pit, one cannot discern the geometry from the shown mine plan (Figure C). A detailed mine plan is required, including elevations as well as opening heights. Such has not been presented. This pit/underground interaction area is complex as well. In this case, a rib pillar against the West pit highwall was apparently blasted out. How much is unknown. A failure now exists paralleling the highwall. This has been attributed to toppling. Remedial work has been proposed in the form of blasting down the highwall in a specific area, then pushing muck underneath the daylighted brow for a very limited distance.

What has been presented is explained insufficiently and does not appear to be founded on a detailed engineering study of the situation. The present evaluation (Lauzier, 2002), indicating that if a 5m "brow" remains between surface and the opening, it will be stable is obviously in error as the brow is failing here at a 5m thickness or greater.

A detailed engineering analysis is required for this area. This will require that the geologic structure, mine openings, and surface topography of the entire area be accurately known and provided to the designer. In addition, the designer should expend more time and effort in understanding the failure mechanisms in play, as well as the effect of frost action, water, and present rock support degradation.

If backfill is to be an option, it should adequately support the brow and immediate area. Uncemented fill will likely not fulfil this purpose as it will compact. In addition, as these are large openings, shown as being greater than 10m in height, appropriate care should be taken to include this aspect in closure design.

17 north portal and K baseline portal

These designs are insufficient as they do not quantify the cover, potential failure modes/geometries, and the degradation of presently installed rock support.

As can be seen in Figure D, these portals are located in areas of low relief. They obviously have some cover, but the liners ("culvert") would not have been utilized if adequate cover could have been quickly attained when driving the openings.

Detailed analysis is required. In addition, ice is not considered adequate backfill material. Rockfill, if utilized, must be jammed to the back in the areas where subsidence could occur, as identified by the aforementioned analysis.

88 portal

The topography and geologic structure for this area are uncertain. However, it is noted that strap ("steel belts", Figure D) has been utilized to wrap the brow (photo, Figure D). This is normally done when it appears that rock blocks can fall from the brow.

Therefore, a detailed engineering analysis is required, showing the geologic structure, accurate topography, and an accurate depiction of the portal face and alignment to some depth at which failure is shown to be improbable. The reasons for the straps, and the effect of the degradation of the presently installed rock support should be included in this analysis as well.

Raises

The concepts presented for sealing the raises are inadequate.

In many cases, as is demonstrated in Figure E, the raises are presently blocked with ice. While backfill may have been placed in these raises, it is uncertain what depth the rock fill has attained.

Backfilling on top of these ice blockages, especially when they are close to the collar (surface) is inappropriate. Ice can settle and creep or the ice bridge may be narrow and fail resulting in surface subsidence and/or an open hole.

The raises should be sealed with an engineered concrete plug or the ice removed and the rock fill verified for the depth of the raise. Alternatively, other potential engineered alternatives may exist.

Portals – general and monitoring

The concepts proposed in general for portal sealing and monitoring are inadequate. Some issues that are outstanding (Figure F) are:

- The backfill of the portal is incomplete. While the stated purpose of the backfill is to provide some limited support of the back, this is unlikely. As the fill is to be pushed into the portal a maximum of 5m, and not placed tight against the back, this will provide no, or at the very best, very limited support to the immediate portal area.
- The rock capping the portal cap is insufficiently supported by adjacent fill or by underlying fill (or concrete) to be considered to be permanently remediated. As well, no detailed stability analyses have been conducted for the portal areas.
- Monitoring should be specifically designed for each portal such that it will take into account all of the above noted details. It should also be verified to function for the time period required for the aforementioned failure modes to manifest.

More detailed engineering work is required. This should include detailed sections of the portal, including specific structures as well as general rock fabric information, true ground profiles to such depth as failure is unlikely to breach surface, realistic engineered backfill options that demonstrably insure rock support to a depth where rock failure can be demonstrated to be unlikely to occur, and the effect of the present portal rock support (bolts, strap, etc.) degrading and being rendered ineffective over time.

Underground opening stability/surface interaction

Monitoring has not been provided to, at the minimum, insure over time that the ground surface over the mine workings is remaining stable.

SUMMARY

While many comments can be offered in particular, the following general comments cover the submitted works:

- The present rock mechanics engineering work, in terms of reclamation is inadequate both from a technical perspective, a field placement perspective, and as a long-term solution.

- In terms of the design guidelines, the presented reclamation design fails to insure the mine openings remain physically sound, neither is the engineering and/or design sufficient to insure that subsidence of the material will not pose a future hazard.
- The placement details are vague and leave too much latitude to the geotechnician on site.
- Monitoring is insufficiently detailed both as to design and placement.

This is the third review of a proposed design. It is suggested that any subsequent proposals include:

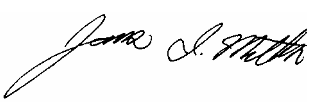
- A detailed engineering analysis of the situation at hand. This to include: material properties, geologic structure (major and minor), installed rock support, local observations, detailed topography, ice present (as well as thickness), and a detailed survey of the mine workings.
- A presentation of the analysis that includes the failure geometries, impact of frost and water action, impact of loss of installed rock support over time, impact of backfill if utilized (including method of placement and assumed properties). This should be projected over time.
- Specific remediation details for each portal, raise, and/or daylighting stope. This has been done here, but should reference the analyses conducted.
- Specific monitoring designed for each portal, the reason for the monitoring selected, and how it will be read and interpreted.

While these may seem elementary, it must be noted that it is sufficiently difficult to review a design without all the information available to the design engineer. Without the above items being clearly provided, including assumptions and analytic methods, it is difficult to determine whether the designer has, indeed, covered all the pertinent design details.

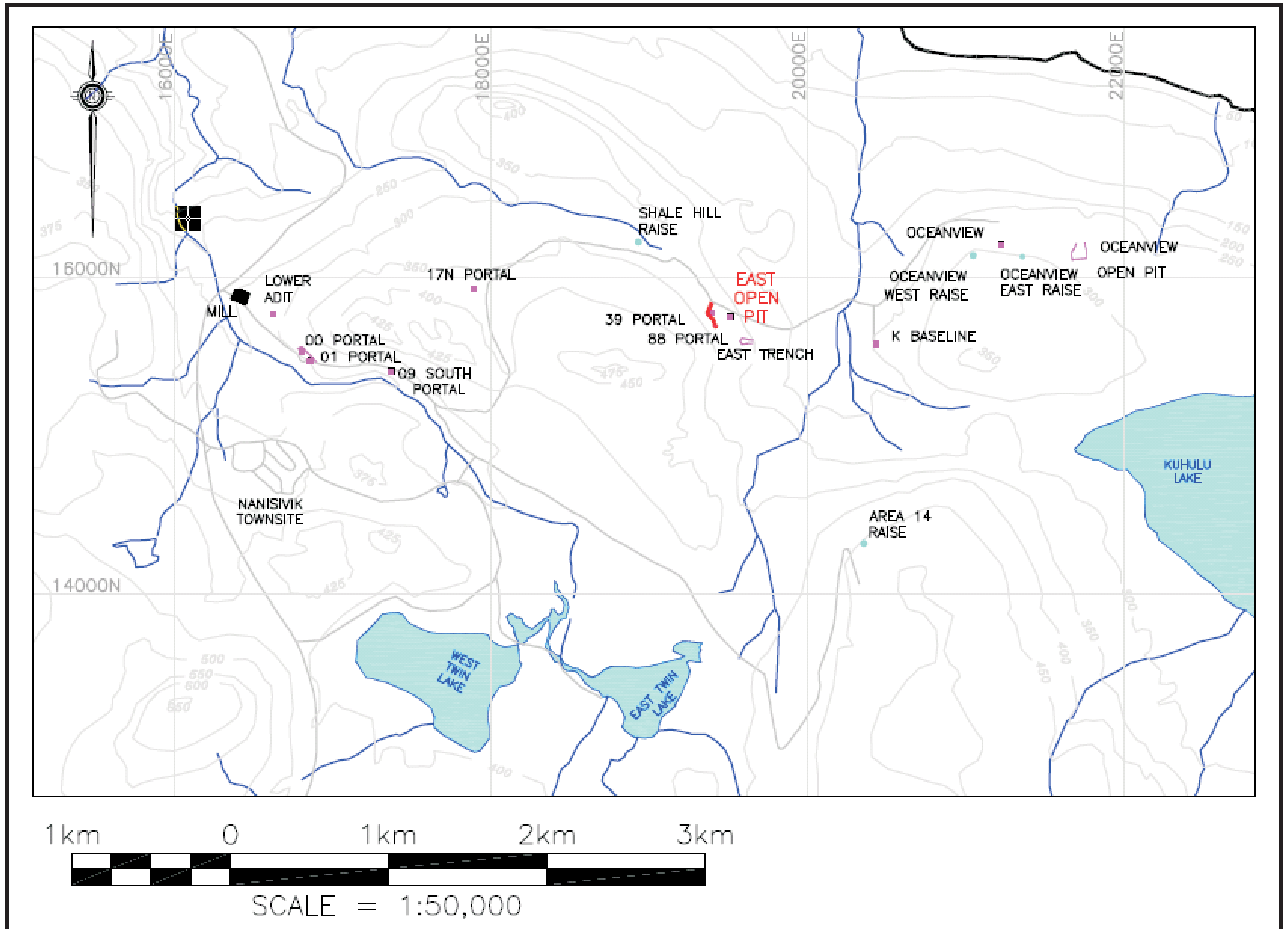
Please note as well that it was difficult to prepare and present the figures accompanying this document as the Adobe files that were provided for review were locked for extraction. Thus, the attached figures will be somewhat unclear as they were taken from screen captures of the figures provided for review.

