



13 May 2016

CORONATION NORTH PROJECT

Groundwater Assessment

Submitted to:
Oceana Gold (New Zealand) Ltd

REPORT



Report Number: 1545831-002-R-Rev2

Distribution:
Jackie St John, Oceana Gold (New Zealand) Ltd





Table of Contents

1.0 INTRODUCTION.....	1
1.1 Background	1
1.2 Objectives.....	1
1.3 Project Description.....	4
1.4 Resource Consents	5
1.4.1 Consents held	5
1.4.2 Consents sought	5
1.5 Scope	6
1.6 Previous Studies.....	6
1.7 Supporting Studies	6
1.8 Report Structure	7
2.0 CLIMATE	7
3.0 HYDROLOGY	9
4.0 GEOLOGY	9
4.1 Introduction	9
4.2 Schist.....	10
4.3 Tertiary Age Sedimentary Rocks	10
4.4 Basalt.....	10
4.5 Alluvium and Colluvium	10
4.6 Geological Structures	11
5.0 GROUNDWATER FLOW ASSESSMENT	12
5.1 Introduction.....	12
5.2 Groundwater Levels.....	13
5.3 Rock Mass Hydrogeological Characteristics.....	13
5.4 Groundwater Recharge	15
5.5 Groundwater Flows to and from Opencast Pits	15
5.5.1 Introduction	15
5.5.2 Groundwater drawdown cone calculations.....	16
5.5.3 Groundwater area of influence calculations	17
5.5.4 Groundwater outflows from opencast pits	20
5.5.5 Net groundwater flows to pit lakes	21



CORONATION NORTH PROJECT GROUNDWATER ASSESSMENT

5.6	Groundwater Seepage through Coronation North WRS	21
6.0	CONTAMINANT TRANSPORT	22
7.0	MONITORING	22
8.0	CONCLUSIONS.....	24
9.0	LIMITATIONS	25
10.0	REFERENCES.....	25

TABLES

Table 1: Mare Burn derived flow statistics.....	9
Table 2: Hydraulic conductivity values applied to schist weathering zones.....	15
Table 3: Coronation North Project initial inflow calculation results.	17
Table 4: Opencast pit areas of influence and calculated inflows.	19
Table 5: Seepage losses from pit lakes at overflow.	20
Table 6: Coronation North WRS seepage areas and rates.	21

FIGURES

Figure 1: Site location plan.....	2
Figure 2: Site layout plan.....	3
Figure 3: Coronation North interpreted geology.	8
Figure 4: Coronation North piezometric surface.....	14
Figure 5: Groundwater area of influence conceptual cross section.....	18
Figure 6: Coronation North WRS primary seepage discharge locations.	23

APPENDICES

APPENDIX A

Resource Consents

APPENDIX B

Groundwater Level and Gully Invert Data

APPENDIX C

Opencast Pit Drawdown Cone Seepage Flow Calculations

APPENDIX D

Opencast Pit Area of Influence Seepage Calculations

APPENDIX E

Opencast Pit Lake Seepage Loss Calculations

APPENDIX F

Opencast Pit and Pit Lake Net Seepage Flows

APPENDIX G

Report Limitations



ABBREVIATIONS

CS5	Coronation Pit Stage 5
EGL	Engineering Geology Limited
Golder	Golder Associates (NZ) Limited
ha	Hectare
m	Metres
MGP	Macraes Gold Project
mRL	Metres relative level; in this case metres above mean sea level.
Mt	million tonnes
OceanaGold	Oceana Gold (New Zealand) Ltd
ORC	Otago Regional Council
WRS	Waste rock stack



1.0 INTRODUCTION

1.1 Background

Oceana Gold (New Zealand) Limited (OceanaGold) operates the Macraes Gold Project (MGP) located in Central Otago, approximately 25 km west of Palmerston. The MGP consists of a series of opencast pits and an underground mine supported by ore processing facilities, waste storage areas and water management systems (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 the 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 Pit Stage 5 (CS5) pit shell.
- Construction and rehabilitation of the planned Coronation North WRS.

These new operations, which are described in greater detail in Section 0, are expected to increase the total consented tonnage of stored mine waste within the Mare Burn catchment from 66 Mt to 274 Mt.

OceanaGold has commissioned Golder Associates (NZ) Limited (Golder) to undertake technical evaluations related to water management at Coronation North. The outcomes of these evaluations are to be used in support of an Assessment of Environmental Effects (AEE). This AEE is to be lodged with the Otago Regional Council (ORC) in support of an application for resource consents to authorise the water management at Coronation North during mining operations and following closure. This report documents the hydrogeological assessment undertaken to assess the effects of the planned Coronation North Project on the surrounding groundwater system.

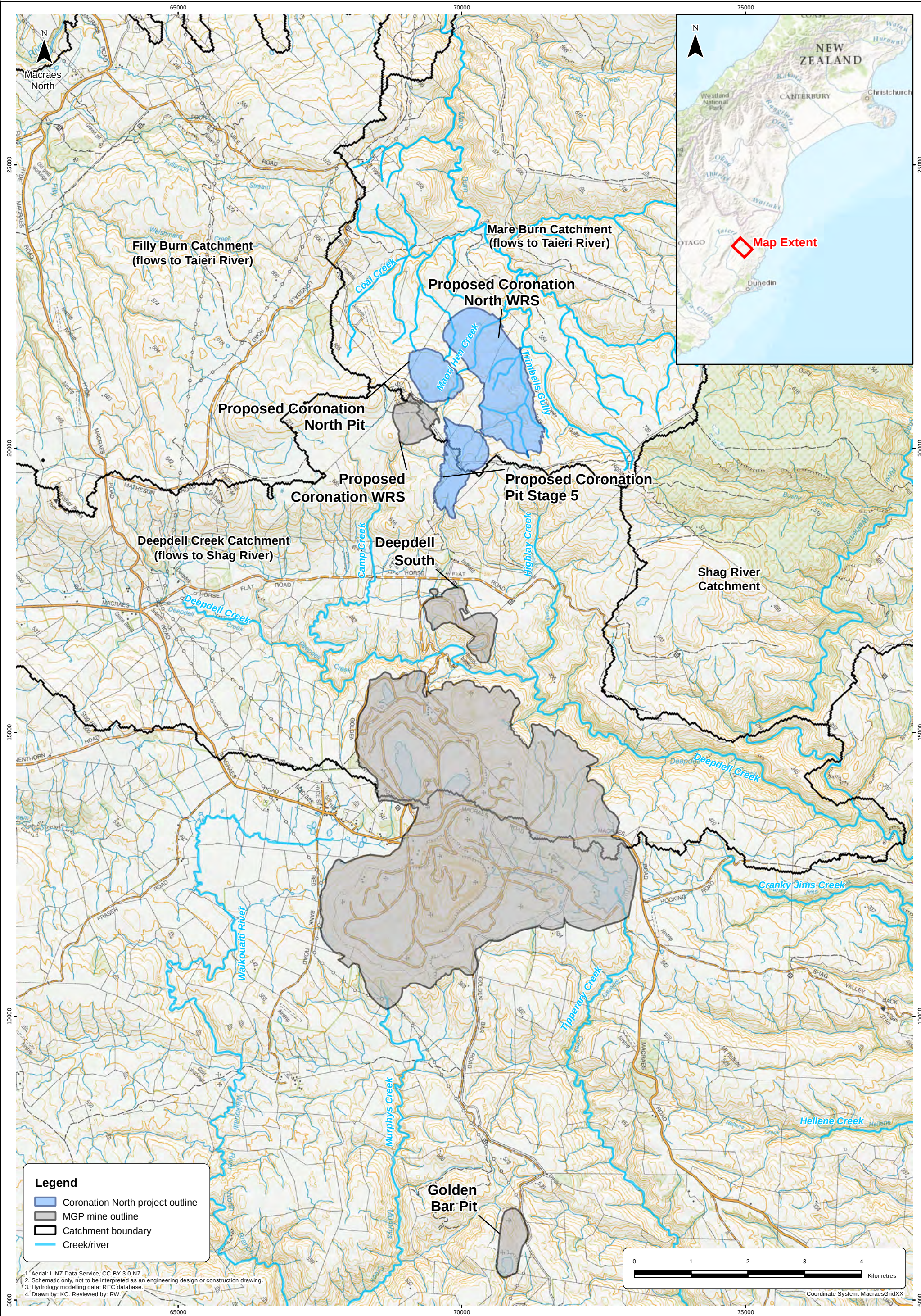
The results of this hydrogeological assessment have been incorporated in surface water and contaminant transport modelling for the Mare Bure catchment, as documented in the surface water model report (Golder 2016a). The primary purposes of the surface water model report are to produce water quality projections for receiving environment waterways, and to 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. Water quality mitigation measures relating to the construction of a freshwater dam to provide a reliable base flow in Mare Burn are documented in a separate report (Golder 2016b).

1.2 Objectives

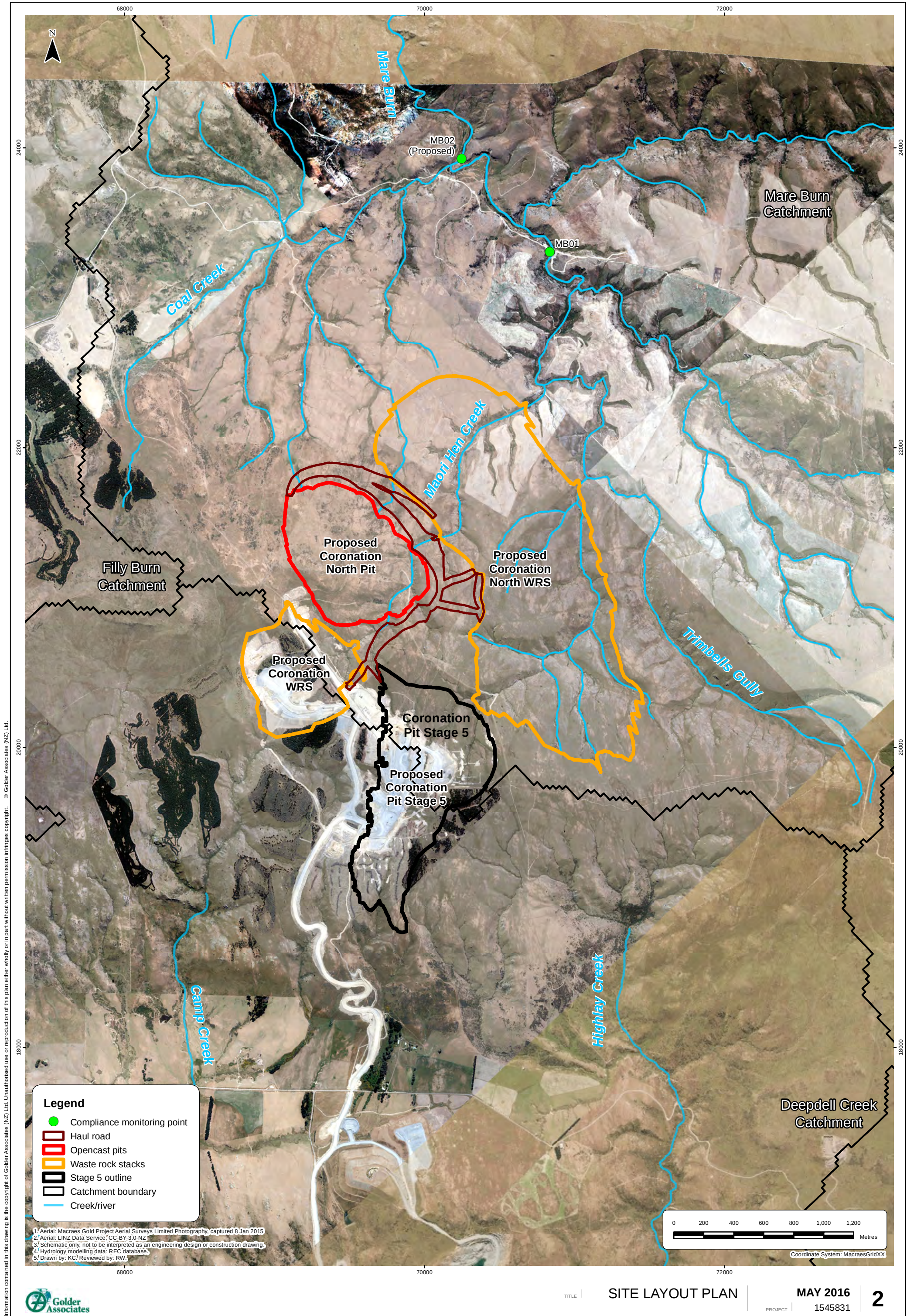
The work completed and documented in this report has been undertaken to meet a number of objectives. These objectives are summarised below.

OceanaGold requires an estimate of the magnitude of groundwater inflows to the opencast pits of the Coronation North Project that will need to be managed during the operational period of this project. As these flows will be managed in conjunction with surface water flows into the pits, the results from this report have been incorporated into the surface water models documented in the Coronation North surface water report (Golder 2016a).



Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.

1. Aerial: LINZ Data Service, CC-BY-3.0-NZ
2. Schematic only, not to be interpreted as an engineering design or construction drawing.
3. Hydrology modelling data: REC database.
4. Drawn by: KC. Reviewed by: RW.



Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.

- Legend
- Compliance monitoring point
 - Haul road
 - Opencast pits
 - Waste rock stacks
 - Stage 5 outline
 - Catchment boundary
 - Creek/river

1. Aerial: Macraes Gold Project Aerial Surveys Limited Photography, captured 8 Jan 2015
2. Aerial: LINZ Data Service, CC-BY-3.0-NZ
3. Schematic only, not to be interpreted as an engineering design or construction drawing.
4. Hydrology modelling data: REC database.
5. Drawn by: KC. Reviewed by: RW.



Coordinate System: MacraesGridXX





Groundwater inflows to and outflows from the planned opencast pits significantly affect the time required for the pit lakes to develop to overflow following the close of mining operations. In addition, groundwater inflows to the pit lakes influence the eventual overflow and discharge rates from the pit lakes, which will present as surface flows at the downstream compliance monitoring point in the distant future. Pit lake inflow calculations are therefore required to support OceanaGold in post closure mine rehabilitation and mitigation measure planning.

1.3 Project Description

The Project area 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 CS5 will potentially 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 also located within the Otago Region, administered by ORC.

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 in the 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 CS5 (Figure 2). The final CS5 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 695 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.



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.

1.4 Resource Consents

1.4.1 Consents held

A list of groundwater related resource consents held by OceanaGold to authorise the construction and subsequent closure of Coronation Pit and Coronation WRS is provided in Appendix A. In summary, these consents authorise:

- The taking of groundwater and surface water for the purpose of dewatering Coronation Pit.
- The taking of groundwater and surface water for the purpose of creating Coronation Pit lake.
- The damming of water in Coronation Pit for the purpose of creating Coronation Pit lake.
- The discharge of water and contaminants from silt ponds associated with the Coronation Pit and Coronation WRS to tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek.
- The discharge of water and contaminants from the Coronation Pit lake to tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek.

The consents authorising these activities expire on 20 October 2048.

Golder understands that the activities authorised by these consents form part of the environmental baseline against which the operational and post-closure effects arising from development of the extension to Coronation Pit are to be assessed.

1.4.2 Consents sought

A list of groundwater related consents sought by OceanaGold to authorise the construction and subsequent closure of Coronation North Pit, Coronation Pit Stage 5 and Coronation North WRS is provided in Appendix A. In summary, these consents are to authorise:

- a) The taking of groundwater and surface water for the purpose of dewatering Coronation North Pit.
- b) The taking of groundwater and surface water for the purpose of dewatering Coronation Pit Stage 5.
- c) The taking of groundwater and surface water for the purpose of creating Coronation North Pit lake.
- d) The taking of groundwater and surface water for the purpose of creating the extended Coronation Pit lake.
- e) The damming of water in Coronation North Pit and Coronation Pit Stage 5 for the purpose of creating the Coronation North Pit lake and the extended Coronation Pit lake.
- f) The discharge of water containing contaminants from the Coronation North WRS to tributaries of Maori Hen Creek, Trimbells Gully and the Mare Burn.
- g) The discharge of water containing contaminants from the Coronation North Pit lake to unnamed tributaries of Maori Hen Creek, Trimbells Gully and the Mare Burn.
- h) The discharge of water containing contaminants from Coronation Pit Stage 5 to unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek.
- i) To discharge water and contaminants from silt ponds associated with Coronation Pit Stage 5, Coronation North Pit, Coronation WRS and Coronation North WRS to unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek.



1.5 Scope

This report documents the groundwater related assessments undertaken to support an AEE for resource consents to authorise the water management at Coronation North during mining operations and following closure. Specifically, the scope of work covered by this report includes:

- An assessment of baseline groundwater conditions for the Coronation North area.
- An evaluation of potential groundwater seepage into the CS5 and Coronation North Pit during their respective operational periods.
- An evaluation of potential groundwater seepage into and out of the CS5 and Coronation North Pit during their respective pit lake development periods following the close of mining operations in each pit and at the stage of maximum potential water level in each pit lake.
- An evaluation of groundwater seepage rates from the Coronation North WRS.
- An assessment of the receiving areas for groundwater seepage from the final pit lakes and the planned Coronation North WRS.

1.6 Previous Studies

The natural groundwater system in the area of the MGP and the effects of planned mining operations on groundwater flows and groundwater quality have been intensively studied at regular intervals over the past three decades to:

- 1) Support the consenting process to establish large scale mining operations planned by BHP Gold Mines at Macraes (GCNZ 1988).
- 2) Support the consenting processes for expansions of the opencast pit areas and waste rock and tailings storage capacity for the site, based on analytical assessment of the natural groundwater system and artificial structures at the site (WWC 1996, WWC 2001, Kingett Mitchell 2000, 2002a).
- 3) Support the consenting processes for expansions of the opencast pit areas and waste rock and tailings storage capacity for the site, based on numerical hydrogeological modelling of the natural groundwater system and artificial structures at the site (Golder 2009, 2011a, 2011b, 2011c, 2012; Kingett Mitchell 1999, 2002b, 2005a, 2005b, 2006).
- 4) Support an application for consents authorising the development of Coronation Pit and Coronation WRS (URS 2013a, 2013b, 2013c).

The collective work undertaken during these previous studies and the consequent very good understanding of the groundwater system at the Macraes Gold Project has been incorporated in the current study. In particular, the work documented in this report takes into account the work undertaken in consenting the Coronation Pit and Coronation WRS, as listed under item 4 above.

1.7 Supporting Studies

Outcomes from the evaluations documented in this report in terms of groundwater flow projections have been incorporated into water balance models for Coronation North developed by Golder and documented in a separate Coronation North Project surface water modelling report (Golder 2016a).

Outcomes from the evaluations documented in this report in terms of groundwater flow projections have also been incorporated in a water quality mitigation assessment report prepared for OceanaGold (Golder 2016b).

Both of the above reports should therefore be considered in conjunction with this groundwater assessment report.



1.8 Report Structure

In addition to this introductory section, this mine water management report contains the following sections:

- Section 2.0 summarises the climate at the MGP, including both rainfall and evapotranspiration.
- Section 3.0 summarises the receiving environment hydrology.
- Section 4.0 summarises the geology of the area of the Mare Burn catchment relevant to the assessment of groundwater flows and contaminant transport associated with the Coronation North Project.
- Section 5.0 summarises the groundwater assessment undertaken to evaluate the seepage flows to, and from the artificial structures to be constructed as part of the Coronation North Project, contaminant transport within the Mare Burn catchment groundwater system from existing and proposed WRS's to receiving water bodies, including the proposed pit lakes.
- Section 6.0 summarises the conceptual transport of contaminants from the artificial structures of the Coronation North Project to surface receiving waters.
- Section 7.0 provides a summary of the proposed monitoring program to be instigated in the Mare Burn catchment to monitor the effects of Coronation North on groundwater.
- Section 8.0 presents the conclusions reached from the studies summarised in this report.
- Section 9.0 introduces Golder's statement of limitations related to the work undertaken and the uses of this report.
- Section 10.0 provides a list of the documents referenced in this report.

2.0 CLIMATE

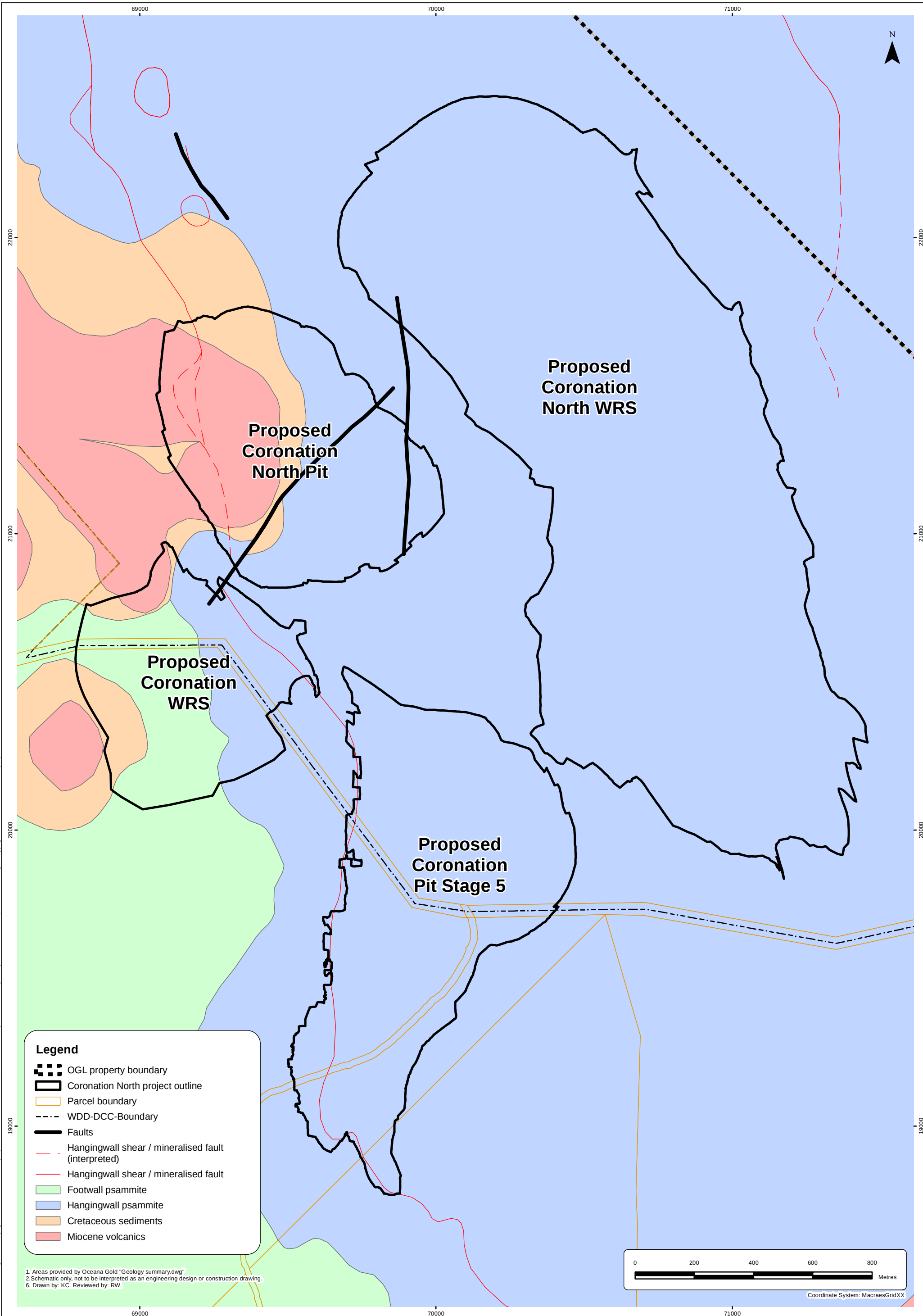
New Zealand lies in the mid-latitude zone of westerly winds, in the path of a succession of anticyclones, which move eastwards. The presence of the Southern Alps, extending the length of the South Island, has a major effect on the climate of the Otago region, as does the ocean, and produces distinct climatic contrasts from west to east. In inland Otago areas 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.

