Before a joint hearing of the

Dunedin City Council	**LUC-2016-230 and LUC-2013-225/A**
Otago Regional Council	**RM16.138**
Waitaki District Council	**201.2016.779 and 201.2013.360-1**

Under	the Resource Management Act 1991
In the matter of	applications by Oceana Gold (New Zealand) Limited for resource consents for the Coronation North Project

Statement of evidence of Brett Sinclair for Oceana Gold (New Zealand) Limited

17 October 2016

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Qualifications and experience

1 My name is Brett Andrew Sinclair.

2 I am a Principal Hydrogeologist with Golder Associates (NZ) Limited, an international ground engineering and environmental consulting company. I am a member of the New Zealand Hydrological Society.

3 I completed my Master of Science degree in Geology at the University of Auckland in 1985. I subsequently completed a Postgraduate Certificate in Applied Environmental Geology at the University of Tübingen, Germany, in 1995.

4 As a professional hydrogeologist I am responsible for groundwater resource assessment, management and groundwater modelling. I have extensive experience internationally in assessing the effects of mining on natural groundwater and associated surface water systems, including the evaluation of mine waste disposal and contaminant transport in water across mine sites.

5 I have been involved with the assessment of water flow and water quality effects, and the development of measures to mitigate these effects, related to various components of the Macraes Gold Project (**MGP**) for the past 16 years.

6 I have produced, or have technically reviewed, the following reports and other documents summarising the evaluation of water management at the proposed Coronation North Project and projected effects of the Coronation North Project on water quality downstream from the mine. These documents were included as appendices to the Assessment of Environmental Effects (**AEE**) lodged in support of the resource consent applications for the Coronation North Project

(a) Coronation North Project. Groundwater assessment. Golder report 1548831-002-R-Rev2 – Appendix 5 of AEE;

(b) Coronation North Project. Surface water modelling. Golder report 1548831_7410-003-R-Rev2 – Appendix 4A of AEE;

(c) Coronation North Project. Water quality mitigation – fresh water dam scenario. Golder report 1548831-004-R-Rev1 – Appendix 15 of AEE;

(d) Arsenic and iron mobility in Coronation North Project surface water. Golder letter 1545831_7410-005-LR-Rev0 – Appendix 4B of AEE;

(e) Coronation North Project consent application – groundwater s92 responses. Golder letter 1545831-006;

(f) Coronation North Project consent application – s92 responses. Golder letter 1545831-007; and

(g) Coronation North Project. Water quality effects, management and mitigation. Golder report 1548831-010-Rev1.

7 In preparing this evidence I have reviewed:

(a) The reports of other witnesses giving evidence relevant to my area of expertise, including:

(i) Dale Oram;

(ii) Jeremy Yeats;

(iii) Dr. Greg Ryder; and

(iv) Paul Weber;

(b) The Staff Recommending Report prepared for the Otago Regional Council (**ORC**), dated 5 October 2016;

(c) Draft proposed consent conditions related to water matters;

(d) Submissions lodged on behalf of the following submitters:

(i) Craig & Erin Howard;

(ii) David & Jocelyn Kinney;

(iii) KTKO Limited; and

(iv) Director General of Conservation.

8 I have read the Code of Conduct for Expert Witnesses set out in the Environment Court of New Zealand Practice Note 2014. I have complied with the Code of Conduct in preparing this evidence and agree to comply with it while giving evidence before the Hearings Panel. This evidence is within my area of expertise, except where I state that I am relying on the evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

Scope of evidence

9 I have been asked by Oceana Gold (New Zealand) Ltd (**OceanaGold**) to prepare evidence in relation to water management for the Coronation North Project. In my evidence I present:

(a) A short introduction to the components of the Coronation North Project relevant to water flow and quality management at the project;

(b) A concise overview of the existing environment within the Mare Burn catchment, as is relevant to water flow and water quality, including the existing water quality compliance criteria applicable for existing mining operations in the catchment;

(c) A summary of the assessment undertaken to evaluate the effects of the two proposed opencast pits on the groundwater system and the results of this assessment;

(d) A summary of the surface water and mine water assessment undertaken to provide projections of surface water flow changes in Mare Burn at MB02 and the results of this assessment;

(e) The proposed water quality compliance point for the Coronation North Project and recommendations on the compliance criteria, together with a comparison of the monitored waterborne contaminants generated by the existing MGP to a range of generic water quality guidelines;

(f) A summary of the water quality effects assessment undertaken by Golder on the contaminants that are likely to require management in order to ensure ongoing compliance with the proposed criteria, specifically sulfate, nitrate, arsenic and iron;

(g) The mitigation measures proposed by OceanaGold to enable the Coronation North Project to comply with the proposed consent criteria, both during the operational period of the project and following closure, together with the scheduling of the proposed mitigation measures; and

(h) A summary of further work OceanaGold is planning to undertake, and water quality mitigation options that OceanaGold is already investigating, to manage the effects of the Coronation North Project on downstream water quality.

10 In addition, I present comments on:

(a) Relevant matters from the Staff Recommending Report;

(b) The proposed surface water monitoring programme; and

(c) Submissions in which water quality or availability issues have been raised.

Executive summary

11 OceanaGold retained Golder Associates (NZ) Limited (**Golder**) to undertake evaluations associated with the proposed Coronation North Project covering:

(a) The MGP mine water management system components relevant to the Mare Burn catchment, within which the Coronation North Project is principally located;

(b) The effects of the opencast pits on the surrounding groundwater system in terms of water availability;

(c) Contaminant losses from the site, including from the proposed opencast pits, waste rock stacks (**WRS's**) and other operational areas of the mine;

(d) The effects of these contaminant losses on water quality in the natural water bodies downstream from the MGP;

(e) The effects of contaminant accumulation on long term water quality in the proposed pit lakes; and

(f) Options for the mitigation of potential effects on downstream water quality.

12 The outcomes of these evaluations were used to support the AEE for the proposed mine extension lodged with the ORC (and territorial authorities).

Background

13 Mining operations at the MGP, located in east Otago within the Shag River catchment, were initiated in 1990. The MGP consists of a series of opencast pits and an underground mine supported by ore processing facilities, waste storage areas and water management systems. In 2012 mining operations on the Coronation Project were initiated. The Coronation Project is a northern extension to the MGP, located within the Mare Burn catchment, which forms part of the Taieri River catchment. In general, the Coronation Project consists of the already consented Coronation Pit and Coronation WRS, together with supporting infrastructure.

14 The Coronation North Project (refer to Figure 1 and Figure 2 attached to this evidence), an extension to the Coronation Project, consists of:

(a) An expansion to the already consented Coronation Pit, termed the Coronation Pit Stage 5;

(b) Construction of the Coronation North Pit;

(c) A reduction in the planned extent of the Coronation WRS;

(d) Construction of the Coronation North WRS; and

(e) Extension of existing haul roads and the existing mine water management system within the Mare Burn catchment.

A broader description of the Coronation North Project has been presented in the evidence of Mr Dale Oram.

15 With respect to the management of water and waterborne contaminants at the Coronation North Project, the most important components of the project consist of the construction of the Coronation North WRS and the Coronation Stage 5 and Coronation North pits. The operational mining period for the Coronation North Project is expected to be 3 years, followed by a 2 year site rehabilitation period. Although the Coronation North Project is expected to be constructed, closed and rehabilitated within a five year period, the management of waterborne contaminants derived from the site will need to continue for a much longer period.

16 OceanaGold has undertaken environmental water quality monitoring at the MGP since 1990 and maintained a database of the monitoring results for all of this time. Much of the work undertaken in support of the assessment of the effects of the Coronation North Project on water quality, as summarised later in my evidence, has been based on the data accumulated from on-site monitoring over the past 25 years.

17 OceanaGold also maintains a flow monitoring station at the Golden Point Weir on Deepdell Creek and an on-site climate monitoring station. Data from these two monitoring stations has been used to support modelling of baseline water flows and the effects of the Coronation North Project on flows in Mare Burn. This data has also been used in modelling the effects of the Coronation North Project, and the proposed mine water management measures, on water quality in Mare Burn.

Existing environment within the Mare Burn catchment

Climate and hydrology

18 The MGP lies within the rain shadow of the Southern Alps. As a consequence the average monthly rainfall calculated for the mine site only exceeds evaporation during three winter months in the year (Figure 3). Even in these months the average rainfall only exceeds the potential evaporative losses by small amounts.

19 The Coronation North Project is located within the headwaters of the Mare Burn catchment, specifically within the catchments of Trimbell's Gully, Maori Hen Creek and Coal Creek, all of which are minor headwater tributaries of Mare Burn (refer to Figure 2 attached to this evidence). The proposed Mare Burn water quality monitoring and compliance point MB02 is located downstream from the confluences with each of the above tributaries.

20 Stream flows in Mare Burn at MB02 have been evaluated based on data derived from OceanaGold's Golden Point Weir flow monitoring station on Deepdell Creek. Golder's interpretation of topography, catchment layouts, geology and climate

indicates stream flows at these two monitoring points should be comparable relative to their respective catchment areas (29.3 km^2 and 40.8 km^2 for MB02 and Golden Point Weir, respectively).

21 On the basis of comparison with Deepdell Creek, flows in Mare Burn are expected to respond rapidly to substantial rainfall events, generating a hydrograph at MB02 that is very peaky, with rapid increases and subsequent decreases in run-off in response to storm events. Groundwater contributions to the stream base flow are very small, with evaporative losses from the creek bed during dry summers exceeding groundwater discharges to the creeks. These characteristics are reflected in the statistical summary of flows calculated for MB02 provided in Table 1 attached to this evidence. The critical points are that Mare Burn is an intermittent stream with flows ceasing during dry summers and a lower quartile flow of only 7.7 L/s, compared to an average flow of about 78 L/s.

Mine features and mine water management

22 The already consented Coronation Pit and Coronation WRS, together with their water management systems, form part of the environmental baseline for the Coronation North Project. These consented structures have been described in the evidence of Mr Dale Oram, so I will not repeat the description here. It is however important to recognise that these existing features were designed and constructed to enable OceanaGold to meet water quality criteria set by the ORC at the Mare Burn compliance monitoring site MB01. More information on these criteria will be presented later in my evidence.

