

21 June 2016

Reference No. 1545831-006

Jackie St John
Oceana Gold (New Zealand) Ltd
PO Box 5442
DUNEDIN 9058

CORONATION NORTH PROJECT CONSENT APPLICATION – GROUNDWATER S92 RESPONSES

Dear Jackie

Oceana Gold (New Zealand) Limited (OceanaGold) has applied to Otago Regional Council (ORC) for consents authorising the construction of the Coronation North Project. Golder Associates (NZ) Limited (Golder) provided technical support to OceanaGold with respect to assessing the effects of the project on groundwater, surface water and water quality.

OceanaGold has subsequently received a letter from ORC, prepared by Tonkin and Taylor Ltd (T&T)¹ providing a request for further information under Section 92 (S92) of the Resource Management Act. OceanaGold has retained Golder to provide responses to the questions in the S92 letter relating to the groundwater assessment for the project.

This letter² provides responses to items (a) to (e) from Table 1 in the S92 request from T&T for further information.

Item a: Section 5.4 Groundwater recharge.

Please provide further information that clarifies how the groundwater recharge rate has been derived and demonstrates that this number is appropriate for both pit inflow calculations and waste rock stack seepage calculations.

Groundwater recharge rates applied to the groundwater assessment were based on recharge rates calculated for the Macraes Gold Project area and documented in Appendix 3 of a report by Kingett Mitchell Limited³. A copy of that appendix is appended to this letter⁴. The evaluation of groundwater recharge rates was carried out based on two independent methodologies:

- 1) An assessment of base flows in Deepdell Creek as measured at a weir maintained at Golden Point by OceanaGold.
- 2) A soil moisture balance modelling approach based on regional climate data.

The groundwater recharge rate of 32 mm per year calculated by Kingett Mitchell is supported by a previously calculated groundwater recharge rate of 30 mm per year for the Macraes Gold Project area identified by Woodward Clyde⁵.

¹ Letter from Tonkin & Taylor Ltd to Otago Regional Council, dated 13 June 2016. Proposed OceanaGold Coronation North Project, Section 92 requests for additional information. T&T reference number 51640.0230.

² This letter is provided subject to the attached statement of limitations.

³ Kingett Mitchell Limited 2005. Macraes Gold Project groundwater and contaminant transport assessment. Report prepared for OceanaGold (New Zealand) Limited by Kingett Mitchell Limited, November 2005. Kingett Mitchell reference number OCEGOMAC005.

⁴ Please note that providing a copy of any section of a Kingett Mitchell report to a client for information purposes does not constitute a reissue of that report by Golder.

⁵ Woodward Clyde (NZ) Limited 1997: Macraes Gold Project Expansion – Addendum to Water Management Report. Unpublished report prepared for Macraes Mining Company Limited.

These groundwater recharge rates for undisturbed catchments have been applied to calibrated groundwater models of the Macraes Gold Project that have been successfully used to predict contaminant transport rates in the groundwater system from a range of mine structures at the site, including the tailings storage facilities and the waste rock stacks^{3,6}.

The recharge rates are considered to be appropriate for both the existing and planned waste rock stacks at the Macraes Gold Project for the following reasons:

- Observed seepage flows from WRS discharge points across the site are within the range of what would be expected from the overlying WRS areas. This observation is based on the 32 mm per year recharge rate and assumes the catchment zone for the discharge point reflects the original topographic catchment area for the gully prior to construction of the WRS.
- Contaminant transport models for the wider Macraes Gold Project area^{3,6} have been used to successfully predict sulfate mass loads derived from WRS seepage and the consequent effects on sulfate concentrations in Deepdell Creek. These models have been calibrated on up to two decades of water quality data from the site, with validated projections of up to 10 years into the future.

It is accepted that seepage discharges from WRSs may vary over a small range in the short term in response to major rainfall events. Work is underway to quantify these variations, however it is expected that these variations are more due to infiltration of run-off water to the WRS batter areas than to the upper surface of the WRS. These variations are not expected to invalidate the overall seepage and mass load projections from the Coronation North WRS.

Item b: Section 5.53 Groundwater area of influence calculations

Please further clarify how the "Reasonable Area of Influence" as described in 5.5.3 is calculated. Please provide further information on how the groundwater divide between the pit and adjacent gullies (as demonstrated in Figure 5) has been established in order to determine the Reasonable Area of Influence.

The following steps were taken in establishing the "reasonable area of influence" for each pit:

1. A line was drawn half way between the boundary of the opencast pit footprint and the outer boundary of the "maximum potential area of influence" catchment. This line provided an initial indication of the position of the catchment divide between groundwater flowing toward the pit and groundwater flowing toward stream gullies surrounding the opencast pit. This interpretation incorporates the assumption that the groundwater hydraulic gradient on the outside of the catchment divide is similar to that on the inside of the divide. Numerical modelling of other pits of the Macraes Gold Project indicates this is a conservative assumption in that the hydraulic gradients toward the opencast pits tend to be steeper than natural groundwater gradients. For this reason, the eventual areas of influence for each of the Coronation North pits are expected to be smaller than the areas identified in the groundwater report.
2. In areas where the topography outside the pit shell extends away from the pit at an elevation above the nearest rim of the pit for a radial distance of more than 500 m (i.e., the pit intersects a ridge line) the boundary of the reasonable area of influence was extended further from the pit boundary, out to about two thirds of the way to the maximum potential area of influence catchment boundary. This was done on the assumption that the hydraulic gradient on the outer side of the groundwater catchment divide along the ridge would be relatively gentle and the area of pit influence could therefore be of greater extent along a ridge or area of higher ground. This is again a conservative assumption, for the same reason as indicated for the definition of the boundary in step 1.
3. Where the "maximum potential area of influence" catchment boundary locally intersects the rim of the planned pit, corresponding to the overflow point of the pit lake, the boundary for the reasonable area of influence also intersects this point.

⁶ Golder 2011. Macraes Phase III Project. Groundwater contaminant transport assessment – Deepdell Creek, North Branch Waikouiti River and Murphys Creek catchments. Report produced for Oceana Gold (New Zealand) Ltd by Golder Associates (NZ) Limited. Golder report 0978110562 R006.

In summary, the reasonable area of influence boundary is approximately half way between the maximum potential area of influence boundary and the pit rim, with allowance made for areas of high ground outside the pit footprint.

Please provide further justification and/or clarification of the following statements presented in Section 5.5.3, under items 1) and 4) "This scenario differs from Scenario 1 in that is also takes into account the groundwater systems in gullies close to the pit, which are unlikely to remain relatively unchanged irrespective of the construction of the pit".

The quoted statement included typographic errors that was missed in the report reviews. It should have read: "This scenario differs from Scenario 1 in that it also takes into account the groundwater systems in gullies close to the pit, which are likely to remain relatively unchanged irrespective of the construction of the pit".

The groundwater flows beneath gully slopes in the areas around the Coronation North Project pits are expected to predominantly remain aligned toward the nearest gully invert, rather than shifting toward the nearest opencast pit. This expectation reflects the nature of the weathering of the schist in the Macraes area, which results in the shallow weathered rock and soils having higher permeability than the underlying less weathered schist. Groundwater seepage flows in this area are predominantly down-slope, reflecting the overlying topography and the rock mass weathering patterns.

Item c: Effects on stream flow and surface water allocation

Please provide further information on the cumulative effects of ground drawdown as a result of mining and as a result of the interception of recharge from the waste rock stacks on surface water recharge and its consequent effects on stream flows, including those gullies draining to the Shag River Catchment.

The cumulative effects of groundwater drawdown and changes to surface water catchments on flows in Mare Burn, which discharges to the Taieri River, are documented in Section 6.2.2 of the report documenting the surface water assessment for the Coronation North Project⁷. Three stages of operations were modelled and documented in the surface water report:

- Stage 1 – A model of the Mare Burn catchment incorporating currently consented operations including the Coronation Pit and Coronation WRS. In the model it is assumed that the Coronation Pit and WRS are fully developed and both are still in the operational phase.
- Stage 2 – A model of the Mare Burn catchment incorporating the structures and waste storage associated with both the fully developed CS5 and Coronation North Pits. It is assumed that only the Coronation North pit and WRS are operational. The Coronation WRS is not included in this model as new mine planning has excluded it from the Mare Burn catchment. The Coronation pit lake is assumed to be developing.
- Stage 3 – A model of the Mare Burn catchment incorporating the structures and waste storage associated with both the fully developed CS5 and Coronation North Pits at post closure. It is assumed the WRSs are rehabilitated.

The model logic diagrams and supporting information are documented in the surface water report⁷. The outcomes of the modelling are summarised as flow duration curves in Figure 1. A statistical summary of the projected Mare Burn hydrology under different stages of mine development is provided in Table 20 of the surface water report, together with the supporting documentation.

The gullies draining to the Shag River that may be influenced by groundwater drawdown by the Coronation North Project pits are expected to be ephemeral during most if not all summer seasons. Flows in the gullies within the area influenced by groundwater drawdown are dominated by rainfall run-off. The projected drawdown of the groundwater table is not expected to have a detectable effect on the flows in these gullies.

⁷ Golder 2016a. Coronation North Project. Surface water modelling. Report produced for Oceana Gold (New Zealand) Ltd by Golder Associates (NZ) Limited, March 2016. Golder report 1545831-003.

