Macraes Phase IV

Golden Bar – Surface and Groundwater Assessment

Oceana Gold New Zealand Ltd.

26 March 2024

→ The Power of Commitment

Project name	Macraes Phase IV						
Document title	Macraes Phase IV | Golden Bar – Surface and Groundwater Assessment						
Project number	12576793						
File name	12576793-REP-Macraes Golden Bar (Stage 2) Final.docx						
Status Code	**Revision**	**Author**	**Reviewer**		**Approved for issue**		
			Name	**Signature**	**Name**	**Signature**	**Date**
S4	Rev0	Jeff Tuck / Bishnu Gautam	Dora Avanidou / Tim Mulliner		Siobhan Hartwell		26/03/2024

GHD Limited

138 Victoria Street, Level 3

Christchurch Central, Canterbury 8013, New Zealand

T +64 378 0900 | **F** +64 3 377 8575 | **E** chcmail@ghd.com | **ghd.com**

The Power of Commitment

Executive Summary

OceanaGold New Zealand Limited (OGNZL) operate the Macraes Gold Project (MGP) in east Otago, situated approximately 56 km north of Dunedin. The MGP began operations in 1990 and currently comprises two operational open cast pits (Frasers and Deepdell North Pits) and two underground mines - Frasers Underground (FRUG) and Golden Point Underground (GPUG), and a processing plant. Waste rock is placed both in pit as backfill and at a number of waste rock stacks (WRSs) located around the open pit margins. Tailings from processed ore is currently stored at the Top Tipperary Tailings Storage Facility (TTTSF). There are also two decommissioned Tailings Storage Facilities (TSFs) the Mixed Tailings Impoundment (MTI) and the SP11 Tailings Storage Facility (SP11).

The Macraes Phase IV (MPIV) project is the next major phase of proposed development at the site which aims to extend the life of mine (LOM) to approximately 2030. Consenting MPIV has been undertaken in stages. So far the MPIV project has involved increasing the capacity of the existing TTTSF to a height of 570 m RL allowing an additional 3.2 Mm^3 of tailings storage, a minor expansion of the existing Innes Mills Open Pit (IMOP) and the placement of embankment structure and wet tailings disposal within the existing Fraser's Pit (FROP) (Frasers Co-disposal / continuity consents project). Expansion and extension of the Golden Point Underground mine (GPUG Ext) has also been subject to a standalone consent application. Surface water and groundwater assessments for these components of MPIV have previously been undertaken by GHD (GHD New Zealand Limited). In addition, MPIV consists of three open pit extensions and further tailings storage in Frasers Pit (Frasers Tailings Facility (FTSF), comprising:

1. The central area comprising life of mine Tailings Storage in FROP and development of the open pit mining extensions in the IMOP;
2. An expansion of the Coronation Pit with waste infilling of the Coronation North Open Pit (situated approximately 4 km to the northwest of IMOP);
3. An expansion of the Golden Bar Pit and the associated Golden Bar WRS (situated approximately 6 km to the southeast of IMOP); and
4. Rehandle of ~5.4Mtones of waste rock from the rehabilitated Northern Gully Waste Rock Stack to the Golden Point Pit.

The scope of this assessment covers the effects of the proposed Golden Bar pit (Stage 2) extension within the Clydesdale Creek and Golden Bar Creek (both tributaries of the Waikouaiti River North Branch (NBWR)) and Murphys Creek and to assess compliance with the current surface water compliance criteria at GB01 and GB02. The compliance location downstream of the proposed development at NB03 on the NBWR also needs to be taken into context with impacts from both the existing and proposed developments in the headwaters of the NBWR as well as the proposed Golden Bar development. Cumulative effects at NB03 are considered in a separate report that addresses the MPIV developments associated with FROP and IMOP developments.

Cumulative water quality effects within Murphys Creek and NBWR resulting from the proposed developments at Golden Bar and Frasers (as part of MPIV) are presented in a separate report that captures proposed mitigations measures within the catchment.

A numerical groundwater 3D model of the Golden Bar pit area has been developed using MODFLOW-USG (flow modelling code) and MODFLOW-USG-TRANSPORT (for solute transport modelling code) and used to assess groundwater inflow into the existing and proposed pit as well as groundwater recovery post mining. The model was calibrated under steady-state conditions using available data from the development of the existing pit lake and groundwater level monitoring before undertaking model predictions.