Rainfall at or near the MGP site has been monitored since 1959, with rainfall data available from four monitoring stations (Golder 2016a). An amalgamation of rainfall data from monitoring stations at Glendale and Golden Point, developed to support the mine water modelling for the Macraes Phase III (MPIII) has been expanded through the incorporation of data recorded from the Glendale, Golden Point and DG15 monitoring stations since 2011. It is anticipated that the Macraes Flat rainfall record would be appropriate to simulate rainfall patterns within the Mare Burn catchment (Golder 2016a).

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).

Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.





CORONATION NORTH PROJECT GROUNDWATER ASSESSMENT

Evaporation data is collected by OceanaGold staff on a weekly basis from an open pan located adjacent to Golden Point rain gauge, near the Mixed Tails Impoundment. 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 (Golder 2011b). 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. 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 (Golder 2016a).

3.0 HYDROLOGY

The Coronation North Project is located within the catchment headwaters of Mare Burn, a left bank tributary of the Taieri River. The Coronation and Coronation North pits, WRS's 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 (Figure 2).

The hydrological characteristics of Mare Burn are likely to be similar to those of Deepdell Creek, due to the comparable climate, geology and elevation of the two catchments (Golder 2016a). For the purposes of understanding the likely flow regime of Mare Burn, specific flow data from Deepdell Creek has been utilised and scaled to the Mare Burn catchment area upstream from the current MB01 water quality compliance site (14.4 km²) and the proposed MB02 site (29.3 km²).

Groundwater-derived base flows in Deepdell Creek are low (Golder 2011b), to the extent that evaporative losses from the creek bed exceed groundwater discharges to the creek during dry summers. For this reason, flows in Deepdell Creek are seasonally intermittent. Stream flows in Mare Burn are also expected to be intermittent on a seasonal basis (Golder 2016a) with low median and lower quartile flow rates (Table 1). Contributing flows to Mare Burn from minor headwater tributaries are expected to cease during most summers, although natural ponding may still occur in the gully inverts for some of these headwaters.

Table 1: Mare Burn derived flow statistics.

	Min	L.Q	Median	Average	U.Q.	Maximum
MB01 Daily average (L/s)	0	3.7	10.1	38.2	30.0	15,607
MB02 Daily average (L/s)	0	7.6	20.5	77.6	60.9	31,755

4.0 GEOLOGY

4.1 Introduction

The eastern area of Otago is underlain principally by Mesozoic age schist of the Torlesse Terrane (Forsyth 2001). Weathering and erosion of the schist over a long period formed the regional Otago peneplain. Eocene and Miocene age alluvial and lacustrine sediments were then deposited on top of the schist bedrock. Miocene age basalts formed localised volcanic cones and shallow intrusive deposits. Post-Miocene tectonic deformation and erosion removed most of the Tertiary age deposits, along with an unknown thickness of schist. The resulting landscape in the Macraes area comprises widespread outcrops of schist and thin cover soils with localised outcrops of Tertiary age rocks (Figure 3).



4.2 Schist

The schist, being a crystalline metamorphic rock, has effectively no primary or intergranular porosity or permeability, except where weathered. Secondary porosity and permeability in the form of fractures and faults provide the major groundwater seepage routes below the surficial, strongly weathered zone (Golder 2010).

It is considered that hydraulic conductivity of the schist increases upward through the schist rock mass due to the increasing intensity of weathering and reducing overburden pressures (Golder 2010). Similar trends or decreasing rock mass permeability with depth have been recorded with respect to fractured crystalline rocks in other areas of the world (Masset & Loew 2010). This trend has been incorporated in several groundwater models of the MGP site (Golder 2010) and is based primarily on an assessment of hydraulic conductivity variation with depth for the Maori Tommy Gully area (GCNZ 1988). OceanaGold differentiates between the schist underlying the Footwall Fault (refer to footwall schist in Figure 3) and the schist overlying the Footwall Fault (refer to hanging wall schist in Figure 3) for operational purposes. There is, however, no significant difference in the hydraulic behaviour of the two schist masses.

4.3 Tertiary Age Sedimentary Rocks

The Highburn Formation consists of Eocene age sandstones, conglomerates, mudstones and low grade coal beds derived from sediments deposited in a non-marine environment. Although not represented in the immediate Coronation North area, Highburn Formation rocks are present within the Coal Creek catchment.

Miocene age claystones and siltstones deposited in a freshwater lake environment comprise the Bannockburn Formation. This formation overlies the schist bedrock within the footprints of Coronation North Pit and Coronation WRS and extends over a localised area to the west of the Coronation North Project.

4.4 Basalt

Miocene age basaltic lava flows and shallow intrusive plugs of the Dunedin Volcanic Group are represented within the footprints of Coronation North Pit and Coronation WRS. These fractured basalts have low primary porosity and seepage flows are mainly through the fracture systems. The basaltic deposits are localised and discontinuous (Forsyth 2001).

4.5 Alluvium and Colluvium

Exploratory and geotechnical drilling and landform comparison indicates that a thin layer of loess covers much of the MGP area (Golder 2010). Sections of loess and colluvium up to two metres thick are exposed in haul road cuts in the Coronation and Deepdell areas of the MGP. The loess soils comprise a very stiff, light yellow grey silt, sandy silt or silty fine sand.

Colluvium has accumulated on the lower slopes of hillsides around the MGP site and in the floor of local gullies. Colluvium mainly comprises fine angular schist gravel in a sandy or silty matrix, with the matrix mainly derived from reworked loess (Golder 2010).

The alluvial fill in the gullies in the vicinity of Coronation North is not considered to have a substantial effect on the regional groundwater flow regime. The fill is neither voluminous enough nor of sufficient area to act as an aquifer or aquitard at the catchment scale under consideration.



4.6 Geological Structures

Hyde Macraes Shear Zone

The Hyde Macraes Shear Zone (HMSZ) consists of three major physical components:

- The Hanging Wall Shear
- The Intrashear Schist
- The Footwall Fault

The position of both the Hanging Wall Shear and the Footwall Fault has been defined through interpolation of intersect data from drilling programs. The ore mineralization is focused on the Hanging Wall Shear and on the immediately underlying Intrashear Schist. As the Footwall Fault is less important in terms of mineralisation and mine planning, the Intrashear Schist and the schist mass that underlies the Footwall Fault is collectively known as Footwall Schist in Figure 3.

Within both the Hanging Wall Shear and the Footwall Fault the structure of the host schist is generally completely disrupted. Both the Hanging Wall Shear and the Footwall Fault are expected to be characterised by greater hydraulic conductivity parallel to the respective structures than perpendicular to them, as is the case in the wider MGP (Golder 2010).

The HMSZ generally trends approximately parallel to the north alignment of the Macraes mine survey grid (Golder 2010). In the area between the Coronation and Coronation North pits however the HMSZ trends more westerly.

Faults

Discontinuities observed in the schist comprise mainly foliation partings. In addition to the foliation parallel discontinuities, several faults have been documented from the area of the Coronation North Pit (Figure 3).

North to northwest striking high angle faults have been identified through interpretation of drillhole data, evaluation of aerial photograph lineaments and direct mapping of outcrops in the Coronation North Project area. Across the wider MGP area faults trending parallel to the Macraes mine grid north have a significant influence on groundwater seepage flows and contaminant transport. The calibration process for existing mine site groundwater models has indicated that these structures result in the north–south permeability of the schist rock mass being greater than the east-west permeability (Golder 2010).

Foliation

The schist bedrock at the MGP site is characterised by eastward dipping foliation and foliation parallel fractures. These foliations typically dip about 15° to 30° towards the east or south east. Foliation orientations rotate approaching major faults in the area, such as Macraes Fault (Golder 2011d).

Basalt Joints

Shallow intrusive basalts and terrestrial basaltic lava flows tend to be characterised by an intensive system of joints derived from the cooling of the basalts following emplacement. As the primary porosity of the lava is generally low this fracture system forms the primary conduit groundwater away from the high ground associated with the volcanic plugs.



5.0 GROUNDWATER FLOW ASSESSMENT

5.1 Introduction

Dewatering of the CS5 and Coronation North pit requires both inflowing surface water run-off and groundwater inflows to be pumped from their respective pit sumps. The abstraction of groundwater through this process results in a cone of drawdown that expands as the pit increases in extent, depth and time of operation. At the close of operations in each pit, pumping from the pit sump ceases. The water level in the sump subsequently rises, overflows the sump and starts to form a pit lake. As the water level in the pit lake rises, the cone of groundwater drawdown decreases in area. Eventually the pit lake surface either stabilises at an elevation below the overflow elevation or the lake overflows through the lowest point of the pit rim. Once this occurs the groundwater drawdown cone also stabilises and becomes part of the long term piezometric surface for the catchment.

If the groundwater drawdown cone induced by the excavation of an opencast pit was imposed on an area characterised by a horizontal piezometric surface, the groundwater within the footprint of the drawdown cone would flow toward the pit. In the case of the Coronation North Project however, the piezometric surface prior to mining was not horizontal. The baseline piezometric surface formed a subdued reflection of the overlying topography (refer Section 5.2). It was, and is, characterised by moderately steep hydraulic gradients toward the gully inverts, with the highest groundwater levels occurring beneath the ridge lines. The drawdown cone induced by the excavation of an opencast pit is imprinted on the baseline piezometric surface. The drawdown cone can result in reduced groundwater levels down-gradient from an opencast pit or on the far side of a ridge from an opencast pit. The induced drawdown may however not be great enough to change the direction of groundwater seepage. In effect, not all of the shallow groundwater within the footprint of the drawdown cone will flow toward the associated opencast pit, even when the pit reaches its maximum operational depth and extent.

The shape of the drawdown cone for an opencast pit is also influenced by the hydraulic characteristics of the rock mass through which the groundwater is flowing. In the Coronation North area the permeability of the schist rock mass is primarily influenced by the structural features of the rock mass. The structural features of the schist, including the schist foliation and the faulting pattern in the area, are oriented along a few main alignments (refer Section 4.6). For this reason the structural pattern of the rock mass is not isotropic. The hydraulic conductivity of the schist is therefore also anisotropic (refer Section 5.3). The distance to which the drawdown cone extends outward from the opencast pit footprint in any particular direction depends on the hydraulic conductivity of the rock mass parallel to this direction.

For the purposes of this assessment, an area of influence for an opencast pit can be defined as the groundwater recharge catchment area within which the groundwater seepage flows take the recharge water (refer Section 5.4) to the pit. The area of influence is not the same as the area of the drawdown cone because:

- 1) As described above, some groundwater within the area of the drawdown cone may still be flowing away from the pit due to the influence of the natural hydraulic gradients.
- 2) If the opencast pit is located in a low topographic area, groundwater from areas at higher elevations may flow naturally toward the pit, even though the contributing area may be outside the drawdown cone.

The area of influence effectively defines the groundwater capture zone for the opencast pit. Prior to the start of mining the groundwater flows within the area of influence would have discharged to down-gradient surface water bodies. Following the start of excavation of the opencast pit these groundwater flows discharge to the pit sump and are managed by the mine water management system.

Following the close of mining operations in the opencast pit and the formation of the pit lake, the groundwater system stabilises. The opencast pit still generates an area of influence however the groundwater flowing into the pit lake is not actively managed and may either overflow out of the lake or escape from the lake through onward seepage through the groundwater system.



5.2 Groundwater Levels

The baseline piezometric surface in the area of the Coronation North Pit and part of the Coronation North WRS has been derived from two sets of data:

- Groundwater measurements made during a survey of water levels in holes drilled as part of the ore resource definition program.
- Gully invert elevations derived from a LIDAR survey of the MGP topography completed for OceanaGold.

Both sets of data are provided in Appendix B of this report.

The piezometric surface was evaluated in a two-stage process. In the first stage the groundwater level data from the drillholes was interpolated without reference to the local topography. The resulting piezometric surface was above the ground level where deeply incised gullies intersected the area covered by the resource drilling. In the second interpretation stage, in areas where the initial piezometric surface was above ground level gully invert data was included in the groundwater elevation dataset for interpolation. This was done based on the assumption that the groundwater in these areas would discharge naturally to the gullies and the piezometric surface would therefore not rise above the gully inverts. The expanded dataset was interpolated to produce a modified piezometric surface. This surface was then compared to the overlying topography to confirm there were no areas where the interpreted surface rose above the ground level. The resulting baseline piezometric surface for the Coronation North Pit and part of the Coronation North WRS area is presented in Figure 4.

5.3 Rock Mass Hydrogeological Characteristics

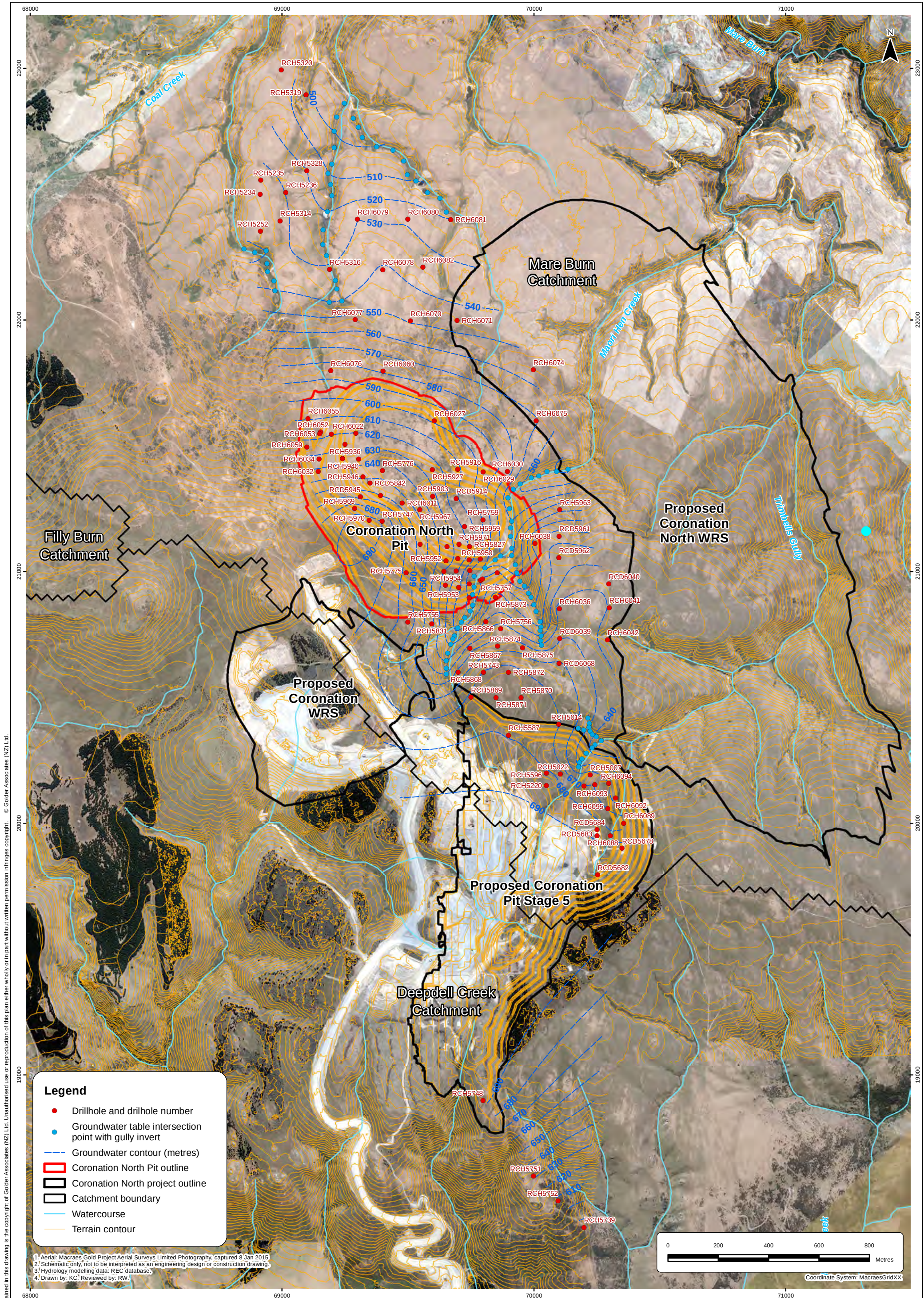
The schist rock mass at the MGP has been subjected to an extended period of weathering, combined with the removal of large overburden loads through erosion. As a result the apertures of fractures and the foliation are greater close to the ground surface than they are at depth (Golder 2011a). This trend is reflected in decreasing rock mass hydraulic conductivity with increasing depth below ground (Table 2).

This trend has been incorporated in several previous groundwater seepage models (Golder 2011a, Kingett Mitchell 2002, WWC 1996, 2001) and is based on an assessment of conductivity variation with depth for the Maori Tommy Gully area (GCNZ 1988). The permeability of the schist rock mass does not differ substantially across the site, as indicated by work undertaken in several areas of the MGP:

- Hydraulic testing undertaken in support of a site wide contaminant transport assessment (Kingett Mitchell 2005a).
- Hydraulic testing undertaken at the proposed Back Road WRS (EGL 2010, Golder 2009).
- Hydraulic testing undertaken in the area of the planned Top Tipperary Tailings Storage Facility (Golder 2011a).

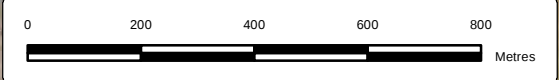
The hydraulic conductivity applied to previous numerical groundwater models of the MGP site has been anisotropic, with a higher value applied in the north-south direction than in the east-west direction (refer Section 4.6). This anisotropy has been applied to simulate the presence of minor faults and near vertical fractures aligned approximately north-south across the site as well as to place an emphasis on the low dip of the schist foliations toward the east.

The schist rock mass in the Coronation North Project area, is not expected to be significantly different structurally from that in other areas of the MGP. For this reason the schist rock mass is expected to behave hydraulically in a manner similar to that consistently shown across the wider MGP area. In evaluating groundwater inflows to the opencast pits, the values for hydraulic conductivity applied to the previous groundwater models of the MGP (Table 2) have been applied (refer Section 5.5).



- Legend**
- Drillhole and drillhole number
 - Groundwater table intersection point with gully invert
 - Groundwater contour (metres)
 - ▭ Coronation North Pit outline
 - ▭ Coronation North project outline
 - ▭ Catchment boundary
 - Watercourse
 - Terrain contour

1. Aerial: Macraes Gold Project Aerial Surveys Limited Photography, captured 8 Jan 2015
2. Schematic only, not to be interpreted as an engineering design or construction drawing.
3. Hydrology modelling data: REC database.
4. Drawn by: KC. Reviewed by: RW.



Coordinate System: MacraesGridXX





Table 2: Hydraulic conductivity values applied to schist weathering zones.

Schist weathering zones ⁽¹⁾	K _x (m/s)	K _y (m/s)	K _z (m/s)
Weathered schist	3.5 x 10 ⁻⁷	1.0 x 10 ⁻⁶	2.5 x 10 ⁻⁷
Moderately weathered schist	1.0 x 10 ⁻⁷	2.5 x 10 ⁻⁷	6.0 x 10 ⁻⁸

Note: 1) Sourced from Golder, 2011a.

The hydraulic characteristics of the basaltic rocks in the Coronation North Project area have not been tested in the field. A comparison of the baseline piezometric surface to the geological map for the area however indicates that the lateral hydraulic gradients within the basaltic rocks are not substantially different to the interpreted gradients within the schist rock mass (Figure 4). Assuming the rate of recharge to the basaltic rock mass is similar to that applicable to the wider catchment, this indicates generally similar hydraulic conductivity. The anisotropy of the hydraulic conductivity resulting from the foliation structure of the schist (Table 2) is expected to be absent in the basalt.

5.4 Groundwater Recharge

An evaluation of the Deepdell Creek catchment groundwater balance was produced by Kingett Mitchell (2005a) based on:

- An average annual rainfall of 607 mm/year across the whole of the MGP site
- An average annual evaporation of 1,092 mm
- An average annual open water evaporation of 764 mm

The calculated regional groundwater recharge rate based on the above input parameters was approximately 32 mm/year. This calculated recharge was supported by an assessment of groundwater derived stream flows in Deepdell Creek at Golden Point Weir and generally agreed with assessments of recharge for other catchments in similar Otago terrain and climatic conditions.

As the updated assessment of annual rainfall across the site is 650 mm and the annual evaporation is slightly less at approximately 1,000 mm (refer Section 2.0), the annual recharge may be slightly more than what was calculated by Kingett Mitchell (2005a). The recharge value of 32 mm/year has been used in previous calibrated groundwater flow and mass transport modelling of the MGP (Kingett Mitchell 2005a, Golder 2011a) and has proven to provide reliable projections for contaminant transport models. For these reasons an annual groundwater recharge rate of 32 mm is retained for this purpose in the current study.