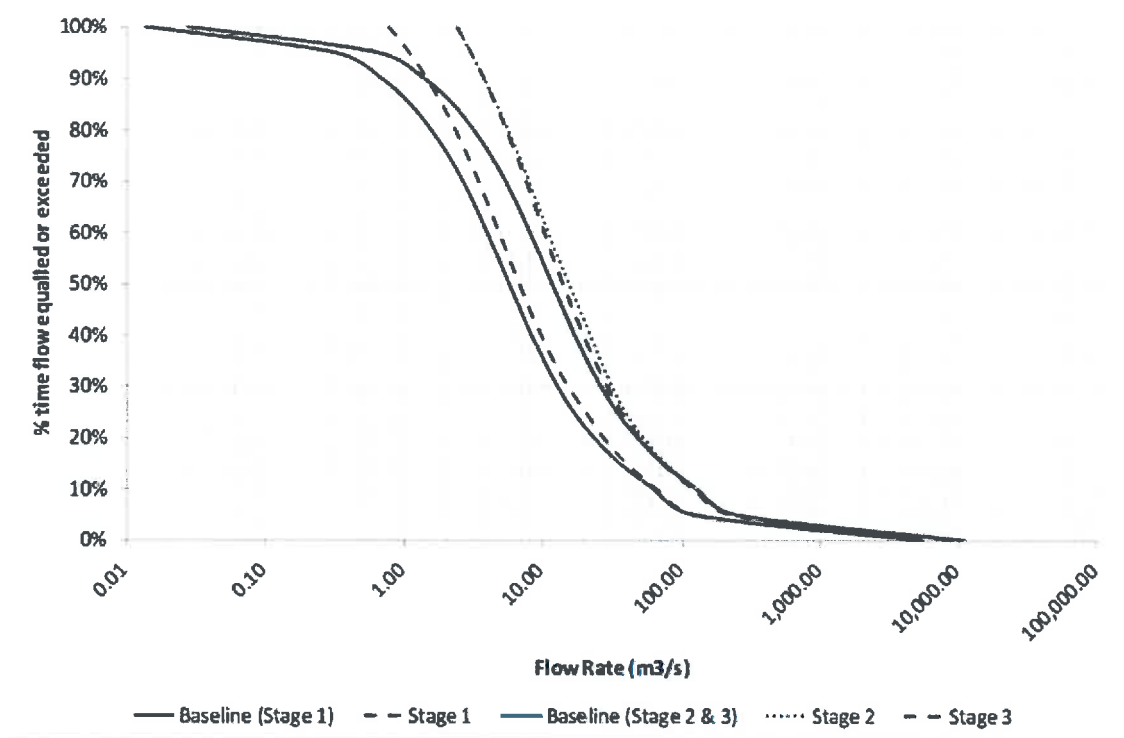


Figure 1: Coronation North Project flow duration results (all stages).

Please provide an assessment of the effects of any reduction in stream flow on allocable flows in both the Taieri and Shag River Catchments as set out in Section 6.4 and Schedule 2 of the Regional Plan: Water for Otago.

The development of the Coronation North Project is not expected to have a detectable effect on the allocable flows in either the Taieri River or the Shag River. During the summer, when the allocable flows may be under pressure, Mare Burn is generally dry at MB02. The gullies within the Shag River catchment close to the Coronation North Project are also dry. Hence no reduction in the availability of allocable water is projected.

Item d: Net seepage flows into pit lakes

Appendix F provides an assessment of net groundwater inflow into the pit lakes following mine closure and states that these inflow rates have been carried through into the surface water modelling. Please comment on whether evaporation from the pit lakes has been taken into account in the surface water modelling and whether evaporation from the pit lakes has also been taken into account in determining the likely timeframes for filling of the pit lakes.

The modelling of the development of the Coronation Stage 5 pit lake and the Coronation North pit lake does take into account evaporative losses from the pit lake in providing projections for the time required for the pit lakes to reach overflow. This modelling has been documented in the surface water report from Golder⁷ supporting the Coronation North Project consents application. A copy of the Coronation North Project surface water model logic for the stage 3 model (post-closure) is provided in Figure 2. Evaporative losses from the catchment run-off and waste rock stack run-off are also calculated in the model, although not specifically identified in this model logic.

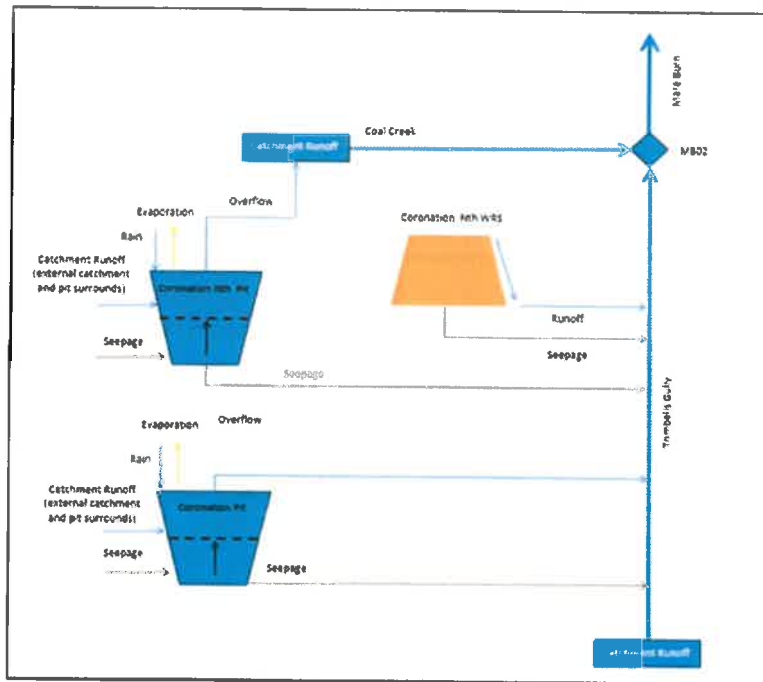


Figure 2: Stage 3 model logic – Coronation North Project closure.

Item e: Section 5.6 Waste rock stack seepage calculations

Section 5.6 concludes that recharge through the waste rock stack will be intercepted and discharge to one of four silt ponds. Please comment on the likely effect of this interception on calculations of groundwater inflows into the mine pits and its consequential effect on the rate of post-closure mine lake filling.

The planned silt ponds are on the eastern and northern sides of the Coronation North WRS, as described in the Coronation North Project surface water report. As such they have no influence on the seepage flows into the opencast pits or on the rate of water level rise in the pits post-closure.

We trust these responses are sufficient to address the items raised in the request for further information. Should you have any questions regarding the content of this letter, please contact the undersigned.

Yours sincerely

GOLDER ASSOCIATES (NZ) LIMITED

Brett Sinclair
Associate, Senior Hydrogeologist

BS/CH/dj

Attachments: Copy of Appendix 3 to report issued by Kingett Mitchell (1995).
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Appendix 3

Water balance calculations

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1. Introduction

One of the more important factors of any conceptual groundwater model is that of groundwater recharge. Recharge and groundwater seepage back into surface water is a distinct part of the terrestrial hydrological cycle. Portions of the rain falling in any catchment will leave the catchment by way of evapotranspiration, overland flow following rain, infiltration of excess soil moisture to groundwater, riparian evaporation and stream flow. The soil, groundwater and surface water systems have varying degrees of storage capacity or delayed yield. Over a long period the storage factors are however negated. Inflows and outflows from the catchment recorded over a long period of several years should balance.

1.1 Rainfall and Evaporation

Rainfall records dating back to January 1959 are available for Glendale Station, located at the headwaters of the NBWR. The long term mean annual rainfall for Glendale for the period January 1959 to December 2001 was 629 mm (KML, 2002).

The median open water annual evaporation has been estimated for the Macraes area at 1064 mm based on pan evaporation data collected from the site for the period January 1993 to September 2004.

1.2 Reported Recharge Calculations

In the case of the Macraes Gold Project, the water balance has been assessed in connection with past groundwater investigations.

A pre-mining water budget for the catchments of tributaries to Deepdell Creek that drain the mine site was determined through analysis of the hydrographs for the tributary streams and Deepdell Creek (GCNZ 1988). It was determined that about 14% of the mean annual rainfall contributes to runoff from the schist catchments. The other 86% is lost through evapotranspiration. Of the runoff, 20% (3% of annual rainfall) was considered to be direct runoff with the other 80% (11% of annual rainfall) being delayed flow. Base flow runoff was estimated to be less than 0.2% of the mean annual rainfall.

Based on this work a subsequent analysis indicated that about 17% of the mean annual rainfall reports as catchment runoff, with the remaining 83% lost through evapotranspiration (WWC 1992). The analysis also indicated that under pre-mining conditions 20% of the runoff (3% of the annual rainfall) reported as direct runoff with the remaining 80% (14% of the annual rainfall) reporting as delayed flow and base flow. On this basis, surface recharge to groundwater which contributed to delayed and base flow in the regional drainage system was calculated to be between 77 and 85 mm/year (WWC 1992). Of this the recharge to deep groundwater was considered to be very small.

Subsequent re-evaluation of the open water evaporation rates indicated that the earlier water balance calculations for the site significantly over-estimated the groundwater recharge, with a corrected estimate of about 30 mm being documented (WWC 1997).

Modelling of the groundwater system at the MGP by Kingett Mitchell (KMA, 2002) indicated the maximum viable recharge rate for the site was about 60 mm/year. The observations against which the model was calibrated could however also have been replicated using a groundwater recharge value of considerably less than 60 mm/year applied to the same model. This value was however utilised for modelling purposes due to the conservative projections of mass flux to the surrounding drainage systems.

Due to anomalies in the water flows reported for monitoring points at the site, the water budget for the Macraes Gold Project site was re-evaluated during 2004, with the results documented in this report.

1.3 Groundwater Recharge Review Methodology

Two independent techniques were applied:

- Soil moisture balances are an established approach to estimating the partitioning between precipitation, evaporation and soil moisture excess. The lumped parameter soil moisture balance technique of Thorpe and Scott has been reviewed against weighing lysimeter records and other proprietary computer models. It was found to be effective in estimating the long-term soil moisture balance using either daily or monthly climate totals, and soil capacity parameters.
- The hydrograph of any continuous stream flow record may be separated to estimate the portions of flow contributed by surface flow across the land surface (runoff) and groundwater. The hydrograph separation technique recognises that the two sources of contribution to total stream flow have distinct reservoir characteristics that can be differentiated. To assist with this differentiation a computer code named Australian Water Balance Model (AWBM) was used.

Rainfall for the Deepdell Creek catchment was compared to that of a comparable catchment for which a stream hydrograph was available. Using this comparison to determine the base flow for Deepdell Creek, and an independent assessment of the soil moisture balance for the catchment, a new value of 32 mm/year was calculated for surface recharge to groundwater. The data utilised, methodology and results are discussed in Sections 5.4 and 5.5.

The runoff characteristics of the North Branch Waikouiti River catchment probably differ from those of Deepdell Creek, given the lower topographic and stream gradients in this catchment. For this study, it is however assumed that the infiltration characteristics are the same. This assumption has been used in previous studies (KML, 2002).

The hydrograph of any continuous stream flow record may be separated to estimate the portions of flow contributed by surface flow across the land surface (runoff) and groundwater. The hydrograph separation technique recognises that the two sources of contribution to total stream flow have distinct reservoir characteristics that can be differentiated. To assist with this differentiation a computer code named Australian Water Balance Model (AWBM) was used.

Using these independent techniques, the period from January 1995 to December 2000 was selected for concurrency of raw data (rainfall, evaporation and flow). All measurements lay within the Deepdell catchment. A parallel hydrograph separation was undertaken on Nenthorn Stream, which shares a watershed with Deepdell Creek in the vicinity of Stag Hill approximately 3 kilometres to the south of the Macraes mining area.