The results of the groundwater modelling provide predictions of groundwater flows into and out of the existing and proposed Golden Bar Pit as well as groundwater seepage from the Golden Bar WRS. The majority of seepage is expected to move laterally within the weathered schist and be captured in silt ponds, the pit sump and/or report to the receiving surface water catchment. In addition, the model predictions indicate that the existing and proposed additional pit dewatering at the Golden Bar pit will have negligible impact to the groundwater contributions to the McCormicks Creek and Murphys Creek flows.

The groundwater contaminant plume from Golden Bar Pit and WRS (conservatively illustrated using sulphate due to its low potential for attenuation within the groundwater system and existing elevated nature in some receiving surface water bodies as a result of past mining activity associated with MGP) is modelled to primarily impact Clydesdale Creek with an estimated sulphate seepage flux of between 26 and 80 kg/day (approximately 20 and 400 years post closure respectively). The McCormicks River catchment to the north of the Golden Bar development is expected to receive a comparatively minor component of contaminants from the Golden Bar development area (estimated sulphate flux of <0.1 kg/day).

An existing sitewide Goldsim Water Balance Model (WBM) has been utilised to estimate future impacts on the receiving water quality as a result of mining and rehabilitation activities. Key updates to the WBM include revised WRS seepage and pit lake water quality estimates, recalibration of key monitoring and compliance points utilising revised catchment boundaries and water quality and revised groundwater inflow / outflow estimates from the groundwater model.

The WBM indicates that the Golden Bar Pit Lake overflow level is likely to be reached after a period of approximately 35-42 years post closure, following which water from Golden Bar Pit Lake would spill into the Golden Bar Creek and ultimately the NBWR.

The WBM shows that in general, sulphate concentrations within the immediate receiving environment (Clydesdale Creek and Golden Bar Creek) are predicted to increase post closure relative to the mining phase due to the increase in sulphate mass from seepage water (from the Golden Bar WRS and Golden Bar Pit Lake). Median modelled sulphate concentrations are predicted to increase (from mining to closure) from 213 to 368 g/m^3 at GB01 (monitoring location in the Clydesdale Creek immediately down-stream of the existing Golden Bar WRS WRS). In Golden Bar Creek, modelled increases in the median sulphate predictions (10 to 276 mg/L at GB02 and 10 to 76 mg/L at NB01) for the mining and long term phases respectively are noted. This increase is primarily due to spill waters from the Golden Bar Pit Lake. Ammoniacal N and Nitrate N concentrations are generally predicted to reduce post closure (following site rehabilitation) relative to the mining phase due to the increased presence of rehabilitated surfaces (compared to non-rehabilitated surfaces which provide a higher relative contribution of these parameters before the closure period). Modelling of other parameters of interest (arsenic, copper, iron, lead and zinc) suggest that they are unlikely to significantly increase in concentration at either GB01, GB02.

In summary, modelling results indicate that the development of the stage two of Golden Bar as outlined will result in a predicted increase in sulphate concentrations associated with WRS development and pit lake spill waters within tributaries of the NBWR. Post closure, improvements in Nitrate N and Ammoniacal N concentrations (relative to the mining phases) are expected as a result of rehabilitation efforts within the catchments. Water quality is expected to remain within the current compliance limits at Clydesdale Creek and Golden Bar Creek throughout both the duration of the operational period and/or post closure period. No measurable impact is expected within the McCormicks catchment to the north.

Contents

Table index

Figure index

Appendices

Abbreviations

Term	Definition
AWBM	Australian Water Balance Model
EOY	End of year
FRUG	Frasers Underground Mine
FTSF	Frasers Pit Tailings Storage
GHD	GHD New Zealand Limited
GMS	Ground Modelling System
GPUG	Golden Point Underground Mine
GPUG ext	Golden Point Underground Mine expansion and extension
IMOP	Innes Mills Open Pit
IMOP	Innes Mills Pit
Kh	Horizontal hydraulic conductivity (Kx, Ky)
Kv	Vertical hydraulic conductivity (Kz)
L/s	Litres per second
L1	Model layer 1
L2	Model layer 2
L4	Model layer 4
LOM	Life of mine
m bgl	Meters below ground level
m RL	Meters relative level (above sea level)
MGP	Macraes Gold Project
MODFLOW-UGS	Flow Modelling Code
MODFLOW-UGS-TRANSPORT	Solute Transport Modelling Code
MTI	Mixed Tailings Impoundment
N	Porosity
NBGR	NBWR at Golden Bar Road and Griffin Road
NBWR	Waikouaiti River North Branch
ne	Effective porosity