I hope this letter satisfies your requirements. I would be pleased to entertain comments at any time.

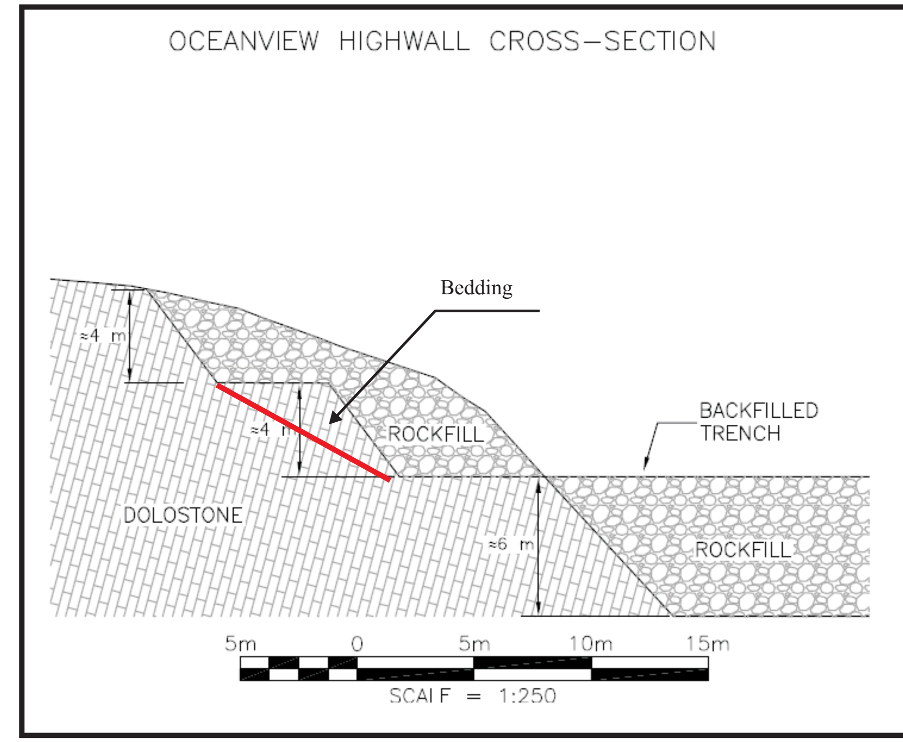
Regards,



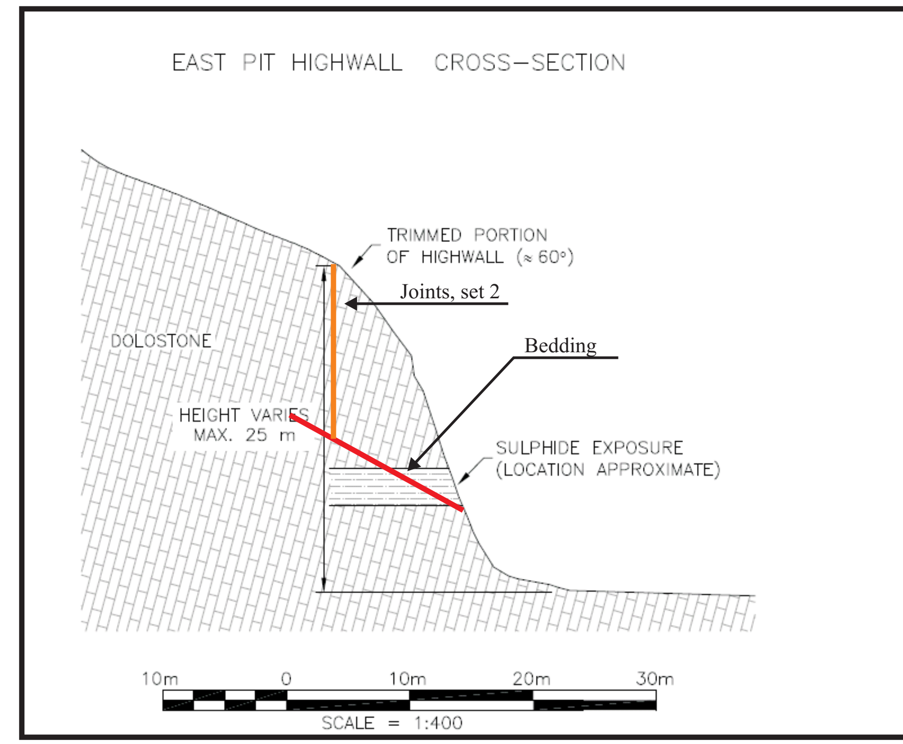
James I. Mathis, Ph.D., P.E., P.Eng.
Rock mechanics engineer



From Figure 22, East pit highwall



From Figure 24, Oceanview pit highwall



From Figure 22, East pit highwall

Notes:
It is unclear from the provided information if the right noted situations have been analyzed for the respective open pits.

Oceanview:
Has the stability of the rock fil, given the shown profile, been analyzed, including pore pressure conditions present during melt. Has the potential complex failure geometry of bedding joints combined with a circular type failure been analyzed?

East pit area:
Have the joints in the bench shown on the schematic section been mapped? If the joint pattern follows that obtained from the West pit area, then bedding joints may create a potential long term failure geometry (frost action driven) as shown. Has this been analyzed and taken into account?

Both geometries assume that the pit walls are north to northeast facing. The lack of a detailed map view and section locations on plan makes this assumption necessary.

DIPS SUMMARY

JOINTS:
1. 58° 89° STRIKE & DIP (RIGHT HAND RULE) 13 of 47
2. 143° 85° STRIKE & DIP (RIGHT HAND RULE) 17 of 47
3. 190° 90° STRIKE & DIP (RIGHT HAND RULE) 6 of 47