2. Groundwater Recharge Calculations

2.1 Soil Moisture

2.1.1 Soil moisture equation

The soil moisture used employs an implementation of the lumped parameter sequential calculation as outlined by Thorpe and Scott (1999). The balance considers a soil moisture store with a finite Available Water Capacity (AWC), often likened to field capacity. Measured pan evaporation is converted to potential evaporation with the use of a 'pan factor' relevant to a reference crop, in this case perennial grass cover. The potential evaporation is integrated with the soil moisture balance by the use of a ratio of soil moisture and available water capacity in a so-called 'choking factor'. The choking factor moderates the actual evapotranspiration to a level consistent with the moisture stored in the soil.

The soil moisture balance is represented in the form of the following equation:

$$S_i = S_{i-1} + R_i + I_i - AET_i - D_i$$

Where:

S_i	=	Soil moisture (mm)
S_{i-1}	=	Soil moisture the month prior (mm)
R_i	=	Rainfall (mm)
I_i	=	Irrigation (mm)
AET_i	=	Actual Evapotranspiration
D_i	=	Drainage through soil or runoff (mm)

Monthly data stadia were used in the 6 year water balance. Although, the lumped parameter soil moisture balance technique was developed for use with daily data, testing and comparison with month totals has shown there to be little loss in accuracy. The pan evaporation data collected at the Macraes mining area since 1992 was used. Rainfall measured at the Golden Point hydrological recorder since 1992 was used to seed the moisture balance model. An available water capacity of 75 millimetres was used. This value was considered representative of the upland soils found across the Deepdell catchment.

2.1.2 Soil moisture balance results

A comparative plot of modelled excess soil moisture in the Deepdell catchment and smoothed creek flow over the same period is presented in Fig. 2.1. From this it can be seen that the soil moisture excess is largely restricted to the winter months, although one pulse is shown in January 2000. Depth equivalent creek flow as measured in Deepdell Creek at Golden Point is less than soil moisture excess, averaging 55 millimetres

per annum. Soil moisture excess averages 61 millimetres over the same period.

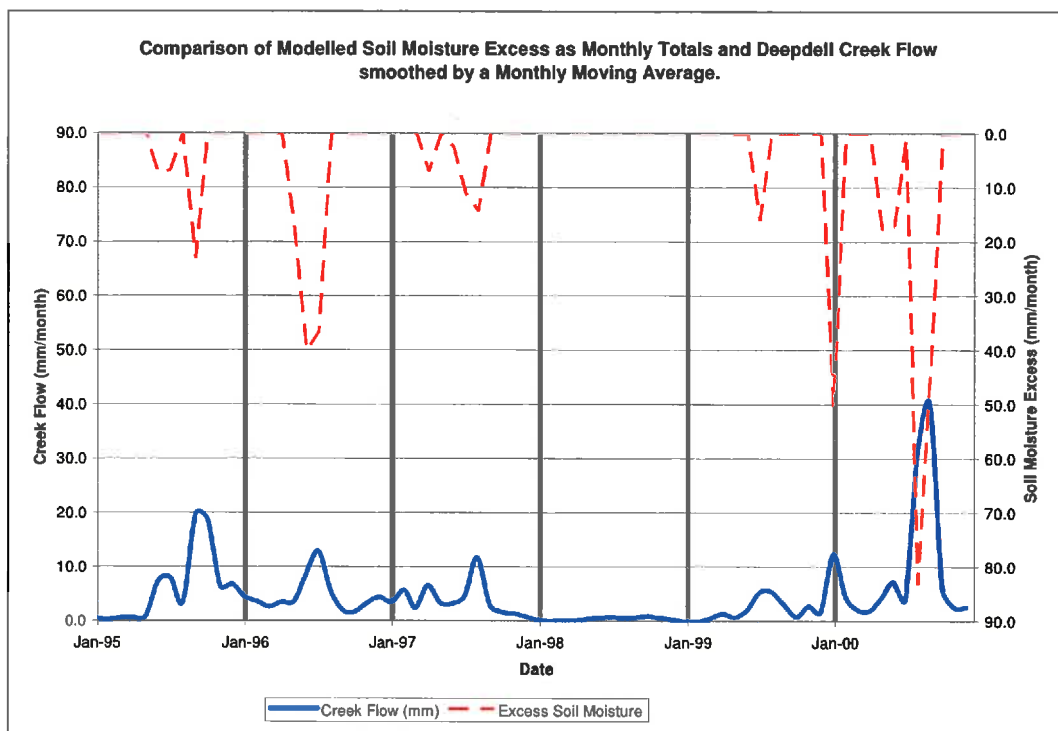


Fig. 2.1: Calculated soil moisture excess for Deepdell catchment.

The correlation between periods of soil moisture excess, which promotes direct surface runoff and recharge and increases in flow of the creek, is also illustrated in Fig. 2.2. Outside the periods of soil moisture excess, creek flow is sustained by the seepage of groundwater, also known as baseflow.

2.2 Hydrograph Flow

2.2.1 Components

Hydrograph separation of direct surface (hortonian) and subsurface (baseflow and interflow) components is illustrated in Fig. 2.2.

The critical time period for the resolution of these curves is estimated by $N = 0.827A^{0.2}$, where A equals the catchment area in square kilometres. The area of the Deepdell catchment is 42.4 square kilometres, and the critical period is thus 1.7 days. Since the time step for baseflow analysis is to be 1 day, the discrimination of 1.7 day rates of change is feasible.

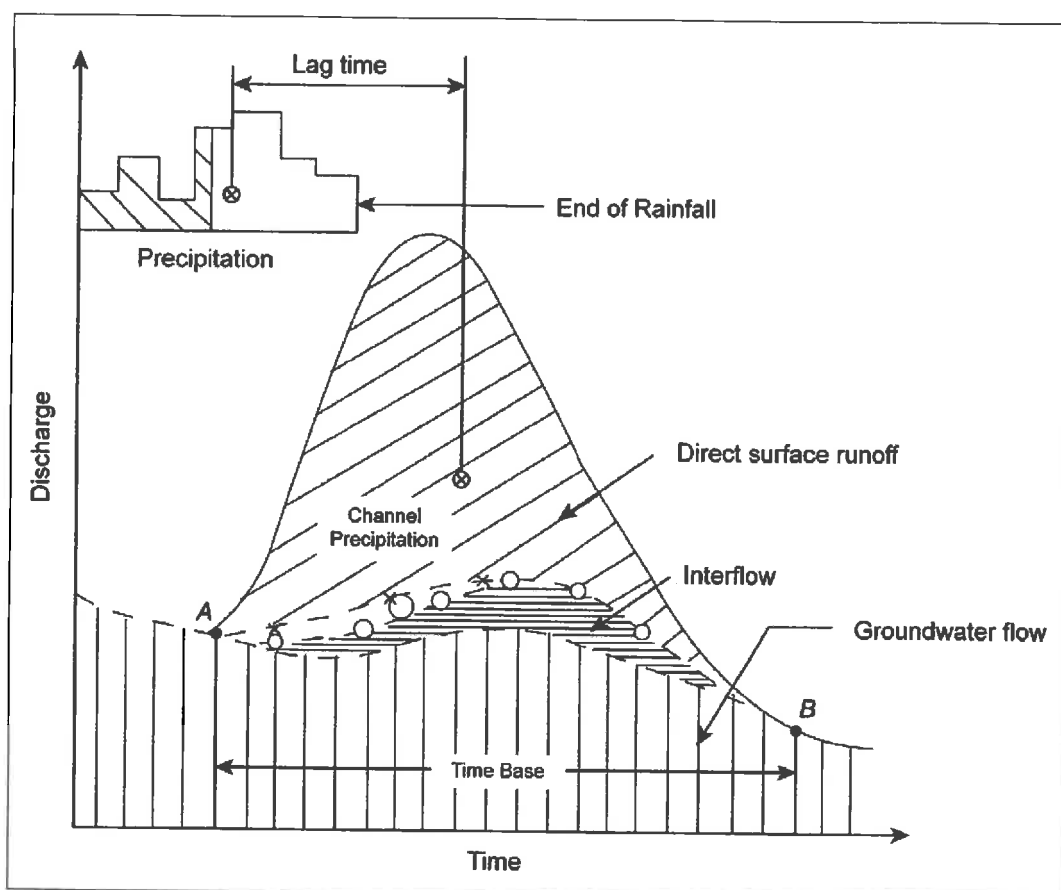


Fig. 2.2: Schematic representation of direct surface flow and baseflow.

The Nenthorn Stream catchment has a larger area of 213 square kilometres above the Mt Stoker gauging site, and an N value of 2.4 days. A comparison of the baseflow index estimated in the larger Nenthorn Stream catchment with that of Deepdell Creek would indicate any errors due to scale dependence.

The daily mean flow values for the six year period from 1995 to 2000 was used for initialising the hydrograph separation of Deepdell Creek. This period was selected in order to maintain consistency with the Deepdell catchment soil moisture balance. For hydrograph separation of the Nenthorn catchment, a longer 10 year period was available from 1 April 1994 to 31 March 2004. This data was used to initialise the baseflow separation.

The NEWBFLOW module of AWBM was run for each data set. In each case the best fit line as selected by the programme was accepted the coefficients recorded. The daily baseflow and direct surface values were exported to a data file for editing in a spreadsheet.

2.2.2 Hydrograph separation results

The flow records of Nenthorn Stream and Deepdell Creek were run in the AWBM code and the parameters derived are presented in Table 2.1

Table 2.1: Flow characterisation parameters for Nenthorn Stream and Deepdell Creek.

Catchment	Baseflow Index (BFI)	Recession Coefficient (K)	Total stream flow (mm/yr)	Surface runoff (mm/yr)	Base flow (mm/yr)
Nenthorn Stream (1994-2004)	0.44	0.90	126	70	56
Deepdell Creek (1995-2000)	0.47	0.92	55	29	26

The hydrograph separation results indicate reasonable consistency between the two watersheds in terms of BFI and recession coefficient. However, the Nenthorn Stream catchment yields substantially greater total stream flow than Deepdell Creek. This is likely to be a consequence of the contrasting topography and rainfall aspect of the Nenthorn Stream catchment. The similarity in the geology of the Nenthorn and Deepdell catchments appears to be reflected in the consistency in BFI and recession coefficients, both indicative of hydrogeological interactions with surface water.

2.3 Riparian Evaporation

Riparian evaporation may significantly diminish the apparent groundwater contribution to stream flow. Groundwater contribution is more prominent in the flow record during dry periods and droughts. During these dry periods, often the only contribution that a stream continues to receive is from groundwater. Groundwater systems tend to display a significant degree of storage and delayed yield, delivering seepage to the gaining portions of perennial water courses throughout the year. Despite this groundwater contribution, many Maniototo and Central Otago streams dry up during dry periods, including Deepdell Creek above Golden Point. Deepdell Creek recorded 74 days of no flow in the 1995 to 2000 period, mostly during the late summers of 1998 and 1999. These days of no flow are found in the months of January, February and March of particularly dry years when potential evaporation is at its highest.

