

TO: OGNZL MP4 Team
Oceana Gold New Zealand Limited (OGNZL)

Date: 18 August 2026

COPY TO: Document No: 10023-016-1

FROM: Annabelle Coates

MP4 COAL CREEK AND CAMP CREEK DAMS - SCHEDULE 9 FISH PASSAGE ASSESSMENT

Introduction

OceanaGold (New Zealand) Limited ('OGNZL') currently undertakes open pit and underground gold mining operations at the Macraes Operation located at Golden Point Road, Macraes Flat, East Otago ('the site'). As part of their ongoing operations, OGNZL continually reviews the remaining life of the Macraes Operation in light of updated knowledge of the gold resource and the economics of mining.

Reflecting recent exploration success and optimisation work, together with higher gold prices, the Macraes Phase Four Project ('MP4' or 'the Project') seeks to extend the life of mining at the Macraes Operation. The Project is identified as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 ('FTAA') as a project providing national or regional benefit.

To enable MP4 to be developed and operate as proposed, water will be stored in two previously consented¹ reservoirs that have yet to be constructed. The two reservoirs will be created by constructing a dam on each of Coal Creek and Camp Creek. The actual and potential effects of the construction and operation of the two dams were described and considered during the consenting process. However, the existing consents have not expressly considered the Freshwater Fisheries Regulations 1983, therefore it has been proposed to include these additional permissions within the wider MP4 Fast-Track application. No components of the initial dam design, construction or discharge regime have been changed since consents were issued, therefore no additional consideration of the effects of the dams, with the exception of how they will impact fish passage, are necessary.

The contents of this memorandum address the requirements under Schedule 9 of the FTAA, which relates to approvals for complex freshwater fisheries activities, as relevant to Camp Creek and Coal Creek dams only.

Background

Full descriptions of the waterways were provided in the relevant impact assessments^{2 3} associated with the original resource consent applications for the dams, respectively. However, for completeness the reaches of each waterway subject to inundation by the reservoirs are briefly described below.

¹ Coal Creek – Waitaki District Council 201.2016.779; Dunedin City Council LUC-2016-234; Otago Regional Council RM16.138.02, .07, .08, .16, .18. Camp Creek – Waitaki District Council 201.2011.35/2; Otago Regional Council RM10.351.35, .36, .37.V1, .38, .39.V1.

² Ryder Consulting, 2011. Oceana Gold Macraes Gold Project, Macraes Phase III -Aquatic Ecology Assessment. April 2011.

³ Ryder Consulting, 2016. OceanaGold (New Zealand Ltd) Coronation Project - Aquatic Ecology Assessment. May 2016.

Camp Creek

Camp Creek is a tributary of Deepdell Creek, which in turn flows into the Shag River. The impacted reach meanders through a gorge. Stock are present throughout. Instream habitat is dominated by short runs and riffles, interspersed by areas of pool. Substrates are dominated by cobbles and gravels with areas of fine sediment, sand and bedrock. Water quality is moderately degraded (elevated nutrients, average water clarity) due to the effects of unrestricted stock access and the large amount of exposed soft sediment in the channel. Water temperatures are expected to be variable given the variable riparian shading.

A summary of fish surveys undertaken in Camp Creek is provided in Table 1. While the fish surveys have been undertaken at various locations within the stream, the combined surveys provide an indication of the species that could be present in, and upstream of the dam. Annual monitoring of fish present in Camp Creek since 2015 has only recorded Taieri flathead galaxiid (*Galaxias depressiceps*; At Risk – Declining). An eDNA survey undertaken in March 2026 detected Taieri flathead galaxiids, as well as longfin (*Anguilla dieffenbachii*; At Risk – Declining) and shortfin (*Anguilla australis*; Not Threatened) eels.

Coal Creek

Coal Creek is a tributary of Mare Burn, which in turn flows into the Taieri River. The impacted reach includes the main stem and a small number of minor tributaries. Only the main stem contains intermittent or permanent water, with peak summer flows often reducing to a series of minimally connected pools. Water flow within the minor tributaries is best described as ephemeral. Substrates are mixed and include areas of cobble, gravel and fine sediment. Stock have access throughout. Water quality in Coal Creek has not been specifically monitored. However, it is expected to be characterised by elevated sediment loads (particularly during rain events) and nutrient concentrations, largely as a result of unimpeded stock access throughout the catchment, and warm temperatures during summer due to a lack of riparian shading.

A summary of fish surveys undertaken in Camp Creek is provided in Table 1. Previous fish surveys² show Taieri flathead galaxiids are present. An eDNA assessment undertaken in March 2026 detected Taieri flathead galaxiid only. No eels were detected, however it is possible eels may be periodically present.

Table 1. Results of fish surveys undertaken in Coal and Camp Creeks at various times.

Waterway	Survey method	Date	Species detected	Conservation status
Camp Creek	Annual monitoring (electric fishing)	2015-2026	Taieri flathead galaxias	At Risk - Declining
	eDNA	March 2026	Taieri flathead galaxias	At Risk - Declining
			Shortfin eel	Not Threatened
			Longfin eel	At Risk - Declining
	Electric fishing ²	October 2010	Longfin eel	At Risk - Declining
Coal Creek	eDNA	March 2026	Taieri flathead galaxias	At Risk – Declining
	Electric fishing ³	April 2016	Taieri flathead galaxias	At Risk – Declining

Schedule 9 Assessment

For the purposes of Schedule 9 of the FTAA, both dams are considered to be complex freshwater fisheries activities. A summary of information required for Schedule 9 is provided in Attachment A.

Designs of each dam, including the location of each dam, can be found in the relevant design reports (Attachment B and C)^{4 5}. Detailed designs will be prepared and submitted with building consent applications.

Impacted habitat

The dams will constitute a complete barrier to fish passage on both waterways, including for fish with climbing abilities. Both dams are located relatively high in each catchment. The Camp Creek dam will have a catchment of 1040 ha, while the Coal Creek dam will have a catchment of 650 ha.

The River Environment Classification (REC2) was used as a way to quantify impacted habitat in the waterways. As the REC does not include consideration of intermittent, permanent and ephemeral habitat, some adjustments to calculations regarding stream length have been made to account for this.

Once constructed, the Coal Creek dam is unlikely to contain habitat upstream of the reservoir, beyond an approximately 400 m reach of intermittent channel that extends from an existing dammed stockwater pond, down to the upper extents of the reservoir. The 650 ha dam catchment accounts for approximately 10% of the Mare Burn catchment, and 0.1% of the Taieri River catchment. The amount of habitat impacted within the Taieri River catchment is negligible.

The Camp Creek dam will retain permanent instream habitat upstream of the reservoir in Camp Creek itself. From review of aerial images, walking some of the upstream tributaries and the REC, approximately 5,000 m of habitat will remain upstream of the reservoir, however at least some of this is expected to be intermittent, particularly in the tributaries of Camp Creek. A conservative estimate of 3,500 m of permanent stream habitat will be retained upstream of the dam. The REC provides information regarding catchment areas. Camp Creek itself has a catchment of approximately 1,134 ha, 1040 of which will be captured by the dam. This equates to the area within and upstream of the dam accounting for 92% of the Camp Creek catchment, 16% of the Deepdell Creek catchment, and 2% of the Shag River catchment.

Fish barriers (dams)

Flathead galaxiids are a non-migratory species. They complete their entire life cycle within a relatively short section of stream. They do not require access to the sea, or to larger bodies of water (e.g. lakes) for breeding. Long and shortfin eels are migratory (diadromous). Adults migrate to the sea to undertake breeding activities, with glass eels (very young eels) re-entering the freshwater environment where they stay until they are ready to breed.

⁴ Engineering Geology Ltd, 2016. Oceana Gold (New Zealand) Ltd Macraes Gold Project Coronation North Project Coal Creek Freshwater Dam Technical Report. 12 May 2016.

⁵ Engineering Geology Ltd, 2011. Oceana Gold (NZ) Ltd, Macraes Gold Project Camp Creek Water Storage Dam Technical Report. April 2011.

Coal Creek

The dam will act as a complete barrier to migration for eels. Habitat upstream of the reservoir in Coal Creek is very limited, and no eels have been detected in Coal Creek during previous surveys³, or recent eDNA assessments. Any loss of migratory ability for eels in Coal Creek will have negligible impacts on eel populations in the Taieri River catchment.

Camp Creek

Habitat in Camp Creek upstream of the reservoir is not ideal for eels. Eels are generally found in higher numbers in waterways with large pools, softer sediments and abundant aquatic vegetation. Such habitat is not present in the upper reaches of Camp Creek which is relatively narrow and moderately steep. While surveys have detected both long and shortfin eels, numbers present are not expected to be large. The minor loss of eel habitat upstream of the Camp Creek dam will not have an overall impact on either long or shortfin eel populations in the wider Shag River catchment. As discussed above, approximately 3,500 m of stream will remain upstream of the dams that could still provide low quality habitat for eels.

Any eels present in Camp Creek upstream of the dam at construction may still be able to access the waterway downstream of the dam during periods of spilling. If this is not possible, the loss of any eels within the dam from the breeding population will be negligible due to the low numbers of eels present as a result of low quality eel habitat.

Positive impacts

The presence of the fish barriers may also provide some beneficial impacts to Taieri flathead galaxiid by reducing the potential for trout and additional eels to access upstream reaches, particularly for Camp Creek. Trout are present in Deepdell Creek, and while they have not been recorded to date in Camp Creek, this does not preclude their presence at some point in the future. Taieri flathead galaxiids are predated upon by both trout and eels and removing predation pressure is expected to have a corresponding positive impact on galaxiid populations. However, this potential benefit is uncertain and has not been relied on as the primary basis for the effects conclusion.

Fish population fragmentation and isolation

Installing complete fish passage barriers on Coal and Camp Creeks is not expected to impede fish passage for flathead galaxiids as the species is non-migratory; however, the dams will prevent local upstream and downstream movement past the dam structures. While the dams are present, the populations in the upper reaches of both Coal and Camp Creek catchments will remain isolated from populations in the lower part of the catchments.

There is the potential for the isolated populations to experience genetic isolation which could have various impacts including inbreeding and proliferation of certain genetic traits (could be positive or negative). The dams will not be present long enough to allow full genetic isolation and ultimately speciation (which requires several thousand generations to occur). There is little research in New Zealand regarding the impacts of dams on non-diadromous fish, with most research relating to dams preventing access to/from the sea for diadromous species. Research in other parts of the world shows varying results with genetic differences detected between fish populations upstream and downstream

of dams in some studies (e.g.⁶), but not in others (e.g.⁷). Taieri flathead galaxiids are restricted to five catchments within eastern Otago. Review of records on the New Zealand Freshwater Fish Database show they have a current distribution of over 450,000 ha of catchment. Within these catchments their sub-populations are already fragmented as a result of naturally drying waterways as well as geographic fragmentation that has occurred over time as river paths change. Both Coal and Camp Creek catchments will retain habitat upstream of the dams. As discussed, Coal Creek habitat upstream of the dam location is relatively small and will support a correspondingly small fish population. A potential loss of the 650 ha catchment upstream of the Coal Creek dam constitutes a negligible amount of the known Taieri flathead galaxiid distribution and significantly smaller loss of long and shortfin eel distribution. Camp Creek, while larger, still provides a small catchment relative to the known habitat of Taieri flathead galaxiid. The loss of the 1040 ha catchment upstream of the Camp Creek dam represents a negligible amount of the known Taieri flathead galaxiid distribution and significantly smaller loss of long and shortfin eel distribution. Assuming worst case scenario, and that genetic inbreeding results in the loss of both populations upstream of the dams, no impact on the wider Taieri flathead galaxiid population is expected, and no impact on the persistence of the species is expected. In reality, the likelihood of either population being lost is low.

Downstream flows during and after dam filling

Filling of the dams is expected to take a number of years, depending on climatic conditions. It is possible flows downstream of the dams may be slightly reduced, or at least more stable and lacking peak flood flows (as flood flows will be captured by the dams), for the period between completion of the dams and when each is full. Depending of the spilling regime, and the time required to refill the dams following each period of spilling, the areas downstream of the dams may be stabilised following commissioning of the dams as well.

Coal Creek

Coal Creek is a tributary of Mare Burn; however, it is a minor tributary and is not considered to provide a significant proportion of flow to Mare Burn. Coal Creek is already subject to very low flows during summer, and these low-flow periods do not appear to affect the permanence of flow in Mare Burn. As such, changes in flow regime associated with the Coal Creek dam are not expected to materially affect fish passage within Mare Burn. Changes in flow regime as a result of the Coal Creek dam will not impact fish passage downstream.

A minimum release flow of 5 L/s for Coal Creek⁸ is proposed to ensure habitat downstream of the dams remains sufficient for fish.

Once the dam is filled, flows will be discharged to supplement the existing flows in Mare Burn. The exact discharge regime required to achieve mitigation for which the dams are necessary will be determined through an adaptive management process. The release of water once the dam has been filled is unlikely to change the permanence of Mare Burn given it is already classified as permanent

⁶ Gouskov, A. & Vorburger, C., 2016, River fragmentation and fish population structure: a comparison of three Swiss midland rivers, *Freshwater Science* **35**:2.

⁷ Ruzich, J., Turnquist, K., Nye, N., Rowe, D. & Larson, W., 2019, Isolation by a hydroelectric dam induces minimal impacts on genetic diversity and population structure in six fish species, *Conservation Genetics*, **20**, p1421.

⁸ Oceana Gold (New Zealand) Limited, 2016, Coronation North Project Assessment of Environmental Effects.

downstream of the confluence of Coal Creek and Mare Burn. No impact on fish passage as a result of dam discharge flows is expected.

Camp Creek

Camp Creek is a tributary of Deepdell Creek. Deepdell Creek itself is intermittent and experiences significant drying reaches during summer. While stabilised flows (flattened flood peak flows) from Camp Creek during the reservoir filling period may result in some reduction of flushing flows in the area downstream of the dam, it is not expected to impact Deepdell Creek permanence or fish passage beyond that which the creek already experiences. A minimum release flow of 2 L/s for Camp Creek⁹ is proposed to ensure habitat downstream of the dams remains sufficient for fish.

Once the dam is filled, flows will be discharged to supplement the existing flows in Deepdell Creek. The exact discharge regime required to achieve mitigation for which the dams are necessary will be determined through an adaptive management process⁹. Ultimately, the release of water once the dam has been filled is likely to increase the permanence of Deepdell Creek, providing increased habitat and passage opportunities for fish species currently present in the waterway.

Overall fish passage conclusion

Overall, while the dams will constitute a complete barrier to fish passage, the impact on the fish communities within the dammed waterways, and those which the dammed waterways flow into, is expected to be minimal.

Summary

OGNZL already hold resource consents that allow for the construction and operation of dams across Camp Creek and Coal Creek, as part of the Macraes Operation. When these resource consents were issued, permits under the Freshwater Fisheries Regulations 1983 were not included. OGNZL have included the fish passage components of these operations within the MP4 Project as part of the FTAA application.

The dams will constitute a complete barrier to fish passage. Despite this, no detrimental impacts on resident fish populations are expected due to the non-migratory nature of flathead galaxiid and the very limited eel habitat (both quality and quantity) present upstream of the dams. Variations in flow during reservoir filling are not expected to alter the permanence of downstream habitats. Minimum flows are proposed to maintain aquatic habitat while the reservoirs are filling.

© Viridis Limited 2026

This document has been prepared by Viridis Limited for Oceana Gold New Zealand Limited (OGNZL) and is intended solely for the purpose for which it was commissioned. It may not be used or relied upon by any third party without the express written consent of Viridis Limited. Viridis acknowledges that this report will be relied upon by a Panel appointed under the Fast Track Approvals Act 2024 and these disclaimers do not prevent that reliance. This document has been produced for New Zealand consenting purposes only. Information contained herein must not be relied on for investment purposes. Unauthorised use, reproduction, or distribution of this document, in whole or in part, is strictly prohibited.

⁹ Oceana Gold (New Zealand) Limited, Macraes Phase III Assessment of Environmental Effects

Attachment A – Schedule 9 Assessment Summary

Table 2. Summary of information required for Schedule 9 assessment.

Clause	Subpart	Comments
(a) in relation to the structure and any fish facility:	(i) a description of the type of structure or fish facility:	A freshwater dam is proposed on each of Coal and Camp Creeks
	(ii) the dimensions of the structure or fish facility:	Designs of each dam, including the location of each dam, can be found in the relevant design reports (Attachment B and C) ^{10 11}
	(iii) the design of the structure or fish facility:	Designs of each dam, including the location of each dam, can be found in the relevant design reports (Attachment B and C) ^{10, 11}
	(iv) the placement of the structure or fish facility:	Designs of each dam, including the location of each dam, can be found in the relevant design reports (Attachment B and C) ^{10, 11}
	(v) the water flows:	Designs of each dam, including the location of each dam, can be found in the relevant design reports (Attachment B and C) ^{10, 11} Impacts of flow on fish passage are discussed in the section ' <i>Downstream flows during and after dam filling</i> '
	(vi) the operating regime:	The exact discharge regime required to achieve this mitigation will be determined through an adaptive management process but will maintain residual flow in the waterways below the dams at a rate of 2 L/s below Camp Creek Dam and 5 L/s below Coal Creek Dam
(b) the freshwater species and values present (with particular focus on threatened, data-deficient, and at-risk species as defined in the New Zealand Threat Classification System):		Taieri flathead galaxiid (<i>Galaxias depressiceps</i> ; At Risk – Declining) Longfin eel (<i>Anguilla dieffenbachii</i> ; At Risk – Declining) Shortfin eel (<i>Anguilla australis</i> ; Not Threatened)

¹⁰ Engineering Geology Ltd, 2016. Oceana Gold (New Zealand) Ltd Macraes Gold Project Coronation North Project Coal Creek Freshwater Dam Technical Report. 12 May 2016.

¹¹ Engineering Geology Ltd, 2011. Oceana Gold (NZ) Ltd, Macraes Gold Project Camp Creek Water Storage Dam Technical Report. April 2011.

	Brown trout (<i>Salmo trutta</i>; Introduced and Naturalised) Habitat descriptions are provided in the Background section
(c) the water quality and quantity in the surrounding habitat (at the proposed structure location, upstream and downstream):	Water quality is discussed in the Background section. Water quality in Camp Creek is moderately degraded (elevated nutrients, average water clarity) due to stock access and the large amount of exposed soft sediment. In Coal Creek it is characterised by elevated sediment loads and nutrient concentrations, as a result of stock access, and warm temperatures during summer due to a lack of riparian shading.
(d) how the passage of fish will be provided for or impeded.	The Schedule 9 assessment section addresses how fish passage may be impacted. While fish passage for eels will be impacted, the barrier will not impact eel populations due to the very limited habitat (limited by both quality and quantity) upstream of the dams, and Taieri flathead galaxiid populations are non-migratory by nature meaning barriers will have little to no impact on their populations.

Attachment B – Camp Creek Dam Design Report



Engineering Geology Ltd

CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS

Unit 7C, Rosedale Office Park, 331 Rosedale Road
Albany, Auckland, New Zealand
PO Box 301054, Albany, North Shore 0752
Phone: 64 9 486 2546 Fax: 64 9 486 2556

Ref: 6914

**OCEANA GOLD (NZ) LTD, MACRAES GOLD
PROJECT
CAMP CREEK WATER STORAGE DAM
TECHNICAL REPORT**

Prepared for:

12 April 2011

Oceana Gold (NZ) Ltd
P O Box 5442
Dunedin
OTAGO



Directors: Christopher P. Gulliver B.Sc, B.E. (Hons), MIPENZ, CPEng, IntPE Trevor Matuschka B.E. (Hons), Ph.D, FIPENZ, CPEng, IntPE
Jeremy Yeats B.Sc (Civ Eng), DIC, M.Sc, MIPENZ, MICE, CPEng, CEng, IntPE **Associate:** John Power B.Sc, TIPENZ

**OCEANA GOLD (NZ) LTD, MACRAES GOLD PROJECT
CAMP CREEK WATER STORAGE DAM
TECHNICAL REPORT**

EXECUTIVE SUMMARY

1. Construction of the Camp Creek Water Storage Dam will provide water storage of approximately 1.4Mm³.
2. A preliminary geotechnical investigation indicates the site is a suitable dam site and that locally derived soils should be suitable for constructing the dam. Further investigations are recommended prior to commencing final design of the dam.
3. A dam breach analysis has been undertaken and on the basis of the results the Potential Impact Classification (PIC) of the Camp Creek Water Storage Dam is assessed to be low.
4. Design concepts for the proposed dam have been developed. It is recommended that the embankment be a zoned earthfill/rockfill structure with a central earthfill zone, rockfill shoulders and with a vertical chimney drain/filter zone. Two spillways (primary and auxiliary) are recommended.
5. Preliminary stability analyses show that the embankment meets normally accepted standards for both static and seismic conditions, but further analyses are recommended at the final design stage.
6. Final design of the embankment will be in accordance with the New Zealand Society on Large Dams (NZSOLD) Guidelines and International Commission on Large Dams (ICOLD) recommendations for embankments.

CONTENTS

	Page No.
1.0 INTRODUCTION	1
2.0 PROJECT HISTORY	1
3.0 SITE GRID	2
4.0 SITE SETTING	2
4.1. Location and Topography	2
4.2. Site Climate	2
5.0 GEOTECHNICAL INVESTIGATIONS	2
6.0 GEOLOGY AND HYDROGEOLOGY	3
6.1. Regional Geology	3
6.2. Site Geology	3
6.2.1. Soils	3
6.2.2. Schist	4
6.3. Groundwater Conditions	4
7.0 SUITABILITY OF SITE	5
8.0 SEISMIC HAZARD	5
9.0 IN-SITU ROCK AND EMBANKMENT FILL CHARACTERISTICS	6
9.1. In-situ Rock	6
9.2. Embankment Fill	7
10.0 GENERAL DESCRIPTION AND WATER STORAGE CAPACITY	8
10.1. General Description	8
10.2. Catchment Area	8
10.3. Storage Capacity	8
10.4. Water Outlet Pipe	8
11.0 EMBANKMENT DESIGN STANDARDS	9
11.1. General	9
11.2. Dam Breach Study and Potential Impact Classification	9
11.3. Recommended Design Standards	10
Stability	10
11.3.1.	10
11.3.2. Flood Protection	11
12.0 EMBANKMENT DESIGN	11
12.1. Embankment Zoning	11
12.2. Embankment Drainage	12

12.3. Seepage Estimates	12
12.4. Stability	12
12.4.1. Potential Modes of Failure	12
12.4.2. Analysis Procedures and Input Parameters	13
12.4.3. Stability Analyses	13
12.5. Embankment Settlement	14
12.6. Spillway Design	14
12.7. Embankment Instrumentation	15
13.0 OPERATION, MAINTENANCE AND SURVEILLANCE	15
14.0 CONSTRUCTION ASPECTS	15
14.1. Construction Volumes	15
14.2. Embankment Construction	16
14.3. Flood Diversion Arrangements	16
14.4. Foundation Preparation	16
14.5. Erosion and Sediment Control	17
14.6. Construction Control and Management	17

REFERENCES

FIGURES 1 TO 14

APPENDIX A - SLOPE STABILITY ANALYSES



12 April 2011

**OCEANA GOLD (NZ) LTD, MACRAES GOLD
PROJECT
CAMP CREEK WATER STORAGE DAM
TECHNICAL REPORT**

1.0 INTRODUCTION

Oceana Gold (New Zealand) Limited (OceanaGold) proposes an extension to the Macraes Gold Project. The extension is called the Macraes Phase III Project and will take the consented mine life through to 2020. A new water storage dam located in Camp Creek is proposed to be consented as a contingency as part of the Macraes Phase III Project. The purpose of the dam is to discharge additional water into Deepdell Creek during dry periods so that acceptable water quality standards are maintained. The proposed dam is located north of the main area of mining. It will provide approximately 1.4Mm³ of water storage. The dam may not be required for some time however it was considered prudent to consent at this stage in conjunction with the rest of the Phase III Project.

Engineering Geology Ltd (EGL) has been contracted by OceanaGold to assess the feasibility of the Camp Creek Dam and to prepare a Technical Report to support a resource consent application. Further geotechnical investigation and design work will be required to support a Building Consent application.

2.0 PROJECT HISTORY

The Macraes Gold Project is located at Macraes Flat in East Otago as shown in Figure 1. Gold and scheelite were initially produced at Macraes by underground mining from the 1890's to the 1920's. Production recommenced for the current operation in 1990 with an open pit mine.

The main features of the Macraes Gold Project are shown in Figure 2. It includes a number of existing pits (Deepdell North and South, Golden Point, Round Hill, Southern, Innes Mills and Frasers) and waste stacks (Deepdell, Northern Gully, Northern Gully South, Round Hill, Back Road and Frasers West and East) and two tailings storage facilities (TSF's), namely the Mixed Tailings Impoundment (MTI) and the Southern Pit Option 11A Impoundment (SP11A). The Macraes Phase III Project will include expansion of the Frasers, Innes Mills, Southern and Round Hill Pits, two new rock stacks (Frasers South and Frasers North), expansion of the Back Road Rock Stack, reclamation of tailings from SP11A and formation of a reclaimed tailings stack (RTS) on the MTI, a new TSF (Top Tipperary) and the Camp Creek Water Storage Dam.



3.0 SITE GRID

All plan grids and references to the site are based on mine north which is approximately 45 degrees anti-clockwise from true north.

4.0 SITE SETTING

4.1. Location and Topography

The location of the proposed Camp Creek Dam is shown in Figure 2. Larger scale plans of the dam are shown in Figures 3, 4 and 5. The dam spans east west across Camp Creek. The western abutment slopes down to Camp Creek at between about 30 to 45 degrees. The slope flattens near creek level, possibly as a result of accumulation of colluvium. The eastern abutment is formed by a ridge that protrudes westwards. The western side of the ridge slopes down to Camp Creek at similar angles as the west abutment. The northern side of the ridge is much flatter (approximately 23 degrees) due to foliation in the underlying schist dipping in this direction. The southern side of the ridge is much steeper, sloping down at up to 60 degrees. This is to be expected as it is orthogonal to foliation.

4.2. Site Climate

A detailed description of the local climate at Macraes is given in the Macraes Gold Project Expansion - Water Management Report (Ref.1), Macraes Gold Project Expansion - Groundwater Impact Assessment (Ref.2) and more recently in the Macraes Phase III Project Water Management Section 2- Climate Report (Ref. 3). These reports include relevant historical records relating to rainfall, evaporation, runoff and temperatures.

The mean annual rainfall recorded since 1959 at the Glendale Station Site, located approximately 6km south-east of the proposed dam is 628 mm with a maximum and minimum annual rainfall of 914mm (recorded 1978) and 395mm (recorded in 1998) respectively. The probable maximum precipitation (PMP) estimated for the Macraes Mine site for a 2 day (48 hour) storm is 700 mm (Ref.1). Approximately 78% of mean rainfall (around 470 mm/year) is estimated to be lost from the study area through evaporative process (Ref.2). These processes include evaporation from surface water features (e.g. streams and ponds) and the soil capillary fringe, as well as transpiration.

5.0 GEOTECHNICAL INVESTIGATIONS

A preliminary geotechnical investigation of the site was undertaken in 2010 by EGL. It consisted of:

- Review of aerial photographs
- Review of existing geological data
- Geological mapping of exposures at the proposed dam site and near vicinity

The results of the geological mapping are summarised in Figure 6.

6.0 GEOLOGY AND HYDROGEOLOGY

6.1. Regional Geology

The basement rock in Central and East Otago comprises Otago schist. The Otago schist is primarily composed of psammitic and pelitic grey schist derived from metamorphism of Mesozoic age sandstone and mudstone. In the area of Macraes Flat, the rocks have been metamorphosed to green schist metamorphic facies, giving a strongly foliated fabric of dark grey micaceous and light grey quartz-rich laminations.

From previous geotechnical investigations and mining operations on site it is apparent that the prominent geological structures at the Macraes Gold Project site include a well developed schistosity with two dominant fault sets. West of the Footwall Fault that is associated with the Hyde – Macraes Shear Zone (HMSZ) the schistosity is folded and has a varying trend over the project area revealing a series of anticlines and synclines. Foliation dips either to the northwest, to the north or to the west and south west. East of the Footwall Fault the schistosity has more of an easterly trend. The Camp Creek Dam is located west of the Footwall Fault and geological mapping at the proposed Camp Creek Dam site indicates foliation dips to the north and northwest.

The major set of faults has an eastern trend. They exhibit Miocene (recent tectonic) deformations and are related to formation of the Alpine Fault. This deformation has faulted and folded the surface within Central and East Otago to produce the present-day basin and range topography. The major east trending fault closest to the proposed dam is the Taieri Ridge Fault that runs along the foothills to the north of the dam site as shown in Figure 7. It is approximately 1.8km north of the proposed dam based on the location inferred by Norris et al (Ref.4).

6.2. Site Geology

6.2.1. Soils

The area of the Camp Creek Dam is covered by a veneer of topsoil, loess, colluvium and residual soil. Based on exposures elsewhere at the Macraes Gold Project site the depth of such soils can be expected to vary from between 0.3m and 2m, but there could be localised zones where the soil is deeper than 3.0m. The deepest soils generally occur on the eastern facing slopes. This is where loess is thickest.

The loess generally comprises silt with some clay and occasionally minor amounts of fine sand and fine schist gravel. The colluvium soil generally comprises a mixture of silt and angular schist gravel and cobbles or gravelly silt with minor clay where the silt is derived from reworked loess. The gravel consists of highly weathered angular fine pebble sized clasts of schist.

Laboratory tests conducted on samples of loess obtained from test pits elsewhere on the mine site include water content, particle size analyses, Atterberg Limits, Pinhole Dispersion, Crumb, compaction and permeability. The results indicate that the soils are typically sandy silt of low plasticity and are dispersive. This is typical of loess derived soils. When used in water retaining embankments filters are very important to prevent internal erosion. The intention is to blend locally derived loess soils with weathered schist to achieve low permeability fill (Zone A1) for the Camp Creek

Dam. This blend has been used successfully to construct existing water storage and tailings storage facility embankments at the Macraes Gold Project.

6.2.2. Schist

The soils are directly underlain by schist comprising well foliated, fine grained pelite to coarser grained psammite.

6.2.2.1. Weathering

The depth of weathering of schist rock in the project area is relatively shallow. Typically the depth of highly or moderately weathered schist (i.e. where weathering has not significantly affected the strength of the schist) is relatively shallow (typically between 2-5m). Slightly weathered rock (having some discolouration, but not significant strength loss) is often encountered to 30m depth or more.

6.2.2.2. Strength

No strength testing has been undertaken on schist in the Camp Creek area. Elsewhere on the Macraes Gold Project typical unconfined compressive strength for unweathered schist is between about 20MPa and 40MPa, normal to bedding (Ref.5). Schist typically has a lower unconfined compressive strength along the foliation, which reflects the layered nature of the rock and the presence of weak, mica-rich laminations. There is no reason to think that the schist strength in the Camp Creek will be different from that found elsewhere in the Macraes Gold Project area.

6.2.2.3. Rock Mass Discontinuities

Joints

Geological mapping at the dam site undertaken by EGL in 2010 indicates the most common joints are steeply inclined to sub-vertical, generally dipping between 55° and 89°. The dominant dip direction of the joints is to the south or southwest with a smaller proportion dipping in a south east to north east direction. Occasional joints dip steeply to the west and north.

Foliation

Geological mapping of the dam site undertaken by EGL in 2010 and fieldwork by Norris et al (Ref.4) on the Taieri Ridge Fault north of the dam site reveals the folded nature of the foliation in this region. Foliation at the dam site generally dips at between about 11° - 28° towards the north or northwest. On the north side of Horse Flat Road north west of the dam site the foliation dips between about 8° to 26° towards the north and north east or 28°-30° to the north and northwest. Further north towards the Taieri ridge fault the foliation changes orientation and generally dips between 20° and 36° to the south west (Ref.4) and is in a similar direction to the foliation west of the Footwall Fault beneath the MTI TSF (Ref.6).

6.3. Groundwater Conditions

No direct measurements of groundwater have been made at the proposed dam site. However, geotechnical investigations elsewhere on site (e.g. Ref's 5 and 6) indicate a generally shallow groundwater level (less than 4m). Downward seepage gradients are normally apparent on ridges with upward seepage gradients in the valley floors.

Permeability tests have been undertaken at various other dam site locations at the Macraes Gold Project site. Typical values vary from between about 5×10^{-6} m/s to 5×10^{-9} m/s. These values are from packer tests which measure the permeability over a limited distance. The rock mass permeability is expected to be lower as defects within schist bedrock are generally not persistent.

In situ permeability testing, using packer tests, would be undertaken as part of the final design of the dam to quantify actual permeabilities at the site and to allow assessment of the scope of foundation treatment required (e.g. depth of foundation keyway and extent and details of grouting). This is normal practice for structures of this type.