5.5 Groundwater Flows to and from Opencast Pits

5.5.1 Introduction

There are several different methods that could have been applied in evaluating potential groundwater inflows to the planned opencast pits of the Coronation North Project. Two methods have been used:

- 1) The first method is based on the use of generic analytical equations to define a groundwater drawdown cone around the pit. This method has been applied in the past (URS 2013a, 2013c) to calculate inflow projections for the Coronation Pit in support of the resource consent application for that pit.
- 2) The second method is based on the concept of an area of influence around each pit, within which all groundwater recharge will flow toward the pit while recharge outside this area flows to other receiving water bodies. The area of influence for each pit is defined based on a clear understanding of the geology, topography and hydrology of the area surrounding the Coronation North Project.



Although the calculations for both methods have been documented in this report, Golder considers the area of influence method produces more technically robust and reliable outcomes for the following reasons:

- 1) Assumptions incorporated into the first method with respect to the groundwater flow patterns through baseline groundwater system prior to mining (refer Appendix C) are not fully valid for the groundwater system at the Coronation North Project. The area of influence method does not incorporate these assumptions.
- 2) The drawdown cone calculations build in simplifications with respect to the pit layout and shape that require subjective decisions on the shape of the drawdown cone.
- 3) The parameters applied in the drawdown cone calculations, such as the hydraulic conductivity of the rock mass, are subject to much uncertainty than the groundwater recharge rate.

These differences between the two methods are reflected in a previously calculated flow of 1,050 m³/day on cessation of mining (URS 2013a) compared to the lower flow rates for the already consented Coronation Pit documented in Section 5.5.3. For these reasons, the area of influence method of calculating groundwater inflows is preferred and considered more appropriate for the purposes of this report. The results from the area of influence calculations have been carried forward into the surface water modelling work undertaken for the Coronation North Project (Golder 2016a).

The drawdown cone method and calculation results have been documented in this report to provide continuity with previous work on the Coronation Pit. In addition, the drawdown cone areas can be used to provide an indication of the potential areas within which groundwater seepage discharges to surface may be affected.

5.5.2 Groundwater drawdown cone calculations

An initial assessment of potential groundwater flows into the opencast pits of the Coronation North Project has been undertaken based on general analytical equations developed by Marinelli and Niccoli (2000). This has been done as an initial check as it follows the methodology used for the calculation of potential groundwater inflows lodged with ORC in support of the application for consents to develop the Coronation Pit (URS 2013c).

These equations provide an estimation of inflows to an opencast pit based on the assumption that the pit will generate a groundwater drawdown cone that is overprinted on a flat, laterally continuous and effectively infinite groundwater system. On that basis, the equations imply that all seepage flows within the footprint of the drawdown cone will discharge to the opencast pit while groundwater outside this footprint will not contribute to inflows to the pit. As this is not a valid assumption in the case of the opencast pits of the Coronation North project, the calculated inflows are considered to be initial estimates only. These issues are addressed by calculating groundwater inflows to each pit through the definition of opencast pit areas of influence (refer Section 5.5.3).

The analytical calculations of groundwater inflows to opencast pits relate to:

- 4) Lateral seepage flows in through the walls of the pit containing a pit lake or at least a sump.
- 5) Upward flows through the floor of the pit.

The conceptual seepage flow model, the assumptions on which it is based, the analytical model and associated seepage flow equations are summarised in Appendix C. The input parameters applied to the calculation of the drawdown cone flows into the pits, and the results of the calculations, are also presented in Appendix C. The results of these seepage flow calculations are summarised in Table 3.



Table 3: Coronation North Project initial inflow calculation results.

Mining stage	Inflow seepage rate – total (m ³ /day)		
	Coronation Pit	CS5	Coronation North Pit
At closure	87	179	146
Pit lake at overflow	97 ⁽¹⁾	130	108

Note: 1) The calculated increase in inflow following development of the pit lake is unlikely to be realistic. This result derives primarily from a larger effective radius of the pit applied to the calculation when the lake is at its overflow level compared to when water level maintained by pumping from sump.

These initial estimates of groundwater seepage flows into the opencast pits are documented here as a check on the inflow calculations based on area of influence presented in Section 5.5.3. They also provide continuity with the groundwater assessment of inflows to Coronation Pit, presented to support the application for consents authorising the construction of Coronation Pit, which were calculated using the same methodology. The previous estimates for groundwater inflows to Coronation Pit ranged from 1,050 m³/day on cessation of mining to 0 m³/day at pit lake overflow (URS 2013a). The inflow values presented in Table 3 have however not been incorporated in the net groundwater flow calculations presented in Section 5.5.5 and carried through into the catchment surface water and contaminant transport calculations.

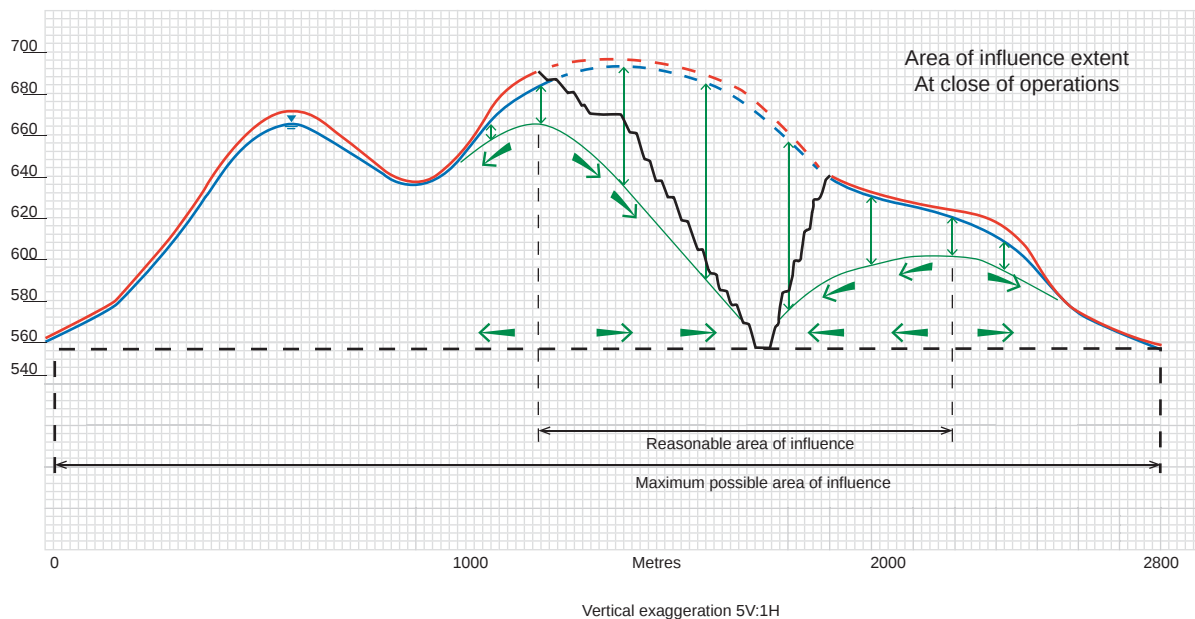
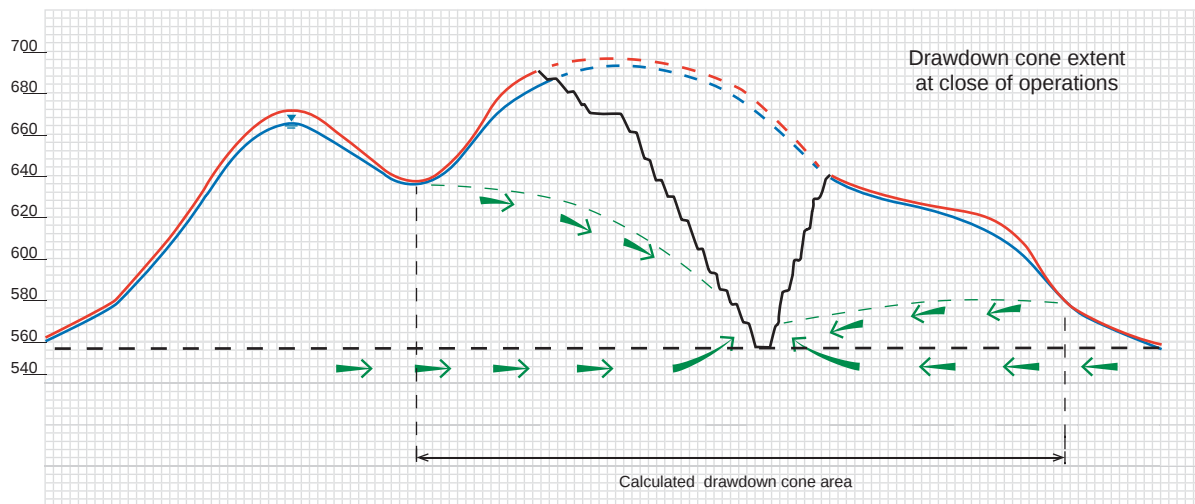
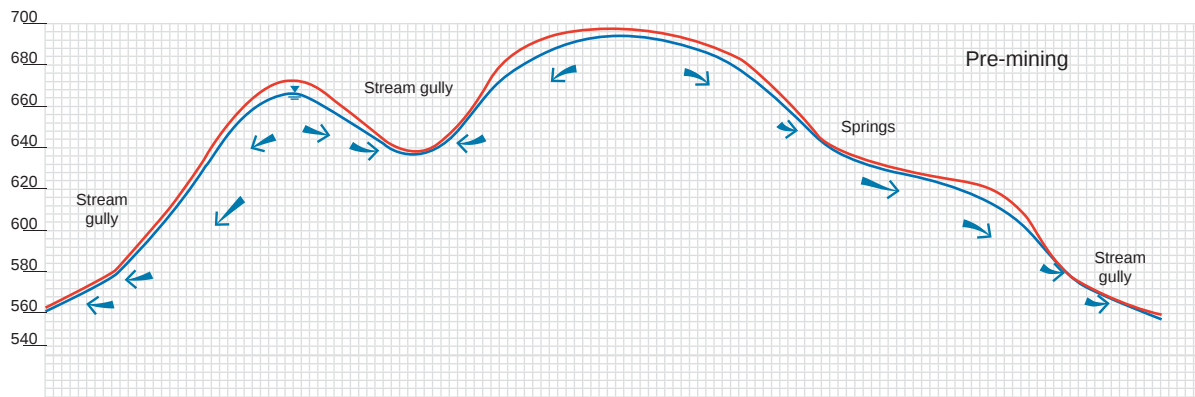
5.5.3 Groundwater area of influence calculations

For the purposes of this assessment, the groundwater area of influence for an opencast pit has been defined as the area outside the pit footprint which contributes groundwater flows to the pit.

The area of influence under this definition differs from the drawdown cone in that it takes into account the shape of the baseline piezometric surface around the pit (Figure 5). In some areas around the planned Coronation North Project pits the area of influence does not extend as far outside the pit footprint as the corresponding calculated drawdown cone, as exemplified in (Figure 5). In other areas the area of influence outside a pit may extend beyond the limit of the drawdown cone. This situation occurs where the pit is excavated into the side of a hill, with a considerable area of undisturbed ground up-slope from the pit footprint. Water recharging to this up-slope area flows downhill toward the pit irrespective of the extent of the drawdown cone.

Four areas of influence have been identified for each opencast pit, corresponding to the following scenarios:

- 1) A maximum potential area of influence catchment for the pit at the close of operations, taking into account the maximum extent of the pit shell and the water level in the sump being managed through the operational dewatering program. This maximum potential catchment is defined for each pit through identifying points in nearby stream gullies that are at the same elevation as the base of the pit. These points are then connected based on the assumption that the area of influence cannot extend outward beyond these points.
- 2) A “reasonable” area of influence catchment for the pit at the close of operations, taking into account the maximum extent of the pit shell and the water level in the sump being managed through the operational dewatering program. This scenario differs from Scenario 1 in that it also takes into account the groundwater systems in gullies close to the pit, which are unlikely to remain relatively unchanged irrespective of the construction of the pit. This implies a localised groundwater divide will develop between these gullies and the pit. The reasonable area of influence has been based on interpretation of hydraulic gradients balanced between the pit and the nearest gullies.



Legend

- | | |
|---|---|
| — Ground surface | - - - Calculated drawdown cone |
| — Pre-mining groundwater surface | ↕ Projected drawdown |
| — Pit shell | → Projected groundwater flow |
| — Operational period groundwater table | → Pre-mining groundwater flow |

1. DRAWN BY: AP REVIEWED BY: SG



GROUNDWATER AREA OF INFLUENCE CONCEPTUAL CROSS SECTION

MAY 2016
PROJECT 1545831



CORONATION NORTH PROJECT GROUNDWATER ASSESSMENT

- 3) A maximum potential area of influence catchment for the pit under post-closure conditions, taking into account the maximum extent of the pit shell and the pit lake surface being at overflow. This maximum potential catchment is defined for each pit through identifying points in nearby stream gullies that are at the same elevation as the overflow level for the pit. These points are then connected based on the assumption that the area of influence cannot extend outward beyond these points.
- 4) A “reasonable” area of influence catchment for the pit under post-closure conditions taking into account the maximum extent of the pit shell and the pit lake surface being at overflow. This scenario differs from Scenario 3 in that it also takes into account the groundwater systems in gullies close to the pit, which are unlikely to remain relatively unchanged irrespective of the construction of the pit. This implies a localised groundwater divide will develop between these gullies and the pit. The reasonable area of influence has been based on interpretation of hydraulic gradients balanced between the pit and the nearest gullies.

As the area of influence defines the groundwater recharge area that contributes to inflows to the opencast pit, the recharge rate multiplied by the area results in an indication of the steady state flows into the pit. Figures presenting the areas of influence for each of the pits in the Coronation North Project are provided in Appendix D, together with the calculations for pit inflows. The areas of influence and the calculated seepage inflows to each pit are summarised in Table 4.

For the purpose of calculating groundwater inflows to each opencast pit during the pit lake filling period, the inflows presented in Table 4 have been interpolated on a linear basis between the operational water level in the pit and the pit lake overflow level (Appendix D). These results have been incorporated in the pit lake surface water modelling assessment undertaken for the Coronation North Project (Golder 2016a).

Table 4: Opencast pit areas of influence and calculated inflows.

Factors	Units	Operational period		Post-closure period	
		Maximum catchment	Reasonable catchment	Maximum catchment	Reasonable catchment
Coronation Pit water level, area of influence and groundwater inflows	mRL	562.5	562.5	640	640
	ha	716	309	239	108
	m ³ /day	628	271	210	95
	L/s	7.3	3.1	2.4	1.1
CS5 water level, area of influence and groundwater inflows	mRL	562.5	562.5	632.5	632.5
	ha	739	341	248	126
	m ³ /day	648	299	218	111
	L/s	7.5	3.5	2.5	1.3
Coronation North Pit water level, area of influence and groundwater inflows	mRL	467.5	467.5	580	580
	ha	779	361	127	107
	m ³ /day	683	316	111	94
	L/s	7.9	3.7	1.3	1.1

Stored groundwater would also be released from the rock mass surrounding each pit as a consequence of the dewatering process. The release of the stored water is however not incorporated in the flows presented in Table 4. Past groundwater assessment work for the MGP and seepage modelling (Golder 2011b) has indicated that effective porosity of the highly and moderately weathered schist is in the order of 0.01 m³/m³. Modelling has indicated the groundwater gradients associated with the drawdown cone that develops around an opencast pit at the MGP are steep, with most of the dewatered rock mass being restricted to the



immediate vicinity of the pit. The rate of release of stored water from the rock mass around an operational opencast pit is limited by the combination of the limited extent of rock mass dewatering, the low drainable porosity of the rock mass and the time required to excavate the pit to its maximum depth. These inflows are considered to be substantially less than the inflow rates presented in Table 4 and would primarily affect the pit water management during the earlier stages of excavation rather than toward the end of mine life. For these reasons water released into the pits due to rock mass dewatering has not been taken into account in the groundwater inflow calculations.

5.5.4 Groundwater outflows from opencast pits

During the operational and immediate post-closure periods of the opencast pits of the Coronation North Project, there is expected to be no loss of water from the pits or the developing pit lakes to the surrounding groundwater system. In the immediate vicinity of the pit the hydraulic gradients within the surrounding rock mass will be consistently toward the pit. As pit lake levels rise however hydraulic gradients develop toward gullies that intersect the pits, resulting in seepage losses from the pits to these nearby gullies.

These seepage losses are not expected to be important in terms of the overall catchment water flow and quality projections (Golder 2016a). They could however slow the rate of late stage pit lake development, thereby delaying the occurrence of pit lake overflow. Pit lake seepage losses through shallow soils and weathered schist have been observed at Golden Bar Pit. Pit lake water balance modelling suggests significant seepage losses are occurring from the developing pit lake in Deepdell South Pit (Golder 2016a). Seepage losses have therefore been estimated for Coronation and Coronation North Pits for incorporation into the mine water model. The calculations used to estimate these seepage losses are summarised in Appendix E.

Seepage losses calculated for the Coronation Pit relate to a single potential flow path toward the north into the Mare Burn catchment. In contrast, seepage losses from CS5 Pit lake may occur both toward the north and toward the south into the Deepdell Creek catchment. The latter seepage flows are however expected to be very small (Table 5).

Table 5: Seepage losses from pit lakes at overflow.

Pit lake	Seepage direction	Flow rate at maximum lake level (m ³ /day)
Coronation Pit	Northeast	2.3
CS5	Northeast through Coronation North WRS	0.3
	South	0.3
Coronation North Pit	Northeast through haul road embankment and Coronation North WRS	17.5
	North	0.6

In the case of Coronation North Pit the lowest natural point of the pit rim would result in pit lake seepage losses toward an unnamed gully to the northeast of the pit. OceanaGold however plans to close this overflow point through constructing the haul road from Coronation North Pit to Coronation North WRS and to the Process Plant. In doing so, OceanaGold plans to construct a low-permeability layer of compacted soil and weathered rock against the upstream face of the haul road embankment. Once this is in place, the Coronation North pit lake will discharge on overflow through a different gully toward the north. Seepage losses from the pit lake toward the northeast will be through both the in-situ soils and rock as well as through the haul road embankment (Table 5). Seepage losses from the pit lake toward the north will be through the in-situ soils and rock.

The calculations presented in Appendix E do not take into account the potential seepage losses through very shallow soils adjacent to the overflow points for each of the pit lakes. Seepage losses through the shallow soils beneath the overflow point from Golden Bar Pit have been observed to substantially exceed the



maximum seepage flow rate documented in Table 5. For this reason, as the lakes developing in CS5 and Coronation North Pit approach to within one to two metres of the overflow elevation seepage flows are likely to exceed those documented in Table 5. This underestimation is not a substantial issue for the assessment of the environmental effects of the Coronation North Project as these discharges can effectively be seen as one component of the surface water discharge from each pit lake.

5.5.5 Net groundwater flows to pit lakes

The net groundwater flows into the Coronation, CS5 and Coronation North Pits are provided in Appendix F. These net flows have been incorporated in the water management model for the Coronation North Project (Golder 2016a). The net flows have been based on linear interpolations of both the seepage inflows to the pit (Section 5.5.3) and seepage losses from the pit lake (Section 5.5.4) and reported at 2.5 m lake stage intervals.

5.6 Groundwater Seepage through Coronation North WRS

Flow rates at the main WRS seepage discharge points have been calculated to provide flow rates for the assessment of possible treatment options, diversion or storage or a combination of water quality mitigation measures. Observations of seepage flows from WRSs at MGP indicate that they store infiltrating rainwater and subsequently release this water continuously throughout the year. The Clydesdale, Northern Gully, Frasers East, Frasers West, Deepdell North and Coronation WRSs all have seepages discharging from the toe of the WRS at various rates.

A WRS acts as an artificial aquifer. Seepage tends to follow the natural topography at the base of the WRS. Discharge of seepage water therefore mostly occurs from WRS underdrains or in natural gullies at the toe of the WRS.

Groundwater seepage through the Coronation North WRS has been calculated based on a rainfall infiltration rate of 32 mm/year, which is equivalent to the regional groundwater recharge rate. This assumption with respect to infiltration rate has been based on the calibration of groundwater flow and contaminant transport models developed for the wider MGP (Golder 2011b). The infiltration rate for the entire planned WRS, which is 233.5 ha in area, averages approximately 205 m³/day (Table 6). It is expected that this discharge rate will vary slightly on a seasonal and annual basis, and potentially over shorter periods in response to major rainfall events. The buffering capacity of the WRSs at the MGP are however very large and overall the discharge flows are expected to be relatively stable.

For the purposes of this assessment, the infiltrating rainwater is expected to accumulate in four buried gullies and thence discharge to one of four silt ponds to be constructed at the downstream toe of the WRS (Figure 6). The WRS areas generating seepage flows to each sub-catchment are based on the areas of these buried sub-catchments. Following construction of the WRS however, a portion of the seepage is expected to by-pass the silt ponds and discharge directly to Trimbells Gully and Coal Creek tributary gullies downstream from the silt ponds.

Table 6: Coronation North WRS seepage areas and rates.

Seepage discharge location	WRS infiltration area (ha)	WRS seepage rate (m ³ /day)
Main WRS seepage discharge point	142.4	124.8
Maori Hen Gully	73.7	64.6
Coal Creek 1	3.7	3.2
Coal Creek 2	13.7	12.0
Total	233.5	204.7



The seepage estimates presented in Table 6 do not include seepage flows originating as run-off from the undisturbed catchments upstream from Coronation North WRS. These run-on flows have however been calculated and documented separately in the Mare Burn catchment mitigation report (Golder 2016b).

6.0 CONTAMINANT TRANSPORT

The transport of mining related contaminants within the groundwater has been assessed for the MGP using 3D numerical modelling to evaluate transport rates and breakthrough curves (Golder 2011a, 2011b). For the purposes of this assessment however, the contaminants derived from the opencast pits and the WRS of the Coronation North Project will almost entirely discharge to surface water bodies within the Mare Burn catchment upstream from a proposed environmental water quality monitoring and compliance point at MB02 (Golder 2016a).

Numerical modelling was not undertaken for this project as there is only one affected compliance monitoring point and the time required for the contaminant mass loads discharging to the receiving waters is not a substantial factor with respect to evaluating mitigation options.