BEDDING:
1. 310° 29° STRIKE & DIP (RIGHT HAND RULE) 5 of 47

From Figure 28, 39 portal area (east adit area) field mapping

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PROJECT: NANISIVIK ROCK MECHANICS REVIEW - III

PIT WALL STABILITY
OCEANVIEW AND EAST PIT

Date: 09/06/2005

A

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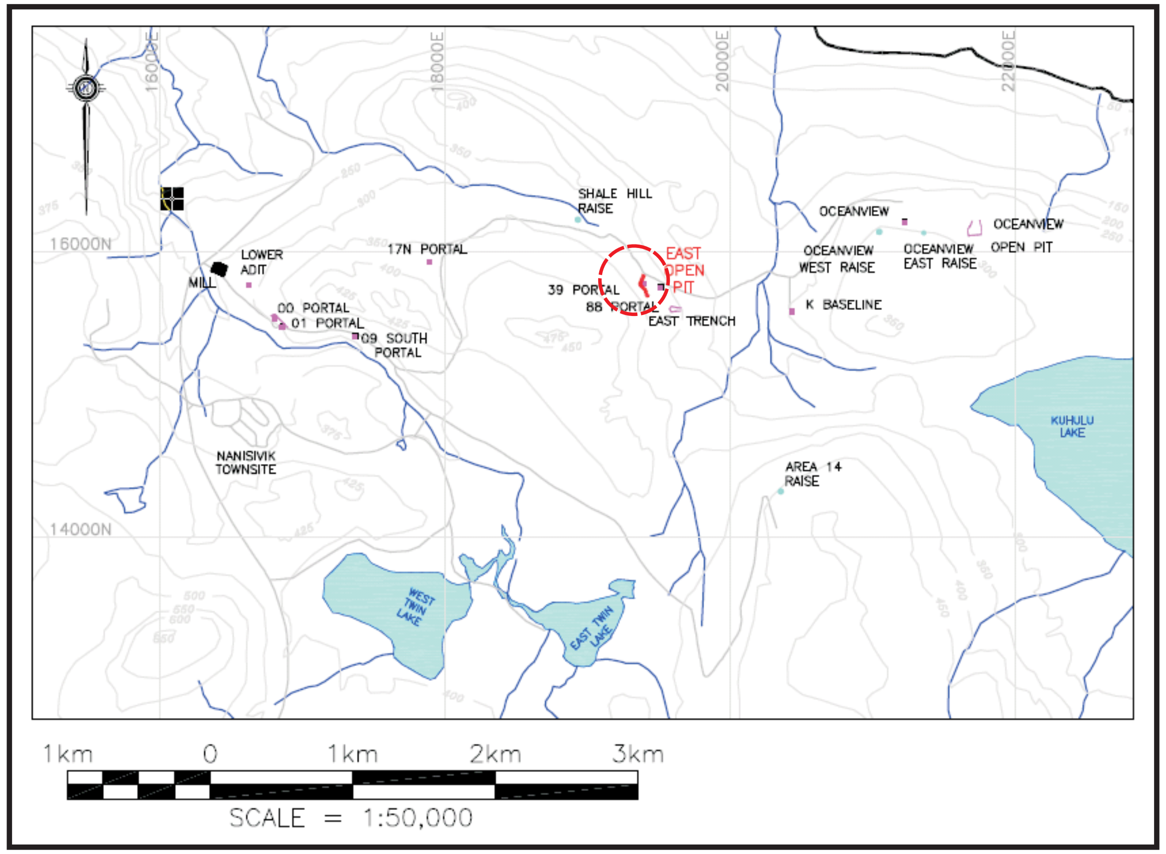
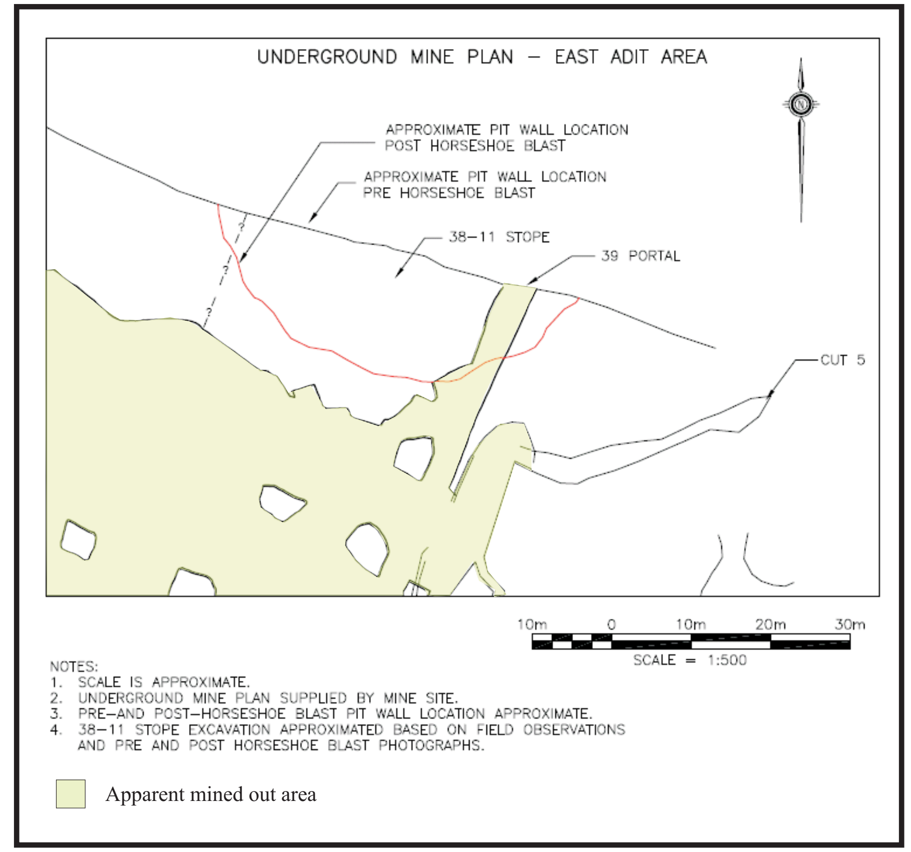
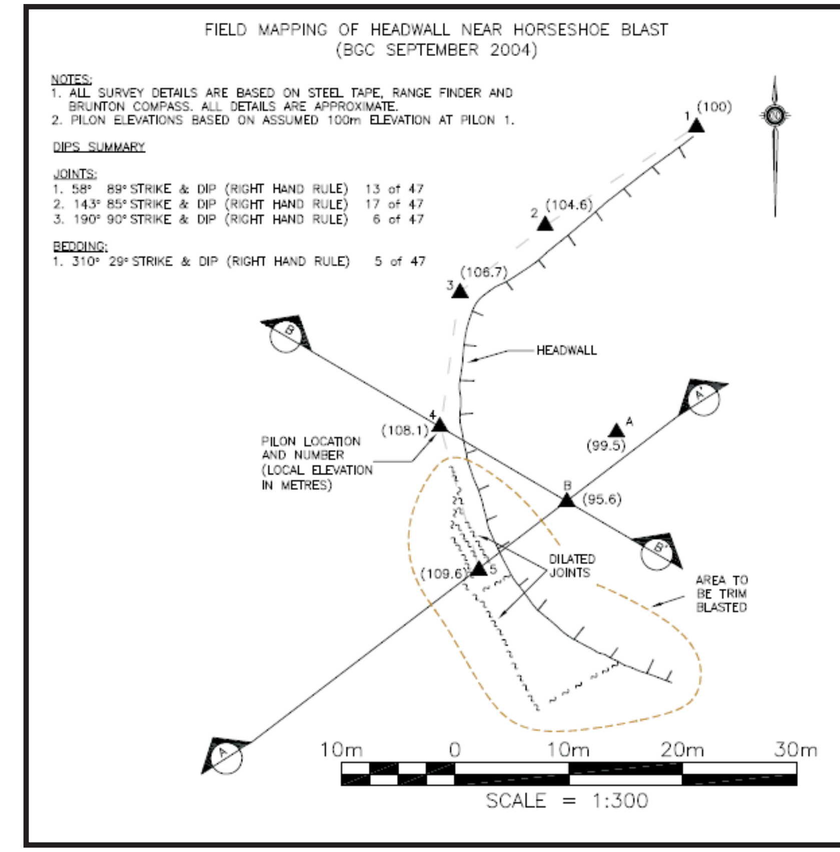


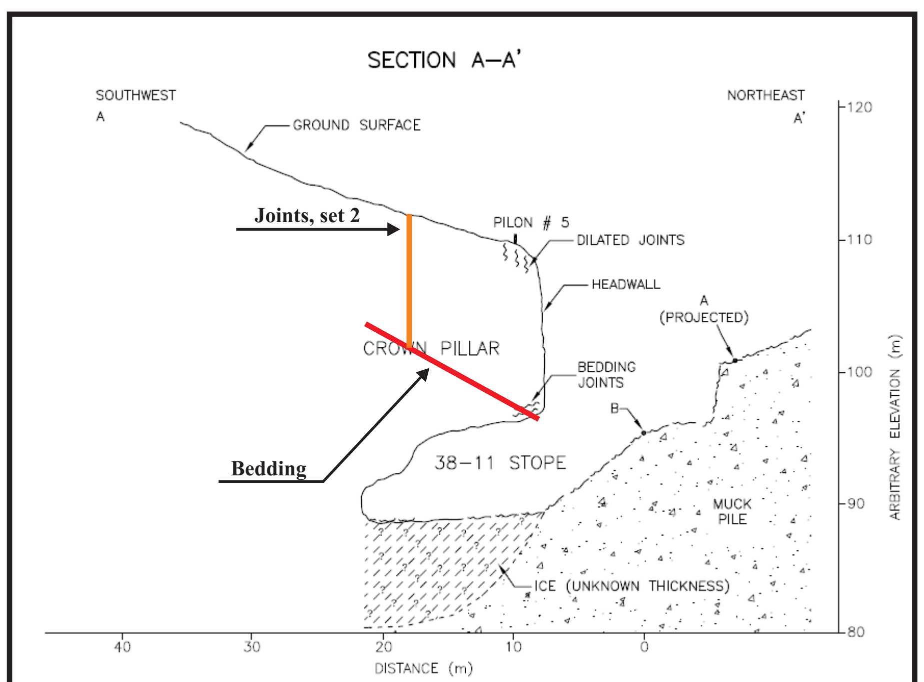
From Figure 22, East pit highwall (showing East adit area)