7.0 SUITABILITY OF SITE

We consider the proposed site of the Camp Creek Dam is suitable for a water storage dam. The preliminary geotechnical investigation undertaken at the site indicates geological conditions are similar to those elsewhere at the Macraes Gold Project where existing water tailings storage embankments have been constructed and have performed successfully for a number of years. No detailed investigation of materials to construct the dam has been undertaken but the geology is very similar to elsewhere at the Macraes Gold Project. We would expect suitable materials for constructing low permeability fill to be obtained from locally derived weathered schist blended with loess and colluvial soils where necessary. As much fill as possible should be derived from within the reservoir area, as this will involve least disturbance to adjacent ground and increase the water storage capacity. Rockfill for the shoulders of the dam and riprap can also be expected to be obtained locally, with most expected to be obtained from the auxiliary spillway excavation.

8.0 SEISMIC HAZARD

In 2005 Geological and Nuclear Sciences (GNS) was engaged to undertake a seismic hazard study for the site (Ref.7). GNS has considerable experience in undertaking such studies both in New Zealand and overseas. The site is located in an area of relatively low historic seismic activity. However, there are some nearby faults that are capable of generating large earthquakes. The locations of faults closest to the proposed dam site are shown in Figure 7. The closest known active fault to the site is the Taieri Ridge Fault which is approximately 1.8km north of the proposed dam. GNS assessed recurrence intervals in the range of between about 3,000 and 25,000 years for this fault as well as for the Billy's Ridge Fault (not shown in Figure 7, as the Macraes Fault is considered an extension of the Billy's Ridge Fault). The Macraes Fault is located approximately 3.1km to the south of the proposed dam.

Probabilistic estimates of seismic hazard in terms of acceleration response spectra were estimated by GNS for use in the design of the existing MTI and SP11A tailings embankments. They are also applicable to the design of the Camp Creek Dam. Spectra were provided for return periods of 150, 475, 1,000, 2,500 and 10,000 years as well as for earthquakes associated with the closest active faults to the site (Billy's Ridge and Taieri Ridge). Spectra for return periods of 150, 475 and 2,500 years are shown in Figure 8.

A rigorous approach was adopted by GNS for determining estimates of seismic hazard. A catalogue of fault sources located within 100km of the site was compiled in conjunction with the Geology Department of University of Otago. This was used to update the

earthquake and fault source model for the region. A logic tree format was adopted to enable explicit treatment of uncertainty. Estimates of ground motions were computed using the updated seismic source model for the region and three alternative attenuation functions (one NZ-based model and two overseas). The greatest weighting was given to the NZ-based model. The resulting spectra were de-aggregated to investigate the principal sources contributing to the peak ground acceleration (pga) and 1 sec period spectral acceleration for 475 and 10,000 year return periods. Several suitable earthquake acceleration time history records were selected, with appropriate scaling factors, for controlling ground motion events revealed by the de-aggregation of the hazard spectra.

Estimates of spectra were generally higher than previous estimates for the site except for short return periods (150 years) where estimates were lower. The increases were greatest for longer return periods. The increases are primarily a result of reassessment of the activities of the three closest faults to the Macraes Gold Project (Billy's Ridge, Taieri Ridge and Hyde faults). These three faults are now all considered capable of generating up to $M_w 7$ earthquakes, and due to their close proximity to the site can be expected to generate very strong shaking. The recurrence intervals for these faults are not known with great accuracy. Recurrence intervals in the range of between about 3,000 and 25,000 years have been considered by GNS in the analyses for the Billy's Ridge and Taieri Ridge faults and between about 1,600 and 10,000 years for the Hyde Fault.

In 2010 a detailed investigation was undertaken of the northern segment of the Billy's Ridge Fault, known as the Macraes Fault, by Golder Associates (Ref.8). The Macraes Fault is adjacent to the Macraes Gold Project. The surface expression of the Macraes Fault is very subdued compared to the other structures that have reported tectonic movement during the Holocene period (last 10,000 years). Golders were able to conclude, based on trenching and soil dating techniques, that the Macraes Fault has not ruptured to the ground surface during the last 11,500 years and that there was no evidence of any late Quaternary deformation. On this basis the annual exceedance probability of rupture of the Macraes Fault is significantly lower than 1/10,000 (0.0001).

The Camp Creek Dam has been assessed to have a low potential impact classification (refer Section 11.2). According to the criteria recommended by Meija et al. (Ref.9) faults with annual exceedance probabilities of less than 1/2,500 (0.004) need not be considered. Consequently the northern segment of the Billy's Ridge Fault (i.e. Macraes Fault) need not be considered when assessing the seismic hazard for the site. The estimates of seismic hazard by GNS have been used in the stability analyses of the Camp Creek Dam (refer section 12.4). They assume that the Macraes Fault is active. This is conservative.

9.0 IN-SITU ROCK AND EMBANKMENT FILL CHARACTERISTICS

9.1. In-situ Rock

The insitu rock beneath the proposed Camp Creek Dam is assumed to be similar to that beneath the MTI and SP11A TSF's and the same shear strength parameters previously used for their design (Ref's 10 and 11) have been adopted as follows.

Rock shallower than 5m below original ground level

Effective cohesion	= 50kPa
Effective friction angle	= 40 degrees

Rock greater than 5m below original ground level

Effective cohesion	= 150kPa
Effective friction angle	= 45 degrees

The above shear strength parameters are based on shearing through relatively intact rock rather than along defects (e.g. foliation, joints or faults). Beneath the eastern half of the upstream shoulder of the dam foliation dips down at about 12° (refer Figure 6). Consequently there is the potential for failure along the rock foliation dipping to the north, with the slip surface daylighting at the bottom of the gully or through the upstream shoulder of the dam. A second set of shear strength parameters has therefore been adopted for foliated rock where failure could potentially occur along the rock foliation and these are given below. The shear strength parameters are the same as those adopted for the pelite schist used in the analysis of the Footwall Fault movement on the western side of the MTI TSF embankment (Ref.12). The shear strength parameters were determined from back-analysis of the western face of the Round Hill and Golden Point pits. The strength parameters will need to be revised at final design following examination of core from investigation boreholes.

Shear strength along rock foliation dipping to the north at typically 12 degrees

Effective cohesion	= 47 kPa
Effective friction angle	= 23 degrees

9.2. Embankment Fill

Existing tailings and water storage embankments at the site have been successfully constructed using rock from mine waste (varies from slightly to highly weathered schist) with local borrow material (primarily loess and colluvium consisting of loess and highly to completely weathered schist) blended with waste rock where necessary to produce low permeability Zone A1 fill. The Camp Creek Dam will be constructed from similar materials borrowed locally rather than obtained from mine waste. However, we would expect the locally borrowed materials to have similar characteristics to the mine waste. A large amount of laboratory and field testing has been undertaken on mine waste materials both prior to construction commencing on site and during the operation of the mine and design parameters have been established. These same parameters have been adopted for preliminary stability analyses of the Camp Creek embankment and are summarised below. The shear strength functions for Zones A1 and B are plotted below Table A1 in Appendix A and show that at low effective stress (less than about 100kPa) the equivalent effective friction angle is about 45 degrees with zero cohesion, which then reduces with increasing effective stress.

Zones A1 and B

Density	22.5 kN/m ³
Shear strength (τ)	$\tau = 2.43\sigma_v'^{0.83}$ where σ_v' is the effective vertical overburden pressure

10.0 GENERAL DESCRIPTION AND WATER STORAGE CAPACITY

10.1. General Description

A layout plan for the proposed dam, including the reservoir is shown in Figure 4. A larger scale plan of the embankment is shown in Figure 5 and a typical cross section and long section is shown in Figure 10. Important characteristics of the proposed dam are summarised below:

Crest level	RL441.5
Maximum height of dam (crest to downstream toe)	29m
Embankment fill volume	110,500m ³
Normal top water level	RL439.5
Freeboard at normal top water level	2m
Storage at normal top water level	1.4Mm ³
Maximum depth of water in reservoir at normal top water level	26m
Reservoir Area at normal top water level	13.7ha
Primary Spillway	pipe, located on west abutment
Auxiliary Spillway	open channel, located on east abutment

10.2. Catchment Area

The catchment area for the dam is 1040ha, and this is shown in Figure 4.

10.3. Storage Capacity

The height-storage curve for the dam is presented in Figure 9. The height-storage curve shows that the reservoir can store 1.37Mm³ at normal top water level. The storage available at the auxiliary spillway crest level (RL440) is 1.44Mm³. These volumes make no allowance for excavation of borrow material from within the reservoir area. Allowing for this the storage at normal top water level will be at least 1.4Mm³.

10.4. Water Outlet Pipe

Water is proposed to be extracted from the embankment via a pipe laid beneath the embankment as shown on the plan in Figure 5, the typical embankment long-section (Figure 10) and on the cross-section through the embankment where the pipe would be located (Figure 11). The pipe is located in a trench excavated into rock on the eastern side of Camp Creek. The pipe is pressurised with a valve at the downstream end to control discharge. A submerged valve is also located at the upstream end. The outlet pipe details will be considered in more detail at the final design stage. There are higher risks associated with a pressurised pipe beneath an embankment than an unpressurised pipe, but the latter is significantly more expensive. It is possible that an unpressurised pipe could be placed inside the pipe required for diversion of flows in Camp Creek during construction. The outlet pipe is shown as a 250dia HDPE pipe, but this could be subject to change at final design. It would be encased in reinforced concrete beneath the upstream shoulder (i.e. Zone A1) and drainage material beneath the downstream shoulder of the embankment. A filter zone would be located immediately downstream of the reinforced concrete section. Possible details for the pipe, including encasement, are shown in Figure 12.

11.0 EMBANKMENT DESIGN STANDARDS

11.1. General

The New Zealand Society on Large Dams (NZSOLD) publication 'New Zealand Dam Safety Guidelines' (Ref.13) is the basis for design, construction and operation of dams in New Zealand. Design requirements are related to the Potential Impact Classification (PIC). Four different potential impact categories are defined (very low, low, medium and high). The categories are based on the incremental losses which a failure might give rise to. Incremental losses are those additional losses that might have occurred for the same natural event if the dam had not failed. In assessing which category is appropriate consideration needs to be given to the consequences of failure (life, socio-economic, financial and environmental). A dam breach study has been undertaken for the Camp Creek Dam (Ref.14). Such a study considers a hypothetical breach of the embankment under both sunny and flood induced conditions. The extent of the flooding is determined and the incremental consequences resulting from the breach are assessed.

11.2. Dam Breach Study and Potential Impact Classification

The consequences of a hypothetical breach of the Camp Creek Dam and determination of the PIC have been assessed in accordance with the Building (Dam Safety) Regulations 2008 (Ref.15). A breach of the dam would result in release of the water from the reservoir into Camp Creek. The water would be expected to flow downstream in a southerly direction for about 1.7km then into Deepdell Creek. Deepdell Creek flows in a north eastern direction and joins the Shag River about 14.7km downstream of the Camp Creek – Deepdell Creek confluence. There are no permanently inhabited structures either on Camp or Deepdell Creek but there are a number adjacent to the Shag River. The nearest permanently inhabited structure is at Waihemo, about 25 km downstream from the proposed dam, but it is located above the predicted breach flood level. The nearest inhabitable structures that could be affected by a dam breach are at Waynestown which is about 37km from the dam. Some houses here have been affected by historic floods. Deepdell Creek is culverted beneath Golden Point Road approximately 5km downstream of the proposed dam. Currently Golden Point Road is a mine Haul Road. There are also a number of bridges located across the Shag River that are potentially at risk. The Golden Point Historic Mining Reserve is located adjacent to Deepdell Creek, approximately 6km downstream of the proposed dam. It includes the old Managers House and a stamper battery.

The most likely initiating event for a sunny day failure of the Camp Creek Dam is a large earthquake. For the flood induced condition a 1 in 100 AEP flood event has been assumed as the initiating event.

The PIC is dependent on the damage levels and the population at risk (PAR). Criteria for assessing damage levels are defined in Table 1 of the Building (Dam Safety) Regulations 2008. Four different categories of damage are specified (residential house, critical or major infrastructure, natural environment and community recovery time). The PIC is determined from Table 2 of the Regulations.

The level of damage due to breach under sunny day conditions is assessed to be minimal for residential houses and critical or major infrastructure. The flow in the Shag River where houses are present is assessed to be no more than a 1 in 10 AEP

flood event and below existing house floor levels. The Golden Point Road crossing at Deepdell Creek would be overtopped by about 3m, but it is not considered critical as it has little traffic and there are alternative roads. Some bridges on minor roads with low traffic volumes located across the Shag River would be overtopped, but by less than has occurred in historic floods. Damage to the natural environment would be greatest in Deepdell Creek as the dam breach flows are much greater than historical flood flows. Overall environmental damage is judged to be moderate based on the assessment that damage would be significant but recoverable. Community recovery time is expected to be very short (days to weeks) and so the damage under this criterion is assessed to be minimal. Consequently the PIC for a sunny day breach is therefore low according to Table 2 of the Dam Safety Regulations (PAR of less than 5 and moderate damage). The moderate damage assessment arises due to potential environmental consequences in Deepdell Creek.

A breach under flood conditions is predicted to result in a rise of up to 0.43m on top of the 1 in 100 AEP flood level in the Shag River where houses or bridges are at risk, except at the Golden Point culvert where the incremental rise is 2.4m. Incremental damage to houses and bridges has been assessed by considering the incremental change in parameter 'dv' where d is the depth of flow above house floor level and v is the velocity of water. Details of this assessment are provided in EGL report (Ref.14). The incremental change in 'dv' as a result of a flood induced breach is relatively small and as a consequence the incremental damage to houses is minimal. The incremental damage to critical infrastructure which consists primarily of road bridges is also assessed to be minimal. Incremental damage to the natural environment would be greatest in Deepdell Creek. The situation is much the same as for the sunny day breach and damage is assessed to be moderate (significant but recoverable). The community recovery time would be expected to be very short (days to weeks) and so the damage under this criterion is assessed to be minimal. The incremental PAR is assessed to be low (less than 5) because the dam breach analysis does not indicate a significant incremental effect and because the ORC have a warning system that is activated when flood events occur (Ref.16). Consequently the PIC for a flood induced breach is low according to Table 2 of Dam Safety Regulations (PAR of less than 5 and moderate damage).

In summary the PIC for a hypothetical breach of the dam under both sunny and flood induced conditions is **low**.

11.3. Recommended Design Standards

11.3.1. Stability

For static loading conditions NZSOLD Guidelines (Ref 13) require a minimum FOS of 1.5.

Industry practice for earthquake design is to consider two levels of earthquake. These are the Maximum Design Earthquake (MDE) and Operating Basis Earthquake (OBE). This is in accordance with recommendations by the International Commission on Large Dams (Ref's 18 and 19) and is endorsed by the NZSOLD Guidelines. The OBE is usually based on the "annual exceedance probability of about 1 in 150". Immediately following an OBE event there should be "either no damage or minor repairable damage". In New Zealand the recommendations of Meija et al. (Ref.8) are normally adopted for determining the MDE. For a low PIC dam Meija et al. recommend that the design ground motion need not exceed the 500 year ground motion. Immediately following an MDE event "some damage is allowable, but it

must not lead to catastrophic failure”. Given the size of the Camp Creek Dam we recommend that the MDE be taken equal to the 2,500 year return period earthquake ground motion.

For this project the OBE and MDE design earthquake ground motion are proposed to be based on the site specific estimates determined by GNS (Ref.7). The OBE and MDE acceleration response spectra, corresponding to the 150 and 2,500 year return period spectra derived by GNS are shown in Figure 8.

11.3.2. Flood Protection

The potential impact consequence of a dam failure in flood conditions is the main determinant in selecting the design flood. The PIC for the dam under flood induced conditions has been assessed as low (refer section 11.2). For low PIC dams the NZSOLD Guidelines state the minimum design flood should be between a 1 in 100 and 1 in 1,000 AEP. We recommend adoption of a 1 in 1,000 AEP flood event.

12.0 EMBANKMENT DESIGN

12.1. Embankment Zoning

The embankment is a zoned earth/rockfill structure. The various embankment zones are shown on the typical cross-section presented in Figure 10.

Comments on the principal features of the embankment zoning follow:

Zone A1

The primary function of this zone is to limit seepage. It will have a maximum specified permeability of 10^{-7} m/s. It also provides sufficient strength to prevent the likelihood of instability, particularly when subject to the design seismic loads. The low permeability Zone A1 is intended to be formed from locally borrowed weathered schist, supplemented with loess, and colluvium where necessary. Zone A1 will require appropriate blending of materials, conditioning and heavy compaction to achieve the specified permeability (10^{-7} m/s).

Zone B

Zone B is a structural rockfill zone forming the upstream and downstream shoulders of the embankment. It will be placed in 0.6m lift heights and subjected to compaction. Zone B fill will be borrowed locally, with most expected to be sourced from the excavation required to form the auxiliary spillway.

Chimney Drain

A 1m wide vertical chimney drain is provided, located near the downstream side of Zone A1. It performs two important functions. It functions to intercept seepage so as to limit the development of pore pressures in the downstream shoulder of the embankment. It is also designed to function as a filter to prevent internal erosion and loss of Zone A1 material into Zone B. The top of the chimney drain corresponds to the invert level of the auxiliary spillway (RL440). The chimney drain will be constructed from Type A1 drainage material that will be designed to be filter-compatible with Zone A1 of the embankment.

Riprap

Selected durable rock (psammitic schist) will be placed on the upstream shoulder to ensure that wave action will not result in erosion of the upstream shoulder.

12.2. Embankment Drainage

The embankment includes a chimney drain to intercept seepage and to act as a filter to prevent internal erosion as described in section 12.1. Seepage into the chimney drain will move vertically to the chimney drain base collector (refer to Figure 13 for details). The chimney drain base collector consists of Type B drainage material. This is free draining gravel with specific limits on particle size. A perforated pipe is incorporated in the base collector drain. The outlet from the chimney drain is located beneath the downstream shoulder of the dam. A possible detail for the outlet is shown in Figure 13. Details of the chimney drain, base collector and chimney drain outlet will need to be confirmed at the final design stage.

12.3. Seepage Estimates

No seepage estimates from the proposed dam have been made. Estimates will be made at the final design stage. Seepage should be less than 2 litres/second based on the performance of other existing water storage dams at the Macraes Gold Project. The existing Lone Pine Water Storage Dam stores approximately 600,000m³ and water ponds to a depth of approximately 23m. Seepage is monitored and is less than 0.5 litres/second.

12.4. Stability

Preliminary stability analyses have been undertaken to confirm the feasibility of the proposed embankment. The results are summarised in the following sections.

12.4.1. Potential Modes of Failure

Instability of the Camp Creek embankment could potentially occur as a result of failure of the embankment or the foundations, or a combination of the two. Possible modes of failure for the embankment include:

1. Instability of the embankment slopes
2. Bearing capacity type failure of the foundations
3. A combination of instability within the embankment and foundations
4. Instability associated with earthquake shaking at the site
5. Piping (internal erosion)
6. Loss of Freeboard

The first, third and fourth modes of failure have been analysed and the results are presented in the following sections. The bedrock beneath the site is relatively strong so the risk of instability involving a bearing capacity type failure of the foundation failure (mode 2 listed above) is negligible. The potential for failure through the foundation rock along foliation which dips unfavourably beneath the eastern half of the upstream shoulder of the embankment has been considered. Foliation dips to the north at about 12° beneath the embankment and so provides a potential failure mechanism below the upstream shoulder of the main embankment.

Piping arising from internal erosion is a potential mode of failure (fifth mode of failure listed above), particularly where the low permeability zone of the embankment is constructed from dispersive or erodible material. The low permeability zone of the embankment (Zone A1) will be comprised of weathered schist supplemented with loess and colluvium. A similar blend of material has been used successively for other water storage embankments associated with the Macraes Gold Project. To prevent internal erosion and piping developing a full height filter zone/chimney drain is proposed.

The sixth mode of failure (loss of freeboard) can arise due to seismically induced deformation and settlement or settlement of foundations and embankment under static loading conditions. Seismically induced deformations are considered in the analyses presented in the following sections for the fourth mode of failure listed above. The likelihood of large settlements leading to loss of freeboard under either static or seismic load conditions is considered unlikely. The foundations for the proposed dam are rock and the embankment is to be constructed from materials that have a relatively high stiffness and are not vulnerable to significant strength loss when subjected to earthquake ground motion. The experience with other embankments constructed from similar materials, associated with the Macraes Gold Project, is that settlements can be expected to be small.

12.4.2. Analysis Procedures and Input Parameters

Stability of the embankment has been analysed using the two-dimensional SLOPE/W computer program. The programme permits the user to select one of several procedures for computing the factor of safety. The stability analyses presented herein utilised the principle of limiting equilibrium and Spencer's solution method (Ref.20). Stability analyses have been conducted for both long-term conditions and seismic loading conditions. For the seismic case the stability has been assessed during earthquake shaking for two cases corresponding to the OBE and MDE (average return periods of 150 and 2,500 years respectively).

The inputs for the stability analyses include a model describing the geometry, material strength and pore pressure conditions of both the embankment and underlying foundations. The highest section of the embankment has been analysed. This will be the most critical.

12.4.2.1. Phreatic Surface

The phreatic surface has been taken at the normal pond water level through Zone A1, extending along the downstream side of the Chimney drain and then following the foundation level downstream of Zone A1. No phreatic surface is assumed within Zone B due to the high permeability of the rock fill.

12.4.2.2. Shear Strength Parameters

The design static shear strength parameters for the insitu rock, waste rock and tailings are discussed in Sections 9.1 and 9.2 respectively. The parameters are also summarised in Table A1 (Appendix A).

12.4.3. Stability Analyses

Stability of the embankment has been analysed for both static (end of construction, drawdown and long-term) and earthquake load cases. The assumptions are presented

in Table A1. Results from the static and seismic analyses are summarised in Tables A2 and A3 respectively. Detailed results are also provided in Appendix A.

Under static loading conditions, the stability analyses indicate factors of safety which are greater than the normally accepted minimum value of 1.5. Under rapid drawdown conditions the calculated minimum factor of safety is 1.52. This is greater than the normally accepted minimum value of 1.3. The critical cases do not involve potential sliding along foliation beneath the upstream shoulder. Nonetheless this particular potential failure mode will need to be carefully considered at the final design stage. If it is found to be of concern a toe buttress fill can be placed against the upstream shoulder.

Seismic stability has been analysed for the Operating Basic Earthquake (OBE) and the Maximum Design Earthquake (MDE). The OBE adopts the 150 year return period level of shaking. The OBE horizontal peak ground acceleration is 0.13 g at the site (Ref.7). The maximum acceleration at the embankment crest is estimated to be 0.32g. Stability has been assessed for a range of potential failure surfaces (depth to embankment height ratios of 0.33, 0.67 and 1). The estimated average lateral acceleration for each slip circle is shown in Table A3.

The MDE adopts the 2,500 year return period level of shaking. The MDE horizontal peak ground acceleration is 0.65g. The maximum acceleration at the embankment crest is estimated to be 1.62g. The estimated average lateral acceleration for each slip circle is shown in Table A3.

Under the OBE loadings, the factors of safety obtained are comfortably greater than 1.0. Consequently no yielding of the upstream or downstream shoulders of the embankment is predicted, indicating satisfactory performance.

Under the MDE loadings some minor permanent displacement, less than 100mm, are predicted for some potential surface failures. The displacements are estimated using the Jibson method (Ref.21). These displacements are unlikely to compromise the integrity of the embankment or result in a loss of freeboard leading to overtopping of the embankment.

12.5. Embankment Settlement

Settlements, following construction of the dam, are expected to be small given the nature of the foundations and the proposed fill. This is supported by the performance to date of existing embankments at the Macraes Gold Project where observed settlements are small.

12.6. Spillway Design

It is proposed that the dam have a primary spillway capable of passing up to the 1 in 100 AEP flood and an auxiliary spillway that, in conjunction with the primary spillway, is capable of passing the 1 in 1,000 AEP flood. The primary spillway is proposed to be a large diameter pipe with a large manhole type inlet structure (1.8m dia). It would be located on the west abutment. The auxiliary spillway is proposed to be an open channel located on the east abutment. The locations of the primary and

auxiliary spillways are shown in Figure 5 and potential details for the auxiliary spillway are shown in Figure 14.

Preliminary modelling, involving routing the design flood through the proposed spillways, has been undertaken to determine the required sizes of the spillways. This indicates a 0.6m diameter pipe would be satisfactory for the primary spillway and a 10m wide channel as shown in Figure 14 would be satisfactory for the auxiliary spillway. The depth of flow over the auxiliary spillway in the 1 in 1,000 AEP flood event would be approximately 0.6m at the inlet weir. The freeboard under this flood event is 0.9m. As the auxiliary spillway only operates infrequently it is not proposed to line the auxiliary spillway channel, although some rock stabilisation may be required in places. The need for and extent would be assessed during construction. More modelling will be required to be undertaken at the final design stage to confirm spillway sizing and details.

12.7. Embankment Instrumentation

The embankment will be instrumented to monitor its performance during operation. Instrumentation will include:

Piezometers

Vibrating wire piezometers will be installed to measure seepage pressures within the embankment and in the foundation. Standpipe piezometers will be located on the abutments. Actual locations will be confirmed at the final design stage.

Deformation Prisms

Deformation prisms will be installed on the downstream face and crest of the embankment to monitor embankment deformations.

Seepage Flows

Seepage flows from the chimney drain will be monitored.

13.0 OPERATION, MAINTENANCE AND SURVEILLANCE

Modern practice, which is endorsed in the NZSOLD Guidelines, requires that dams be operated and maintained and that appropriate surveillance is undertaken to ensure long-term safety. Surveillance would include regular visual inspections as well as monitoring of piezometers, seepage flows and dam deformations. In addition surveillance would involve dam safety inspections (routine, intermediate and comprehensive) in accordance with the scope and frequency recommended by NZSOLD. Normally the requirements for Operation, Maintenance and Surveillance are documented in a Manual that is prepared at the final design stage.

14.0 CONSTRUCTION ASPECTS

14.1. Construction Volumes

The estimated construction volumes for the TTTSF embankment to RL560 are summarised below.

Zone A1	47,000m ³
Zone B	58,000m ³
Chimney Drain	1,800m ³
<u>Riprap</u>	<u>3,700m³</u>
Total	110,500m ³

These estimates allow for stripping of topsoil to an average depth of 100mm and 1.5m of foundation sub excavation below Zone A1 and an average of 0.5m of foundation sub excavation below Zone B.

14.2. Embankment Construction

Embankment construction would be undertaken either by a Contractor employed by OceanaGold or with OceanaGold's own equipment. Material to construct the embankment will be borrowed locally.

Materials for Zones A1 and B are placed in thin layers (350mm for Zone A1 and 600 mm for Zone B) and would be compacted to achieve the specified gradation, density and permeability requirements. Zone A1 fill would need to be blended and conditioned prior to compaction to achieve the specified permeability.

Compaction of Zone A1 can be achieved using sheepsfoot or vibrating pad foot rollers. Zone B would be compacted with a vibrating drum roller.

14.3. Flood Diversion Arrangements

Flows in Camp Creek will be diverted through a culvert during construction of the dam. The diversion culvert will be located in Camp Creek and be designed to pass a 1 in 10AEP flood event. In the event of larger floods water will be channelled across the top of the embankment fill, against the abutment on the eastern side of Camp Creek, and be discharged over insitu rock back into Camp Creek. Construction of the dam is expected to take approximately 6-9months and so the period of risk is relatively short.

14.4. Foundation Preparation

The foundations for the dam will be situated on natural ground. Foundation preparation of the natural ground beneath the embankment will consist of stripping vegetation and excavating loess, colluvium and alluvium and shaping of the schist bedrock to achieve an acceptable geometry prior to placement of fill.

Foundation surfaces below Zone A1 will need to be cleaned off with compressed air to enable observation of defects and assessment of the need for any special treatment such as slush or pressure grouting or the installation of additional subsoil drainage. Experience to date with the schist bedrock and insitu permeability testing elsewhere at the Macraes Gold Project indicates that it has a relatively low permeability. Generally slush grouting has been necessary to infill any small fractures apparent following foundation excavation with low pressure grouting used to infill open defects in the schist rock.

Any irregularities in the excavated foundation surface that cannot be removed by excavation will be treated with dental concrete.

14.5. Erosion and Sediment Control

Good earthworks practices will be required to reduce the quantity of silt laden runoff. This includes:

- construction of temporary sediment retention facilities immediately downstream of the works
- clean water diversion drains around borrow areas
- silt ponds or decanting earth bunds and other sediment control devices at borrow areas (e.g. silt fences, lined channels from silt ponds to natural water courses)
- minimising areas of loose, uncompacted material
- providing a reasonable buffer distance between borrow areas and Camp Creek
- Providing a culvert to divert flows from Camp Creek below the embankment during construction

A site specific erosion and sediment control plan will be prepared at the final design stage which will detail specific requirements for construction.

Experience to date at the Macraes Gold Project indicates that only small quantities of silt laden runoff are generated because most of the fill is rockfill and runoff percolates down through the downstream rockfill shoulder. This acts as a filter to remove silt.

14.6. Construction Control and Management

Construction of the embankment will most likely be under the direct supervision of staff from OceanaGold. A number of staff, assisted by surveyors and the Designer as necessary, are dedicated to this task with the ongoing raising of the existing TSF's. They assist the Contractor in planning construction activities and observe all construction activities. In addition, they undertake control testing of fill placed in the embankment as detailed in the Contract Specification and undertake regular visual inspections as part of the surveillance requirements.

Report Prepared by
ENGINEERING GEOLOGY LTD



T. Matuschka (CPEng)

Reviewed by



J. Yeats (CPEng)

REFERENCES

1. Woodward-Clyde (NZ) Ltd. (1996) 'Macraes Mining Company Limited, Macraes Gold Project Expansion - Water Management'.
2. Woodward-Clyde (NZ) Ltd. (1996) 'Macraes Mining Company Limited, Macraes Gold Project Expansion - Groundwater Impact Assessment'.
3. Golder Associates. (2010) 'Macraes Phase III Project, Water Management Section 2 – Climate', Report Number 0978110-562 R002.
4. Norris, R.J. and Nicolls, R. (2004) 'Strain Accumulation and Episodicity of Fault Movements in Otago', EQC Research Report 01/445.
5. Golder Associates. (2010) 'Top Tipperary TSF Preliminary Geotechnical Assessment', Report Number 1078301051.002.
6. GCNZ Consultants. (1989) 'Macraes Joint Venture Gold Project, Waste Rock and Tailings Disposal System Geotechnical Site Investigation Report'.
7. Litchfield, N., McVerry, G.H., Smith, W., Berryman, K.R. and Stirling, M. (2005) 'Seismic Hazard Study for Tailings Embankments at Macraes Gold Project' GNS Client Report 2005/135'.
8. Golder Associates. (2010) 'Top Tipperary TSF Active Fault Hazard Assessment', Report Number 1078301051/002-R100C.
9. Meija, L., Gillon, M., Walker, J. and Newson, T. (2001) 'Criteria for Developing Seismic Loads for the Safety Evaluation of Dams of Two New Zealand Owners', NZSOLD/ANCOLD Conference on Dams, pp 1-10.
10. Engineering Geology Ltd. (2009) 'Oceana Gold Ltd, Macraes Mine, Mixed Tailings Impoundment, Raise Embankment to RL539, Design Report'.
11. Engineering Geology Ltd. (2006) 'Oceana Gold Limited, Mixed Tailings and Southern Pit Option 11A Impoundment, Proposed Raising to RL551, Engineering Feasibility Report'.
12. Pells Sullivan Meynick. (2000) 'Anderson Lloyd, Analysis of Land Movement', Report PSM71.R11.
13. New Zealand Society on Large Dams. (2000) 'New Zealand Dam Safety Guidelines'.
14. Engineering Geology Ltd. (2011) 'Camp Creek TSF Dam Breach Study'.
15. New Zealand Government. (2008) 'Building (Dam Safety) Regulations 2008'.
16. Otago Regional Council. (2007) 'Flood Response Handbook'.
17. Stewart, D.W. (1986) 'Otago Catchment Board, Flood Report for the February and March 1986 Floods'.

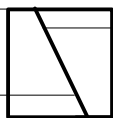
18. International Commission on Large Dams. (1998) 'Selecting Seismic Parameters for Large Dams', Bulletin 72.
19. International Commission on Large Dams. (1995) 'Tailings Embankments and Seismicity', Bulletin 98.
20. Spencer, E. (1967) 'A Method of Analyses of the Stability of Embankments Assuming Parallel Inter-Slice Forces', Geotechnique, Vol. 17, No. 1, pp 11-26.
21. Jibson, R.W. (2007) 'Regression Models for Estimating Coseismic Landslide Displacement', Engineering Geology 91, pp209-218.