Water quality

23 OceanaGold has monitored water quality in Mare Burn at MB01 on a monthly basis as part of the MGP environmental monitoring programme since January 2015. A summary of the accumulated data is attached to this evidence as Table 2. This water quality data from MB01 is similar to that of Deepdell Creek upstream from the MGP.

24 In the past OceanaGold has not routinely monitored nitrate nitrogen or ammoniacal nitrogen at MB01, although samples are now being tested for these parameters on a quarterly basis. Non-routine sampling of water from the Coronation Pit sump has however identified elevated concentrations of both contaminants in the pit water. I have been advised by Ms Debbie Clarke, Senior Environmental Advisor at the Macraes Gold Project, that mine water from Coronation Pit is currently only discharged to Mare Burn during periods of high flow in the receiving stream. This is a precautionary measure to minimise the potential effects of these contaminants on Mare Burn, while appropriate management measures are instigated.

Groundwater effects assessment

25 The effects of the Coronation North Project on the surrounding groundwater system have been assessed through identifying a maximum potential area of influence for each pit and a corresponding reasonable area of influence. For both pits these areas of influence have been identified for the end of the operational pit life and for a post-closure stage when the pit lake has formed to the overflow point. These areas of influence have been used to calculate potential groundwater inflows to the opencast pits at different stages of their life and following closure.

26 The maximum possible extent to which each pit can influence the surrounding groundwater system is represented by the maximum potential area of influence at the end of the operational mine life. This area of influence has been calculated by identifying points in each of the gullies surrounding the pit that has an elevation equivalent to that of the final pit floor. Pumping from the opencast pit cannot draw water from areas further down these gullies as this would imply drawing groundwater uphill. These points are then connected to define an oval shape around each pit, representing the maximum area of influence for each pit.

27 The maximum areas of influence for the Coronation Pit Stage 5 and for the Coronation North Pit are presented in Figure 4 and Figure 5 attached to my evidence. The effects of both pits on the groundwater system are limited to the upper catchments of Coal Creek, Maori Hen Creek and Trimbells Gully and a few headwater tributaries to Deepdell Creek. Groundwater bores or springs located outside the maximum areas of influence defined for these two pits at the close of mining operations would not be affected by mining related decreases in water availability from the bore.

28 Groundwater inflows to each pit were calculated by multiplying the area of pit influence by the average rate of groundwater recharge for the MGP area. This recharge has been calculated from soil moisture balance models and stream base flow assessments to be approximately 32 mm per year. This recharge rate has been applied to groundwater models of the MGP that have been used to support past resource consent applications. As the Mare Burn catchment is similar in many respects to other catchments that intersect the MGP, in my opinion this recharge rate is appropriate for use in evaluating the effects of mining on the groundwater system of the Mare Burn catchment.

29 Mining induced groundwater drawdown would potentially decrease groundwater discharges to nearby gullies and streams. This decrease is however not considered to be a significant issue because:

(a) Most of these gullies already carry intermittent flows and are dry in summer;

(b) The potentially affected gullies to the east of the pits are to be infilled by the Coronation North WRS, which will itself act as an artificial aquifer providing a continuous flow of water to Mare Burn;

(c) A few of these headwater tributaries will be cut off from Mare Burn by construction of the pits, and therefore not contribute to flows in Mare Burn; and

(d) The remaining affected gullies are tributaries of Coal Creek, with confluences upstream from the proposed fresh water dam.

30 As far as I am aware, there are no water supply wells located within the maximum potential areas of influence as described above and almost all of the affected land is owned by OceanaGold.

31 Based on the information presented in Golder's assessment of groundwater effects from the Coronation North Project (Golder 2016a), and for the reasons summarised above, it is my opinion that groundwater drawdown resulting from this project will not affect any water supply bores or flows in Mare Burn. David and Jocelyn Kinney have raised a concern about the effect the Coronation North Project may have on springs and streams on their property. I do not consider any effects will arise, and I discuss this later in my evidence.

32 Groundwater drawdown resulting from construction of Coronation Pit Stage 5 will potentially reduce flows in upper tributary gullies of Deepdell Creek. This effect will however be almost exactly the same as the consented effects arising from the existing Coronation Pit and, as such, there will not be a detectable difference from the consented baseline.

Surface water flow effects assessment

33 In preparing this section of my evidence I have relied on catchment water flow modelling work undertaken by other Golder staff using the GoldSim software package and documented in the reports listed in Paragraph 6 of my evidence. I am not a GoldSim modeller, although I reviewed the model input parameters and the results based on my knowledge of stream behaviour at the MGP site. I also had the models reviewed independently by an approved Golder GoldSim model reviewer in Canada. The information presented in this section of my evidence has been summarised from the documents listed in Paragraph 6 of my evidence. From my experience of the hydraulic behaviour of the groundwater and surface water systems at the MGP, I am comfortable that the information presented in this section of my evidence is a reliable reflection of the surface water system at the Coronation North Project.

34 A calibrated surface water model for the Coronation North Project has been developed using GoldSim modelling package. The input data for the flow model, as documented in the surface water model report by Golder (Golder 2016b), was derived from:

(a) Coronation North Project layouts and pit water level / volume / surface area relationships provided by OceanaGold;

(b) Artificial rainfall and evaporation records developed by Golder and based on data from climate monitoring stations in the area of the MGP. These records are extended versions of similar records used to support the consenting of the Macraes Phase III Project (**MPIII**);

(c) A set of run-off coefficients calibrated against the stream flow record from Deepdell Creek. These coefficients are the same as those used in the surface water model developed to support the consenting process for the MPIII;

(d) A WRS average infiltration rate of 32 mm/year. There is some uncertainty regarding the seasonal and weather related variability of this rate, which OceanaGold is seeking to address through undertaking flow monitoring at a seepage discharge point at the toe of an existing WRS. This recharge rate has been used in work undertaken by Golder over the past decade to simulate contaminant loads from WRS areas in the wider MGP and has generated reasonably reliable receiving water quality projections. Individual site observations of WRS seepage discharge rates are also generally in line with what would be expected based on this infiltration rate; and

(e) Groundwater inflows to each opencast pit based on the groundwater seepage flow rates calculated from the areas of influence as described in the previous Section of my evidence.

35 Surface water models were developed to simulate:

(a) The current Coronation Project layout, which constitutes the consented baseline for the project;

(b) The Coronation North Project operational period, assuming both opencast pits are being actively dewatered at the same time; and

(c) The post-closure period, with the objective of evaluating the pit lake development times for each pit and the long term flow patterns in Mare Burn at MB02.

36 In addition, a directly comparable model was developed to simulate the pit lake development in the Deepdell South Pit, to provide a further check on the validity of the capacity of the calibrated run-off parameters to provide reliable projections for pit lake filling times. When this model was run, the modelled rise in pit lake water level corresponded well with the measured rise in water level until the last few metres before overflow, which was probably influenced by increased seepage losses to Deepdell Creek through the pit wall. This outcome provided a further validation of the performance of the surface water model.

37 The model outcomes indicate that:

(a) The Coronation Pit Stage 5 lake will take in the order of 160 years to fill, following which overflow would occur through the base of the Coronation North WRS to Mare Burn; and

(b) The Coronation North pit lake will fill to overflow in around 400 years.

These very long filling times reflect the limited contributing catchment areas outside each pit footprint and the local climate with evaporation exceeding rainfall for much of the year. When considering time periods of this duration there is substantial uncertainty around the late stages of pit filling. In addition, in developing these models it was assumed that the climate patterns of the past 60 years will reflect the climate into the future. For these reasons the calculated filling times should be taken as indicating that the pits will not contribute water or contaminants to Mare Burn, or the Deepdell Creek catchment, for a long time into the future.

38 The simulated changes in surface water flows in Mare Burn at MB02 resulting from changes in operations at the Coronation North Project are summarised in Table 3 attached to my evidence. The baseline flows at MB02 take into account the existing Coronation Pit operation. The key outcome from the modelling is that the contribution of seepage flows from the proposed Coronation North WRS results in the 5^{th} percentile low flows shifting from 0.6 L/s to 3.0 L/s.

39 In effect, the WRS contributes an artificial base flow to Mare Burn, which would also change the stream at MB02 from being intermittent to permanent. The median to high flows in Mare Burn would not be substantially affected.

Proposed water quality compliance criteria for MB02

40 OceanaGold's currently consented mining operation in the Mare Burn catchment, together the wider MGP operations, have been designed and are being undertaken to comply with existing receiving water quality criteria set by the ORC through various past consenting processes. These criteria, which apply at the existing Mare Burn compliance point MB01 and at most of the other surface water

compliance points defined immediately downstream from MGP operational areas, are provided in Table 4 attached to this evidence. OceanaGold is seeking that these existing criteria be applied to the new compliance point at MB02, and this is a difference from the approach being recommended by the reviewer the ORC has engaged in relation to the Coronation North Project.

Water quality effects assessment

41 As I outlined in Paragraph 33 above, in preparing this section of my evidence I have also relied on catchment water flow and contaminant transport modelling work undertaken by other Golder staff using the GoldSim software package and documented in the reports listed in Paragraph 6 of my evidence, along with my review of model input and the outcomes of the model review carried out in Canada.

42 Golder has undertaken an initial comparison of water quality data sourced from the OceanaGold environmental database with generic ecological guidelines suggested by the ORC reviewer. The water quality data relate to:

(a) Seepage water from several existing WRS at the MGP;

(b) Water quality in the Golden Bar and Deepdell South pit lakes, which have been developing for several years; and

(c) Water quality in Deepdell Creek, at the DC07 compliance point downstream from the MGP.

The outcomes from this comparison are summarised in Table 5 and Table 6 attached to my evidence.

43 The water quality data summary provided in Table 5 highlights that dissolved metals in the WRS seepage water and in pit lake water would meet the ecological water quality guideline values listed most or all of the time, without dilution or the need for further mitigation measures. The exception is arsenic in pit lake water, which is discussed later in my evidence. Given the consistency of the water quality data recorded from WRS areas located across the whole MGP, and from the two developing pit lakes, I consider this data to be reasonably reflective of what may be expected from the Coronation North Project in the future.