The contaminant transport assessment for the Coronation North Project has been undertaken through the allocation of specific water quality characteristics to flows from different sources within the GoldSim catchment water model developed for the Mare Burn catchment (Golder 2016a). The documentation of the water quality allocated to groundwater seepage flows originating from the Coronation WRS is presented in the surface water modelling report and is therefore not replicated here. The contaminant mass loads calculated in the surface water modelling report are based on the groundwater flow rates presented above.

A very small discharge of water from the CS5 into the Deepdell Creek catchment has been calculated (Table 5). This flow rate and the associated contaminant mass load, is too small to be detectable when considering the management of contaminants related to the wider MGP.

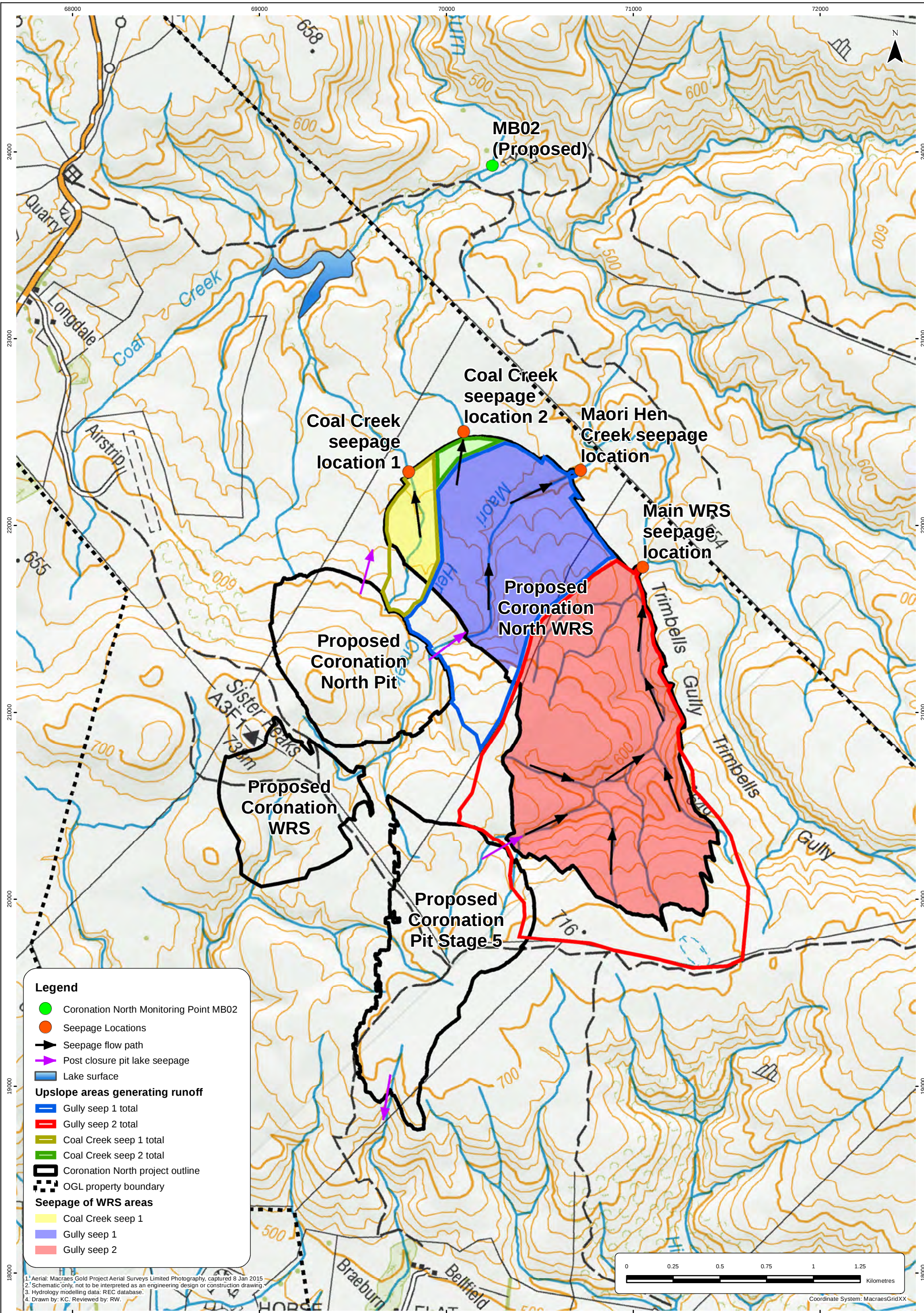
7.0 MONITORING

Groundwater level and quality monitoring is not considered to be necessary for environmental monitoring purposes at the Coronation North Project for the following reasons:

- The pit lakes in CCS5 and Coronation North Pit are projected to require a considerable period to rise to an overflow elevation, or to an elevation where seepage outflows from the pits may be detectable.
- All seepage flows carrying contaminants from the Coronation North WRS are projected to discharge to creek beds within the Mare Burn catchment upstream from MB02. On that basis it is not necessary to track potential groundwater seepage flows that may discharge toward other catchments.
- Most of the groundwater seepage flows carrying contaminants from the Coronation North WRS are projected to be focused along the gullies buried beneath the WRS. It is considered more practical and useful to monitor the flow rates and quality of discharge water at several points around the toe of the WRS than to monitor nearby groundwater levels and quality.

The recommended water quality and flow monitoring summarised below is considered to be sufficient for the purpose of confirming the projected effects of the Coronation North Project on Mare Burn water quality.

Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.





Golder therefore recommends the following monitoring components be incorporated into an environmental monitoring program for the Coronation North Project:

- Continuous WRS seepage discharge flow monitoring between one of the Coronation North WRS silt ponds and the toe of the WRS. The recommended location is at the main discharge point (Figure 6), provided there is sufficient space for installation of an appropriate monitoring system at this site.
- Monthly sampling and water quality analysis of water discharging from the toe of the Coronation North WRS. The parameters for water quality analysis should be consistent with the existing environmental WRS water quality monitoring program at the MGP, with an emphasis on the water quality compliance parameters applied at MB02.
- Monitoring of discharge flows and discharge schedules from the pit sumps to the silt ponds prior to discharge to natural surface water bodies in the Mare Burn catchment, or to irrigation areas outside the pit footprints.
- Monitoring of the quality of water discharged to the environment from the opencast pit dewatering program. The parameters for water quality analysis should be consistent with the existing environmental water quality monitoring program at the MGP, with an emphasis on the water quality compliance parameters applied at MB02.
- Water level monitoring in the CS5 and Coronation North Pit to be initiated at the closure of the dewatering program for each pit.
- Water quality monitoring in each pit lake on a monthly basis. The parameters for water quality analysis should be consistent with the existing environmental water quality monitoring program at the Deepdell South and Golden Bar pit lakes, with an emphasis on the water quality compliance parameters applied at MB02.

8.0 CONCLUSIONS

Groundwater seepage flows related to the construction and operation of the already consented Coronation Pit, CS5 and Coronation North Pit are documented in this report and the calculation methodology presented. These seepage flows have been calculated based on the interpretation of areas of influence for each pit. These areas of influence are at their maximum extent when the pits reach the end of their respective operational lives and subsequently contract as the pit lakes are allowed to develop. Within each area of influence, all rainfall recharging the groundwater system is assumed to discharge to the associated opencast pit. The groundwater inflow rate to each pit is therefore calculated as being equivalent to the total groundwater recharge within the area of influence for that pit.

The groundwater inflow rates to each pit have been calculated for two representative points in the mine life:

- The end of the operation life of the pit
- On reaching the overflow level of the pit lake.

These flows have been interpolated on a linear basis to provide an estimate of seepage flows into the pit lakes at different stages of their development.

As the developing pit lakes approach overflow, small seepage losses through the soils and weathered schist bedrock are expected to develop. These seepage flows are small compared to the inflows to the pit but may affect the rate of pit lake development. The calculated seepage losses from the pit lakes have therefore been combined with the calculated inflows to provide a net seepage rate to each pit. The net seepage rates documented in this report have been applied in the surface water modelling for the pit lake development, which is documented in a separate report (Golder 2016a).



9.0 LIMITATIONS

Your attention is drawn to the document, "Report Limitations", as attached in Appendix G. 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.

10.0 REFERENCES

EGL 2010. Oceana Gold Ltd Macraes Mine Back Road tailings storage facility design report. Report prepared for OceanaGold (New Zealand) Ltd by Engineering Geology Limited.

Forsyth PJ (compiler) 2001. Geology of the Waitaki area. Institute of Geological and Nuclear Sciences 1:250 000 geological map 19.

GCNZ 1988. Macraes Joint Venture. Macraes Gold Mine Project Otago, Environmental Impact Assessment, Volume 2c. Report prepared for BHP Gold Mines (NZ) Limited by Groundwater Consultants New Zealand Limited, August 1988.

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

Golder 2010. 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 2011a. Macraes Phase III Project. Top Tipperary Tailings Storage Facility hydrogeological assessment. Prepared for Oceana Gold (New Zealand) Limited by Golder Associates (NZ) Limited, April 2011.

Golder 2011b. 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 2011c. Macraes Phase III Project. Tailings storage facility drainage rates following closure. Report prepared for Oceana Gold (New Zealand) Ltd by Golder Associates (NZ) Limited, April 2011.

Golder 2011d. Top Tipperary TSF Active Fault Hazard Assessment. Report prepared for OceanaGold (New Zealand) Limited by Golder Associates (NZ) Limited, April 2011.

Golder 2012. Golden Bar pit lake development - initial review. Report produced for Oceana Gold (New Zealand) Ltd by Golder Associates (NZ) Limited, March 2012.

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

Golder 2016b. Coronation North Project. Water quality mitigation – fresh water dam scenario. Report produced for Oceana Gold (New Zealand) Ltd by Golder Associates (NZ) Limited, March 2016. Golder report 1545831-004.

Kingett Mitchell 1999. Deepdell Project area pit geochemistry and water assessment. Report prepared for Gold and Resource Development Ltd by Kingett Mitchell & Associates Limited, October 1999.

Kingett Mitchell 2000. Surface water and groundwater management - Southern Pit tailings. Report prepared for Gold and Resource Development Ltd by Kingett Mitchell & Associates Limited, April 2000.



CORONATION NORTH PROJECT GROUNDWATER ASSESSMENT

Kingett Mitchell 2002a. Geochemistry and water management Golden Bar open pit project. Report prepared for GRD Macraes Limited by Kingett Mitchell Limited, August 2002.

Kingett Mitchell 2002b. Macraes Gold Project tailings capacity expansion: water management and geochemistry technical report. Report prepared for GRD Macraes Limited by Kingett Mitchell Limited, September 2002.

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

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

Kingett Mitchell 2006. Macraes Gold Project. Frasers underground mine groundwater and contaminant transport assessment. Report prepared for OceanaGold (New Zealand) Ltd by Kingett Mitchell Limited, July 2006.

Marinelli F, Niccoli W L 2000. Simple analytical equations for estimating ground water inflow to a mine pit. Ground Water 38 (2) 311-314.

Masset O, Loew S 2010. Hydraulic conductivity distribution in crystalline rocks, derived from inflows to tunnels and galleries in the Central Alps, Switzerland. Hydrogeology Journal 18: 863–891.

URS 2013a. Coronation Project water management – Coronation pit lake assessment. Report prepared for Oceana Gold (New Zealand) Ltd by URS New Zealand Limited. 30 May 2013.

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

URS 2013c. Macraes Coronation Project – Coronation pit lake and groundwater assessment. Report prepared for Oceana Gold (New Zealand) Ltd by URS New Zealand Limited. 27 August 2013.

WWC 1996. Macraes Gold Project expansion – groundwater impact assessment. Report prepared for Macraes Mining Company Limited by Woodward Clyde (NZ) Limited.

WWC 2001. Assessment of Frasers Pit lake water balance and water quality. Report prepared for Macraes Mining Company Limited by Woodward Clyde (NZ) Limited.



APPENDIX A

Resource Consents



1.0 INTRODUCTION

This appendix summarises consents related to groundwater and surface water management at the Coronation North Project. Specifically, the following are provided in this appendix:

- A list of existing consents held by OceanaGold that are relevant to mine water management and water quality management in the Mare Burn catchment (Section 2.0).
- A list of consents sought by OceanaGold, to authorise development of the Coronation North Project, that are relevant to mine water management and water quality management in the Mare Burn catchment (Section 3.0).

The list provided in Section 3.0 is correct at the time of reporting however further consents may have been identified as being necessary by the time the Assessment of Environmental Effects has been completed and the application for consents lodged.

2.0 EXISTING CONSENTS HELD BY OCEANAGOLD

OceanaGold holds the following resource consents relevant to water management associated with the operation and closure of Coronation Pit and Coronation WRS.

- RM12.378.05 To discharge water and contaminants from silt ponds to unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek for the purpose of operating silt ponds associated with the Coronation Pit and the Coronation WRS and for the purpose of disposing of water from the dewatering of Coronation Pit
- RM12.378.07 To take groundwater for the purpose of dewatering Coronation Pit and use for the purpose of dust suppression
- RM12.378.08 To discharge waste rock to land in Coronation Pit for the purpose of disposing of waste rock
- RM12.378.09 To permanently divert water around Coronation Pit and into unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek for the purpose of preventing surface water ingress and managing surface water runoff
- RM12.378.10 To take surface water for the purpose of dewatering Coronation Pit and use for the purpose of dust suppression
- RM12.378.11 To take groundwater for the purpose of creating the Coronation Pit lake.
- RM12.378.12 To take surface water for the purpose of creating the Coronation Pit lake.
- RM12.378.13 To discharge water containing contaminants from the Coronation Pit lake to unnamed tributaries of Maori Hen Creek, Trimbells Gully and the Mare Burn for the purpose of operation of the Coronation Pit lake.
- RM12.378.14 To dam water in Coronation Pit for the purpose of creating the Coronation Pit lake.

In each case the consent expires on 20 October 2048.

Golder understands that the activities authorised by these consents form part of the environmental baseline against which the operational and post-closure effects arising from development of the extension to Coronation Pit are to be assessed.



3.0 CONSENTS SOUGHT BY OCEANAGOLD

OceanaGold is now seeking to obtain resource consents, or vary existing resource consents, to authorise the following activities related to the Coronation North Project:

- a) The discharge of water containing contaminants from the Coronation North Pit lake to unnamed tributaries of Maori Hen Creek, Trimbells Gully and the Mare Burn for the purpose of operation of the Coronation North Pit lake.
- b) To take groundwater for the purpose of creating the Coronation North Pit lake.
- c) To take surface water for the purpose of creating the Coronation North Pit lake.
- d) To dam water in Coronation North Pit for the purpose of creating the Coronation North Pit lake.
- e) The discharge of water containing contaminants from the Coronation North WRS to unnamed tributaries of Maori Hen Creek, Trimbells Gully and the Mare Burn.
- f) The discharge of water containing contaminants from the extended Coronation Pit to unnamed tributaries of Maori Hen Creek, Trimbells Gully and the Mare Burn for the purpose of operation of the Coronation Pit lake.
- g) To take groundwater for the purpose of creating the extended Coronation Pit lake.
- h) To take surface water for the purpose of creating the extended Coronation Pit lake.
- i) To dam water in Coronation Pit for the purpose of creating the extended Coronation Pit lake.
- j) To discharge water and contaminants from silt ponds to unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek for the purpose of operating silt ponds associated with the Coronation Pit, the Coronation North Pit, the Coronation WRS and the Coronation North WRS and for the purpose of disposing of water from the dewatering of Coronation Pit and Coronation North Pit.
- k) To take groundwater for the purpose of dewatering Coronation North Pit and use for the purpose of dust suppression.
- l) To take surface water for the purpose of dewatering Coronation North Pit and use for the purpose of dust suppression.
- m) To discharge waste rock to land in Coronation North Pit for the purpose of disposing of waste rock.
- n) To permanently divert water around Coronation North Pit and into unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek for the purpose of preventing surface water ingress and managing surface water runoff.

j:\projects-dynamics\2015\7410\1545831_oceanagold(nz)\tld_coronationnorthpitwaterassessment\deliverables\002 groundwater report\appendices\1545831-002-appendix a - resource consents.docx



APPENDIX B

Groundwater Level and Gully Invert Data



APPENDIX B

Groundwater Level and Gully Invert Data

OceanaGold undertook a survey of groundwater depths in exploration and resource drillholes during January 2016. The results, which have been used to develop the groundwater table in the Coronation North area, are documented in Table B1.

Table B1: Coronation North groundwater survey data.

Hole ID	East (m)	North (m)	Elevation (mRL)	Depth to water (m)	Groundwater elevation (mRL)
DDW6025	69240.36	21449.61	635.15	11.84	623.31
RCD5678	70350.12	19900.23	696.011	11.04	684.97
RCD5682	70253.24	19795.46	699.768	14.22	685.55
RCD5683	70250.51	19950.06	688.012	19.1	668.91
RCD5684	70251.17	19974.72	685.531	16.67	668.86
RCD5842	69349.72	21352.3	652.478	14.74	637.74
RCD5914	69691.86	21290.45	610.908	11.57	599.34
RCD5945	69310.58	21297.24	666.505	17.91	648.60
RCD5961	70100.72	21141.17	615.767	17.37	598.40
RCD5962	70100.16	21054.85	625.25	30.03	595.22
RCD6039	70103.03	20734.29	649.817	10.44	639.38
RCD6040	70297.05	20952.44	637.692	19.48	618.21
RCD6068	70100.87	20635.97	661.015	6.06	654.96
RCH5007	70224.29	20192.74	665.884	19.1	646.78
RCH5014	70098.8	20394.1	670.847	9.67	661.18
RCH5022	70105.28	20195.73	677.942	26.12	651.82
RCH5220	70050.1	20150.34	683.718	34.75	648.97
RCH5234	68912.92	22500.33	538.747	5.56	533.19
RCH5235	68915.59	22555.19	534.795	5.61	529.19
RCH5236	69015.3	22507.07	529.518	1.92	527.60
RCH5252	68914.21	22353.18	540.416	10.37	530.05
RCH5314	68993.04	22394.08	533	3.8	529.20
RCH5316	69189.27	22201.51	531.29	0.43	530.86
RCH5319	69094.87	22895.52	501.95	4.45	497.50
RCH5320	68997.05	22993.78	518.59	13.24	505.35
RCH5328	69098.5	22594.17	520.34	4.47	515.87
RCH5587	69899.87	20350.43	679.421	28.93	650.49
RCH5596	70049.86	20200.07	681.591	32.36	649.23
RCH5739	70199.26	18394.78	585.066	19.51	565.56
RCH5743	69800.07	20600.13	670.64	16.42	654.22
RCH5747	69398.36	21199.78	689.789	35.39	654.40
RCH5748	69798.24	18899.29	693.114	64.13	628.98
RCH5751	69998.93	18598.8	631.344	33.52	597.82
RCH5752	70096.35	18500.12	607.501	10.18	597.32
RCH5755	69499.93	20800.09	665.998	13.27	652.73
RCH5756	69867.71	20772.29	645.718	10.94	634.78



APPENDIX B

Groundwater Level and Gully Invert Data

Hole ID	East (m)	North (m)	Elevation (mRL)	Depth to water (m)	Groundwater elevation (mRL)
RCH5757	69788.87	20964.28	601.436	13.96	587.48
RCH5759	69798.51	21206.83	599.501	8.66	590.84
RCH5775	69492.97	20995.46	667.12	19.69	647.43
RCH5776	69399.29	21401.17	646.904	11.32	635.58
RCH5826	69691.79	21001.57	623.017	21.49	601.53
RCH5827	69744.92	21100.68	619.577	20.69	598.89
RCH5828	69655.74	21100.01	633.42	14.19	619.23
RCH5829	69547.84	21108.13	656.944	34.71	622.23
RCH5831	69595.04	20793.1	643.557	11.25	632.31
RCH5833	69744.2	20896.98	599.513	4.92	594.59
RCH5844	69391.72	21301.97	659.39	16.86	642.53
RCH5866	69809.53	20801.54	632.092	16.36	615.73
RCH5867	69746.01	20694.9	646.97	17.94	629.03
RCH5868	69699.95	20600.42	654.755	16.9	637.86
RCH5869	69750.83	20501.39	671.847	19.29	652.56
RCH5870	69949.65	20499.92	676.163	18.52	657.64
RCH5871	69849.74	20500.16	677.865	16.04	661.83
RCH5872	69899.88	20600.28	674.313	16.71	657.60
RCH5873	69848.11	20898.23	627.011	18.49	608.52
RCH5874	69855.35	20703.56	655.541	20.33	635.21
RCH5875	69955.52	20696.62	655.644	9.48	646.16
RCH5903	69598.52	21299.41	632.958	24.98	607.98
RCH5916	69697.92	21405.9	611.904	28.45	583.45
RCH5927	69596.55	21405.79	625.017	18.75	606.27
RCH5936	69249.99	21506.15	625.97	14.33	611.64
RCH5939	69240.36	21449.61	635.15	11.85	623.30
RCH5940	69304.85	21448.68	634.803	5.55	629.25
RCH5946	69321.27	21377.3	648.189	16.75	631.44
RCH5950	69743.48	21046.01	615.765	25.44	590.33
RCH5951	69698.3	21051.1	626.602	25.03	601.57
RCH5952	69651.2	21043.77	634.912	26.89	608.02
RCH5953	69702.2	20936.21	613.902	18.54	595.36
RCH5954	69648.96	20946.29	624.504	9.29	615.21
RCH5955	69643.76	21000.67	628.957	11.27	617.69
RCH5959	69724.2	21179.63	617.735	17.23	600.51
RCH5963	70103.54	21245.98	587.934	10.66	577.27
RCH5967	69547.77	21245.84	645.994	27.41	618.58
RCH5969	69288.43	21251.35	687.271	38.58	648.69
RCH5970	69346.55	21204.32	692.964	39.7	653.26
RCH5971	69702.59	21108.9	626.464	25.16	601.30
RCH5973	69744.3	20952.7	594.805	1.22	593.59



APPENDIX B

Groundwater Level and Gully Invert Data

Hole ID	East (m)	North (m)	Elevation (mRL)	Depth to water (m)	Groundwater elevation (mRL)
RCH5974	69787.65	21048.88	600.807	10.64	590.17
RCH5975	69746.13	21003.7	600.004	10	590.00
RCH6011	69477.52	21272.06	654.534	11.65	642.88
RCH6020	69195.52	21546.77	619.685	12.06	607.63
RCH6022	69293.09	21549.62	620.334	6.87	613.46
RCH6027	69605.13	21599.04	598.491	28.36	570.13
RCH6029	69799.43	21396.59	596.969	10.7	586.27
RCH6030	69894.91	21398.85	587.077	20.56	566.52
RCH6032	69143.53	21397.73	642.193	14.74	627.45
RCH6034	69147.74	21448.63	632.597	13.88	618.72
RCH6036	70102.21	20852.63	646.278	14.87	631.41
RCH6038	70004.48	21112.77	616.817	21.72	595.10
RCH6041	70299.97	20856.52	639.535	18.03	621.51
RCH6042	70292.47	20728.39	633.878	3.41	630.47
RCH6052	69153.47	21555.71	616.109	8.5	607.61
RCH6053	69149.4	21548.32	616.489	8.7	607.79
RCH6055	69102.67	21609.06	609.458	5.99	603.47
RCH6059	69098.84	21496.13	623.693	4.49	619.20
RCH6060	69401.98	21796.72	578.526	19.5	559.03
RCH6064	69795.53	20971.95	601.69	14.48	587.21
RCH6066	69854.95	20995.71	602.967	15.19	587.78
RCH6070	69510.04	21995.6	549.005	6.26	542.75
RCH6071	69695.01	21998.67	544.616	3.77	540.85
RCH6074	69997.72	21801.94	554.546	9.64	544.91
RCH6075	70009.4	21599.87	571.024	14.94	556.08
RCH6076	69193.52	21798.18	585.824	8.4	577.42
RCH6077	69290.52	22001.29	554.342	10.43	543.91
RCH6078	69400.38	22199.92	541.415	6.45	534.97
RCH6079	69300	22400	530	5.09	524.91
RCH6080	69499.9	22400.33	528.71	9.31	519.40
RCH6081	69669.82	22399.73	520.179	1.56	518.62
RCH6082	69559.83	22209.54	533.992	3.04	530.95
RCH6087	70242.21	20153.02	669.688	22.65	647.04
RCH6088	70304.68	19950.69	681.045	12.42	668.63
RCH6089	70357.41	20000.36	676.034	12.92	663.11
RCH6092	70325	20100	655	6.11	648.89
RCH6093	70199.51	20147.51	670.042	12.76	657.28
RCH6094	70297.28	20158.71	660.45	13.32	647.13
RCH6095	70294.36	20059.05	669.522	20.21	649.31

Note: Data provided by OceanaGold.