FIGURES



Figure 1

Source: NZMS Sheet 15 Waitaki.



Engineering Geology Ltd
2 Esmonde Rd, PO Box 33-426, Takapuna
Ph (09)486-2546 Fax (09)486-2556

OCEANA GOLD LTD
Macraes Gold Project- Locality Plan

Ref. No.: 1410
Date: 26 June 2002
Drawn: SP
File: local.grf

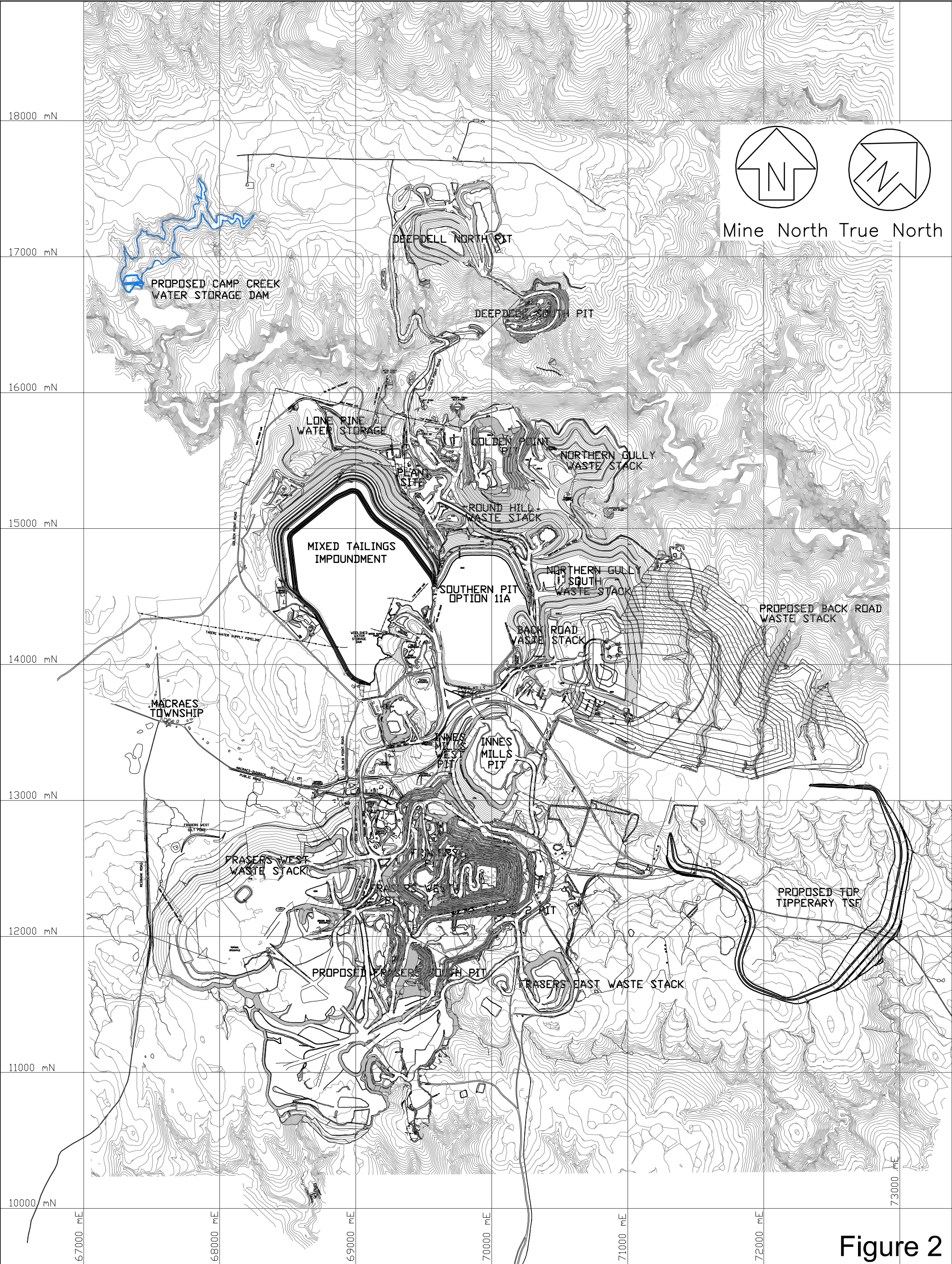
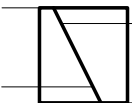


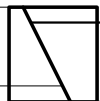
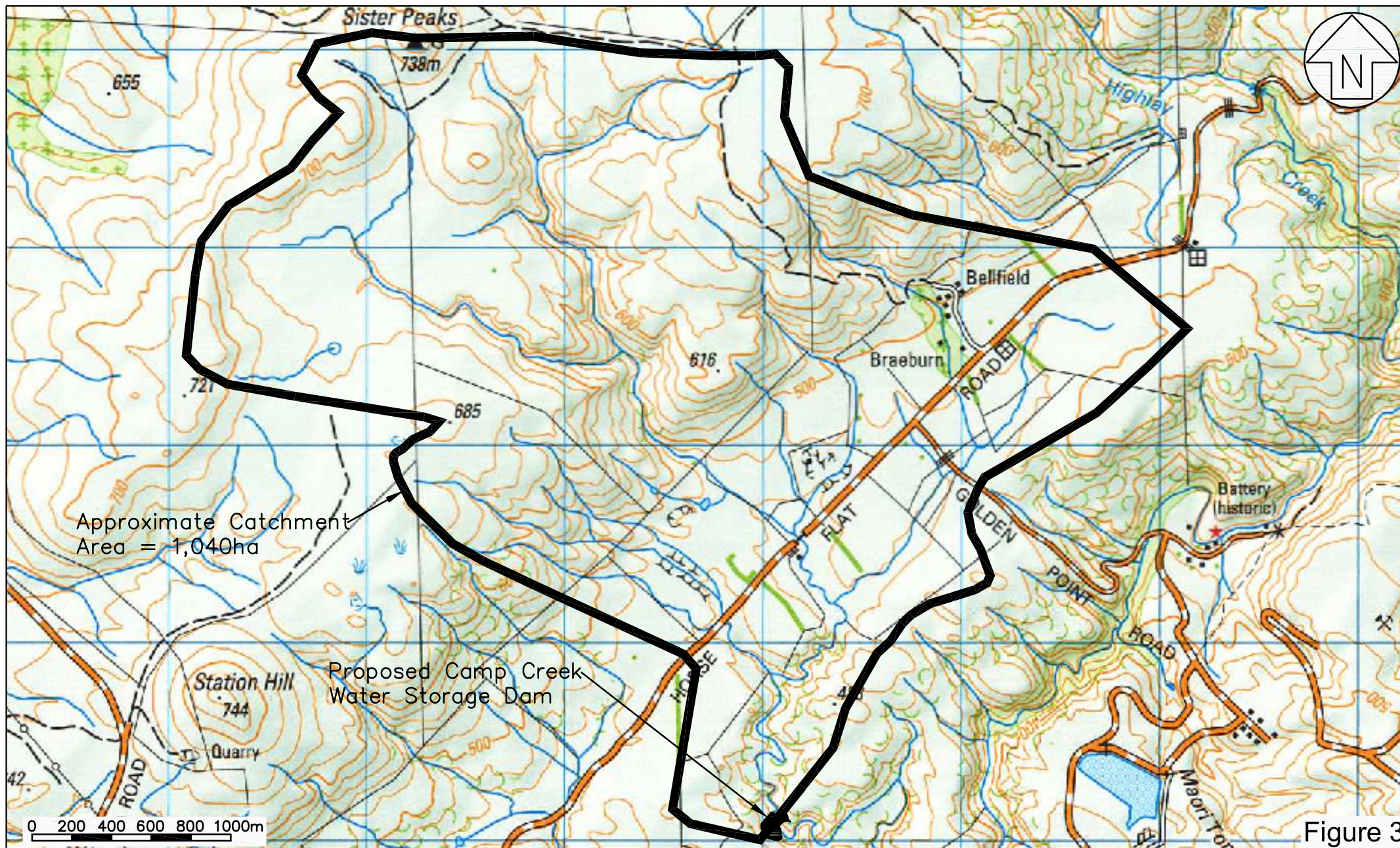
Figure 2



ENGINEERING GEOLOGY LTD
Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD (NZ) LTD, MACRAES GOLD PROJECT
Camp Creek Water Storage Dam
Site Plan

Drawing No. 6914-Fig 2
Date: 9 Mar 2011
Drawn: BL
Scale: 1:25000 (©A3)
Filename: 6914-Fig 2.dwg



ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD (NZ) LTD, MACRAES GOLD PROJECT
Camp Creek Water Storage Dam
Catchment Area Plan

Drawing No. 6914-Fig 3
Date: 8 Mar 2011
Drawn: BL
Scale: 1:25000 (@A4)
Filename: 6914-Fig 3.dwg

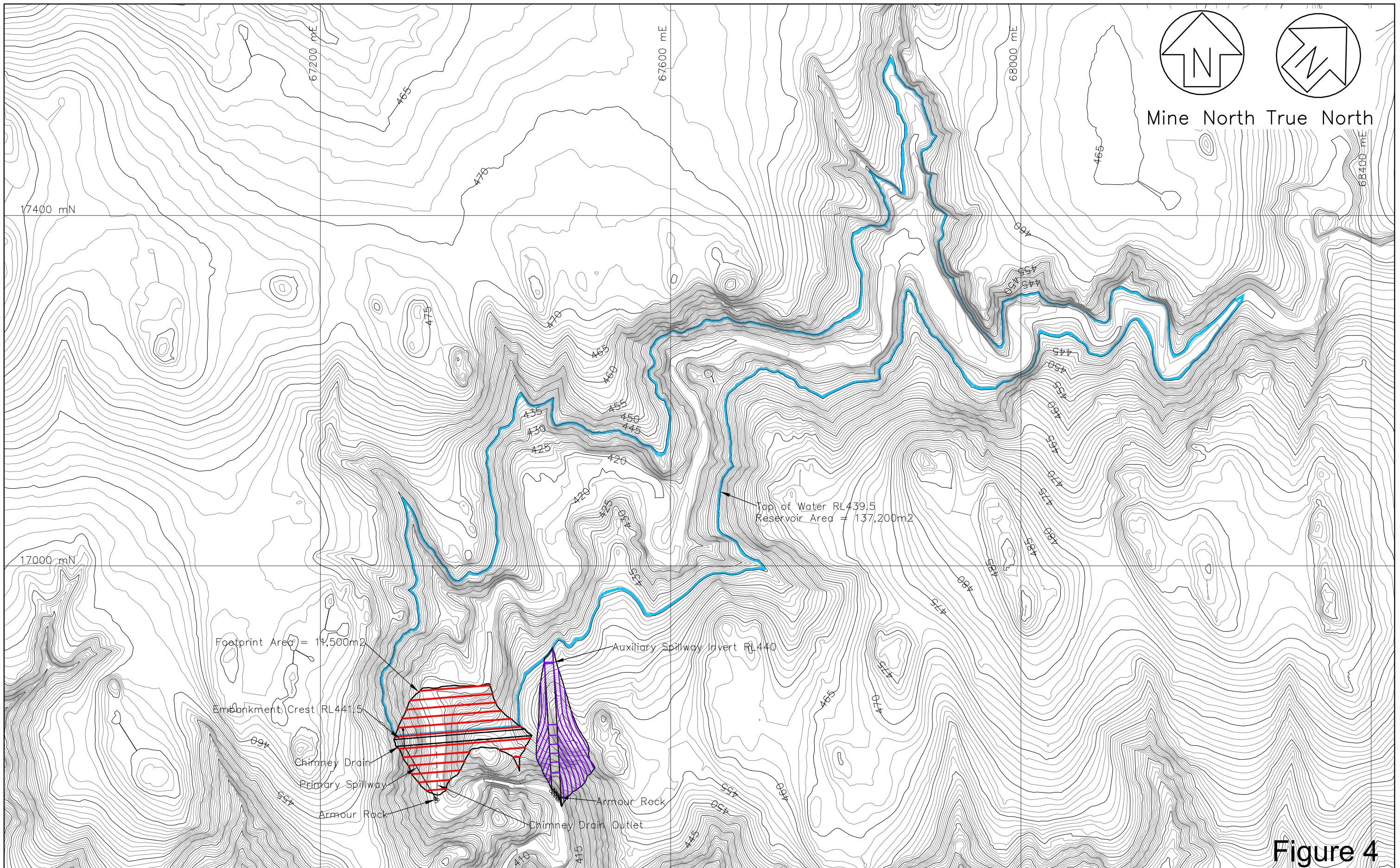
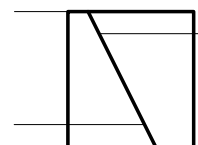


Figure 4



ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD (NZ) LTD, MACRAES GOLD PROJECT
Camp Creek Water Storage Dam
Layout Plan

Drawing No. 6914-Fig 4
Date: 21 Jan 2011
Drawn: BL
Scale: 1:4000 (@A3)
Filename: 6914-Fig 4.dwg

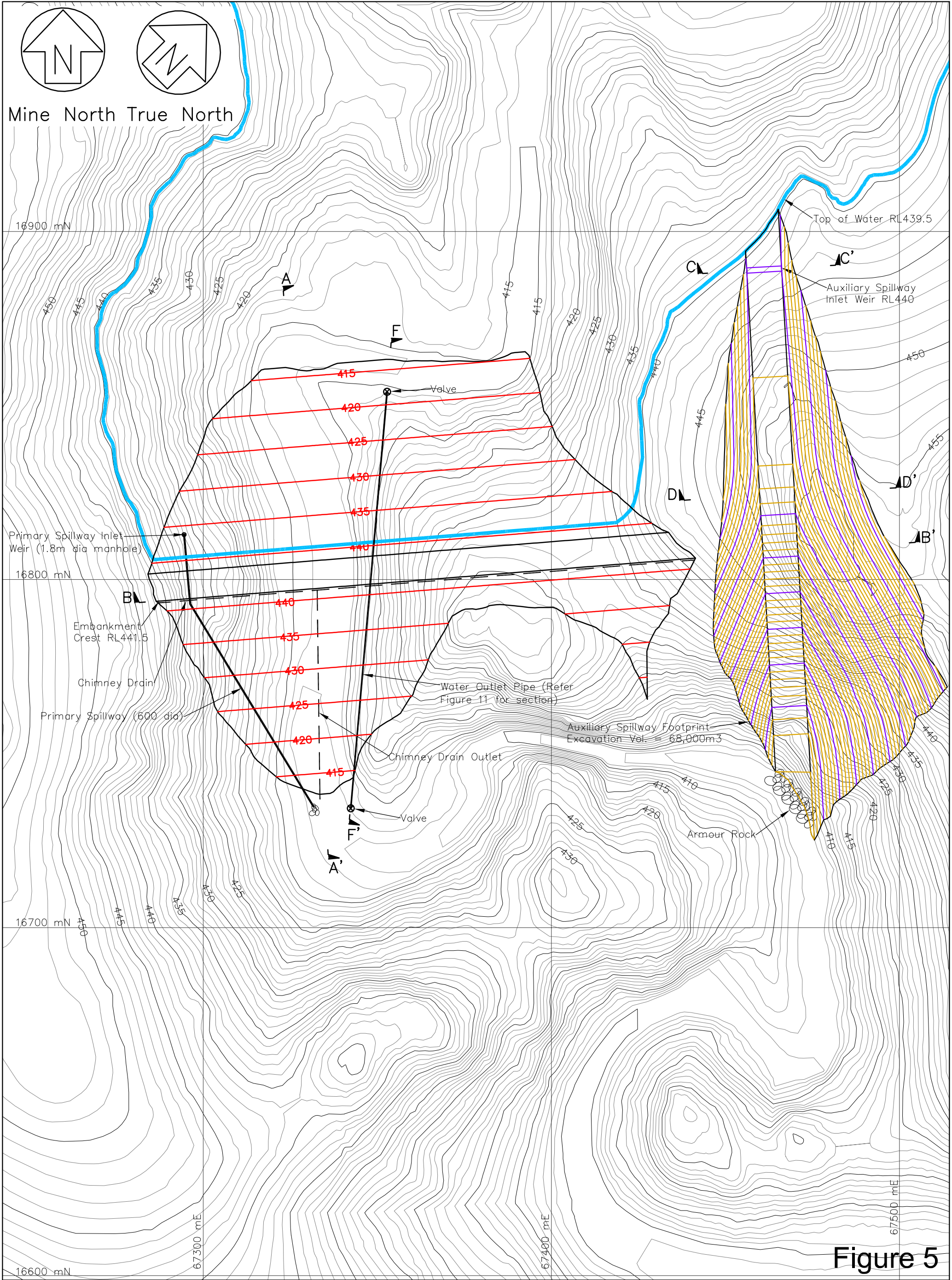
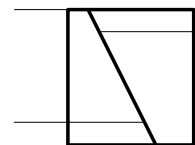
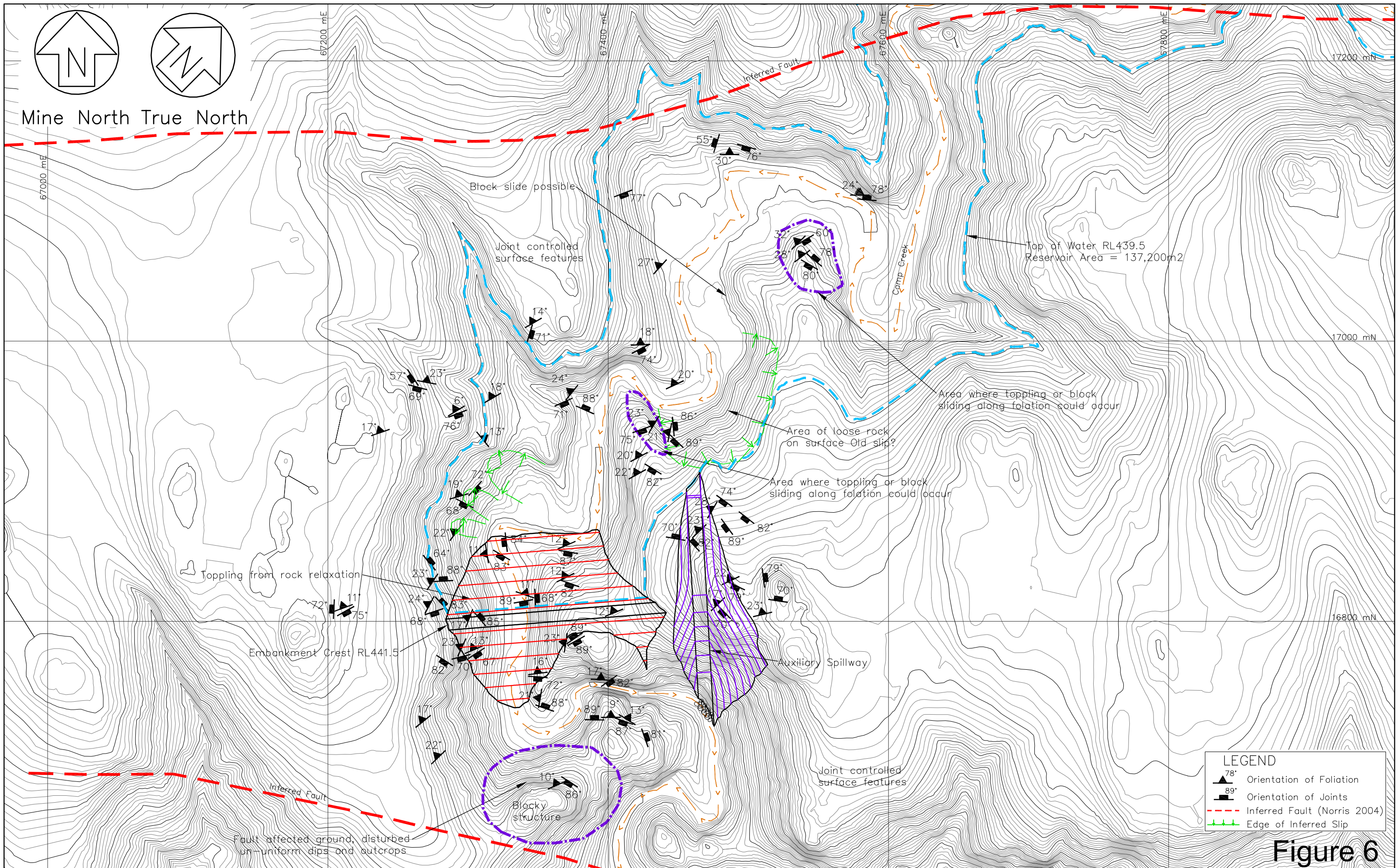


Figure 5

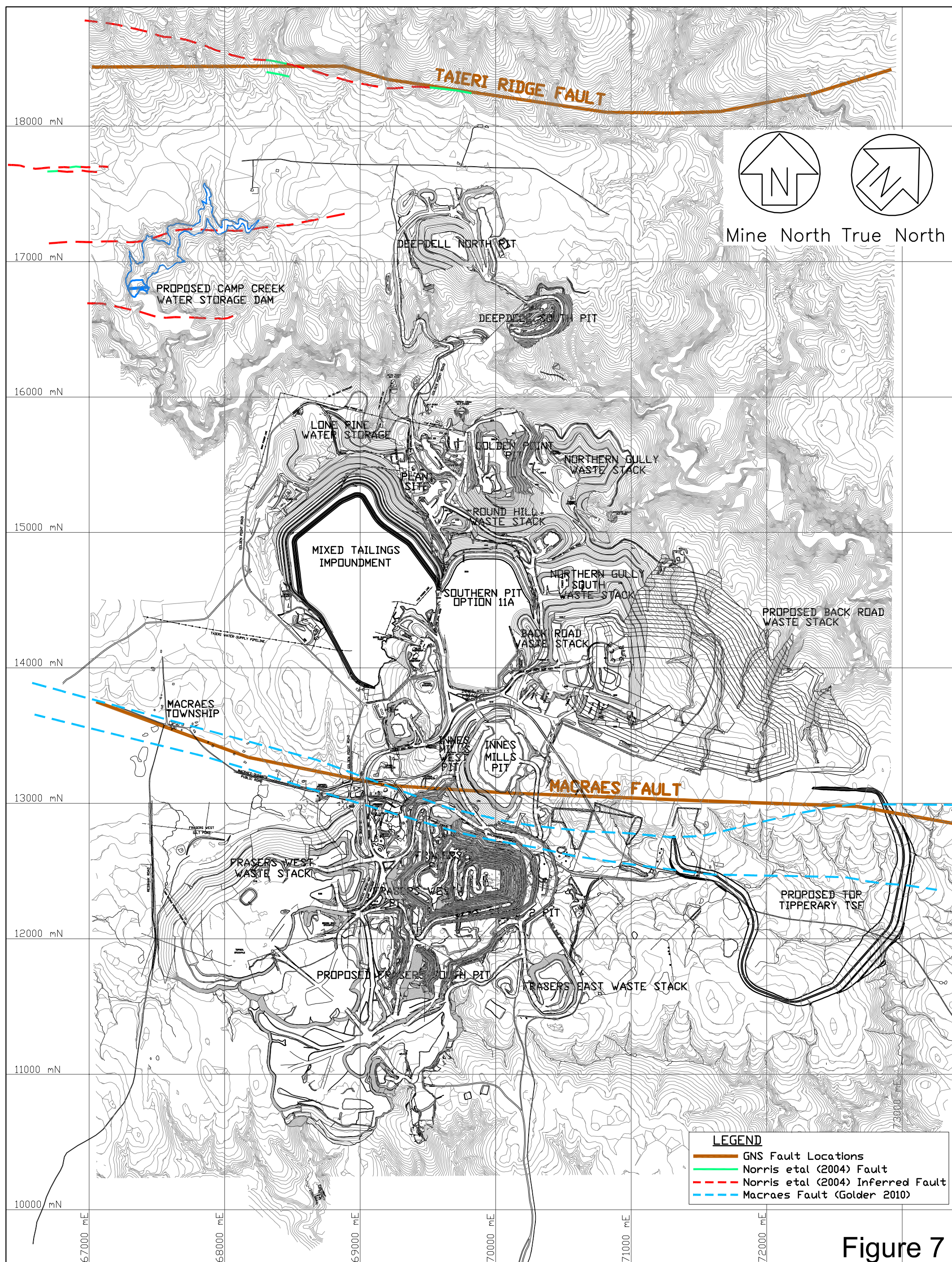


ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD (NZ) LTD, MACRAES GOLD PROJECT **Camp Creek Water Storage Dam** *Geological Mapping*

Drawing No. 6914-Fig 6
Date: 21 Jan 2011
Drawn: MC/BL
Scale: 1:2500 (@A3)
Filename: 6914-Fig 6.dwg



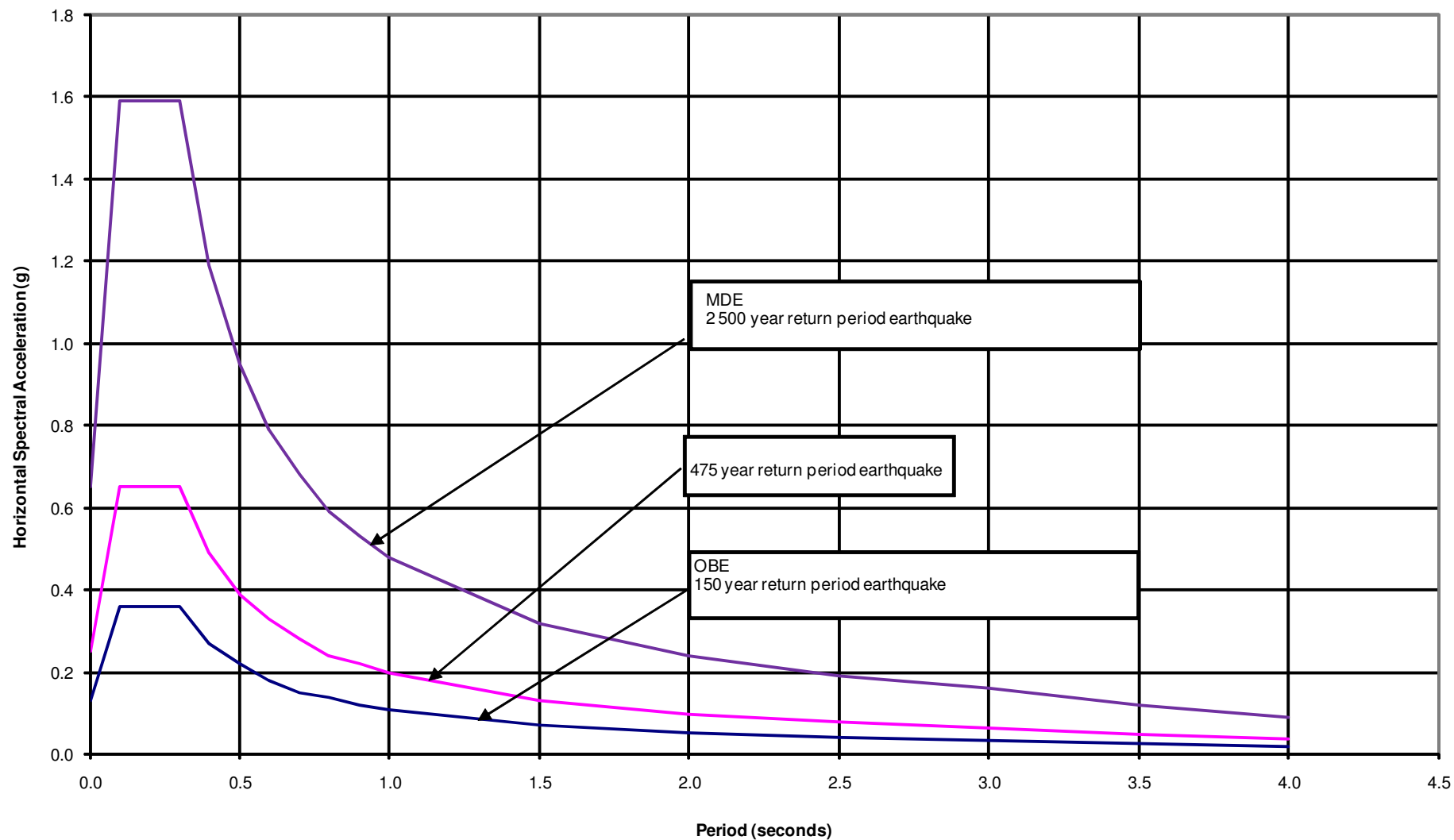
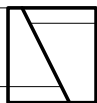


Figure 8



ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD (NZ) LTD, MACRAES GOLD PROJECT
Camp Creek Water Storage Dam
Acceleration Response Spectra (5% Damping)

Drawing No. 6914-Fig 8

Date: 16 Mar 2011

Drawn: BL

Filename: 6914-Fig 8.dwg

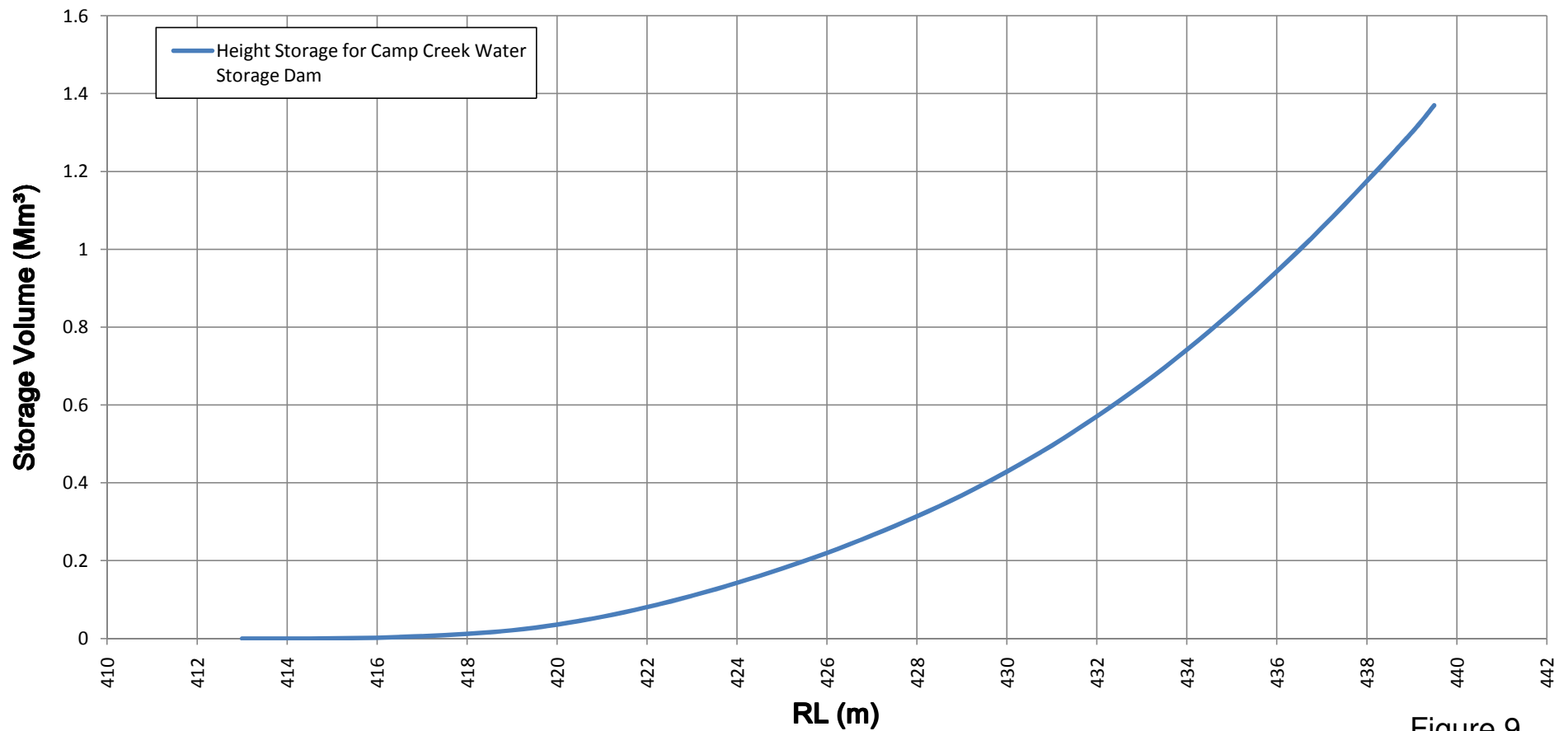
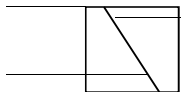