44 The data presented in Table 5 indicates the primary contaminant of concern with respect to potential ecological effects is sulfate, which is reflected in the proposed water quality compliance criteria for MB02. Nitrate has also been identified as a potential concern with respect to in-stream ecology, as discussed later in my evidence.

45 In considering the WRS water quality data summarised in Table 5 it is important to recognise that these concentrations have effectively been measured in silt ponds at the point of seepage discharge from each WRS. These concentrations do not take into account any additional in-stream dilution that would apply at the catchment compliance monitoring point. These concentrations also do not take into account any mitigation measures that may be instigated to improve the quality of the discharge water. In effect, the water quality data summarised in Table 5 indicates WRS seepage monitored at the MGP is of reasonable quality and would meet most of the ecological guidelines identified. By extension, the same may be expected for WRS seepage water from the proposed Coronation North WRS. The exceptions to this conclusion are sulfate, nitrate-nitrogen and ammoniacal-nitrogen, which I will discuss shortly.

46 For comparison purposes, the water quality monitoring data related to the DC07 and DC08 compliance monitoring points in Deepdell Creek as summarised in Table 6 also indicate that the primary contaminant requiring management in this catchment is sulfate. This reflects the predominant current source of contaminants to Deepdell Creek being the WRS areas within the catchment. A comparison with the British Columbia guidelines for sulfate in water, which are hardness dependent (refer to Figure 6) indicates that the sulfate concentrations in water influenced by the MGP mining operations are below the hardness dependent toxicity guideline values up to concentrations of approximately 400 g/m^3. I have reviewed data from several mine water discharges from the site and the same conclusion is consistently reached. For water with sulfate concentrations exceeding 400 g/m^3 the guidelines recommend testing to confirm site specific effects. I have been advised by OceanaGold that a programme of testing, complemented by some focused galaxid surveys in streams influenced by mine water, is being considered to improve our understanding of the effects of sulfate on galaxids.

47 Nitrate-nitrogen and ammoniacal-nitrogen are contaminants that are not generally monitored on a regular basis at the MGP. Recent assessment of the available pit sump, pit lake and WRS discharge data for both parameters has identified that both nitrate-nitrogen and ammoniacal-nitrogen will probably need to be managed in the future at the Coronation North Project.

48 Ammoniacal-nitrogen and nitrate-nitrogen are both derived from the dissolution of blasting residues in pit sumps (for example, refer to Figure 7 attached to this evidence) and in WRS areas, with this effect being commonly observed internationally. This source accounts for elevated concentrations of both parameters in the pit sumps and of nitrate-nitrogen in WRS seepage water during and immediately following mining operations. In general, the concentrations of nitrate-nitrogen and ammoniacal-nitrogen in WRS seepage water and in a developing pit lake would be expected to decrease over time, as the residues

become oxidised, are transported away by the seepage water or are diluted by the accumulation of water in the pit. This expected decrease in concentration has been observed to occur in the Frasers Pit sump and in the Golden Bar Pit lake.

49 In the case of WRS seepage water, as observed at the Northern Gully silt pond (Figure 8), ammoniacal-nitrogen concentrations decrease substantially following the close of mining operations, reflecting the oxidation process to nitrate. Nitrate concentrations were also observed to decrease over a period of about three years, although the concentrations subsequently increased again, as shown in Figure 8 attached to this evidence. Similar increases were also observed at seepage discharge monitoring points for other WRSs at the MGP. The reason for this increase is not yet known, and is the subject of further investigations by OceanaGold. It is however possible that the weathering of the schist waste may be releasing ammonium from the mica minerals, which then oxidises to nitrate.

50 As emphasised in Table 5, elevated although decreasing concentrations of arsenic have been measured in the pit lakes at the MGP. There are no water quality compliance criteria applicable to the pit lakes at the MGP, and at this stage it is not clear how low the arsenic concentrations will drop before reaching a stable concentration. With respect to the Coronation North Project, these elevated arsenic concentrations are not an immediate compliance issue for water quality in Mare Burn as the pit lakes are not projected to overflow for a considerable time into the future.

51 Since the close of operations at the Deepdell South and Golden Bar pits dissolved arsenic concentrations in the pit lake water have decreased from between 0.7 g/m^3 and 0.5 g/m^3 to concentrations of between 0.1 g/m^3 and 0.3 g/m^3 over periods of about four years. This trend may continue, or could be enhanced through the in-situ treatment of the pit lake water. Past modelling of arsenic attenuation in the groundwater system at the MGP indicates seepage outflows from the Coronation North pits through in-situ soils and weathered rock would also result in a substantial decrease in arsenic concentrations in the discharge water. Arsenic can also be removed from surface discharge flows through the installation of small treatment systems at the point of pit lake overflow, if required.

Water quality effects mitigation measures and scheduling

52 OceanaGold is proposing to construct a freshwater dam on Coal Creek, to provide a steady dilution flow to Mare Burn upstream from MB02. A surface water model of the Mare Burn catchment incorporating the Coal Creek dam was developed by Golder and used to evaluate the viability of the dam as a mitigation measure for water quality at MB02.

53 Coal Creek at the chosen dam site carries intermittent flows, with modelled inflows to the reservoir varying between 0 L/s and approximately 2,500 L/s, at an average inflow of around 16 L/s. Taking into account a continuous release of 5 L/s, the modelled stored water volume varied between 400 ML and 677 ML, with a median volume of around 650 ML. This outcome indicates a reservoir of this volume could provide a reliable discharge at 5 L/s through dry summer periods. This surface water modelling undertaken by Golder has identified that a continuous constant discharge of 5 L/s from this reservoir would result in ongoing compliance with the 1,000 g/m^3 sulfate limit proposed for MB02.

54 For some time now sulfate has been the primary contaminant of issue in discharge water at the MGP. The Coal Creek dam and the associated constant discharge flow was originally proposed as a means of managing sulfate concentrations downstream in Mare Burn. Recently however nitrogen loads to Mare Burn and in-stream nitrate-nitrogen concentrations have been identified as also requiring management.

55 The surface water model used to evaluate the effectiveness of the Coal Creek dam to dilute sulfate discharges has also been used to assess dilution of the nitrate-nitrogen concentrations that may appear in seepage water from the Coronation North WRS. The outcomes of this modelling have been documented in the Golder report on water quality effects, management and mitigation (Golder 2016e). Construction of Coal Creek dam and release of water from the reservoir at a rate of 5 L/s should result in OceanaGold being able to meet the NPS 2014 Attribute B guideline concentrations for nitrate-nitrogen in streams (Figure 9). The reviewing officer's report has identified the NPS 2014 Attribute B guidelines (refer to Table 7 attached) as being appropriate for the site. As the source of the nitrates in the WRS seepage water has not yet been confirmed, other management options may present themselves or the concentrations may decline again over time and therefore not require long term management.

56 Although OceanaGold is not proposing to have compliance criteria for either nitrate-nitrogen or ammoniacal-nitrogen at MB02, short-term nitrate management measures for Coronation North Project mine water are being planned. I have been advised that OceanaGold is investigating options for the management of nitrate and ammoniacal nitrogen in the mine water. These options include irrigation to land, treatment using wetlands and discharging of mine water only during higher flow periods in Mare Burn. I have also been advised by OceanaGold that a fall-back water management option would be to pump the pit sump water from both pits, together with the WRS seepage water from the main Coronation North WRS seepage discharge points (Figure 10) back to the mine water management system at the MGP process plant. This is not a long term water management measure but could be put in place if necessary to manage

both sulfate and nitrate concentrations in the Mare Burn during the operational period of the project.

57 The scheduling of the currently proposed water quality management measures is an important factor in the planning of the Coronation North Project (refer to Figure 11 attached). The instigation of mine water management measures is to be carried out on a staged basis, with the shift from one stage to the next depending on the data derived from the planned environmental monitoring of the site:

(a) OceanaGold is investigating options for managing mine water discharges during the operational mining period and the short term post-closure period. These options include irrigation to land, treatment using wetlands and discharging to Mare Burn during high flow periods provided this can be done while continuing to comply with the water quality criteria applicable at MB02. OceanaGold has advised me that the fall-back option is to actively manage mine water from the Coronation North Project by pumping the water back to the MGP water management system, where it will be used in the ore processing plant.

(b) During an intermediate post-closure period, the WRS discharge water may be released directly to Mare Burn, provided the water quality compliance criteria for MB02 would not be exceeded.

(c) OceanaGold plans to optimize the design of the proposed Coal Creek freshwater dam, taking into account other water quality management and mitigation options. As I understand it, the optimized dam is to be constructed and available to provide a constant discharge flow to Mare Burn prior to the start of the long-term post-closure period. Once the planned constant discharge flow from the Coal Creek dam is in place, seepage water from the WRS can be released to Mare Burn. It is clear that other water management options that would enable OceanaGold to reduce the size of the dam, or possibly negate the need for a dam, may be identified in the meantime and be incorporated in OceanaGold's water management planning for long-term post-closure period.

Comments on ORC's Staff Recommending Report

58 Concerns have been raised in the Staff Recommending Report regarding the effects of groundwater drawdown around the two opencast pits and the effects this drawdown could have on local stream flows. I have addressed these concerns in Paragraph 29 of my evidence. In summary, although the projected groundwater drawdown could reduce stream flows within the Mare Burn catchment slightly, this effect on water flows would be offset by the construction of the Coronation North WRS. The expected continuous discharges from the

WRS would more than offset the potential loss of natural groundwater contributions to Mare Burn.

59 Concerns have been raised in the Staff Recommending Report regarding a range of waterborne contaminants downstream from the Coronation North Project. These concerns have been addressed in part in Paragraphs 41 through to 44 of my evidence. OceanaGold has advised me that investigations are planned to address concerns regarding the potential issue of sulfate toxicity on galaxids. These investigations include the surveys of galaxid populations in sections of streams affected by elevated sulfate concentrations sourced from the MGP.