NZTM	New Zealand Transverse Mercator
OGNZL	Oceana Gold New Zealand Limited
PED	Potential evaporation defecit
RCP	Representative concentration pathways
RMS	Root Mean Square
SP11	SP11 Tailings Facility
SRMS	Scaled Root Mean Square
Ss	Specific storage
SW	Stormwater
Sy	Specific yield
TSF	Tailings Storage Facility
TTTSF	Top Tipperary Tailings Storage Facility
WBM	Water balance model
WRS	Waste rock stack

1. Introduction

OceanaGold New Zealand Limited (OGNZL) operate the Macraes Gold Project (MGP) in east Otago, situated approximately 56 km north of Dunedin. The MGP began operations in 1990 and currently comprises two operational open cast pits (Frasers and Deepdell North Pits), two underground mines - Frasers Underground (FRUG) and Golden Point Underground (GPUG), and a processing plant. Waste rock is placed both in pit and at a number of waste rock stacks (WRSs) located around the open pit margins. Tailings from processing ore is stored at the Top Tipperary Tailings Storage Facility (TTTSF). There are also two decommissioned Tailings Storage Facilities (TSFs) - the Mixed Tailings Impoundment (MTI) and the SP11 Tailings Storage Facility (SP11).

A current site layout plan highlighting the main site facilities is shown in Figure 1.

