May 2016

CORONATION NORTH PROJECT

Surface Water Modelling

Submitted to:
Oceana Gold (New Zealand) Limited
22 Maclaggan Street
Dunedin 9016

REPORT

Report Number. 1545831_7410-003-R-Rev2

Distribution:

Jackie St John, Oceana Gold (New Zealand) Ltd

A world of capabilities delivered locally

Golder Associates

Table of Contents

TABLES

FIGURES

APPENDICES

ABBREVIATIONS

ANZECC	Australian and New Zealand Environment and Conservation Council
AWBM	Australian Water Balance Model
CS5	Coronation Pit Stage 5
EGL	Engineering Geology Limited
Golder	Golder Associates (NZ) Limited
ha	Hectare
HIRDS	High Intensity Rainfall Design System
IDF	Intensity, duration and frequency
IPCC	Intergovernmental Panel on Climate Change
km^2	square kilometres
m	Metres
MAM	Mean Annual Minimum flow
MGP	Macraes Gold Project
MoH	New Zealand Ministry of Health
mRL	Metres relative level; in this case metres above mean sea level.
Mt	million tonnes
NZDWS	New Zealand Drinking Water Standard
OceanaGold	Oceana Gold (New Zealand) Ltd
ORC	Otago Regional Council
SPMP3	Monitoring well SPMP3 installed in Northern Gully waste rock stack
WAD	Weak acid dissociable – used with reference to cyanide
WRS	Waste rock stack

1.0 INTRODUCTION

1.1 Background

Oceana Gold (New Zealand) Limited (OceanaGold) operates the Macraes Gold Project (MGP) located in east Otago, approximately 25 km west of Palmerston. The MGP consists of a series of open pits and an underground mine supported by ore processing facilities, waste storage areas and water management systems (Figure 1).

OceanaGold has an ongoing program of exploration drilling, ore reserves review and mine design optimisation. Consequently, operational pit designs are regularly updated. The performance of existing waste storage facilities and the requirement for additional waste storage capacity is also regularly reviewed. As a result of a recent review of ore reserves, OceanaGold is planning to undertake mining operations on the Coronation North ore body, which is located to the northwest of the existing Coronation Pit (Figure 2) within the Mare Burn catchment. These mining operations, which together constitute the Coronation North Project (the Project), generally consist of:

- Construction, operation and closure of the planned Coronation North Pit, together with an associated haul road connecting to the ore processing plant at the MGP.
- Extension of the existing Coronation Pit beyond its consented limits to what has been termed the Coronation Stage 5 (CS5) pit shell.
- Construction and rehabilitation of the planned Coronation North waste rock stack (WRS).

These new operations, which are described in greater detail in Section 1.2, are expected to increase the total consented tonnage of stored mine waste within the Mare Burn catchment from 66 Mt to 274 Mt.

Golder Associates (NZ) Limited (Golder) has been engaged by OceanaGold to undertake technical assessments for mine water management that are to support the resource consent application. This report documents the project surface water model development and the outcomes of this modelling program.

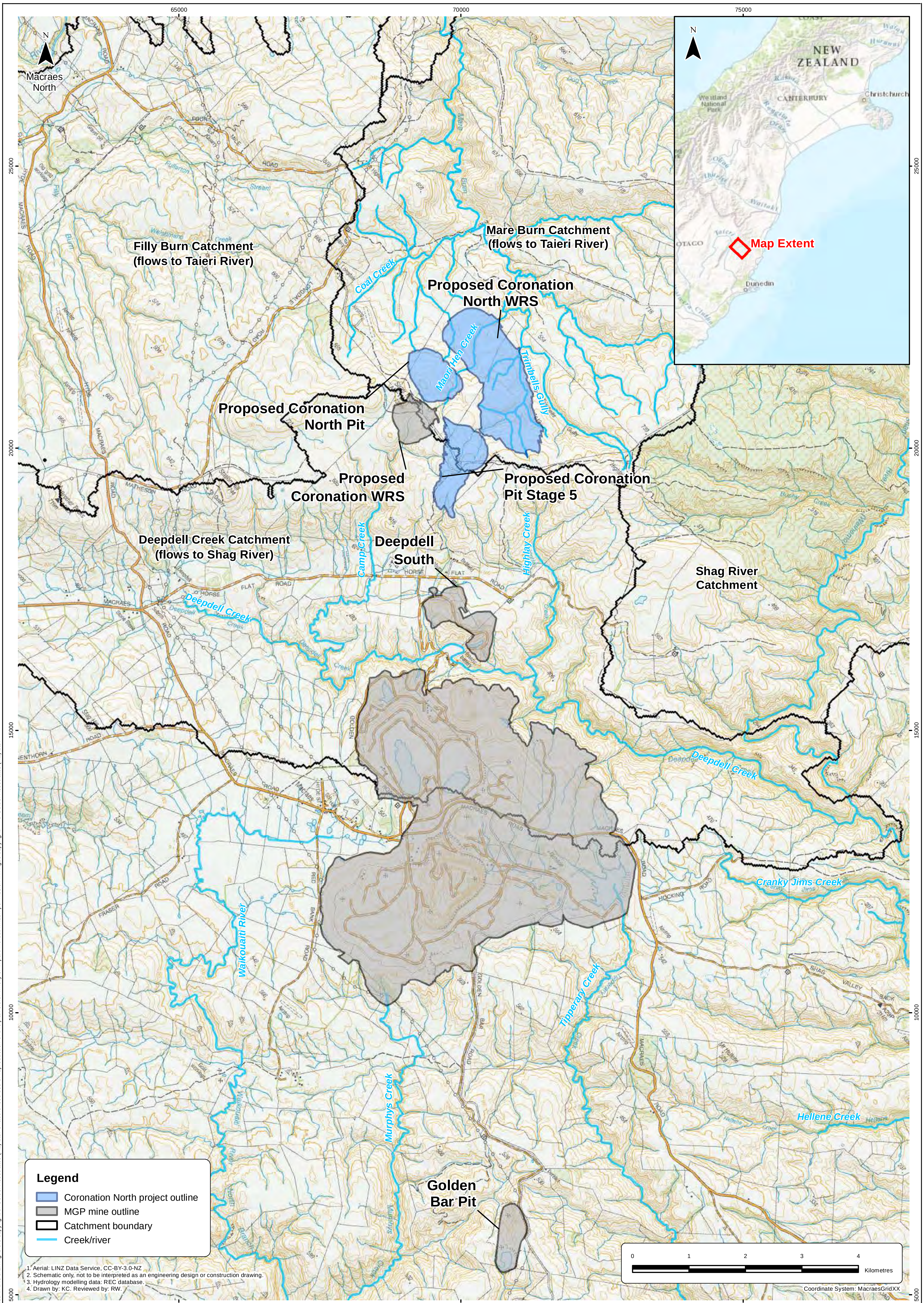
The main purpose of the surface water model report is to produce water quality projections for receiving environment waterways and compare these projections to existing or proposed receiving environment water quality criteria. This comparison is used to assess likely compliance with the criteria and to identify the need for specific mitigation measures.

The scope of the modelling program and this report does not include assessment of potential mitigation measures and their performance.

1.2 Project Description

The Project is located to the north of Horse Flat Road, intersecting a ridgeline which delineates the divide between the Shag River and Taieri River catchments (Figure 2). The Project operations will be located primarily within the Mare Burn catchment, which forms part of the wider Taieri River catchment. Within the Mare Burn catchment, the Project will intersect the tributary catchments of Coal Creek, Maori Hen Creek and Trimbells Gully. The proposed Coronation Pit Stage 5 (CS5) will extend into the Camp Creek and Highlay Creek catchments, which contribute to Deepdell Creek catchment and the wider Shag River catchment.

The boundary between the districts of the Waitaki District Council and the Dunedin City Council passes through the Project area. The Coronation North WRS and Coronation North Pit will be entirely within the Dunedin City Council District. The proposed CS5 extension will be largely within the Waitaki District. The entire Project is located within the Otago Region, administered by the Otago Regional Council (ORC).



Golder Associates

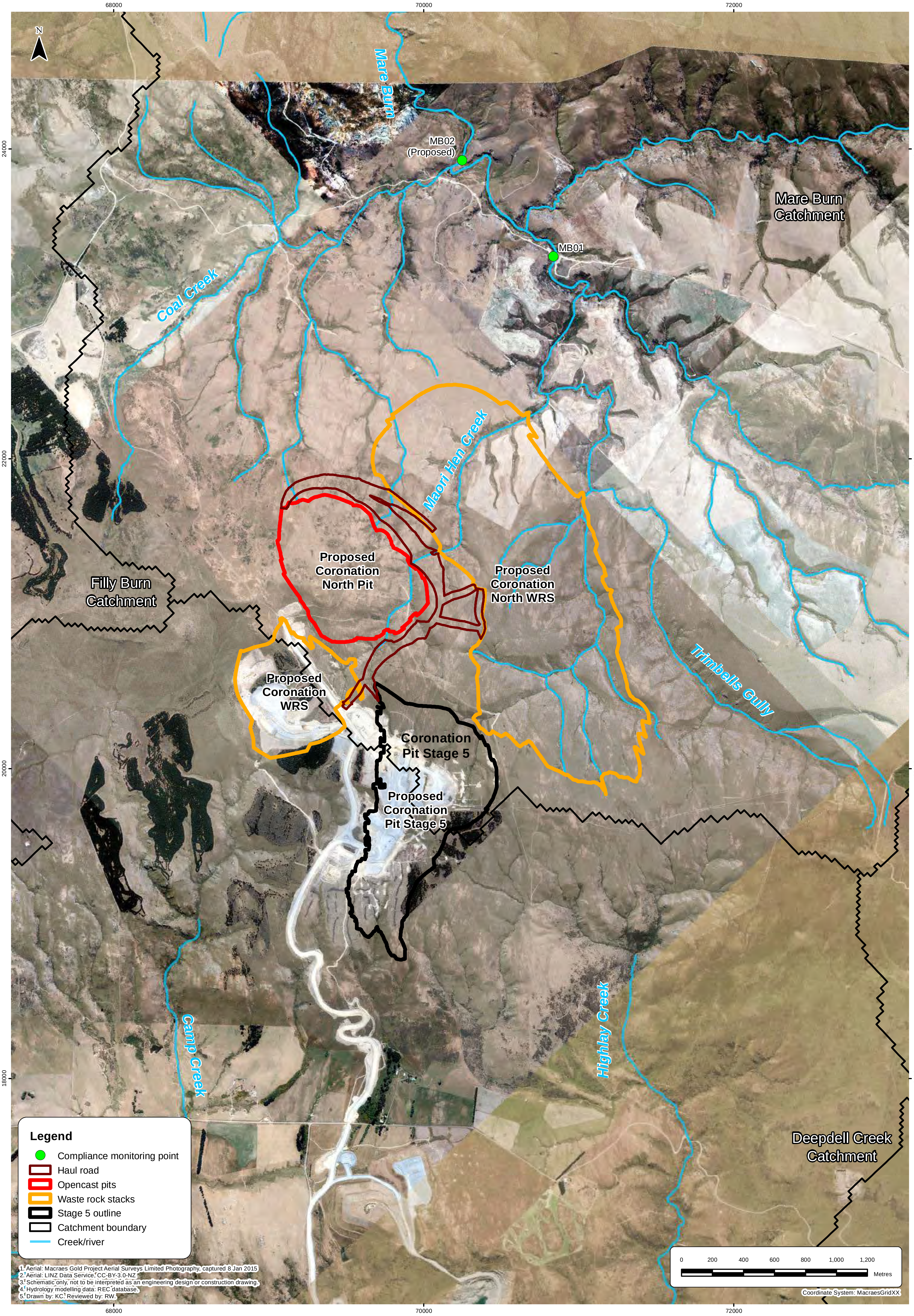
TITLE SITE LOCATION PLAN

MAY 2016

PROJECT 1545831

1

S:\GIS\Projects-Dynamics\2015\7410\1545831_OceanaGold(NZ)Ltd_CoronationNorthPitWaterAssessment\MapDocuments\002\Fig01_SiteLocationPlan_A3P_GIS.mxd



Golder Associates

TITLE SITE LAYOUT PLAN

MAY 2016

PROJECT 1545831

2

S:\GIS\Projects-Dynamics\2015\7410\1545831_OceanaGold(NZ)Ltd_CoronationNorthPitWaterAssessment\MapDocuments\002\Fig02_SiteLayoutPlan_A3P_GIS.mxd

Mining operations on the Project are scheduled to commence in July 2016. The estimated duration of the operation and rehabilitation phases of the Project is approximately five years. Mining operations are planned to be continuous, 24 hours a day, seven days a week. Mining methods will involve drilling and blasting operations similar to those already conducted at Coronation Pit and the wider MGP.

OceanaGold plans to extend the existing Coronation Pit, which is currently consented to cover an area of 62 ha, primarily toward the south to form the CS5 (Figure 2). The final CS5 pit design is expected to be similar to the one depicted in Figure 2, which has a total area of 85 ha.

An ore resource that intersects the footprint of the already consented Coronation WRS is the target of the planned Coronation North Pit. The planned extent of the Coronation WRS will therefore be reduced from that already consented, to enable construction of the Coronation North Pit. The final design for the Coronation North Pit is expected to be similar to the one depicted in Figure 2.

OceanaGold plans to construct the Coronation North WRS to the North East of the existing Coronation Pit and the planned Coronation North Pit. The Coronation North WRS design depicted in Figure 2 is capable of containing the total excavated waste material from Coronation North Pit and the CS5 expansion. Coronation North WRS is designed to reach a maximum elevation of 495 mRL and have an area of approximately 234 ha.

There is potential for the opportunistic placement of backfill within both of the planned pits. If this occurs, the size of the planned WRSs may decrease in proportion to the amount of backfill placed in the pits. The placement of backfill within the planned opencast pits has however not been taken into account in the technical evaluations documented in this report.

The existing haul road from the Process Plant to Coronation Pit will be extended by about two kilometres toward the north to reach the Coronation North Pit. The planned haul road will loop around the northern side of Coronation North Pit, supported by embankments that infill two gullies that intersect the pit footprint.

Surface water run-off around the pits, WRSs and haul road is to be managed with diversion drains and silt control dams located in gullies downstream of disturbed areas. Prior to any disturbance within a catchment, sediment control measures are to be installed.

Surface water and groundwater collected in the pits during operations will be pumped out to mine water sumps located adjacent to the pits. Water from the sumps will be used for dust control and any surplus water is to be discharged via a silt pond or irrigated on surrounding land.

The closure plan for Coronation North comprises progressive rehabilitation of the Coronation and Coronation North WRSs, formation of pit lakes within both pits and decommissioning of the silt ponds to become stock water ponds. In addition, the haul road from the pits and WRSs to Horse Flat Road is to be rehabilitated.

1.3 Scope

The scope for this package of works consists of the following:

An assessment of the potential effects of the proposed Coronation North pit and WRS on the water quality of the Mare Burn. This assessment includes the development of a GoldSim model to simulate the Mare Burn catchment at the existing surface water quality compliance point and one proposed water quality compliance point downstream. Three versions of the catchment model would therefore be developed:

i) A currently consented operations model incorporating Coronation Pit, the projected Coronation Pit lake and the currently planned Coronation WRS.

ii) An effects model incorporating the structures and waste storage associated with both Coronation and Coronation North Pits and WRSs.

iii) A closure model incorporating the structures and waste storage associated with both Coronation and Coronation North Pits and WRSs.

A pit lake development module will also be incorporated into the mine water management model, simulating the projected development of pit lakes in both the Coronation and Coronation North pits. This module will be calibrated through using it to simulate the historical development of the pit lakes in the Deepdell South Pit.

With respect to water flows and water quality at the existing compliance point, the proposed GoldSim assessment of the effects of Coronation North Pit and WRSs on water quality will be reported against two periods:

i) One operational stage of the mine, constituting the maximum extent of the pit and the WRS.

ii) The post-closure period of the Coronation operations, including the pit lakes at their long term water level.

1.4 Existing Models

A number of surface water models have been prepared by Kingett Mitchell Limited (Kingett Mitchell) (now Golder Associates (NZ) Limited), for the site. The purpose of these models ranged from evaluating the site wide water balance and process water demand, to assessing effects from site activities including pit lake formation and site discharges (Golder 2011a, 2011b, Kingett Mitchell 2002, 2005).

The existing models were developed using a mining industry specific model developed by Kingett Mitchell, which utilises a spreadsheet platform to model hydrology and water quality for the site and receiving environments. The model includes a calibration process that matches predicted and actual hydrographs and flow duration curves by varying a number of coefficients for rapid run-off and antecedent flows including a base flow yield factor.