60 The discharge of potentially deoxygenated water to Mare Burn from the Coal Creek dam has been raised as a potential issue, with associated effects of iron and sulphide in the reduced form on the downstream ecology. As set out in Golder's water quality effects management and mitigation report (Golder 20106e), OceanaGold has mitigated this potential issued by incorporating in the dam concept design the installation of:

(a) A floating decant syphon from the reservoir, to ensure water is discharged from the most highly oxygenated zone of the reservoir.

(b) An outlet pipe through the toe of the embankment to avoid the need for a pumped discharge.

(c) An outflow cascade to increase the level of oxygenation in the discharged water.

(d) A settling pond to provide time for contaminants in the water to oxidise, precipitate and subsequently settle out of the water column.

(e) A small wetland to help filter out any remaining precipitated contaminants before the water is discharged to the bed of Coal Creek downstream from the dam.

Comments on submissions

61 The Director General of Conservation has lodged a submission with the ORC regarding effects of the proposed Coronation North Project on the Mare Burn. Specifically:

(a) That "all practicable measures need to be taken in order to reduce sediment and contaminant discharges (particularly turbidity, sulfates, iron and arsenates) from the new mining operations and/or construction operations from entering the water bodies in the vicinity of the Coronation North Project to avoid adverse effects on aquatic ecosystems"; and

(b) That “a variable dam discharge to resemble natural flow conditions is preferable to a flat line discharge”

62 In response to the above concerns I note that OceanaGold has committed to undertake a full review of all practicable options to reduce sulfate discharges from the Coronation North Project to the Mare Burn. The objectives of this review are to improve the outcomes of the proposed water quality management measures while also improving the cost effectiveness of the overall package of water quality management measures to be implemented at the Coronation North Project. Some potential options for WRS seepage water quality management are described in the evidence from Mr Paul Weber. In relation to other contaminants listed in the Director Generals' submission, in my opinion the expected levels in the Mare Burn should not be of concern with the proposed management methods.

63 A variable discharge flow was considered when Golder evaluated the potential for the proposed Coal Creek freshwater dam to enable OceanaGold to comply with the water quality criteria proposed for MB02 on an ongoing basis. Installation of a system to provide a variable discharge flow was not identified as the preferred option for a number of reasons, including the fact that the equipment required is likely to be more complex, less reliable, require more monitoring and maintenance and potentially require more intensive management. Irrespective of the mechanism used to manage the discharge, the main objective is to provide a reliable flow of clean water to Mare Burn upstream from MB02 at a rate of 5 L/s during low flow periods. The modelling also indicates that periodic overflows from the freshwater dam will contribute to Mare Burn during high flow periods.

64 Craig and Erin Howard’s submission lodged with the ORC raised a concern regarding “maintaining the quality of our drinking water, especially with the waste rock seepage and sulfate concentrations forecasted to increase in the future.” The Howard homestead is located close to Horse Flat Road within the Deepdell Creek catchment, downstream from the already consented and partially constructed Coronation WRS. The Coronation North Project would not result in any additional waste rock storage within the Deepdell Creek catchment. The only new structure associated with the Coronation North Project that could potentially contribute additional contaminant loads to the Deepdell Creek catchment is the Coronation Pit Stage 5, at the time of final development and overflow of the pit lake. The pit lake filling projections documented in Golder’s surface water modelling report indicates the Coronation Pit Stage 5 will take in excess of 100 years to fill to overflow. At that stage the calculated seepage loss from the pit lake into Deepdell Creek catchment will be approximately 0.3 m^3/day. I would expect this flow to be lost to evaporation during summer and be subject to substantial dilution during the cooler months. Although this seepage could contribute slightly to flows in the stream that passes a short distance to the south

of the Howard homestead I would not expect it to influence water quality in the homestead bore.

65 David and Jocelyn Kinney's submission lodged with the ORC identified concerns regarding the effects of the proposed Coronation North Pit on the reliability of groundwater fed springs and streams on their property. The property of relevance to the submission is a 766 ha hill country block located on the eastern side of the Taieri River. This block is within approximately 4.7 km of the Coronation North Pit at its closest approach. As described in Paragraph 27 of my evidence, any groundwater bores or springs located outside the maximum areas of influence defined for the Coronation Pit Stage 5 and the Coronation North Pit would not be affected by mining related decreases in water availability from the bore or spring. The maximum potential areas of influence are presented in Figure 4 and Figure 5 attached to this evidence. Neither pit as shown in these figures will have an influence on groundwater levels or availability to the west of Coal Creek. In addition, construction and operation of the proposed Coal Creek dam would locally result in raised groundwater levels to the west of Coal Creek.

Conclusion

66 In my opinion, groundwater drawdown resulting from construction of the Coronation Pit Stage 5 and Coronation North Pit will result in small temporary effects on flows in Mare Burn up until the time that the proposed Coal Creek fresh water dam is constructed. Following that time, the effects of the groundwater drawdown on baseline conditions will be restricted to land owned by OceanaGold.

67 Construction of the Coronation North WRS will result in ongoing and continuous seepage discharging from four points at the toe of the WRS. Unless these flows are collected and pumped back to the Coronation Pit water management system, they will collectively contribute approximately 2.4 L/s to Mare Burn under low flow conditions and result in Mare Burn becoming a permanently flowing water body at the MB02 compliance point.

68 I would expect sulfate concentrations in the Coronation North WRS seepage water to increase over time. Several years after the close of operations at the Coronation North Project, the seepage water concentrations are likely to increase to a level that I would expect mitigation measures to be required to enable OceanaGold to continue to meet the proposed sulfate criterion of 1,000 g/m^3 at MB02 into the future.

69 OceanaGold proposes to construct the Coal Creek fresh water dam and release a constant flow of 5 L/s from this reservoir to provide dilution water in Mare Burn at MB02. The current design of the Coal Creek dam would support a constant

discharge of 5 L/s, which would enable OceanaGold to meet the proposed sulfate compliance limit on an ongoing basis.

70 Ongoing work on reducing sulfate concentrations in the WRS discharge water (as described in the evidence from Paul Weber) and nitrate management in the Mare Burn catchment may reduce or even negate the need for the planned Coal Creek dam.

Brett Sinclair

17 October 2016

References

Golder 2016a. Coronation North Project. Groundwater assessment. Report prepared for Oceana Gold (New Zealand) Ltd by Golder Associates (NZ) Limited. Golder report number 1545831-002.

Golder 2016b. Coronation North Project. Surface water modelling. Report prepared for Oceana Gold (New Zealand) Ltd by Golder Associates (NZ) Limited. Golder report number 1545831-003.

Golder 2016c. Coronation North Project. Water quality mitigation – freshwater dam scenario. Report prepared for Oceana Gold (New Zealand) Ltd by Golder Associates (NZ) Limited. Golder report number 1545831-004.

Golder 2016d. Arsenic and iron mobility in Coronation North Project surface water. Letter to Jackie St John, Oceana Gold (New Zealand) Ltd, from Golder Associates (NZ) Limited. 23 May 2016. Golder reference number 1545831_7410-005.

Golder 2016e. Coronation North Project. Water quality effects, management and mitigation. Report prepared for Oceana Gold (New Zealand) Ltd by Golder Associates (NZ) Limited. Golder report number 1545831-010.

Appendix 1 – Figures

Figure 1: Site location plan.

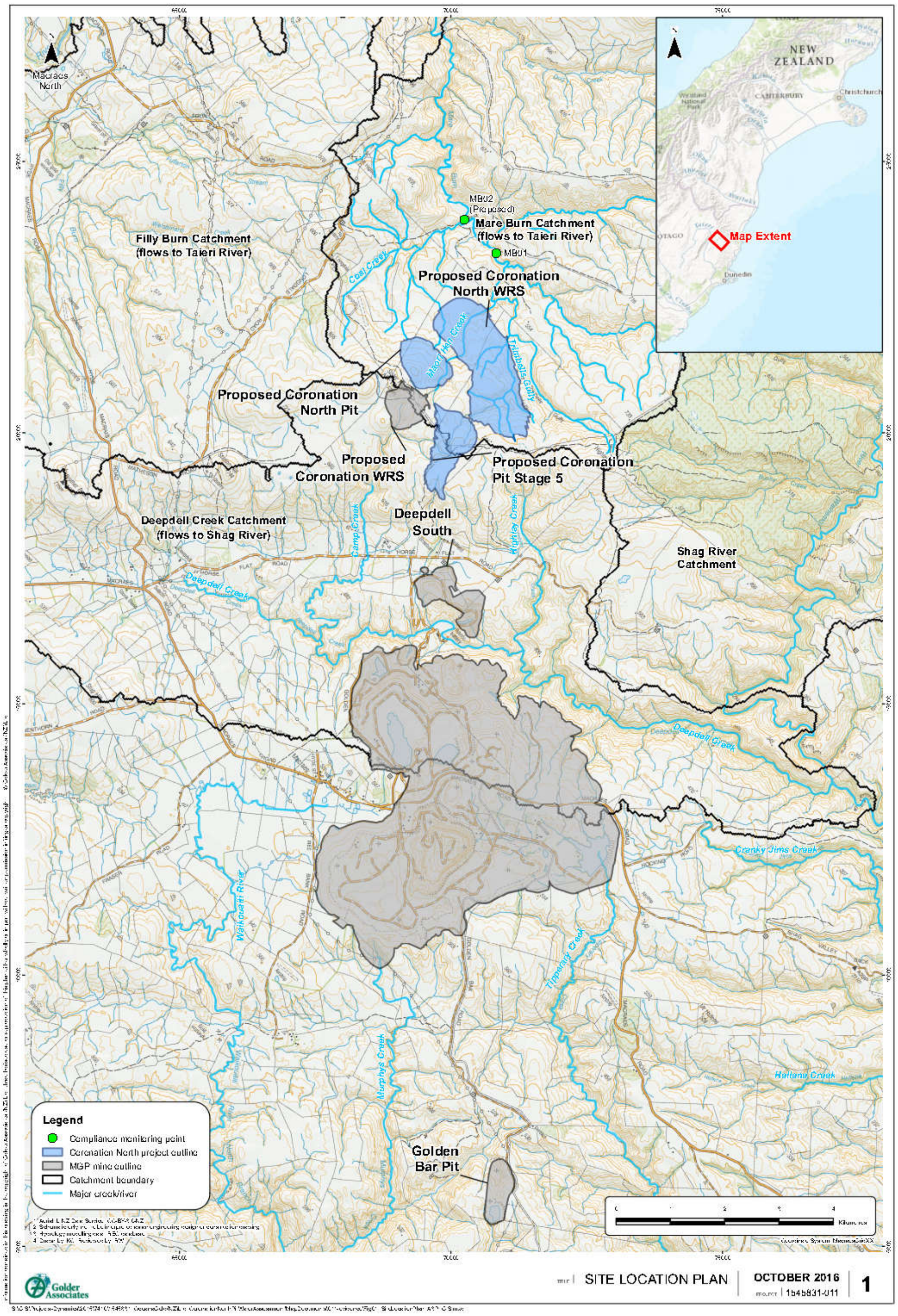


Figure 2: Site layout.