The riparian zone is the shallow alluvium and basement rock margins of a stream into which groundwater seepage emerges. When the stream is low, a significant portion of emerging seepage waters are directly evaporated and do not contribute to stream flow. In hot, dry conditions the combined effects low stream flow and high evaporation potential is sufficient to reduce stream to connected pools with minimal flow between

pools. The consequent increase in water and substrate temperature often interacts to accelerate evaporation and entirely stop stream flow. So, although groundwater continues to be contributed to the stream, the effects of riparian evaporation as such so that stream flow fails. Groundwater levels may also decline in response to reduced recharge so that the length of gain stream is diminished.

In an effort to estimate the effect of riparian evaporation on Deepdell Stream, the pan evaporation rate is applied to the riparian zone of Deepdell Creek upstream of Golden Point. In a similar manner to the 'choke' used in the soil water balance, the late summer evaporation is limited in recognition of the fact that evaporation can not be depleted beyond the capacity of the creek to be dehydrated. The following dimensions and parameters used in estimating riparian evaporation are presented in Table 2.2.

Table 2.2: Factors applied to Deepdell Creek catchment groundwater recharge calculation.

Parameter	Units	Value
Length of Deepdell mainstream u/s of Golden Point	m	8,973
Estimated riparian area	m ²	395,040
Estimated catchment area	m ²	42,419,700
Evaporation pan factor	%	110

Riparian evaporation was calculated for each of the 72 months and a total of 6.3 mm per annum averaged across the Deepdell Creek catchment was estimated.

3. Water Balance

A series of water balances can be drawn up from the soil moisture balance and hydrograph separation discussed above. These are represented in the following equations, where all values are presented in units of mm/year.

Water balance based on soil moisture balance

$$\begin{aligned} \text{WB} &= R_i - \text{AET}_i - D_i \\ 0 &= 505 - 444 - 61 \end{aligned}$$

Where: WB = Average annual water balance
 R_i = Total rainfall
 AET_i = Actual evapotranspiration
 D_i = Drainage through soil or runoff

Water balance based on hydrograph separation and riparian evaporation estimates

$$\begin{aligned} \text{WB} &= R_i - \text{AET}_i - Q_s - E_r \\ 0 &= 505 - 444 - 55 - 6 \end{aligned}$$

Where: Q_s = Total surface flow
 E_r = Riparian evapotranspiration

Surface water balance

$$\begin{aligned} \text{SWB} &= Q_s - \text{DSF} - \text{BF} \\ 0 &= 55 - 29 - 26 \end{aligned}$$

Where: SWB = Surface water balance
 DSF = Direct surface runoff
 BF = Baseflow

The balance of the excess precipitation can therefore be represented as follows:

$$\begin{aligned} D_i &= \text{DSF} + \text{BF} + E_r \\ 61 &= 29 + 26 + 6 \end{aligned}$$

In this manner, the two independent water balance systems show themselves to be consistent with each other.

As the surface water measured at the Golden Point recorder did not include the riparian evaporation, the estimation of long-term groundwater recharge needs to take this into account. There are two components of groundwater contribution, the groundwater contribution in baseflow and the groundwater contribution removed from the creek flow before it can be measured. These components need to be added together in order to estimate the original groundwater recharge. Hence, the groundwater recharge is calculated to be 32 mm/year for the period 1995 – 2000.

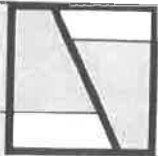
4. Conclusions

Past groundwater models and discharge estimates have been based on regional groundwater recharge rates of up to 85 mm/year.

Due to anomalous discharge flows recorded at several points around the Macraes Gold Project site, it is considered that this value is an over estimate.

Calculations of groundwater recharge based on stream hydrograph records and soil water balance models indicate groundwater recharge is likely to be about 32 mm/year.

This result supports the recharge value of about 30 mm/year documented by Woodward Clyde (WWC 1997) and indicates that earlier estimates generally overstated the recharge by 100% or more.



Ocena Gold (New Zealand) Ltd
PO Box 5442
DUNEDIN 9058

22 June 2016

Attention: Jackie St John

Dear Jackie,

**RE : MACRAES CORONATION NORTH PROJECT
EROSION AND SEDIMENT CONTROL
RESPONSE TO s92**

Further to your email dated 16 June 2016 with attached Tonkin & Taylor (T&T) letter dated 13 June 2016 including s92 request for additional information we comment as follows using the same item numbering as given in T&T's letter. Our comments are related to the S92 queries on our ESC and WRS reports for the Coronation North Project.

Item f (Deviation from Auckland Regional Council & Environment Canterbury ECR Guidelines)

The main deviation from Environment Canterbury Guidelines is in the design and detailing of the sediment retention ponds because of the larger catchments required for the Coronation North Project (up to about 20 hectares). Environment Canterbury suggest an upper catchment limit of 10 hectares for the sediment retention ponds included in their guidelines (Auckland Regional Council guidelines restrict the catchment to 5 hectares for essentially the same pond detail). The proposed design of the sediment ponds for the Coronation North Project is more rigorous than that proposed in the above guidelines because of the increased runoff and follows the design approach of a small water retention dam (refer Table 1 of our ESC report). This design approach has been used successfully for existing silt ponds at the Macraes Gold Project.

Item g (Design rainfall events)

The Environmental Canterbury 20% (1 in 5year) ARI 10 hour event using NIWA HIRDS V3 amounts to 55mm rainfall and our design approach using the 24 hour rainfall from a 72 hour duration 2 year ARI storm amounts to 70mm of rainfall. Our approach is therefore more conservative. The hyetograph is not relevant as the 24 hour rainfall used in our design is only to determine the live storage volume assuming no outflow during the design period (ie no flood routing required for the spillway design to determine the live storage).

Item h (Catchments)



The attached Stage 1 to 3 plans show how it is proposed to stage the stormwater runoff control for the Coronation North WRS, together with the total catchment areas (refer also

Figure 5 in the ESC report for location of drains). The storage capacity of all the silt ponds is anticipated to be less than 20,000m³ (dead plus live storage). The drain capacities and silt pond dimensions and details will be determined as part of the detailed design for the Erosion and Sediment Control Plan. This will be carried out in consultation with OceanaGold when more detailed information is available on the haul roads and WRS layout and construction sequence.

Item n (Geometric rules for the WRS)

The final WRS will have a maximum batter slope of 1V:3H with no berms/benches. The crest will be profiled to a minimal camber, generally sufficient to shed water runoff with no significant surface ponding.

During construction the WRS will be raised in a series of lifts with a maximum height of 20m. The tipped WR generally has a maximum slope of about 37 degrees to the horizontal. The next lift is then stepped back such that the final batter slope can be dozed down to 1V:3H.

Item o (Design assumptions for initial WR placement)

The 'stripping and foundation preparation' comprises dozing off the vegetation and topsoil, except in the immediate incised gullies which are left intact. The soil cover is generally very thin and the stripping often exposes the weathered rock. Any soft unsuitable zones are undercut.

No specific 'coarse rock fill' is selected for placement in the gullies. However, when tipping the WR the coarse rock rolls to the bottom of the batter slope and the tipping sequence is worked such that the coarse rock typically ends up in the bottom of the gullies.

The 'initial toe fill' is the first WR lift placed in the bottom of the gullies immediately upstream of the silt ponds/silt control. It effectively levels the area and allows the silt control and clean water diversions to be formalised. It also provides additional silt control protection to the downstream area while carrying out further 'stripping and foundation preparation'.

Item p (Foliation shears)

The shear strength function used in the design report for "shear along foliations and minor faults/shear zones" ($c' = 47\text{kPa}$ and $\phi = 23^\circ$) is based on the back analysis of pit wall stability at the Macraes Gold Project by Pells Sullivan Meynink Pty Ltd. It is feasible that lower shear strength parameters may be relevant within significant shear zones (eg. Footwall Fault) but no such zones were observed daylighting on the slopes, or known to occur around the proposed WRS. Experience on site indicates that shear zones, other than the Footwall fault, are generally not continuous over long distance and the bulk rock strength used for "shear along foliations and minor faults/shear zones" provides a reasonable estimate for design at the Macraes Gold Project.

Item q (Waste rock shear strength function)

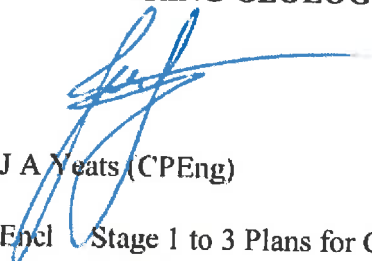
The strength function used for the design of the Coronation North WRS is the same as that used by Engineering Geology Ltd for Coronation WRS, and other WRS at the Macraes Gold Project (Copy of Coronation WRS design report attached).

Item r (Redesign of Coronation WRS)

The report does not include the redesign of the Coronation WRS as the reduced WRS will fall within the envelope of the original WRS design and have the same final batter slopes. Consequently the factor of safety (stability) of the 'redesigned' WRS will be equal to or greater than that of the original WRS design.