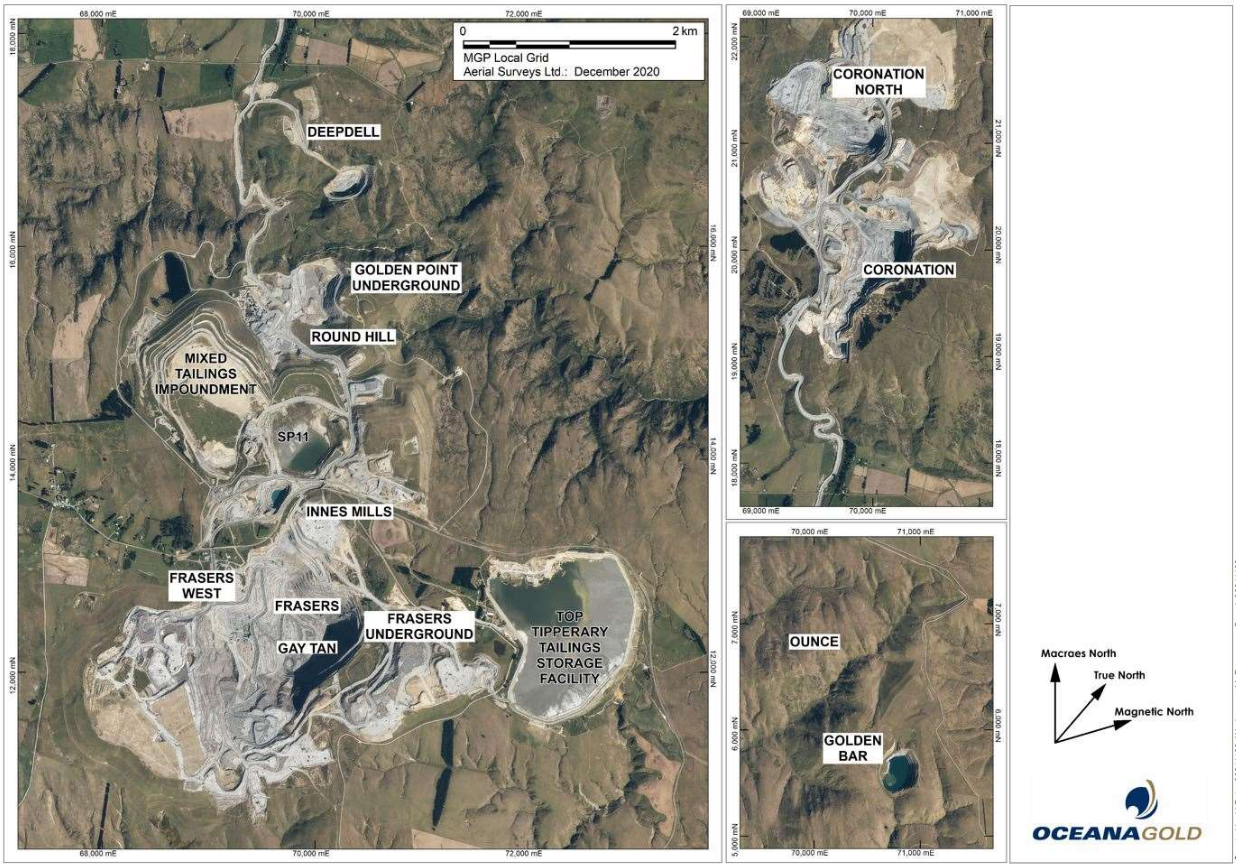


Figure 1 Macraes site plan

Macraes Phase IV (MPIV) project is the next major proposed development at MGP which aims to extend the life of mine (LOM) to around 2030. To support MPIV it is being consented in three stages:

– Stage 1. Consent renewals;
– Stage 2. Existing tailings facilities; and
– Stage 3. Open pit and underground mine extensions and Frasers TSF.

Stage 2 of the MPIV project has involved increasing the capacity of the existing TTTSF to a height of 570 m RL allowing an additional 3.2 Mm^3 of tailings storage, the minor expansion of the existing Innes Mills Open Pit (IMOP) beyond the MPIII consented limits and the construction of a dry mixed tailings / waste rock embankment structure within the existing Fraser's Pit (Frasers Co-disposal[1]). Surface water and groundwater assessments of Stage 2 (of

[1] Frasers Co-Disposal was consented in early 2023. Dry tailings will no longer be co-disposed with waste in the construction of the Frasers Backfill embankment. An initial stage including wet tailings is currently being consented.

MPIV) have previously been undertaken by GHD (GHD New Zealand Limited) and are reported in the following documents:

- GHD 2022a. TTTSF 570 Crest Raise. Surface Water and Groundwater Assessment. Prepared for Oceana Gold New Zealand Limited.
- GHD 2022b. Frasers Co-disposal Surface Water and Groundwater Assessment. Report prepared for Oceana Gold (New Zealand Ltd, 10 November 2022.

OceanaGold have brought forward some aspects of Stage 3 to manage operational continuity risks. In October 2023, it applied for an expansion and extension of GPUG (GPUG ext) and in December 2023, applied for a further minor extension of IMOP and an initial stage of tailings storage in the Frasers Tailings Storage Facility (FTSF) instead of a dry tailings co-disposal as part of the Continuity Consent Project (CCP). Surface water and groundwater assessments of these two components have previously been undertaken and are reported in the following documents:

- GHD 2023a. Golden Point Underground Extension – Analytical Assessment of Effect on Deepdell Creek. Report prepared for Oceana Gold New Zealand Ltd, 12 October 2023.
- GHD 2023b. Continuity Consent Project (CCP). Surface and Groundwater Assessment. Report prepared for Oceana Gold New Zealand Ltd, 04 December 2023.

For the purposes of the assessment presented here, these stages (and their previously modelled assumptions and effects) are considered consented and built.

Notwithstanding the previous assessed TTTSF crest raise and the Frasers backfill construction, the key components of the Stage 3 development in relation to surface water and groundwater effects are as follows:

- Frasers Pit Tailings Storage. FTSF will be filled with a further 30 Mt of tailings.
- Open Pit Mining extensions in Innes Mills (Stages 9-10), Golder Bar (Stage 2) and Coronation (stage 6).

1.1 Proposed mining activities

Specific details regarding the proposed Golden Bar pit expansion and mining activities which are incorporated in this assessment are included in Section 2. This assessment outlines the groundwater and surface water assessment for the proposed second stage development at Golden Bar open pit mining and waste rock stack development (‘Golden Bar extension’) as depicted in Figure 2. Cumulative impacts on the receiving surface waters in the NBWR associated with this (Golden Bar Stage 2) and other MPIV developments are covered in GHD, 2024a.