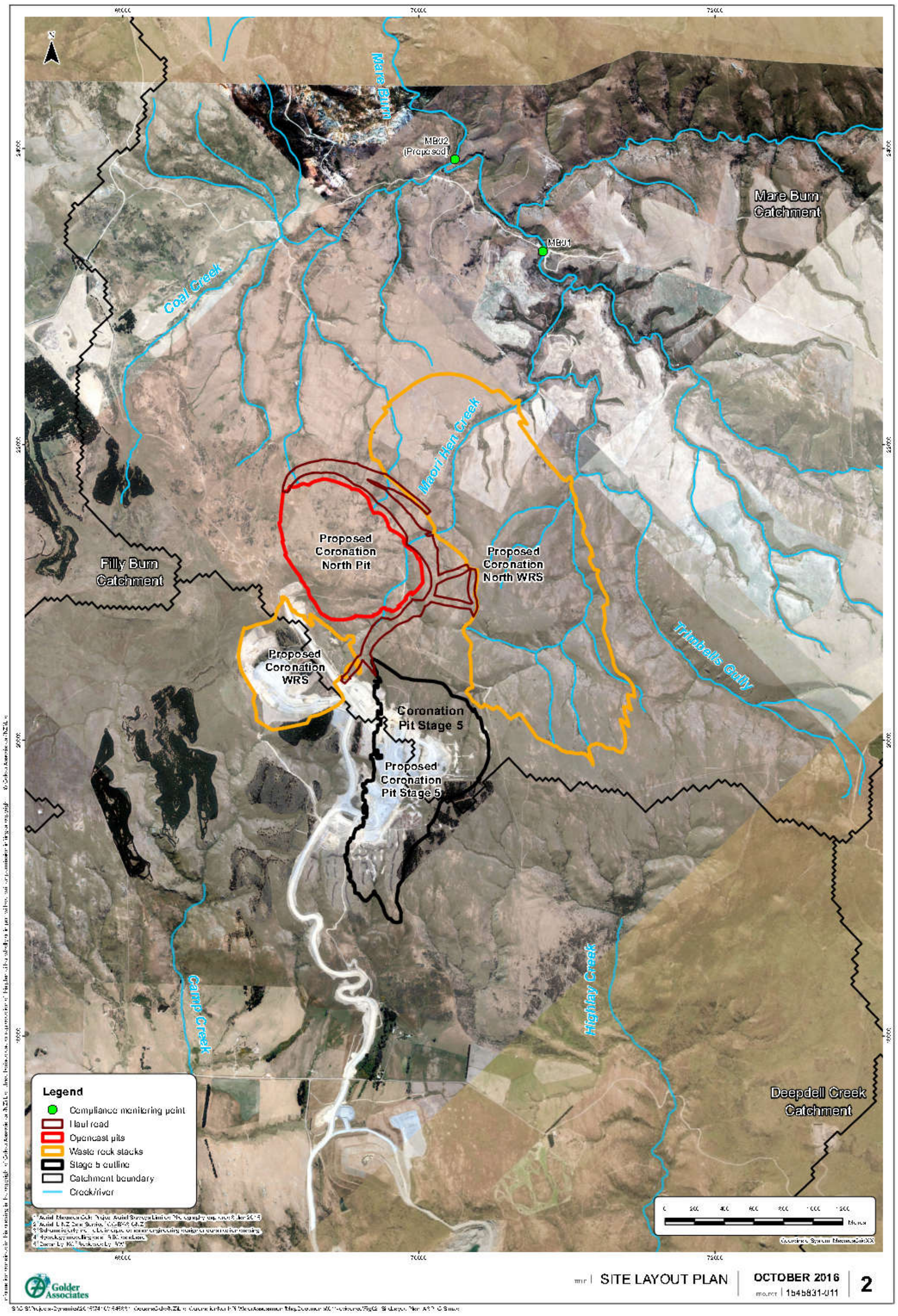


Figure 3: MGP average monthly rainfall and evaporation.

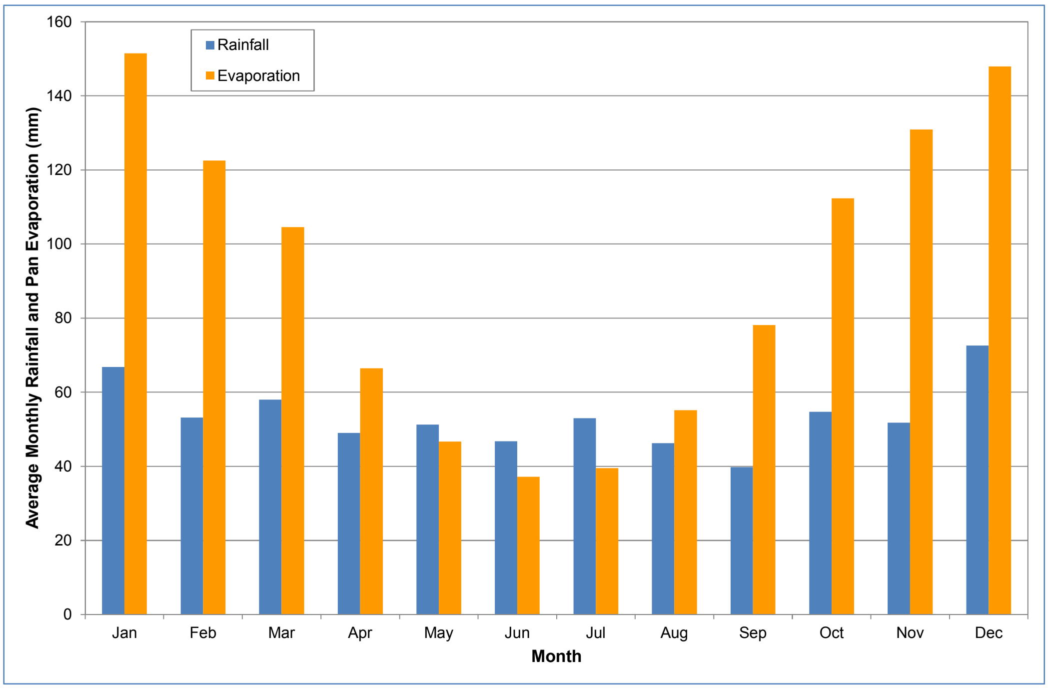


Figure 4: Coronation Pit Stage 5 groundwater area of influence.

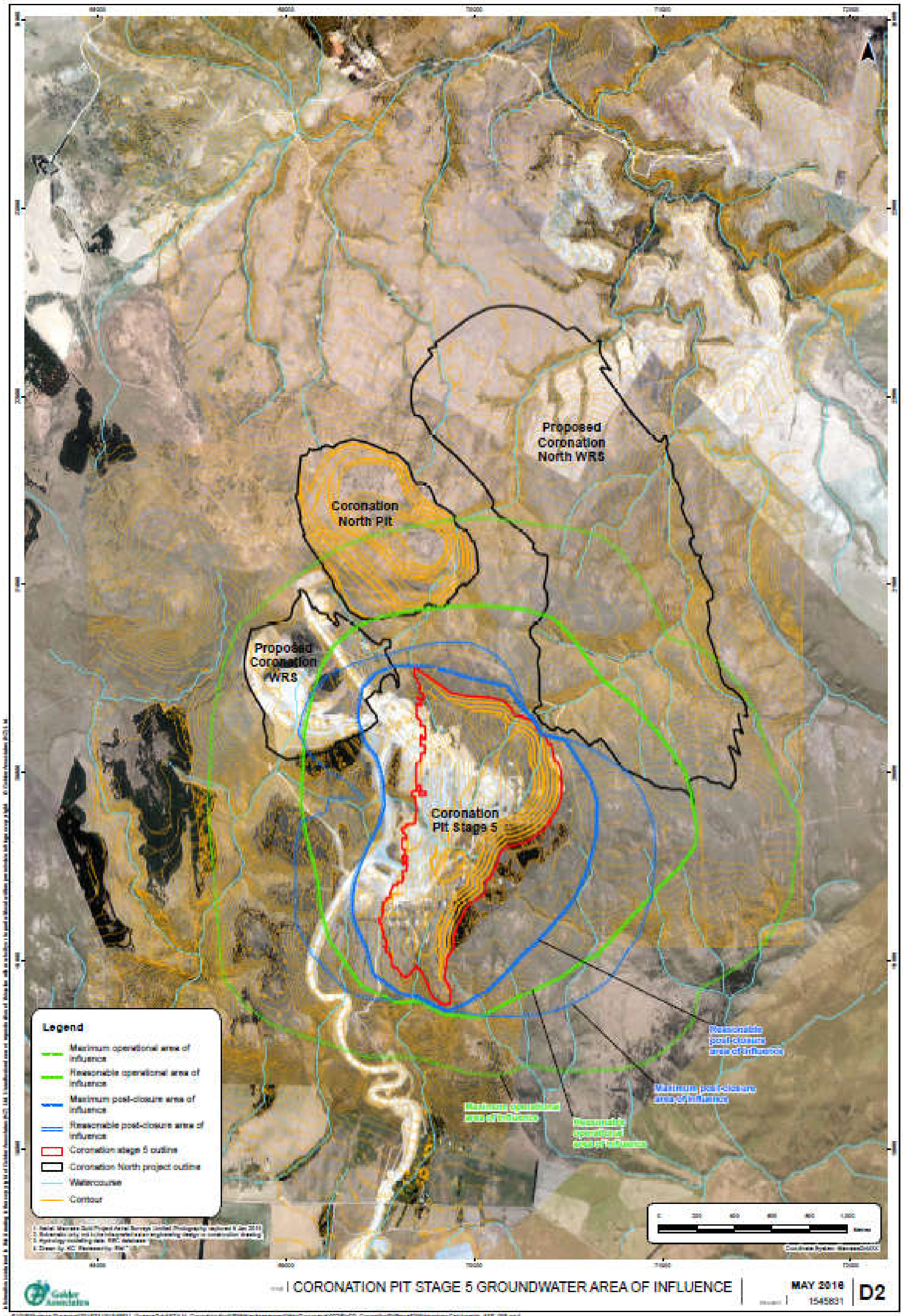


Figure 5: Coronation North Pit groundwater area of influence.