Following the merger of Kingett Mitchell and Golder, the Kingett Mitchell model has been integrated into a different modelling platform known as GoldSim (http://www.goldsim.com/Home/#). The GoldSim model has been further developed to provide improved calibrations and allow more probabilistic analysis for projected outcomes.

2.0 CLIMATE

2.1 Regional Climate Overview

New Zealand lies in the mid-latitude zone of westerly winds, in the path of a succession of anticyclones, which move eastwards (Metservice 2016). The presence of the Southern Alps, extending the length of the South Island, has a major effect on the climate of the Otago region, as does the ocean, and produces distinct climatic contrasts from west to east. In inland Otago areas, just east of the mountains, the climate appears to be more continental in character than coastal areas where there is a more noticeable marine influence.

The distribution of rainfall is mainly controlled by mountain features and the highest rainfalls occur where the mountains are exposed to the direct sweep of the westerly and north-westerly winds. The MGP lies to the east of the main ranges and is therefore a dry area with extended periods of little or no rain. The climate at the MGP is however moderated to some degree by the ocean, which makes it significantly cooler than inland regions further north.

2.2 Rainfall

General

Rainfall at or near the MGP site has been monitored since 1959, with rainfall data available from four monitoring stations (Table 1). Rainfall data from these stations has been collected and archived by OceanaGold. When considered together, this data provides a relatively complete rainfall record for the Macraes Flat area from 1959 to 2015.

Average annual rainfall varies for these sites between approximately 500 mm and 650 mm. The Deepdell Creek station receives the least rainfall. Golden Point and Glendale stations receive similar amounts, around 150 mm more annually than the Deepdell Creek station (Golder 2011b).

An amalgamation of rainfall data from the Glendale and Golden Point data was developed to support the mine water modelling for the Macraes Phase III Project (MPIII) and documented in a report (Golder 2011a), which was lodged with the ORC to support consenting of MPIII. This amalgamated data set has been expanded through the incorporation of data recorded from the Glendale, Golden Point and DG15 monitoring stations since 2011, without changing the earlier data. This updated amalgamated data set is henceforth referred to in this report as the Macraes Flat rainfall record. The Macraes Flat rainfall record represents the most complete and representative rainfall dataset available for the MGP site.

Table 1: Summary of rainfall monitoring sites.

Station Name	Location (NZMS 260)	Elevation (m)	Recording Authority	Date Begin	Date End
Deepdell Creek	I42 079 365	360	Boroman Consultants	19/03/1990	Ongoing
Glendale	I42 124 353	550	NIWA	13/01/1959	30/04/2013
Golden Point	I43 080 366	527	OceanaGold	01/01/1993	Ongoing
DG15	I42 087 330	500	OceanaGold	11/04/2013	Ongoing

Mare Burn catchment rainfall

No rainfall data exists for the Mare Burn catchment. The topography within the Mare Burn catchment ranges from a maximum of 820 mRL to a minimum elevation of 450 mRL at a proposed new water quality compliance monitoring point MB02 (refer Section 6.3). On this basis, it is anticipated that the Macraes Flat rainfall record would be appropriate to simulate the rainfall patterns expected within the Mare Burn catchment.

Annual average rainfall for the Macraes Flat rainfall record is around 650 mm and may vary from as little as 400 mm to as much as 1,000 mm based on the 55 year record. Slightly higher rainfall may occur in the upper parts of the Mare Burn catchment, given the slightly higher elevation, but this is not expected to be significant in terms of water management for the Coronation North Project. Rainfall varies seasonally, with the wettest months tending to be December and January and the driest month being September (Figure 3).

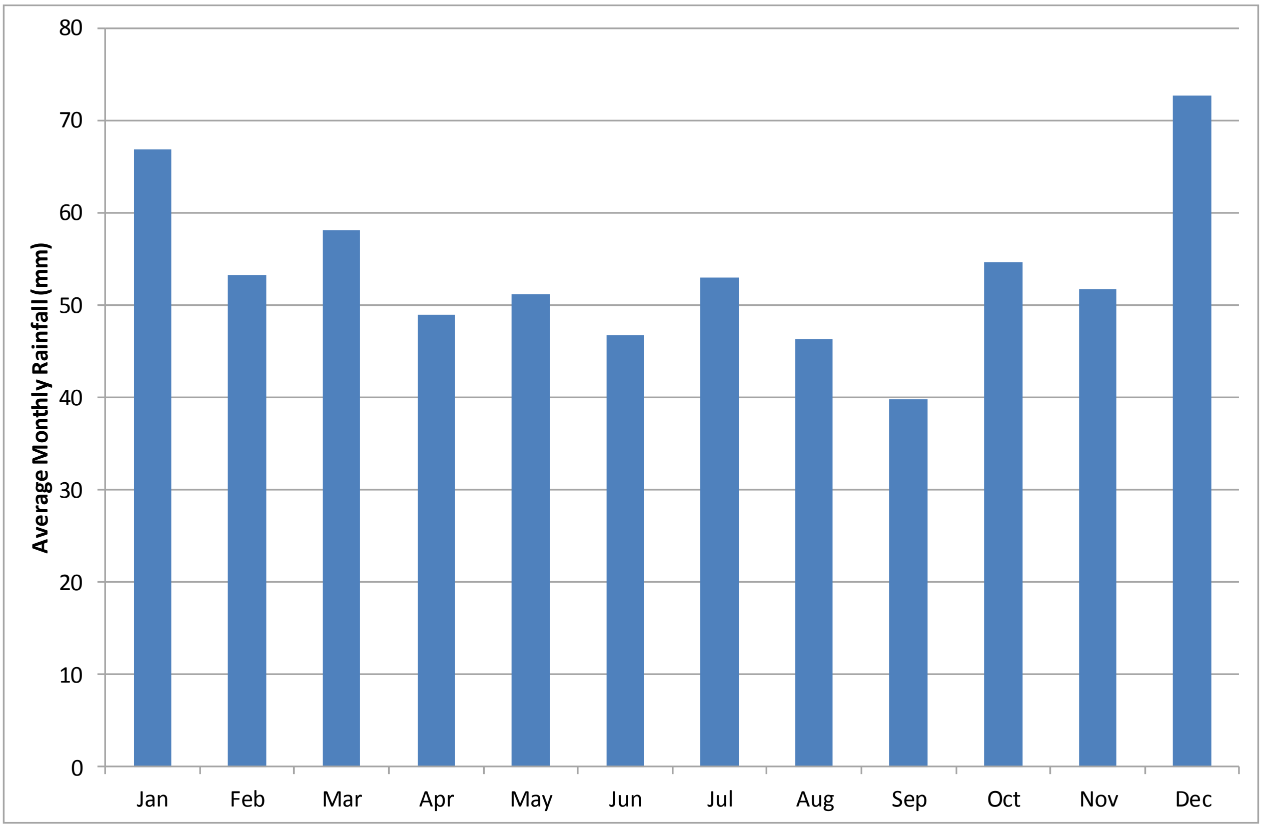


Figure 3: Average Monthly Rainfall – Macraes Flat rainfall record.

2.3 Evaporation

General

Evaporation data is collected by OceanaGold staff on a weekly basis from an open pan located adjacent to the Golden Point raingauge, near the Mixed Tailings Impoundment. This station is henceforth referred to as the Golden Point evaporation pan. Evaporation data is available from 1992 to present. Pan evaporation data analysed as part of the MPIII consenting project indicated average annual evaporation rates for the site of around 1,000 mm.

Pan evaporation and Penman evapotranspiration data is available from climate stations operated by NIWA and located reasonably close to the MGP site (Table 2). The Palmerston (site I50471) and Middlemarch (site I50513) monitoring stations are located 25 km and 31 km respectively from the MGP site. These two stations are situated at lower elevations, 21 m RL and 213 m RL, respectively than the MGP. The Palmerston site has recorded considerably less annual pan evaporation (around 700 mm) than the Golden Point evaporation pan. The Middlemarch site has recorded a similar amount, approximately 1,100 mm annually, to the Golden Point evaporation pan. Further details on these evaporation monitoring stations and detailed analysis of evaporation data was documented in support of the MPIII consenting process (Golder 2011a).

Mare Burn catchment evaporation

Given the proximity of the Mare Burn catchment to the Golden Point evaporation pan, and the small variation expected due to the similar elevations, Golden Point evaporation can be accepted as representative for the Mare Burn Catchment. An extended pan evaporation dataset was generated during the MPIII project and this is used to approximate evaporation within the Mare Burn catchment. This extended dataset was developed from correlation between pan evaporation (Golden Point) and the Palmerston data. Palmerston data was utilised as this had a significantly longer record than Middlemarch (Golder 2011a).

Pan evaporation can be expected to vary monthly with the largest evaporation occurring in January and the least occurring in June. Generally monthly pan evaporation exceeds 100 mm in October through March and is below 80 mm per month in April through September. Figure 4 presents the calculated monthly average evaporation variation at the MGP site.

Table 2: Summary of evaporation monitoring sites.

Station Name	Location (NZMS 260)	Distance from MPG (km)	Elevation (m)	Recording Authority	Date Begin	Date End
Golden Point	I43 080 366	0	527	OceanaGold	01/01/1993	Ongoing
Palmerston site I50471		25	21	NIWA	13/01/1959	Ongoing
Middlemarch site I50513		31	213	NIWA	01/01/1993	Ongoing

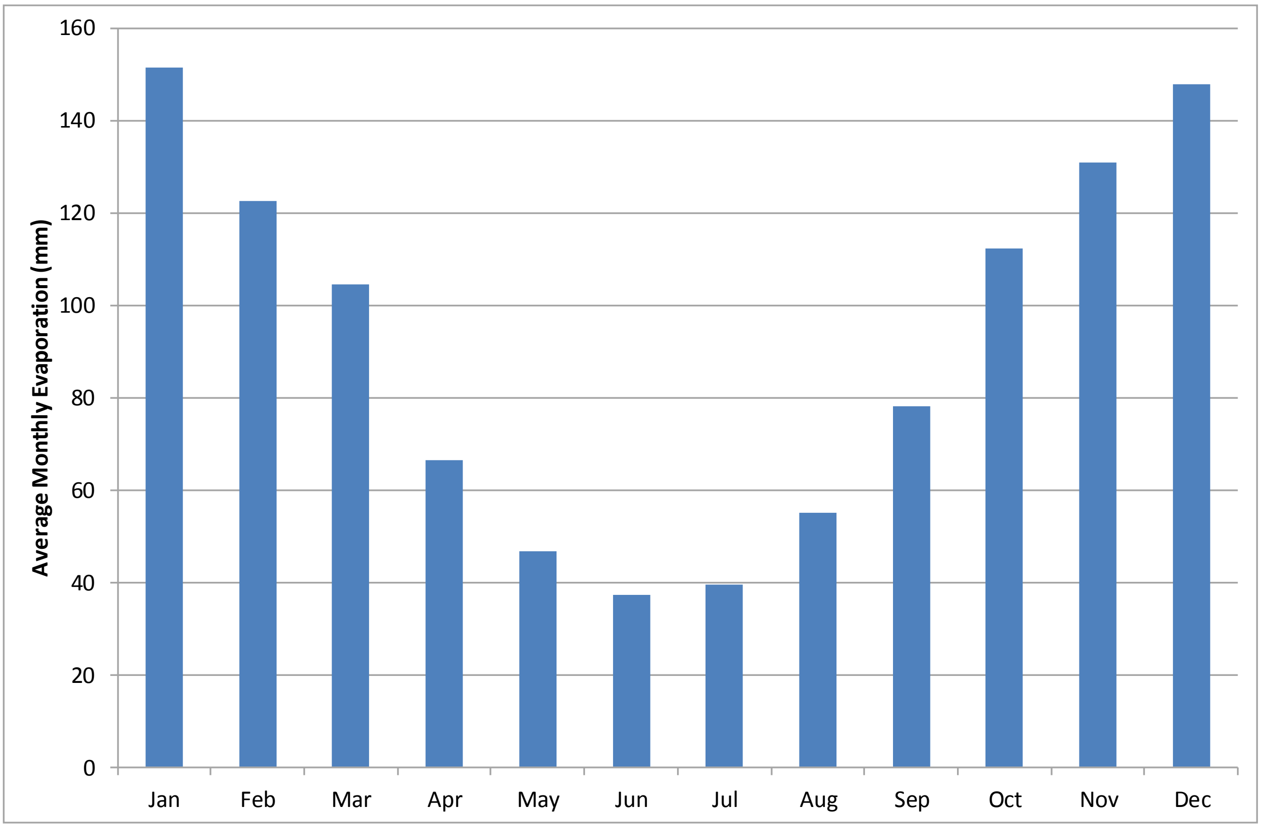


Figure 4: Average Monthly Pan Evaporation

3.0 HYDROLOGY

3.1 Overview

The Coronation North Project is located within the headwaters of the Mare Burn catchment, a left bank tributary of the Taieri River. The Coronation and Coronation North pits, WRSs and other associated mine infrastructure extend across Trimbell's Gully, Maori Hen Creek and Coal Creek, all of which are minor headwater tributaries of Mare Burn (See Figure 1).

3.2 Deepdell Creek

A water level recorder was installed in Deepdell Creek, close to the Golden Point Road ford, and commissioned in late 1985. The history of the monitoring station is summarised in a report by Golder (2011a). The Deepdell Creek catchment upstream of the weir is around 40.8 km^2 in area.

Flow data from Deepdell Creek has been analysed for the period 1985 to 2015. Instantaneous and daily average flow statistics for the Golden Point Weir are presented in Table 3. The specific flow rates (flow per unit area are also included).

Flow in Deepdell Creek is dominated by periods of relatively low flow with a large number of short duration flash and flood events. Daily average flow at Golden Point weir is approximately 108 L/s (2.65 L/s/ km^2) with a much lower median flow of 28.7 L/s (0.70 L/s/ km^2). Flow records indicate Deepdell Creek has ceased to flow on a number of occasions through the summers of 1998, 1999, 2004, 2007, 2009, and 2015. The daily average flows summarised in Table 3 are generally comparable with those documented in the water balance report (URS 2013a) lodged with ORC in support of the Coronation Pit consent application. The maximum daily average flow documented by URS (2013a) was however approximately 22,000 L/s or 50 % of the maximum average daily flow in Table 3. The lower quartile calculated by URS was also 2 L/s less than that presented in Table 3. These differences may be due to the difference in the length of monitoring records available for analysis, which in the URS report finished in 2010.

Table 3: Deepdell Creek flow statistics.

Parameters (1)	Min	L.Q. (2)	Median	Average	U.Q. (3)	Maximum
Instantaneous (L/s)	0.0	10.7	28.1	110.1	83.5	73,695
Daily average (L/s)	0.0	10.7	28.7	108.2	85.0	44,220
Instantaneous (L/s/km^2)	0.00	0.26	0.69	2.70	2.05	1,806
Daily average (L/s/km^2)	0.00	0.26	0.70	2.65	2.08	1,084

Notes: 1) Flows calculated based on midnight to midnight for the monitoring period July 1985 – December 2015.
2) Lower quartile.
3) Upper quartile.

Monthly average flow rates are presented in Figure 5. Monthly average flow varies between around 40 L/s in February to around 200 L/s in June. Average flows are generally low in the months of November through April. Statistics on low flow percentiles and daily average low flow data and high flow data for Deepdell Creek at Golden Point weir is summarised in Golder 2011b.

3.3 Mare Burn

The Mare Burn catchment is does not have a permanent flow recorder or any lengthy continuously recorded dataset. A limited amount of continuous data was collected in the 2009/2010 irrigation season by Otago Regional Council at the confluence with the Taieri River (ORC 2009). The catchment area for that monitoring site was approximately 5,800 ha. A number of discrete water resource gauging's have also been performed at the same location.

The limited data available to date indicates that the Mare Burn catchment ceases to flow on occasions with a minimum recorded flow of 0 L/s (ORC 2009). According to the dataset indicates the Mare Burn ceased to flow from January 2010 to April 2010 (ORC 2009). Peak flows of around 9 m^3/s were also recorded in 2009/2010 indicating reasonable flood flows from the catchment are possible.

Given the climate, geology and elevation of the Mare Burn catchment, it is likely to be hydrologically similar to Deepdell Creek. For the purposes of understanding the likely flow regime of Mare Burn, specific flow data from Deepdell Creek, presented in Section 3.2, has been utilised and scaled to the Mare Burn catchment area upstream from the current MB01 compliance site (13.8 km^2) and the proposed MB02 site (29.3 km^2). The derived flow statistics are presented in Table 4 and can be used as an indication of likely flows at the respective sites.