APPENDIX B

Groundwater Level and Gully Invert Data

An initial assessment of the groundwater table across the Coronation North area, based solely on the groundwater survey data presented in Table B1, identified areas where the interpreted groundwater table would be above the ground level. These areas were limited to gullies intersecting the area of interest.

In areas where the gully inverts were at higher elevations than the preliminary groundwater table, it was assumed that groundwater discharges to these gullies would prevent the groundwater table from rising above the gully invert levels. It was therefore also assumed that the groundwater table was intersecting the gully invert in areas where the preliminary groundwater table was above the ground surface at the time of the groundwater survey. On that basis, the gully invert elevations listed in Table B2 were assumed to also represent points on the groundwater table for the purposes of evaluating the groundwater table layout for the Coronation North area.

The piezometric surface documented in the main report has been derived from a combination of the drillhole survey data presented in Table B1 and the gully invert data presented in Table B2.

Table B2: Coronation North gully invert data.

East (m)	North (m)	Gully invert elevation (mRL)
70176.84	20378.18	657.50
70197.85	20370.45	652.50
70215.31	20418.83	655.00
70221.01	20396.39	650.00
70219.40	20380.44	647.50
70224.00	20365.69	645.00
70233.14	20353.03	642.50
70248.22	20344.04	637.50
70267.69	20329.04	630.00
70242.99	20313.23	635.00
70231.51	20299.42	637.50
70207.86	20279.06	642.50
70191.45	20256.28	645.00
70180.76	20241.80	647.50
70177.43	20223.73	650.00
68849.21	22282.55	525.00
68892.22	22267.30	527.50
68937.53	22274.62	530.00
68940.28	22224.42	532.50
69652.52	22428.94	517.50
69627.48	22483.15	515.00
69577.41	22507.04	512.50
69532.73	22552.50	510.00
69497.27	22577.11	507.50
69482.80	22632.50	505.00
69440.85	22674.23	502.50
69375.63	22687.48	500.00



APPENDIX B

Groundwater Level and Gully Invert Data

East (m)	North (m)	Gully invert elevation (mRL)
70176.84	20378.18	657.50
69319.40	22725.64	497.50
69303.74	22766.10	495.00
69282.54	22800.33	492.50
69247.41	22861.50	490.00
69217.39	22805.83	495.00
69207.49	22749.50	500.00
69207.41	22685.24	502.50
69197.60	22618.65	507.50
69182.85	22582.25	510.00
69192.71	22537.94	512.50
69197.64	22493.13	515.00
69180.58	22430.78	520.00
69162.72	22358.27	522.50
69162.44	22300.31	525.00
69177.14	22256.17	527.50
69211.71	22157.57	532.50
69217.84	22123.02	535.00
68942.25	22192.64	535.00
68967.46	22154.68	537.50
68972.56	22115.68	540.00
69187.72	22070.64	540.00
69237.45	22076.71	540.00
69912.42	21064.72	580.00
69927.26	21027.34	582.50
69932.48	20996.31	587.50
69944.61	20961.91	592.50
69962.74	20942.97	597.50
69978.92	20915.41	602.50
69988.88	20898.96	605.00
70000.69	20868.49	610.00
70009.12	20842.88	612.50
70024.87	20801.98	617.50
70027.92	20779.64	620.00
70025.07	20765.97	625.00
70029.04	20743.86	630.00
70026.88	20726.10	635.00
70030.48	20707.78	642.50
70136.29	21407.45	547.50
70090.28	21397.40	550.00



APPENDIX B

Groundwater Level and Gully Invert Data

East (m)	North (m)	Gully invert elevation (mRL)
70176.84	20378.18	657.50
70052.66	21396.83	552.50
70019.90	21379.93	555.00
69989.88	21372.43	557.50
69946.08	21347.60	560.00
69919.37	21327.41	562.50
69897.51	21293.52	565.00
69902.60	21249.36	567.50
69912.52	21199.55	570.00
69907.63	21173.81	572.50
69907.40	21140.83	575.00
69912.57	21092.54	577.50
69868.01	21062.35	580.00
69846.27	21046.55	582.50
69805.75	21015.75	587.50
69762.47	20981.53	590.00
69762.56	20939.45	592.50
69757.50	20909.55	595.00
69757.40	20865.82	597.50
69747.68	20844.25	600.00
69725.21	20817.40	602.50
69712.52	20799.47	605.00
69697.55	20777.41	607.50
69684.95	20744.67	612.50
69678.17	20733.06	615.00
69670.18	20710.29	620.00
69657.45	20676.20	625.00
69652.39	20646.35	630.00
69652.56	20616.23	635.00
69652.49	20593.26	640.00

Note: Data derived from Coronation North topographic surfaces provided by OceanaGold.

j:\projects-dynamics\2015\7410\1545831_oceanagold(nz)\ltd_coronationnorthpitwaterassessment\deliverables\002 groundwater report\appendices\1545831-002-appendix b - groundwater level data.docx



APPENDIX C

Opencast Pit Drawdown Cone Seepage Flow Calculations



1.0 INTRODUCTION

General analytical equations have been developed by Marinelli and Niccoli (2000) for estimating the groundwater seepage flows into an opencast pit that contains a pit lake. Specifically, the equations developed relate to:

- 1) Lateral seepage flows in through the walls of the pit containing a pit lake or at least a sump.
- 2) Upward flows through the floor of the pit.

The conceptual seepage flow model, the assumptions on which it is based, the analytical model and associated seepage flow equations are summarised in the following sections.

2.0 SEEPAGE EQUATION DERIVATION

2.1 Conceptual Model

The conceptual model for seepage flows into an opencast pit is summarised in Figure C1. The image presents a radial cross section of the pit, with the left hand side of the image located at the centre of the pit.

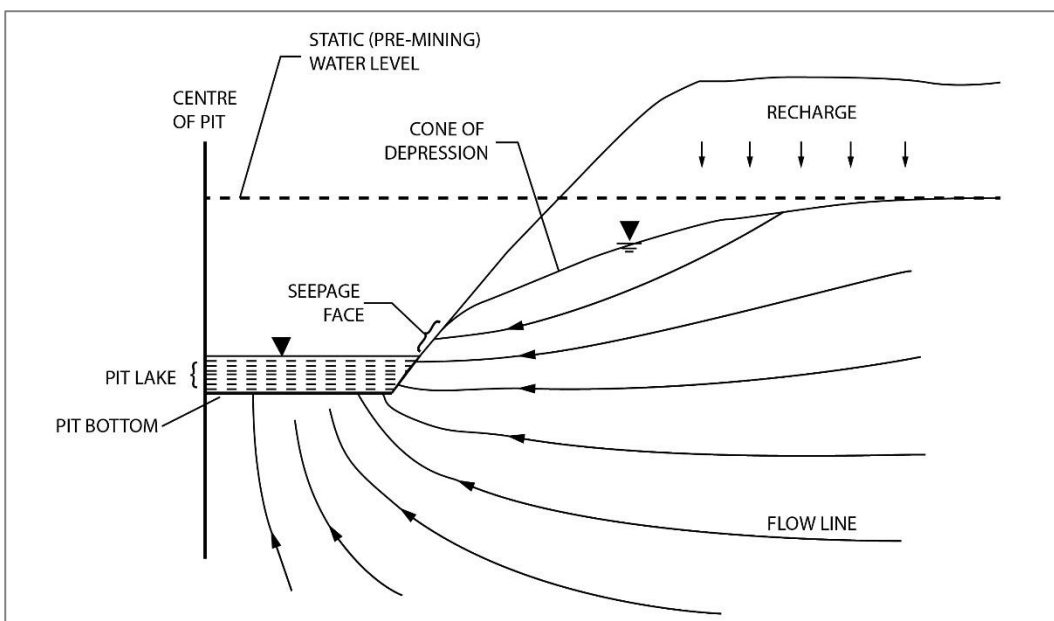


Figure C1: Pit inflow conceptual model.

The applicability of any general analytical solution to a groundwater inflow calculation for an opencast pit depends on the degree to which the assumptions and boundary conditions incorporated in the conceptual and analytical models correspond to the actual hydrogeological conditions in and surrounding the pit. In this case the model incorporates the following assumptions related to the groundwater seepage prior to the start of mining and seepage flows toward the pit at the stage simulated.

- 1) The aquifer around the opencast pit is laterally extensive, to the extent that its limits are far enough from the pit that they do not influence the extent to which the groundwater drawdown generated by the pit can extend.



APPENDIX C

Opencast pit drawdown cone seepage flow calculations

- 2) The aquifer is laterally homogenous and horizontally isotropic, although allowance is made for the vertical hydraulic conductivity of the rock mass to differ from the horizontal hydraulic conductivity.
- 3) The aquifer is not bounded by an impermeable boundary at any known depth beneath the pit and can therefore be considered to be effectively of infinite depth.
- 4) Steady state flow conditions apply at the pit. Applying this assumption means that water drawn out of storage in the rock mass during the dewatering process is not accounted for in this conceptual model.

2.2 Analytical Equations

For the purpose of developing the analytical equations, the conceptual model presented in Figure C1 is separated into two components, represented as Zones 1 and 2 in Figure C2.

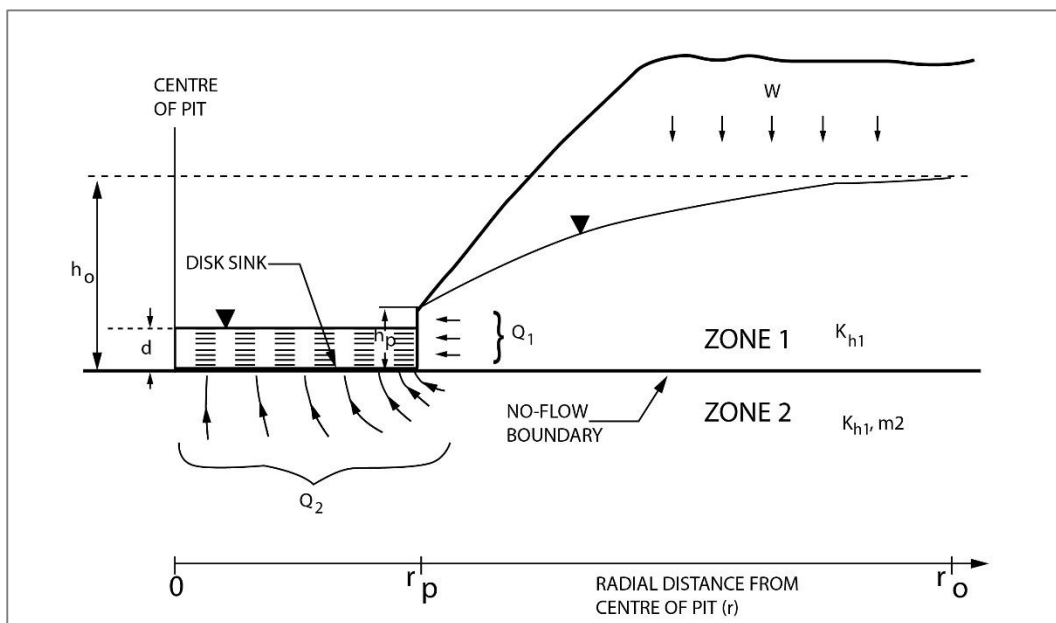


Figure C2: Pit inflow analytical model.

The analytical model incorporates the following additional assumptions regarding the layout of the pit and the flows of groundwater toward the pit.

- 1) The pit walls can be approximated as an upright circular cylinder.
- 2) The static groundwater table prior to the start of mining was approximately horizontal.
- 3) Groundwater flow toward the pit in Zone 1 is horizontal.
- 4) Uniform distributed recharge occurs across the site as a result of rainfall infiltration.
- 5) All recharge within the radius of the drawdown cone generated by the pit is captured by the pit.
- 6) Groundwater flow toward the pit is axially symmetric.



APPENDIX C

Opencast pit drawdown cone seepage flow calculations

Taking into account the above assumptions, the groundwater flow within Zone 1 can be numerically approximated by equations 1 and 2, below. The groundwater flow within Zone 2 can be numerically approximated by equations 3 and 4, below. The derivation for these equations is provided in the paper by Marinelli and Niccoli (2000).

$$\text{Equation 1} \quad h_0 = \sqrt{h_p^2 + \frac{W}{K_{h1}} \left[r_0^2 \ln \left(\frac{r_0}{r_p} \right) - \frac{(r_0^2 - r_p^2)}{2} \right]}$$

$$\text{Equation 2} \quad Q_1 = W\pi(r_0^2 - r_p^2)$$

$$\text{Equation 3} \quad Q_2 = 4r_p \left(\frac{K_{h2}}{m_2} \right) (h_0 - d)$$

$$\text{Equation 4} \quad m_2 = \sqrt{\frac{K_{h2}}{K_{v2}}}$$

Where:

W	=	Recharge flux (m/s)
K_{h1}	=	Horizontal hydraulic conductivity in Zone 1 (m/s)
K_{h2}	=	Horizontal hydraulic conductivity in Zone 2 (m/s)
K_{v2}	=	Vertical hydraulic conductivity in Zone 2 (m/s)
h_0	=	Initial saturated thickness above the base of Zone 1 (m)
h_p	=	Saturated thickness at the pit wall (m)
r_p	=	Effective pit radius (m)
r_0	=	Radius of drawdown cone of the pit (m)
d	=	Depth of the pit lake (m)

2.3 Analytical Process

Most of the parameters listed in Section 2.2 can be derived from investigations at the site prior to the start of mining or approximated from the pit design. The main parameter that cannot be directly determined or estimated in advance from field investigations is the drawdown cone radius generated by the pit (r_0). As the groundwater flows are effectively calculated directly from the area of the drawdown cone around the pit multiplied by the recharge rate, the radius of the drawdown cone is the critical factor needing to be determined.

Equation 1 cannot simply be rearranged to provide a calculated value for r_0 . Consequently the value for r_0 is derived through iteratively solving Equation 1 with different values for r_0 applied until the result for h_0 approximately equals the measured thickness of saturated rock above the planned base of the pit. Once a value for r_0 has been derived, Equation 2 can be solved directly. Equations 3 and 4, which relate to seepage flows through Zone 2 can both be solved directly provided the appropriate field data is available, or has been otherwise calculated.



3.0 MACRAES GOLD PROJECT PIT INFLOW CALCULATIONS

3.1 Coronation Pit - Consented

The above equations have been applied to the layout for the currently consented Coronation Pit as a check to the seepage flow calculations based on reasonable catchments documented in the main body of the report. Seepage inflow calculations have been made for two stages of the pit development:

- 1) The pit at its maximum extent and depth, with the water level maintained at a low level in the sump by pumping. Input parameters for the calculation for this scenario are presented in Table C1.
- 2) The pit at its maximum extent and depth, with the water level in the pit lake equal to the lowest point on the pit rim, implying the pit lake would be overflowing at this stage. Input parameters for the calculation for this scenario are presented in Table C2.

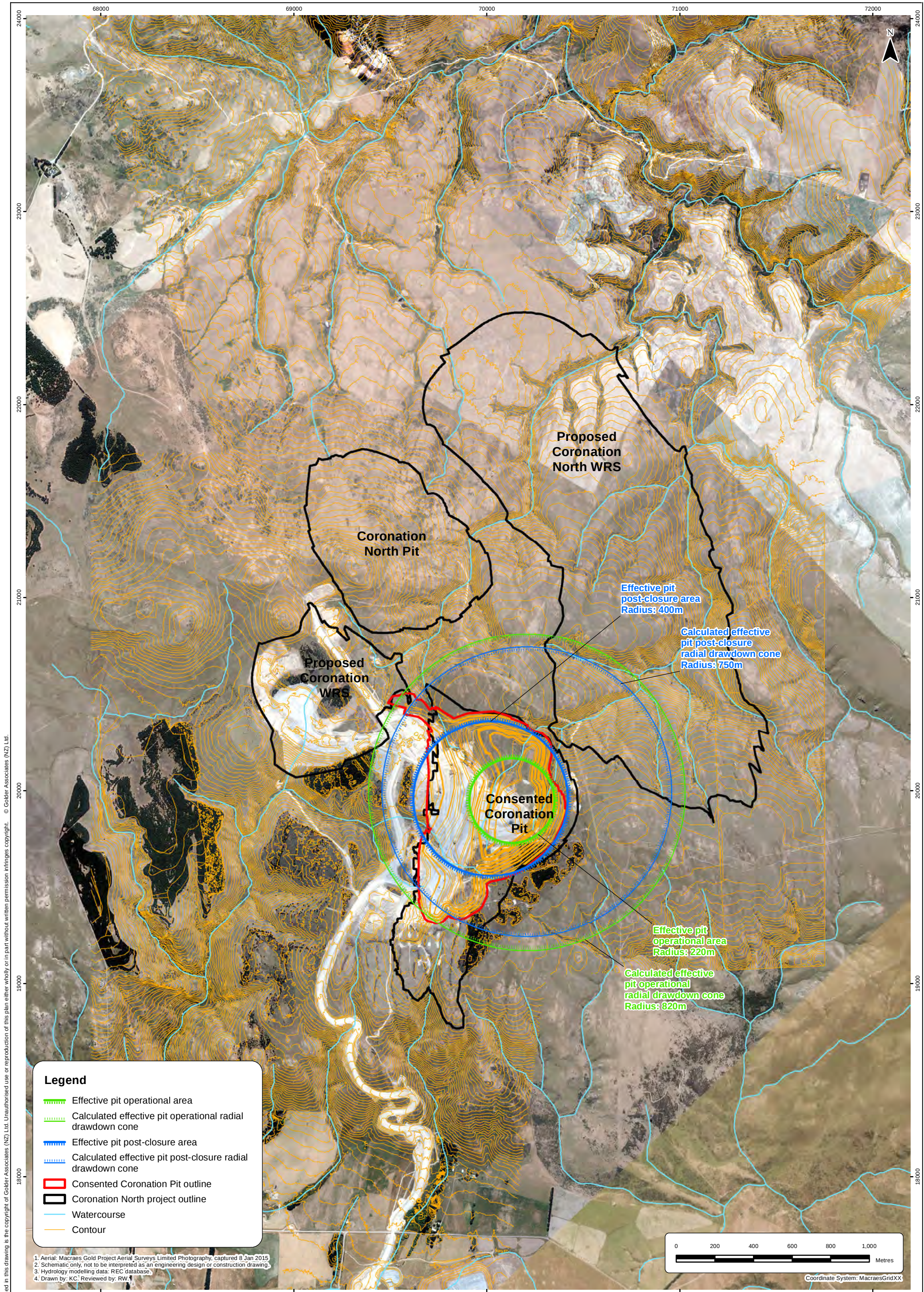
The results from applying the analytical equations to these two stages in the projected life of Coronation Pit are summarised in 4.0. The effective pit radius and the calculated pit drawdown cone radius for both of the above scenarios are presented in Figure C3. Limitations to be considered in the use and interpretation of these results are presented in Section 5.0 of this Appendix.

Table C1: Seepage calculation input parameters for Coronation Pit at closure.

Parameter	Units	Value	Notes
W	m/s	1×10^{-9}	Based on a recharge of 32 mm/year (Golder 2010a)
K _{h1}	m/s	1×10^{-8}	Based on K _h for slightly weathered schist (Golder 2010a)
K _{h2}	m/s	3×10^{-9}	Based on K _h for unweathered schist (Golder 2010a)
K _{v2}	m/s	5×10^{-10}	Based on K _v for unweathered schist (Golder 2010a)
h ₀	m	130	Height from pre-mining groundwater table at 690 mRL to base of proposed pit at 560 mRL.
h _p	m	2.0	Estimate from observations at other MGP pits – matches depth of water in pit sump.
r _p	m	220	Estimated from pit layout design
d	m	2.0	Assumed depth of water in pit sump.

Table C2: Seepage calculation input parameters for Coronation Pit with pit lake at overflow.