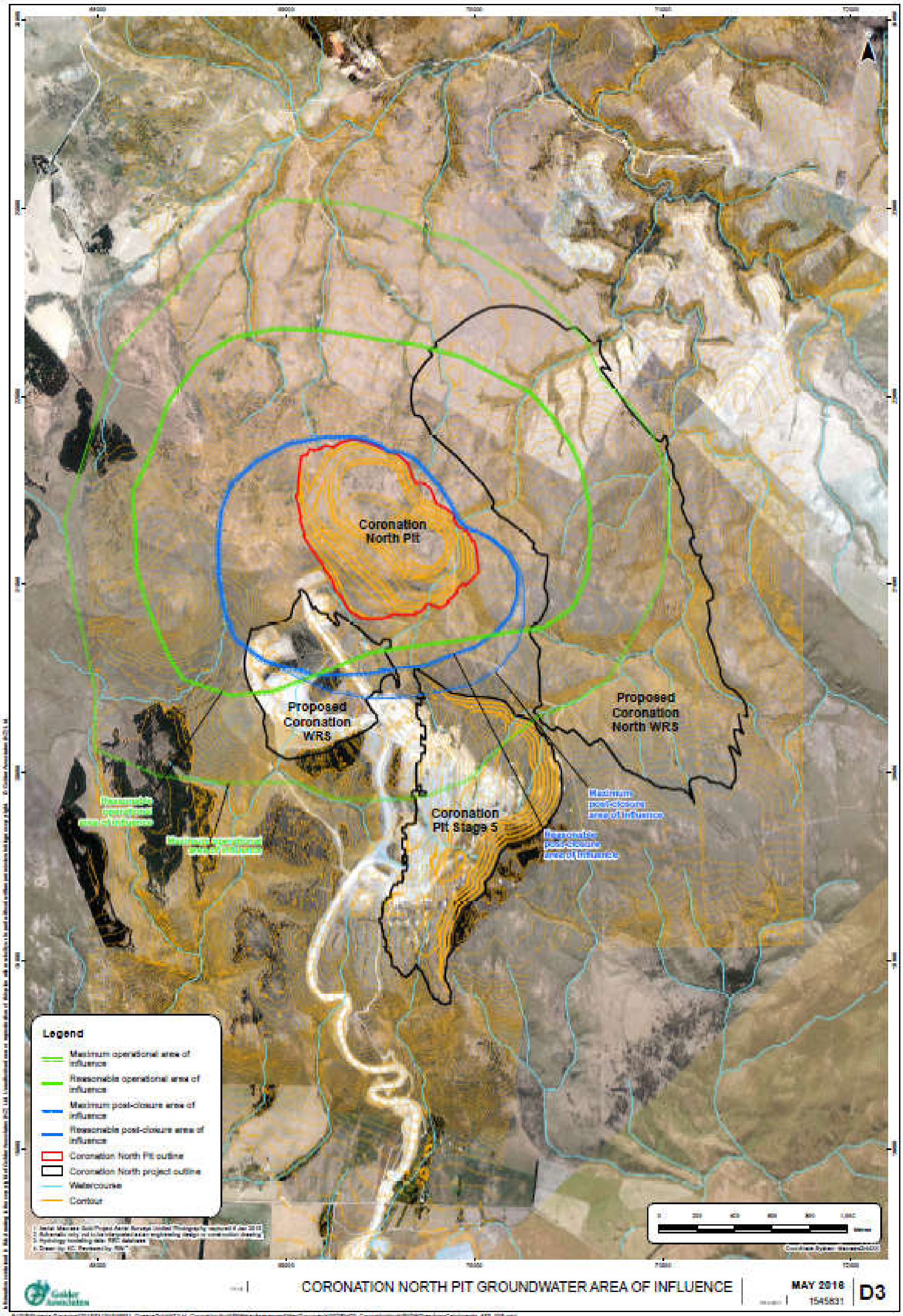


Figure 6: Sulfate to hardness relationship in Deepdell Creek at downstream compliance point, 1990 to 2015.

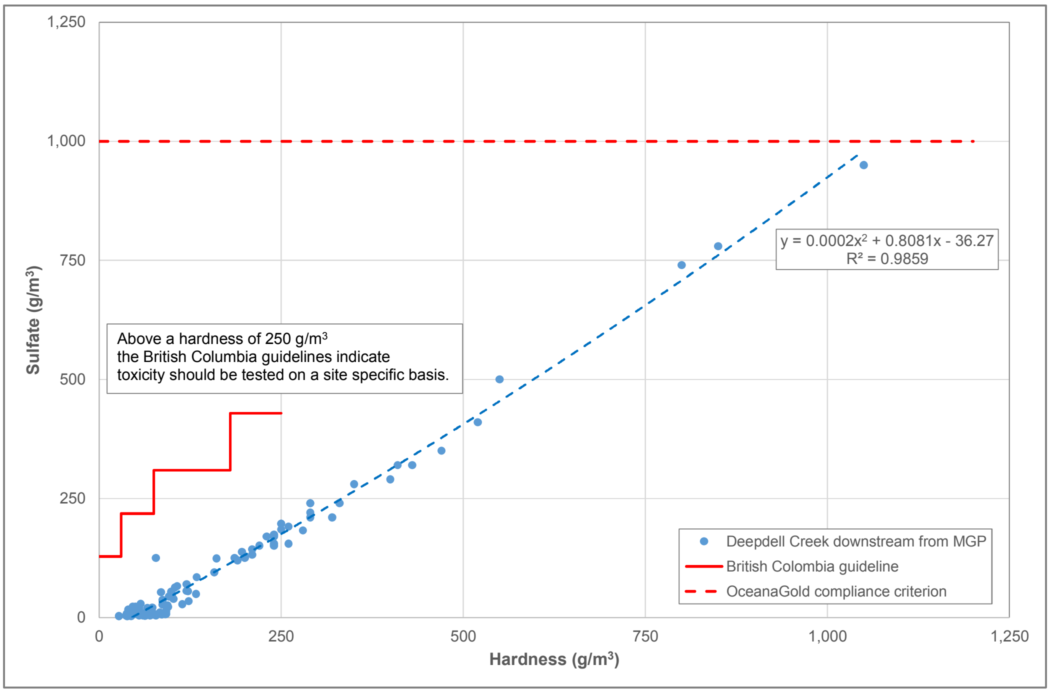


Figure 7: Frasers Pit sump nitrate-N and ammoniacal-N concentrations.

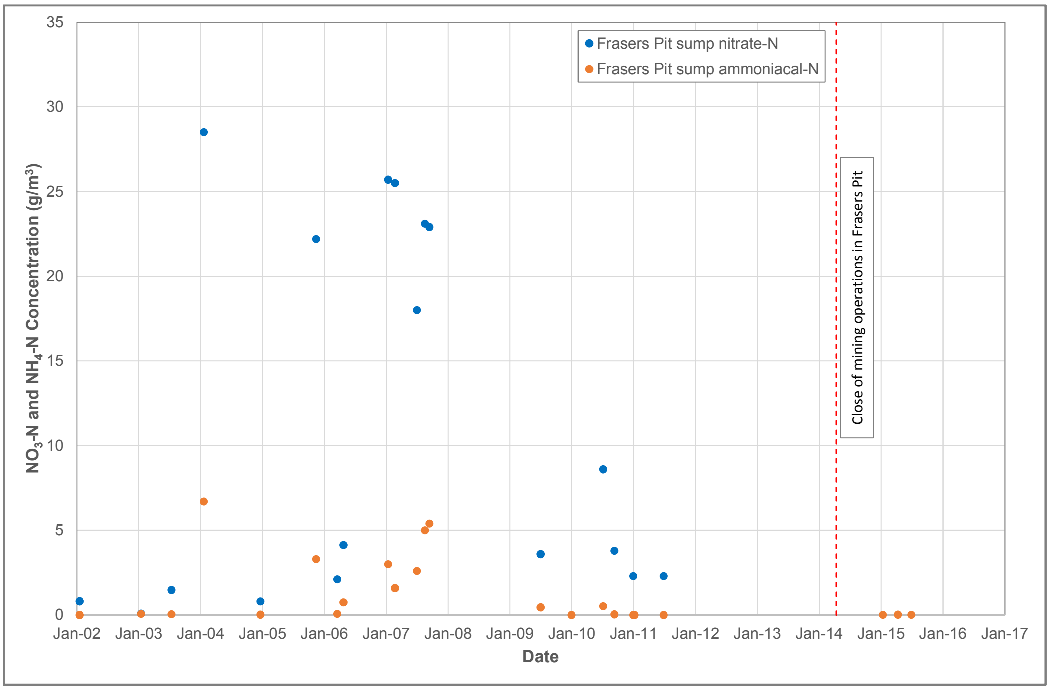


Figure 8: Waste rock stack seepage NO_3-N concentrations.