The scaled data indicates that, without development in the catchment, daily average flows in Mare Burn at the MB01 compliance point may vary between 0 L/s and 14,960 L/s. Average flows are likely to be around 37 L/s, with median flows around 10 L/s. These flows are similar to those presented in the water balance from the Coronation Pit surface water balance modelling report (URS 2013), although the lower quartile and median values (Table 4) are slightly lower in the URS report.

Daily average flows at site MB02 may vary between 0 L/s and 31,760 L/s. Average flows are likely to be around 78 L/s with median flows around 21 L/s.

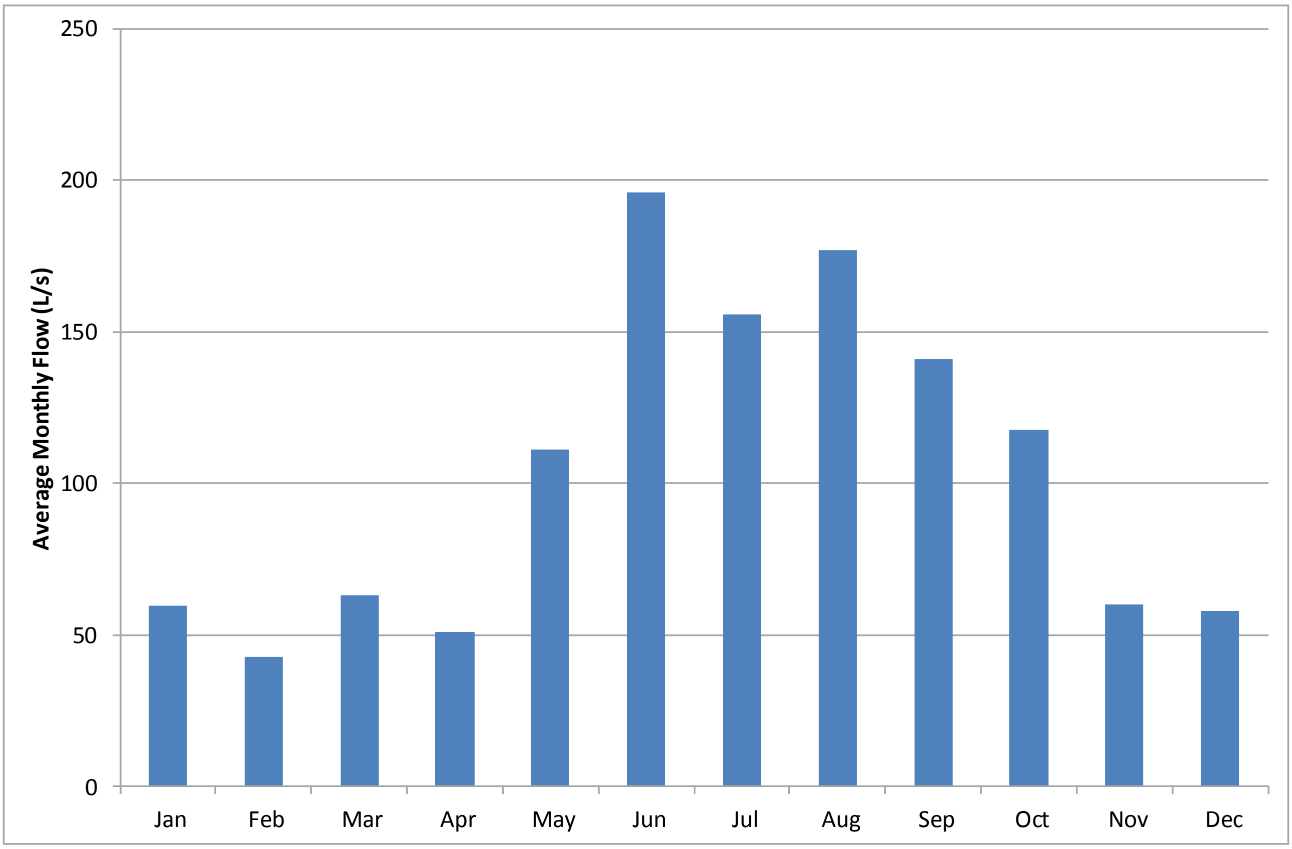


Figure 5: Deepdell Creek monthly average flow.

Table 4: Mare Burn derived flow statistics.

	Min	L.Q	Median	Average	U.Q.	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

4.0 WATER QUALITY

4.1 Introduction

As part of an ongoing environmental monitoring program at the MGP, water quality sampling has been undertaken at various locations (surface and groundwater) within the site footprint and in waterways upstream and downstream from the active mine areas since 1991. The data are used for consent compliance monitoring, early detection of potential issues and general site characterisation purposes.

An evaluation of water quality from specific sampling points at the MGP has been undertaken to provide an estimate of water quality for modelling of the Mare Burn catchment during operational mining and following closure of the MGP. These assessments are summarised in the following sections and documented in detail in Appendix C.

4.2 Mare Burn

Surface water quality downstream of the Coronation North Project within the Mare Burn is currently monitored at a number of locations. The compliance point MB01 is located approximately 80 m downstream from the confluence with the Trimbell's Gully tributary of Mare Burn. Table 5 summarises the water quality measured at MB01 to date. Data presented were collected between December 2014 and November 2015.

Table 5: Summary of water quality monitoring data from MB01 (Dec 2014 – Nov 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.

The existing mining operations within the Mare Burn catchment (Coronation Pit and WRS) commenced in late 2014. The data presented in Table 5, which post-dates the start of mining operations in the catchment, may therefore not represent baseline water quality within Mare Burn. For that reason, baseline water quality utilised for the MPIII project (Golder 2011a) was compared to the MB01 data (refer to Appendix A for comparison). The MPIII baseline data derives from monitoring water quality in Deepdell Creek upstream from the MGP mining operations. The comparison of water quality data from MB01 with the MPIII baseline data indicates that the water quality presented in Table 5 is similar to the baseline water quality in the Deepdell Creek catchment. In addition, there is no indication of decreasing water quality or rising concentrations for any of the monitored parameters during the reviewed period. Therefore the Mare Burn water quality data from the MB01 compliance monitoring site for the period from December 2014 to November 2015 has been adopted as the baseline water quality for the Coronation North Project.

4.3 Pit Lakes and Sumps

Review of the environmental monitoring data from the MGP indicates that the quality of water in operational pit sumps differs substantially from that in lakes that develop in the opencast pits following closure. The quality of water in a pit sump can also vary, depending on where the sump is located with respect to the mineralised zone within the pit. Water quality data from two monitoring sites at the MGP have been identified as having extended recording periods and being representative of the expected pit water quality in the Coronation North Project. Data from the Frasers Pit sump is expected to be representative of operational pit water quality, while data from Golden Bar Pit lake is expected to be representative of the post-closure pit lake water quality.

The water quality data collected during the operational period of Frasers Pit prior to 2008, a period of approximately 10 years, is considered to be indicative of the water quality that may be expected from the pit sumps in both Coronation and Coronation North Pits prior to the close of mining operations in these pits (Table 6). Although Frasers Pit is much larger than either CS5 or Coronation North Pit and has some WRS seepage contributing to the pit inflows, the water quality in this pit sump is considered to be the most comparable dataset from the MGP environmental monitoring database.

There are two existing pit lakes at the MGP, Deepdell South and Golden Bar. Golden Bar and Deepdell South have been closed for several years. The quality of water in these two pit lakes has varied over time following the cessation of mining operations in each pit as the lakes have increased in volume, depth and surface area. The water quality in each of these two lakes has followed a similar route toward maturity and both pits are similar in size to the pits in the Coronation North Project. The water quality from Golden Bar Pit has been selected as providing an indication of long term water quality in the planned CS5 and Coronation North Pit (Table 6) as this pit is closer in size to the Coronation North Pit and CS5.

Table 6: Water quality from the operational Frasers Pit sump and Golden Bar Pit lake post-closure.

Parameter	Frasers Pit (1998 – 2008)		Golden Bar Pit (2010 – 2015)	
	Average	95th Percentile	Average	95th Percentile
pH (unitless)	8.1	8.8	8.3	8.3
Conductivity (mS/m)	732	941	823	921
Calcium	64.1	89.7	78.9	82.3
Chloride	11.4	18.9	6.3	7.0
Magnesium	35.7	51.0	59.1	76.1
Potassium	8.3	15.8	4.1	4.8
Sodium	35.1	54.7	12.6	14.6
Sulfate	176	301	284	302
Cyanide $_{WAD}$	0.006	0.010	<0.001	<0.001
Arsenic	0.18	0.54	0.24	0.29
Copper	0.002	0.002	0.0007	0.0013
Iron	0.23	0.85	0.035	0.13
Lead	<0.001	<0.001	0.00013	0.00023
Zinc	0.04	NA	0.006	0.0093

Notes: All units g/m^3 unless otherwise stated. All concentrations are total dissolved concentrations. N/A – no data available.

Water quality monitoring records for the Golden Bar pit lake start from late 2004. The water quality in this lake changed substantially during the period through to late 2008 during the early stages of pit lake development, only becoming relatively stable after that date. Concentrations of dissolved arsenic in particular have however been decreasing in the pit lake since late 2007, with this trend continuing (refer Appendix A). As this data is used as an indication of long term water quality in the Coronation North Project pits, only the Golden Bar Pit lake water quality data for the period from 2010 onward has been evaluated for this purpose.

The main contaminants of concern (elevated levels when compared with compliance limits) within pit water are arsenic and iron. Both Frasers pit and Golden Bar pit have arsenic and iron levels that exceed the compliance criteria in receiving waters, as such if these are released to the environment during low flows, compliance criteria can be exceeded.

4.4 Waste Rock Stack Seepage

With respect to ongoing compliance with the existing water quality criteria applicable at MB01, the primary dissolved contaminants of concern in WRS seepage are sulfate and iron. The concentration of sulfate in the seepage water is influenced by oxidation of the sulfide minerals during weathering of the waste rock and the amount of time the sulfide minerals have been exposed to weathering. For the purposes of this assessment sulfate is considered to be transported conservatively, in that it is not subject to natural removal or degradation processes. Dilution is the main mechanism by which sulfate concentrations are reduced. Evaporation of the transporting water can result in the precipitation of sulfide minerals during very dry periods. However, these minerals tend to be soluble and can be subsequently remobilised once the availability of water increases again.

Water quality data from WRS monitoring sites at the MGP indicate that when WRS are initially constructed, sulfate levels in seepage water are relatively low (i.e. less than 50 g/m^3). Over time, sulfate concentrations increase and have been measured at up to 2,900 g/m^3 (Table 7). WRS seepage water quality for the simulated Coronation North Project has been derived from water quality data from the Northern Gully western underdrain and Clydesdale Creek silt pond located at the toe of the Golden Bar WRS (Appendix A). The trends in seepage water quality with increasing WRS age are consistent across the MGP and Golder is confident that the quality of seepage water from the Coronation North WRS will follow a similar trend through to a long term stable water quality. Specific measures to improving long-term WRS seepage water quality are being investigated by OceanaGold, which could reduce contaminant concentrations in the receiving water bodies. At this stage however these measures are in the pre-feasibility stage of development and have therefore not been incorporated in the water modelling undertaken for this project.

Dissolved iron concentrations are elevated in WRS seepage discharges. The iron tends to precipitate out in the stream beds and silt ponds immediately downstream from the discharge points. Although iron has been simulated as being conservatively transported in the Mare Burn catchment water model, this is not the case at the site. For example, the dissolved iron concentrations observed in the Northern Gully silt pond are normally below the laboratory detection limit of 0.04 g/m^3. In contrast, the WRS seepage water discharging from underdrains into the silt pond normally regularly has concentrations in excess of 0.5 g/m^3 (Table 7). This contrast is considered to be predominantly a consequence of iron precipitation as sulfate concentrations detected in water from the silt pond since 2011 have generally been similar to the concentrations in seepage water discharging to the pond.

5.0 WATER BALANCE MODEL

5.1 GoldSim

The surface water model for the Coronation North Project has been developed using GoldSim Pro (Vers.11.1) software. GoldSim is a graphical object-oriented modelling environment with the capacity to carry out dynamic probabilistic simulations. GoldSim has been applied successfully in a decision support role to a range of water balance, water quality and water resource projects and is the industry standard for many mine water related assessments both in NZ and worldwide.

Table 7: Summary of water quality in Clydesdale Creek silt pond and Northern Gully underdrain.

Parameter (1)	Clydesdale Creek silt pond (2003-2008)		Northern Gully western underdrain (2010-2016) (2)	
	Average	95th Percentile	Average	95th Percentile
pH (unitless)	7.7	8.3	7.8	8.0
Conductivity (mS/m)	663	1,224	3,797	4,036
Calcium	67.9	125.4	471	514
Chloride	6.1	6.1	15.0	24.8
Magnesium	6.4	6.4	428	466
Potassium	4.6	5.9	12.4	14.3
Sodium	19.9	26.4	62.8	68.2
Sulfate	238	611	2,520	2,900
Cyanide $_{WAD}$	N/A	N/A	0.001	0.002
Arsenic	0.005	0.010	0.009	0.013
Copper	0.001	0.002	0.002	0.005
Iron	0.29	1.34	0.76	2.2
Lead	0.0001	0.002	0.001	0.001
Zinc	N/A	N/A	0.033	0.043

Notes: 1) All units g/m^3 unless otherwise stated. Concentrations are all total dissolved concentrations. N/A – no data available.
2) Water quality data from monitoring well SPMP3, which is installed in the Northern Gully WRS, was also considered for comparison purposes. With the exception of dissolved iron (0.07 g/m^3 in SPMP3), the 95th percentile concentrations recorded for the other parameters were similar to those presented in this table.

5.2 Model Description

5.2.1 Coronation North Project model stages

For a model to be useful it must suitably represent actual conditions. The first stage in achieving this is to accurately conceptualise existing and proposed activities at the site. Following discussions with OceanaGold, three conceptual models covering different phases of water management at the Coronation North Project were developed:

- Stage 1 – A model of the Mare Burn catchment incorporating currently consented operations including the Coronation Pit and Coronation WRS (Model logic presented in Figure 6). 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 (Model logic presented in Figure 7). 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 (Model logic presented in Figure 8). It is assumed the WRSs are rehabilitated.

For each stage the model integrates relevant surface water and groundwater processes to enable prediction of flows and water quality at the catchment water quality compliance monitoring points. Each model incorporates mine site infrastructure such as pits and sumps, WRSs and undisturbed catchment areas.

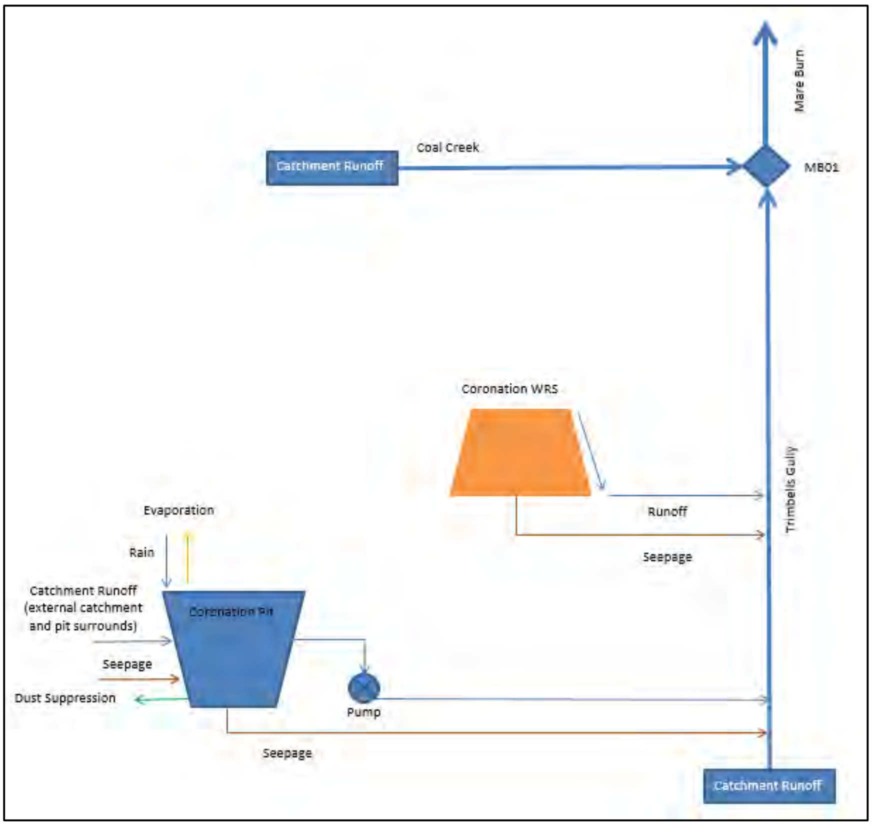


Figure 6: Stage 1 model logic – Coronation operational water model.