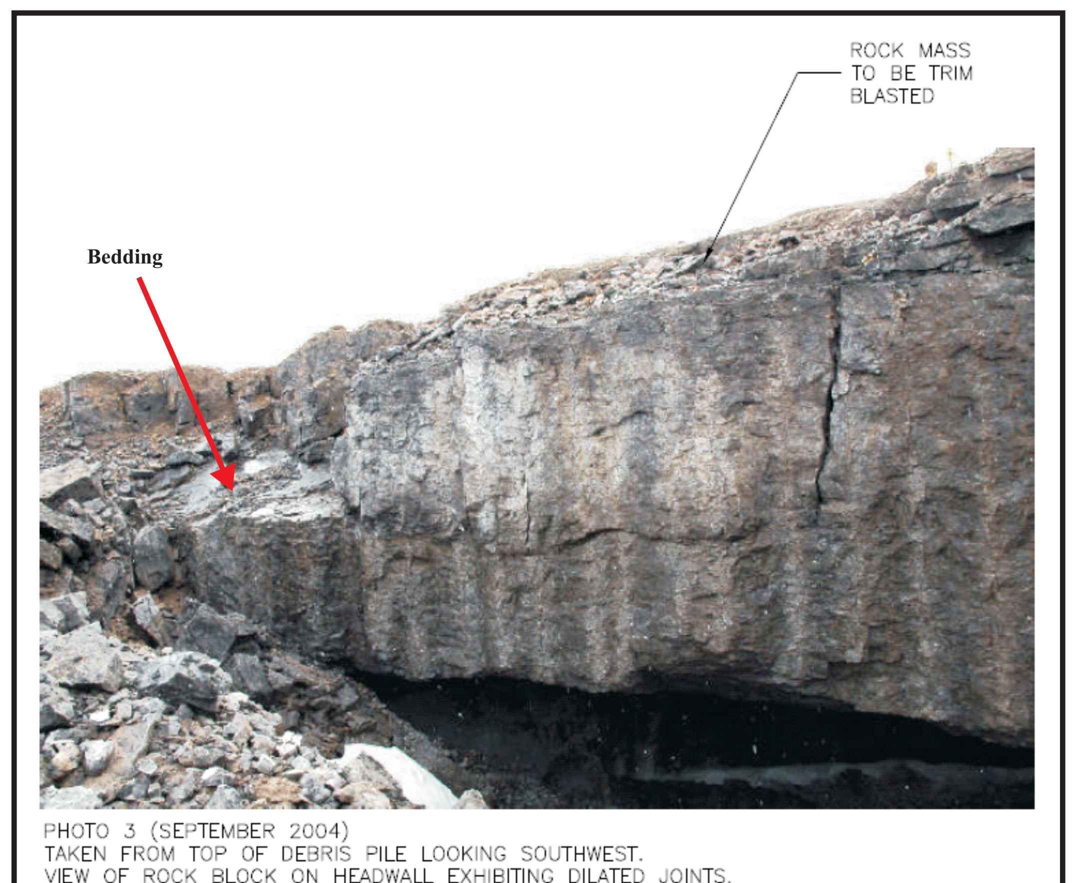
From Figure 29, Plan detail of Horseshoe blast area



From Figure 29, Section and failure, Horseshoe blast area



From Figure 29, Section A-A'



From Figure 29, Photo of failure area

Notes:
It is unclear from the provided information if the shown interpretation correct.

First, in the center diagram above, the mined out area does not appear to daylight in the pit. Yet, the photos and sections clearly show a daylighting stope.

A detailed map is necessary, showing the amount of cantilevered, undercut rock remaining, as well as multiple sections through the area. No stability analysis has been conducted. This is required.

The visible failure mode in the photograph appears to be a plane shear on bedding with a side and back releases by the cross joint sets (see joint attitudes numerically in upper right, sectionally to left). This is also consistent with the area in failure shown in the upper left detail map. The northernmost section of the failure area has limited freedom of motion, potentially restricting failure of this sort.

In a situation such as this, with overhanging rock, viable kinematic failure mechanisms, frost and water action potentially driving such mechanisms, blast damage, etc, a detailed engineering stability analysis is warranted, as is a specific detailed monitoring plan. Visual assessment is insufficient.