Yours faithfully

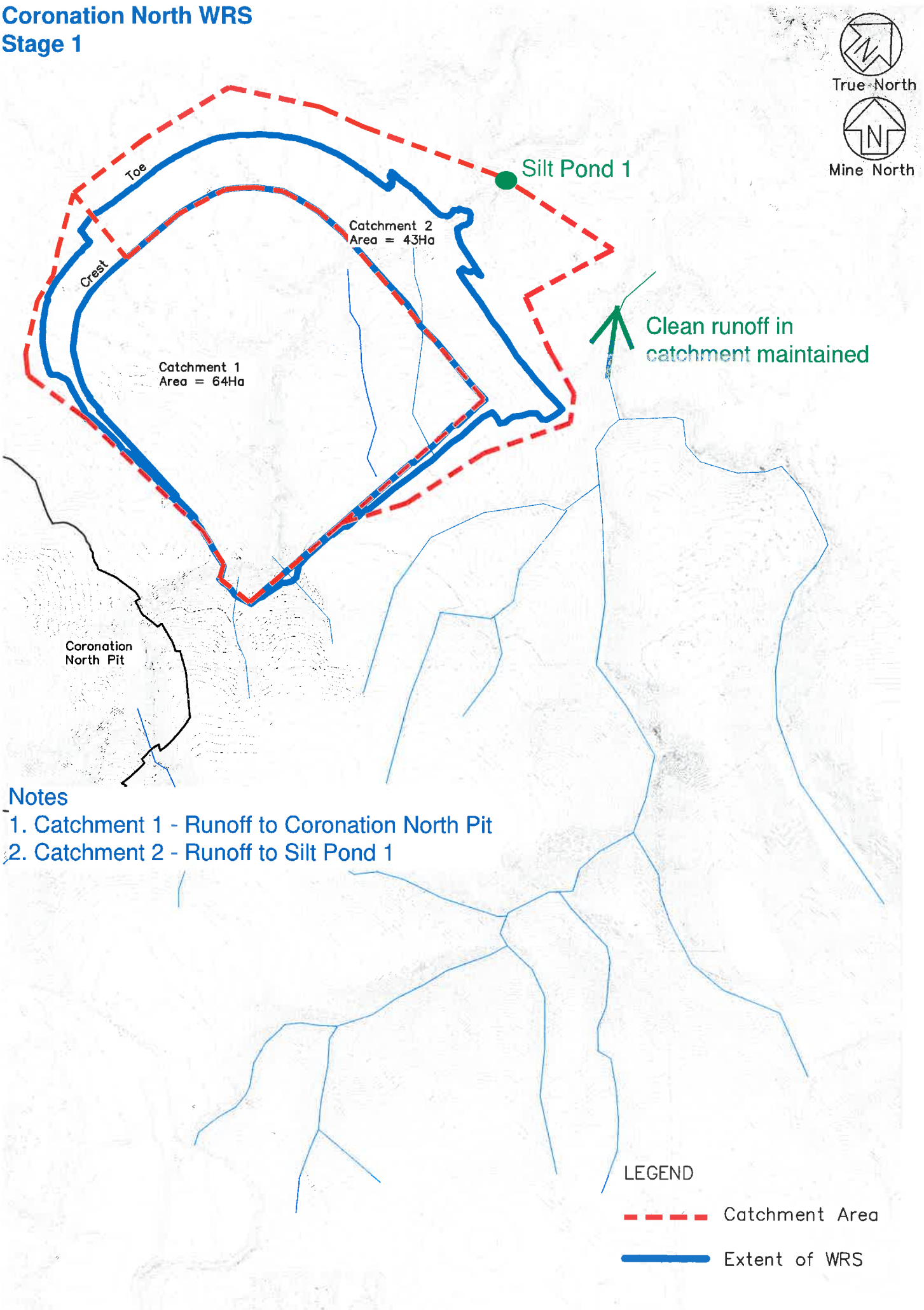
ENGINEERING GEOLOGY LTD



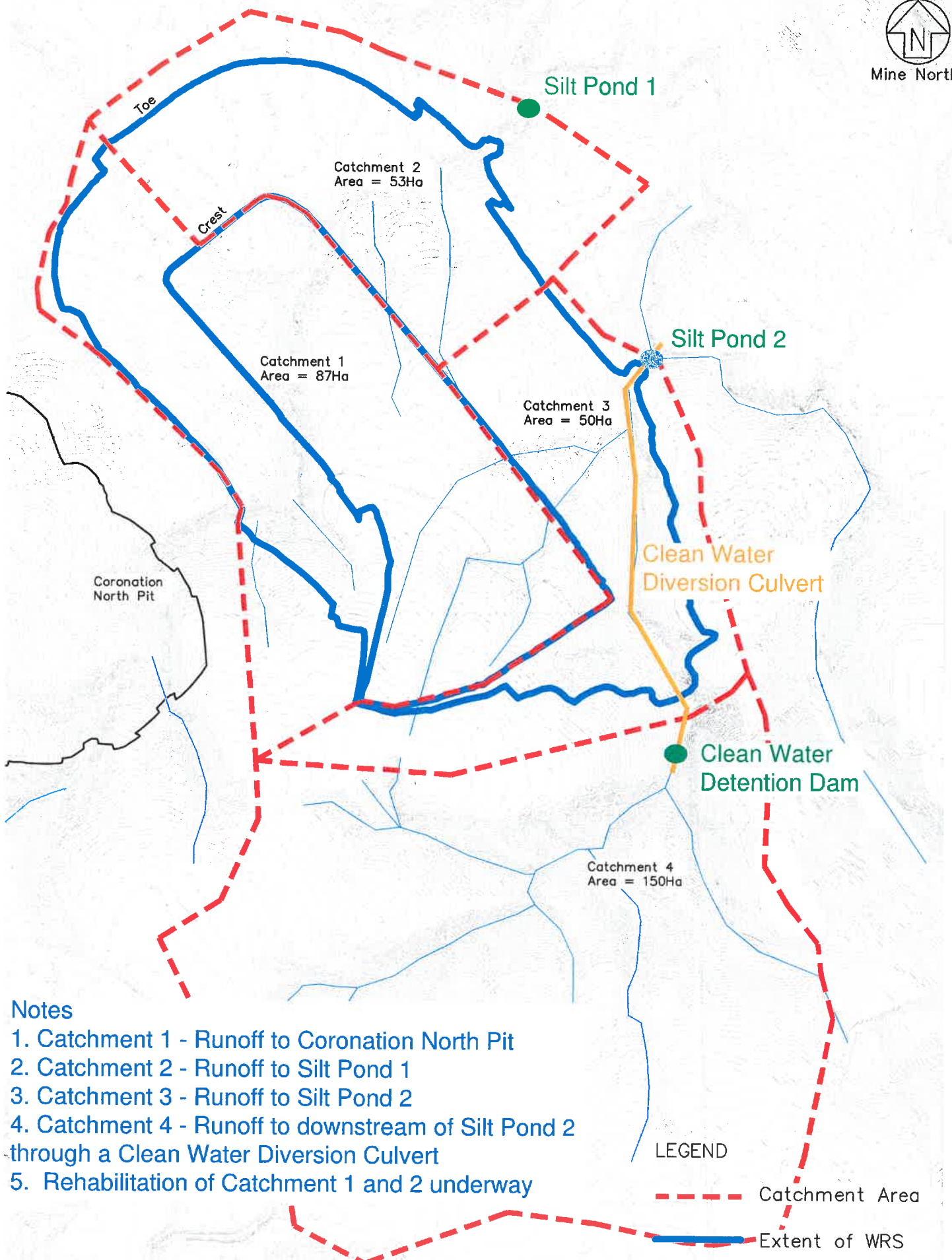
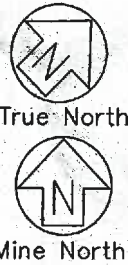
J A Yeats (CPEng)

Encl Stage 1 to 3 Plans for Coronation North WRS
EGL Coronation WRS Design Report (Ref 7703 dated 12.6.14)

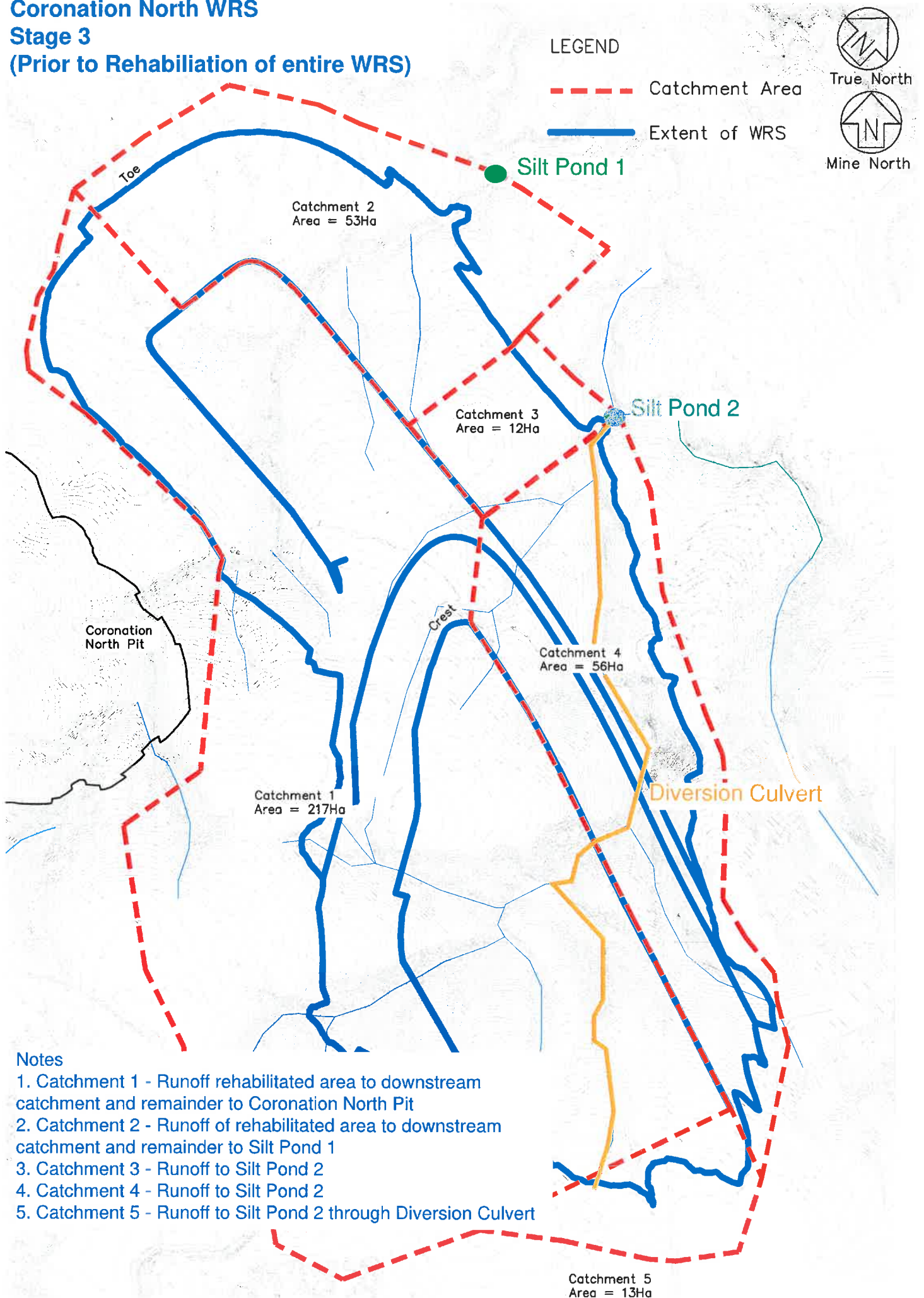
Coronation North WRS
Stage 1



Coronation North WRS Stage 2



Coronation North WRS
Stage 3
(Prior to Rehabilitation of entire WRS)



CORONATION NORTH WASTE ROCK STACK

COMPLIANCE AND MONITORING SCHEDULE

GENERAL PROVISIONS

1. This schedule describes monitoring and sampling required pursuant to consent numbers RM16.XXX.03, RM16.XXX.04 and RM16.XXX.05 in addition to any monitoring specified in those consents.
2. The design of all monitoring and sampling programmes shall be to the satisfaction of the Consent Authority. Where the consent to which the monitoring programme relates, directs that an Operations and Management Plan shall be prepared then the monitoring programme shall be incorporated into that plan.
3. The parameters analysed, site locations and frequency of sampling shall be reviewed as part of the annual review of the management plan for the consent(s) to which this monitoring relates. New parameters, sites and frequencies may be approved by the Consent Authority under an application by the consent holder for a change of conditions for monitoring made pursuant to Section 127 of the Act.
4. All sampling procedures, including collection, transportation of samples and laboratory analyses undertaken in accordance with this consent must be performed to IANZ registered standards, or otherwise as specifically approved by the Consent Authority.
5. Reporting shall be quarterly unless specified otherwise. A quarterly consolidated report containing all sampling and monitoring results shall be submitted to the Consent Authority within one month of the end of the quarter being reported. This report shall highlight any particular features arising from monitoring and sampling and shall provide appropriate commentary on such features.
6. Where a monitoring location is destroyed, engulfed, made redundant or unusable for any other reason, the consent holder shall, in consultation with the Consent Authority:
 - a) discuss and determine whether an alternative monitoring location is required and if so where it should be located; and
 - b) assign a timeframe for establishment of the new monitoring location.