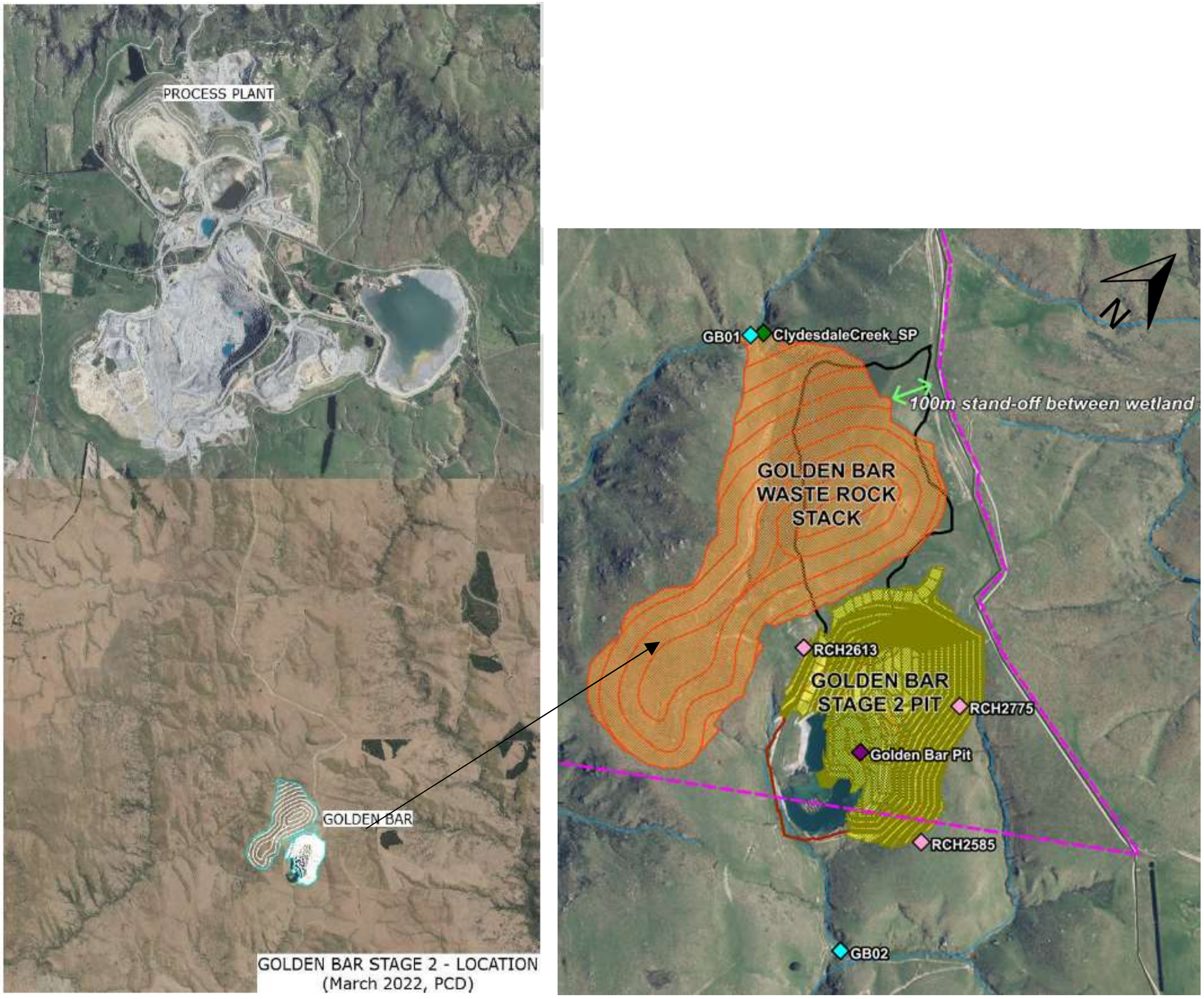


Figure 2 Golden Bar Waste Rock Stack and Stage two Development.