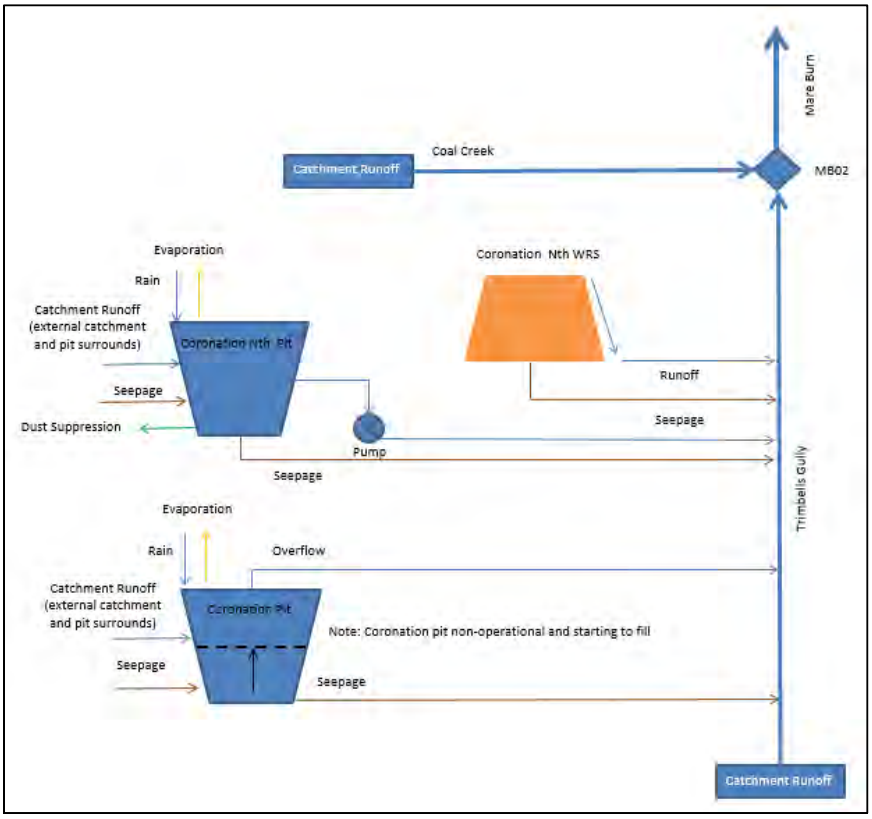


Figure 7: Stage 2 model logic – Coronation North operational water model.

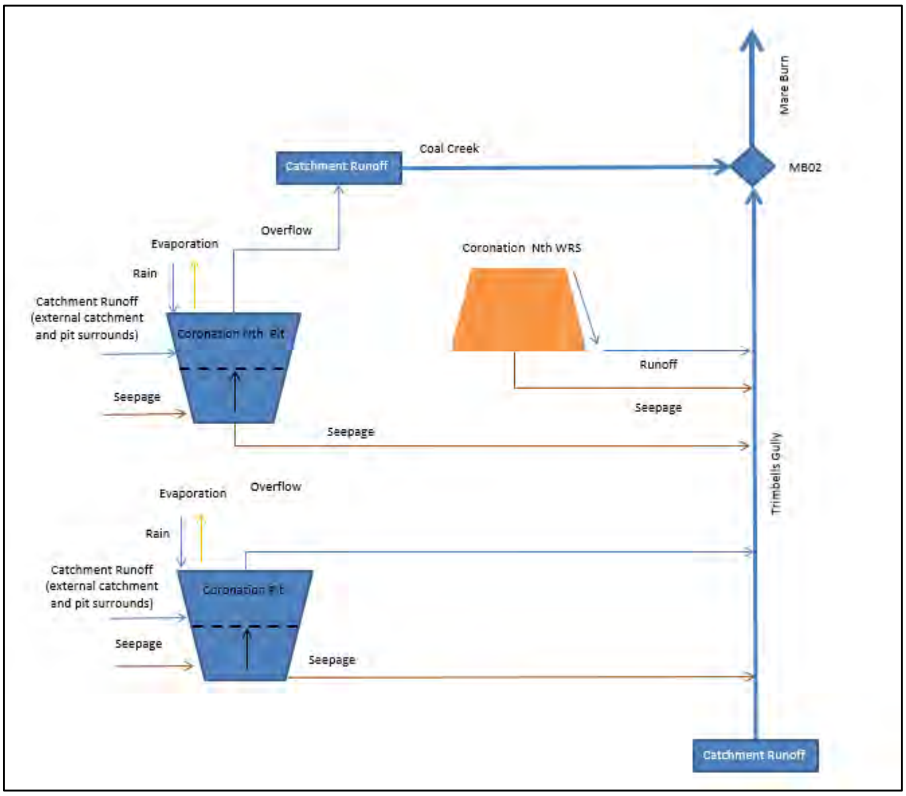


Figure 8: Stage 3 model logic – Coronation North Project closure.

In each of the mine stage models the run-off and groundwater seepage form the Coronation North WRS is simulated as discharging to Trimbells Gully. A small proportion of the Coronation North WRS run-off and groundwater seepage will however discharge to tributaries of Coal Creek (Golder 2016b). For modelling purposes, the Coronation North WRS was treated as a single unit with all discharges being combined in the mass load at MB01.

5.2.2 Model timing

Each model developed for the project runs on a daily time step. For each modelled scenario (mine development stage), the model is run incorporating all mine infrastructure for the respective stage.

The Stage 1 model allows for a simulation running 100 years into the future. The Stage 2 and 3 models provide for simulations running 300 years into the future (to allow time for pit lake formation and stabilisation).

5.2.3 Model extents and projection points

All major Coronation North Project mining infrastructure features have been incorporated within the model stages. For Stage 1, the model extends from the existing MB01compliance point within the Mare Burn catchment to the catchment headwaters. It is assumed that a portion of the seepage and run-off from the currently consented Coronation WRS reports to the south into Deepdell Creek. The Coronation pit extends through the catchment divides but overflow discharges from the pit would report to the north into the Mare Burn catchment.

In Stage 2 and Stage 3, the proposed compliance point MB02 supersedes the existing MB01 site due to the expanded area of mining activities in the catchment. MB02 is located approximately one kilometre downstream of MB01. The same assumptions documented above for Stage 1 also apply to the models for Stages 2 and 3.

5.3 Model limitations

The limitations associated with the model specification presented in this document include the following:

- The numerical modelling approach is designed to be used for surface water flow and quality evaluations for the purposes of assessing potential adverse environmental effects and supporting an application for resource consents. The model incorporates simplifications to the internal mine water management system, as additional detail was not considered necessary for these purposes. At this stage of development the model is not considered to be of sufficient detail to be used for feasibility level engineering designs or detailed mine water management evaluation.
- Assumptions built into this model include water management objectives that are not necessarily valid under all operational conditions and scenarios. For this reason the model is not considered to be suitable for detailed mine water management design purposes.

5.4 Model Inputs

5.4.1 Meteorological inputs

Rainfall

Model rainfall input data is the Macraes Flat rainfall record (refer Section 2.2), a combined dataset spanning from 1959 to 2015 (around 55 years). The Macraes Flat data set utilises rainfall from the Glendale, Golden Point and DG15 rain gauges. Further information on the development of this data set is presented in Golder (2011a, 2011b).

For predictive modelling, GoldSim utilises a time shifting option where the rainfall data is randomly selected from the 55 year Macraes Flat rainfall record to generate a user specified rainfall series. Any length of rainfall data can be developed, however it is based on the 55 years of rainfall available.

Evaporation

Evaporation data utilised in the model is based on monthly average data indicative of pan evaporation data collected onsite between 2008 and 2015.

A daily dataset was developed at part of the MPIII modelling work (Golder 2011a). This data is based on a relationship with the Palmerston Climate station evaporation (site I50471) and pan evaporation data collected at Golden Point. More details on the relationship are outlined in Golder (2011a, 2011b).

This data is utilised for run-off modelling (utilised in the rainfall-run-off calibration (see Golder 2011a)) and also for calculation of discharges from site storages (i.e., pit lakes). A pan factor of 0.7 has been applied for all pit lake evaporation, as documented in the section on verification modelling (refer Section 5.5).

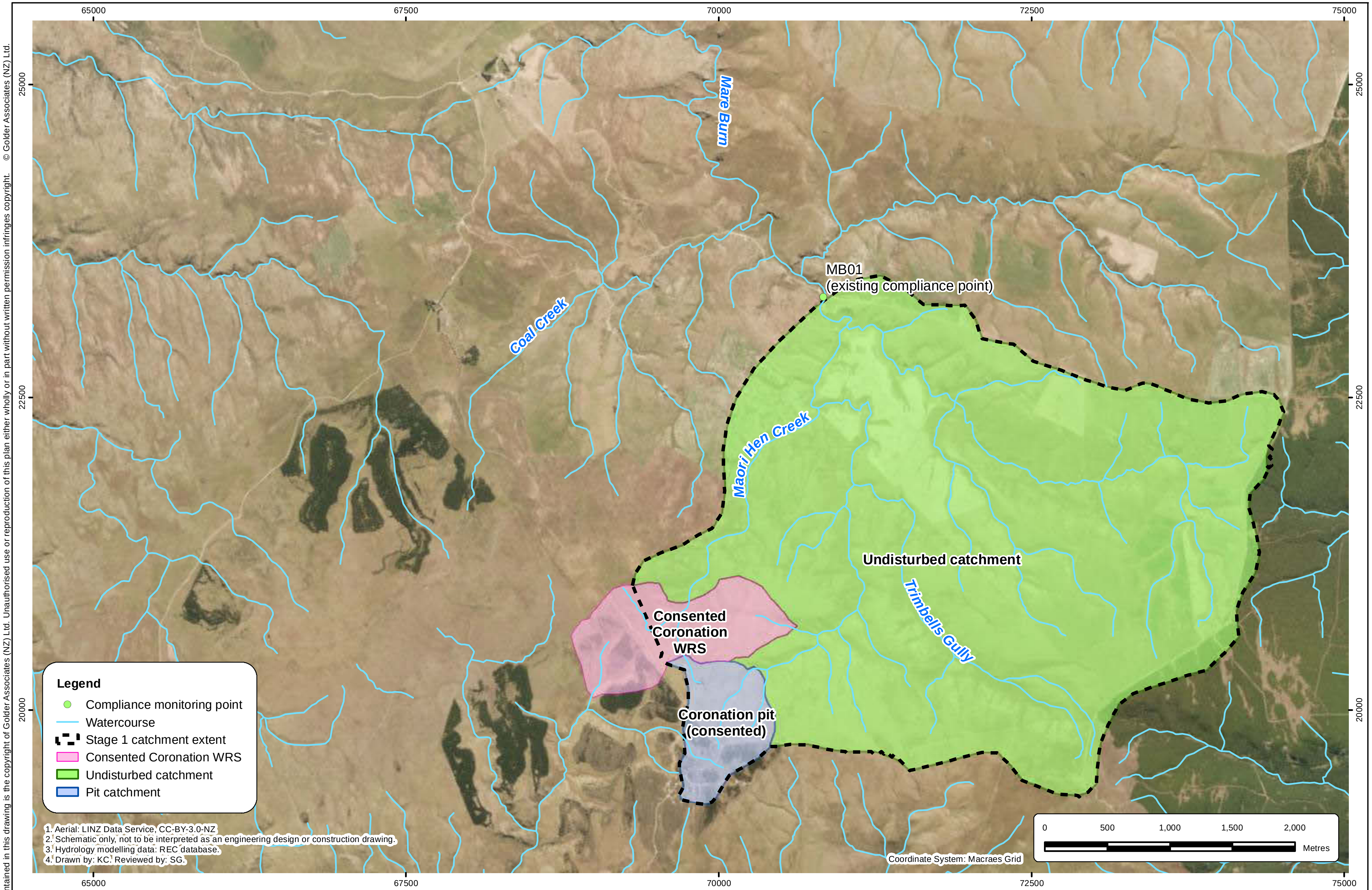
For predictive modelling, GoldSim samples evaporation data from the 29 year Macraes Flat evaporation record and utilises this for future evaporation scenarios.

5.4.2 Catchment areas and mining elements

Catchment areas have been defined within the mining area by mining stages (as presented in Section 5.2.1). The catchment layout for Stage 1 is presented in Figure 9. The catchment layouts for Stage 2 and Stage 3 are presented in Figure 10.

Catchments for each mining stage have been delineated based on run-off quantity and run-off quality. Three main catchment types have been identified for simplicity:

- Impacted catchments – Pits, haul roads, hardstands.
- WRS catchments – WRS and associated road and hardstands.
- Undisturbed catchments – Areas with soil surfaces not impacted by mining activities.



Golder Associates

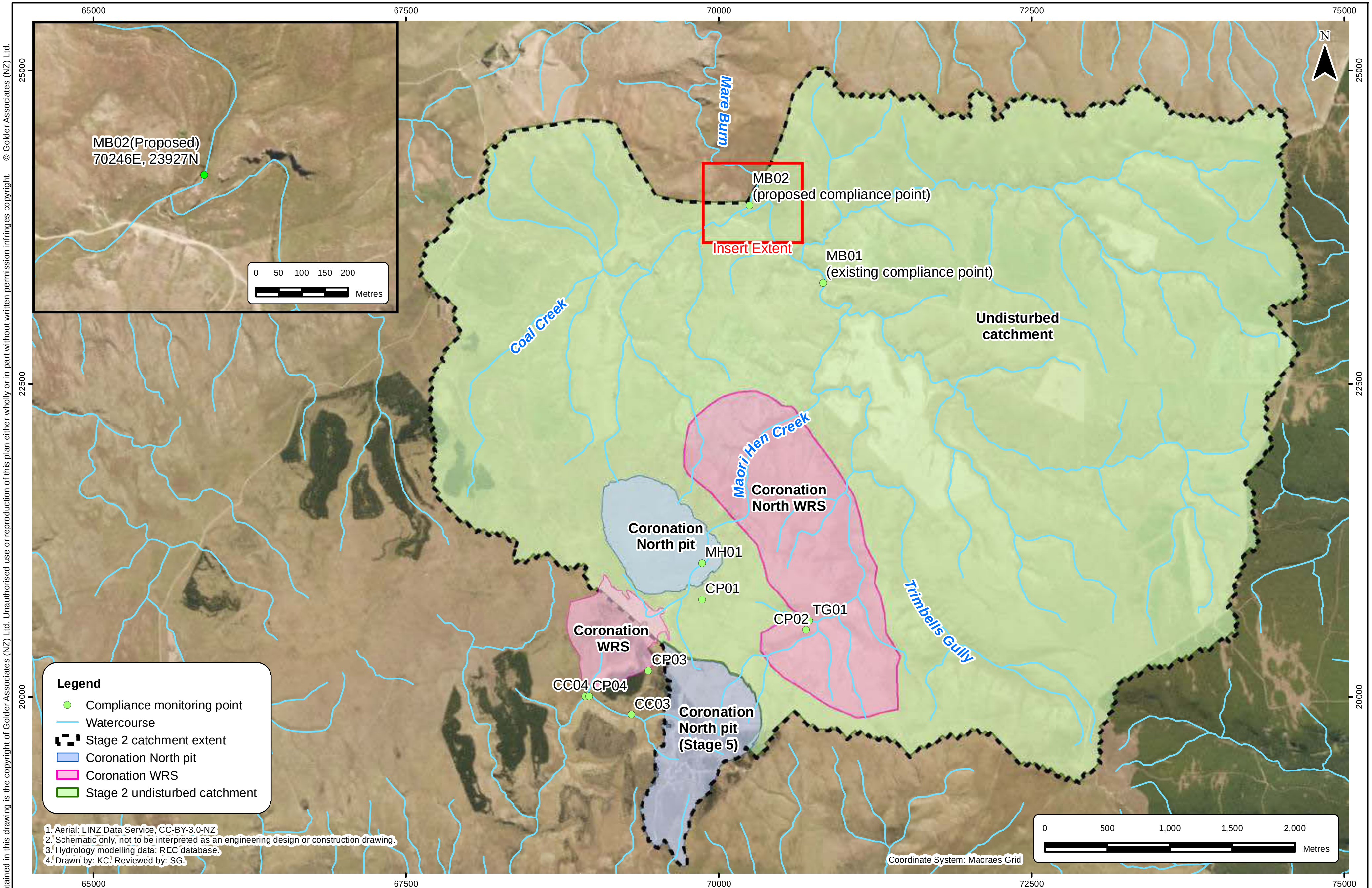
TITLE STAGE 1 - CORONATION PIT AND WRS OPERATIONAL CATCHMENT LAYOUT

MAY 2016

PROJECT 1545831

9

S:\GIS\Projects-Dynamics\2015\7410\1545831_OceanaGold(NZ)Ltd_CoronationNorthPitWaterAssessment\MapDocuments\003\Fig09_Stage1CoronationCatchmentLayout_A4L_GIS.mxd



Golder Associates

TITLE STAGE 2 AND 3 - CORONATION NORTH PIT AND WRS CATCHMENT LAYOUT

MAY 2016

PROJECT 1545831

10

S:\GIS\Projects-Dynamics\2015\7410\1545831_OceanaGold(NZ)Ltd_CoronationNorthPitWaterAssessment\MapDocuments\003\Fig10_Stage2n3CoronationNorthCatchmentLayout_A4L_GIS.mxd

Table 8 presents the respective catchment areas simulated in the model by stages and also presents the baseline case (pre mining) areas to the compliance points MB01 and MB02 for comparison.