REPORTING OF NON-COMPLIANCE

Any non-compliance with any compliance criteria shall be reported to the Consent Authority within 24 hours of the non-compliance first being detected.

COMPLIANCE CRITERIA

This following describes the compliance criteria pursuant to consent numbers RM16.XXX.03, RM16.XXX.04 and RM16.XXX.05.

(a) Narrative Standard for Receiving Waters

The waters of the Mare Burn, shall at all times be free of contaminants attributable to mineral processing and associated activities in concentrations which adversely affect directly or indirectly water uses or which adversely affect humans, animals, plants and/or aquatic life.

(b) Numerical Compliance Criteria

(i) Mare Burn Compliance Point (MB02)

Surface water within the Mare Burn at the Mare Burn Compliance Point, MB02 (approximately NZTM2000 1392955 4980551) shall not exceed the following water quality compliance criteria (where the metals standards are all soluble determinations), unless infallible evidence can be provided that the level of a parameter is either naturally occurring or unrelated to mining activities:

Constituent	Standard (g/m ³) unless stated otherwise
Arsenic	0.15
Cyanide _{WAD}	0.1
Copper ^a	0.009
Iron	1.0
Lead ^a	0.0025
Zinc ^a	0.12
Sulphate	1,000
pH (range)	6.0 - 9.5 pH units

^a Note: Copper, lead and zinc standards shall be hardness related limits in accordance with the following. Values given in the tables above assume a hardness of 100g/m³ CaCO₃.

$$\text{Copper Limit (g/m}^3\text{)} = \frac{0.96 \cdot e^{\frac{0.8545[\ln(\text{hardness})] - 1.702}{1000}}}{1000}$$

$$\text{Lead Limit (g/m}^3\text{)} = \frac{(1.46203 - [\ln(\text{hardness})(0.145712)]) \cdot e^{\frac{1.273[\ln(\text{hardness})] - 4.705}{1000}}}{1000}$$

$$\text{Zinc Limit (g/m}^3\text{)} = \frac{0.986 \cdot e^{\frac{0.8473[\ln(\text{hardness})] + 0.884}{1000}}}{1000}$$

(ii) Waste Rock – ANC/MPA Ratio

The acid neutralising capacity to maximum potential acidity (ANC:MPA) ratio, as referred to in California Administrative Code Article 7, 1992, shall be greater than 3:1 in rock discharged into the Waste Rock Stack.

MONITORING

(i) Surface Waters

The consent holder shall collect monthly representative water samples from the following surface water sites (as shown on Figure 1):

- (i) Mare Burn Monitoring Point MB01 (approximately NZTM2000 1394176 4980401);
- (ii) Mare Burn Compliance Point MB02 (approximately NZTM2000 1392955 4980551);
- (iii) Coal Creek Monitoring Point CCMP01 immediately upstream of the confluence with the Mare Burn (approximately NZTM2000 1392985 4980236).

All surface water sampling shall occur on the same day.

Samples shall be analysed for the following parameters:

Constituent	Monthly
Major cations:	
calcium	✓
magnesium	✓
potassium	✓
sodium	✓
Major anions:	
bicarbonate	✓
carbonate	✓
chloride	✓
sulphate	✓
pH	✓
Conductivity	✓
Arsenic	✓
Copper	✓
Iron	✓
Lead	✓
Zn	✓
Cyanide (WAD)	✓

With the prior written approval of the Consent Authority, the consent holder may reduce the frequency of monitoring or the number of contaminants being monitoring in accordance with the table above where it is shown that maintenance of the original monitoring programme is not required. The Consent Authority may, by notice in writing at any time, require the consent holder to resume the monitoring programme as set out in the table above.

(ii) Waste Rock Stack Seepage

The consent holder shall obtain representative samples of groundwater seepage from the toe of the Coronation North Waste Rock Stack at the following points (as shown on Figure 2):

- Trimbells Gully (at the main waste rock stack seepage point);
- Maori Hen Gully;
- Coal Creek 1; and
- Coal Creek 2.

Construction of the waste rock stack will be progressive therefore commencement of monitoring of groundwater seepage will be dependent on a) waste rock being deposited in the catchment of each seepage collection point

(as shown on Figure 2) and b) there being sufficient seepage water discharged to allow a sample to be collected.

Samples shall be analysed for the following parameters at the following intervals:

Constituent	Monthly	Quarterly
Major cations:		
calcium	✓	
magnesium	✓	
potassium	✓	
sodium	✓	
Major anions:		
bicarbonate	✓	
carbonate	✓	
chloride	✓	
sulphate	✓	
pH	✓	
Conductivity	✓	
Copper		✓
Iron		✓
Lead		✓
Total Inorganic Nitrogen		✓
Arsenic		✓

(iii) Waste Rock Stack Seepage Flow Monitoring

The consent holder shall install and operate a flow monitoring station at the main waste rock stack seepage discharge point in Trimbells Gully.

The flow monitoring system installed shall be capable of providing a continuous flow record in an electronic format.

The final location and method of flow monitoring shall be determined in consultation with the Consent Authority. If the Trimbells Gully site is deemed unsuitable, the location of the flow monitoring station shall be moved to another toe seepage point following consultation with the Consent Authority.

(iv) Waste Rock ANC/MPA Ratio

The consent holder shall, at monthly intervals collect representative samples of waste rock from the Coronation North Waste Rock Stack.

(v) Aquatic Biological Monitoring

The consent holder shall engage a suitably qualified and experienced freshwater biologist to design and undertake an aquatic biological monitoring programme.

Biological monitoring shall be undertaken at the following sites as shown on Figure 3:

- Mare Burn at MB02 (approximately NZTM2000 1392955 4980551); and
- Mare Burn at MB01 (approximately NZTM2000 1394176 4980401).

Monitoring of macro-invertebrates and periphyton shall be carried out at each of the sites on one occasion during each of the following periods each year:

- December to February inclusive;
- March to May inclusive;
- June to August inclusive; and
- September to November inclusive

(unless there are insufficient flows to support any significant aquatic community). A flow reading shall be completed on each monitoring occasion.

Macroinvertebrate sampling shall include calculation and consideration of Macroinvertebrate Community Index (MCI) and its semi-quantitative variant (SQMCI).

An annual electric fishing survey shall be carried out at each of the sites (unless there are insufficient flows) during the period 1 February to 31 March inclusive. A flow reading shall be completed at each site. Within six months of the exercise of any of the consents to which this schedule is attached, a standard electric fish surveying method shall be developed in consultation with the Consent Authority and documented. This method shall be followed for every subsequent fish survey undertaken in accordance with this schedule.

All aquatic biology monitoring shall be undertaken during low or stable flows.

ComponentstobeMonitored

1. Benthic macro-invertebrates - the taxonomic composition and abundances shall be monitored at all sites.
2. Fish - the taxonomic composition and abundances of fish shall be monitored by an electric-fishing survey at each of the sites.
3. Benthic Algae - a qualitative assessment of the height and percentage cover of dominant species of benthic algae shall be made at all sites.