1.2 Purpose of this report

The purpose of this report is to present the results of the groundwater and surface water modelling associated with the proposed extension of Golden Bar Pit– a component of the OGNZL proposed Stage 3 of the MPIV project, to support the Assessment of Environmental Effects. Assessing the potential effect on the receiving surface water bodies is the key objective of this report.

1.3 Scope and limitations

1.3.1 Scope of works

GHD has been engaged by OGNZL to assess the surface and groundwater effects associated with the Macraes Phase IV project for the purposes of applying for resource consent. This report has been prepared in line with the GHD proposal dated 22 March 2022 and subsequent variations to that scope and presents the findings of the surface water and groundwater studies associated with the project.

The modelling scope and extents include:

– Groundwater dewatering and recharge/recovery and its effects associated with the downdip extension of the Golden Bar Pit.

- An assessment of the water balance and contaminant mass transport effects from the proposed Golden Bar Pit and WRS extensions. The scope of the outputs covers the effects within the Clydesdale Creek and Golden Bar Creek tributary at the monitoring location NB01 (tributaries of Murphys Creek and Waikouaiti River North Branch (NBWR)).
- Effects further down catchment (MC02 and NB03) as a result of the proposed Golden Bar development are covered in GHD, 2024.

Effects associated with the dewatering and discharge of water from the existing the Golden Bar Pit Stage 1 are covered separately in GHD, 2023 (Appendix B).

1.3.2 Limitations

This report: has been prepared by GHD for Oceana Gold New Zealand Ltd. and may only be used and relied on by Oceana Gold New Zealand Ltd. for the purpose agreed between GHD and Oceana Gold New Zealand Ltd. as set out in section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than Oceana Gold New Zealand Ltd. arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared the surface water and groundwater models for, and for the benefit and sole use of, Oceana Gold New Zealand Ltd. to support consenting and must not be used for any other purpose or by any other person.

The Models are a representation only and does not reflect reality in every aspect. The Models contains simplified assumptions to derive a modelled outcome. The actual variables will inevitably be different to those used to prepare the Models. Accordingly, the outputs of the Models cannot be relied upon to represent actual conditions without due consideration of the inherent and expected inaccuracies. Such considerations are beyond GHD's scope.

The information, data and assumptions ("Inputs") used as inputs into the Models are from publicly available sources or provided by or on behalf of the Oceana Gold New Zealand Ltd., (including possibly through stakeholder engagements). GHD has not independently verified or checked Inputs beyond its agreed scope of work. GHD's scope of work does not include review or update of the Models as further Inputs becomes available.

The Models are limited by the mathematical rules and assumptions that are set out in the Report or included in the Models and by the software environment in which the Models are developed.

The Models are customised and not intended to be amended in any form or extracted to other software for amending. Any change made to the Models, other than by GHD, is undertaken on the express understanding that GHD is not responsible, and has no liability, for the changed Models including any outputs.

GHD has prepared this report on the basis of information provided by Oceana Gold New Zealand Ltd. and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.4 Key Assumptions

GHD has relied upon data (project timeline and schedule, shapefiles, volumes and material properties) provided by OGNZL to inform this assessment, we have assumed that the data is correct and representative of the groundwater and surface water environment. GHD has also relied upon the information presented in previous assessments. These sources are referenced through the report.

1.4.1 Modelling Limitations and Assumptions

The results of numerical models are dependent on the level of detail incorporated and the accuracy of the parameters used in the development and calibration of the model. As a result, modelled effects cannot be exact.

Actual effects will vary somewhat (and maybe larger or smaller) than those predicted. In general, the assumptions utilised in the modelling are considered conservative. It is not possible to collect all the data needed to characterise the aquifer system in detail and therefore a number of assumptions have been made and are discussed below. The following assumptions were made:

- The production schedules and plans are an estimate of the LOM plan and assumptions have been made regarding the end of year (EOY) surfaces and proposed timeline.
- Waste rock deposited into Golden Bar WRS has the same hydrogeological properties as other waste rock material across the MGP site.
- Groundwater recharge is applied at the same rate to all units.
- A very small (0.0001 mg/L) background sulphate concentration (aquifer and rivers) was applied to all groundwater model layers.

Future additional data, refinement of these assumptions and of the adopted parameter values by further calibration would help reduce predicted uncertainties and will improve accuracy of the model outputs.

Additional assumptions and limitations of the modelling undertaken are detailed throughout the report.