Parameter	Units	Value	Notes
W	m/s	1×10^{-9}	Based on a recharge of 32 mm/year (Golder 2010a)
K _{h1}	m/s	1×10^{-8}	Based on K _h for slightly weathered schist (Golder 2010a)
K _{h2}	m/s	3×10^{-9}	Based on K _h for unweathered schist (Golder 2010a)
K _{v2}	m/s	5×10^{-10}	Based on K _v for unweathered schist (Golder 2010a)
h ₀	m	130	Height from pre-mining groundwater table at 690 mRL to base of proposed pit at 560 mRL.
h _p	m	80	Assumed to be the same as the depth of the pit lake.
r _p	m	400	Estimated from pit layout design
d	m	80	Height from base of proposed pit at 560 mRL to overflow elevation of 640 mRL.



Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.

1. Aerial: Macraes Gold Project Aerial Surveys Limited Photography, captured 8 Jan 2015
2. Schematic only, not to be interpreted as an engineering design or construction drawing.
3. Hydrology modelling data: REC database.
4. Drawn by: KC. Reviewed by: RW.



TITLE | CORONATION PIT CALCULATED DRAWDOWN CONE LAYOUTS

PROJECT | MAY 2016
1545831 | C3



3.2 Coronation Pit - Stage 5

The above equations have been applied to the layout for the proposed Coronation Stage 5 Pit as a check to the seepage flow calculations based on reasonable catchments documented in the main body of the report. Seepage inflow calculations have been made for two stages of the pit development:

- 1) The pit at its maximum extent and depth, with the water level maintained at a low level in the sump by pumping. Input parameters for the calculation for this scenario are presented in Table C3.
- 2) The pit at its maximum extent and depth, with the water level in the pit lake equal to the lowest point on the pit rim, implying the pit lake would be overflowing at this stage. The effective pit radius and the calculated pit drawdown cone radius for both of the above scenarios are presented in Figure C4. Input parameters for the calculation for this scenario are presented in Table C4.

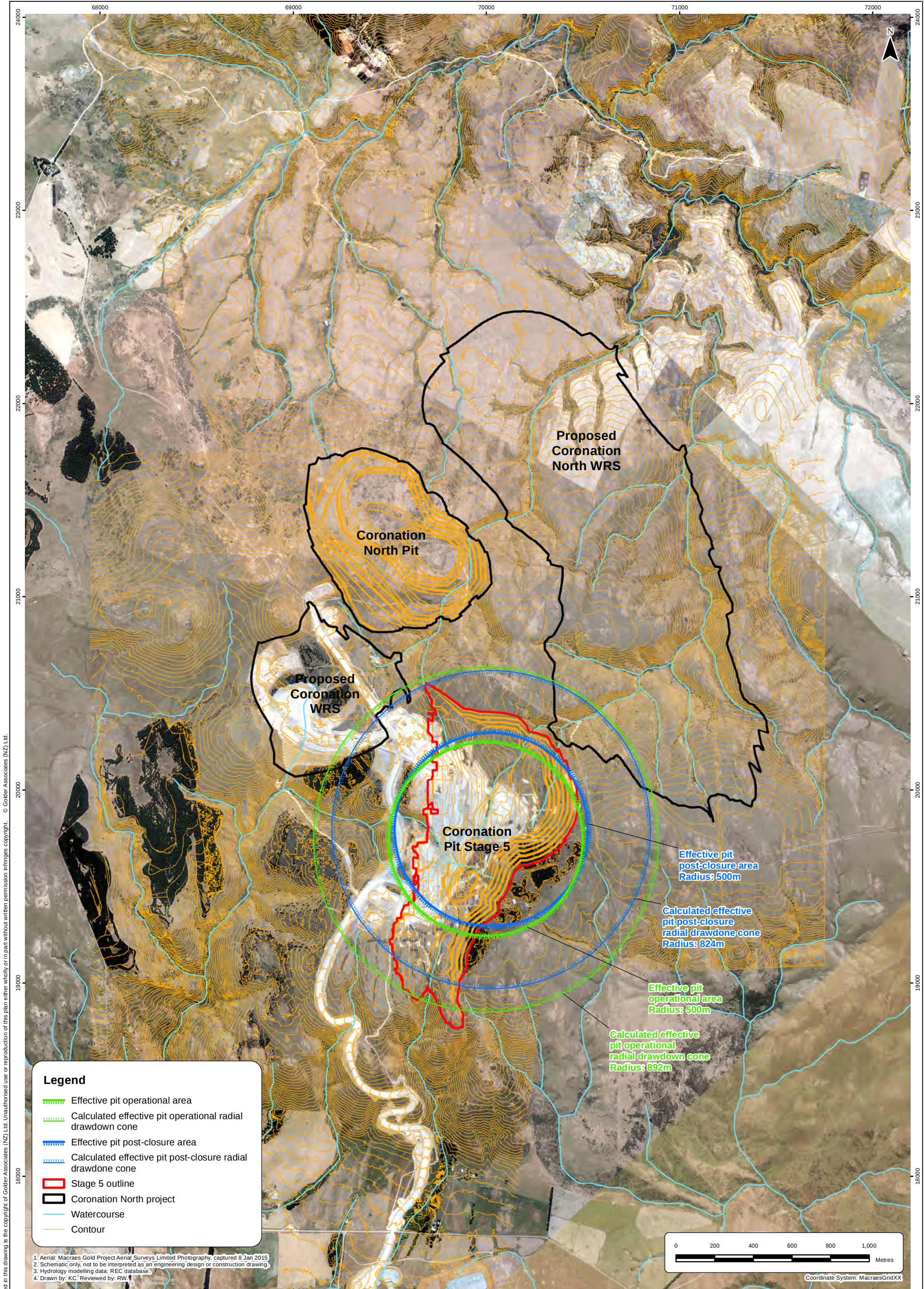
The results from applying the analytical equations to these two stages in the projected life of Coronation Pit Stage 5 are summarised in Section 4.0. Limitations to be considered in the use and interpretation of these results are presented in Section 5.0 of this Appendix.

Table C3: Seepage calculation input parameters for Coronation Pit Stage 5 at closure.

Parameter	Units	Value	Notes
W	m/s	1×10^{-9}	Based on a recharge of 32 mm/year (Golder 2010a)
K_{h1}	m/s	1×10^{-8}	Based on K_h for slightly weathered schist (Golder 2010a)
K_{h2}	m/s	3×10^{-9}	Based on K_h for unweathered schist (Golder 2010a)
K_{v2}	m/s	5×10^{-10}	Based on K_v for unweathered schist (Golder 2010a)
h_0	m	138	Height from pre-mining groundwater table at 690 mRL to base of proposed pit at 552 mRL.
h_p	m	2.0	Estimate from observations at other MGP pits – matches depth of water in pit sump.
r_p	m	500	Estimated from pit layout design
d	m	2.0	Assumed depth of water in pit sump.

Table C4: Seepage calculation input parameters for Coronation Pit Stage 5 with pit lake at overflow.

Parameter	Units	Value	Notes
W	m/s	1×10^{-9}	Based on a recharge of 32 mm/year (Golder 2010a)
K_{h1}	m/s	1×10^{-8}	Based on K_h for slightly weathered schist (Golder 2010a)
K_{h2}	m/s	3×10^{-9}	Based on K_h for unweathered schist (Golder 2010a)
K_{v2}	m/s	5×10^{-10}	Based on K_v for unweathered schist (Golder 2010a)
h_0	m	138	Height from pre-mining groundwater table at 690 mRL to base of proposed pit at 552 mRL.
h_p	m	80	Assumed to be the same as the depth of the pit lake.
r_p	m	500	Estimated from pit layout design
d	m	80	Height from base of proposed pit at 552 mRL to overflow elevation of 632 mRL.



Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.

Legend

Effective pit operational area

Calculated effective pit operational radial drawdown cone

Effective pit post-closure area

Calculated effective pit post-closure radial drawdown cone

Stage 5 outline

Coronation North project

Watercourse

Contour

1. Aerial: Macraes Gold Project Aerial Surveys Limited Photography, captured 8 Jan 2015
2. Schematic only, not to be interpreted as an engineering design or construction drawing.
3. Hydrology modelling data: REC database.
4. Drawn by: KC. Reviewed by: RW.



Coordinate System: MacraesGridXX





3.3 Coronation North Pit

The above equations have been applied to the layout for the proposed Coronation North Pit as a check to the seepage flow calculations based on reasonable catchments documented in the main body of the report. Seepage inflow calculations have been made for two stages of the pit development:

- 1) The pit at its maximum extent and depth, with the water level maintained at a low level in the sump by pumping. Input parameters for the calculation for this scenario are presented in Table C5.
- 2) The pit at its maximum extent and depth, with the water level in the pit lake equal to the lowest point on the pit rim, implying the pit lake would be overflowing at this stage. The effective pit radius and the calculated pit drawdown cone radius for both of the above scenarios are presented in Figure C5. Input parameters for the calculation for this scenario are presented in Table C6.

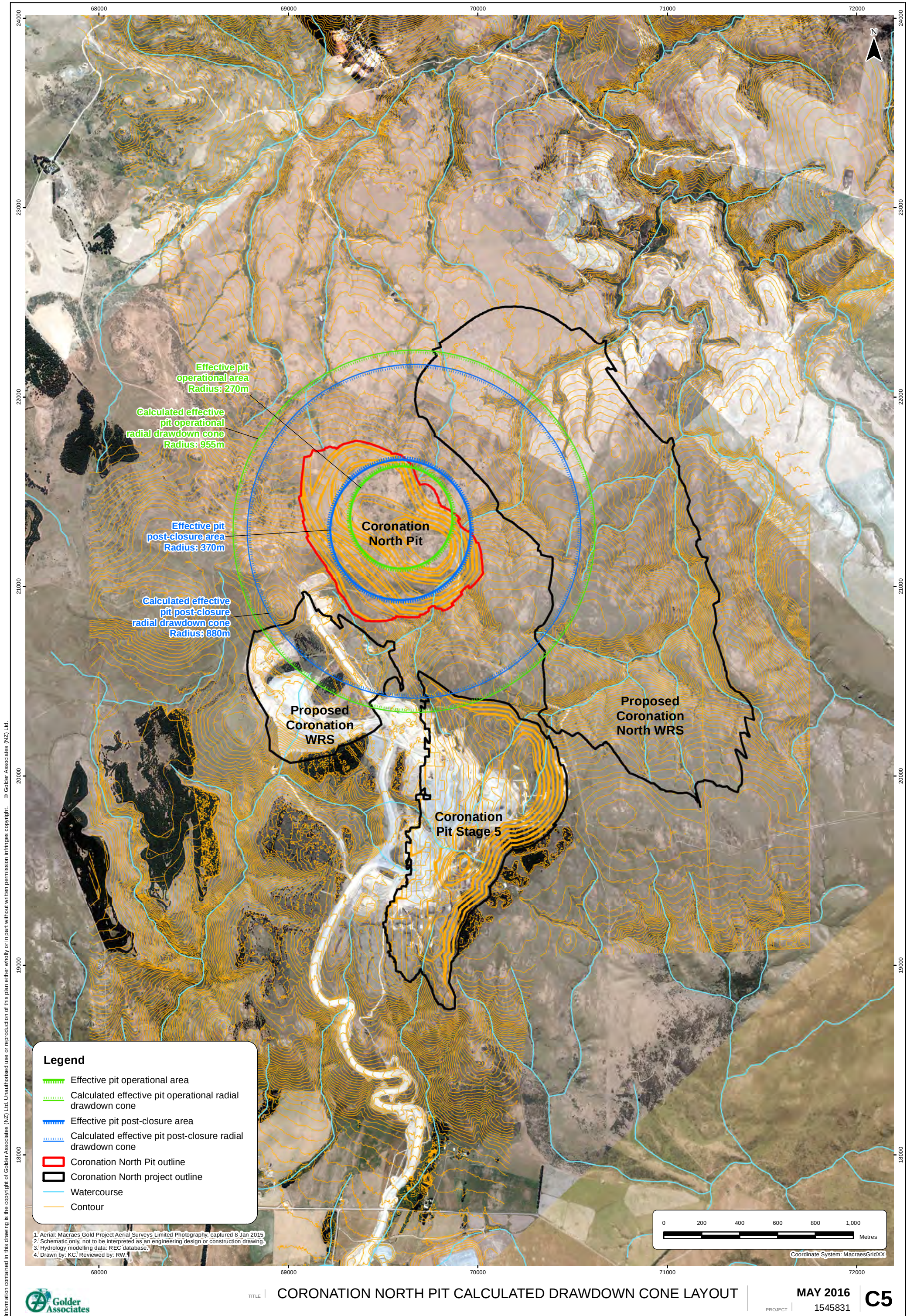
The results from applying the analytical equations to these two stages in the projected life of Coronation Pit Stage 5 are summarised in Section 4.0. Limitations to be considered in the use and interpretation of these results are presented in Section 5.0 of this Appendix.

Table C5: Seepage calculation input parameters for Coronation North Pit at closure.

Parameter	Units	Value	Notes
W	m/s	1×10^{-9}	Based on a recharge of 32 mm/year (Golder 2010a)
K_{h1}	m/s	1×10^{-8}	Based on K_h for slightly weathered schist (Golder 2010a)
K_{h2}	m/s	3×10^{-9}	Based on K_h for unweathered schist (Golder 2010a)
K_{v2}	m/s	5×10^{-10}	Based on K_v for unweathered schist (Golder 2010a)
h_0	m	165	Height from pre-mining groundwater table at 640 mRL to base of proposed pit at 465 mRL.
h_p	m	2.0	Estimate from observations at other MGP pits – matches depth of water in pit sump.
r_p	m	500	Estimated from pit layout design
d	m	2.0	Assumed depth of water in pit sump.

Table C6: Seepage calculation input parameters for Coronation North Pit with pit lake at overflow.

Parameter	Units	Value	Notes
W	m/s	1×10^{-9}	Based on a recharge of 32 mm/year (Golder 2010a)
K_{h1}	m/s	1×10^{-8}	Based on K_h for slightly weathered schist (Golder 2010a)
K_{h2}	m/s	3×10^{-9}	Based on K_h for unweathered schist (Golder 2010a)
K_{v2}	m/s	5×10^{-10}	Based on K_v for unweathered schist (Golder 2010a)
h_0	m	165	Height from pre-mining groundwater table at 640 mRL to base of proposed pit at 465 mRL.
h_p	m	113	Assumed to be the same as the depth of the pit lake.
r_p	m	370	Estimated from pit layout design
d	m	113	Height from base of proposed pit at 465 mRL to overflow elevation of 578 mRL.



Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.



4.0 INFLOW CALCULATION RESULTS

The results for the opencast pit inflow calculations described in the previous sections of this appendix are summarised below. Specifically:

- The calculated inflows and drawdown cone radius for the consented Coronation Pit are summarised in Table C7.
- The calculated inflows and drawdown cone radius for Coronation Pit Stage 5 are summarised in Table C8.
- The calculated inflows and drawdown cone radius for Coronation North Pit are summarised in Table C9.

Table C7: Coronation Pit inflow calculation results.

Coronation Pit stage	Drawdown cone radius (m)	Inflow seepage rate – Zone 1 (m ³ /day)	Inflow seepage rate – Zone 2 (m ³ /day)	Inflow seepage rate – total (m ³ /day)
At closure	566	75	12	87
Pit lake at overflow	693 ⁽¹⁾	88	9	97

Note: 1) The increased drawdown cone radius for pit lake at overflow is unlikely to be realistic. This radius result derives primarily from the larger effective radius of the pit applied to the calculation when lake is at overflow level compared to when water level maintained by pumping from sump.

Table C8: Coronation Pit Stage 5 inflow calculation results.

Coronation Pit stage	Drawdown cone radius (m)	Inflow seepage rate – Zone 1 (m ³ /day)	Inflow seepage rate – Zone 2 (m ³ /day)	Inflow seepage rate – total (m ³ /day)
At closure	892	150	29	179
Pit lake at overflow	824	118	12	130

Table C9: Coronation North Pit inflow calculation results.

Coronation Pit stage	Drawdown cone radius (m)	Inflow seepage rate – Zone 1 (m ³ /day)	Inflow seepage rate – Zone 2 (m ³ /day)	Inflow seepage rate – total (m ³ /day)
At closure	731	127	19	146
Pit lake at overflow	707	100	8	108



APPENDIX C

Opencast pit drawdown cone seepage flow calculations

5.0 LIMITATIONS

It is important to recognise that the calculations presented in this Appendix represent an initial assessment of potential groundwater inflows to the pit lakes only. These calculations take no account of the topography in the Coronation area of the MGP. The presence of deep gullies close to Coronation Pit and Coronation North Pit influences the pre-mining groundwater gradients across the site. These gullies also limit the extent of potential mining induced groundwater drawdown around each pit. For this reason the results from these calculations should be considered as order of magnitude indications only.

In addition, the calculations presented in Section 3.0 only take into account groundwater inflows to each pit. Potential seepage outflows from the pits through the weathered schist as the water level in the pit lakes approaches the overflow level have not been incorporated in these calculations.

j:\projects-dynamics\2015\7410\1545831_oceanagold(nz)\ltd_coronationnorthpitwaterassessment\deliverables\002 groundwater report\appendices\1545831-002-appendix c - pit lake analytical seepage calculations.docx



APPENDIX D

Opencast Pit Area of Influence Seepage Calculations



APPENDIX D

Opencast pit area of influence seepage calculations

The area of influence assessments on which the groundwater inflows to the opencast pits of the Coronation North Project have been based are summarised in this appendix. The groundwater inflow calculations for the already consented Coronation Pit summarised in Table D1 are based on the area of influence layouts presented in Figure D1. The groundwater inflow calculations for the CS5 summarised in Table D2 are based on the area of influence layouts presented in Figure D2. The groundwater inflow calculations for the Coronation North Pit summarised in Table D3 are based on the area of influence layouts presented in Figure D3.

Table D1: Area of influence seepage inflows calculated for Coronation Pit.

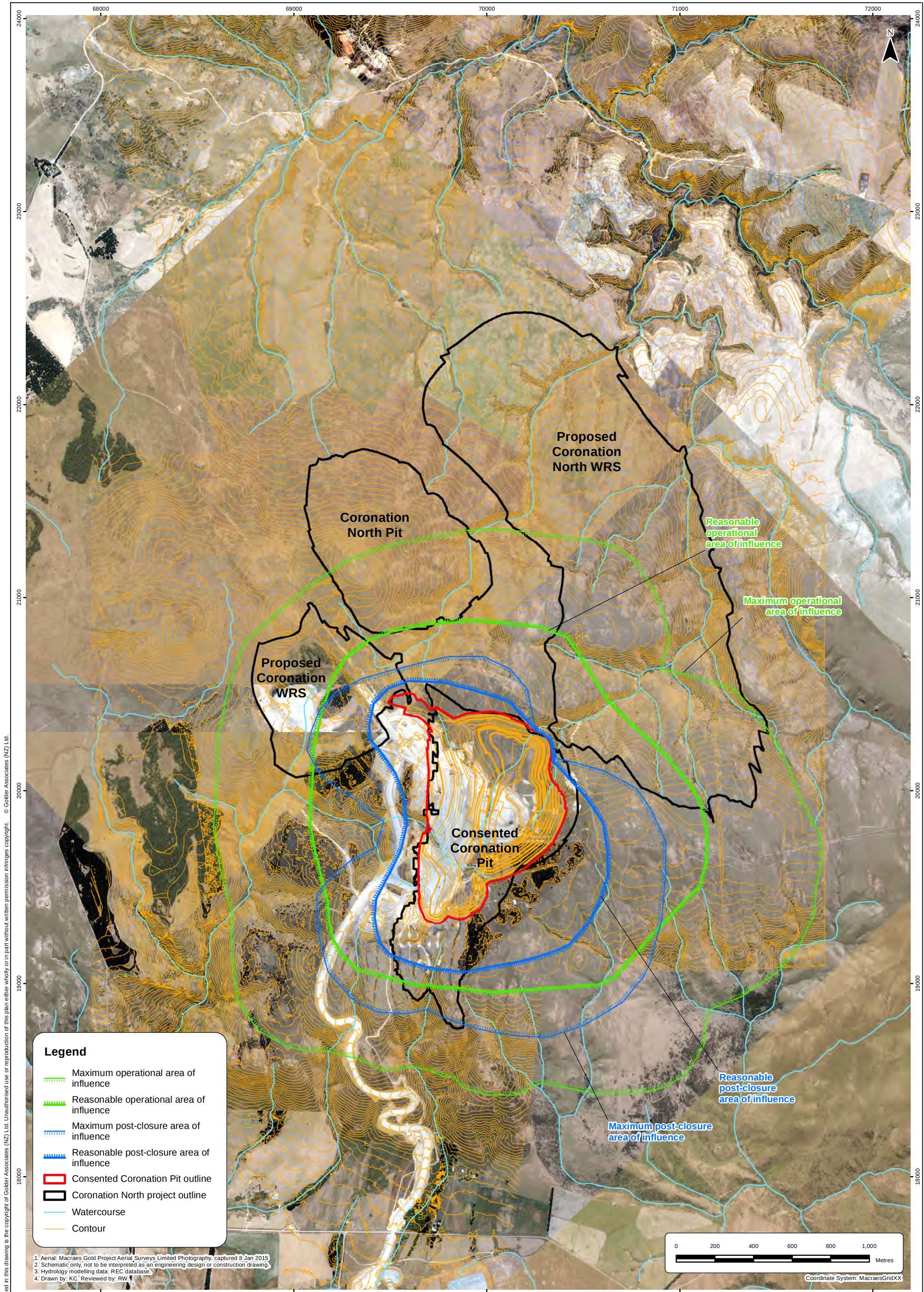
Parameters	Units	Operational period		Post-closure period	
		Maximum catchment	Reasonable catchment	Maximum catchment	Reasonable catchment
Full catchment	m ²	7,188,000	3,113,000	2,689,000	1,379,000
Pit floor / lake area	m ²	24,000	24,000	298,000	298,000
Area of influence	ha	716	309	239	108
Recharge	m/year	0.032	0.032	0.032	0.032
	m/day	8.8 x 10 ⁻⁵	8.8 x 10 ⁻⁵	8.8 x 10 ⁻⁵	8.8 x 10 ⁻⁵
Seepage inflow	m ³ /day	628	271	210	95
	L/s	7.3	3.1	2.4	1.1

Table D2: Area of influence seepage inflows calculated for Coronation Pit Stage 5.