Figure 9

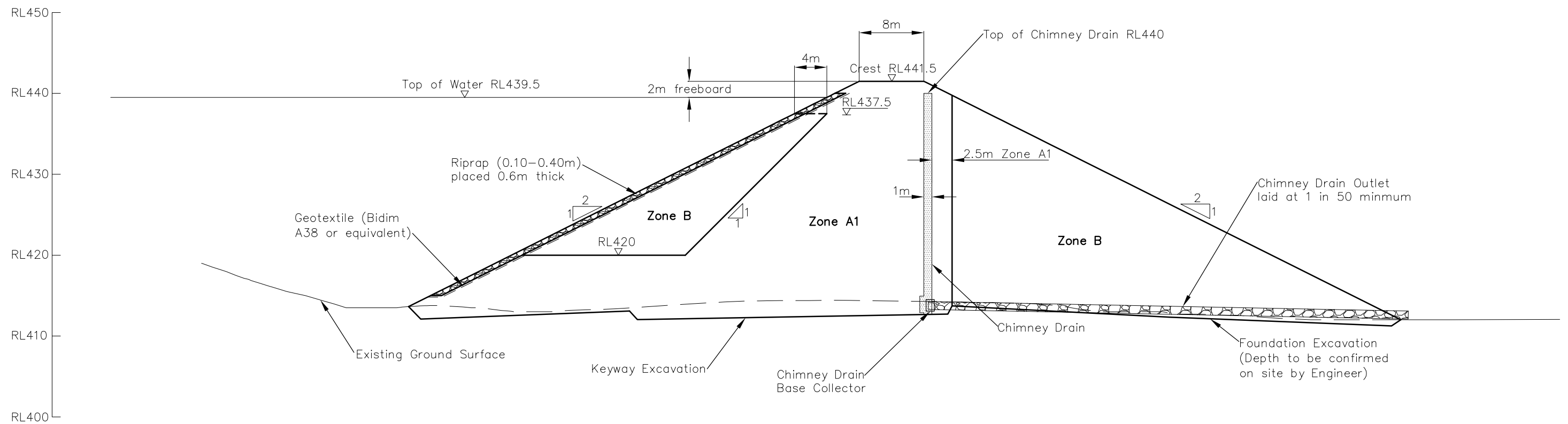


Engineering Geology Ltd

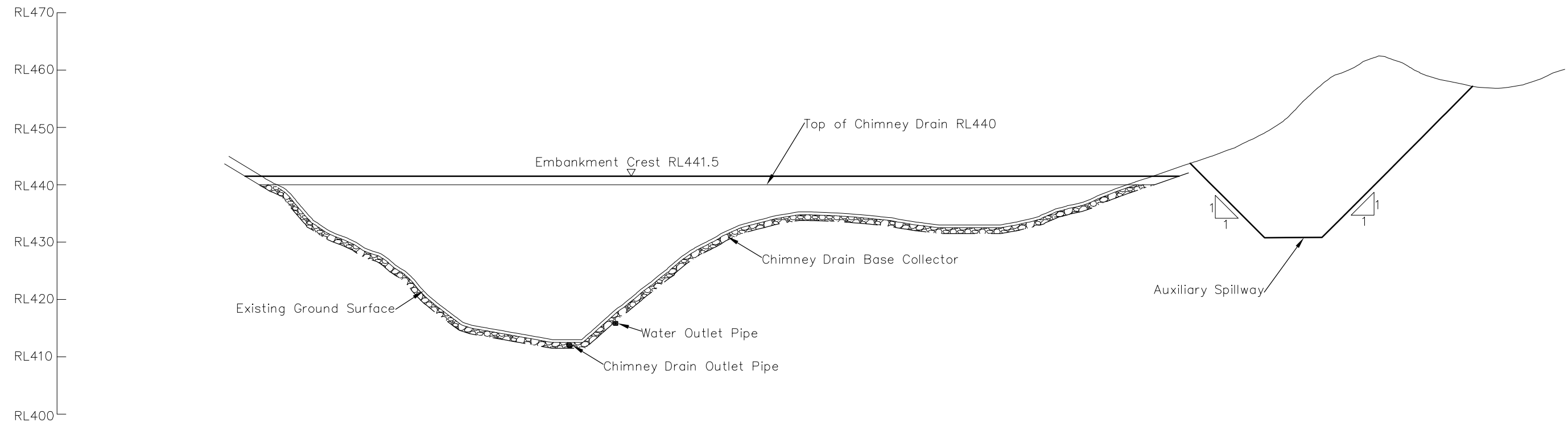
Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Auckland, NZ Ph (09) 4862546 Fax (09) 4862556

OCEANA GOLD (NZ) LTD
Camp Creek Water Storage Dam
Height Storage Curve

Ref. No: 6914 - Fig 9
Date: 26 Jan 2011
Drawn: BL
File: 6914 - Fig 9.xlsx

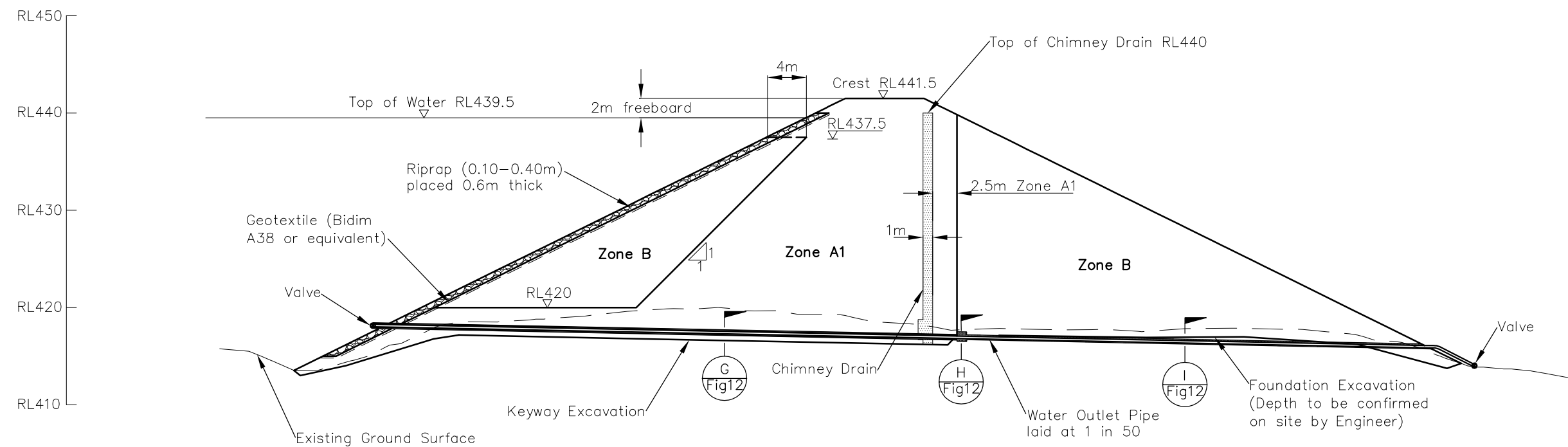


EMBANKMENT CROSS – SECTION A – A'
Scale 1:500 (@A3)



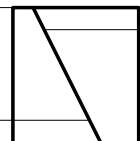
EMBANKMENT LONG – SECTION B – B'
Scale 1:750 (@A3)

Figure 10



EMBANKMENT CROSS – SECTION F – F' AT WATER OUTLET PIPE

Figure 11

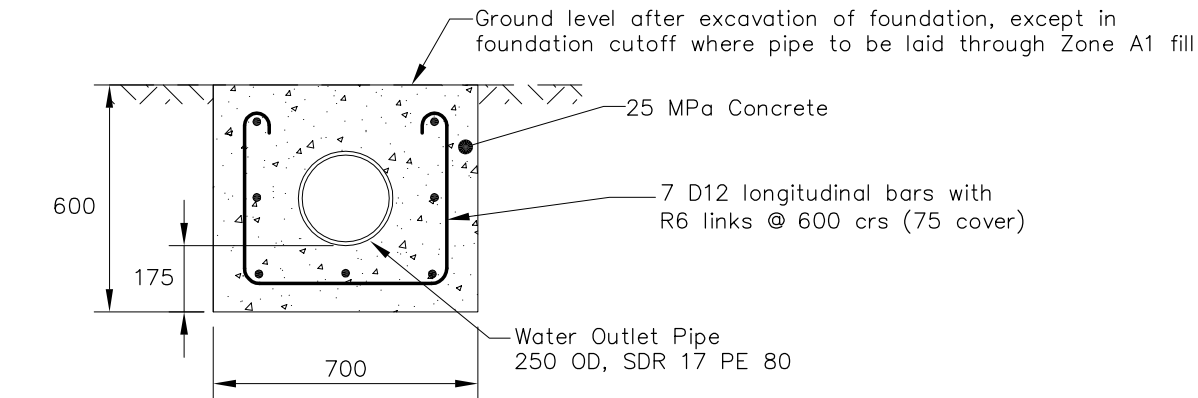


ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486–2546, Fax (09)486–2556

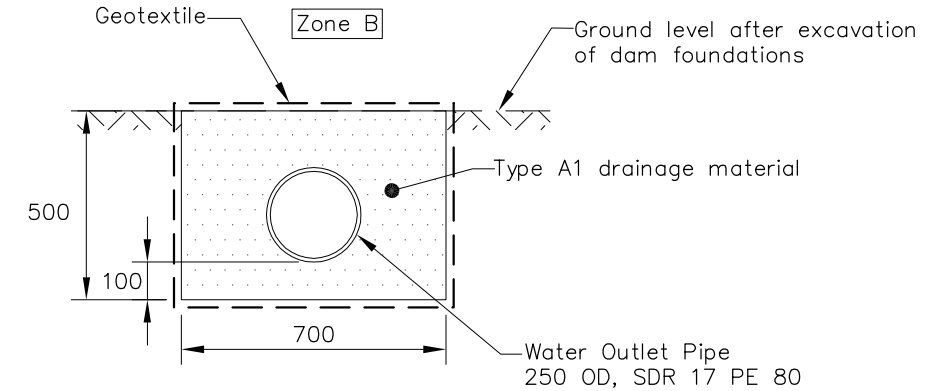
OCEANA GOLD (NZ) LTD, MACRAES GOLD PROJECT
Camp Creek Water Storage Dam
Section at Water Outlet Pipe

Drawing No. 6914–Fig 11
Date: 31 Mar 2011
Drawn: BL
Scale: 1: 500 (@A3)
Filename: 6914–Fig 11.dwg

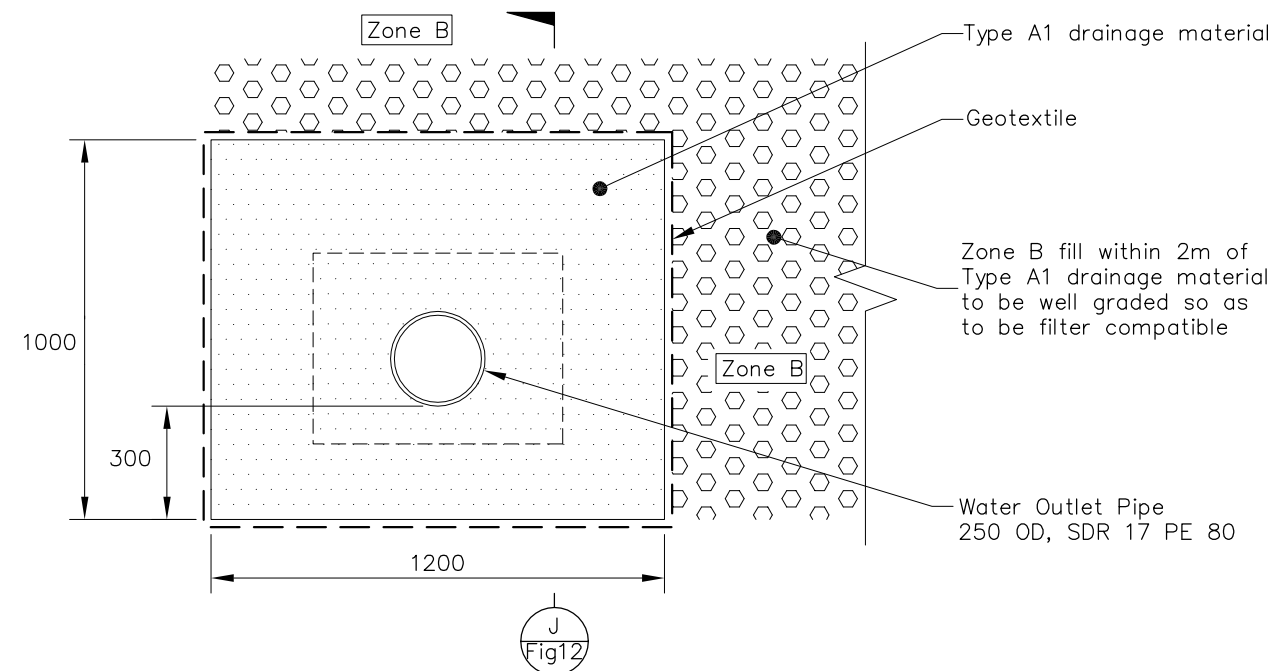


WATER OUTLET PIPE BENEATH AND THROUGH ZONE A1 (G Fig11)

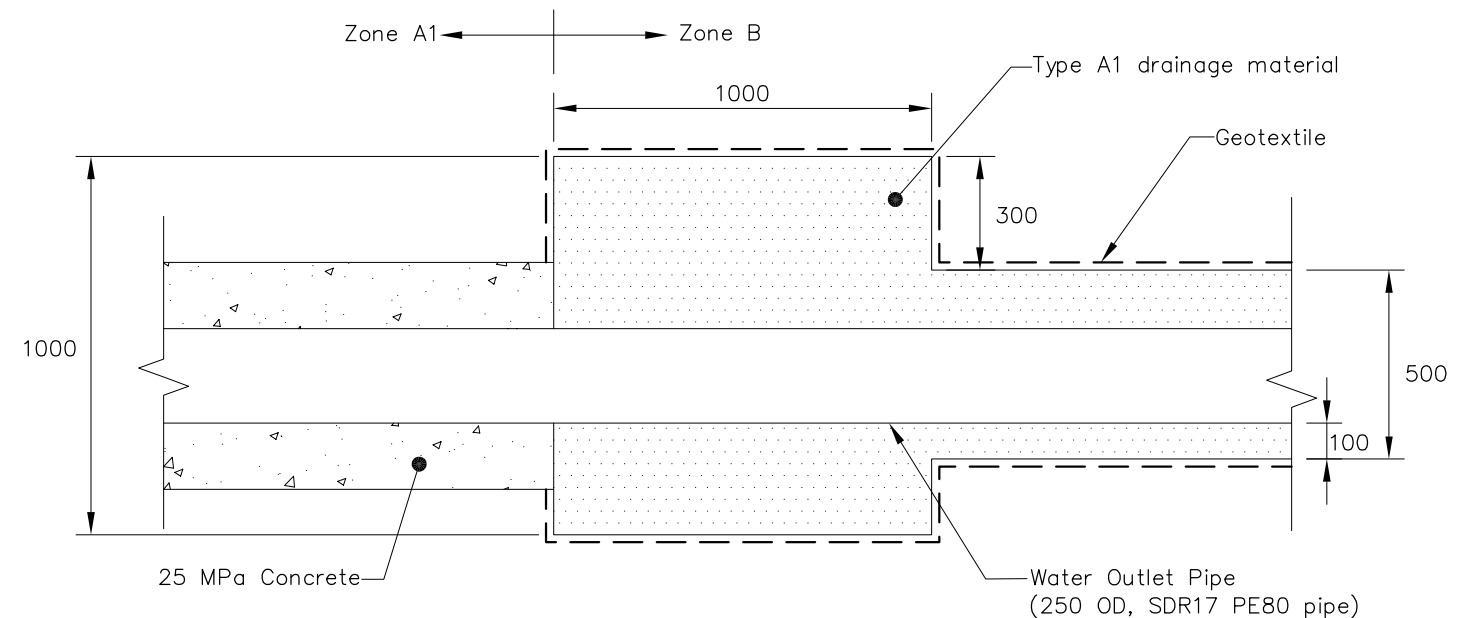
Note: Concrete shall have an expanding agent added to it (Denka CSA (No. 20) or equivalent). Immediately following placement of concrete the top of the concrete shall be covered with polythene and 1.5m of loose fill placed above. The loose fill shall be removed after 24 hours and the specified compacted fill place above after 5 days.



WATER OUTLET PIPE BENEATH ZONE B (I Fig11)

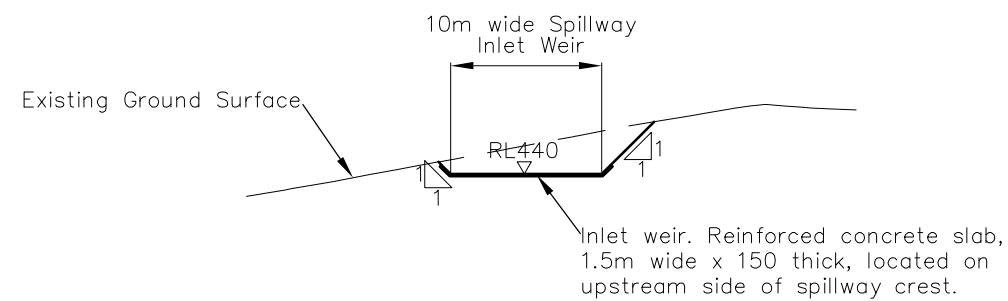


WATER OUTLET PIPE THROUGH FILTER/SEEPAGE INTERCEPTOR DRAIN (H Fig11)

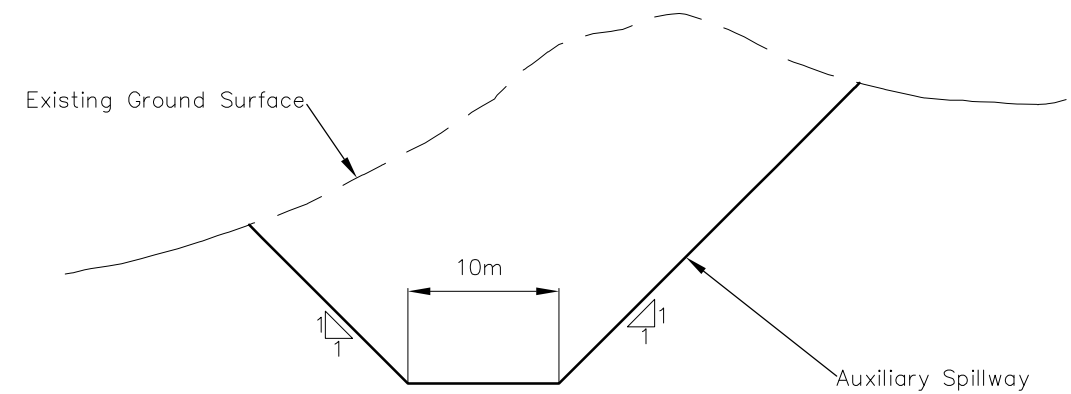


WATER OUTLET PIPE THROUGH FILTER/SEEPAGE INTERCEPTOR DRAIN (J Fig12)

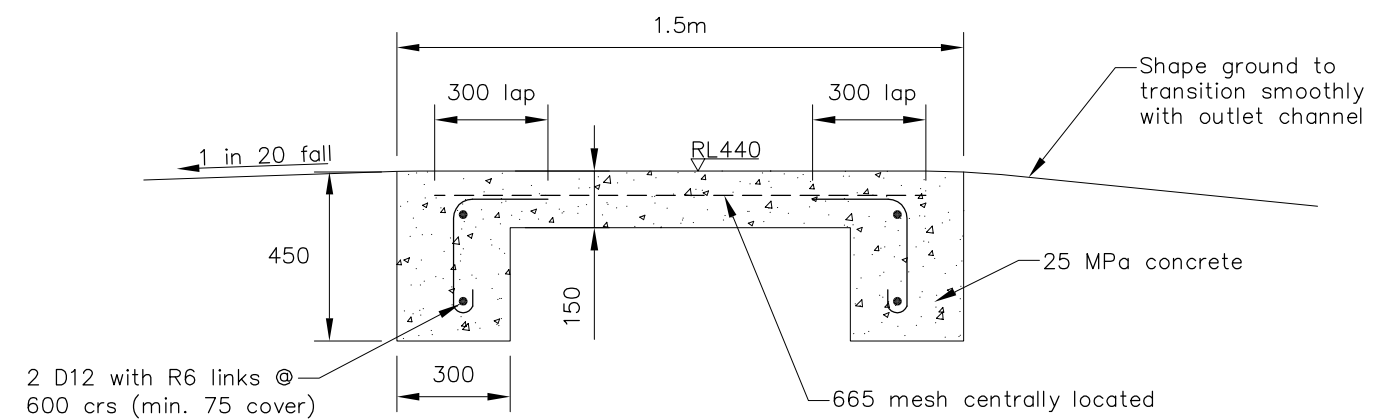
Figure 12



**AUXILIARY SPILLWAY CROSS – SECTION
AT INLET WEIR C – C'**
Scale 1:500 (@A3)

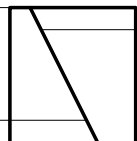


**AUXILIARY SPILLWAY CROSS – SECTION
AT CHANNEL D – D'**
Scale 1:500 (@A3)



AUXILIARY SPILLWAY – INLET WEIR DETAIL
Scale 1:20 (@A3)

Figure 14



ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD (NZ) LTD, MACRAES GOLD PROJECT
Camp Creek Water Storage Dam
Auxiliary Spillway Sections and Details

Drawing No. 6914-Fig 14
Date: 21 Jan 2011
Drawn: BL
Scale: As shown
Filename: 6914-Fig 14.dwg

APPENDIX A

SLOPE STABILITY ANALYSES

Table A1
Summary of Properties for Stability Analyses

Zone	Density (kN/m ³)	c' (kPa)	φ' (°)	Notes / Phreatic Surface
Zone A1 ⁽¹⁾	22.5	$\tau=2.43\sigma'^{0.83}$		Refer SLOPE/W figures
Zone B ⁽¹⁾	22.5	$\tau=2.43\sigma'^{0.83}$		Refer SLOPE/W figures
Schist (0 to 3m depth)	23.5	50	40	Refer SLOPE/W figures
Schist Bedrock	26	150	45	Failure through intact rock. Refer SLOPE/W figures for phreatic surface.
Schist (failure along foliation)	23.5	47	23	Refer Slope/W figures

⁽¹⁾ Strength function plotted below

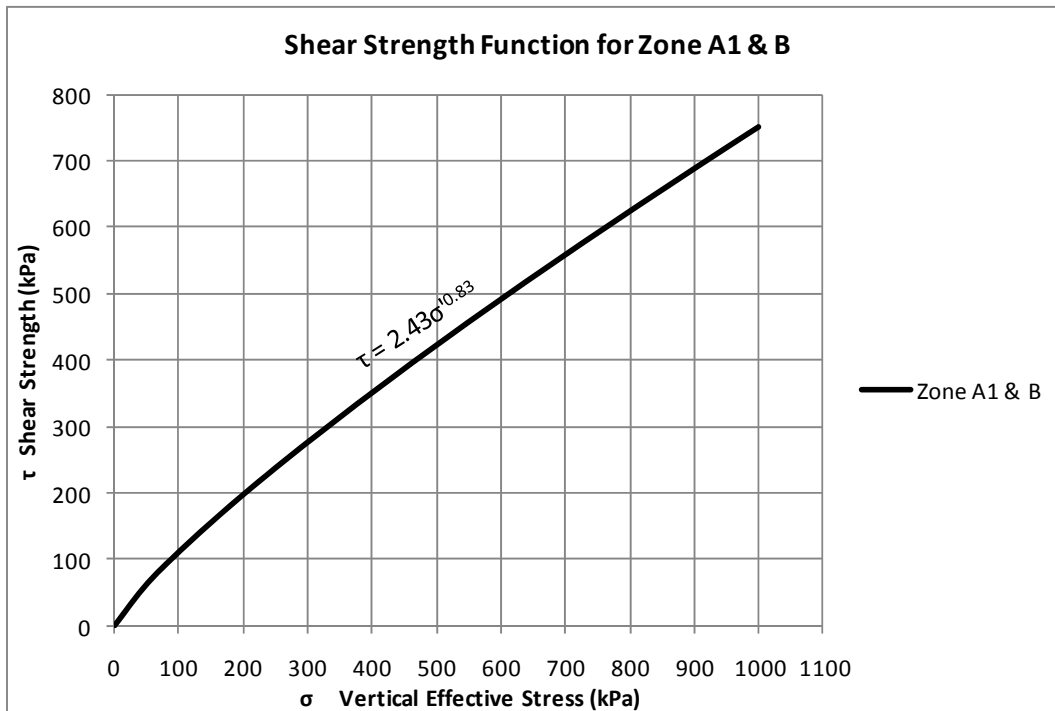


TABLE A2.
SUMMARY OF RESULTS FOR STATIC STABILITY ANALYSES

Figure No.	Circle Location	Loading	Factor of Safety	Notes
A2	DS	ESA	2.37	end of construction
A3	US	ESA	2.39	end of construction
A4	DS	ESA	2.36	operating conditions
A5	US	ESA	1.52	rapid drawdown
A12	US	ESA	1.77	rapid drawdown, failure along foliation

DS = downstream US = upstream ESA = Effective Stress Analysis

Note: Refer to Figures A1 to A12 for detailed results of stability the calculations

TABLE A3
SIMPLIFIED DEFORMATION ANALYSIS DURING EARTHQUAKE SHAKING
USING PSEUDOSTATIC STABILITY ANALYSES

Loading		kh (g) ⁽¹⁾	kc (g) ⁽²⁾	Predicted Permanent Deformation ⁽³⁾ (cm)		Depth of Failure Surface	Figure No.
Earthquake	Mw			u ₅₀	u ₅		
150 year		0.11	-	-	-	H	A6
150 year		0.15	-	-	-	$\frac{2}{3}H$	A7
150 year		0.26	-	-	-	$\frac{1}{3}H$	A8
MDE		0.55	0.46	0.0	0.29	H	A9
MDE	7.0	0.75	0.52	0.2	1.7	$\frac{2}{3}H$	A10
MDE		1.28	0.65	0.9	7.6	$\frac{1}{3}H$	A11

Note: Three cases considered for each loading. Failure through top 1/3 and 2/3 of embankment and failure full depth through embankment to determine most critical displacement.

- (1). kh (g) = average acceleration within the potential failure mass for various return period earthquakes
- (2). kc (g) = yield acceleration within the potential failure mass for a FOS = 1.0, determined using pseudostatic stability analyses.
- (3). Simplified permanent deformation determined using Jibson (2007). u₅₀ and u₅ are displacements with 50% and 5% probably of exceedance respectively.

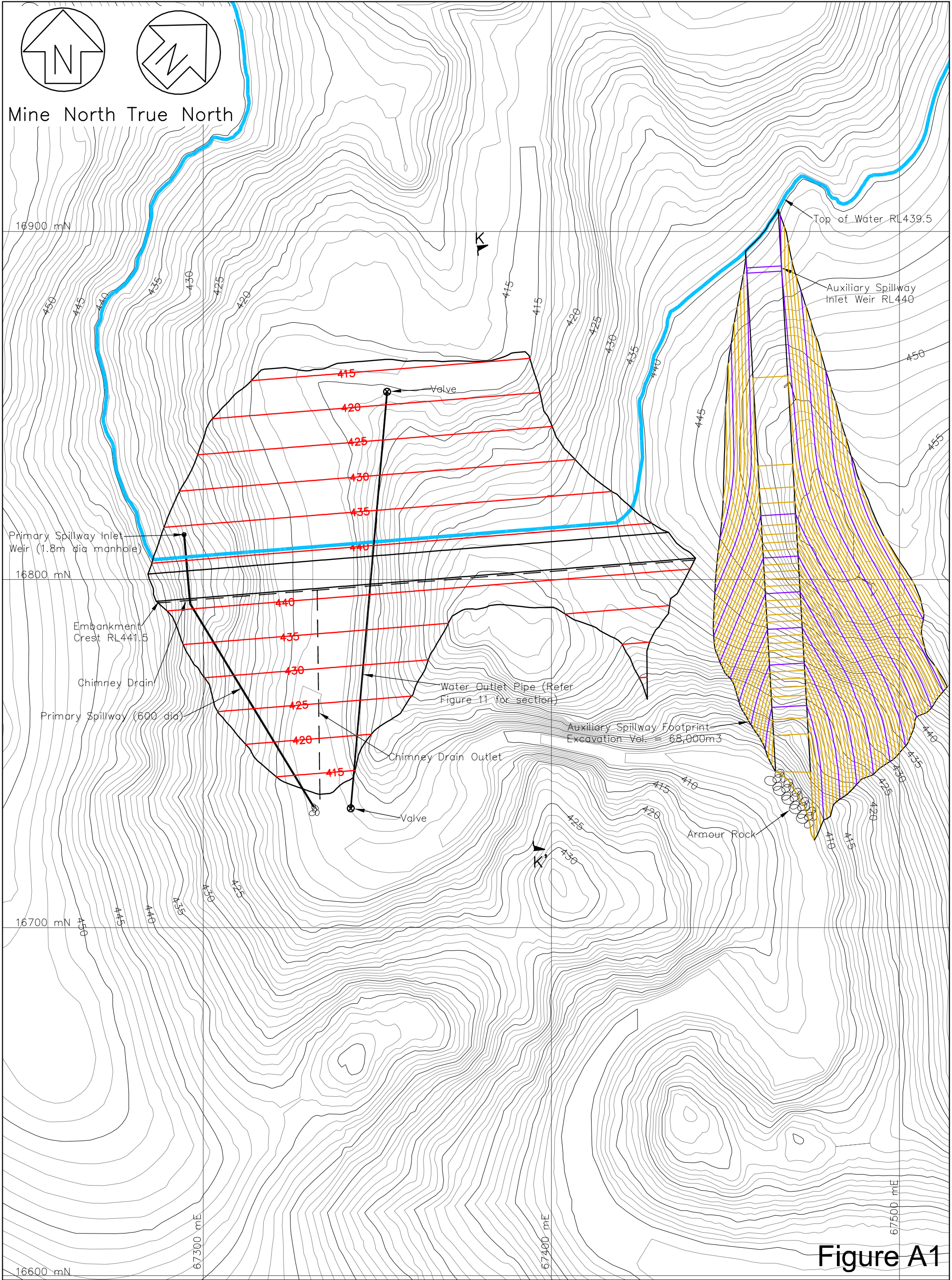
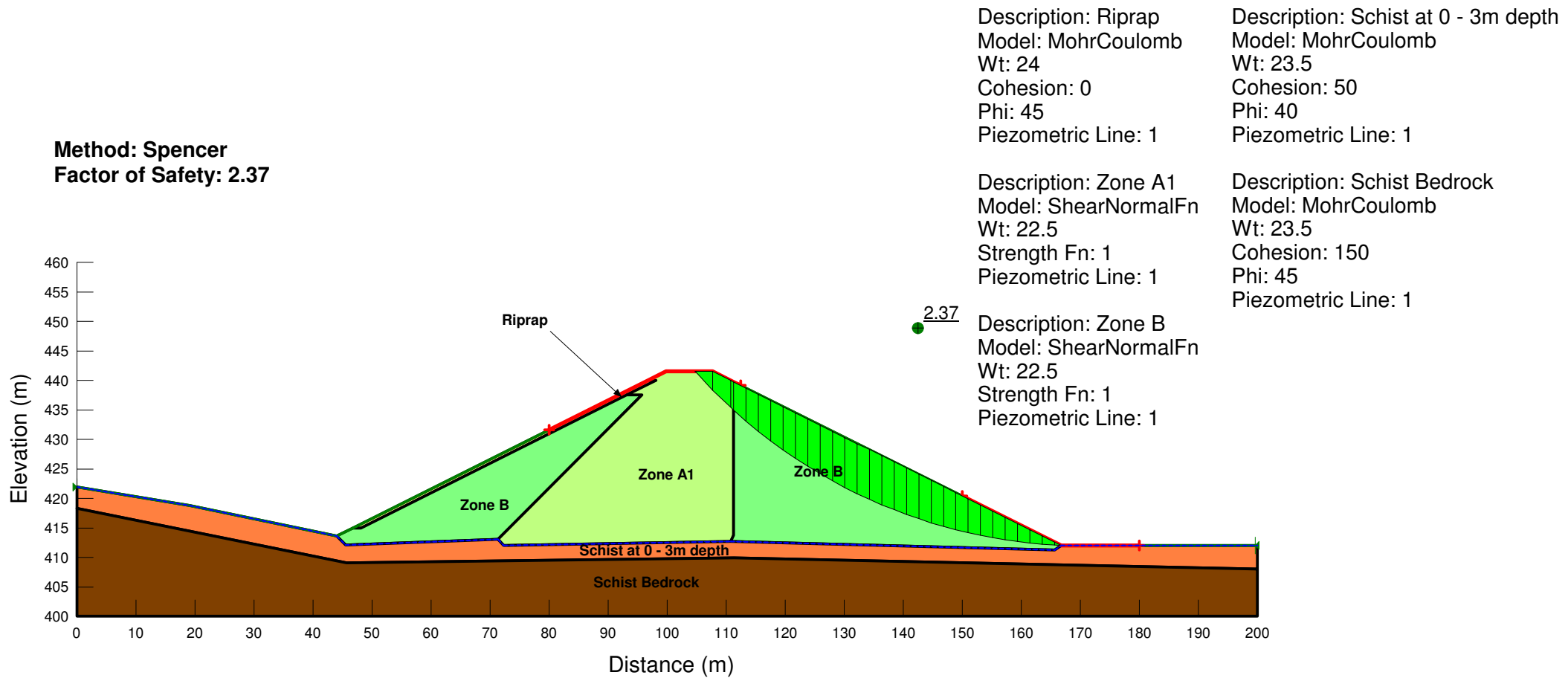
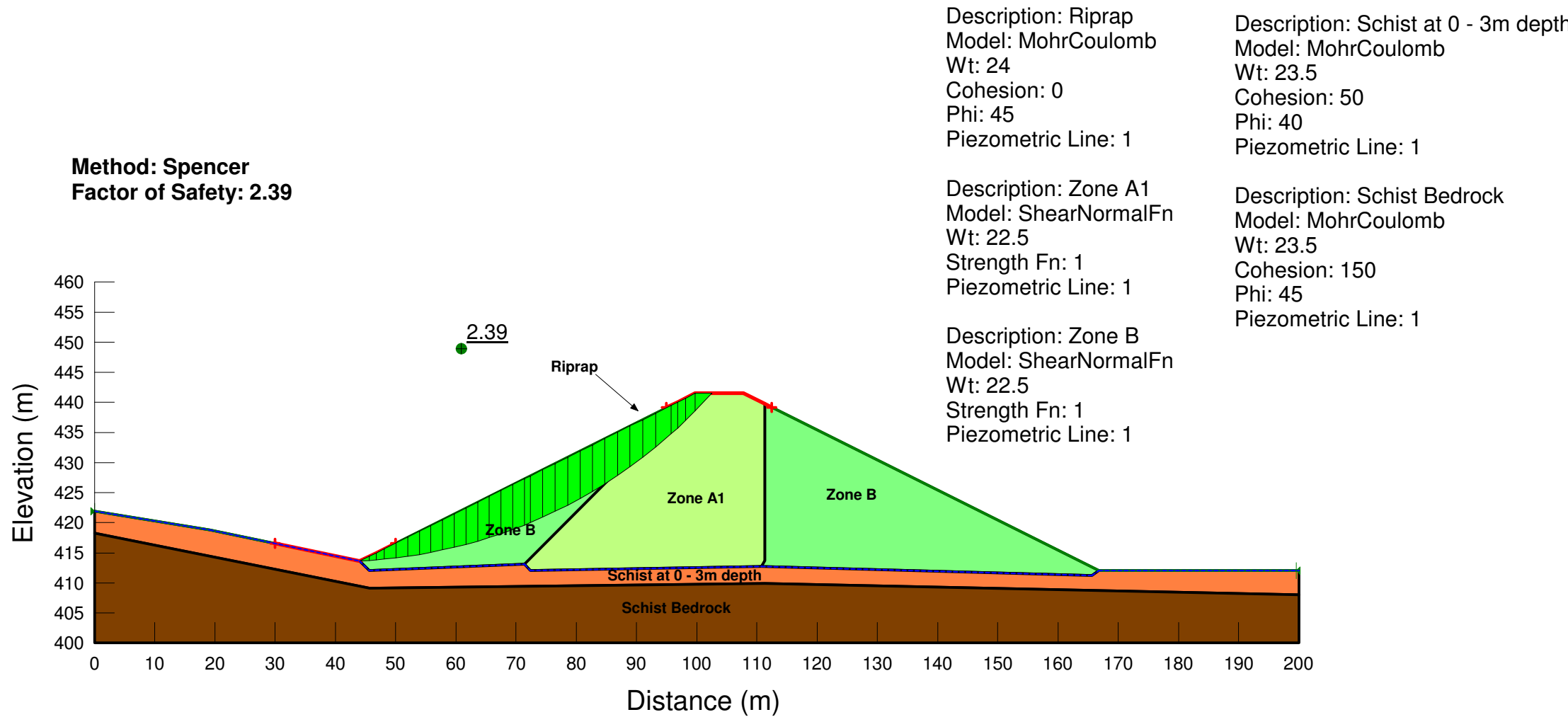