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PROJECT: NANISIVIK ROCK MECHANICS REVIEW - III

PIT WALL AND STOPE STABILITY
EAST PIT AREA

Date: 09/06/2005

B

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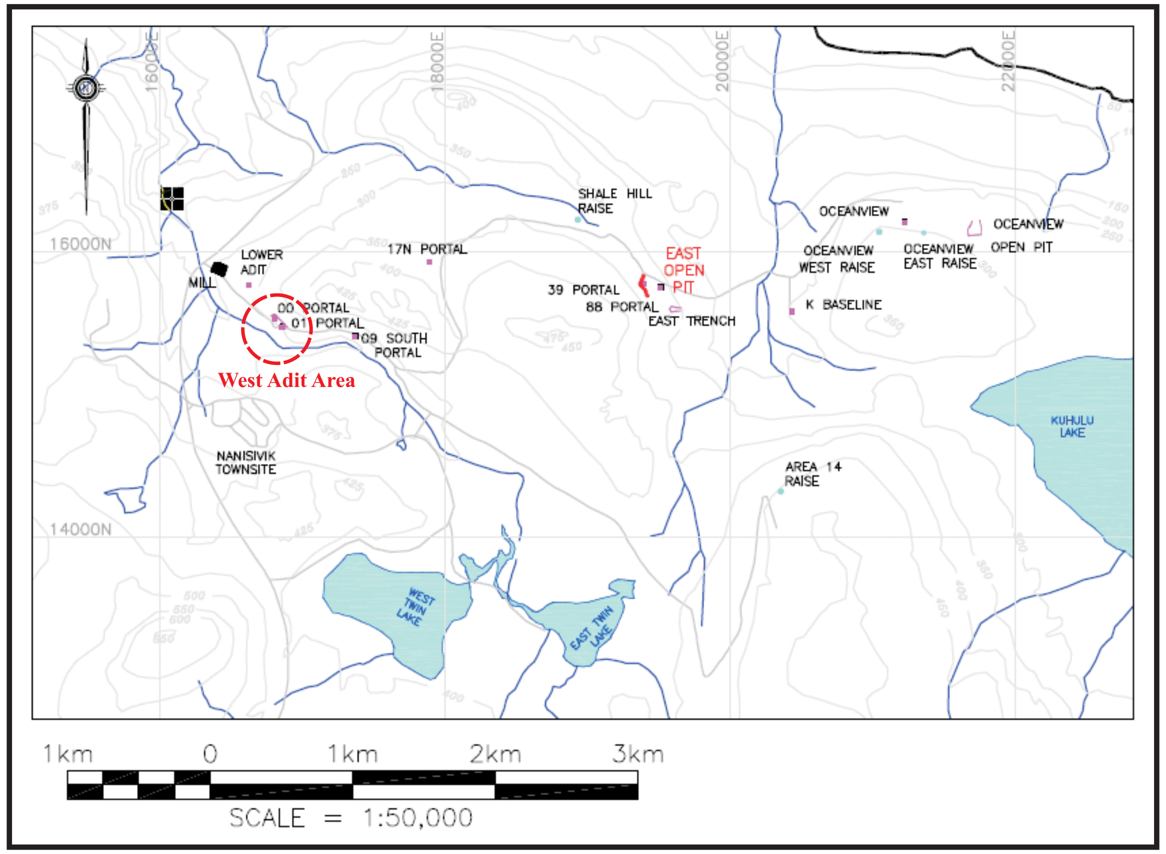
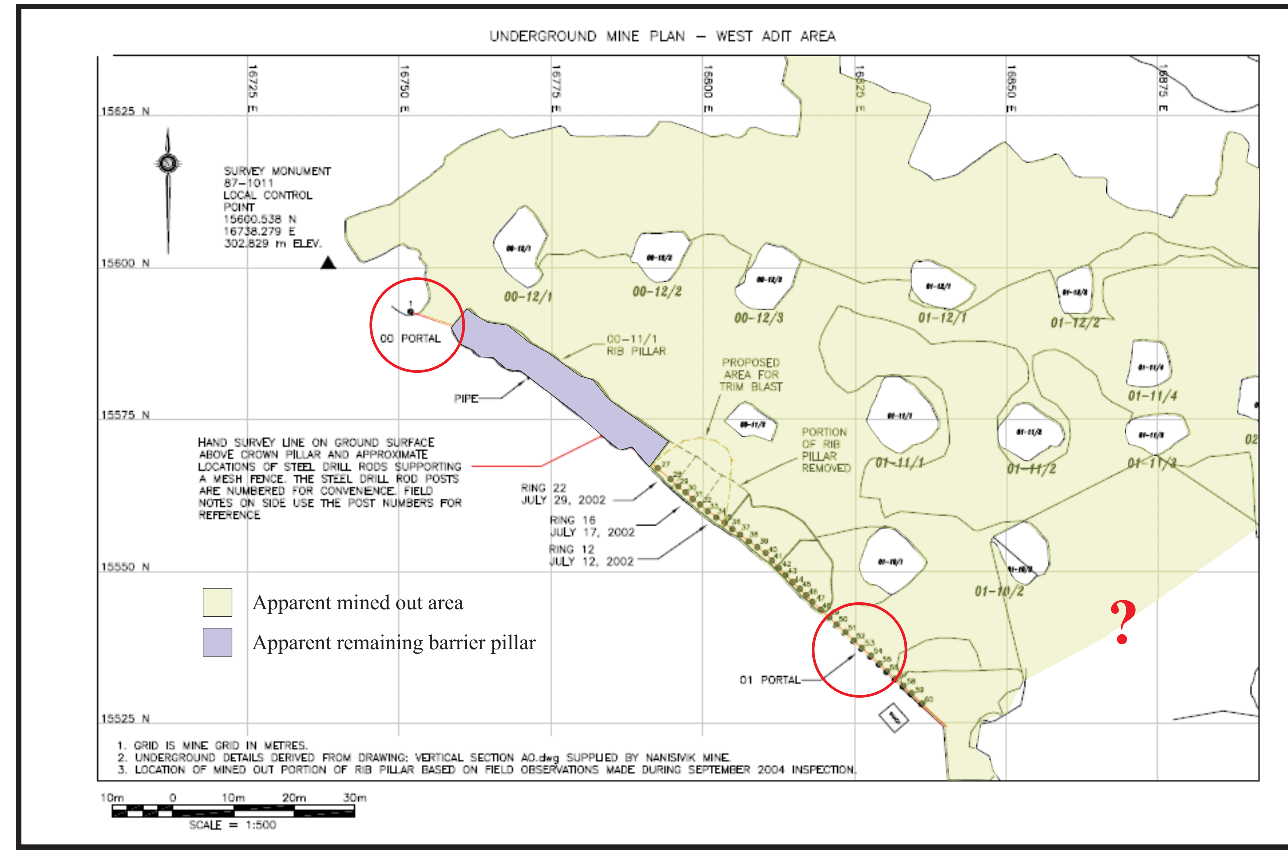
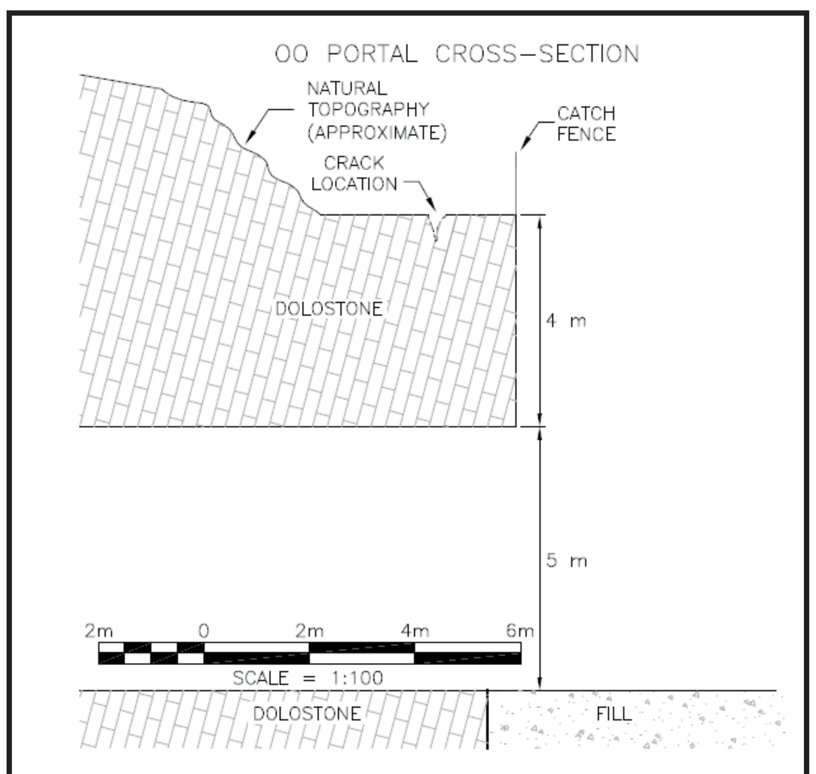


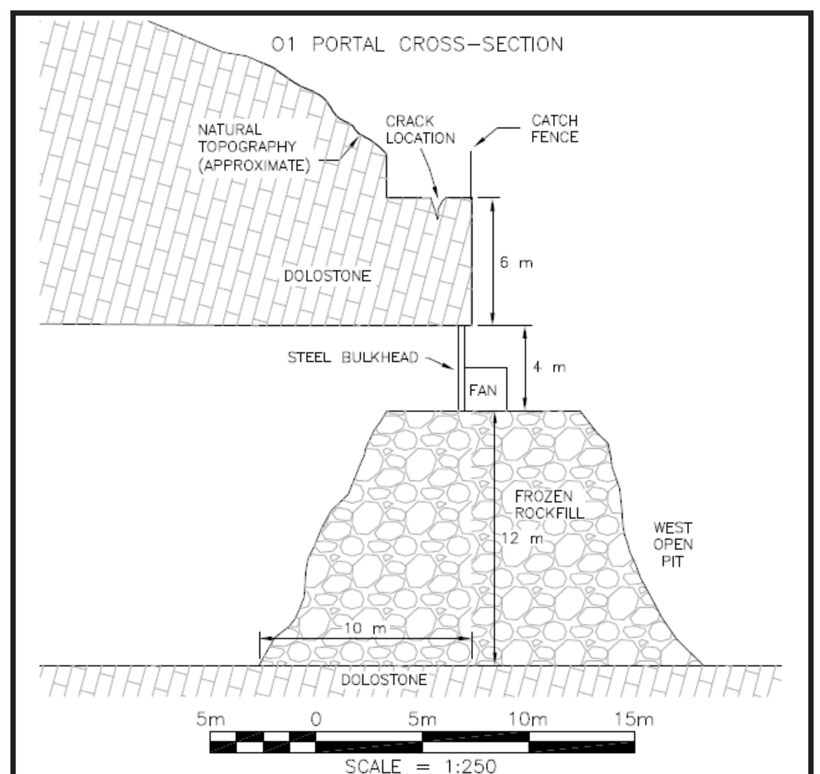
From Figure 22, East pit highwall (showing East adit area)



From Figure 28, Underground mine plan



From Figure 9, 00 Portal cross section



From Figure 10, 01 Portal cross section

Notes:
It is unclear from the provided information if the shown interpretation correct.

First, in the upper right diagram above, it is unclear what is mined, what remains, where the pillars are located, what portion of the barrier pillar has been mined, etc. This is insufficient. Neither planning and analysis, nor review, can be conducted on drawings of this nature.

Sections are shown to the left indicating the apparent dimensions, failure mechanisms, etc. of the area. These, too, are incomplete in terms of present rock support, expectations of failure progression, engineering analysis, and final remediation.

In a situation such as this, with overhanging rock, viable kinematic failure mechanisms, frost and water action potentially driving such mechanisms, blast damage, etc, a detailed engineering stability analysis is warranted, as is a specific detailed monitoring plan. Visual assessment is insufficient.