The Stage 1 catchment model area is larger than the Stage 1 baseline area due to parts of Coronation Pit extending outside the Mare Burn catchment into Deepdell catchment. As any overflow from Coronation Pit will ultimately report to Mare Burn following closure, the catchment area for MB01 is increased from the baseline area due to the location and elevation of the overflow.

Table 8: Catchment areas of the mine site.

Stage	Catchment	Area (ha)	Total Area (ha)	Comments
Baseline (Stage 1)	Undisturbed	1,384	1,384	Areas calculated to existing compliance Point MB01
Pre-mining (Stage 2)	Undisturbed	2,930	2,930	Areas calculated to existing compliance Point MB02
1	Impacted	62	1,462	Areas calculated to existing compliance Point MB01.
	WRS	76		
	Undisturbed	1,324		
2	Impacted	127	2,987	Areas calculated to proposed compliance Point MB02
	WRS	234		
	Undisturbed	2,626		
3	Impacted	180	2,987	Areas calculated to proposed compliance Point MB02
	WRS (Rehab)	234		
	Undisturbed	2,573		

The modelled total catchment areas for Stage 2 and Stage 3 are also larger than the Mare Burn catchment upstream from the proposed compliance point MB02 due to the expansion of Coronation Pit to the south into the Deepdell Creek catchment. Any overflows from the CS5 will ultimately report to the Mare Burn at closure due to the location and elevation of the overflow.

The currently consented Coronation WRS layout is around 104 ha in area and extends across the Deepdell Creek/Mare Burn catchment divide (see Figure 9). A small portion of the Coronation WRS extends into Deepdell Creek (around 28 ha) with the remainder in the Mare Burn catchment. This is the layout simulated in the Stage 1 model.

The planned development of the Coronation North Pit has resulted in the Coronation WRS being re-configured due to operational constraints. Under the Coronation North Project, the Coronation WRS is now proposed to be a fraction of the size of the consented Coronation WRS and entirely located within the Deepdell Creek catchment with all seepage flows and run-off reporting to Deepdell Creek catchment. Therefore the models simulating Stage 2 and Stage 3 do not include the Coronation WRS. The Stage 1 model still incorporates the consented WRS area of 76 ha within the Mare Burn catchment.

5.4.3 Catchment run-off

Natural catchment run-off coefficients

For natural undisturbed catchments the Australian Water Balance Model (AWBM) run-off calculator is used to convert catchment rainfall to run-off on a daily time step basis. The AWBM run-off calibration for Deepdell Creek was used extensively in catchment run-off simulations to support the MPIII consenting process. Comprehensive documentation of the AWBM calculator and Deepdell Creek calibration is outlined in the Golder water management report for MPIII (Golder 2011a). The Deepdell Creek AWBM run-off calculator yields around 11 % of rainfall reporting as run-off on average. This yield is consistent with observed yields for the Deepdell Creek catchment.

There is no reliable flow monitoring data available from the Mare Burn catchment on which to base a catchment specific AWBM calibration. As the Deepdell Creek catchment is a neighbouring catchment to the Mare Burn catchment, with a similar total topographic elevation range, the AWBM calibration developed for the Deepdell Creek catchment has been applied.

Pit areas and other mining impacted areas

Run-off from pit areas and other mine impacted areas are based on volumetric run-off coefficients. Table 9 outlines the run-off coefficients used for impacted mining areas such as pits. Rainfall events were analysed for likely return periods and an appropriate coefficient assigned to each event. These coefficients are consistent with those applied in the water modelling for the MPIII project (Golder 2011a). For impacted areas, the model predicts around 14 % of rainfall reporting as run-off.

Table 9: Impacted area run-off coefficients.

	Rainfall (mm)	Run-off Coefficients	Rainfall Event
Pit Areas	0 – 10	0.05	<1 year
	10 – 50	0.2	1 – 5 year
	50 – 90	0.4	>5 year but <20 year
	>90	0.7	>20 year

Waste rock stacks

Run-off from WRSs is based on volumetric run-off coefficients. Anecdotal evidence from operations and environmental staff at the MGP suggests that very little run-off occurs from WRSs at the MGP. The relatively flat capped surfaces of the WRSs, the compaction of the upper surfaces due to vehicle traffic and the porous nature of the deeper stored waste rock results in water either evaporating from the WRS cap or percolating through and entering the groundwater system. For the purposes of modelling the run-off coefficients in Table 10, which are consistent with those applied in modelling of the MPIII project, have been adopted. Rainfall events were analysed for likely return period and an appropriate coefficient assigned to each event. For WRSs, the model predicts around 3.5 % rainfall reporting as run-off. WRS run-off does not differ during operational and closure stages.

Table 10: WRS run-off coefficients.

	Rainfall (mm)	Run-off Coefficients	Rainfall Event
WRS Areas	0 – 10	0	<1 year
	10 – 50	0.05	1 – 5 year
	50 – 90	0.15	>5year but <20 year
	>90	0.4	>20 year

5.4.4 Pit level, Surface Area and Volume Assumptions

For each pit the design was analysed and the pit elevation, surface area and cumulative volume were calculated based on design drawings provided by OceanaGold. All pits modelled assume full pit development as this is assumed to represent the worst case scenario in terms of environmental effects. For each pit the overflow elevation, the pit lake area at overflow and the maximum volume at overflow are summarised in Table 11. The pit shell geometry for the Coronation and Coronation North pits is provided in Appendix B.

Modelling of the pit lakes for Stage 2 and Stage 3 incorporates the expanded Coronation Pit design (CS5).

Table 11: Pit maximum capacity and overflow RL.

	Water elevation at overflow (1) (m)	Maximum Area (m^2)	Maximum volume (m^3)
Coronation Pit	640.0	279,320	11,132,769
CS5	632.5	176,208	13,195,947
Coronation North Pit	580.0	422,718	23,286,109

Note: 1) Relative to the Macraes grid vertical elevations.

The overflow point for the CS5 is at the northern rim of the pit, with the outflow from the pit flowing down a short section of gully before meeting the Coronation North WRS. Observations of several seepage discharge areas from WRS areas at the MGP indicate the basal deposits in each WRS are highly permeable. Golder confidently expects that outflows from CS5 of several litres per second could enter the WRS without the development of a pond against the upstream face of the stack. Following the overflow of the Coronation Pit lake, some minor ponding of the discharge water may occur occasionally against the upstream face, however Golder confidently expects this to be a temporary feature. OceanaGold may also selectively place coarse waste material in the base of the gully which would accept the overflow from Coronation Pit, to enhance the drainage from the pit.

The overflow point from Coronation North Pit is located at the northwestern edge of the pit. During the operational mining period in this pit the gully immediately downstream from the overflow point would be infilled by a haul road embankment. OceanaGold has advised that the engineered fill placed in this gully to support the haul road will be removed during the closure and rehabilitation of the pit.

5.4.5 Operational Inputs

Dust Suppression

For Stage 1 and Stage 2, it is assumed that some water from the pits is used for dust suppression. Dust suppression usage values for the Coronation mining area were provided by OceanaGold (Email from D. Clarke, OceanaGold, 27 January 2016) and analysed. An estimate of 1,400 m^3 per week water usage for this purpose has been assumed for modelling purposes, based on current usage and an assumption that dust suppression activities will be undertaken year round.

Pit Pumping

It is assumed that when the open pits are operational (Stage 1 and Stage 2), excess water accumulated in the pit from seepage and pit run-off is pumped to the Mare Burn. The pumping logic is such that the pump switches "on" when water levels exceed a depth of one metre in the pit sump and triggered to "off" when the levels return to 0.5 m above pit sump bottom. Pit pumping rates are set at 18.5 L/s, the current pumping achievable from Coronation Pit (Pers. comm. S Mossman, OceanaGold, 27 January 2016).

5.4.6 Hydrogeological Inputs

Pits and pit lakes groundwater assumptions

Groundwater inflow rates to the already consented Coronation Pit and to the planned Coronation North Pit and CS5 have been estimated by calculating an area of influence for each pit. This area of influence is the area of mining induced groundwater drawdown related to the pit in question. It is assumed that within this area, all infiltrating rainfall that acts to recharge the groundwater system will discharge to the pit. Groundwater flows into the opencast pits at the MGP are generally considered to be very stable. On this basis, the groundwater seepage to a pit is calculated by multiplying the area of influence by the annual groundwater recharge rate. The recharge in this area of Otago is approximately 32 mm/year (Golder 2010a).

The area of influence changes depending on a number of factors, including the water level in the pit sump or lake. The seepage inflows to the pit change as the water level within the pit changes. This is specifically relevant to the groundwater inflows to the pit following closure, as the pit lake develops. In order to estimate seepage inflows to the pit lakes, areas of influence have been produced for each pit. One area of influence has been produced for each pit to reflect the groundwater conditions around the pit at closure, when the water level in the base of the pit is at a low managed level. A second area of influence has been produced for each pit to reflect the groundwater conditions around the pit at a stage when the pit lake has reached the overflow level. The inflows calculated for each pit lake at closure and at overflow are summarised in Table 12. A linear interpolation of projected groundwater inflows between these stages in pit lake development is presented in Appendix C. Detailed information on the groundwater flow calculations with respect to the opencast pits seepage inflow rates is provided in a separate report (Golder 2016).

Table 12: Estimated groundwater seepage flow into opencast pits at closure and at overflow.

Opencast Pit	Lake stage	Water elevation (mRL)	Seepage inflow (m^3/day)
Coronation Pit (consented)	Operational level at closure	562.5	271
	Pit lake overflow	640	95
CS5	Operational level at closure	562.5	299
	Pit lake overflow	632.5	130
Coronation North Pit	Operational level at closure	580	94
	Pit lake overflow	467.5	316

As the water level in each pit rises toward overflow, there comes a stage when seepage outward from the pit lake starts to occur. This outward seepage is through the weathered schist rock mass toward downstream sections of gullies that intersect the pit rim. The rate of seepage increases as the water level in the pit rises. The seepage flows have been estimated based on the geometry of the down-gradient gully, the expected hydraulic conductivity of the weathered rock mass, the hydraulic gradient out of the pit and the seepage flow path length. Seepage outflow rates estimated for each pit are summarised in Table 13. A linear interpolation of projected groundwater outflows between these stages in pit lake development is presented in Appendix C. Detailed information on the groundwater flow calculations with respect to the open pit seepage outflow rates are provided in a separate report (Golder 2016).

Table 13: Estimated groundwater seepage flow out of opencast pits.

Opencast Pit	Lake stage	Water elevation (mRL)	Seepage outflow (m^3/day)
Coronation Pit (consented)	Lowest seepage outflow level	622.5	0.01
	Pit lake overflow	640	2.31
CS5	Lowest seepage outflow level	625	0.03
	Pit lake overflow	632.5	0.3
Coronation North Pit	Lowest seepage outflow level	542.5	0.01
	Pit lake overflow	580	18.1

The net groundwater flow rates into each of the simulated opencast pits are presented in Appendix C. The groundwater inflow to each pit is calculated in the GoldSim model on a dynamic basis based on the daily water level in the pit.

WRS seepage assumptions

The large WRS areas at the MGP act as artificial aquifers. These aquifers are primarily recharged by rainfall infiltration through the upper surface of the WRS. Recharge to the WRSs is however limited by the compacted upper surface due to traffic by haul trucks and other machinery. Annual recharge to the WRS areas at the MGP is estimated at 32 mm (Golder 2010a) multiplied by the area of the WRS (Table 14). For the purposes of flow modelling, this recharge is considered to discharge again to the receiving water bodies with effectively no delay.

Table 14: Coronation project WRS seepage.

Project	Area of WRS within Mare Burn catchment (ha)	Seepage rate (m^3/day)
Coronation Project	76	67
Coronation North Project	234	205

As described above, the WRS discharges are modelled with a fixed outflow rate based on area. Detailed flow monitoring data is not available for WRSs at the site and anecdotal evidence of constant seepage outflow is relied upon. Observations suggest both the Frasers East and Frasers West WRSs have continuous seepage outflows. Discharge flow rates may however change slightly on a seasonal basis. Should the WRS seepages prove to vary seasonally, it is possible the discharge projections incorporated in the model over the summer periods may overestimate what would actually occur.

Seasonal variability in WRS discharges has not been incorporated in the models documented in this report, as there is insufficient data available to calibrate a variable discharge simulation. OceanaGold is planning to install a flow monitoring station at the toe of a WRS to obtain data on WRS seepage flow variability. Once data from one to two years of monitoring becomes available, a calibrated WRS seepage module can be incorporated into the GoldSim model to refine the estimates of the effects of WRS discharges on baseflows in the respective receiving environment waterways. This monitoring, together with refinement of the water quality projections for MB02 documented later in this report, can be completed before the close of mining operations at the Coronation North Project. These improved projections can also be used to optimise any water quality mitigation measures required to enable OceanaGold to comply with compliance criteria at MB02 over the long term.

5.4.7 Water quality assumptions

Introduction

The water quality assumptions used in this assessment are outlined in Table 15 (undisturbed and WRS run-off), Table 16 (WRS seepage) and Table 17 (pit lake) and are described in further detail below. Appendix A provides relevant water quality statistical analysis of available data from the Coronation North Project and the wider MGP site.

It is important to recognise that the values applied for different water quality input datasets do not necessarily represent a geochemically stable combination of values. This is because the values selected are derived statistically from the chosen monitoring dataset. The numbers presented in Table 15, Table 16 and Table 17 represent concentrations for each parameter that will be exceeded 5 % of the time, however these exceedances are not expected to happen at the same time for all parameters.

Undisturbed surface run-off water quality for Mare Burn

For modelling purposes, the average water quality for Mare Burn (MB01 site) from December 2014 to November 2015 (refer Section 4.2) has been used to represent undisturbed surface run-off water quality in the models (Table 15) as the dataset does not cover a long enough period to confidently identify seasonal or other naturally recurring variations in water quality. Although mining at Coronation Pit in the Mare Burn catchment commenced in late 2014 the water quality data collected from MB01 is still considered to be reflective of the undisturbed catchment (refer Section 4.2).

WRS run-off water quality

Anecdotal evidence from staff at the MGP site indicates that WRS run-off occurs uncommonly. Water quality samples from WRSs tend to be collected from silt dams located at the toe of the various WRSs on site. Even after heavy rainfall, these samples represent a mixture of run-off water and WRS seepage water, with the latter being the dominant component. Therefore, impacted area run-off quality values applied in the MPIII project (refer Golder 2011a) have also been applied for operational WRS run-off in the current models. It is assumed that when WRSs are rehabilitated for closure, run-off water quality will be similar to that from undisturbed areas of the catchment. Assumptions for WRS run-off water quality are presented in (Table 15).

Table 15: Undisturbed and WRS run-off water quality assumptions.

Parameter (1)	Undisturbed (all stages) (2)	WRS (Stage 1 and 2) (3)	WRS (Stage 3) (2)
Arsenic	0.0019	0.1	0.0019
Sulfate	6.4	286	6.4
Cyanide $_{WAD}$	0.0005	0.001	0.0005
Copper	0.0009	0.002	0.0009
Iron	0.24	0.135	0.24
Lead	0.0002	0.001	0.0002
Sodium	9.3	28	9.3
Potassium	1.7	4	1.7
Calcium	11.3	63	11.3
Magnesium	2.8	34	2.8
Zinc	0.0009	0.005	0.0009
Chloride	5.3	13	5.3

Notes:
1) All data in units of g/m^3.
2) Mean values from MB01 dataset (Table 5) except for cyanide $_{WAD}$ and zinc, which have mean values applied to allow for results below the detection limit (Appendix A).
3) WRS run-off water quality used in MPIII water quality modelling and compliance simulations (Golder 2011a)

Table 16: Coronation North WRS seepage water quality assumptions.