Figure A1



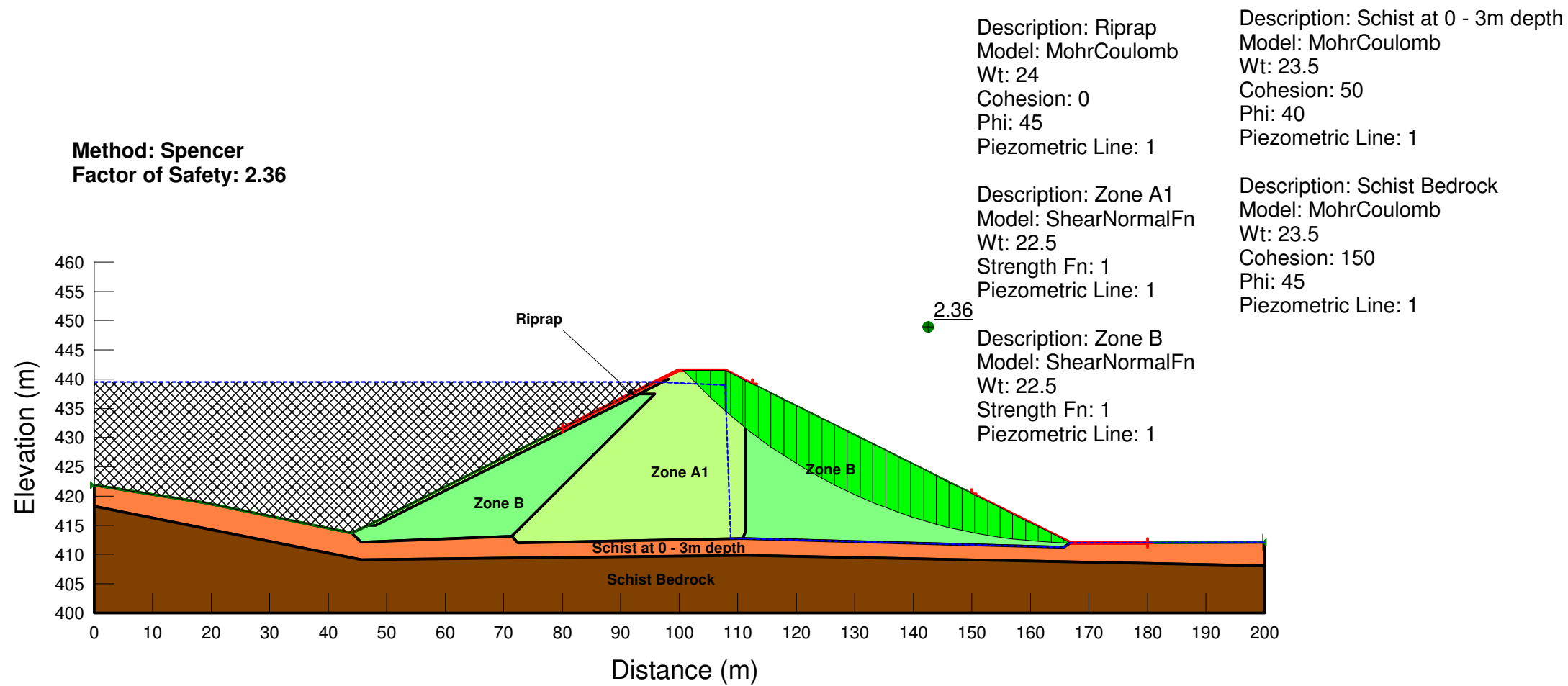
OGL - CAMP CREEK DAM
Static Analysis - Section A - A'
End of Construction - Downstream Shoulder

Figure A2



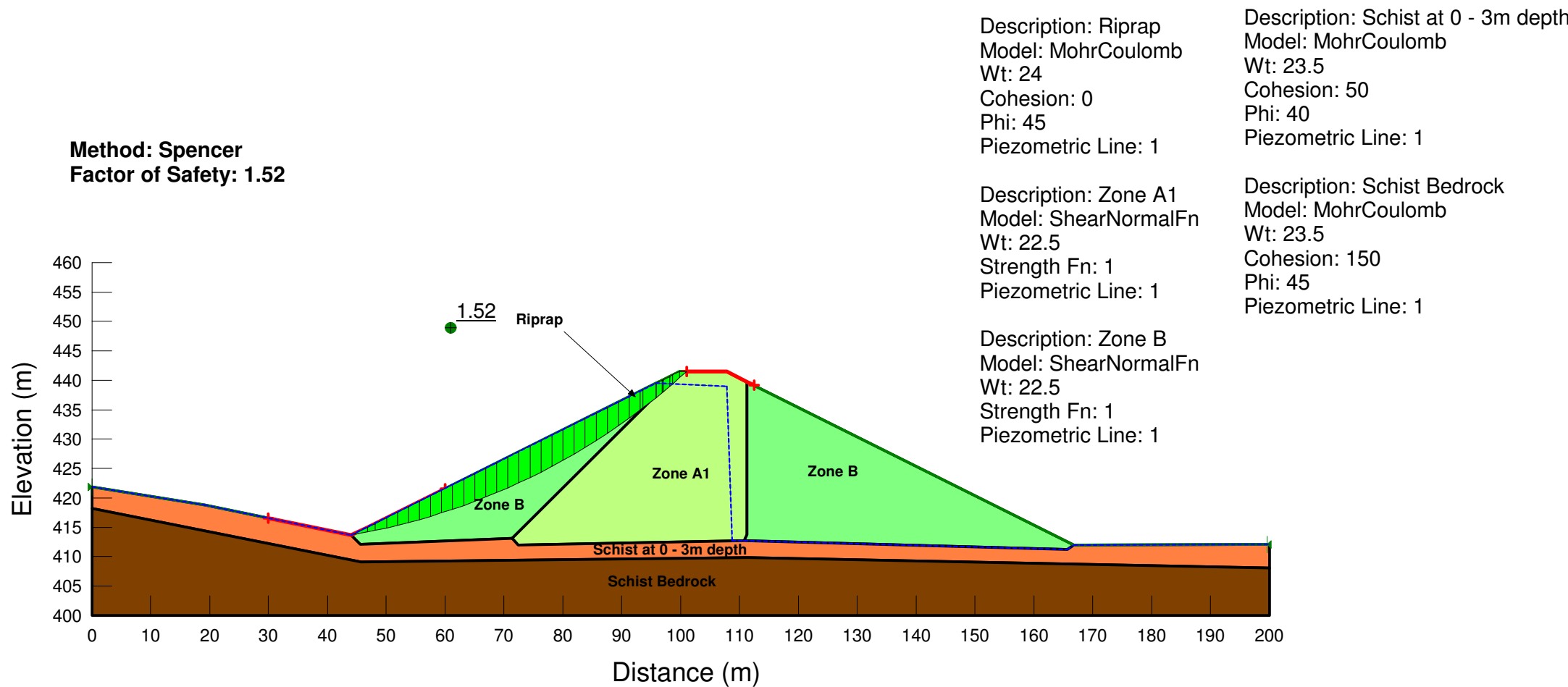
OGL - CAMP CREEK DAM
Static Analysis - Section A - A'
End of Construction - Upstream Shoulder

Figure A3



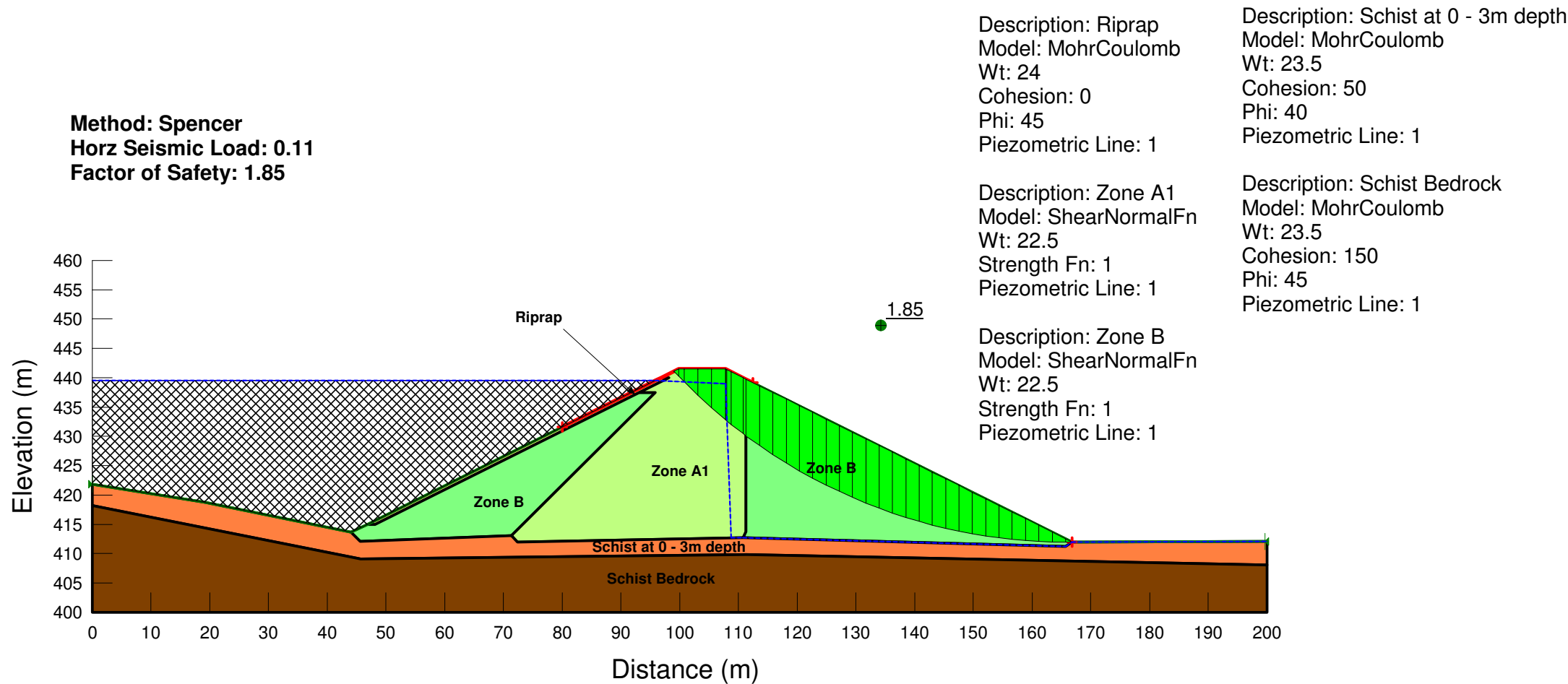
OGL - CAMP CREEK DAM
Static Analysis - Section A - A'
Long Term - Downstream Shoulder

Figure A4



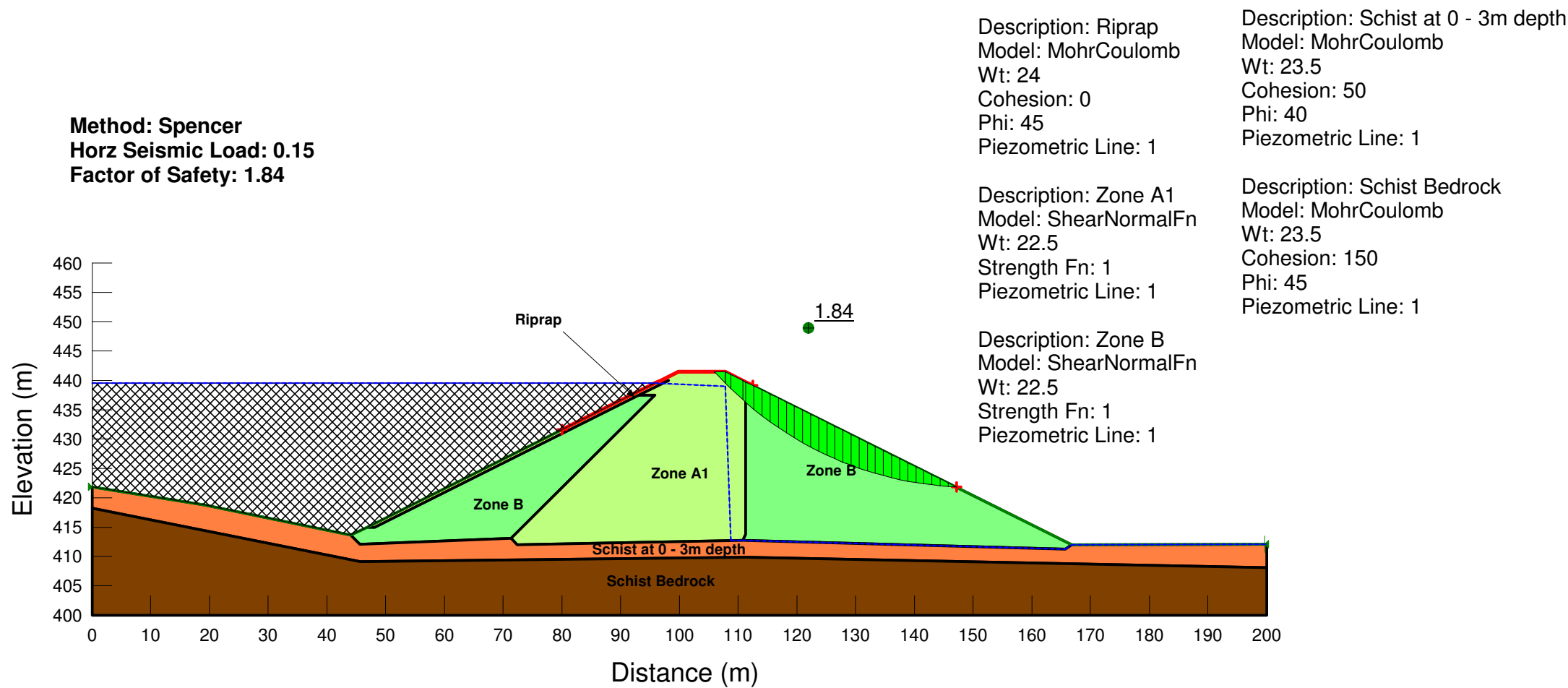
OGL - CAMP CREEK DAM
Static Analysis - Section A - A'
Rapid Drawdown - Upstream Shoulder

Figure A5



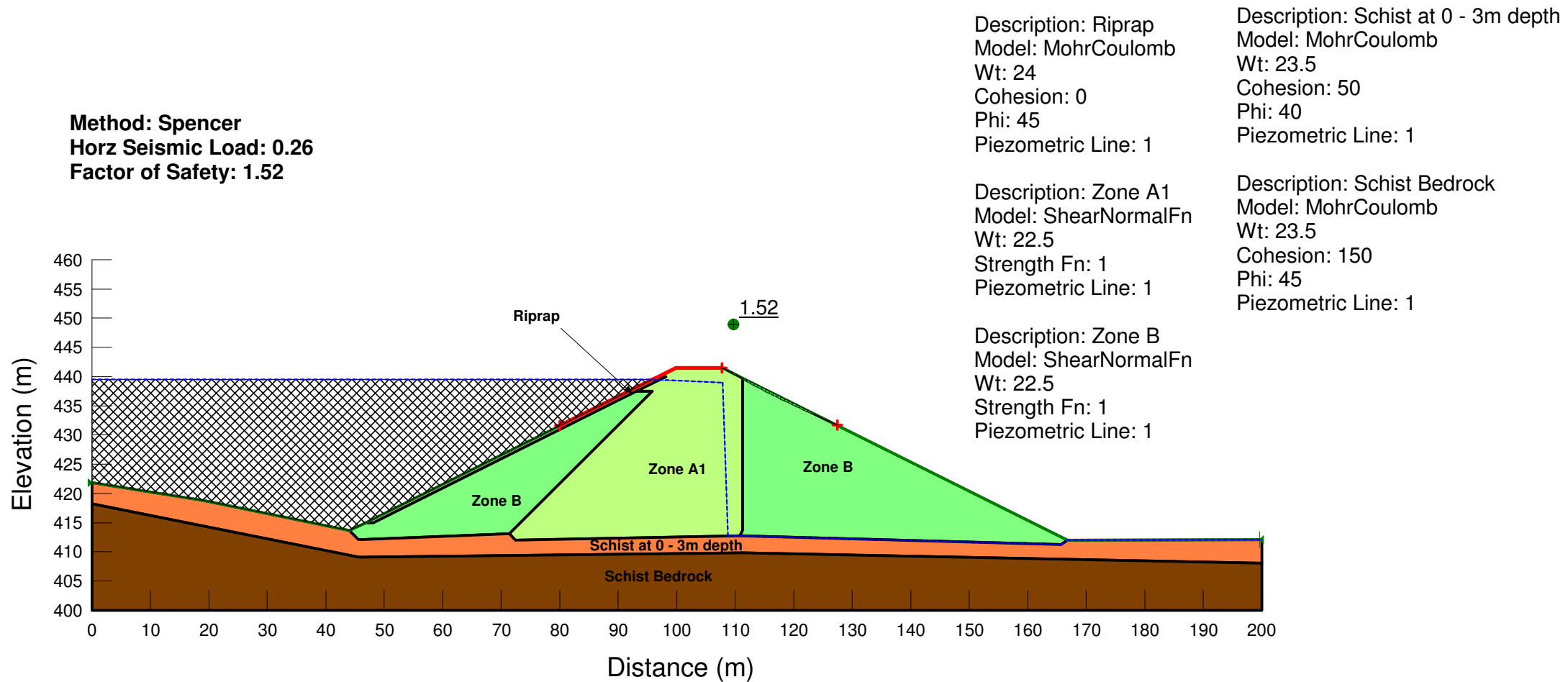
Oceana Gold Mine - Camp Creek Dam
Seismic Analysis - Section A - A'
OBE Downstream Shoulder Full Dam Height

Figure A6



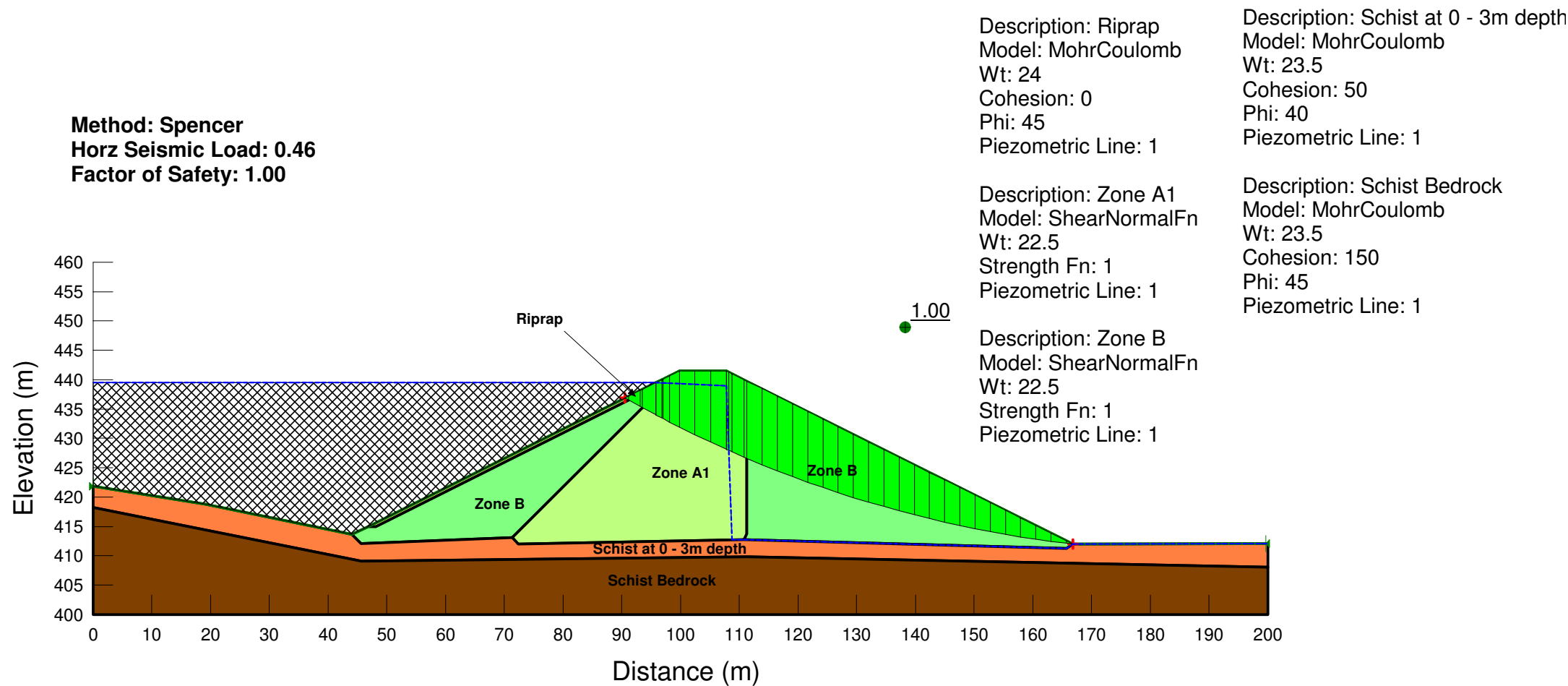
OGI - CAMP CREEK DAM
Seismic Analysis - Section A - A'
OBE - Downstream Shoulder
Two Thirds of Dam Height

Figure A7



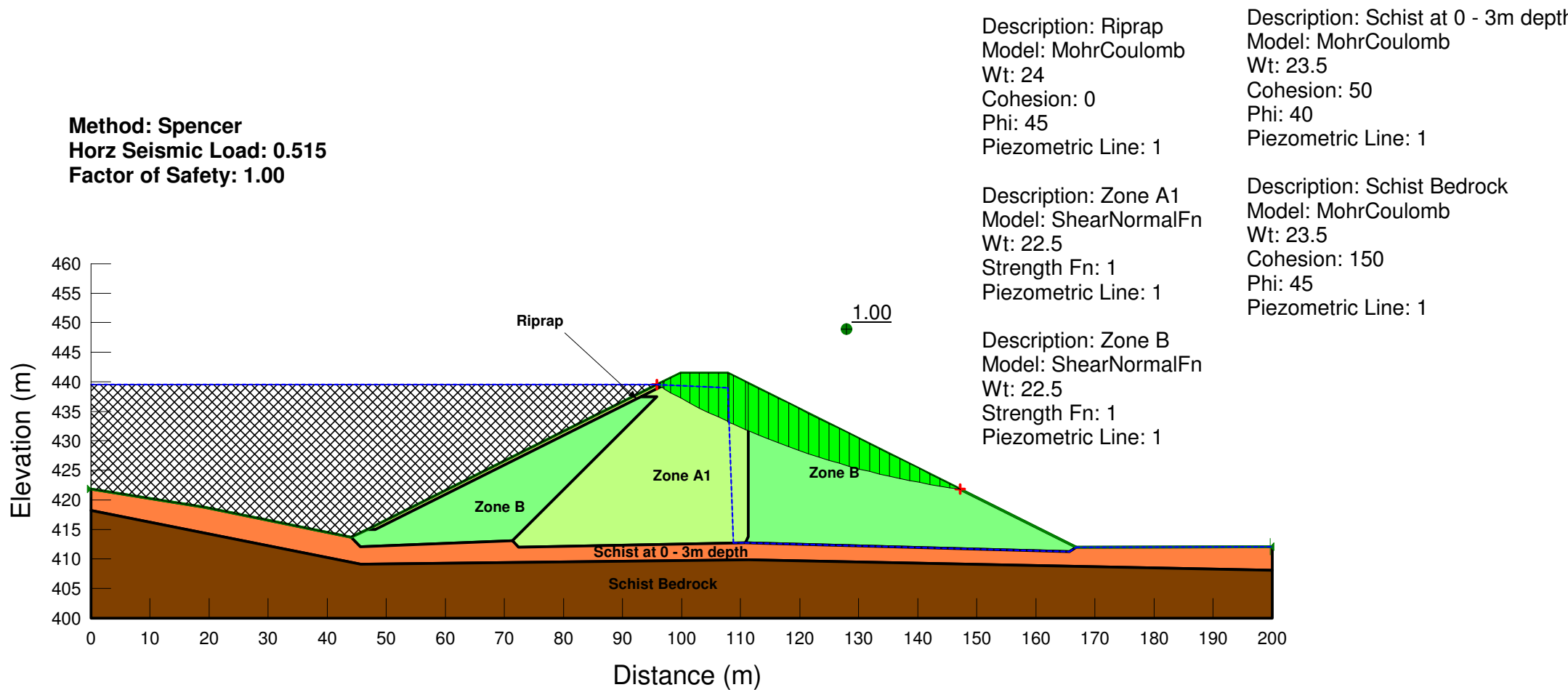
OGL - CAMP CREEK DAM
Seismic Analysis - Section A - A'
OBE - Downstream Shoulder
One Third of Dam Height

Figure A8



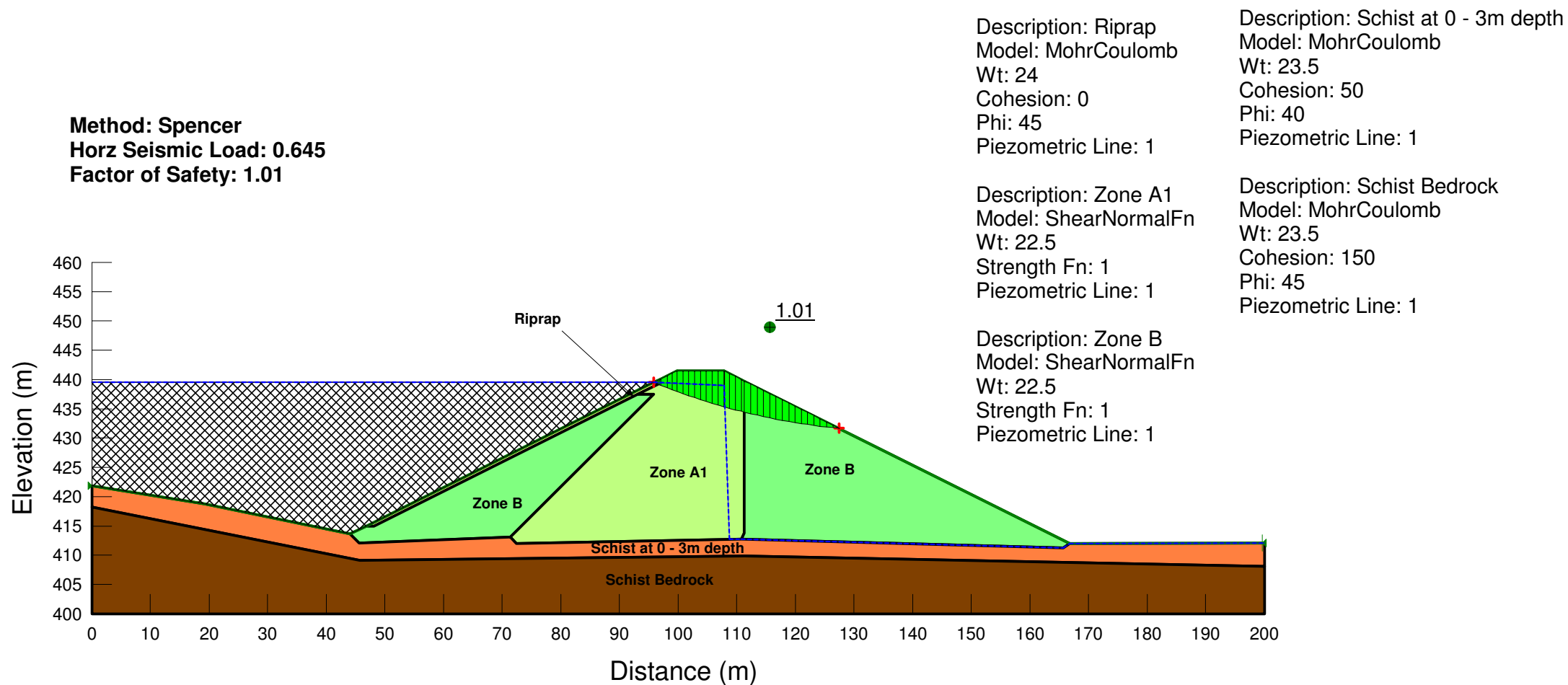
OGL - CAMP CREEK DAM
Seismic Analysis - Section A - A'
MDE - Downstream Shoulder
Full Dam Height - Yield Acceleration