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PROJECT: NANISIVIK ROCK MECHANICS REVIEW - III

PIT WALL AND STOPE STABILITY
WEST ADIT AREA

Date: 09/06/2005

C

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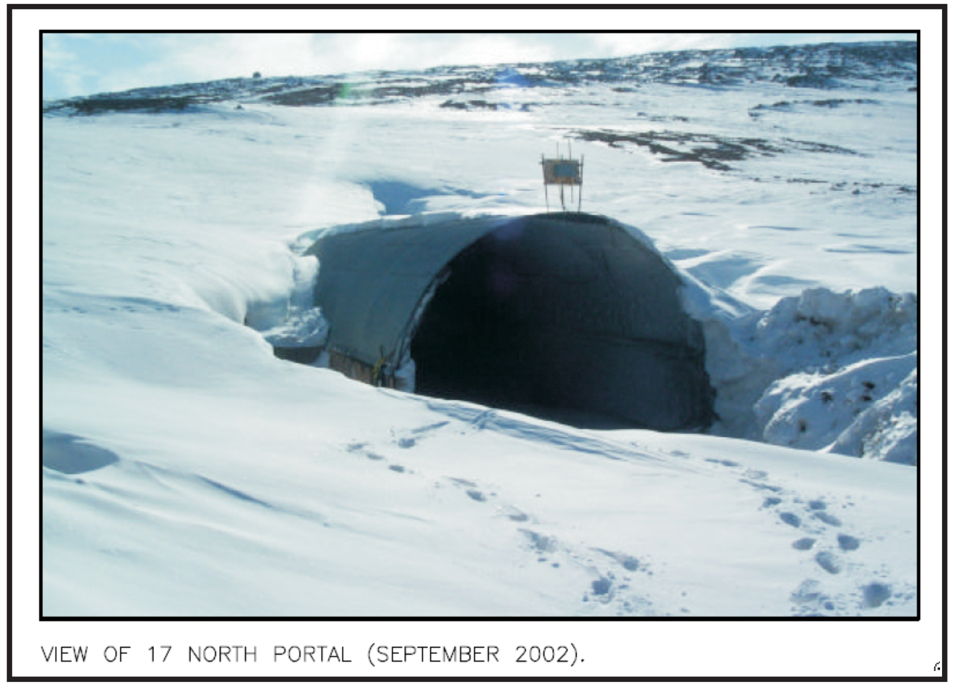
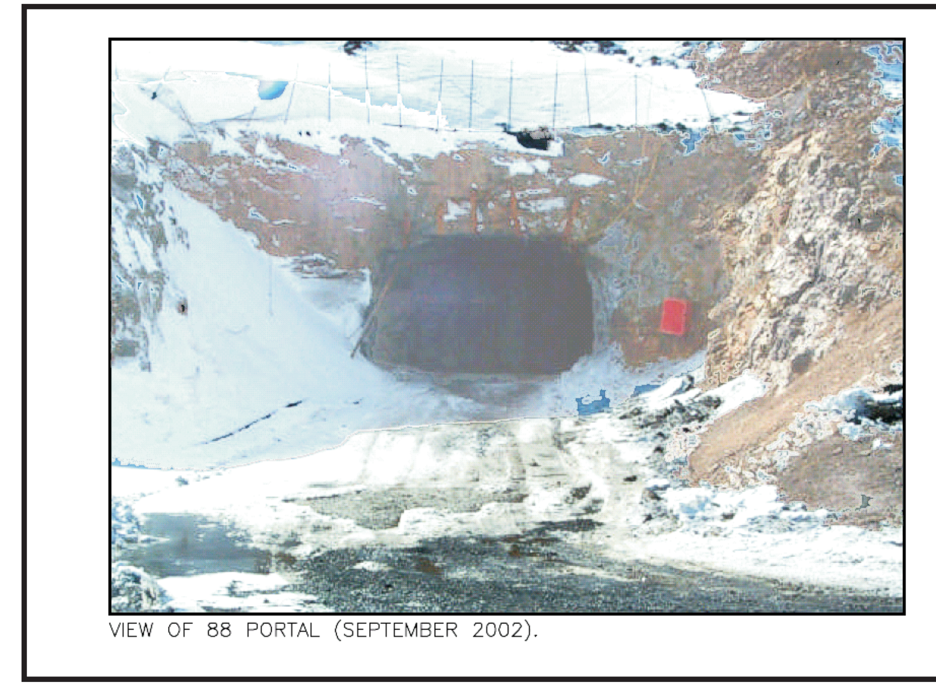
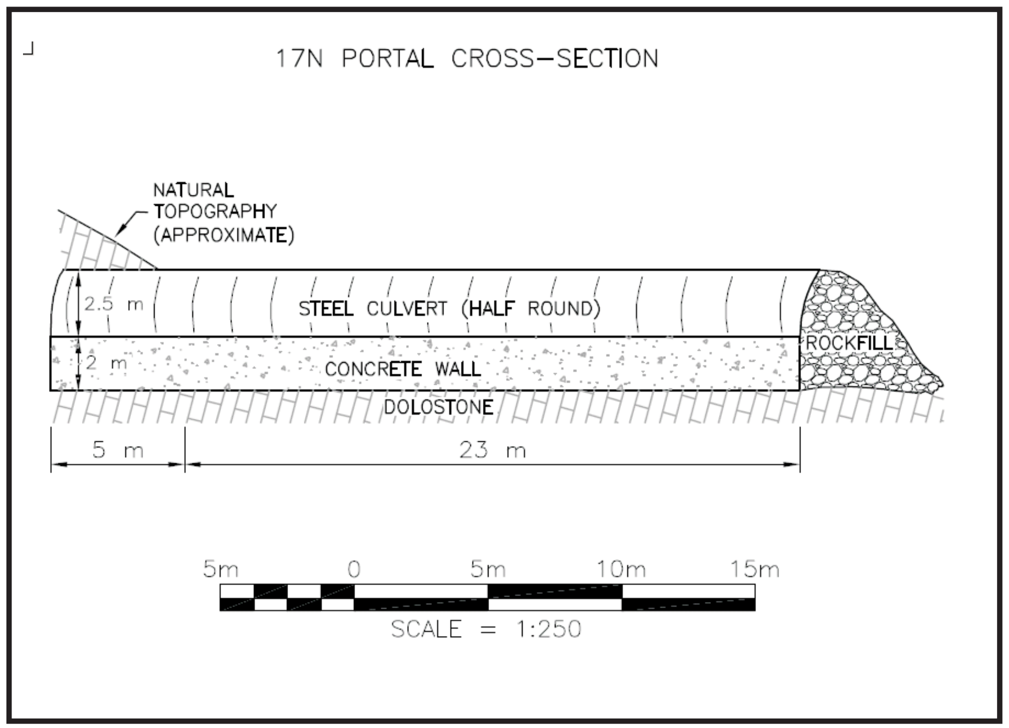