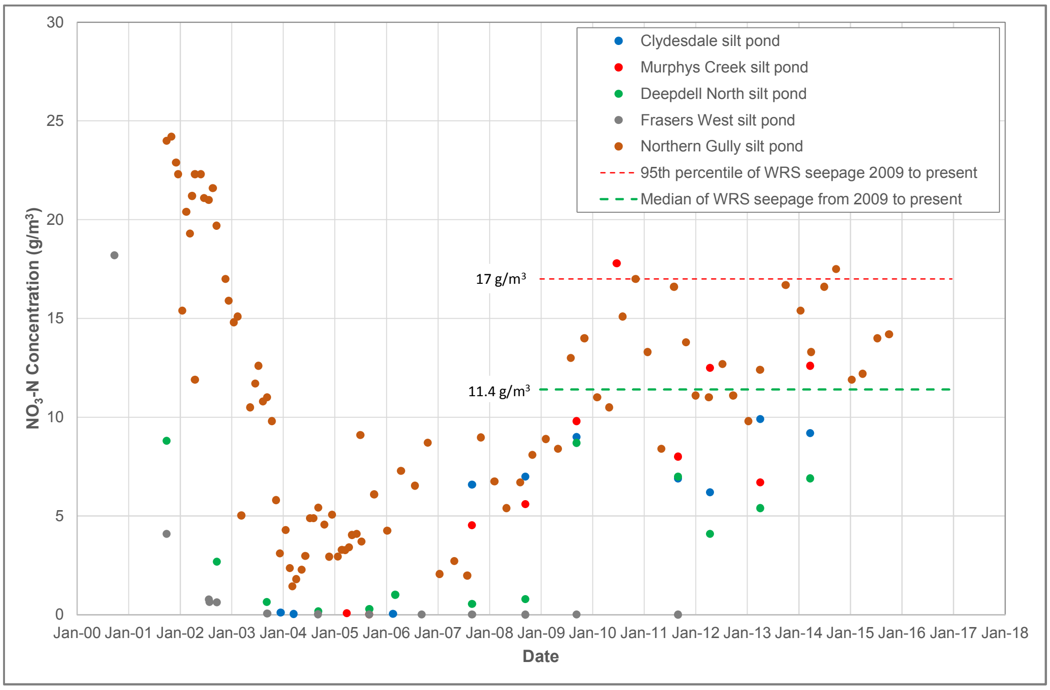


Figure 9: Nitrate-N mitigated exceedance frequency based on median WRS leachate concentration of 11.4 g/m³.

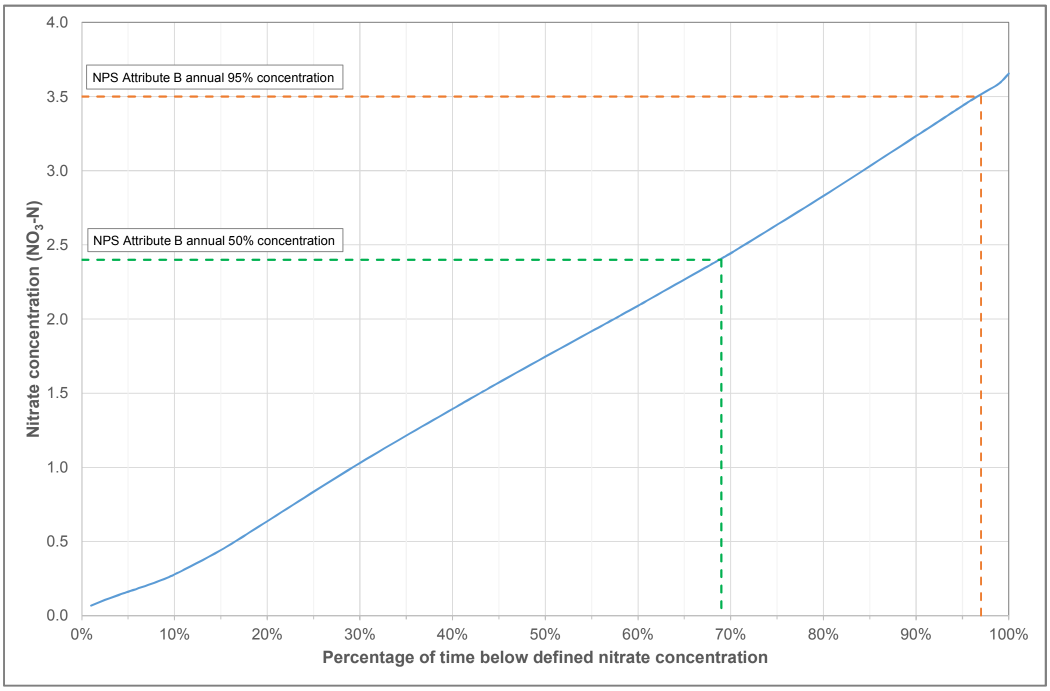


Figure 10:Coronation North WRS. Primary seepage discharge locations.

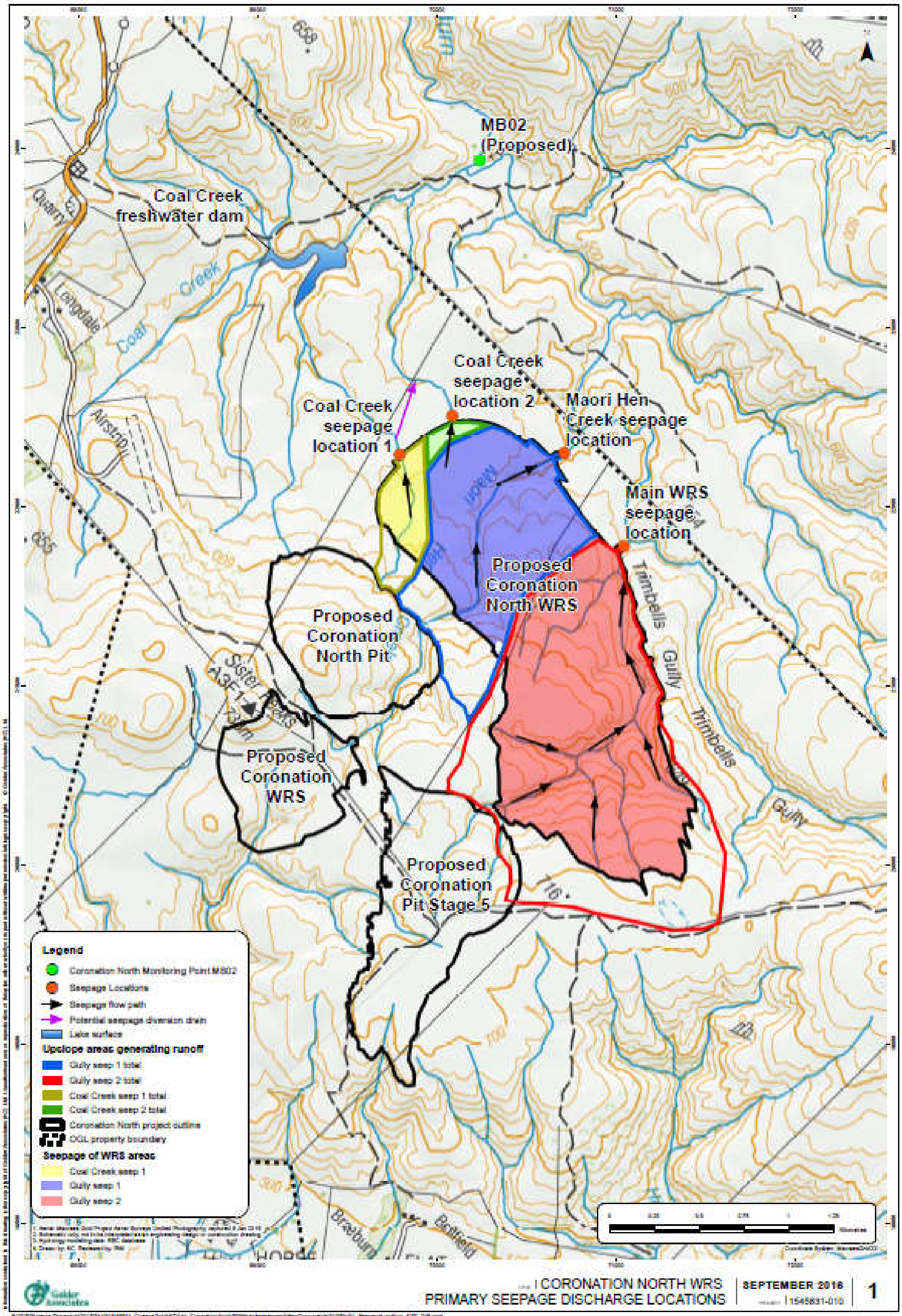
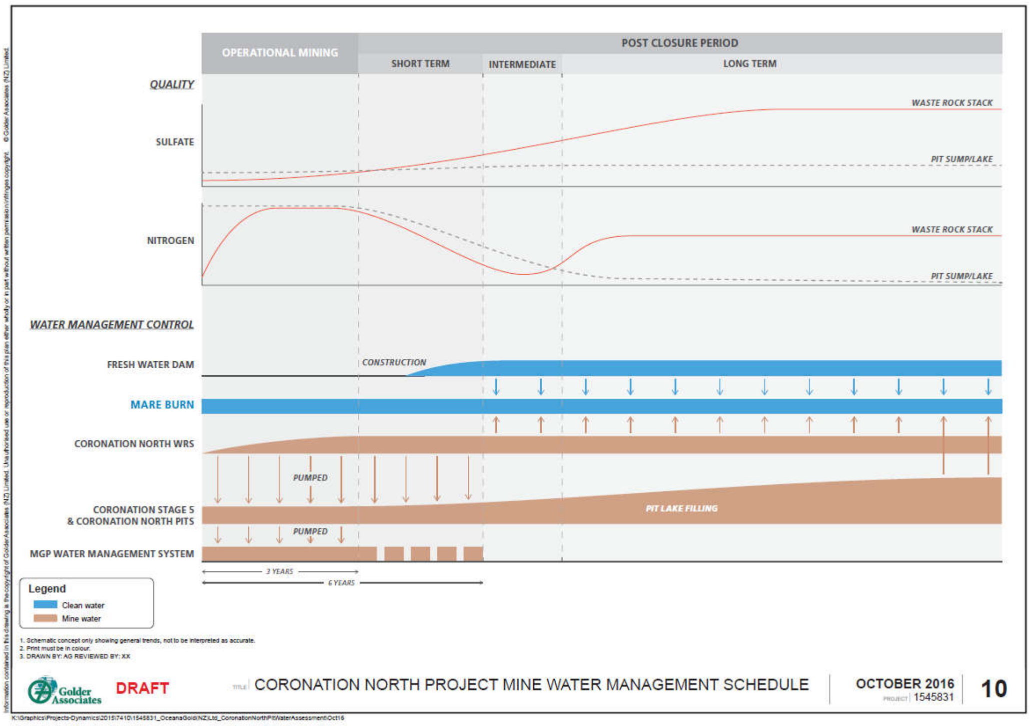


Figure 11:Coronation North Project mine water management schedule.