Figure A9



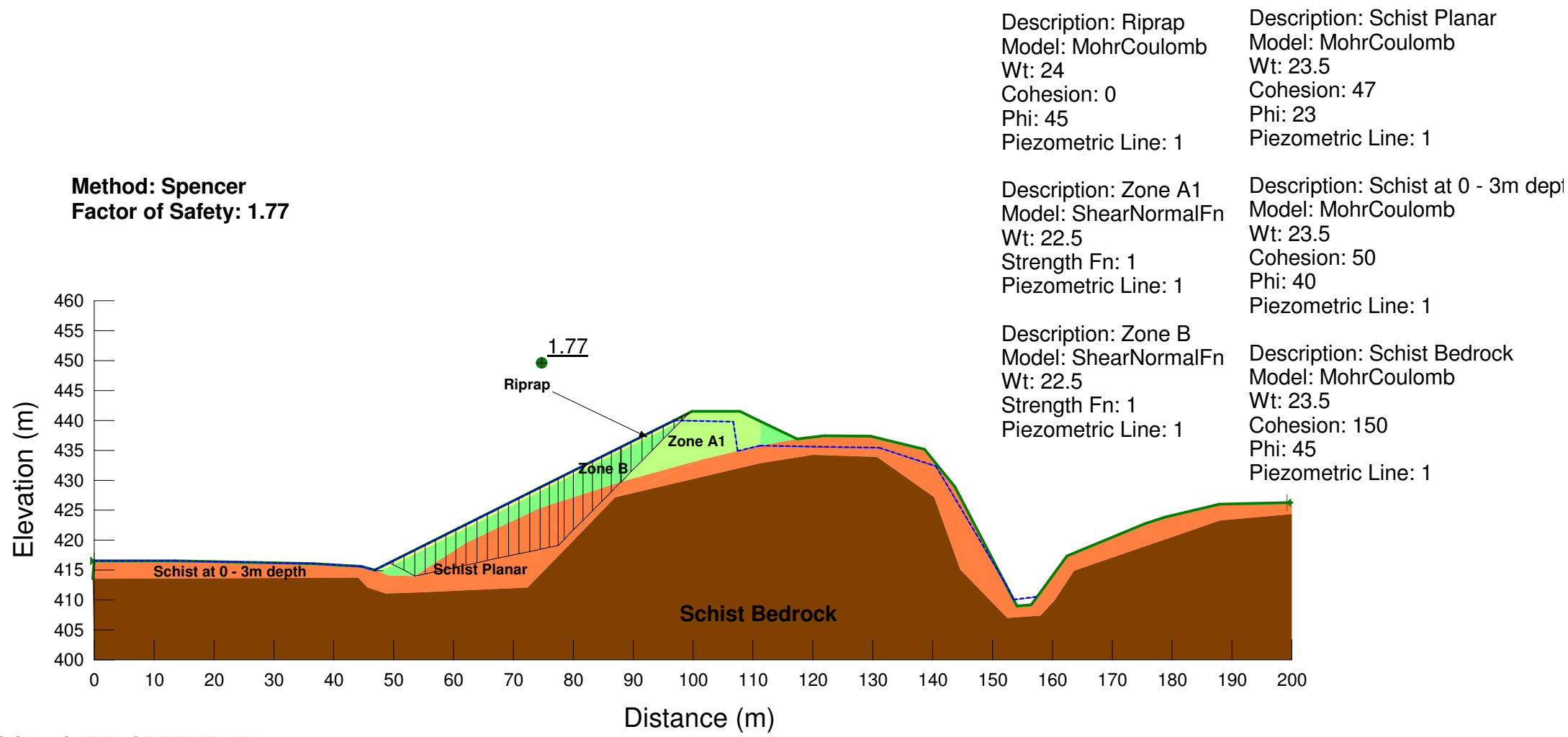
OGL - CAMP CREEK DAM
Seismic Analysis - Section A - A'
MDE - Downstream Shoulder
Two Thirds of Dam Height - Yield Acceleration

Figure A10



OGL - CAMP CREEK DAM
 Seismic Analysis - Section A - A'
 MDE - Downstream Shoulder
 One Third of Dam Height - Yield Acceleration

Figure A11



OGL - CAMP CREEK DAM
Static Analysis - Section K - K'
Rapid Drawdown - Upstream Shoulder
(Failure along Foliations)

Figure A12

Attachment C – Coal Creek Dam Design Report



**OCEANA GOLD (NEW ZEALAND) LTD
MACRAES GOLD PROJECT
CORONATION NORTH PROJECT
COAL CREEK FRESHWATER DAM
TECHNICAL REPORT**

Prepared for:

12 May 2016

Oceana Gold (NZ) Ltd
P O Box 5442
Dunedin
OTAGA



CONTENTS

	Page No.
1.0 INTRODUCTION	1
2.0 SITE GRID	1
3.0 SITE SETTING	2
3.1. General	2
3.2. Site Climate	2
4.0 GEOLOGY	2
4.1. Regional Geology	2
4.2. Site Geology	3
4.2.1. Soil	3
4.2.2. Schist	3
4.3. Groundwater Conditions	3
5.0 SUITABILITY OF SITE	4
6.0 SEISMIC HAZARD	4
7.0 IN-SITU ROCK AND EMBANKMENT FILL CHARACTERISTICS	4
7.1. In-situ Rock	4
7.2. Embankment Fill	4
8.0 DESIGN STANDARDS	5
8.1. Flood Design	5
8.2. Freeboard	5
8.3. Stability	5
9.0 GENERAL DESIGN FEATURES	6
9.1. General Description	6
9.2. Catchment Area	6
9.3. Water Storage Capacity	6
9.4. Spillway	6
10.0 DAM DESIGN	7
10.1. Embankment	7
10.2. Embankment Zoning	7
10.3. Riprap	7
10.4. Embankment Drainage	7
10.5. Spillway Design	8
10.6. Modelling of Spillway Performance	8
10.7. Water Discharge Outlet Pipe	9
10.8. Rehabilitation and Erosion Protection	9

10.9. Seepage Estimates	9
10.10. Embankment Settlement	9
11.0 OPERATION, MAINTENANCE AND SURVEILLANCE	9
12.0 CONSTRUCTION ASPECTS	10
12.1. Construction Volumes	10
12.2. Embankment Construction	10
12.3. Flood Diversion Arrangements	10
12.4. Foundation Preparation	10
12.5. Erosion and Sediment Control	11
12.6. Construction Control and Management	11

REFERENCES

FIGURES 1 TO 12



**OCEANA GOLD (NEW ZEALAND) LTD
MACRAES GOLD PROJECT
CORONATION NORTH PROJECT
COAL CREEK FRESHWATER DAM
TECHNICAL REPORT**

12 May 2016

1.0 INTRODUCTION

Oceana Gold (New Zealand) Limited (OceanaGold) propose to construct a freshwater storage dam in Coal Creek, north of the Macraes Gold Project, at Macraes Flat in East Otago (refer Figure 1). The dam is referred to as the Coal Creek Freshwater Dam and is located north west of the Coronation North Project as shown in Figure 2.

Golder Associates have carried out water management studies for the Coronation North Project and the Coal Creek Dam is a potential mitigation requirement of this work (Ref.1). Their water modelling studies show that the dam requires a storage volume of approximately 685,000m³.

Engineering Geology Ltd (EGL) has been contracted by OceanaGold to assess the feasibility of constructing the Coal Creek Freshwater Dam and prepare a technical report. This report describes the technical aspects of the proposed dam and is to support the application for Resource Consent. Detailed design will be carried out for Building Consent following Resource Consent approval and confirmation that the dam is required for the development of the Coronation North Project. The final design will be documented in a Design Report which will be used to support the application for a Building Consent.

The maximum height of the dam (crest to downstream toe) is about 27m with a reservoir area, ie at normal top water level, of about 9.3ha. The fill volume required for the embankment construction is about 30,000m³. No detailed hypothetical dam breach study has been carried out for the Coal Creek Freshwater Dam and preliminary review of the downstream catchment indicates that it will be either Low or Medium PIC. For this technical report a Medium PIC has conservatively been adopted. The detailed dam breach study will be carried out prior to the detailed design.

2.0 SITE GRID

All plan grids, references and geological orientations are to mine north which is approximately 45 degrees anti-clockwise from true north.



3.0 SITE SETTING

3.1. General

The location of the proposed Coal Creek Freshwater Dam is shown in Figures 2 and 3. It is to the north-west of the Coronation North Project and is located in Coal Creek, which flows into the Mare Burn, before flowing into the Taieri River about 7.5km downstream of the Coal Creek Freshwater Dam. The dam embankment spans north-east south-west across a narrow gully. The northern abutment is at about 1V:2.2H and the southern abutment about 1V:2.5H. The gully floor at the embankment site slopes downstream at about 1V:40H.

3.2. Site Climate

The mean annual rainfall for the site is about 650mm. From previous hydrological studies carried out at the Macraes Gold Project it is estimated that about 80% of the mean rainfall is lost from the area through evaporative process. These processes include evaporation from surface water features (e.g. streams and ponds) and the soil capillary fringe, as well as transpiration.

4.0 GEOLOGY

4.1. Regional Geology

The basement rock in Central and East Otago comprises Otago schist. The Otago schist is primarily composed of psammitic and pelitic grey schist derived from metamorphism of Mesozoic age sandstone and mudstone. In the area of Macraes Flat, the rocks have been metamorphosed to green schist metamorphic facies, giving a strongly foliated fabric of dark grey micaceous and light grey quartz-rich laminations.

From previous geotechnical investigations and mining operations on site it is apparent that the prominent geological structures at the Macraes Gold Project site include a well-developed schistosity with two dominant fault sets. West of the Footwall Fault that is associated with the Hyde – Macraes Shear Zone (HMSZ) the schistosity is folded and has a varying trend over the project area revealing a series of anticlines and synclines. Foliation dips either to the northwest, to the north or to the west and south west. East of the Footwall Fault the schistosity has more of an easterly trend. The Coal Creek Freshwater Dam is located east of the Footwall Fault.

The major set of faults has an eastern trend. They exhibit Miocene (recent tectonic) deformations and are related to the formation of the Alpine Fault. This deformation has faulted and folded the surface within Central and East Otago to produce the present-day basin and range topography. The major east trending fault closest to the proposed dam is the Taieri Ridge Fault that runs along the foothills to the east of the dam site.

4.2. Site Geology

A site walkover was conducted on 7th April 2016. The area of the dam is covered by topsoil with Schist rock exposures on the slopes of the gully. Site specific geotechnical investigation and geological mapping will be carried out for the detailed design.

4.2.1. Soil

Based on previous investigations for the Macraes Gold Project it is anticipated that the depth of soils will typically vary between 0.3m and 2.0m comprising top soil, loess, colluvium and residual soil. The loess generally comprises silt with some clay and occasionally minor amounts of fine sand and fine schist gravel. The colluvium soil generally comprises a mixture of silt and angular schist gravel and cobbles or gravelly silt with minor clay where the silt is derived from reworked loess. The gravel consists of highly weathered angular fine pebble sized clasts of schist.

4.2.2. Schist

The soils are directly underlain by schist comprising well foliated fine grained pelite to coarser grained psammite.

4.2.2.1. Weathering

The depth of weathering of schist rock is generally relatively shallow. Typically the depth of highly or moderately weathered schist (i.e. where weathering has not significantly affected the strength of the schist) is between 2 to 5m depth. Slightly weathered rock (having some discolouration, but not significant strength loss) is often encountered to 30m depth or more.

4.2.2.2. Strength

The unconfined compressive strength for the unweathered schist is generally between about 20MPa and 40MPa normal to the bedding. Schist typically has a lower unconfined compressive strength along the foliation, which reflects the layered nature of the rock and the presence of weak, mica-rich laminations.

4.3. Groundwater Conditions

No direct measurements of groundwater have been made at the proposed dam site. During the site walkover there was no evidence of seepage exiting the slopes and water was present sitting in the gully floor with a very marginal apparent flow. Downward seepage gradients are often apparent on ridges and upward seepage gradients in the valley floors.

Permeability tests have been undertaken at various other dam locations at the Macraes Gold Project. Typical values vary from between about 5×10^{-6} m/s to 5×10^{-9} m/s. These values are from packer tests which measure the permeability over a limited distance. The rock mass permeability is expected to be lower as defects within schist bedrock are generally not persistent.

5.0 SUITABILITY OF SITE

The geological conditions at the proposed dam site are expected to be similar to those elsewhere at the Macraes Gold Project where existing water retention dams, silt ponds and tailings storage facilities have been constructed and have performed successfully for a number of years. We would expect suitable materials for constructing low permeability fill to be obtained from locally derived weathered schist blended with loess and colluvial soils where necessary. As much fill as possible should be derived from within the spillway excavation and the reservoir area, as this will involve the least disturbance to adjacent ground and increase the water storage capacity. Rockfill for the shoulders of the dam and riprap can also be expected to be obtained locally, with most expected to be obtained from the auxiliary spillway excavation. Site specific geotechnical investigation and field mapping will be carried out for the detailed design.

It is noted that there are some features of historical interest on site and OceanaGold has included them in the archaeological investigations for the Coronation North Project.

6.0 SEISMIC HAZARD

In 2005 Geological and Nuclear Sciences (GNS) was engaged to undertake a seismic hazard study for the Macraes Gold Project site (Ref.3). The site is located in an area of relatively low historic seismic activity. However, there are some nearby faults that are capable of generating large earthquakes up to M_w 7. The recurrence intervals for these faults are not known with great accuracy. Recurrence intervals in the range of between about 3,000 and 25,000 years have been considered by GNS in the analyses for the Billy's Ridge and Taieri Ridge faults and between about 1,600 and 10,000 years for the Hyde Fault. The closest active fault to the site is the northern segment of the Taieri Ridge Fault, which is 11km east of the Coal Creek Freshwater Dam embankment.

7.0 IN-SITU ROCK AND EMBANKMENT FILL CHARACTERISTICS

7.1. In-situ Rock

The in-situ rock beneath the proposed Coal Creek Freshwater Dam is assumed to be similar to that used in the design of the water storage dams, silt ponds and tailings storage facilities at the Macraes Gold Project. The following shear strength parameters have been adopted for design.

Effective cohesion	= 50kPa
Effective friction angle	= 40 degrees

7.2. Embankment Fill

Existing tailings and water storage embankments at the site have been successfully constructed using rock from mine waste (varies from slightly to highly weathered schist) with local borrow material (primarily loess and colluvium consisting of loess and highly to completely weathered schist) blended with waste rock where necessary to produce low permeability Zone A1 fill. The Coal Creek Freshwater Dam will be constructed from similar materials borrowed locally rather than obtained from mine waste. However, we would expect the locally borrowed materials to have similar characteristics to the mine waste. A large amount of laboratory and field testing has

been undertaken on mine waste materials, both prior to construction commencing on site and during the operation of the mine. The design parameters have been established accordingly. These same parameters are to be adopted for detailed design for stability analyses of the Coal Creek Freshwater embankment and are summarised below. The shear strength functions for Zones A1 and B are presented below.

Zones A1 and B

Density	22.5 kN/m ³
Shear strength (τ)	$\tau = 2.43\sigma_v'^{0.83}$ where σ_v' is the effective vertical overburden pressure

8.0 DESIGN STANDARDS

The dam is to be designed in accordance with the New Zealand Society of Large Dams (NZSOLD) Dam Safety Guidelines (Ref.2). The design criteria are dependent on the potential impact classification (PIC). No detailed hypothetical dam breach study has been carried out for the Coal Creek Freshwater Dam and preliminary review of the downstream catchment indicates that it will be either Low or Medium PIC. For this technical report a Medium PIC has conservatively been adopted. The detailed dam breach study will be carried out prior to the detailed design.

8.1. Flood Design

For medium potential impact dams NZSOLD recommends the Inflow Design Flood (IDF) for sizing spillways be taken between 1 in 1,000 and 1 in 10,000 AEP. We have adopted a 1 in 5,000 AEP for design.

8.2. Freeboard

NZSOLD Guidelines recommend a minimum freeboard of 0.9m above the IDF which is the criteria adopted at this stage. The size of the spillways has been designed to meet these criteria. The freeboard takes into account wind set up and wave run up affects which will be considered for detailed design.

8.3. Stability

Embankment stability will be analysed during detailed design. The Criteria follows:

- For stability assessment under static (short term and long term) and rapid drawdown conditions the conventional factors of safety of $F \geq 1.5$ and $F \geq 1.2$ will be adopted respectively.
- To assess stability under earthquake loads NZSOLD recommends two performance criteria. The lower level known as the Operating Basis Earthquake (OBE) is based on a 150 year return period level shaking. Embankments should withstand this load with no significant damage (i.e. only minor, repairable damage permitted). The higher level known as the Safety Evaluation Earthquake (SEE) has been taken equal to the medium ground motion associated with a 2,500 year return period. This is recommended for a Medium PIC dam.

9.0 GENERAL DESIGN FEATURES

9.1. General Description

The dam will be designed in accordance with the New Zealand Society Dams (NZSOLD) Dam Safety Guidelines (Ref.2). A layout plan for the proposed dam, including the reservoir is shown in Figure 3. It is formed by an embankment on the north eastern side of the reservoir within a "V" shaped incised gulley. Important features of the proposed dam are summarised below:

Crest level	RL487
Maximum height of dam (crest to downstream toe)	27m
Embankment fill volume	30,000m ³
Normal top water level	RL484
Freeboard at normal top water level	3.0m
Storage at normal top water level	685,000m ³
Maximum depth of water in reservoir at normal top water level	21.5m
Reservoir area at normal top water level	9.3ha
Primary Spillway	Pipe, located on west abutment
Auxiliary Spillway (option A)	Open channel, North abutment Cut Volume 21,000m ³
Auxiliary Spillway (Option B)	Open channel, South abutment Cut Volume 60,000m ³

9.2. Catchment Area

The catchment area for the dam is approximately 650 hectares as shown in Figure 2.

9.3. Water Storage Capacity

The elevation-storage curve for the reservoir is presented in Figure 6. The storage capacity at normal operating level is 685,000m³. This storage volume includes no allowance for any possible excavation of borrow material from within the reservoir area which could increase the storage volume.

9.4. Spillway

The main objective of the design is to have an economical spillway with a capacity to safely discharge flood flows from a rare event (5000 year design rainfall). This is achieved by equipping the dam with a primary and auxiliary spillway. The primary spillway is located on the west abutment. Two options for the auxiliary spillway have been considered. Option 1 is on the northern abutment and Option 2 on the southern abutment, as shown in Figure 3. Flood routing has been undertaken to assess the performance of the spillways. This is described in detail in Section 10.6.

10.0 DAM DESIGN

10.1. Embankment

The embankment is zoned earthfill/rockfill with the crest at RL487 as shown in Figure 5. It comprises a 5m wide crest with upstream and downstream shoulder slopes of 1V:2H. The materials used to construct the embankment will be sourced mainly from the excavations from the spillway and supplemented by borrow material if deemed necessary. The volume of fill required for construction is approximately 30,000m³, excluding fill for the foundation excavation.

10.2. Embankment Zoning

Comments of the principal features of the embankment zoning shown in Figure 5 follow:

Zone A1

The primary function of this zone is to limit seepage. It will have a maximum specified permeability of 10⁻⁷m/s. It also provides sufficient strength to prevent the likelihood of instability, particularly when subject to the design seismic loads. The low permeability Zone A1 is intended to be formed from locally borrowed weathered schist, supplemented with loess and colluvium where necessary. Zone A1 will require appropriate blending of materials, conditioning and heavy compaction to achieve the specified permeability (10⁻⁷ m/s).

Zone B

Zone B is a structural rockfill zone forming the upstream and downstream shoulders of the embankment. It will be placed in 0.6m lift heights and subjected to compaction. Zone B fill will be borrowed locally, with most expected to be sourced from the excavation required to form the auxiliary spillway.

Chimney Drain

A 1.0m wide vertical chimney drain is provided, located near the downstream side of Zone A1. It performs two important functions. It functions to intercept seepage so as to limit the development of pore pressures in the downstream shoulder of the embankment. It is also designed to function as a filter to prevent internal erosion and loss of Zone A1 material into Zone B. The top of the chimney drain corresponds to the invert level of the primary spillway (RL484). The chimney drain will be constructed from Type A1 drainage material. It is filter compatible with Zone A1.

10.3. Riprap

Selected durable rock (psammitic schist) will be placed on the upstream shoulder to ensure that wave action will not result in erosion of the upstream shoulder.

10.4. Embankment Drainage

The embankment includes a chimney drain to intercept seepage and to act as a filter to prevent internal erosion (refer Figure 5). Seepage into the chimney drain will move vertically to the chimney drain base collector. The chimney drain base collector consists of Type B drainage material (refer Figure 8). This is free draining

gravel with specific limits on particle size. A perforated pipe is incorporated in the base collector drain. The outlet from the chimney drain is located beneath the downstream shoulder of the dam.

10.5. Spillway Design

Modelling has been undertaken to optimise the design of the spillways and to ensure their performance will meet design objectives.

The primary spillway is located on the west abutment and consists of a 1500mm diameter manhole entry structure with a 710mm diameter polyethylene outlet pipe (710OD, SDR26, PE100) as shown in Figures 3, 4, 7, 10 and 11.

The auxiliary spillway has been sized to safely discharge a 1 in 5,000 event rainfall with a freeboard of 1m (refer Figures 4 and 5). The spillway consists of an open channel excavated into rock with a 20m base width at the inlet control weir. Two spillway options have been considered, including Option 1 which is located on the northern abutment and Option 2 which is situated on the southern abutment, as shown in Figure 3. The spillway size will be finalised during the detailed design in accordance with the detailed dam breach analyses.

10.6. Modelling of Spillway Performance

The elevation-storage curve for the proposed impoundment is shown on Figure 6. Storage effects and the discharge capacity of the outlet works can attenuate the inflow to the reservoir so that the outflow discharge is reduced. Rainfall intensities up to 100 year events at Longdale Road, Macraes Flat were obtained from the NIWA High Intensity Rainfall System (HIRDS v3).

Estimates of the 1 in 5,000 AEP rainfall event have been derived using Gumbel's extreme value distribution theory. Flood routing through the reservoir for the 1 in 5,000 AEP design rainfall event to determine spillway performance and peak water elevations has been modelled with the program HEC-HMS (Hydrologic Modelling System from the Hydrologic Engineering Centre) (Ref.4).

There is no defined temporal rainfall pattern for this area. The design rainfall has been based on a 72 hour design rainfall event with critical rainfall intensities for all durations between 10 minutes and 72 hours included. This assumption is conservative.

The overall catchment area of the reservoir system is 650 ha. It was assumed that at the beginning of the design rainfall event the water level is at the maximum normal operating level, i.e. RL484. The reservoir level will rise under flood conditions and water will flow down the primary pipe spillway and the auxiliary spillway channel. The results of flood routing are shown in Figure 12. The peak inflow for the 1 in 5,000 AEP IDF into the reservoir is estimated to be approximately 66m³/s. The peak outflow over the auxiliary spillway is estimated to be 55m³/s. The reservoir water level rises to a maximum level of RL 486. This occurs about 37 hours after the start of the IDF. The primary spillway will operate the entire duration of the storm whereas the auxiliary spillway will be engaged for about 12 hours. The minimum freeboard is 1.0m ignoring any wind and wave run up effects and long term embankment settlement.

10.7. Water Discharge Outlet Pipe

Water is to be constantly discharged from the dam at a rate of about 5l/s to augment the downstream flow in Coal Creek. The discharge will be via a pipe laid beneath the embankment as shown on the plan in Figures 3, 4 and 7 and 9. The pipe is 250OD, SDR17, PE100 and located in the northern side of Coal Creek.

10.8. Rehabilitation and Erosion Protection

Riprap comprising 100 to 400mm size durable rock (psammitic schist) is to be placed 0.5m thick on the upstream shoulder of the dam. Topsoil and grass is to be placed on the downstream shoulder of the embankment.

10.9. Seepage Estimates

No seepage estimates from the proposed dam have been made. Estimates will be made during the detailed design stage. Seepage should be less than 2 litres/second based on the performance of other existing water storage dams at the Macraes Gold Project.

10.10. Embankment Settlement

Settlements, following construction of the dam, are expected to be small given the nature of the foundations and the proposed fill. This is supported by the performance to date of existing embankments at the Macraes Gold Project where observed settlements are small.

11.0 OPERATION, MAINTENANCE AND SURVEILLANCE

An Operation, Maintenance and Surveillance Manual will be prepared that sets out the operational and maintenance requirements necessary to ensure the ongoing safety of the dam. Monitoring and inspections are a fundamental part of the dam safety process. These range from routine regular inspections to more comprehensive reviews at longer periods. Specific requirements in accordance with NZSOLD Dam Safety Guidelines (Ref.2) will be prepared for the dam.

Operation of the dam will be under the control of OceanaGold.

Operational activities include clearing debris that may accumulate around spillway inlets and channel, clearing any rockfalls within the auxiliary spillway and ensuring unobstructed discharge of the seepage drains and outlet water pipe

Maintenance activities include repairing any erosion around the perimeter of the reservoir, maintaining riprap on the upstream shoulder, removing weeds or trees from the upstream and downstream shoulders or crest of the dam, maintaining the grass cover on the downstream shoulder and dam crest and maintenance of the outlet valve.

To ensure the safety of the dam regular inspections are to be undertaken. Standard forms will be provided for this purpose. More detailed inspections will be required on first filling. Thereafter inspections will be undertaken on a monthly basis and during periods of heavy rain.

12.0 CONSTRUCTION ASPECTS

12.1. Construction Volumes

The estimated construction volumes for the Coal Creek Freshwater Dam embankment are summarised below.

Zone A1	13,000m ³
Zone B	30,000m ³
Chimney Drain	1,600m ³
Riprap	1,600m ³
Total	46,200m ³

Note that the above fill quantities include for an average of 2m depth of foundation excavation below the existing ground level.

12.2. Embankment Construction

Embankment construction would be undertaken either by a Contractor employed by OceanaGold or with OceanaGold's own equipment. Material to construct the embankment will be borrowed locally.

Materials for Zones A1 and B are placed in thin layers (350mm for Zone A1 and 600 mm for Zone B) and compacted to achieve the specified gradation, density and permeability requirements. Zone A1 may need to be blended and conditioned prior to compaction to achieve the specified gradation and permeability.

Compaction of Zone A1 can be achieved using sheepsfoot or vibrating pad foot rollers. Zone B is compacted by loaded truck movements and vibrating drum roller.

12.3. Flood Diversion Arrangements

A temporary cofferdam and bypass pipe, supplemented by pumping if required, will initially be used to bypass flows during foundation excavation. The water discharge pipe will then be constructed and base flows in Coal Creek diverted through it during construction of the dam. In the event of larger floods, water will be channelled across the top of the embankment fill, against the abutment on the southern side of Coal Creek, and discharged over insitu rock back into the creek. Construction of the dam will be undertaken over summer and is expected to take approximately 3 to 6 months, allowing for a favourable weather window. The period of risk is relatively short.

12.4. Foundation Preparation

The foundations for the dam will be situated on natural ground. Foundation preparation of the natural ground beneath the embankment will consist of stripping vegetation and excavating loess, colluvium and alluvium and shaping of the schist bedrock to achieve an acceptable geometry prior to placement of fill.

Foundation surfaces below Zone A1 will need to be cleaned off with compressed air to enable observation of defects and assessment of the need for any special treatment such as slush or pressure grouting or the installation of additional subsoil drainage.

Experience to date with the schist bedrock and insitu permeability testing elsewhere at the Macraes Gold Project indicates that it has a relatively low permeability. Generally slush grouting has been necessary to infill any small fractures apparent following foundation excavation with low pressure grouting used to infill open defects in the schist rock.

Any irregularities in the excavated foundation surface that cannot be removed by excavation will be treated with dental concrete.

12.5. Erosion and Sediment Control

Good earthworks practices will be required to reduce the quantity of silt laden runoff. This includes:

- construction of temporary sediment retention facilities immediately downstream of the works
- clean water diversion drains around borrow areas
- silt ponds or decanting earth bunds and other sediment control devices at borrow areas (e.g. silt fences, lined channels from silt ponds to natural water courses)
- minimising areas of loose, uncompacted material
- providing a reasonable buffer distance between borrow areas and Coal Creek
- Providing a culvert to divert flows from Coal Creek below the embankment during construction

A site specific erosion and sediment control plan will be prepared at the final design stage which will detail specific requirements for construction.

Experience to date at the Macraes Gold Project indicates that only small quantities of silt laden runoff are generated because most of the fill is rockfill and runoff percolates down through the downstream rockfill shoulder. This acts as a filter to remove silt.

12.6. Construction Control and Management

Construction of the embankment will be under the direct supervision of staff from OceanaGold. A number of staff, assisted by surveyors and the designer as necessary, will be dedicated to this task drawing from their experience gained during the construction of the existing facilities at the Macraes Gold Project including ongoing raising of TSF's. They assist the Contractor in planning construction activities and observe all construction activities. In addition, they undertake control testing of fill placed in the embankment as detailed in the Contract Specification and undertake regular visual inspections as part of the surveillance requirements.

ENGINEERING GEOLOGY LTD

Report Prepared by

A handwritten signature in black ink, appearing to be 'J Wu', written in a cursive style.

J Wu (Geotechnical Engineer)

A handwritten signature in blue ink, appearing to be 'R Amigh', written in a cursive style.

R Amigh (CPEng)

Reviewed by

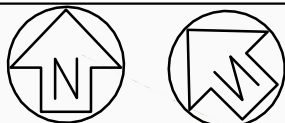
A handwritten signature in black ink, appearing to be 'J A Yeats', written in a cursive style.

J A Yeats (CPEng)

REFERENCES

1. Golder Associates (2015) 'Coronation North Project, Water Quality Mitigation - Fresh Water Dam Scenario, DRAFT'.
2. New Zealand Society on Large Dams. (2015) 'New Zealand Dam Safety Guidelines'.
3. Litchfield, N., McVerry, G.H., Smith, W., Berryman, K.R. and Stirling, M. (2005) 'Seismic Hazard Study for Tailings Embankments at Macraes Gold Project' GNS Client Report 2005/135'.
4. Hydrologic Engineering Center (2010) 'Hydrologic Modeling System HEC-HMS, User's Manual' version 3.5, August 2010. US Army Corps of Engineers, Institute for Water Resource, Hydrologic Engineering Centre.