From Figure 12, 17 North portal

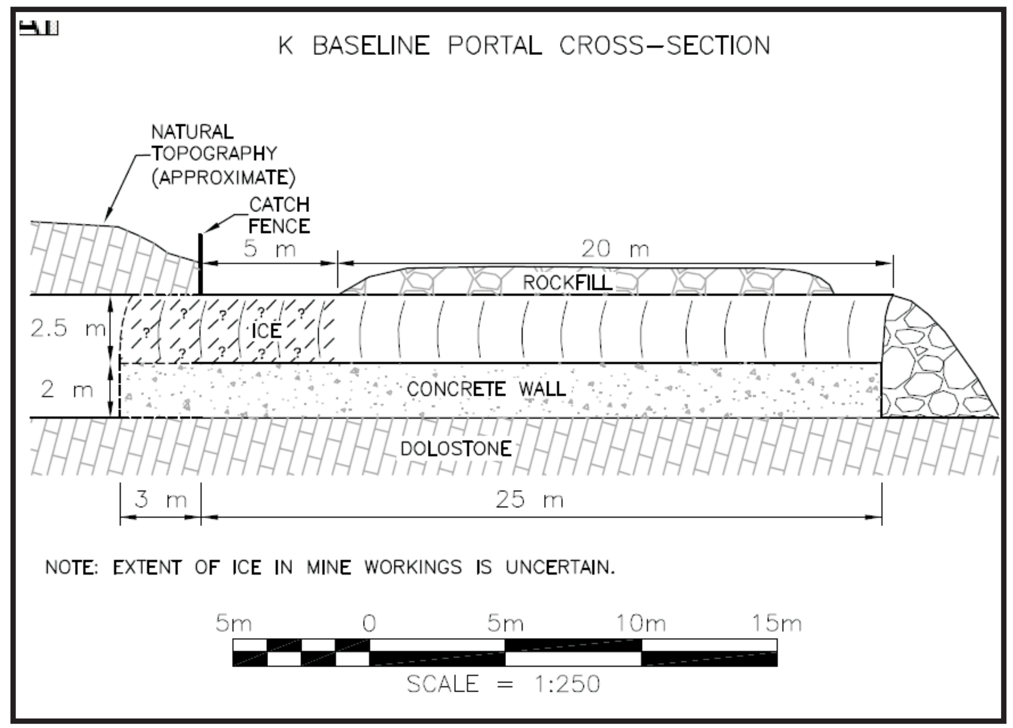
From Figure 15, K baseline portal



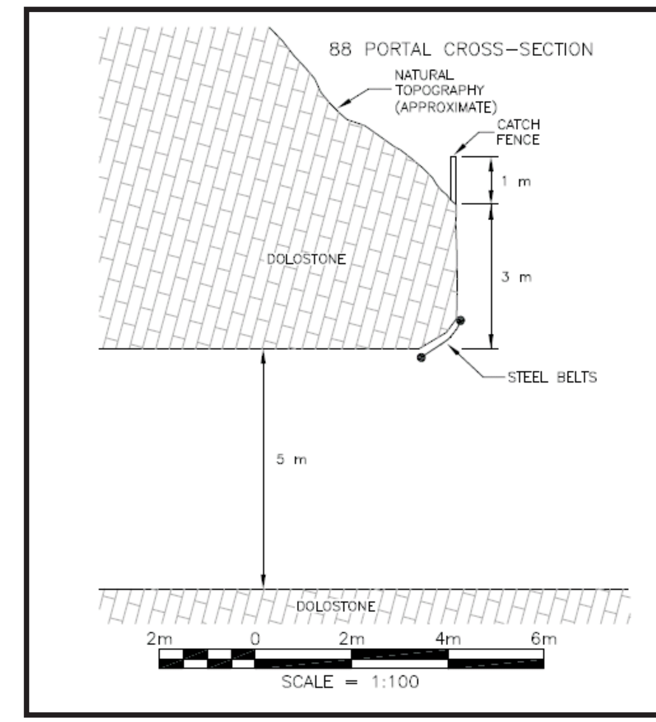
From Figure 14, 88 portal



From Figure 12, 17 North portal section



From Figure 15, K baseline portal, section



From Figure 14, 88 portal cross section

Notes:
It is unclear from the provided information if the shown interpretation correct.

First, all of the shown portals appear to have relatively shallow cover (from photographs) for quite some depth into the rock mass. This lack of cover is not shown in the provided sections, nor are the geologic structure and associated failure modes shown.

In addition, ice is not generally approved as a permanent backfill material.

In general, detailed engineering design, including adequate geologic sections, failure modes, and provided permanent rock support has not been provided.

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PROJECT: NANISIVIK ROCK MECHANICS REVIEW - III

PORTAL GEOMETRIES
INCOMPLETE CLOSURE INFORMATION

Date: 09/06/2005

D

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VIEW OF SHALE HILL RAISE (PRE SEPTEMBER 2002).

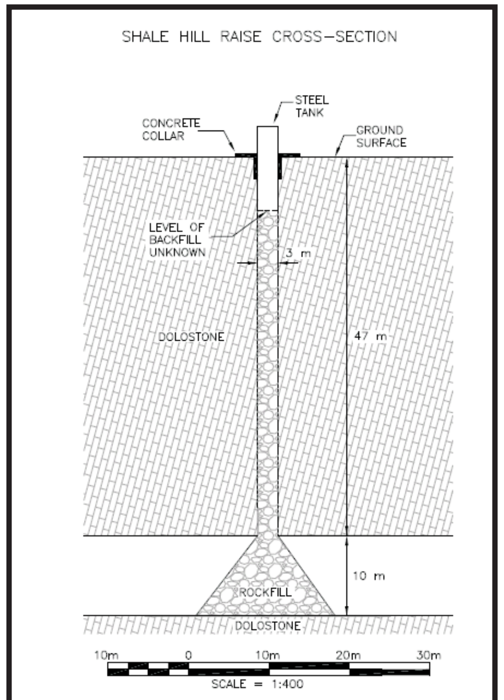
From Figure 17, Shale hill raise

VIEW OF SHALE CAP ON OCEANVIEW EAST RAISE (SEPTEMBER 2002).

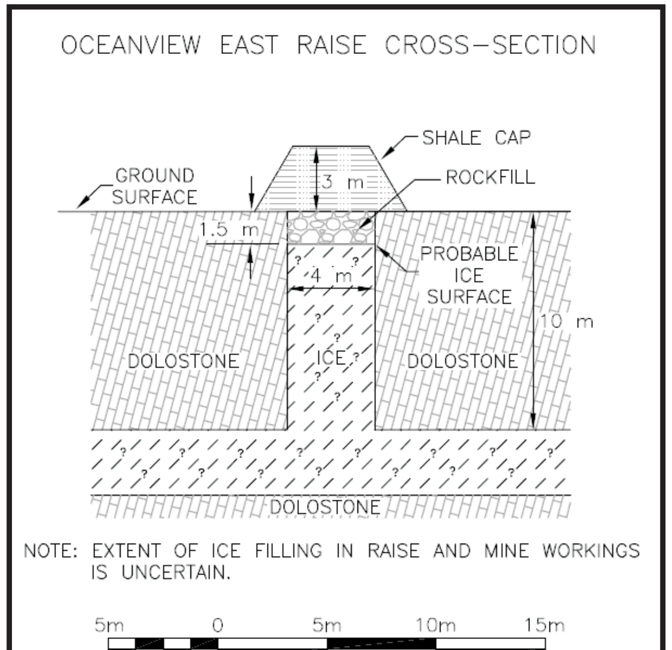
From Figure 18, Oceanview east raise

VIEW OF OCEANVIEW WEST RAISE (PRE SEPTEMBER 2002).

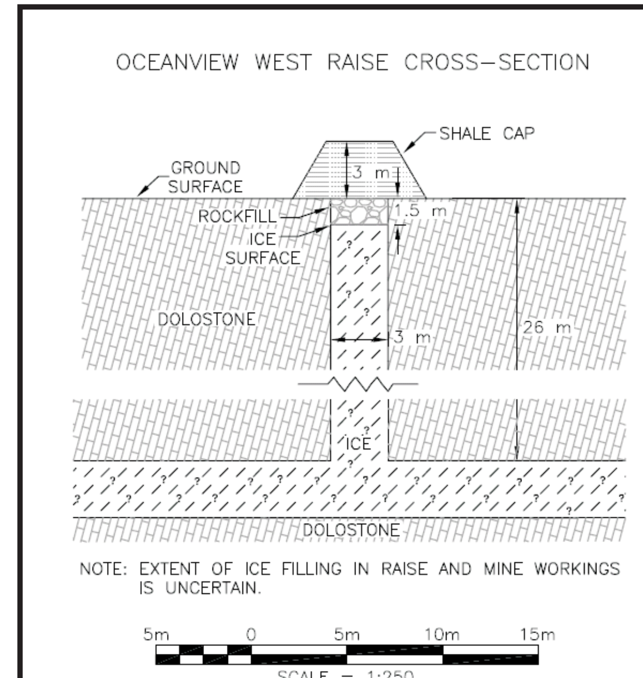
From Figure 19, Oceanview west raise



From Figure 17, Shale hill raise section



From Figure 18, Oceanview east raise section



From Figure 19, Oceanview west raise section

Notes:

First, it is apparent from all the shown sections that the raises are blocked with ice. Even if rock fill has been placed in the raise, it is uncertain to what depth the fill is found.

This is inadequate as Ice is not generally approved as a permanent backfill material.

In this case, if the depth to the rock fill is unknown, then a permanent concrete plug should be placed at the raise collar. The thickness of this plug is the responsibility of the design engineer.