Parameter (1)	Operational (Stage 1 and 2) (2)	Closure and post closure (Stage 3) (3)
Arsenic	0.03	0.01
Sulfate	611	2,900
Cyanide $_{WAD}$	0.002	0.002
Copper	0.005	0.005
Iron	1.34	2.2
Lead	0.001	0.001
Sodium	26.4	68.2
Potassium	5.9	14.3
Calcium	125	514
Magnesium	101.2	466
Zinc	0.043	0.043
Chloride	14.4	24.8

Notes:
1) All values presented in units of g/m^3.
2) Derived from Clydesdale Creek silt pond data (Table 7) except for cyanide $_{WAD}$ and zinc, which derive from the Northern Gully underdrain (Table 7).
3) Derived from the Northern Gully underdrain data (Table 7).

Table 17: Pit water quality assumptions.

Parameter (1)	Operational (Stage 1 and 2)	Closure (Stage 3)
Arsenic	0.54	0.29
Sulfate	301	302
Cyanide $_{WAD}$	0.010	0.001
Copper	0.002	0.001
Iron	0.85	0.13
Lead	0.001	0.0002
Sodium	54.7	14.6
Potassium	15.8	4.8
Calcium	89.7	82.3
Magnesium	51.0	76.1
Zinc	0.04	0.0009
Chloride	18.9	7.0

Note: 1) All values presented in units of g/m^3.

WRS seepage water quality

Two seepage assumptions are used in the modelling, as summarised in Section 4.4 and presented in Table 16:

- For operational periods (Stage 1 and Stage 2) the 95th percentile value for each water quality parameter from the first five years recorded seepage from the Clydesdale WRS has been used. Where data were missing, data from monitoring of Northern Gully silt pond as described below was substituted.
- For closure and post closure (Stage 3), the 95th percentile value for each water quality parameter from the Northern Gully silt pond monitored between 2010 and 2015 has been used. Northern Gully WRS is the longest standing WRS at the MGP site and is considered the best available estimate for WRS seepage quality over the longer term.

Pit and pit lake water quality

For the purposes of modelling, pit wall run-off and groundwater seepage water quality that reports to pits has not been modelled separately. Instead a fixed water quality for pit sump water has been assumed based on pit water quality data from samples obtained from Frasers Pit and Golden Bar Pit during operational mining and closure periods. It is recognised that the relative exposures of mineralised to non-mineralised rock in each opencast pit is different.

Frasers Pit data were analysed over the operational mining period between 1998 and 2008 (Section 4.3) and used to represent operational mining pit water quality. Golden Bar pit water quality data were analysed between 2010 and 2015 (Section 4.3) and used to represent closure pit water quality.

Pit water quality assumptions are presented in Table 17. These values represent the 95th percentile values over the operational (Stage 2) and closure (Stage 3) period of mining.

5.5 Model Verification

5.5.1 Overview

Model verification was undertaken to assess the suitability of the run-off generator and its ability to accurately predict run-off from impacted areas (pit walls and mining areas) and therefore suitably predict pit lake filling rates. A similar assessment was documented in the surface water management report that supported the consenting of the MPIII Project (Golder 2011a).

For the purposes of this verification assessment, a water balance model was set up to simulate the pit lake recovery in the decommissioned Deepdell South Pit. Run-off flows were simulated based on the calibrated run-off calculator settings used in the MPIII Project. Modelled results were compared to recent observed water level readings obtained by OceanaGold staff between 2004 and 2015.

5.5.2 Assumptions

Inputs to the model included the following input assumptions:

- Deepdell South pit catchment area:
  - Impacted catchment of 12.6 ha.
  - Non-impacted catchment of 11.1 ha.
- Pit geometry:
  - The pit shell and profile has been analysed by GIS and a volume, area and level curve constructed. Maximum pit elevation at overflow was set at 379 mRL, the maximum pit volume was 126 ML, the pit lake surface area at 379 m RL was 1.8 ha.
- Pit inflows:
  - The groundwater inflow rate was incorporated from previous groundwater modelling (Golder 2010a). A fixed groundwater inflow rate of 16 m^3/day was assumed.
  - Direct rainfall to the pit lake was calculated based on a dynamic lake surface area calculator in GoldSim.
- Pit outflows are calculated on a daily basis, including:
  - Evaporation from the pit lake surface.
  - Pit lake overflow to Deepdell Creek (although currently the pit lake does not overflow).
  - No pit seepage outflow was assumed.

5.5.3 Results

A comparison of the model outputs with measured lake levels is presented in Figure 11. The key results are:

- Modelled outcomes are considered acceptable from late 2003 to May 2010; modelled water levels track actual water levels with reasonable accuracy.
- In late 2010, modelled results indicate the lake should have overflowed (and continue to do so). Observed lake levels diverge from this trend.
- It is likely that leakage from the pit through the intact pit wall toward Deepdell Creek is influencing water levels at elevations above approximately 372 m RL, keeping the pit lake from overflowing. An allowance for this leakage has not been incorporated in the model.
- Applying an evaporation factor or pan factor (PF) to the evaporation data affects water level trends in the pit. Two scenarios have been simulated, with pan factors of 1 and 0.7, with the results presented in Figure 11. A pan factor of 0.7 provides an improved fit to the water level data and has therefore been applied in the predictive modelling of the Coronation and Coronation North Pit lakes for this project.

The Deepdell South pit lake modelling undertaken and presented in this section indicates that the model run-off and pit lake module can be used as a reasonable estimate for the purposes of this project. The model is sensitive to groundwater seepage projections (inflows/outflows). Any significant groundwater loss from the pit lakes results in water level projections varying substantially.

The modelled pit lake water levels outcomes vary significantly from observed water levels after 2009. Run-off from a major rainfall event in that year results in the model indicating a rapid change in water level and subsequent overflow of the pit lake. This was not observed and in contrast the pit water level stabilised. Seepage losses from the pit lake through the low pit wall and to historical underground mine workings extending under the pit wall from the Deepdell Creek valley side (D Clarke, OceanaGold, pers. comm.) appear to have influenced the late stage lake development. These seepage losses have not been taken into account in the model.

6.0 MODEL RESULTS

6.1 Pit Lake Development

6.1.1 Coronation Pit lake development

It has been assumed that Coronation Pit will be maintained in a dewatered state during Stage1 of mining. During Stage 2 all dewatering operations are to cease in the pit (assumed at year 2020) and the lake will consequently start to fill with no operational controls from that point onward. The pit lake modelling undertaken assumes the CS5 layout will represent the closure layout of the pit. This is an expanded pit from what has been previously consented. Pit water storage, elevation and area assumptions incorporated in the model are documented in Appendix B.

There are three key inflows to the lake and three key outflows from the lake as presented in Table 18.

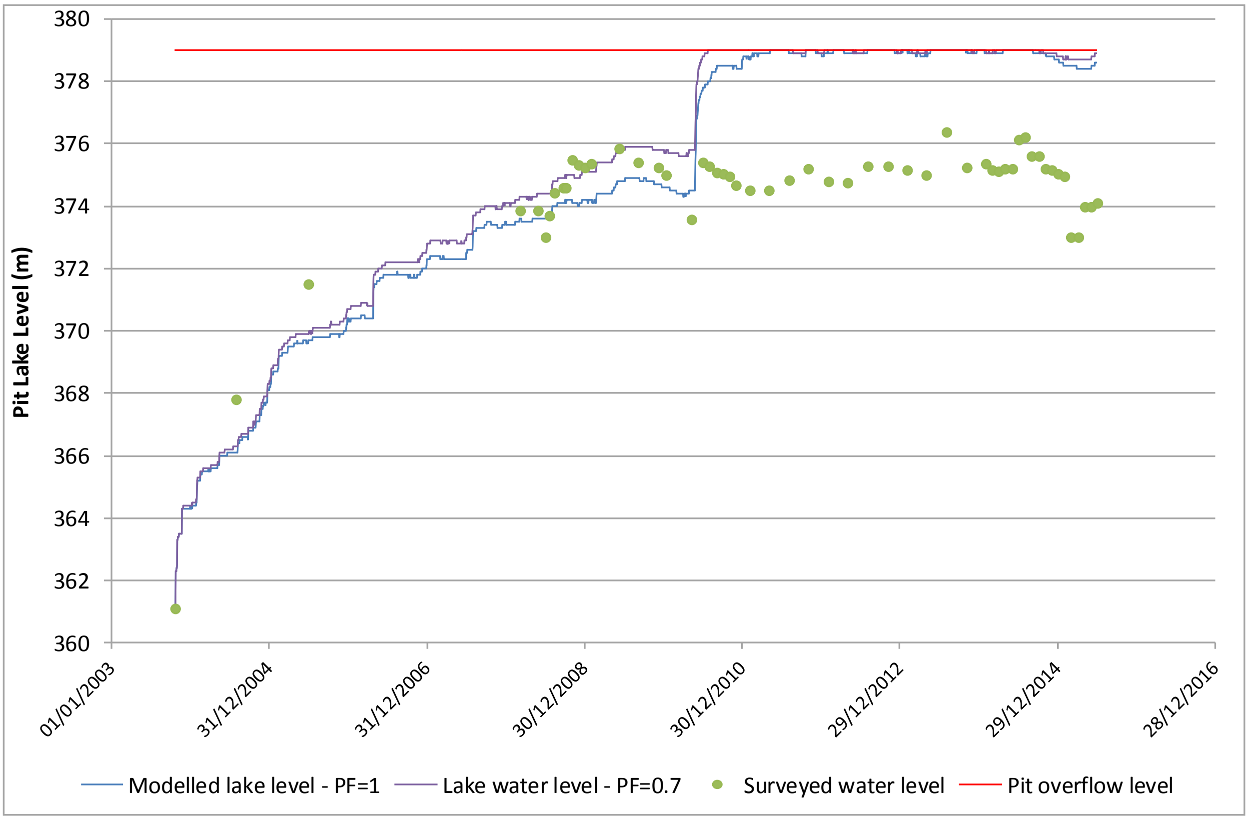


Figure 11: Deepdell South pit projected volumes.

Table 18: Factors influencing Coronation Pit lake inflows and outflows.

Inflows	Outflows
Direct lake rainfall	Lake surface evaporation
Groundwater seepage from surrounding catchments	Seepage outflow when the lake is above the 622.5 m RL level.
■ Run-off from pit wall area below the overflow level – 35.3 ha ■ Run-off from additional pit wall and catchment above the overflow level – 49.9 ha	Discharge to Mare Burn when lake reaches an overflow level of 632.5 m RL.

The outcomes of the modelling, as presented in Figure 12 indicate that the pit lake takes in the order of 160 years to fill, following which overflow would occur through the base of the Coronation North WRS to Mare Burn.

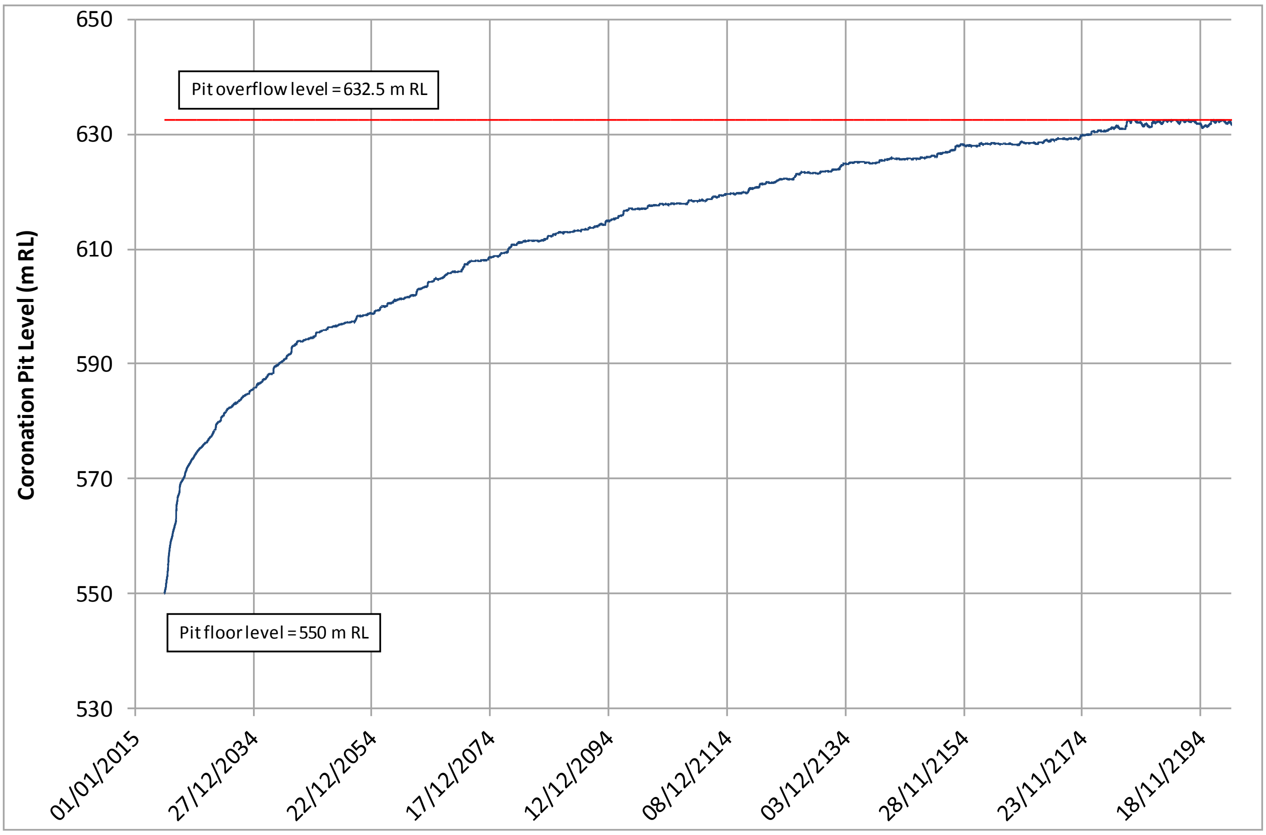


Figure 12: Coronation pit lake development.

6.1.2 Coronation North Pit Lake Development

The Coronation North pit is to be maintained in a dewatered state during the Stage 2 mining period. Following the end of Stage 2, all operations cease in the pit (assumed at year 2020) and the lake will consequently start to fill with no operational controls from that point onward.

There are four key inflows to the lake and three key outflows or water losses from the lake as presented in Table 19. In simulation of this stage of the mine, it has been assumed that diversion drains have been removed from around the southern edge of the pit. This diversion drain is expected to be infilled and rehabilitated at closure of the pit. If the diversion drain is not infilled following closure, it is expected that the drain would wash out at some stage following closure and the run-off collected by the drain would subsequently report to the pit in any case.

Table 19: Coronation North Pit lake inflows and outflow assumptions.

Inflows	Outflows
Direct lake rainfall	Lake surface evaporation
Groundwater seepage from surrounding catchments	Seepage outflow when the lake is above the 547.5 m RL level.
Pit wall area run-off: Pit wall area below overflow level – 42.2 ha	Discharge to Mare Burn when lake reaches overflow level.
Reporting catchment run-off: Catchment to the southeast, directed into the pit at closure – 52.7 ha	

The outcomes of the modelling, as presented in Figure 13 indicate that the pit lake will fill to overflow in around 400 years.