Parameters	Units	Operational period		Post-closure period	
		Maximum catchment	Reasonable catchment	Maximum catchment	Reasonable catchment
Full catchment	m ²	7,421,000	3,436,000	2,940,000	1,722,000
Pit floor / lake area	m ²	29,000	29,000	458,000	458,000
Area of influence	ha	739	341	248	126
Recharge	m/year	0.032	0.032	0.032	0.032
	m/day	8.8 x 10 ⁻⁵	8.8 x 10 ⁻⁵	8.8 x 10 ⁻⁵	8.8 x 10 ⁻⁵
Seepage inflow	m ³ /day	648	299	218	111
	L/s	7.5	3.5	2.5	1.3

Table D3: Area of influence seepage inflows calculated for Coronation North Pit.

Parameters	Units	Operational period		Post-closure period	
		Maximum catchment	Reasonable catchment	Maximum catchment	Reasonable catchment
Full catchment	m ²	7,818,000	3,635,000	1,726,000	1,530,000
Pit floor / lake area	m ²	29,000	29,000	458,000	458,000
Area of influence	ha	779	361	127	107
Recharge	m/year	0.032	0.032	0.032	0.032
	m/day	8.8 x 10 ⁻⁵	8.8 x 10 ⁻⁵	8.8 x 10 ⁻⁵	8.8 x 10 ⁻⁵
Seepage inflow	m ³ /day	683	316	111	94
	L/s	7.9	3.7	1.3	1.1



Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.

Legend

Maximum operational area of influence

Reasonable operational area of influence

Maximum post-closure area of influence

Reasonable post-closure area of influence

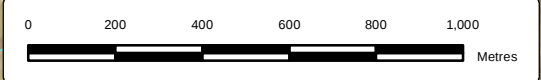
Consented Coronation Pit outline

Coronation North project outline

Watercourse

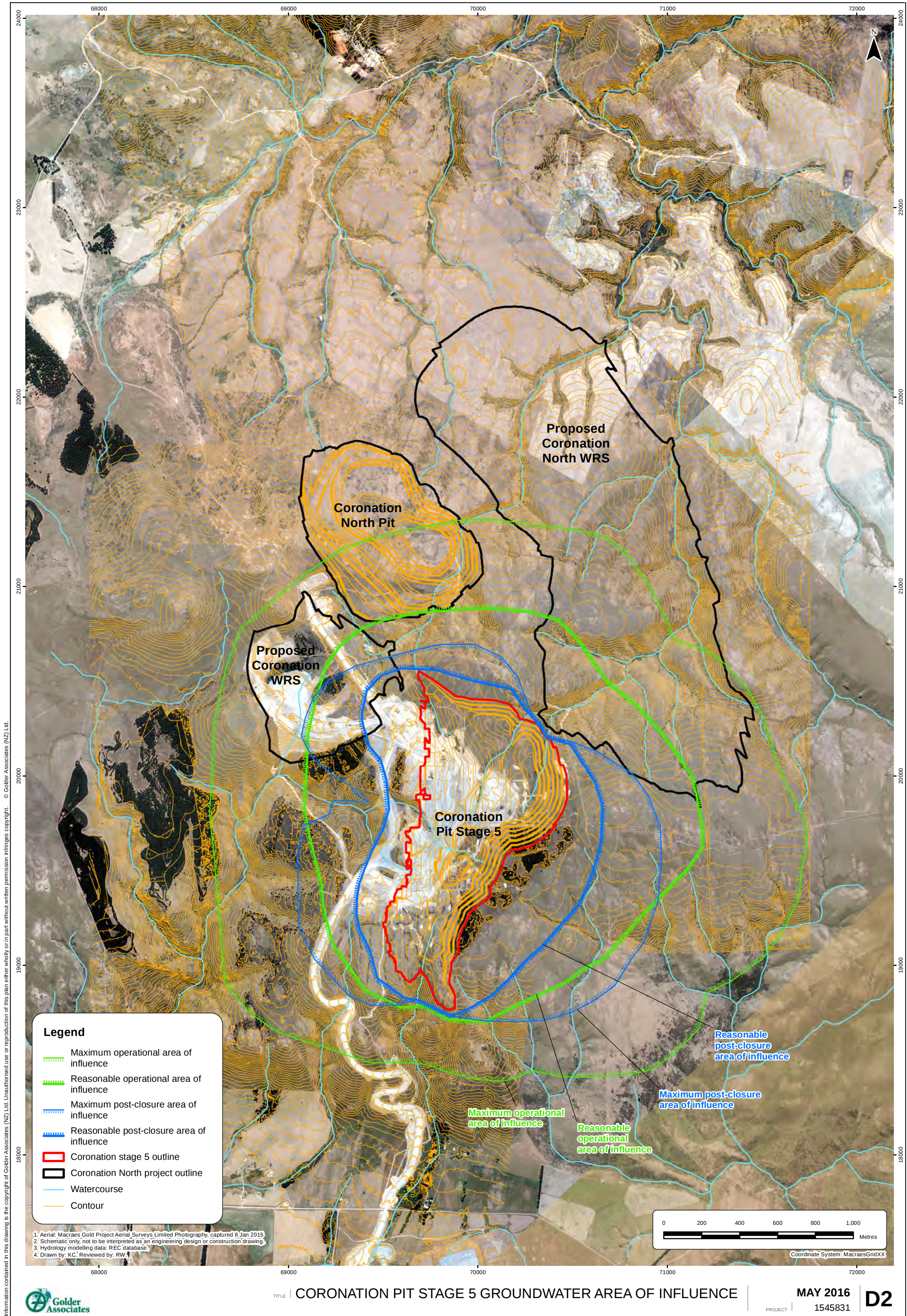
Contour

1. Aerial: Macraes Gold Project Aerial Surveys Limited Photography, captured 8 Jan 2015
2. Schematic only, not to be interpreted as an engineering design or construction drawing.
3. Hydrology modelling data: REC database.
4. Drawn by: KC. Reviewed by: RW.



Coordinate System: MacraesGridXX





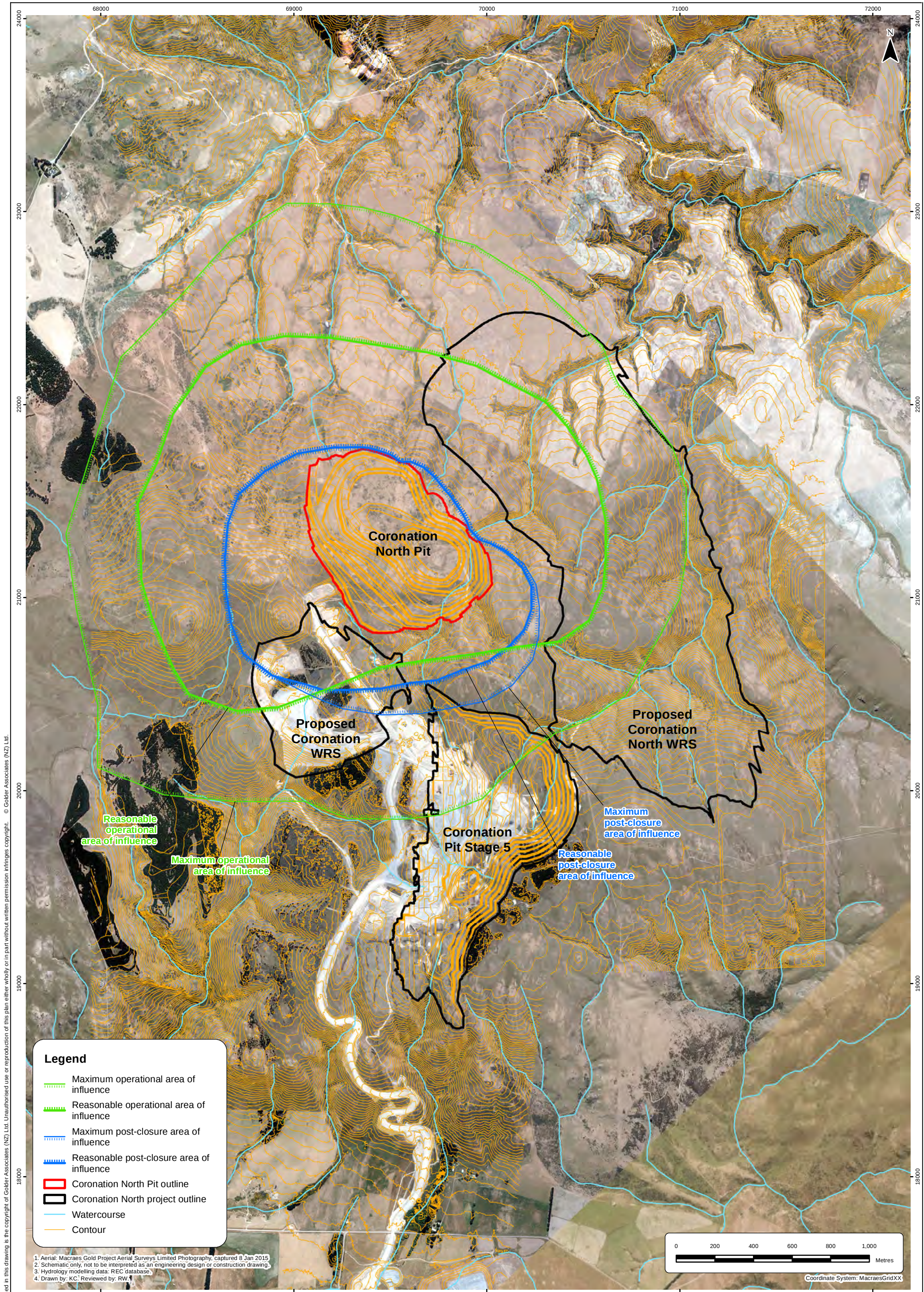
Legend

- Maximum operational area of influence
- Reasonable operational area of influence
- Maximum post-closure area of influence
- Reasonable post-closure area of influence
- Coronation stage 5 outline
- Coronation North project outline
- Watercourse
- Contour

1. Aerial: Macraes Gold Project Aerial Surveys Limited Photography, captured 8 Jan 2015
2. Schematic only, not to be interpreted as an engineering design or construction drawing.
3. Hydrology modelling data: REC database.
4. Drawn by: KC. Reviewed by: RW.



Coordinate System: MacraesGridXX



Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.



TITLE

CORONATION NORTH PIT GROUNDWATER AREA OF INFLUENCE

PROJECT | MAY 2016
1545831

D3



APPENDIX E

Opencast Pit Lake Seepage Loss Calculations



1.0 INTRODUCTION

As the surface of the pit lake rises toward overflow in each of the three pits under consideration in this assessment, the opportunity for seepage losses from the lake to down-gradient gullies increases. These seepage losses slow the rate of water level rise in the pit lake and increase the potential time the pit lake requires to reach overflow.

Estimates have been calculated for seepage losses from the pit lake to down-gradient gullies using the Darcy formula. These estimates take into account the geometry of the pit rim in the area of the overflow point and, in the case of the Coronation Pit Stage 5, an additional low point on the pit rim toward the Deepdell Creek catchment.

The general calculation methodology is presented in Section 2.0 of this Appendix. The results of the seepage calculations for the consented Coronation Pit, Coronation Pit Stage 5 and Coronation North Pit are presented in Section 3.0 of this appendix.

The rock mass in the area of the projected outflow seepages has not been investigated in detail through drilling and hydraulic testing of the in-situ rock. Even with such investigations and with detailed 3D modelling of each seepage flow path, there would remain a degree of uncertainty regarding the calculated seepage rates. These detailed investigations have not been undertaken because the outflow seepage rates from the pit lakes are not a major factor in the overall outcomes of the catchment assessment for the Coronation North Project.

Overall, the calculated outflows from the lakes are relatively small compared to the inflows to the lakes. These seepage flows mostly discharge directly to the down-gradient gullies that will also be carrying the overflow water. For these reasons, uncertainty regarding the seepage flows primarily affects the calculation of the rate of late stage lake level rise and late stage lake filling times. The water quality projections for the Coronation North Project documented in a separate report (Golder 2016a) are not significantly affected by uncertainty in the pit lake outflow seepage rates.

2.0 CALCULATION METHODOLOGY

The calculation applied in estimating seepage flows from the pit lakes to down-gradient gullies is based on the use of the Darcy equation.

$$Q = kA \frac{dH}{dL}$$

Where:

- Q = Seepage flow in m³/s.
- k = Hydraulic conductivity of the rock mass through which the seepage is flowing in m³/s.
- A = Cross sectional area of the rock mass through which the seepage is flowing in m².
- dH = Difference in elevation between the pit lake surface and the down-gradient discharge point in m.
- dL = Distance between the pit lake and the downstream discharge point in m.

The hydraulic conductivity of the rock mass is based on the regional hydraulic conductivity values applied in previous modelling of the groundwater system at the MGP (Golder 2010a). For the first 10 m below the ground surface the rock mass is considered to be highly weathered and a hydraulic conductivity (k) of 3.5×10^{-7} m/s has been applied in the calculation. Below that depth the rock mass is considered to be



APPENDIX E

Opencast pit lake seepage loss calculations

moderately weathered and a hydraulic conductivity of 3.5×10^{-7} m/s has been applied. As the seepage paths out of the lakes pass through both highly and moderately weathered rock mass zones, some judgement has been used in defining the appropriate hydraulic conductivity to be applied in each step of the calculation.

3.0 PIT LAKE SEEPAGE OUTFLOWS

The seepage loss calculations for each of the opencast pits in the Coronation North Project have been based on the flow paths presented in this appendix. Specifically:

- The seepage loss flow paths for the already consented Coronation Pit are presented in plan view in Figure E1.
- The seepage loss flow paths for Coronation Pit Stage 5 are presented in plan view in Figure E2.
- The seepage loss flow paths for Coronation North Pit are presented in plan view in Figure E3.

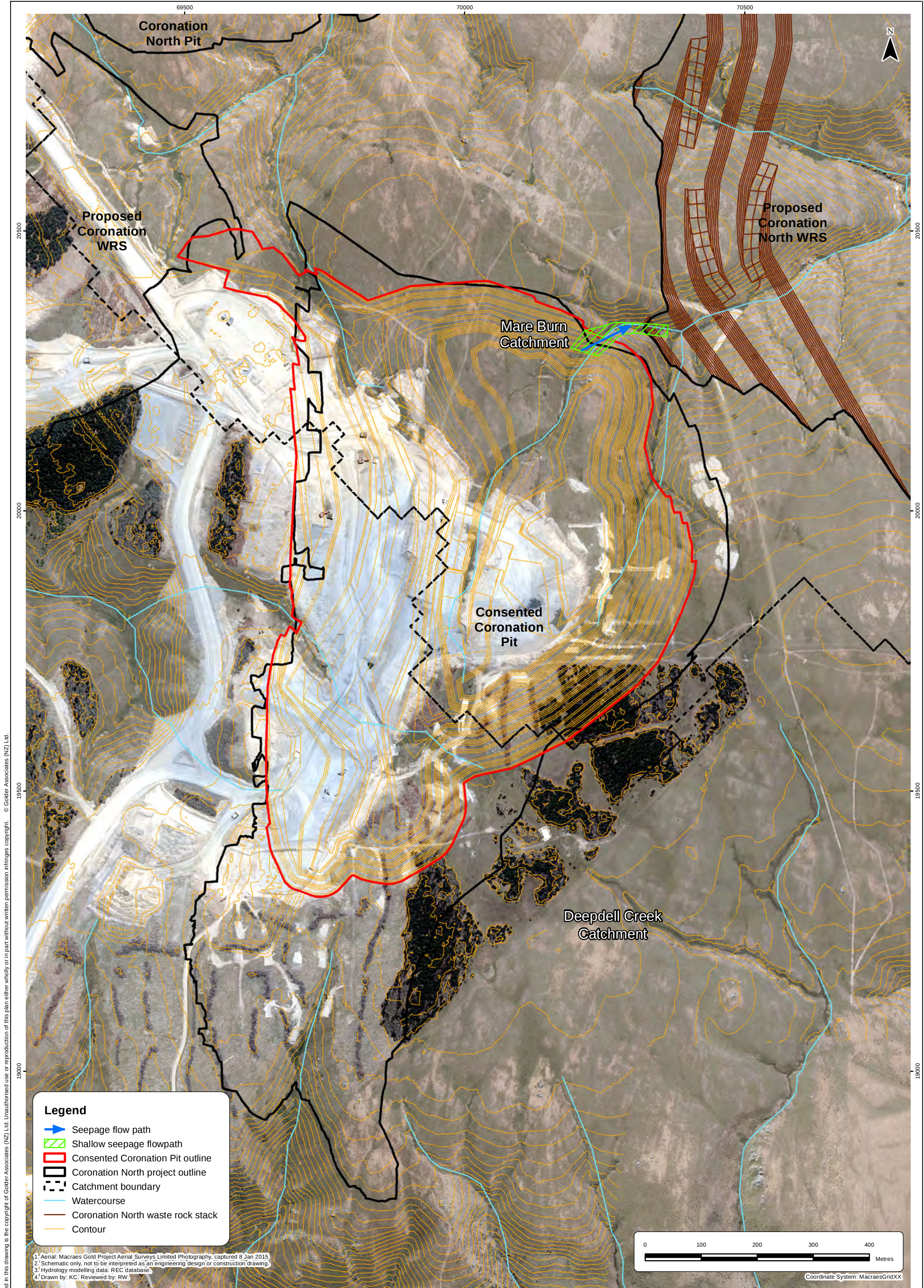
The calculated seepage flows for each of the opencast pits in the Coronation North Project are summarised in tables presented in this appendix. Specifically:

- The seepage losses calculated for the already consented Coronation Pit are presented in Table E1.
- The seepage losses calculated for Coronation Pit Stage 5 are presented in Table E2
- The seepage loss flow paths for Coronation North Pit toward the northeast are presented in Table E3.
- The seepage loss flow paths for Coronation North Pit toward the north are presented in Table E4.

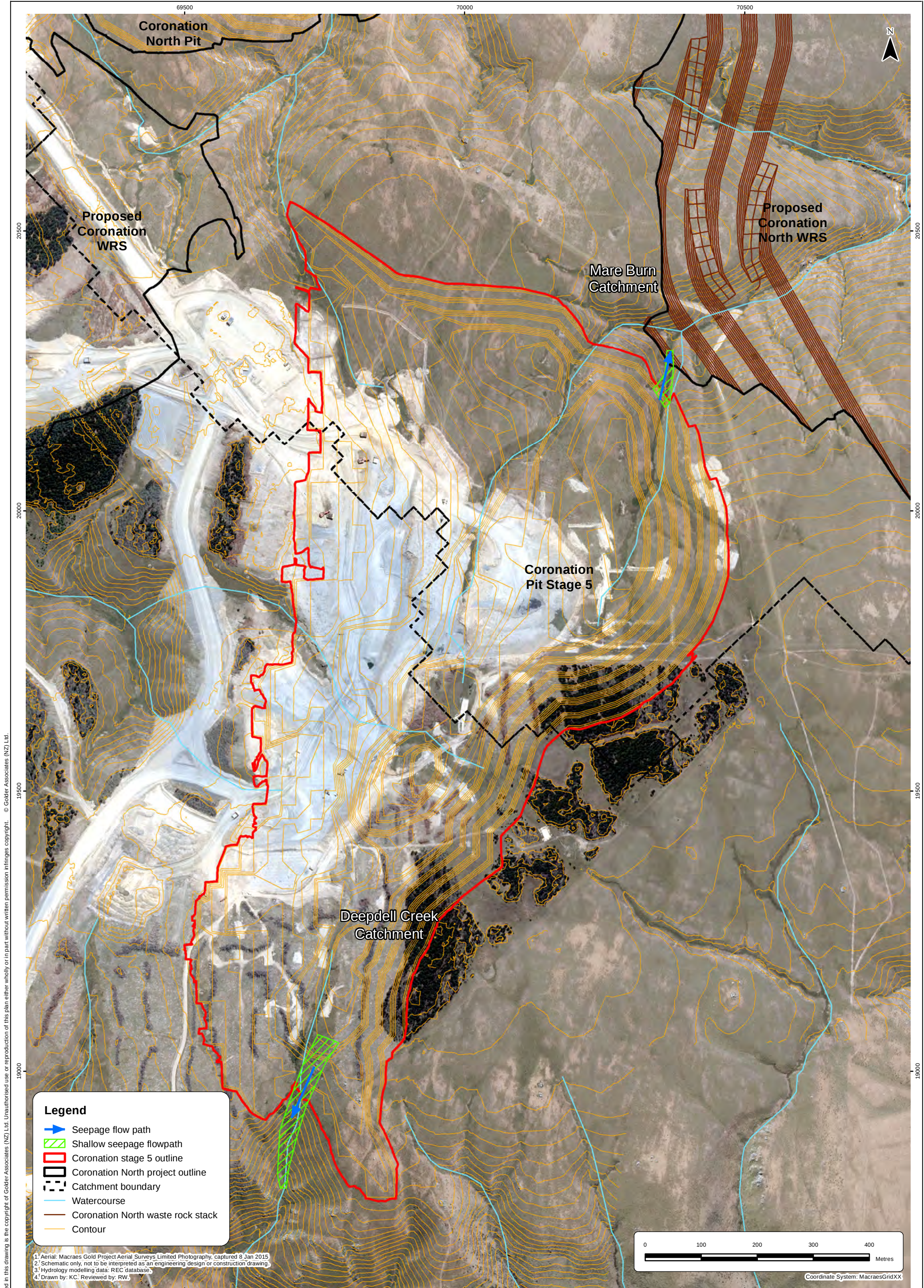
In the case of the planned Coronation North Pit two sets of seepage flow losses are presented as two distinct seepage flow paths have been evaluated. The seepage flow path toward the northeast relates to a gully which will be infilled by the Coronation North WRS and by an embankment to be constructed to support the haul road to the Coronation North Pit. The invert for this gully intersects the Coronation North Pit shell at a lower elevation than does the gully invert that forms the planned overflow path out of the pit toward the north.

OceanaGold plans to install a layer of compacted weathered rock and clay against the upstream face of the haul road embankment to reduce seepage losses down the gully toward the northeast. It is reasonably expected that this sealing layer can be constructed to design criteria that are equivalent to the Zone A materials used in the tailings storage embankments at the MGP. On this basis, the hydraulic conductivity applied to the seepage calculations for the haul road embankment is 1×10^{-7} m/s, equivalent to the Zone A design criteria.