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PROJECT: NANISIVIK ROCK MECHANICS REVIEW - III	
RAISE GEOMETRIES INCOMPLETE CLOSURE INFORMATION	Date: 09/06/2005
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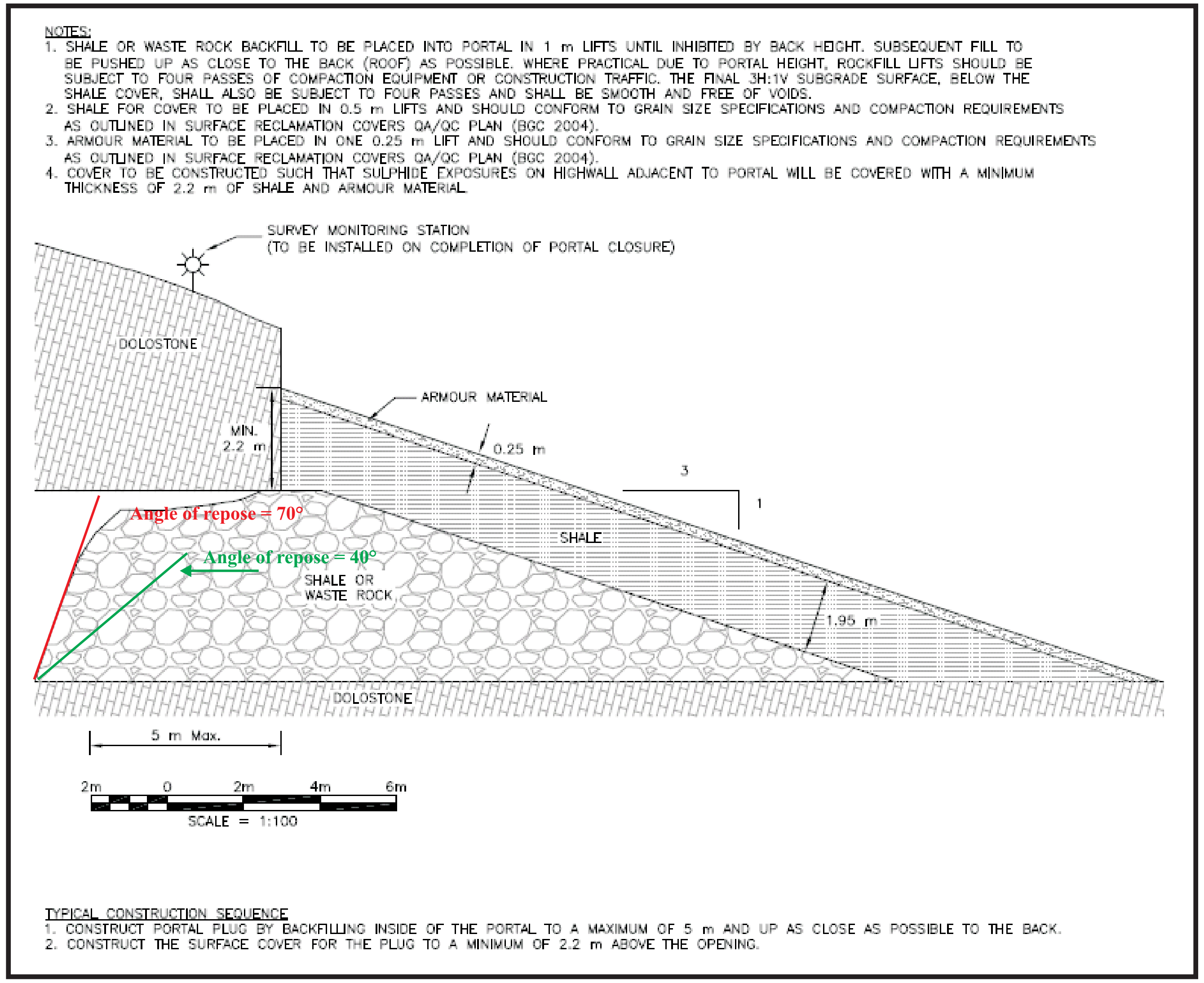
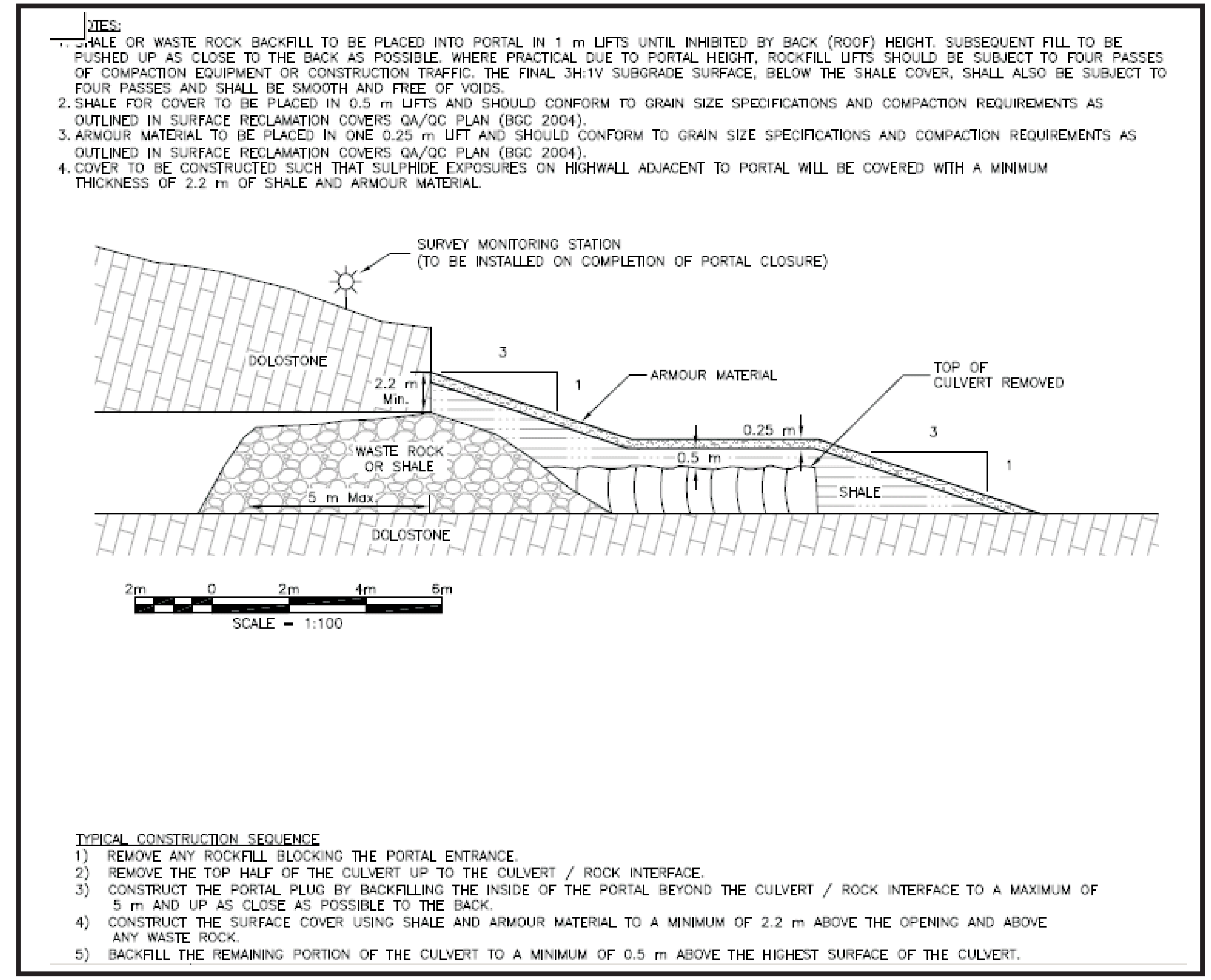


From Figure 25



From Figure 26

Notes:

The portal reclamation schemes are generally found to be inadequate.

The backfill of the portal is incomplete. While the stated purpose of the backfill is to provide some support of the back, this is unlikely. As the fill is to be pushed into the portal a maximum of 5m, and not placed tight against the back, this will provide no, or at the very best, very limited support to the immediate portal area. Note that the angle of repose of blasted muck rarely exceeds 40°.

The rock capping the portal cap is insufficiently supported by adjacent fill or by underlying fill (or concrete) to be considered to be permanently remediated.

More detailed engineering work is required. This should include detailed sections of the portal, including specific structures as well as general rock fabric information, true ground profiles to such depth as failure is unlikely to breach surface, realistic engineered backfill options that demonstrably insure rock support to a depth where rock failure can be demonstrated to be unlikely to occur, and the effect of the present portal rock support (bolts, strap, etc.) degrading and being rendered ineffective over time.

Monitoring should be specifically designed for each portal such that it will take into account all of the above noted details. It should also be verified to function of the time period required for the aforementioned failure modes to manifest.

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PORTAL CLOSURE	Date: 09/06/2005
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