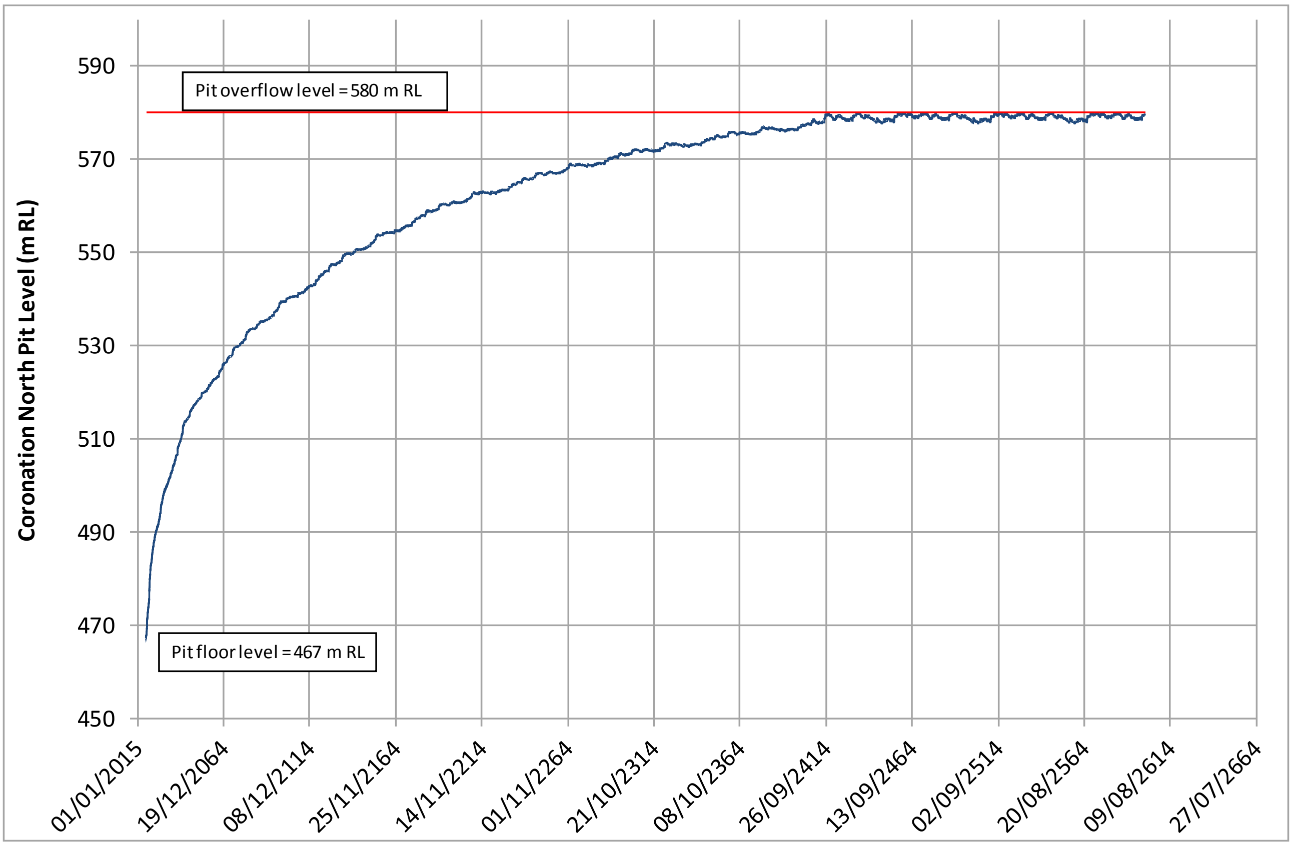


Figure 13: Coronation North Pit lake development.

6.2 Site Discharge Projections

6.2.1 Introduction

The Mare Burn and associated headwater tributaries have the potential to be impacted by the current mine development as well as future expansion associated with the Coronation North Project. Hydrology in the catchment may be altered due to:

- Changes in catchment land use and catchment extents;
- Pit dewatering activities; and
- Increases in evaporation from storages.

This section presents the baseline hydrology and projected changes to the flow regime from the Coronation North development (Stage 3).

6.2.2 Changes to Catchment Hydrology

Flow statistics for the baseline model run (both at MB01 and MB02) and each of the predictive model stages are summarised in Table 20. The baseline hydrology has been derived through applying the Australian Water Balance Model (AWBM) rainfall run-off generator calibrated for the Deepdell Creek catchment. This model was successfully utilised in the MPIII water management consenting. The model estimates daily run-off volumes from rainfall and evaporation data and accounts for antecedent wetness within the catchment. It is the standard rainfall/run-off model utilised for water resource investigations throughout Australia.

It should be noted here that the AWBM is calibrated to the Deepdell Creek flow data collected at Golden Point Weir. The calibration parameters are targeted to ensure the modelled flow data fits the observed low median and average flows as closely as possible. The calibration does not fit the peak daily average flow particularly well however, this is not the intention of the model.

Flow duration curves for all scenarios are presented in Figure 14. This presents the amount of time that a certain flow is either equalled or exceeded.

Table 20: Catchment hydrology comparison.

Scenario (1)	Catchment area (ha) (1)	Simulated flows (L/s)			
		5th percentile flow	Median flow	Average flow	Maximum flow
Baseline (MB01)	1,384	0.3	5.7	31	5,500
Stage 1	1,440	1.1	6.8	33	5,000
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

Note: 1) Catchment areas differ between baseline and model stages due to additional catchment intersected outside the Mare Burn catchment. For example, the CS5 pit extends through the Deepdell Creek catchment creating additional catchment area relative to the baseline scenario. Baseline flows for MB02 include changes resulting from construction of already consented Coronation Pit and Coronation WRS. This is why the MB02 baseline statistics in this table differ from those in Table 4

The GoldSim model for the baseline Mare Burn catchment has been primarily calibrated against the lower flow components of the scaled flow record for Mare Burn (refer Section 3.3). Although the model understates the peak flows that may be expected from the catchment, the calibration outcomes for the lower flow periods are considered acceptable (refer Section 5.4.3).

Modelling of Stage 1 (operational) includes the addition of the Coronation WRS and Coronation Pit. Modelling indicates that with the addition of the WRS and the pit, low flows will increase by around 0.8 L/s at the 5th percentile flow. This increase is primarily due to the water storage and buffering effect of the Coronation WRS.

Modelling of Stage 2 (operational stage including the Coronation North WRS and Coronation North Pit) indicates that a similar increase of baseflows in Mare Burn will result. The 5th percentile low flows increase by around 2.4 L/s when compared to baseflow at MB02. The simulated flows for Stage 3 (post-closure) are similar to the Stage 2 results.

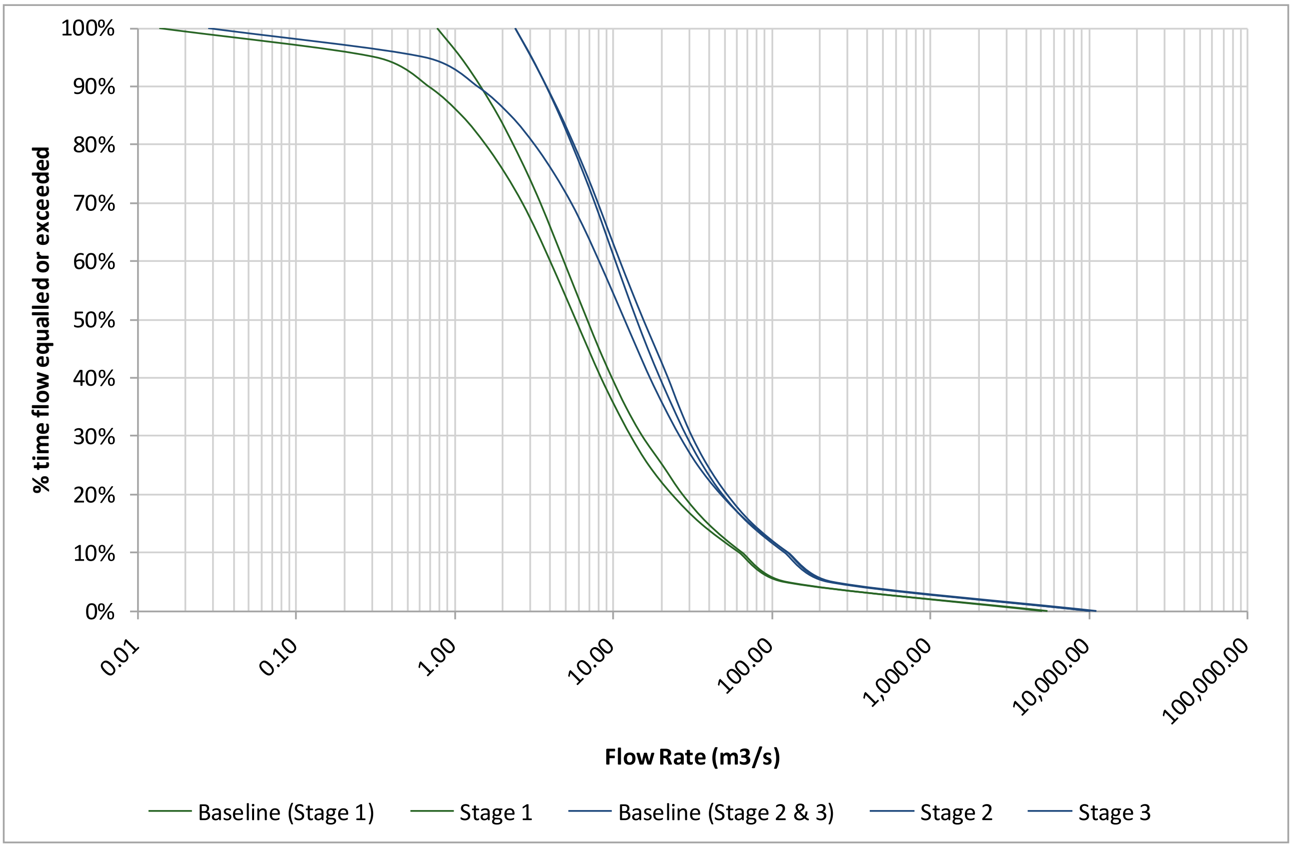


Figure 14: Coronation North Project flow duration results (all stages).

6.2.3 Discussion

Based on anectodal evidence from other upper catchment tributaries at the MGP site (including upper Tipperary Creek at the rock weir flow monitoring site and Deepdell Creek at the Golden Point weir) the upper reaches of Mare Burn are likely to carry naturally intermittent flows (baseline scenarios). This means, in drier months (summer) the flows are low and during particularly dry summers or parts of summer the Mare Burn headwaters will likely be dry.

The modelling results of the three stages of mining and closure indicate that median, average and maximum flow rates will not vary significantly from the baseline scenarios. The modelling however shows that low flows (5th percentile flows) will increase due to the additional storage and buffering represented by the WRS constructed within the catchment. Following closure, the model indicates that these baseflows may remain slightly higher than what would be considered normal for a catchment in this area (i.e., 3 L/s at 5th percentile flow). The model also indicates that construction of the Coronation WRS within the Mare Burn catchment would result in the flows at MB01 and MB02 becoming permanent rather than intermittent.

As noted previously (Section 4.4) WRS seepage is modelled with a fixed outflow rate based on area. Observations of WRS discharges indicate they are not ephemeral and are relatively constant in rate. There may be some seasonal variability in these discharge rates, however there is insufficient data available to demonstrate the degree of potential variability. The use of a constant discharge flow to simulate the effects of the WRS areas on downstream water quality is expected to provide conservative outcomes in that lower discharges during summer would result in smaller contaminant mass loads requiring management within the catchment.

6.3 Mare Burn Water Quality Projections

6.3.1 Introduction

The Mare Burn and associated headwater tributaries have the potential to be impacted by current mine development as well as future expansion associated with the Coronation North Project. This section presents the:

- Proposed water quality compliance criteria for Mare Burn at a new proposed compliance point, MB02.
- Current baseline water quality within the catchment.
- Modelled water quality projections for the current Coronation development, Stage 1.
- Modelled water quality predictions for the Coronation North Project, Stage 2.
- Modelled water quality predictions for the long term closure of the Coronation North Project, Stage 3.

For the modelled Stage 2 and Stage 3, the proposed compliance point MB02 is the point at which water quality predictions are made. This proposed monitoring point is located approximately one kilometre from the existing MB01 compliance point. This new compliance point has been proposed as it is the most up-stream point on Mare Burn that is still located downstream from all tributary catchments that would be affected by mining operations and post-closure seepage and surface water discharges from the Coronation North Project.

6.3.2 Compliance Criteria

The primary usage of water from Mare Burn is considered to be for stock watering. No potable water supply takes are known to exist along Mare Burn.

The existing compliance criteria for the current Coronation project (Stage 1) compliance point MB01 are presented in Table 21. It is proposed that the same criteria should be applied to the MB02 compliance monitoring point. These criteria also match those applying at the DC08 compliance point on Deepdell Creek downstream from the main area of the MGP (Golder 2011a and Golder2011b). These proposed criteria have been compared to New Zealand drinking water standard NZDWS 2008 and the ANZECC 2000 stock water drinking standards in Table 21.

Table 21: MB01 and MB02 compliance criteria.

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) Copper, lead and zinc compliance criteria for MB01 are hardness related.

6.3.3 Mare Burn at MB01 –Stage 1

The Stage 1 model incorporates the consented Coronation pit and the Coronation WRS. It is assumed that most water generated within the pit (run-off and seepage) is pumped to Mare Burn without substantial delay. Some pit water is utilised for dust suppression. WRS run-off and seepage report to the Mare Burn via a number of gully/drainage lines.

Table 22 summarises the projected water quality during Stage 1 at the existing compliance point MB01 on Mare Burn. The operational period of mining commenced in late 2014 and it is expected to take between two and five years to complete the mining and decommissioning of Coronation Pit. For the purposes of modelling, approximately 100 years of water quality projections have been produced and analysed to incorporate variation in the climate patterns in the results.

During Stage 1, the primary contaminants that could potentially exceed the existing compliance criteria are arsenic and iron. The results of modelling indicate that:

- Arsenic concentrations may exceed the compliance limit of 0.15 g/m^3 about 6% of the time
- Iron concentrations may exceed the compliance limit of 1.0 g/m^3 about 8% of the time
- Sulfate concentrations remain within the compliance limit as it is not expected that the sulfate concentrations in WRS leachate during the operational period of the already consented Coronation Pit would exceed this compliance limit (refer Table 16).

Appendix D presents the model results in the form of a 100 year projected water quality series and also a cumulative frequency plot.

In relation to dissolved arsenic and iron, it is important to recognise that the model will overestimate instream concentrations, as neither of these elements is conservatively transported (as was assumed for modelling purposes) in the surface water and soil around the MGP. This is discussed further in Section 6.3.7.

Table 22: Summary of projected water quality at MB01 for Stage 1.

Parameter (1)	Minimum	Mean	95th Percentile	Maximum	Compliance limit	Exceedances
Arsenic	0.002	0.03	0.18	0.52 (2)	0.15	YES
Sulfate	7.0	145	439	601	1,000	NO
Cyanide (WAD)	0.001	0.001	0.004	0.010	0.1	NO
Copper	0.001	0.001	0.002	0.002	0.009	NO
Iron	0.141	0.48	1.03	1.32	1.0	YES
Lead	0.0002	0.0006	0.0015	0.002	0.0025	NO
Sodium	9.3	15.0	26.7	53.5	-	N/A
Potassium	1.7	3.2	6.5	15.4	-	N/A
Calcium	11.4	38.3	92.9	123.5	-	N/A
Magnesium	2.9	25.0	73.2	99.6	-	N/A
Zinc	0.001	0.011	0.033	0.042	0.12	NO
Chloride	5.3	7.8	13.1	18.7	-	N/A

Notes: 1) All units g/m^3

2) The maximum concentration for arsenic is higher than concentrations normally recorded by environmental monitoring at the MGP as a few anomalously high analysis results from the Frasers Pit sump have influenced the 95th percentile for operational pit sump water quality.

6.3.4 Mare Burn at MB02 – Stage 2

The Stage 2 model incorporates the expanded Coronation Pit (CS5), Coronation North Pit and Coronation North WRS. Coronation WRS is not incorporated in the model as the design provided by OceanaGold indicates that consenting of Coronation North WRS would alleviate the need for Coronation WRS to extend into the Mare Burn catchment. It is assumed that during this stage of operations Coronation Pit will be decommissioned and filled as a pit lake. The Coronation North Pit is assumed to be still operational and water accumulating within the pit (run-off and seepage) is pumped to Mare Burn. Some pit water is however utilised for dust suppression. Run-off and seepage from Coronation North WRS discharges to Mare Burn.

Table 23 summarises the projected water quality for the proposed compliance point MB02 on Mare Burn. In order for the climate related variability of the results to be fully captured, 300 years of water quality projections have been produced and incorporated in the model. This length of climatic record also provides adequate time for Coronation Pit lake to fill to overflow. The data presented below and in Table 23 summarises the results prior to the overflow from Coronation pit to Mare Burn.

During Stage 2, the primary contaminants that exceed compliance criteria in the model results are arsenic and iron. The results of modelling indicate that:

- Arsenic concentrations may exceed the compliance limit of 0.15 g/m^3 about 8 % of the time
- Iron concentrations may exceed the compliance limit of 1.0 g/m^3 about 8 % of the time

Appendix D presents the model results in the form of a 300 year predicted water quality series and also a cumulative frequency plot.

Table 23: Summary of projected water quality at MB02 for Stage 2.