FIGURES



True North Mine North

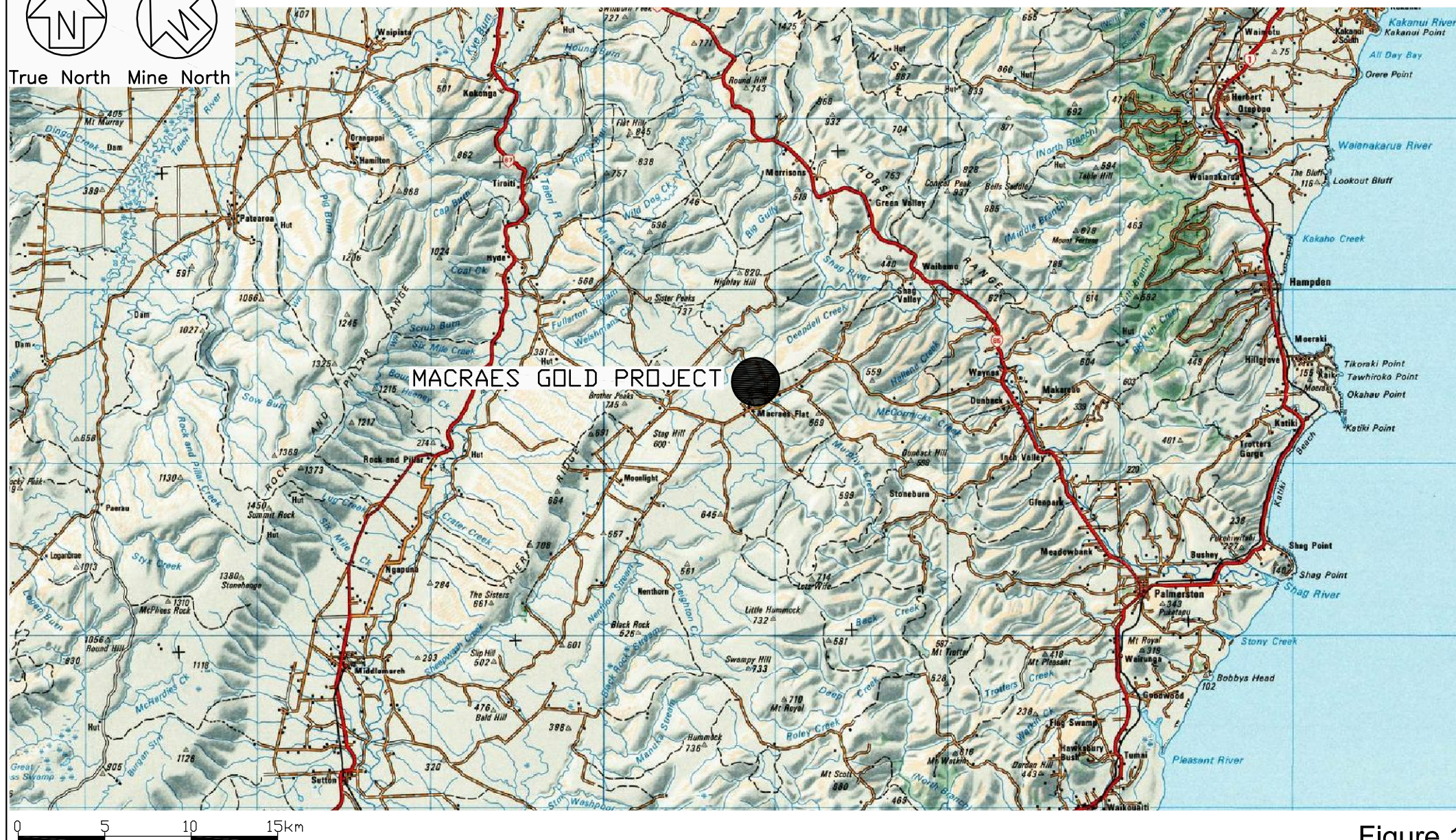
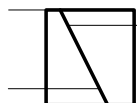


Figure 1



ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD
MACRAES GOLD PROJECT
Locality Plan

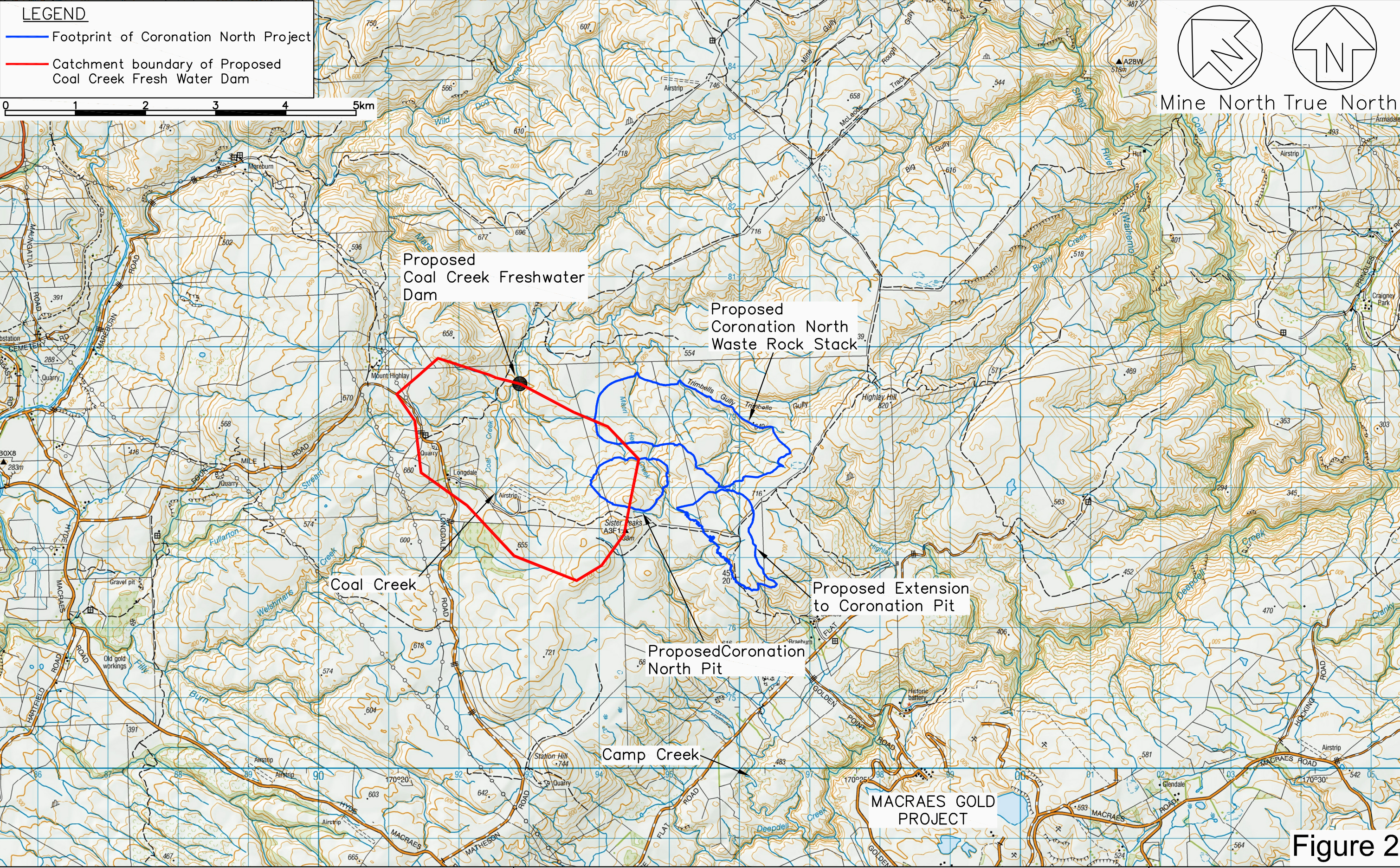
Drawing No. 8122-Fig 1

Date: May 2016

Drawn: JS

Scale: 1:300,000 (©A4)

Filename: 8122-Fig 1.dwg



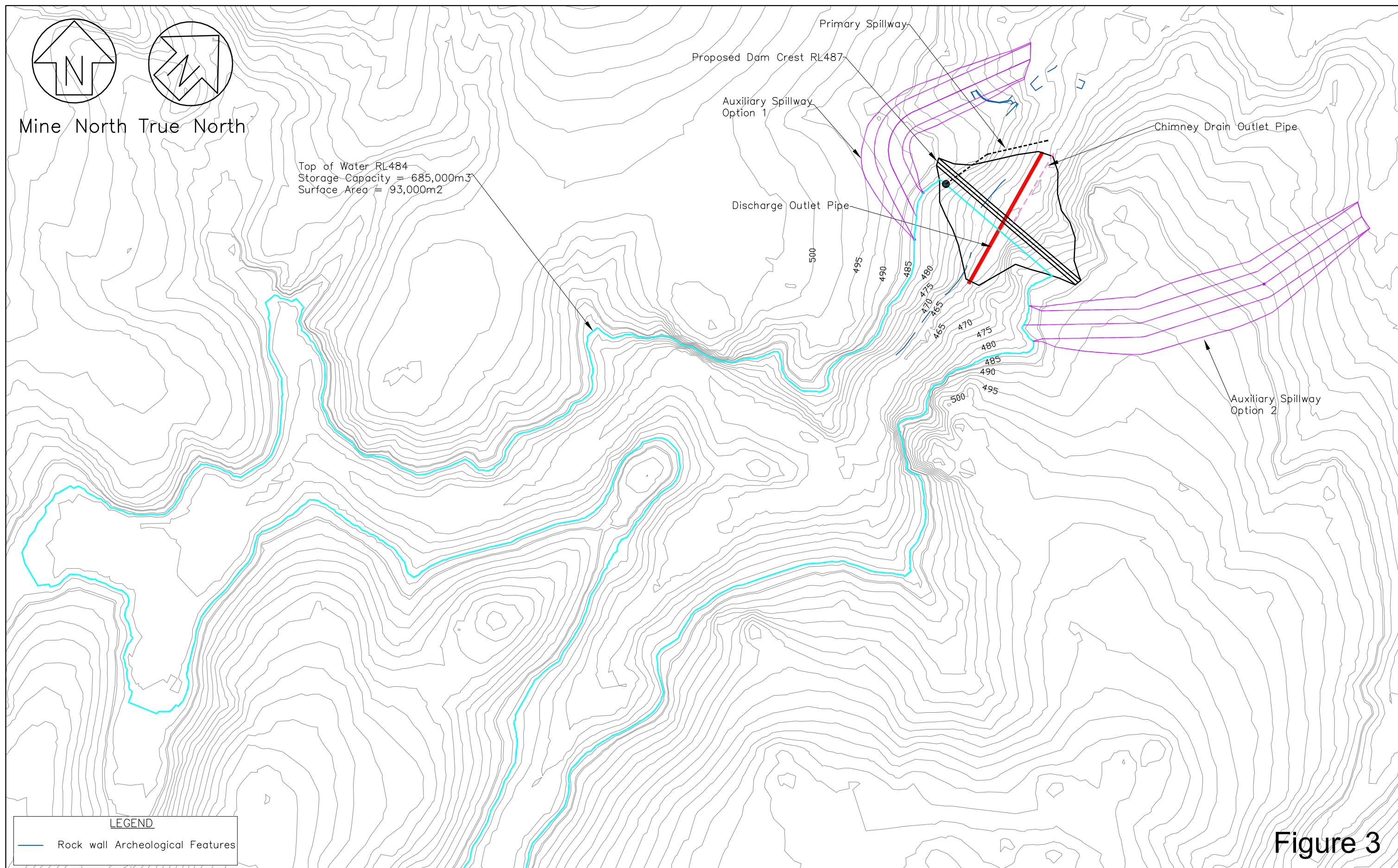
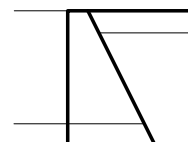


Figure 3

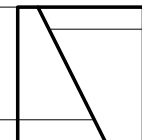
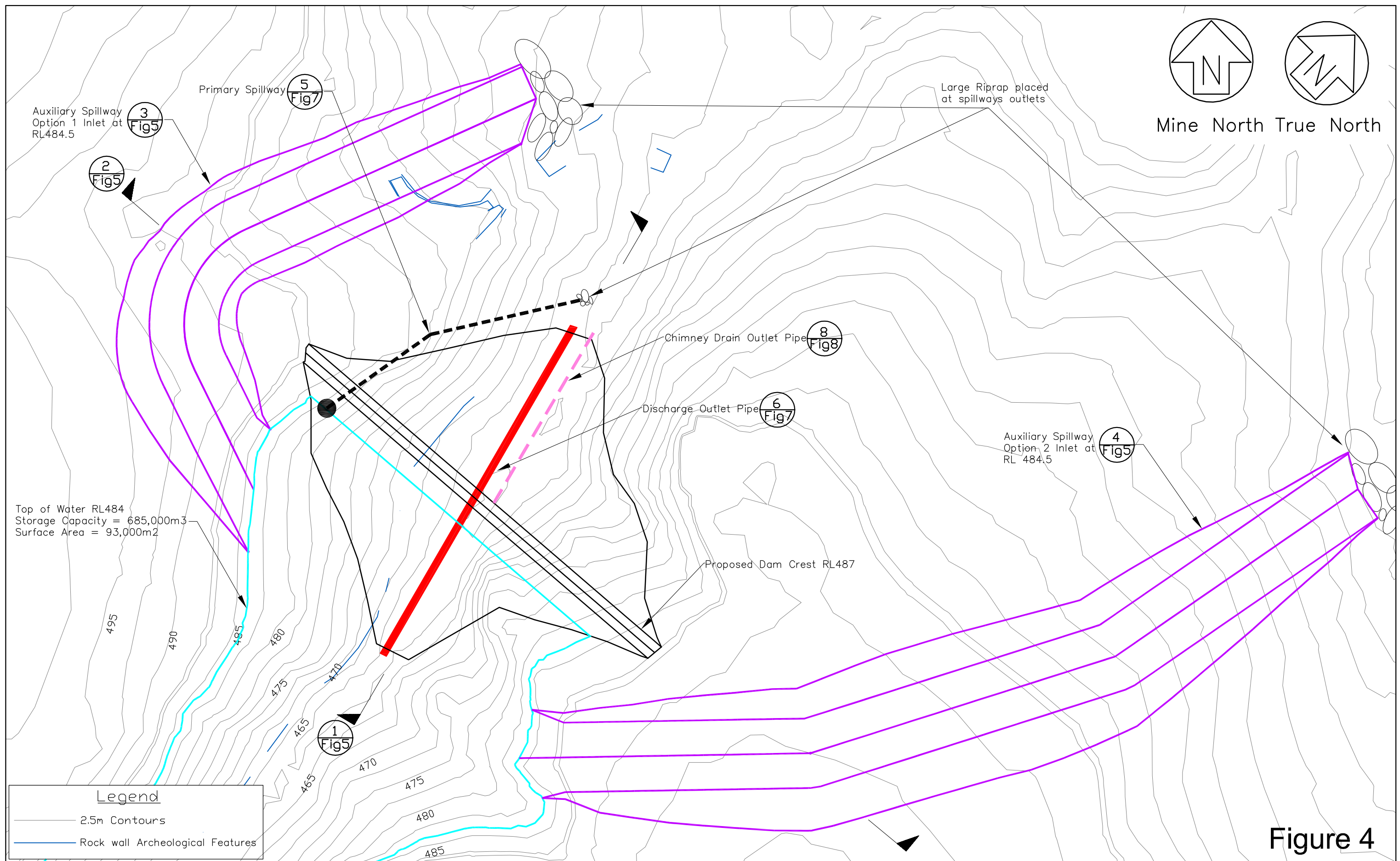


ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD (New Zealand) LTD, MACRAES GOLD PROJECT
Coronation North Project
Proposed Coal Creek Freshwater Dam
Site Plan

Drawing No. 8122-Fig 3
Date: May 2016
Drawn: JS
Scale: 1:2,500 (@A3)
Filename: 8122-Fig3.dwg



ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD (New Zealand) LTD, MACRAES GOLD PROJECT **Coronation North Project** **Proposed Coal Creek Freshwater Dam** **Embankment Layout**

Drawing No. 8122-Fig 4
 Date: May 2016
 Drawn: JS
 Scale: 1:1000 (@A3)
 Filename: 8122-Fig4.dwg

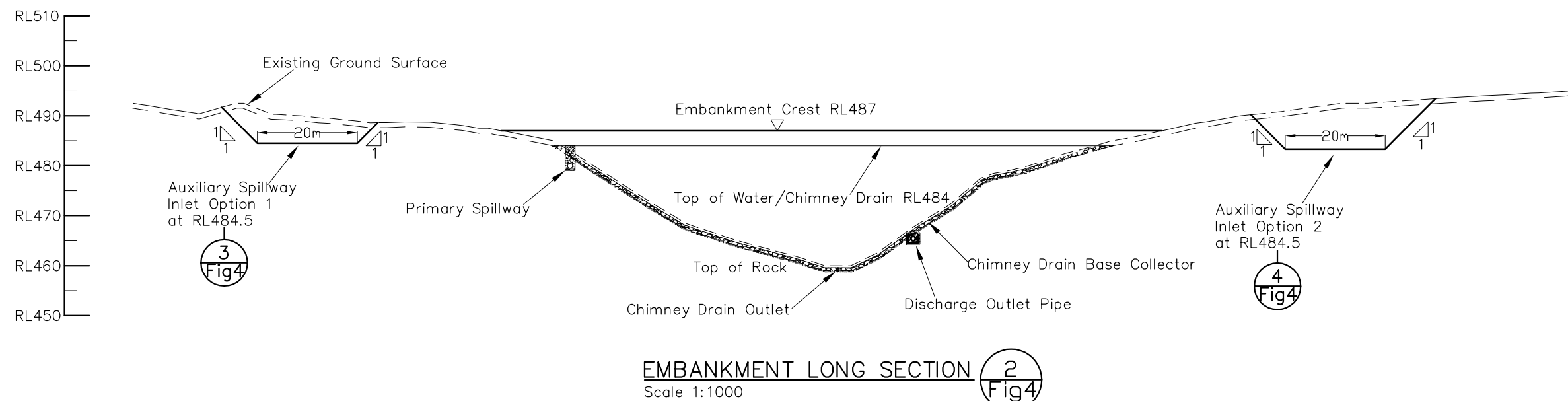
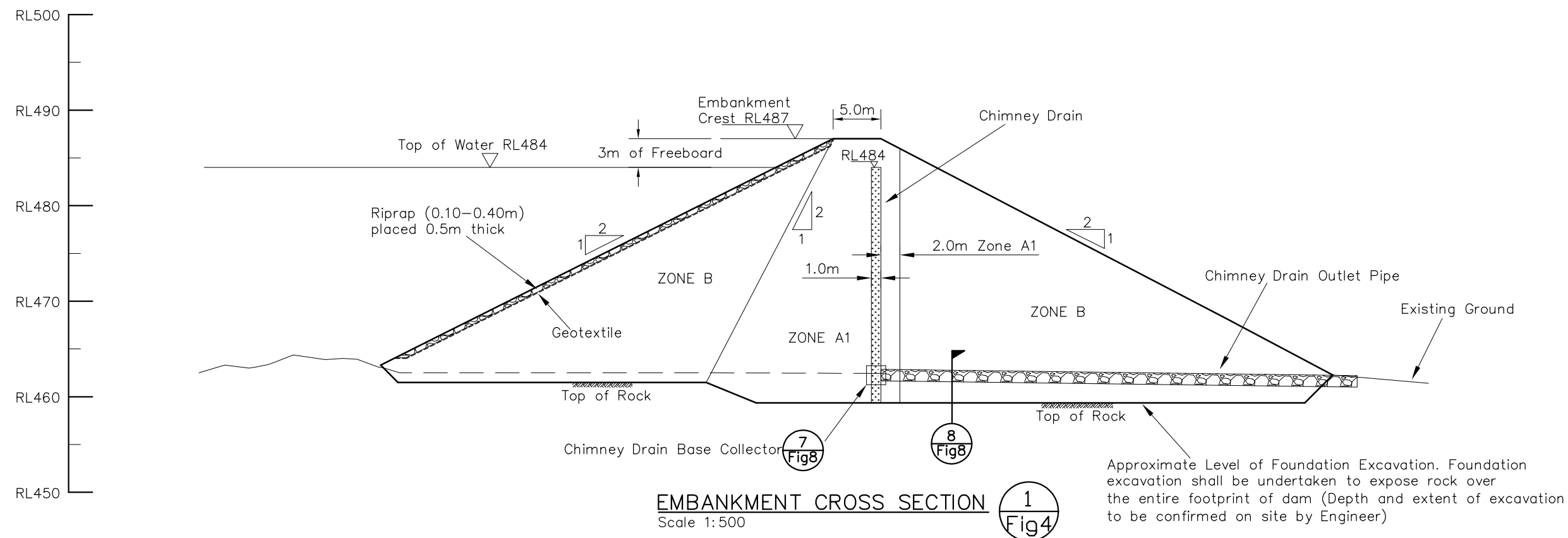


Figure 5

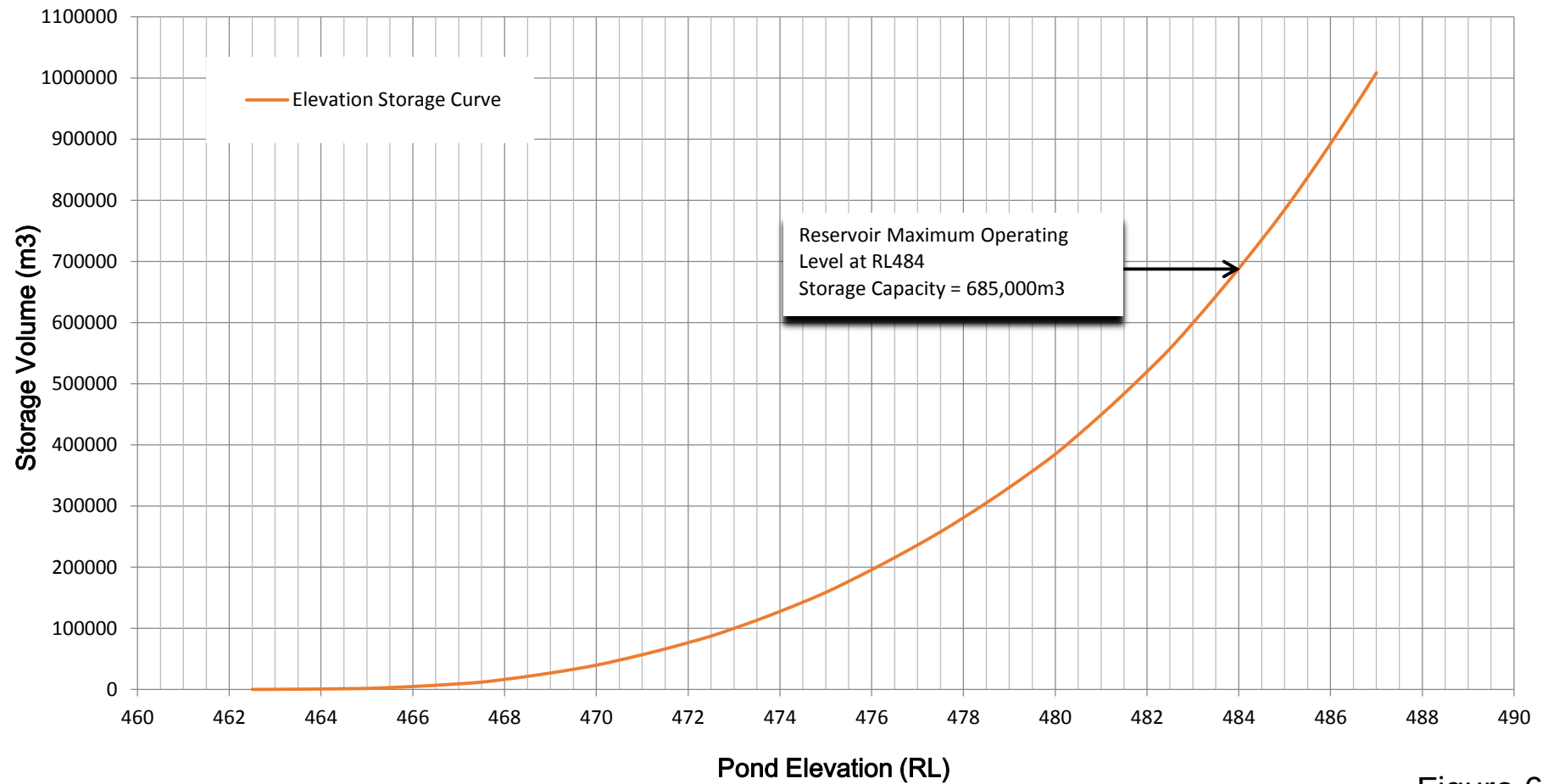
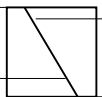


Figure 6



Engineering Geology Ltd
Unit 7C, 331 Rosedale Rd, PO Box 301054,
Albany

OCEANA GOLD (NZ) LTD, Macraes Gold Project
Proposed Coal Creek Freshwater Dam
Elevation - Storage Curve

Ref. No: 8122
Date: May 2016
Drawn: JW
File: 8122

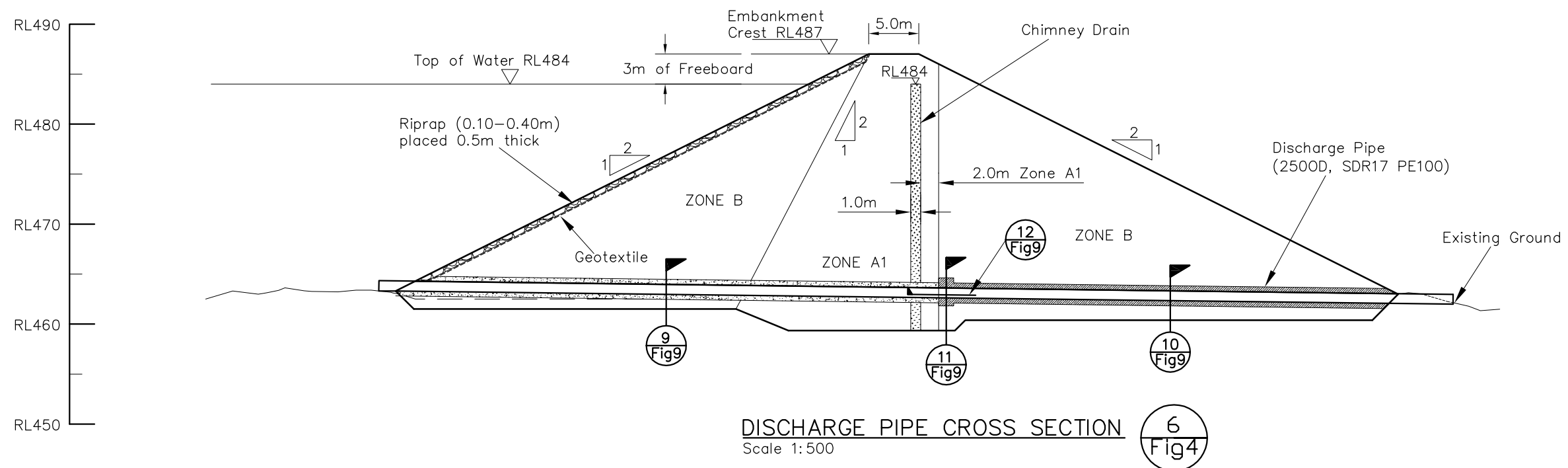
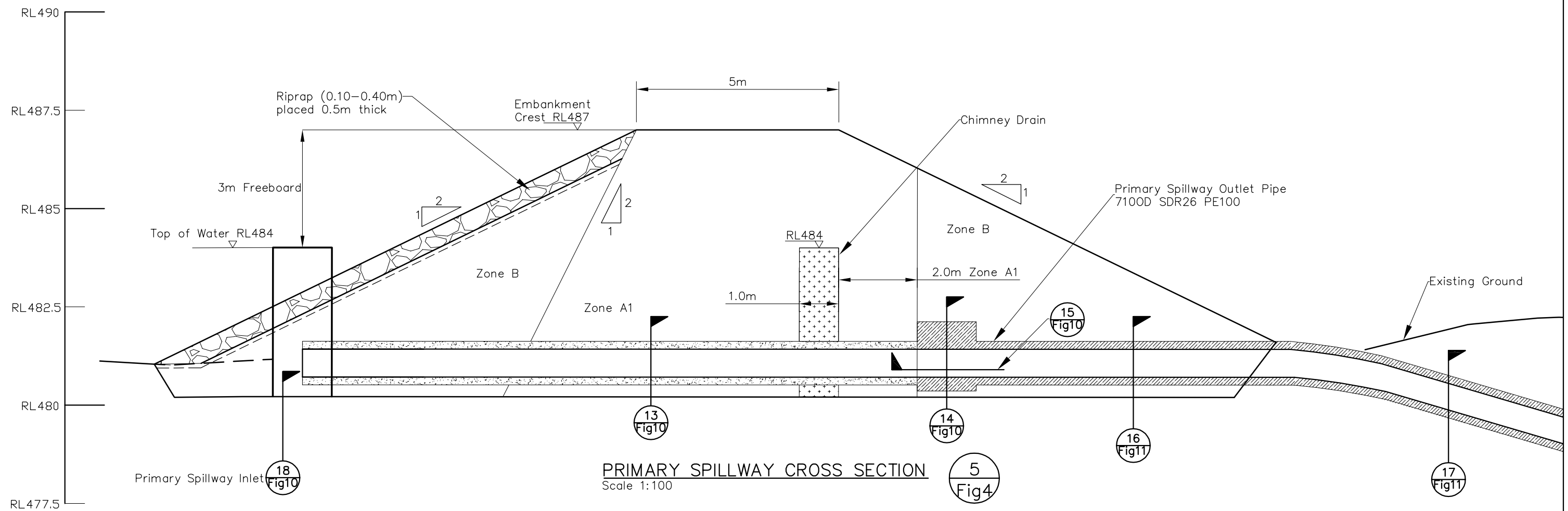
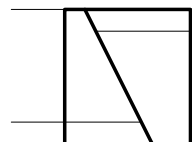


Figure 7

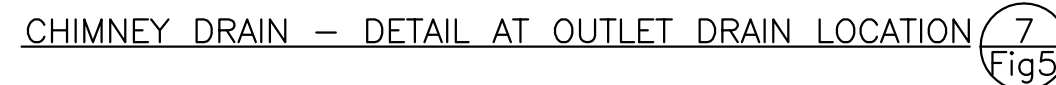


ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486–2546, Fax (09)486–2556

OCEANA GOLD (New Zealand) LTD, MACRAES GOLD PROJECT
Coronation North Project
Proposed Coal Creek Freshwater Dam
Primary Spillway and Discharge Pipe Cross Sections

Drawing No. 8122–Fig 7
Date: May 2016
Drawn: JS
Scale: As shown (@A3)
Filename: 8122–Fig7.dwg



1m

ZONE B

Geotextile

Type B drainage material

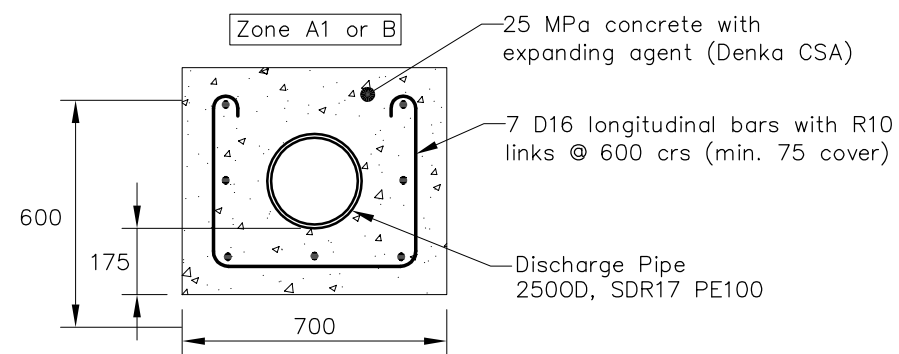
600

100

1100D, SDR13.6 PE100 non perforated pipe

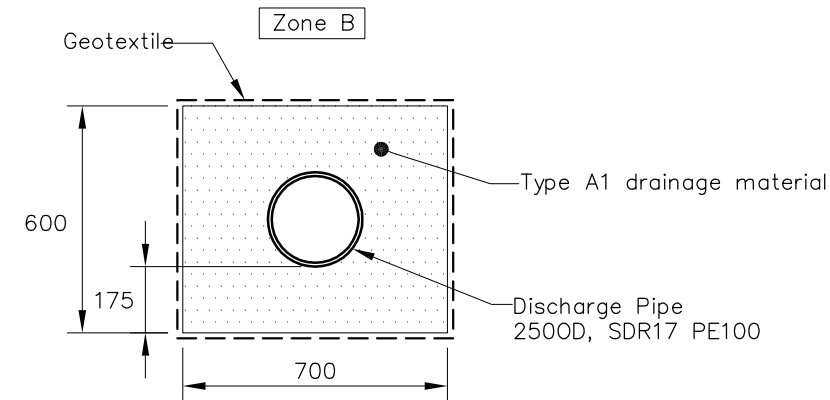
CHIMNEY DRAIN OUTLET 8
Fig5

Drawing No. 8122—Fig 8
Date: May 2016
Drawn: JS
Scale: 1: 25 (@A3)
Filename: 8122—Fig8.dwg



DISCHARGE PIPE THROUGH ZONES A1 & B (UPSTREAM SHOULDER ONLY)

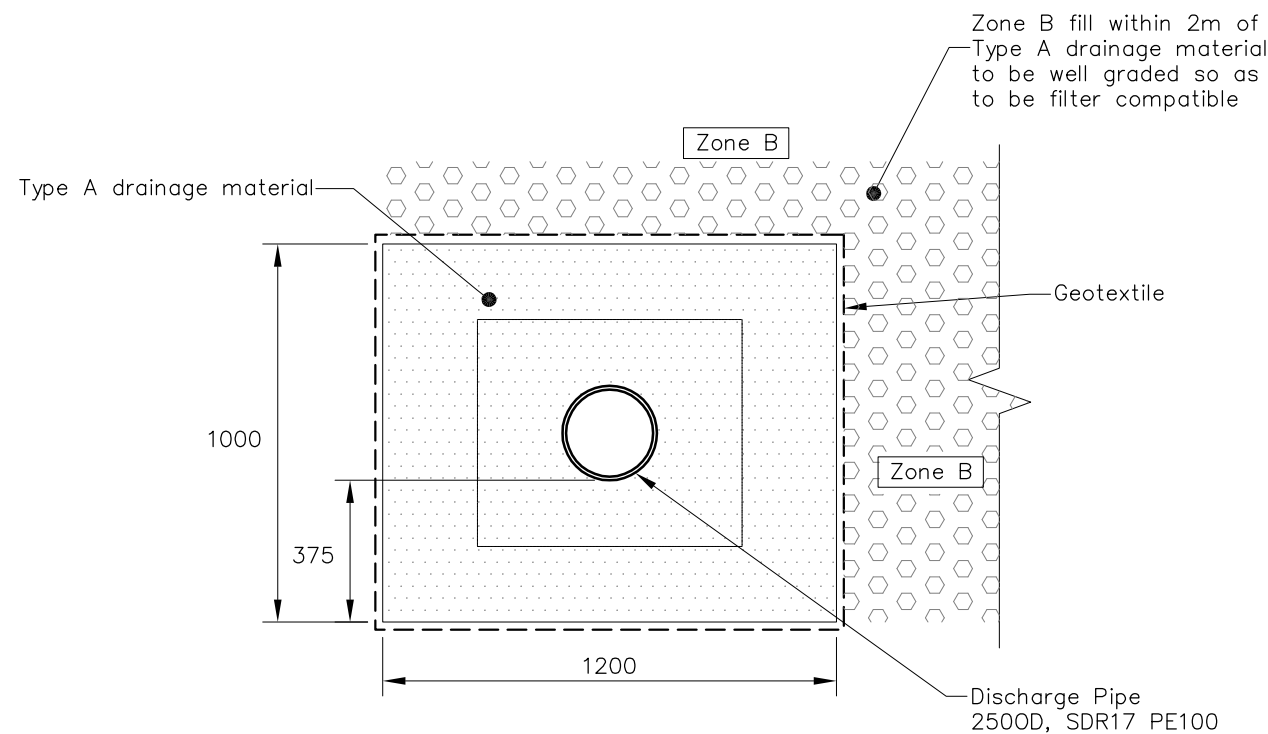
9
Fig 7



DISCHARGE PIPE THROUGH ZONE B (DOWNSTREAM SHOULDER)

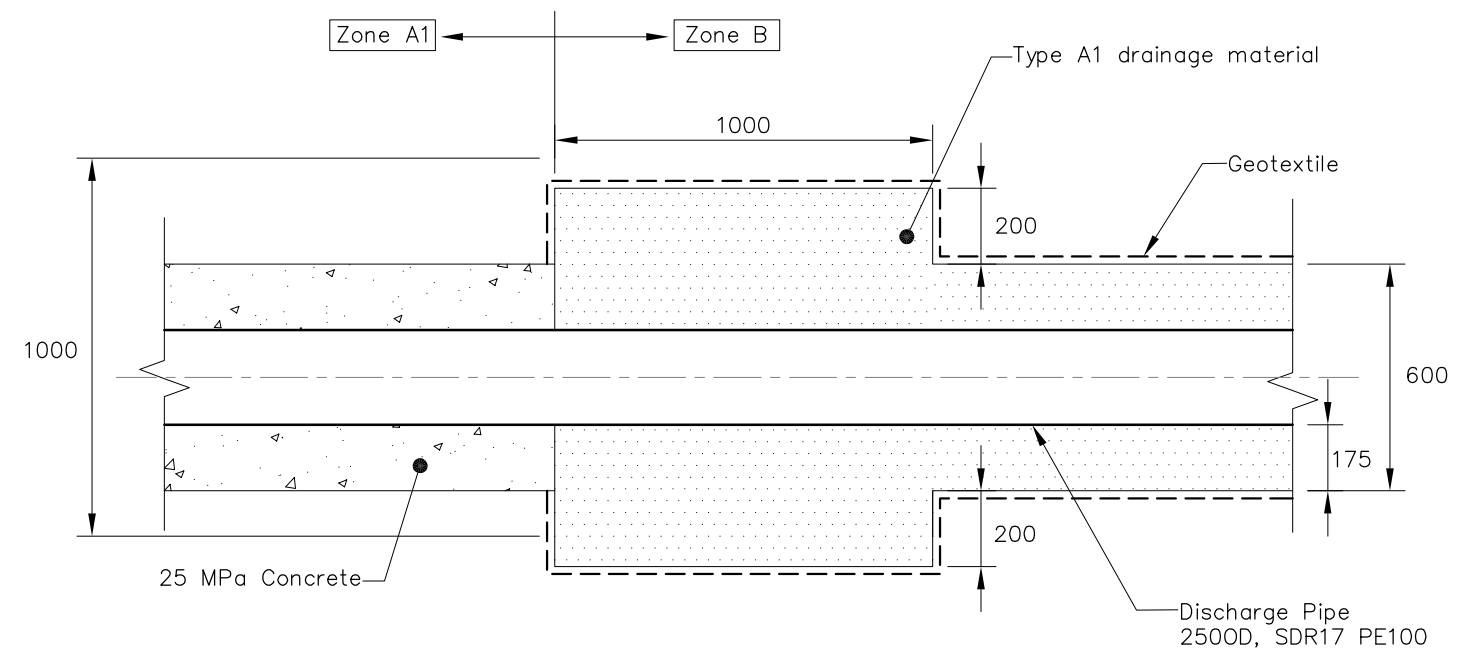
10
Fig 7

Note: Concrete shall have an expanding agent added to it (Denka CSA (No. 20) or equivalent). Immediately following placement of concrete the top of the concrete shall be covered with polythene and 1.5m of loose fill placed above. The loose fill shall be removed after 24 hours and the specified compacted fill place above after 5 days.