Appendix 2 – Tables

Table 1: Calculated compliance point MB02 flow statistics and percentiles.

Parameter	Minimum	Lower Quartile	Median	Average	Upper Quartile	Maximum
MB01 daily average (L/s)	0	3.6	9.7	36.6	28.8	14,960
MB02 daily average (L/s)	0	7.7	20.6	77.7	61.0	31,760

Table 2: Summary of MB01 water quality monitoring data (2014 – 2015).

Parameter (1)	Minimum	Mean	95th Percentile	Maximum	Number of samples
Arsenic	<0.0010	0.0019	0.0050	0.0050	12
Sulfate	1.3	6.4	11.1	11.6	12
Cyanide (WAD)	<0.001	0.0012	0.0015	0.0016	4
Copper	<0.0006	0.0009	0.0014	0.0016	12
Iron	0.08	0.24	0.54	0.54	12
Lead	<0.0001	0.0002	0.0010	0.0018	12
Sodium	5.5	9.3	13.3	13.5	12
Potassium	0.4	1.7	4.7	6.2	12
Calcium	4.0	11.3	19.2	19.2	12
Magnesium	1.2	2.8	4.4	4.4	12
Zinc	0.001	0.002	0.005	0.006	5
Chloride	3.9	5.3	7.7	8.8	12

Notes: 1) All units g/m^3.
2) WAD - weak acid dissociable.

Table 3: Catchment hydrology comparison.

Scenario (1)	Catchment area (ha) (1)	Simulated flows (L/s)			
		5th percentile flow	Median flow	Average flow	Maximum flow
Baseline (MB02)	2,930	0.6	12	64	11,100
Stage 2	2,987	3.0	15	65	10,200
Stage 3	2,987	3.0	14	63	10,100

Table 4: Compliance criteria proposed by OceanaGold for MB02.

Parameter (1)	**Existing at MB01 and proposed for MB02**	**ANZECC 2000 (stock water)**	**NZDWS 2008** (2)
pH (unitless)	6.0 – 9.5	-	7.0 – 8.5
Sulfate	1,000	1,000	250
$Cyanide_{WAD}$	0.1	-	0.08
Arsenic	0.15	0.5	0.01
Copper (3)	0.009	0.5	2
Iron	1.0	N/A	0.2
Lead (3)	0.0025	0.1	0.01
Zinc (3)	0.12	20	-

Notes:
1) All units g/m^3 unless stated.
2) Some of these values are maximum acceptable values while others are guideline values for aesthetic determinands.
3) Proposed copper, lead and zinc compliance criteria for MB02 are hardness related:

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

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

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

Table 5: Comparison of measured data from WRS silt dams and existing MGP pit lakes with potential ecologically relevant guidelines.

Parameter (1)	Proposed MB02 compliance criteria	Reviewer identified environmental protection guidelines	WRS discharges (2,3)	Golden Bar pit lake (2,3)	Deepdell South pit lake (2,3)
pH (unitless)	6.0 – 9.5	6.5 – 9.0	6.4 – 8.64	7.0 – 8.41	7.8 – 8.45
Dissolved copper	0.009 (5)	0.0014	<0.001 – 0.004 (4)	<0.0005 – 0.059 (4)	<0.0005 – 0.001
Dissolved zinc	0.12 (5)	0.008	<0.005 – 0.04	0.002 – 0.0093	0.0012 – 0.0038
Dissolved nickel		0.011	<0.005 – <0.01	ND	ND
Dissolved lead	0.0025 (5)	0.0034	<0.0001 – 0.00031 (4)	<0.0001 – 0.0042 (4)	<0.0001 – 0.00012
Dissolved silver		0.00005	ND	ND	ND
Arsenic	0.15	0.013, 0.024	<0.005 – 0.024 (4)	0.01 – 0.599	0.128 – 0.497
Iron	1	1	<0.04 – 0.39	<0.02 – 0.58	<0.02 – 0.16
Manganese		0.5	ND	ND	ND
Cyanide	0.1	0.007	NA	NA	NA
Sulphate	1,000	128 (429)	Up to 2,900	50 – 320 (6)	43.7 – 410
Dissolved oxygen		>7.0 (>5.0)	ND	ND	ND
Nitrate (NO_2-N)		2.4 (3.5) (7)	Refer Section 4.1 and Appendix A, Golder 2016e.		
Ammonia (NH_4-N)		<0.24 (<0.40) (7)	Refer Section 4.1 and Appendix A, Golder 2016e.		
Turbidity		30 % – 50 % change in clarity	ND	ND	ND
Suspended solids		30 % – 50 % change in clarity	ND	ND	ND

Notes: 1) All units in g/m^3 except pH. Number of samples analysed varies with site and parameter.
2) Colour definitions. Compared to potential ecological protection criteria indicated by reviewer. **Green = meets criterion; Blue = likely meets criterion but hardness dependent; Orange = possibly meets criterion but hardness dependent; Red = does not meet criterion.**
3) ND = no data; NA = not applicable as no cyanide or cyanide bearing wastes are being used or stored in Mare Burn catchment.
4) High end of range defined as 95th percentile to exclude individual anomalous results.
5) Criterion is hardness dependent, as per Table 3 attached to this evidence.
6) Single highly anomalous value of 2,100 g/m^3 removed from dataset.
7) Attribute B criteria from NPS (MfE 2014). First value is the median criterion and the value in brackets is the 95th percentile criterion.

Table 6: Comparison of measured data from Deepdell Creek and Mare Burn with potential ecologically relevant guidelines.

Parameter [1]	**Proposed compliance criteria at MB02**	**Reviewer identified environmental protection guidelines**	**DC01 & DC02 [2,3] Deepdell Upstream**	**DC07 & DC08 [2,3] Deepdell Downstream**	**Mare Burn MB01 & MB02 [2,3]**
pH (unitless)	6.0 – 9.5	6.5 – 9.0	6.5 – 8.47	7.0 – 8.81	7.2 – 8.1
Dissolved copper	0.009	0.0014	<0.0005 – 0.002	<0.0005 – 0.0031	<0.0005 – 0.0016
Dissolved zinc	0.12	0.008	ND	<0.001 – 0.006	<0.001 – 0.0011
Dissolved nickel		0.011	ND	ND	ND
Dissolved lead	0.0025	0.0034	<0.0001 – 0.001	<0.0001 – 0.00178	<0.0001 – 0.00181
Dissolved silver		0.00005	ND	ND	ND
Arsenic	0.15	0.013, 0.024	<0.001 – 0.005	0.0015 – 0.03 [4]	<0.001 – 0.0082
Iron	1	1	0.08 – 0.58	0.02 – 0.38	0.2 – 0.84
Manganese		0.5	ND	ND	ND
Cyanide	0.1	0.007	NA	NA	NA [5]
Sulphate	1,000	128 (429)	1.3 – 29	9.9 – 1,020	1.3 – 78
Dissolved oxygen		>7.0 (>5.0)	ND	ND	ND
Nitrate		2.4 (3.5) [6]	Refer Section 4.1 and Appendix A, Golder 2016e.		
Ammonia		0.24 (0.40) [6]	Refer Section 4.1 and Appendix A, Golder 2016e.		
Turbidity		30 % – 50 % change in clarity	ND	ND	ND
Suspended solids		30 % – 50 % change in clarity	ND	ND	ND

Notes: 1) All units in g/m^3 except pH. Number of samples analysed varies with site and parameter.
2) Colour definitions. Compared to potential ecological protection criteria indicated by reviewer. **Green = meets criterion; Blue = likely meets criterion but hardness dependent; Orange = possibly meets criterion but hardness dependent; Grey = contaminant probably not sourced from MGP operations; Red = does not meet criterion.**
3) ND = no data; NA = not applicable as no cyanide or cyanide bearing wastes are being used or stored in Mare Burn catchment.
4) Only two samples out of 67 obtained since start of 2005 exceeded 0.024 g/m^3. Downstream arsenic concentrations have not increased since the start of MGP operations in 1990.
5) Anomalous CN was detected in catchment during mining but traced by OceanaGold to pipeline section from process plant being used for water management at Coronation Pit.
6) Attribute B criteria from NPS (MfE 2014). First value is the median criterion and the value in brackets is the 95th percentile criterion.

Table 7: Nitrate-N and ammoniacal-N NPS attributes for toxicity (MfE 2014).

Parameter	Attribute state	Annual median	Annual 95th percentile	Narrative attribute
Nitrate-N (g NO_3-N/m^3)	A	≤ 1.0	≤ 1.5	High conservation value system. Unlikely to be effects even on sensitive species.
	B	> 1.0 and ≤ 2.4	> 1.5 and ≤ 3.5	Some growth effect on up to 5 % of species.
Ammoniacal-N (g NH_4-N/m^3) (1)	A	≤ 0.03	≤ 0.05	99 % species protection level: no observed effect on any species tested.
	B	> 0.03 and ≤ 0.24	> 0.05 and ≤ 0.4	95 % species protection level: starts impacting occasionally on the 5 % most sensitive species.

Note: 1) Based on pH 8 and temperature of 20 °C.