Parameter (1)	Minimum	Mean	95th Percentile	Maximum	Compliance limit	Exceedances
Arsenic	0.002	0.03	0.21	0.48	0.15	YES
Sulfate	7.1	173	481	605	1,000	NO
Cyanide (WAD)	0.001	0.004	0.007	0.009	0.1	NO
Copper	0.002	0.008	0.009	0.009	0.009	NO
Iron	0.1	0.5	1.1	1.3	1.0	YES
Lead	0.0002	0.0004	0.0009	0.0010	0.0025	NO
Sodium	9	16	28	51	-	N/A
Potassium	1.7	3.4	7.3	14.7	-	N/A
Calcium	11	44	101	124	-	N/A
Magnesium	3	29	80	100	-	N/A
Zinc	0.001	0.013	0.036	0.043	0.12	NO
Chloride	5.3	8.3	13.6	18.4	-	N/A

Notes: 1) All values presented in units of g/m^3

6.3.5 Mare Burn at MB02 – Stage 3

The Stage 3 model represents closure of the Coronation North Project and incorporates the expanded Coronation Pit, Coronation North Pit and Coronation North WRS. It is assumed that the Coronation and Coronation North pits are filling as pit lakes. The WRS has been rehabilitated and WRS run-off and seepage reports to Mare Burn. No active pumping or dust suppression is taking place.

Table 24 summarises the projected contaminant concentrations at the proposed compliance point MB02. For the purposes of modelling, 300 years of water quality projections have been produced following mine closure (assumed to occur in 2020) to allow for some variation in the climate patterns. The data presented below and in Table 24 summarises the model results for the period following 160 years from closure to allow for the Coronation Pit lake to overflow to Mare Burn.

During Stage 3, the primary contaminants that are modelled to exceed compliance criteria are arsenic, iron and sulfate. The results of modelling indicate that:

- Arsenic concentrations may exceed the compliance limit of 0.15 g/m^3 about 2 % of the time
- Iron concentrations may exceed the compliance limit of 1.0 g/m^3 about 23 % of the time
- Sulfate concentrations may exceed the compliance limit of 1,000 g/m^3 about 27 % of the time

Appendix D presents the model results in the form of a 300 year predicted water quality series and also cumulative frequency plots for most of the listed parameters. As with the results from the previous model stages, these outcomes are considered to be conservatively high with respect to iron and arsenic, due to their capacity to react with surrounding soils and precipitate out of the discharged waters. This conservatism is discussed further in Section 6.3.7.

Table 24: Summary of projected water quality at MB02 for Stage 3.

Parameter (1)	Minimum	Mean	95th Percentile	Maximum	Compliance limit	Exceedance
Arsenic	0.002	0.01	0.01	0.26	0.15	YES
Sulfate	7.3	739	2,293	2,863	1,000	YES
Cyanide $_{WAD}$	0.001	0.004	0.005	0.005	0.1	NO
Copper	0.002	0.008	0.009	0.009	0.009	NO
Iron	0.2	0.7	1.8	2.2	1.0	YES
Lead	0.0002	0.0004	0.0008	0.0010	0.0025	NO
Sodium	9	24	56	67	-	N/A
Potassium	1.7	4.9	11.7	14.1	-	N/A
Calcium	11	161	434	509	-	N/A
Magnesium	3	139	409	508	-	N/A
Zinc	0.001	0.012	0.034	0.042	0.12	NO
Chloride	5.3	10.2	20.7	24.6	-	N/A

Notes: 1) All values presented in units of g/m^3 unless otherwise stated.

6.3.6 Taieri River

The Taieri River is used as a source of potable water downstream from the confluence with Mare Burn. There is no maximum acceptable value for sulfate in the New Zealand drinking water standards. The 2008 drinking water standard guideline value (GV) for sulfate is 250 g/m^3.

Flow monitoring on the Taieri River is undertaken by ORC at Tiroiti, upstream from the confluence with Mare Burn. For the period between 1986 and 2003 the low flow recorded at the automated flow monitoring station at Tiroiki was approximately 720 L/s (Raineffects 2003). The minimum flow at Tiroiti below which primary consent water takes must cease is 1,100 L/s.

To assess the risk of sulfate concentrations in the Taieri River exceeding the GV, we can take a very conservative assumption that the maximum sulfate concentration generated by the Coronation North Project of approximately 2,900 g/m^3 (Table 24) occurs at MB02 during Stage 3, not only under low flow conditions but also up to median flows of 14 L/s (Table 20). This equates to a sulfate mass load of approximately 40 g/s at MB02 under median flows. This mass load introduced to the Taieri River under low flow conditions of 720 L/s would raise the sulfate concentration in the river by approximately 55 g/m^3.

Sulfate concentrations in the Taieri River have been measured by OceanaGold at the water intake for the MGP supply pipeline. The detected concentrations were approximately 10 g/m^3 or less. On this basis, even the conservatively large sulfate mass load from the Coronation North Project indicated above would not result in the GV being approached in the Taieri River, even under the lowest flows in the river.

Applying the same conservative calculation logic as presented above to arsenic, the concentration in the Taieri would increase by approximately 0.005 g/m^3, which is less than the drinking water standard maximum acceptable value of 0.001 g/m^3. For reasons discussed in Section 6.3.7 with respect to model conservatism, Golder expects the concentrations of arsenic at MB02 to be substantially less than those presented in Table 24 and any resulting increase in the Taieri River is likely to be undetectable.

6.3.7 Discussion

Model Conservatism

Modelling indicates that exceedances of the water quality compliance criteria are possible for arsenic, iron and sulfate. For other analytes, modelling indicates that compliance can be achieved 100 % of the time without specific mitigation being required

Arsenic non-compliances may arise from pit sump water containing elevated arsenic levels being pumped to the Mare Burn during active mining activities. Projected iron non-compliances arise from WRS seepage with elevated iron levels discharging to Mare Burn during the operational and post-closure stages of the mine. Water quality inputs for arsenic and iron are based on the 95th percentile concentrations observed within similar active and decommissioned pits and WRSs. These are considered to be conservative estimates for both analytes and on average these concentrations are lower.

Adding further conservatism to the results, arsenic and iron are both considered to be transported non-conservatively. That is they are considered to form reactive solutes and are prone to reductions in mass due to chemical and biological processes (i.e., oxidation of iron). This means that although concentrations within the pit and WRSs may be high, chemical and biological processes soon reduce the concentrations of these solutes once they combine with soils and natural waters. This expectation was supported through PHREECQ modelling undertaken as part of the MPIII project that indicated order of magnitude reduction in concentrations of arsenic and two orders of magnitude reductions in iron (Golder 2011a). Observations made at the MGP regarding the concentrations of dissolved iron and arsenic in WRS discharge water compared to surface water quality downstream from the discharge points also demonstrates that iron and arsenic are not conservatively transported in the discharged water.

The model is less conservative with respect to sulfate. Projected sulfate non-compliances are directly related to WRS seepage and the highest sulfate concentrations in mine waters relevant to the Coronation North Project come from monitoring of existing WRSs. Monitoring data show sulfate levels are generally of similar elevated concentrations and show little variation across the MGP. The concentrations are high relative to the compliance limits. Therefore, the 95th percentile seepage water quality assumption used in the modelling is expected to be fairly representative of the WRS seepage post-closure. Sulfate is considered to be conservatively transported, meaning concentrations are not attenuated in the environment around the MGP except through dilution. This is supported by PHREECQ modelling undertaken as part of the MPIII project that indicated major ions are effectively transported conservatively and the sulfate predictions outlined in this report are accurate (Golder 2011a).

Stage 1 and Stage 2

Modelling suggests that for Stage 1 and Stage 2 of the Coronation North Project, the primary contaminants that may exceed compliance criteria are arsenic and iron. As discussed, the primary source of arsenic is from the active pit sumps, where it is likely that run-off and seepage water has mixed through mineralised zones exposed in the pit. The resulting water quality that reports to the pit sump has the potential to have elevated arsenic concentrations. WRS seepage is the primary source of dissolved iron in the model.

Simulated concentrations of arsenic and iron within the pit sump and WRS, respectively, exceed the compliance limits applicable at MB01/MB02 on occasions (refer Appendix D). It should however be reiterated that the non-conservative transport of both arsenic and iron in the environment at the MGP means that these contaminants are unlikely to cause water quality exceedances at MB01/MB02.

Sulfate should not be an issue during mining Stage 1 and Stage 2 as site data indicates that waste rock weathering and leaching processes will not produce concentrations of sulfate that exceed the compliance criteria of 1,000 g/m^3 within the operational timeframe of the Coronation North Project (assumed currently as five years).

Stage 3

Modelling suggests that for the Stage 3 model outcomes, the primary contaminants of concern are arsenic, sulfate and iron.

The primary source of sulfate and iron is from seepage from Coronation North WRS. WRS seepage sulfate and iron concentrations for the closure modelling are assumed at 2,900 g/m^3 and 2.2 g/m^3 respectively. These concentrations considerably exceed the respective compliance limits of 1,000 g/m^3 and 1.0 g/m^3.

The arsenic exceedance relates to the Coronation pit overflow. As per the Stage 2 model, water stored in the pit is likely to have elevated levels of arsenic. When this water combines with low flows in the Mare Burn, exceedances may be possible. Arsenic exceedances are not expected to be seen until the pit overflows. This is estimated to be around 160 years from pit decommissioning. In the meantime, observation of water quality in existing pit lakes on site indicates the trend for arsenic concentrations in the lakes is downward. The water quality in these pit lakes is reasonably expected to comply with the proposed arsenic limit for MB02 within a few years. On that basis, it can be reasonably expected that the Coronation and Coronation North pit lakes may comply with the downstream criteria for arsenic before overflow occurs.

6.4 Scope of Mitigation Required for Compliance

The outcomes of the water modelling documented in this report identify where management measures may be necessary in order to ensure the Coronation North Project operates within consent compliance limits. The mitigation requirements outlined in this section relate to the proposed Coronation North Project and specifically compliance point MB02.

Based on the assumptions used in this assessment, unless mitigation is implemented, instream concentrations of arsenic and iron may periodically exceed the proposed compliance limits at MB02 during the operational and closure stages. During closure, instream concentrations of sulfate may also exceed the proposed compliance limit at MB02 on occasion (Table 25). Mitigation options to manage this risk will need to be developed and implemented. Mitigation options are discussed further below.

Table 25: MB02 mitigation requirements.

Mine Stage	Parameter		
	Arsenic	Iron	Sulfate
Operational (Stage 1 and Stage 2)	YES	YES	NO
Closure (Stage 3)	YES	YES	YES

Modelling results indicate that during the operation phases, only arsenic and iron concentrations in the discharge water may need to be managed. It is likely that natural attenuation will reduce concentrations of dissolved iron in the discharge water from the WRS below the compliance limits before the water discharges from the silt ponds to be constructed in the gullies downstream from the WRS. The concentrations of dissolved iron and arsenic in the discharge water from both Coronation and Coronation North Pits can be managed through site monitoring and operational controls on the discharge water. If necessary, specific mitigation measures can be implemented to reduce the arsenic concentrations in the pit water prior to discharge to the local environment.

As outlined for the operational scenarios, it is likely that natural attenuation of arsenic and iron will ensure that compliance with the relevant consent criteria is achieved following site closure. A mitigation strategy is however required to enable compliance with the sulfate limit at MB02 into the future.

A range of water management mitigation measures were reviewed as part of the MPIII project (Golder 2011c). A suite of passive and active mitigation measures were identified that were suitable to mitigate for arsenic, iron and sulfate at closure. It is expected that an appropriate set of water management measures and operational controls can be instigated by OceanaGold that would enable the Coronation North Project to continue to operate within the proposed water quality criteria. Water management measures can be put in place prior to the closure of the site that would enable ongoing compliance with the proposed water quality criteria following closure.

7.0 CONCLUSIONS

OceanaGold is proposing to undertake an expansion of mining operations, referred to as the Coronation North Project, within the Mare Burn catchment. Planned operations include active open pit mining and the storage of waste rock in areas previously not influenced by the mining operation. As part of the environmental consenting of the Coronation North Project, a mine water management model has been constructed to simulate dissolved contaminant transport in the Mare Burn catchment.

As part of the proposed Coronation North Project, a new water quality compliance monitoring point will be required downstream from the current environmental monitoring point MB01. This new monitoring point is required to ensure contaminant losses from the entire impacted mining footprint are suitably captured. A new compliance point MB02, located approximately 1 km downstream, is proposed. Compliance limits that are currently consented at the MB01 site are proposed to be transferred to the MB02 site.

Flow and contaminant modelling was undertaken using industry standard GoldSim water balance modelling software. Results indicate that the proposed compliance limits are likely to be exceeded at MB02 either during the operational period of the mine or following mine closure unless mitigation measures are undertaken. The modelled exceedances are for dissolved arsenic, iron and sulfate, however the modelled outcomes are considered to be very conservative in the cases of iron and arsenic.

As the surface water models used for this project incorporate an assumption of conservative contaminant transport within surface water bodies, the modelled exceedances for arsenic are unlikely to occur. Arsenic is subject to geochemical reactions, precipitation and adsorption in the natural environment. Dissolved iron is also unlikely to present an issue at the compliance points, due to its capacity to rapidly oxidise and subsequently precipitate. Mitigation measures may however be required to minimise any possible issues of iron flocculants and discolouration of stream beds close to points of discharge.

The primary water quality issue identified is the need to manage sulfate concentrations in receiving surface water bodies. As sulfate is conservatively transported in water, it does not become naturally attenuated except through dilution. Sulfate concentrations within the Mare Burn are predicted to eventually exceed the compliance limit during low flow conditions. Mitigation measures are therefore considered to be necessary to ensure water quality within the Mare Burn is within the compliance limits set.

It is expected that an appropriate set of water management measures can be instigated by OceanaGold that would enable the Coronation North project to operate within the proposed water quality criteria. Water management measures can be put in place prior to the closure of the site that would enable ongoing compliance with the proposed water quality criteria following closure.

Changes to catchment hydrology resulting from the planned Coronation North Project are minor. These changes consist primarily of increased baseflows within the Mare Burn. As the consented Coronation Project would already result in a shift from intermittent to permanent flows in Mare Burn at MB01, there is little change projected for the consistency of base flows in the stream.

8.0 LIMITATIONS

Your attention is drawn to the document, “Report Limitations”, as attached in Appendix E. The statements presented in that document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks to which this report relates which are associated with this project. The document is not intended to exclude or otherwise limit the obligations necessarily imposed by law on Golder Associates (NZ) Limited, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

9.0 REFERENCES

ANZECC 2000. Australian and New Zealand guidelines for fresh and marine water quality. Australian and New Zealand Environment and Conservation Council.

Golder 2009. Water management technical report. Macraes Gold Project Back Road tailings storage facility. Report prepared for OceanaGold (New Zealand) Limited by Golder Associates (NZ) Limited, August 2009.

Golder 2010a. Macraes Phase III Project – groundwater contaminant transport assessment - Deepdell Creek, North Branch Waikouaiti River, and Murphys Creek catchments. Report prepared for OceanaGold (NZ) Limited by Golder Associates (NZ) Limited. Golder report 0978110562-006. December 2010.

Golder 2010b. Macraes Phase III Project – water quality database review. Report prepared for OceanaGold (NZ) Limited by Golder Associates (NZ) Limited. Golder report 0978110562-012. December 2010.

Golder 2011a. Macraes Phase III Project – site wide surface water model. Report prepared for OceanaGold (NZ) Limited by Golder Associates (NZ) Limited, 0978110562-008. April 2011.

Golder 2011b. Macraes Phase III Project – water management summary report. Report prepared for OceanaGold (NZ) Limited by Golder Associates (NZ) Limited, 0978110562-002. April 2011.

Golder 2011c. Water quality effects mitigation options. Report prepared for OceanaGold (NZ) Limited by Golder Associates (NZ) Limited. 0978110562-009. April 2011.

Kingett Mitchell 2002. Macraes Gold Project Tailings Capacity Expansion: Water Management and Geochemistry Technical Report, prepared by Kingett Mitchell Limited for GRD Macraes Limited, September 2002.

Kingett Mitchell 2005. Frasers East waste rock stack: hydrology and surface water management. Report prepared for OceanaGold (New Zealand) Limited by Kingett Mitchell Limited, February 2005.

Metservice 2016. New Zealand Climate. New Zealand Metservice. http://about.metservice.com/our-company/learning-centre/new-zealand-climate/. Accessed 16th February 2016.

NZDWS 2008. Drinking-water Standards for New Zealand 2005 (Revised 2008). Prepared by Ministry of Health. 2008.

Raineffects 2003. A comprehensive review of the surface water resources of the Strath Taieri. Report prepared for Dunedin City Council and Federated Farmers Strath Taieri Branch Raineffects Limited.

URS 2013a. Coronation Project water management – water balance and sulfate modelling. Report prepared for Oceana Gold (New Zealand) Ltd by URS New Zealand Limited. May 2013.