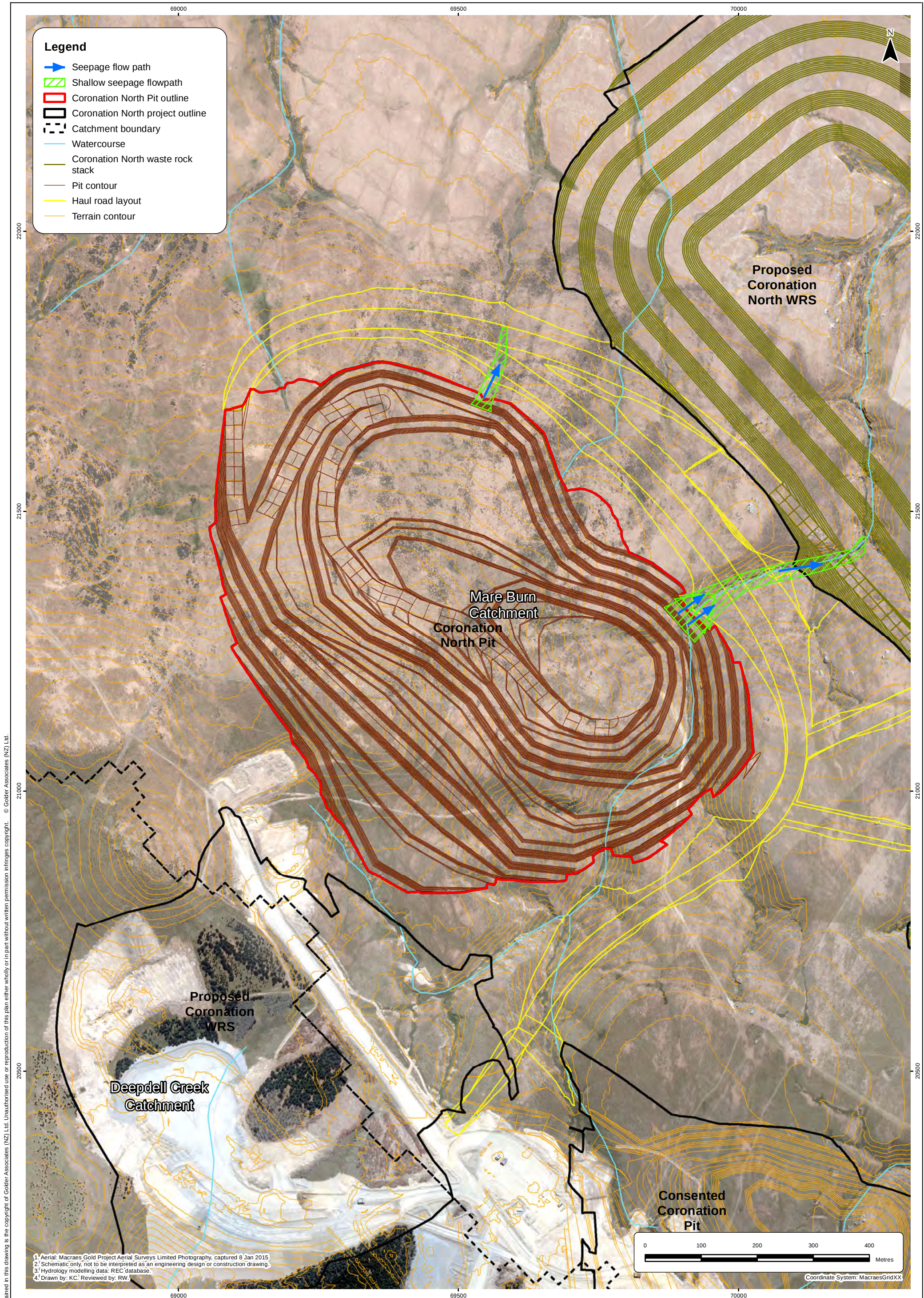
The seepage losses from the opencast pits as presented in this appendix have been carried though into the calculations for net groundwater flows to each opencast pit as presented in Appendix F attached to this report.



Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.



Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.



Information contained in this drawing is the copyright of Golder Associates (NZ) Ltd. Unauthorised use or reproduction of this plan either wholly or in part without written permission infringes copyright. © Golder Associates (NZ) Ltd.





APPENDIX E

Opencast pit lake seepage loss calculations

Table E1: Groundwater seepage outflows from Consented Coronation Pit lake.

Lake elevation	Discharge elevation	Head differential (dH)	Flow path length (dL)	Hydraulic conductivity	Flow width path	Flow per metre elevation change	Average flow per lake slice	Cumulative seepage flow	
mRL	mRL	m	m	m/s	m	m ³ /s	m ³ /s	m ³ /s	m ³ /day
640	620	20	110	3.5×10^{-7}	20	1.3×10^{-6}	5.9×10^{-6}	2.7×10^{-5}	2.31
637.5	620	17.5	88	3.5×10^{-7}	50	3.5×10^{-6}	8.0×10^{-6}	2.1×10^{-5}	1.80
635	620	15	89	3.5×10^{-7}	50	2.9×10^{-6}	6.7×10^{-6}	1.3×10^{-5}	1.10
632.5	620	12.5	91	3.5×10^{-7}	50	2.4×10^{-6}	3.6×10^{-6}	6.0×10^{-6}	0.52
630	620	10	99	1×10^{-7}	50	5.1×10^{-7}	1.1×10^{-6}	2.4×10^{-6}	0.21
627.5	620	7.5	101	1×10^{-7}	50	3.7×10^{-7}	7.5×10^{-7}	1.3×10^{-6}	0.11
625	620	5	110	1×10^{-7}	50	2.3×10^{-7}	4.3×10^{-7}	5.7×10^{-7}	0.05
622.5	620	2.5	110	1×10^{-7}	50	1.1×10^{-7}	1.4×10^{-7}	1.4×10^{-7}	0.01
620	620	0	110	1×10^{-7}	50	0	0	0	0



APPENDIX E

Opencast pit lake seepage loss calculations

Table E2: Groundwater seepage outflows from Coronation Pit Stage 5 lake.

Lake elevation	Discharge elevation	Head differential (dH)	Flow path length (dL)	Hydraulic conductivity	Flow path width	Flow per metre elevation change	Average flow per lake slice	Cumulative seepage flow	
mRL	mRL	m	m	m/s	m	m ³ /s	m ³ /s	m ³ /s	m ³ /day
Flow toward South (Deepdell Creek catchment)									
632.5	620	12.5	85	1×10^{-7}	40	5.9×10^{-7}	1.3×10^{-6}	3.7×10^{-6}	0.32
630	620	10	85	1×10^{-7}	40	4.7×10^{-7}	1.0×10^{-6}	2.4×10^{-6}	0.20
627.5	620	7.5	85	1×10^{-7}	40	3.5×10^{-7}	7.4×10^{-7}	1.3×10^{-6}	0.11
625	620	5	85	1×10^{-7}	40	2.4×10^{-7}	4.4×10^{-7}	5.9×10^{-7}	0.05
622.5	620	2.5	85	1×10^{-7}	40	1.2×10^{-7}	1.5×10^{-7}	1.5×10^{-7}	0.01
620	620	0	85	1×10^{-7}	40	0	0	0	0
Flow toward East (Trimbells Gully catchment)									
632.5	620	12.5	280	3.5×10^{-7}	30	4.7×10^{-7}	1.2×10^{-6}	3.5×10^{-6}	0.30
630	620	10	280	3.5×10^{-7}	40	5.0×10^{-7}	1.1×10^{-6}	2.3×10^{-6}	0.20
627.5	620	7.5	280	3.5×10^{-7}	40	3.8×10^{-7}	7.8×10^{-7}	1.2×10^{-6}	0.10
625	620	5	280	3.5×10^{-7}	40	2.5×10^{-7}	3.6×10^{-7}	4.0×10^{-7}	0.03
622.5	620	2.5	280	1×10^{-7}	40	3.6×10^{-8}	4.5×10^{-8}	4.5×10^{-8}	0.004
620	620	0	280	1×10^{-7}	40	0	0	0	0



APPENDIX E

Opencast pit lake seepage loss calculations

Table E3: Groundwater seepage outflows from Coronation North Pit lake toward northeast.

Lake elevation	Discharge elevation	Head differential (dH)	Flow path length (dL)	Hydraulic conductivity	Flow path width	Flow per metre elevation change	Average flow per lake slice	Cumulative seepage flow	
mRL	mRL	m	m	m/s	m	m ³ /s	m ³ /s	m ³ /s	m ³ /day
Seepage through haul road embankment									
580	560	20	10	1×10^{-7}	80	1.6×10^{-5}	3.5×10^{-5}	1.1×10^{-4}	9.15
577.5	560	17.5	10	1×10^{-7}	70	1.2×10^{-5}	2.7×10^{-5}	7.1×10^{-5}	6.10
575	560	15	10	1×10^{-7}	60	9.0×10^{-6}	1.9×10^{-5}	4.4×10^{-5}	3.80
572.5	560	12.5	10	1×10^{-7}	50	6.3×10^{-6}	1.2×10^{-5}	2.5×10^{-5}	2.15
570	560	10	10	1×10^{-7}	36	3.6×10^{-6}	7.3×10^{-6}	1.3×10^{-5}	1.09
567.5	560	7.5	10	1×10^{-7}	30	2.3×10^{-6}	4.1×10^{-6}	5.3×10^{-6}	0.46
565	560	5	10	1×10^{-7}	20	1.0×10^{-6}	1.3×10^{-6}	1.3×10^{-6}	0.11
562.5	560	2.5	10	1×10^{-7}	0	0	0	0	0
Seepage through in-situ soils and rock beneath haul road embankment									
580	560	20	70	3.5×10^{-7}	80	8.0×10^{-6}	1.9×10^{-5}	9.6×10^{-5}	8.28
577.5	560	17.5	70	3.5×10^{-7}	80	7.0×10^{-6}	1.6×10^{-5}	7.7×10^{-5}	6.66
575	560	15	70	3.5×10^{-7}	80	6.0×10^{-6}	1.4×10^{-5}	6.1×10^{-5}	5.26
572.5	560	12.5	70	3.5×10^{-7}	80	5.0×10^{-6}	1.1×10^{-5}	4.7×10^{-5}	4.07
570	560	10	70	3.5×10^{-7}	80	4.0×10^{-6}	8.8×10^{-6}	3.6×10^{-5}	3.10
567.5	560	7.5	70	3.5×10^{-7}	80	3.0×10^{-6}	6.3×10^{-6}	2.7×10^{-5}	2.34
565	560	5	70	3.5×10^{-7}	80	2.0×10^{-6}	3.8×10^{-6}	2.1×10^{-5}	1.80
562.5	560	2.5	70	3.5×10^{-7}	80	1.0×10^{-6}	3.3×10^{-6}	1.7×10^{-5}	1.48
560	540	20	350	3.5×10^{-7}	80	1.6×10^{-6}	3.8×10^{-6}	1.4×10^{-5}	1.20
557.5	540	17.5	350	3.5×10^{-7}	80	1.4×10^{-6}	3.3×10^{-6}	1.0×10^{-5}	0.87
555	540	15	350	3.5×10^{-7}	80	1.2×10^{-6}	2.8×10^{-6}	6.9×10^{-6}	0.59
552.5	540	12.5	350	3.5×10^{-7}	80	1.0×10^{-6}	2.3×10^{-6}	4.1×10^{-6}	0.35
550	540	10	350	3.5×10^{-7}	80	8×10^{-7}	1.2×10^{-6}	1.9×10^{-6}	0.16
547.5	540	7.5	350	1×10^{-7}	80	1.7×10^{-7}	3.6×10^{-7}	6.4×10^{-7}	0.06
545	540	5	350	1×10^{-7}	80	1.1×10^{-7}	2.1×10^{-7}	2.9×10^{-7}	0.02
542.5	540	2.5	350	1×10^{-7}	80	5.7×10^{-8}	7.1×10^{-8}	7.1×10^{-8}	0.01
540	540	0	350	1×10^{-7}	80	0	0	0	0



APPENDIX E

Opencast pit lake seepage loss calculations

Table E4: Groundwater seepage outflows from Coronation North Pit lake toward north.

Lake elevation	Discharge elevation	Head differential (dH)	Flow path length (dL)	Hydraulic conductivity	Flow path width	Flow per metre elevation change	Average flow per lake slice	Cumulative seepage flow	
mRL	mRL	m	m	m/s	m	m ³ /s	m ³ /s	m ³ /s	m ³ /day
580	560	20	280	3.5×10^{-7}	30	7.5×10^{-7}	2.0×10^{-6}	7.3×10^{-6}	0.63
577.5	560	17.5	280	3.5×10^{-7}	40	8.8×10^{-7}	2.0×10^{-6}	5.2×10^{-6}	0.45
575	560	15	280	3.5×10^{-7}	40	7.5×10^{-7}	1.7×10^{-6}	3.2×10^{-6}	0.28
572.5	560	12.5	280	3.5×10^{-7}	40	6.3×10^{-7}	9.6×10^{-7}	1.5×10^{-6}	0.13
570	560	10	280	1×10^{-7}	40	1.4×10^{-7}	3.1×10^{-7}	5.3×10^{-7}	0.046
567.5	560	7.5	280	1×10^{-7}	40	1.1×10^{-7}	1.1×10^{-7}	1.1×10^{-7}	0.019
565	560	5	280	1×10^{-7}	40	7.1×10^{-8}	7.1×10^{-8}	1.1×10^{-7}	0.009
562.5	560	2.5	280	1×10^{-7}	40	3.6×10^{-8}	3.6×10^{-8}	3.6×10^{-8}	0.003
560	560	0	280	1×10^{-7}	40	0	0	0	0



APPENDIX F

Opencast Pit and Pit Lake Net Seepage Flows



APPENDIX F

Opencast pit and pit lake net seepage flows

The calculated net groundwater seepage rates to the consented Coronation Pit and pit lake are presented in Table F1. These seepage rates are a combination of:

- Groundwater inflows to the pit lake based on the area of influence calculations presented in Appendix D.
- Seepage outflows from the pit lake as the water level approaches the overflow elevation presented in Appendix E.

These net seepage rates have been carried through into the surface water modelling for the Coronation North Project (Golder 2016a).

Table F1: Groundwater flow to and from consented Coronation Pit lake.

Pit lake surface elevation (mRL)	Groundwater inflow ⁽¹⁾ (m ³ /day)	Groundwater outflow ⁽²⁾ (m ³ /day)	Net groundwater flow (m ³ /day)
640 (overflow elevation)	95	-2.31	92
637.5	100	-1.80	99
635	106	-1.10	105
632.5	112	-0.52	111
630	117	-0.21	117
627.5	123	-0.11	123
625	129	-0.05	129
622.5	135	-0.01	135
620	140		140
617.5	146		146
615	152		152
612.5	157		157
610	163		163
607.5	169		169
605	174		174
602.5	180		180
600	186		186
597.5	191		191
595	197		197
592.5	203		203
590	208		208
587.5	214		214
585	220		220
582.5	225		225
580	231		231
577.5	237		237
575	242		242
572.5	248		248
570	254		254
567.5	259		259
565	265		265
562.5 (pit base)	271		271

Notes 1) Inflows calculated for pit lake when empty and at overflow. Inflows at intermediate elevations based on linear interpolation between the two end points.
2) Outflows calculated stepwise as presented in Appendix E and defined here as negative flows toward the pit.



APPENDIX F

Opencast pit and pit lake net seepage flows

The net groundwater seepage rates to the consented Coronation Pit Stage 5 Pit and pit lake are presented in Table F2. These seepage rates are a combination of:

- Groundwater inflows to the pit lake based on the area of influence calculations presented in Appendix D.
- Seepage outflows from the pit lake as the water level approaches the overflow elevation presented in Appendix E.

These net seepage rates have been carried through into the surface water modelling for the Coronation North Project (Golder 2016a).

Table F2: Groundwater flows to and from Coronation Pit Stage 5 lake.

Pit lake surface elevation (mRL)	Groundwater inflow ⁽¹⁾ (m ³ /day)	Groundwater outflow to East ⁽²⁾ (m ³ /day)	Groundwater outflow to Deepdell Creek ⁽²⁾ (m ³ /day)	Net groundwater flow (m ³ /day)
632.5	130	-0.30	-0.32	130
630	136	-0.20	-0.20	136
627.5	142	-0.10	-0.11	142
625	148	-0.03	-0.05	148
622.5	154	0.00	-0.01	154
620	160	0.00	0.00	160
617.5	166			166
615	172			172
612.5	178			178
610	184			184
607.5	190			190
605	196			196
602.5	202			202
600	208			208
597.5	214			214
595	221			221
592.5	227			227
590	233			233
587.5	239			239
585	245			245
582.5	251			251
580	257			257
577.5	263			263
575	269			269
572.5	275			275
570	281			281
567.5	287			287
565	293			293
562.5	299			299

Notes 1) Inflows calculated for pit lake when empty and at overflow. Inflows at intermediate elevations based on linear interpolation between the two end points.
2) Outflows calculated stepwise as presented in Appendix E and defined here as negative flows toward the pit.



APPENDIX F

Opencast pit and pit lake net seepage flows

The net groundwater seepage rates to the planned Coronation North Pit and pit lake are presented in Table F3.

- Groundwater inflows to the pit lake based on the area of influence calculations presented in Appendix D.
- Seepage outflows from the pit lake as the water level approaches the overflow elevation presented in Appendix E.

These net seepage rates have been carried through into the surface water modelling for the Coronation North Project (Golder 2016a).

Table F3: Groundwater flows to and from Coronation North Pit lake.

Pit lake elevation (mRL)	Groundwater inflow ⁽¹⁾ (m ³ /day)	Groundwater outflow ⁽²⁾ (m ³ /day)	Net groundwater flow (m ³ /day)
580	94	-18.06	76
577.5	99	-13.21	86
575	104	-9.34	94
572.5	109	-6.35	102
570	114	-4.23	109
567.5	119	-2.82	116
565	124	-1.92	122
562.5	128	-1.48	127
560	133	-1.20	132
557.5	138	-0.87	137
555	143	-0.59	143
552.5	148	-0.35	148
550	153	-0.16	153
547.5	158	-0.06	158
545	163	-0.02	163
542.5	168	-0.01	168
540	173	0.00	173
537.5	178		178
535	183		183
532.5	188		188
530	193		193
527.5	198		198
525	203		203
522.5	208		208
520	212		212
517.5	217		217
515	222		222
512.5	227		227
510	232		232
507.5	237		237
505	242		242



APPENDIX F

Opencast pit and pit lake net seepage flows

Pit lake elevation (mRL)	Groundwater inflow ⁽¹⁾ (m ³ /day)	Groundwater outflow ⁽²⁾ (m ³ /day)	Net groundwater flow (m ³ /day)
502.5	247		247
500	252		252
497.5	257		257
495	262		262
492.5	267		267
490	272		272
487.5	277		277
485	282		282
482.5	287		287
480	291		291
477.5	296		296
475	301		301
472.5	306		306
470	311		311
467.5	316		316

Notes 1) Inflows calculated for pit lake when empty and at overflow. Inflows at intermediate elevations based on linear interpolation between the two end points.
2) Outflows calculated stepwise as presented in Appendix E and defined here as negative flows toward the pit.

j:\projects-dynamics\2015\7410\1545831_oceanagold(nz)\ltd_coronationnorthpitwaterassessment\deliverables\002 groundwater report\appendices\1545831-002-appendix f - calculated net seepage flows.docx



APPENDIX G

Report Limitations



Report Limitations

This Report/Document has been provided by Golder Associates (NZ) Limited ("Golder") subject to the following limitations:

- i) This Report/Document has been prepared for the particular purpose outlined in Golder's proposal and no responsibility is accepted for the use of this Report/Document, in whole or in part, in other contexts or for any other purpose.
- ii) The scope and the period of Golder's Services are as described in Golder's proposal, and are subject to restrictions and limitations. Golder did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Report/Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Golder in regards to it.
- iii) Conditions may exist which were undetectable given the limited nature of the enquiry Golder was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Report/Document. Accordingly, if information in addition to that contained in this report is sought, additional studies and actions may be required.
- iv) The passage of time affects the information and assessment provided in this Report/Document. Golder's opinions are based upon information that existed at the time of the production of the Report/Document. The Services provided allowed Golder to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.
- v) Any assessments, designs and advice made in this Report/Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Report/Document.
- vi) Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Golder for incomplete or inaccurate data supplied by others.
- vii) The Client acknowledges that Golder may have retained subconsultants affiliated with Golder to provide Services for the benefit of Golder. Golder will be fully responsible to the Client for the Services and work done by all of its subconsultants and subcontractors. The Client agrees that it will only assert claims against and seek to recover losses, damages or other liabilities from Golder and not Golder's affiliated companies. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any legal recourse, and waives any expense, loss, claim, demand, or cause of action, against Golder's affiliated companies, and their employees, officers and directors.
- viii) This Report/Document is provided for sole use by the Client and is confidential to it. No responsibility whatsoever for the contents of this Report/Document will be accepted to any person other than the Client. Any use which a third party makes of this Report/Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Report/Document.

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australia & NZ	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

AUCKLAND

Tel +64 9 486 8068
 Fax +64 9 486 8072

Level 2
 Nielsen Centre
 129 Hurstmere Road
 Takapuna
 Auckland 0622

PO Box 33-849
 Takapuna 0740

WELLINGTON

Tel +64 4 974 6397

Level 1
 93 The Terrace
 Wellington 6011

PO Box 5234
 Wellington 6145

HAMILTON

Tel +64 7 859 2356
 Fax +64 9 486 8072

Room 31 in the Homestead
 Ruakura Research Centre
 10 Bisley Road
 Hamilton 3214

PO Box 19-479
 Hamilton 3244

NELSON

Tel +64 3 548 1707
 Fax +64 3 548 1727

Level 3
 295 Trafalgar Street
 Nelson 7010

PO Box 1724
 Nelson 7040

CHRISTCHURCH

Tel +64 3 377 5696
 Fax +64 3 377 9944

Level 1
 214 Durham Street
 Christchurch 8011

PO Box 2281
 Christchurch 8140

DUNEDIN

Tel +64 3 479 0390
 Fax +64 3 474 9642

Level 7B
 John Wickliffe House
 265 Princes Street
 Dunedin 9016

PO Box 1087
 Dunedin 9054