Figure 1 – Surface Water Quality Monitoring Sites

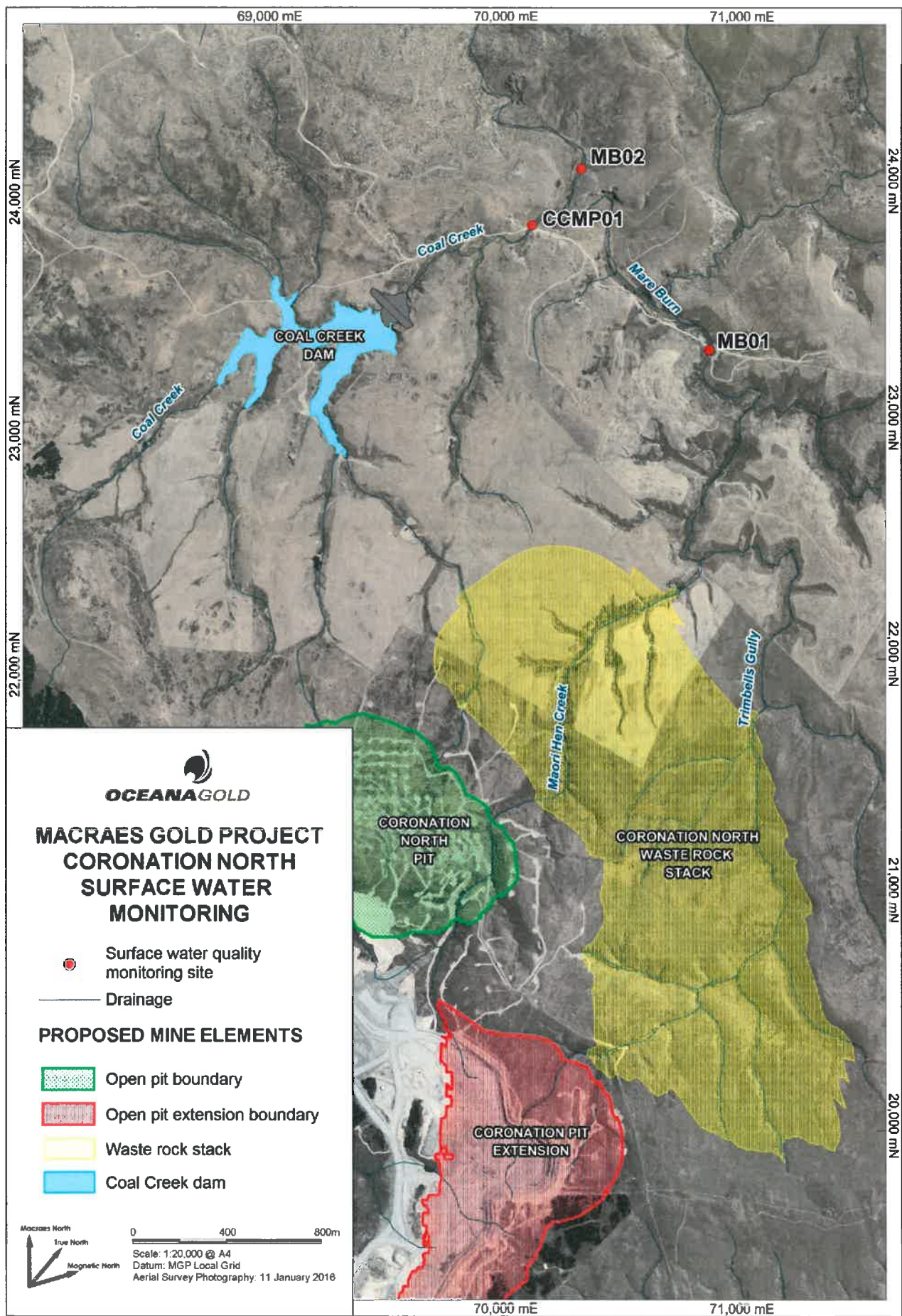


Figure 2 – Coronation North Waste Rock Stack Seepage Monitoring Points

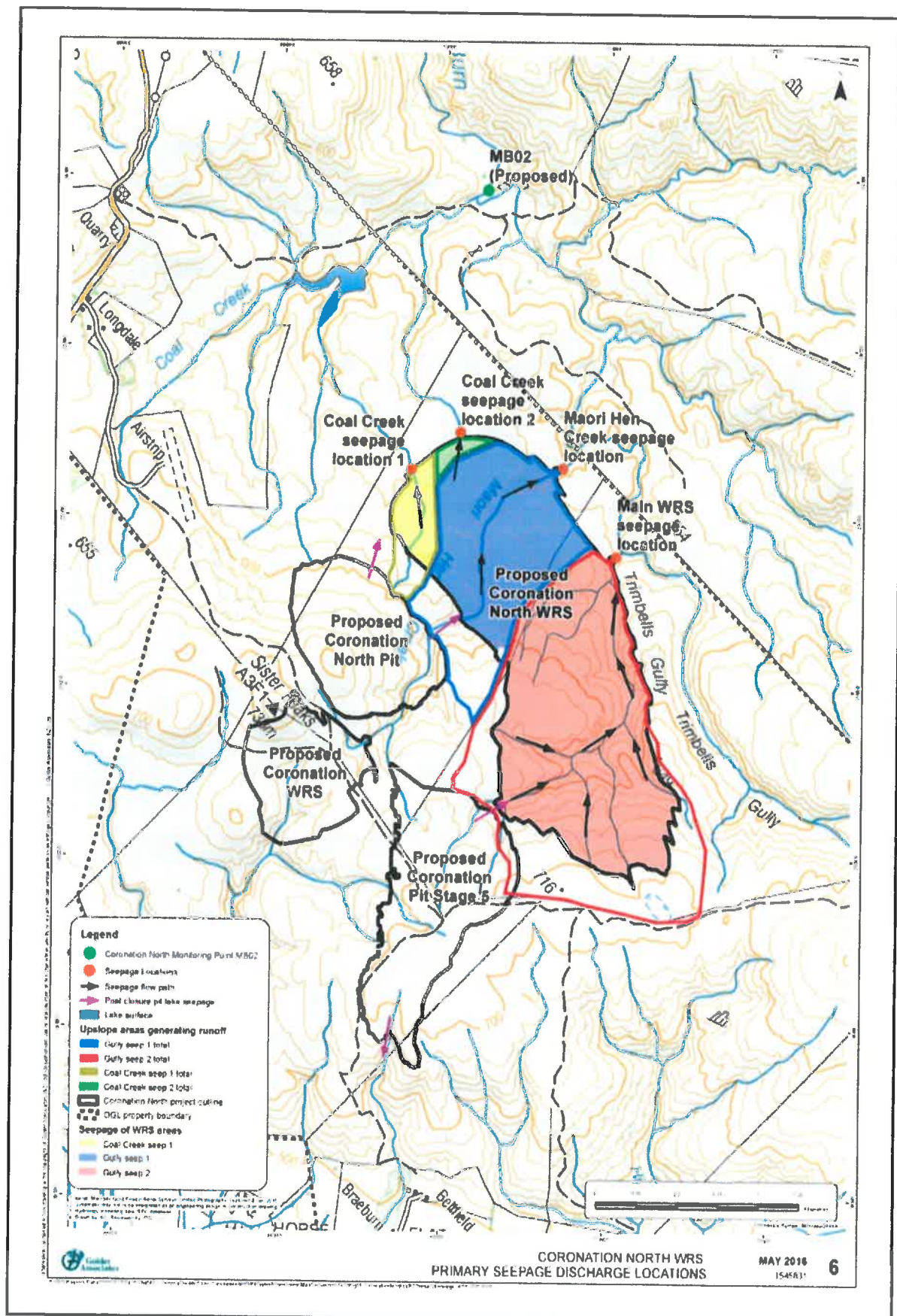
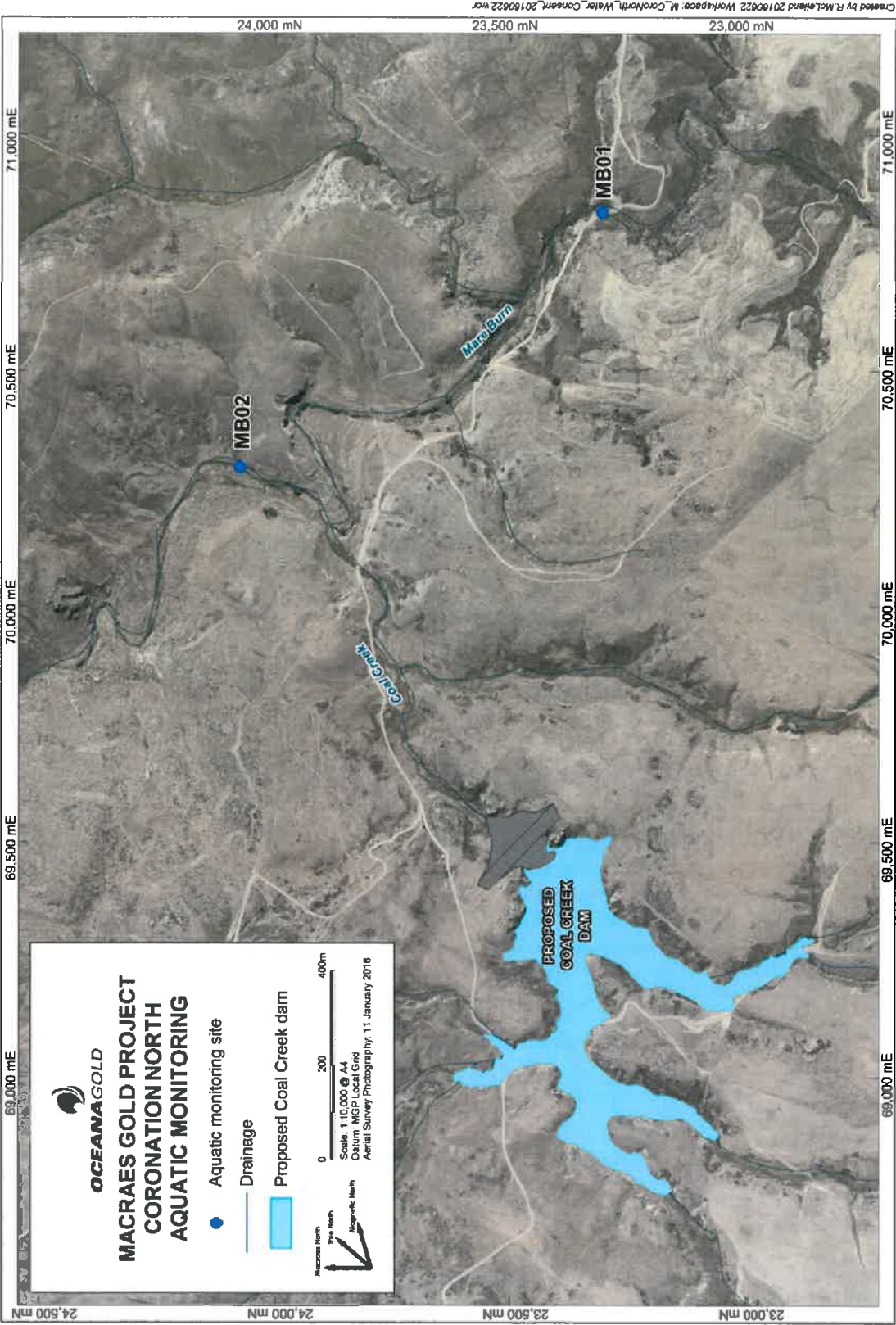


Figure 3 - Aquatic Monitoring Sites



different here than in the other pits at Macraes. No structural or geotechnical data exists for Coronation North.

Given the geotechnical uncertainty of the Coronation North area, the base risk is generally higher than for the other pits. However, the pit design produces relatively shallow walls so the risk is generally considered to be moderate. The exception is the south-eastern end of the pit which abuts a steep gorge. A confluence of major lineaments also is inferred to affect this end of the proposed pit.

A detailed review of the qualitative risk for the slope sectors is presented in Appendix A.

3.3 Recommendations

The geotechnical model for Coronation North needs to be developed to reduce the uncertainty of conditions.

- Seven boreholes have been planned to target the proposed pit walls, in particular the south-eastern end of the pit (Reference 3).
- Structural interpretation of major structures needs to be carried out.

4 CORONATION

4.1 Design

The recommended slope design for the Coronation pit comprised (Reference 2):

- The top two 15 m high benches were expected to be in weathered rock mass and hence were to be battered at 50°
- Southern and northern walls
 - 15 m high, 70° batters and 7.5 m wide berms producing a 60 m high 49° (toe to toe) inter-ramp slope
- Eastern and western walls
 - 15 m high, 60° batters and 7.5 m wide berms producing a 60 m high 43° (toe to toe) inter-ramp slope.
- An alternative batter geometry of 22.5 m high batters and 11.5 m wide berms was suggested.