DISCHARGE PIPE THRU FILTER/SEEPAGE INTERCEPTOR DRAIN

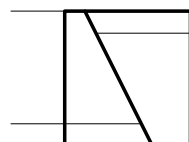
11
Fig 7



DISCHARGE PIPE THROUGH FILTER/SEEPAGE INTERCEPTOR DRAIN

12
Fig 7

Figure 9



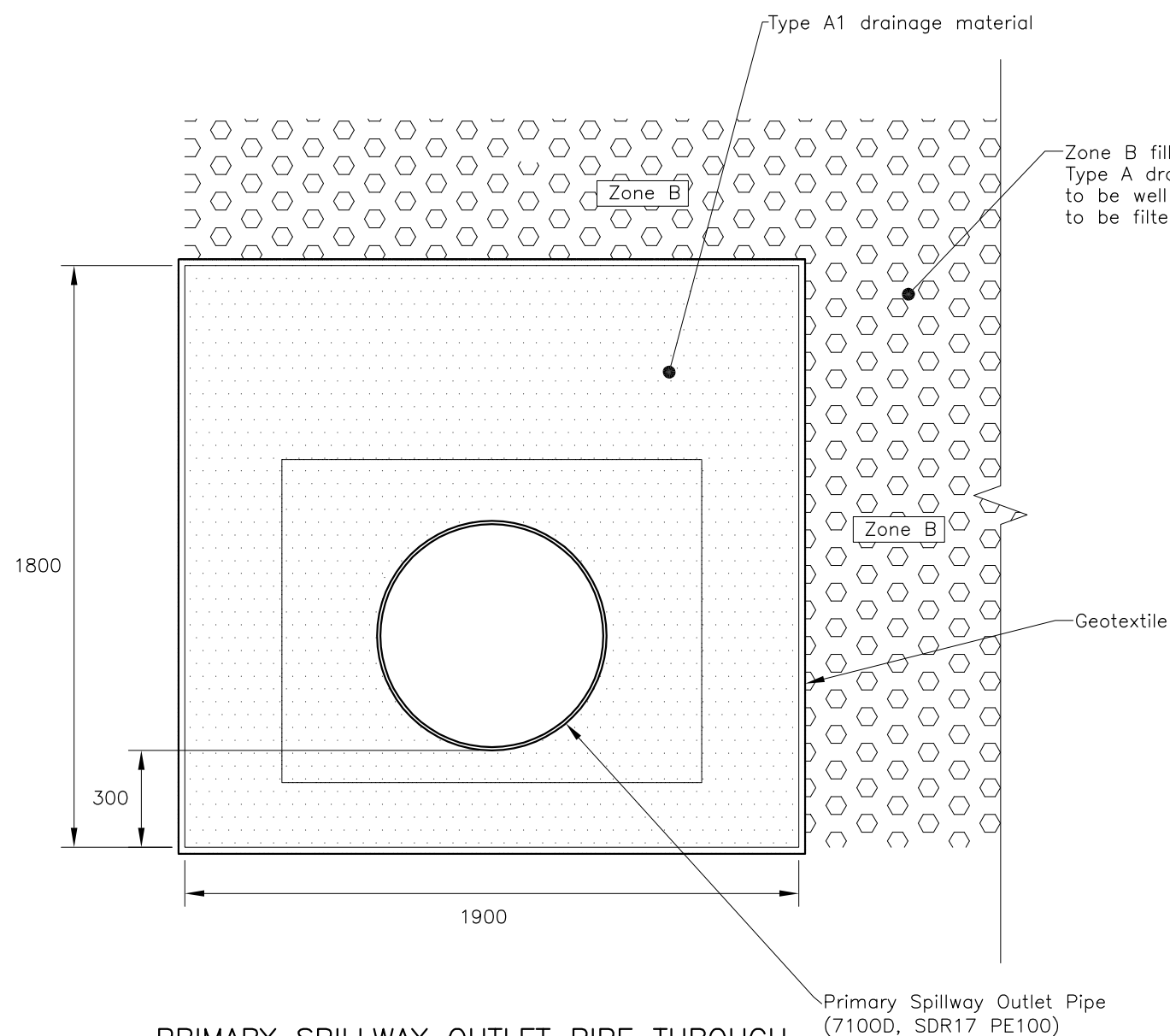
ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

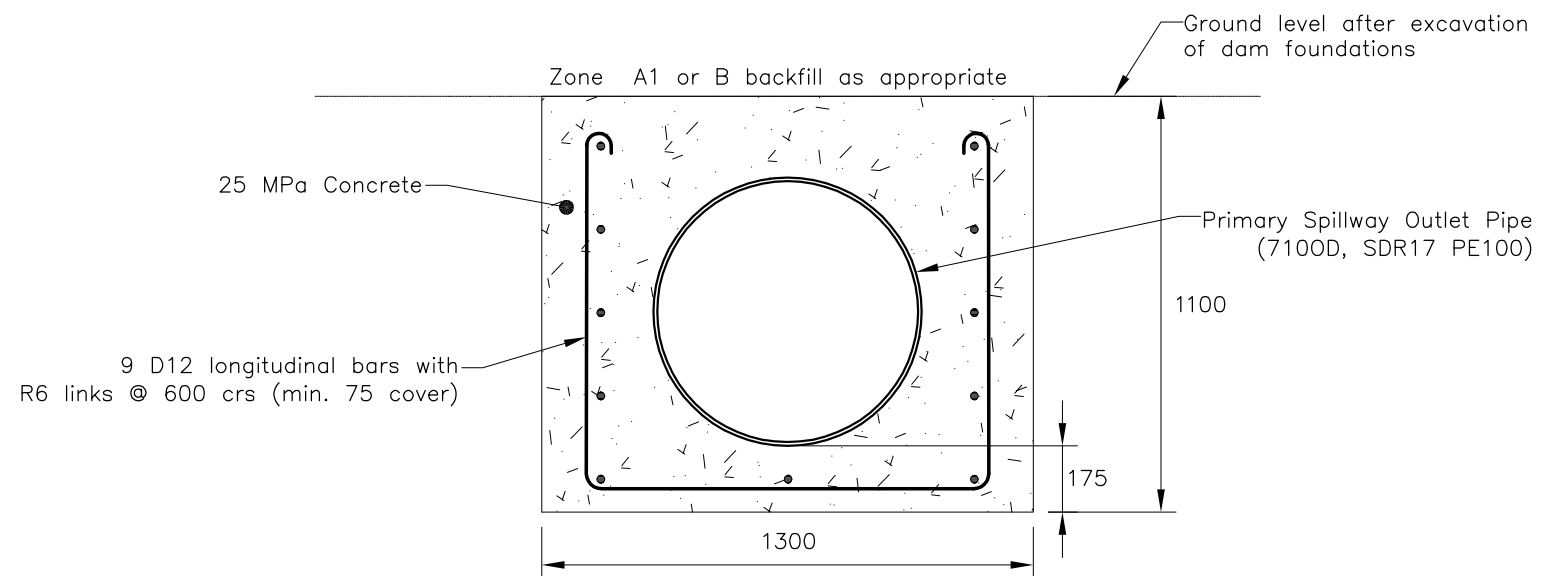
OCEANA GOLD (New Zealand) LTD, MACRAES GOLD PROJECT
Coronation North Project
Proposed Coal Creek Freshwater Dam
Discharge Pipe Details

Drawing No. 8122-Fig 9
Date: May 2016
Drawn: JS
Scale: 1:20 (@A3)
Filename: 8122-Fig9.dwg

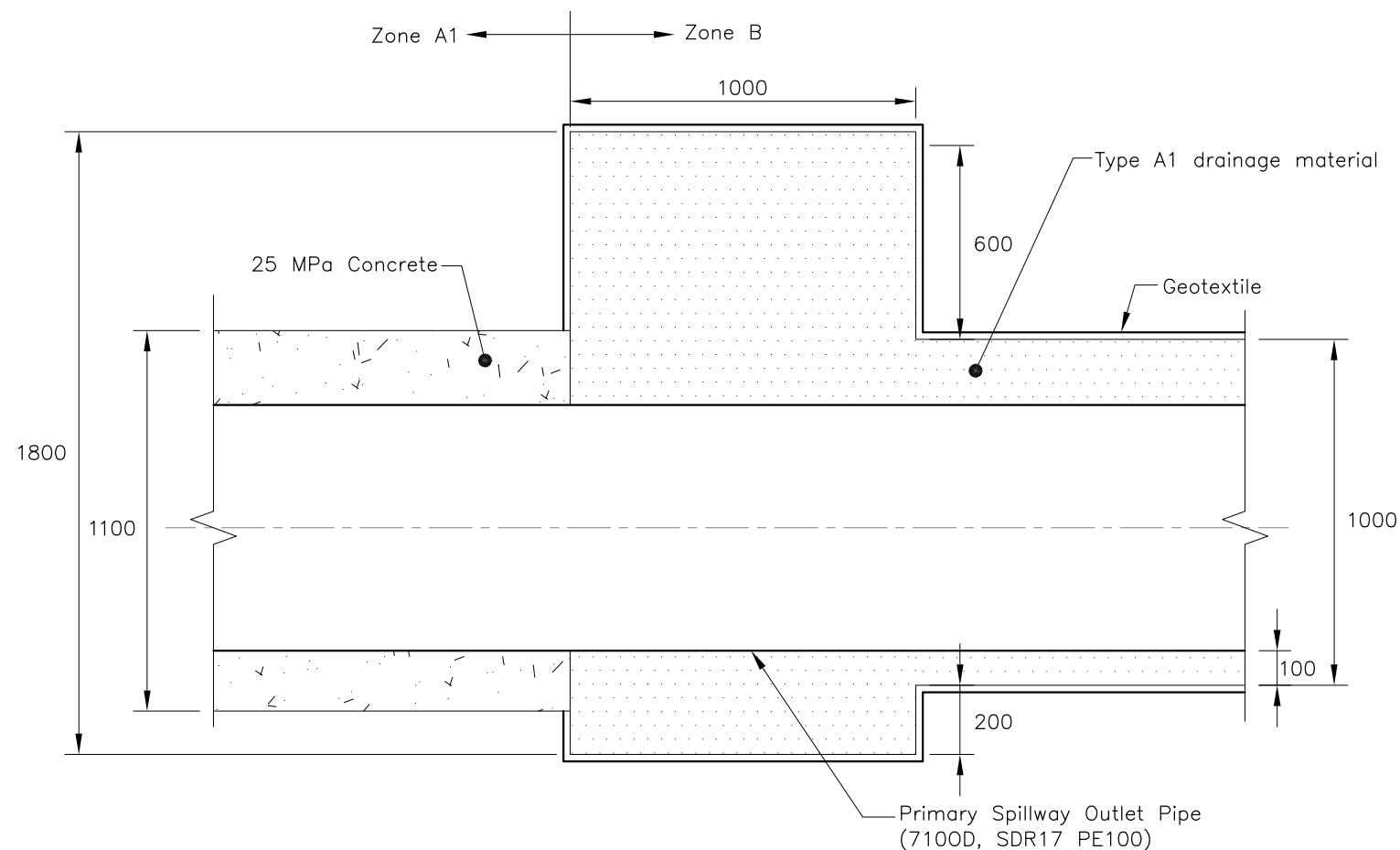
Note: Concrete shall have an expanding agent added to it (Denka CSA (No. 20) or equivalent). Immediately following placement of concrete the top of the concrete shall be covered with polythene and 1.5m of loose fill placed above. The loose fill shall be removed after 24 hours and the specified compacted fill placed above after 5 days.



**PRIMARY SPILLWAY OUTLET PIPE THROUGH
FILTER/SEEPAGE INTERCEPTOR DRAIN** (14 Fig7)

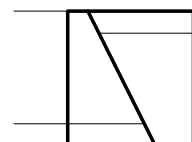


**PRIMARY SPILLWAY OUTLET PIPE BENEATH
ZONES A1 & B (UPSTREAM SHOULDER ONLY)** (13 Fig7)



**PRIMARY SPILLWAY OUTLET PIPE THROUGH
FILTER/SEEPAGE INTERCEPTOR DRAIN** (15 Fig7)

Figure 10

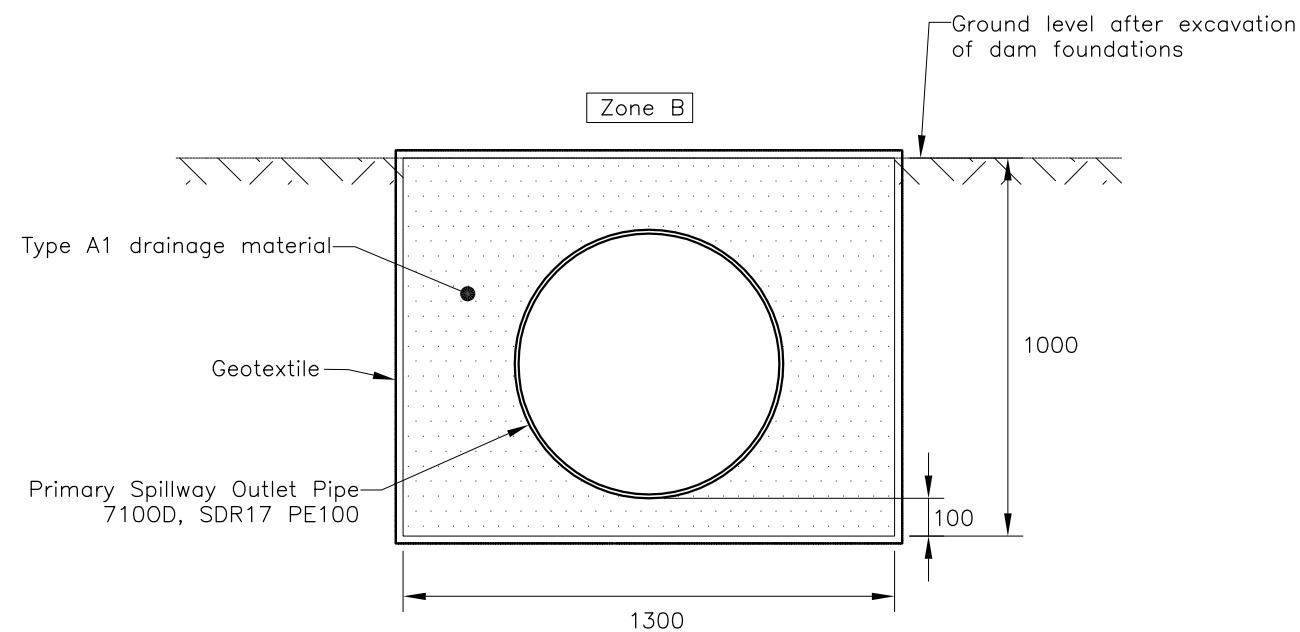


ENGINEERING GEOLOGY LTD

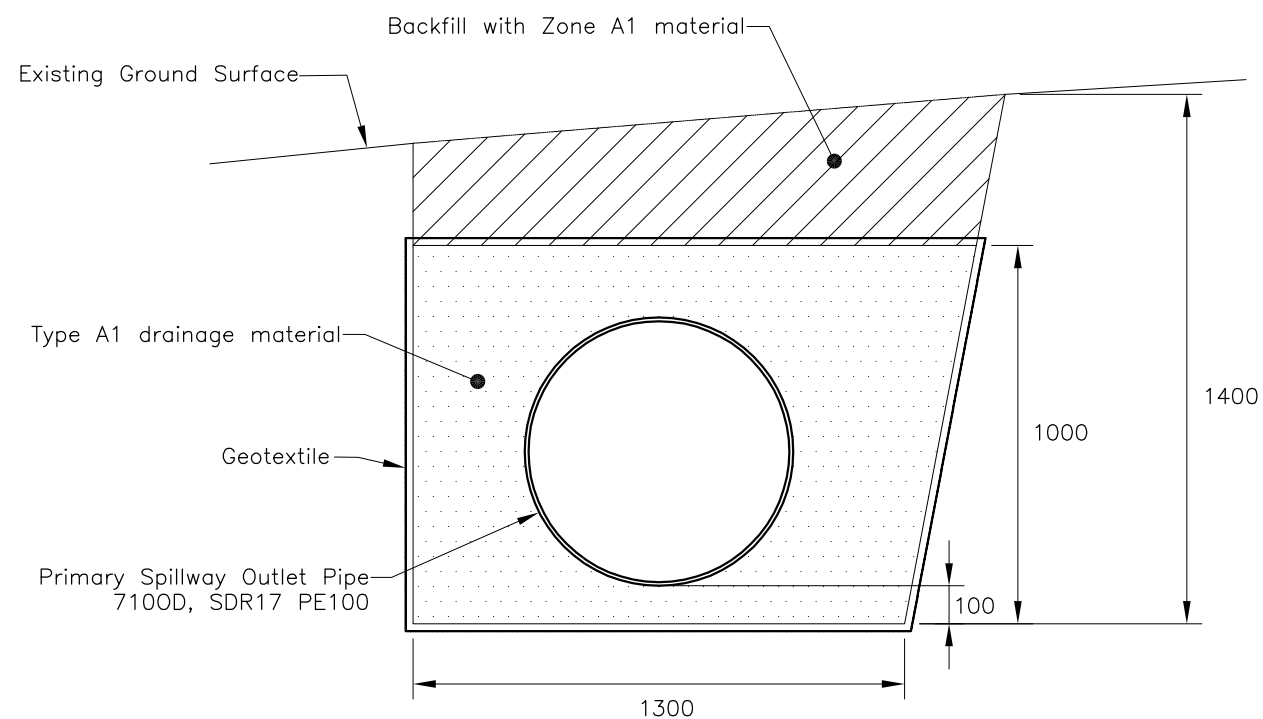
Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD (New Zealand) LTD, MACRAES GOLD PROJECT
Coronation North Project
Proposed Coal Creek Freshwater Dam
Primary Spillway Details 1

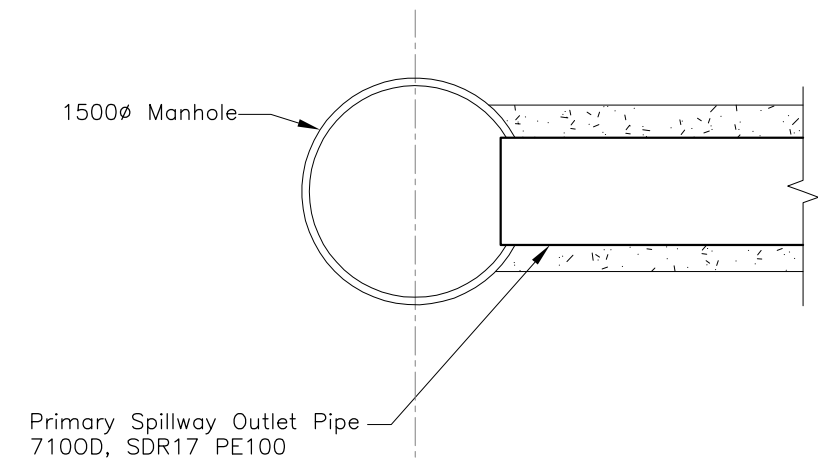
Drawing No. 8122-Fig 10
Date: May 2016
Drawn: JS
Scale: 1:20 (@A3)
Filename: 8122-Fig10.dwg



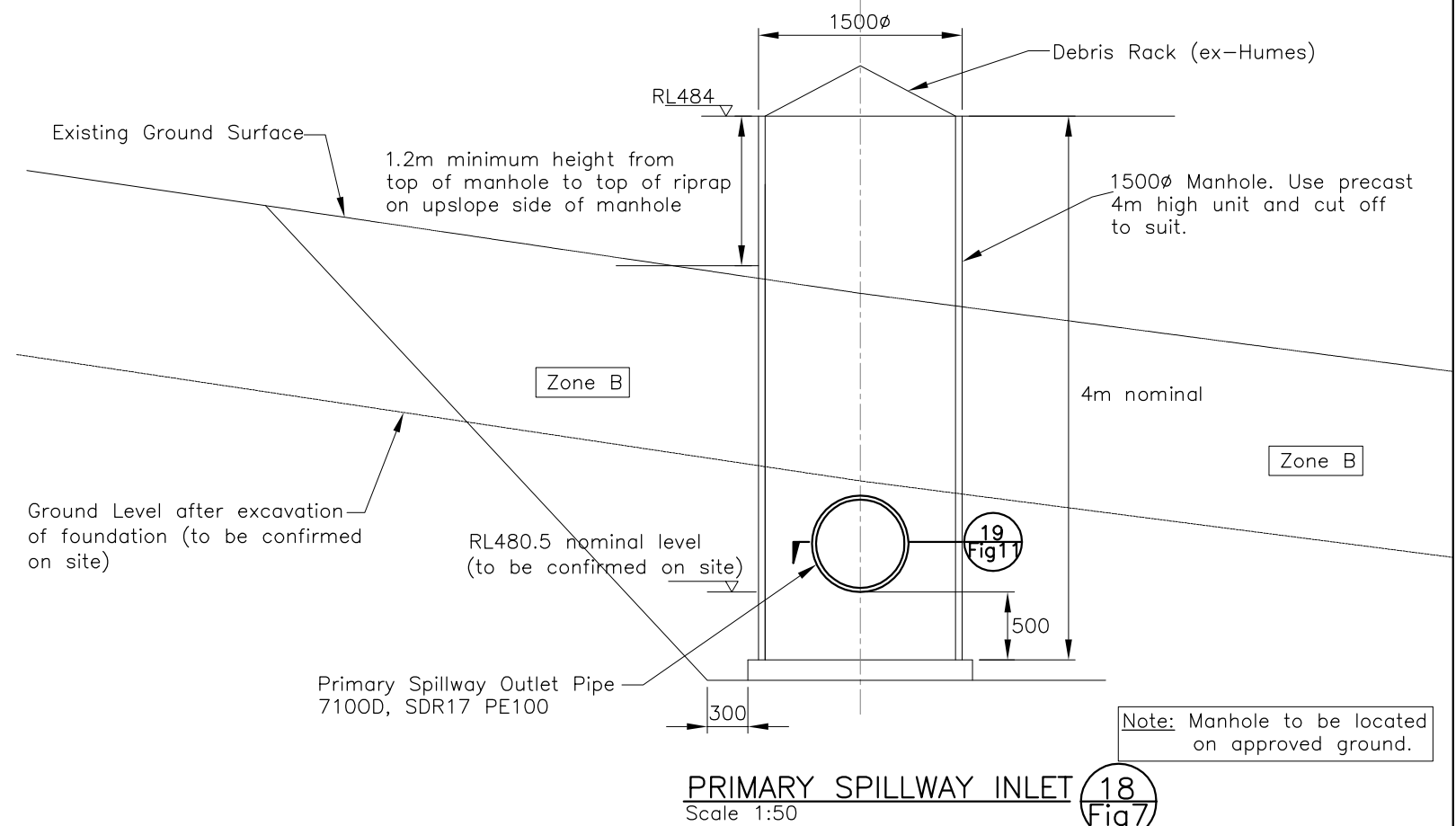
**PRIMARY SPILLWAY OUTLET PIPE BENEATH
ZONE B (DOWNSTREAM SHOULDER)** 16
Fig7
Scale 1:20



**PRIMARY SPILLWAY OUTLET PIPE
DOWNSTREAM OF EMBANKMENT** 17
Fig7
Scale 1:20

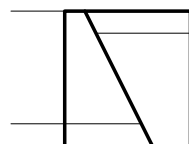


PRIMARY SPILLWAY INLET SECTION 19
Fig11
Scale 1:50



PRIMARY SPILLWAY INLET 18
Fig7
Scale 1:50

Figure 11



ENGINEERING GEOLOGY LTD

Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD (New Zealand) LTD, MACRAES GOLD PROJECT
Coronation North Project
Proposed Coal Creek Freshwater Dam
Primary Spillway Details 2

Drawing No. 8122-Fig 11
Date: May 2016
Drawn: JS
Scale: As shown (@A3)
Filename: 8122-Fig11.dwg

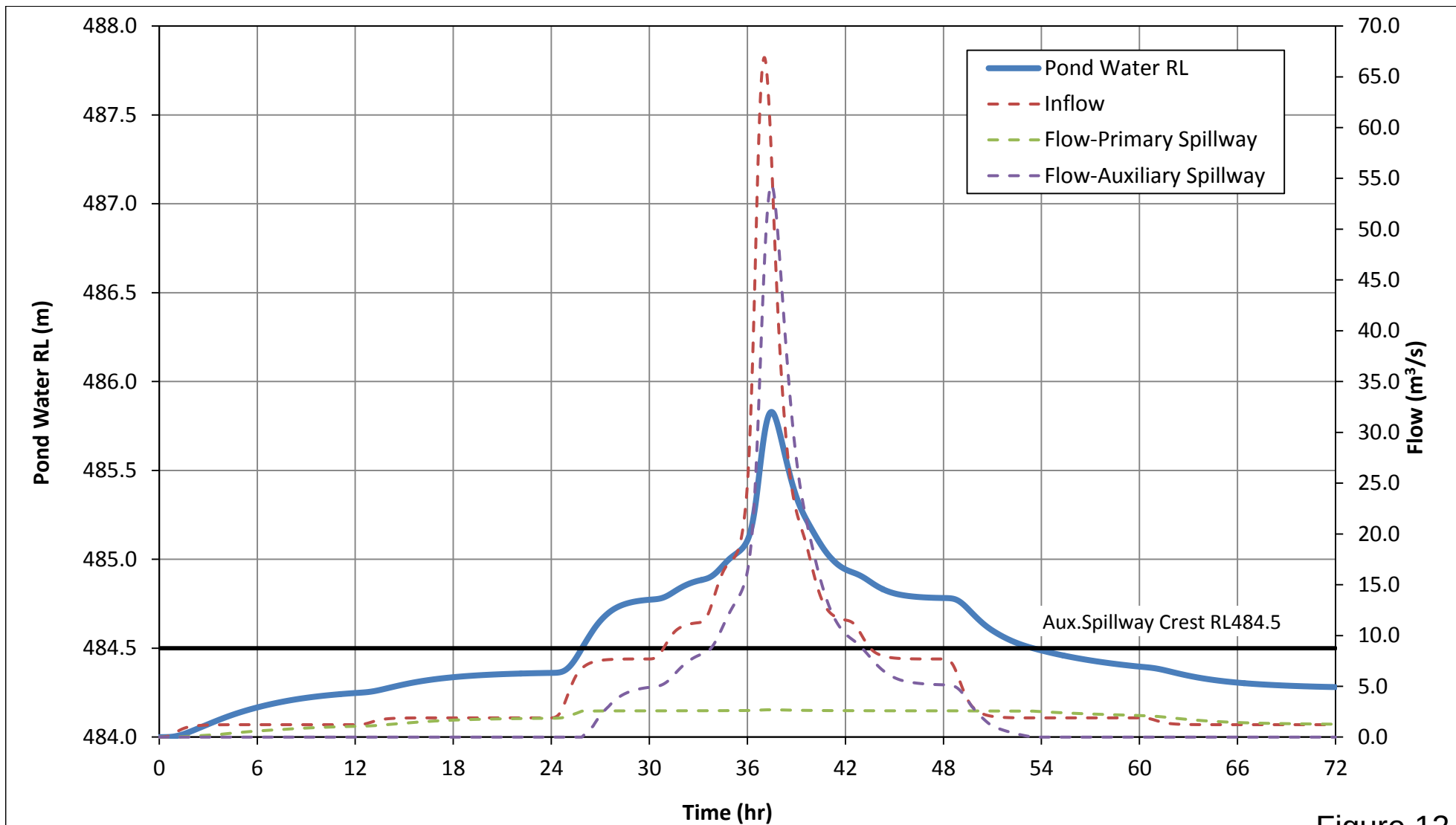
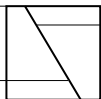


Figure 12



Engineering Geology Ltd
Unit 7C, 331 Rosedale Rd, PO Box 301054,
Auckland

OCEANA GOLD (NZ) LTD, Macraes Gold Project
Coal Creek Freshwater Dam
Hydraulic Routing Curves - 5000 Year Design Rainfall Event

Ref. No: 8122
Date: May 2016
Drawn: JW