Reviewing the three stages of pit development, which are shown in plan in Figure 7 and in section in Figures 8 to 10, confirms that the designs are in keeping with the above recommendations. Specifically,

- The upper-most batters in the weathered zone are 50°
- Generally 22.5 m high batters and 11.5 m wide berms are used.

4.2 Risk Assessment

4.2.1 East Walls

A number of existing failures on Coronation Stage 1 east walls have been caused by north-south trending, westerly dipping faults (Reference 4). The instability associated with these structures includes wedge failures and cracking. As these faults are expected to be continuous at pit scale, it is likely that the east walls of the proposed Stage 2 and 3 pits will also experience instability.

A number of unfavourably oriented slope sectors for Coronation east walls are included in Stages 2 and 3. These slope sectors are at risk of wedge and planar failure from north-south trending moderately west dipping fault and shear structures. They are identified in Appendix B and shown in Figures 11 to 12 as having a high risk of instability.

Figure 7 shows that Fault B may also influence the stability of east walls. This structure does however dip to the east and therefore into the wall.

- Fault B is generally located behind the eastern wall of Stage 2 however, the distance varies from daylighting to approximately 200 m
- Fault B strikes obliquely across the eastern wall of Stage 3. Localised bench scale failures can occur particularly if moderate west dipping fault and shear structures are also present.

4.2.2 West Walls

The west walls generally follow the Hanging Wall Shear (HWS) and are off-set at least 50 m from the Footwall Fault (FF) for each stage, refer to the sections in Figures 8 to 10. Past experience indicates that this off-set distance does not result in significant displacements along the FF. The FF is therefore not likely to pose a major risk to the stability of Coronation west walls.

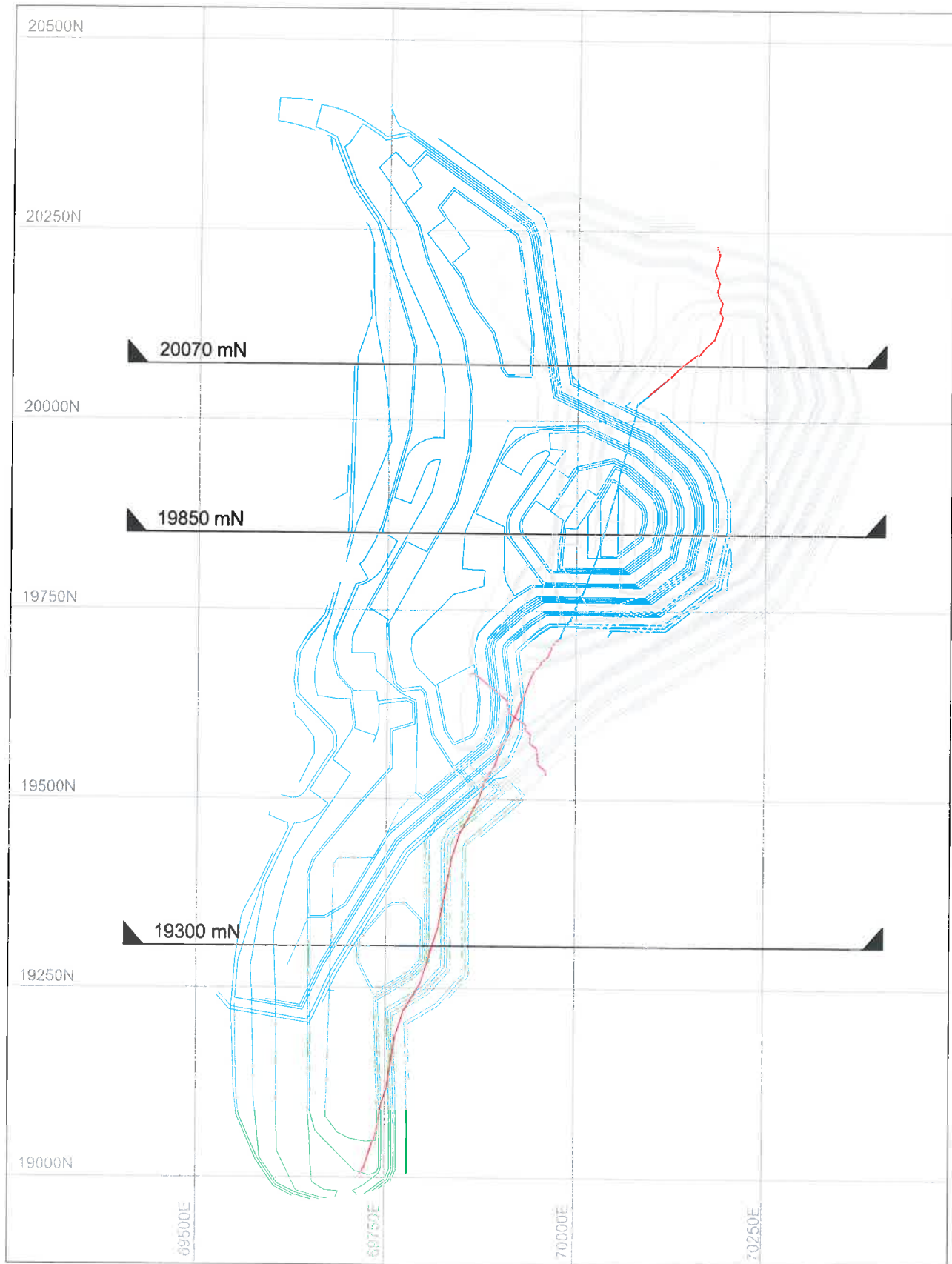
Fault B poses a minor risk to the stability of the access road on the western wall of Stage 4. This fault strikes obliquely across the western wall, outcrops along the access road and its dip is also sympathetic to design batter angles. There is a risk of failure though as the slope angles are shallow, the risk is considered low.

A detailed review of the qualitative risk for each slope aspect is presented in Appendix B.

4.3 Recommendations

The impact of the north-south trending faults on the stability of the east wall is known by OceanaGold. It is understood that this risk is being managed by the day-to-day mining operations.

Geotechnical face mapping of east walls is recommended to facilitate the design of future cutbacks and pits.



LEGEND

- Coronation Pit Stage 2
- Coronation Pit Stage 3
- Coronation Pit Stage 4
- Fault A
- Fault B

0 50 100 150 200
Scale (m)



Pells Sullivan Meynink

OceanaGold
Macraes Mine
Geotechnical Review of LOM Design 2015
CORONATION PIT STAGES 2 TO 4
PIT PLAN

PSM71-194R

Figure 7

APPENDIX B

QUALITATIVE RISK ASSESSMENT – CORONATION PIT

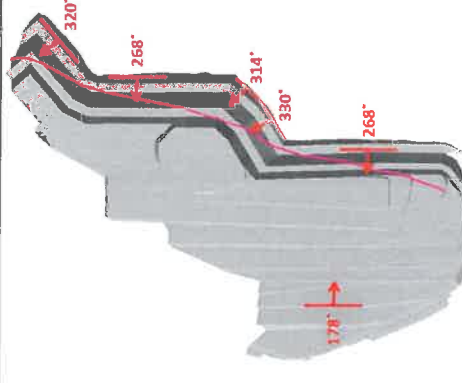
APPENDIX B QUALITATIVE RISK ASSESSMENT – CORONATION PIT

PHASE	SLOPE ASPECT (Azimuth °)	MAXIMUM OVERALL SLOPE HEIGHT (m)	BENCH GEOMETRY			INTER-RAMP ANGLE (°)	QUALITATIVE RISK	LOCATION ON PIT
			BATTER ANGLE (°)	HEIGHT (m)	BERM (m)			
Stage 2	216	42	60	22.5	11.3	42	Low	
	262	45	60	22.5	11.3	43	Low	
	206	55 – 98	60	22.5	11.3	42	Low	
	224	104	50 & 60	22.5	11.3	42	Low	
	272	112	50 & 60	22.5	11.3	43	Low	
	324	115	50 & 60	22.5	11.3	41	Low	
	001	104	50 - 70	22.5	11.3	47	Low	
	322	55	50 & 60	22.5	11.3	42	Low	
	268	61	50 & 60	22.5	7.5 - 11	43	Low	
	320	47	50 & 60	15	7.5	41	High - wedge failure associated with N-S trending west dipping faults.	
	301	40	50 & 60	15	7.5	39	Moderate	
	010	28	60	22.5	12.4	43	Low	
	105	28	50 & 60	8	22.3	25	Low	
	099	90	50 & 60	2 - 10	12 - 22.3	15	Low	
	070	45	50 & 60	2 - 10	15 - 32	15	Low	

N.B. Fault B represented by magenta line.



APPENDIX B Cont.
QUALITATIVE RISK ASSESSMENT – CORONATION PIT

PHASE	SLOPE ASPECT (Azimuth °)	MAXIMUM OVERALL SLOPE HEIGHT (m)	BENCH GEOMETRY			INTER-RAMP ANGLE (°)	QUALITATIVE RISK	LOCATION ON PIT
			BATTER ANGLE (°)	HEIGHT (m)	BERM (m)			
Stage 3	320	51	50 & 60	22.5	11.3	40	High (Possible wedge failure associated with N-S trending west dipping faults)	
	268	60	50 & 60	22.5	11.3	42	High (Possible planar failure associated with N-S trending west dipping faults)	
	314	58	50 & 60	22.5	11.3	42	High (Possible wedge failure associated with N-S trending west dipping faults)	
	330	55	50 & 60	22.5	11.3	41	High (Possible wedge failure associated with N-S trending west dipping faults)	
	268	44	50 & 60	22.5	7.5	44	Low	
	178	35	60	25.5	7 - 25	11	Low	

N.B. Fault B represented by magenta line.

**APPENDIX B Cont.
QUALITATIVE RISK ASSESSMENT – CORONATION PIT**

PHASE	SLOPE ASPECT (Azimuth °)	MAXIMUM OVERALL SLOPE HEIGHT (m)	BENCH GEOMETRY			INTER-RAMP ANGLE (°)	QUALITATIVE RISK	LOCATION ON PIT
			BATTER ANGLE (°)	HEIGHT (m)	BERM (m)			
Stage 4	200	71	60	22.5	11.3	43	Low	
	187	82	60	22.5	11.3	35	Low	
	206	90	60	22.5	11.3	42	Low	
	255	100	60	22.5	11.3	47	Low	
	297	105	50 - 60	22.5	11.3	44	Low	
	330	150	50 - 70	22.5	11.3	43	Low	
	318	65	50 & 60	8 - 22	8 - 33	31	Low	
	090	67	50 & 60	2.5 - 17	14 - 20	16	Low	
	060	32	50 & 60	2.5	8	14	Low	

N.B. Fault B represented by magenta line.