2. Mining Operations

A summary of the main proposed activities (shown in Figure 3) and schedule for Stage 2 Golden Bar development (OGNZ, Project description, dated 9 March 2023) is outlined below.

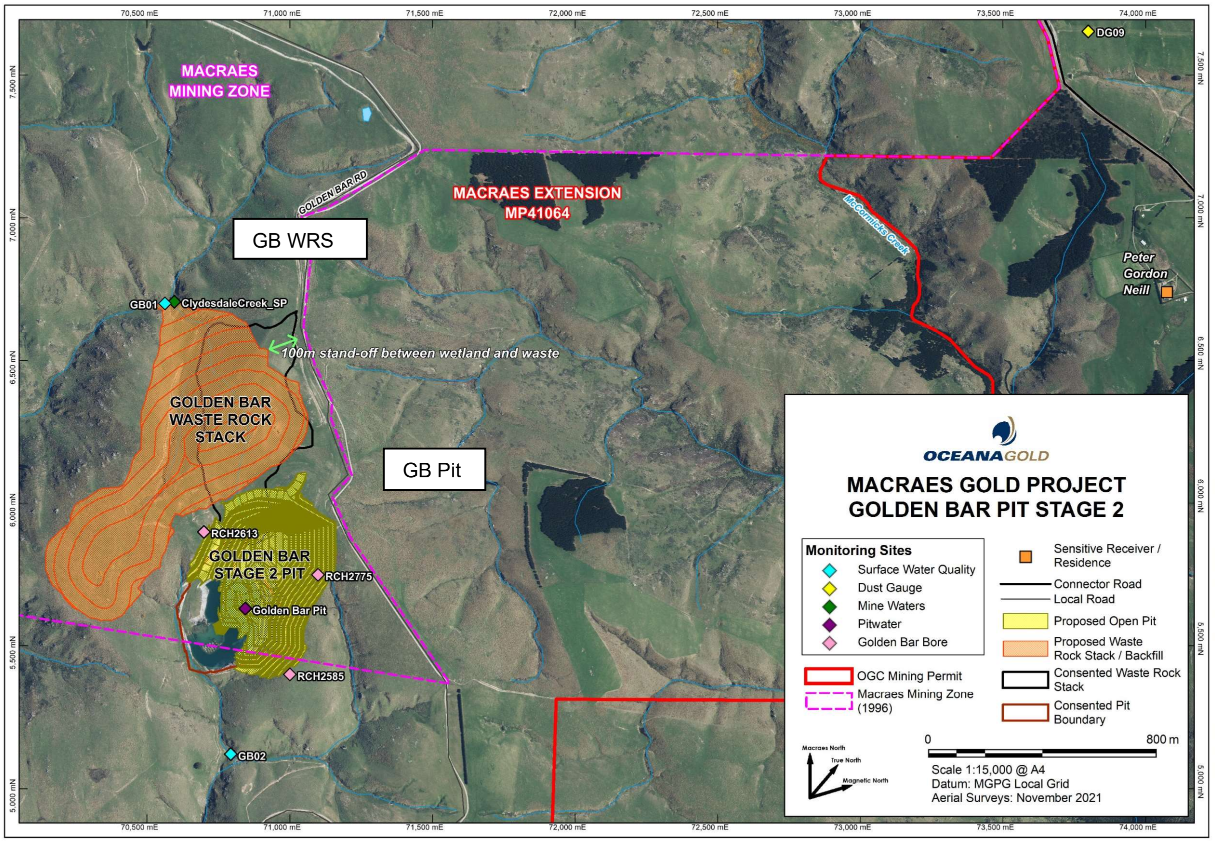


Figure 3 Golden Bar Stage 2 Open Pit

2.1 Open Pit Excavation

- The proposed expansion of the pit consists of an approximately 200 m expansion to the northeast (Figure 3).
- Much of the expanded footprint is over previously disturbed ground from the first stage of mining at Golden Bar during 2004-2006 which has now been rehabilitated. This land was previously used for equipment park up areas and crib facilities.
- The highest point of the pit rim is approximately 580 mRL with the lowest point 497.5 mRL. The deepest part of the pit is at 420 mRL, about 45 m deeper than the existing pit.

2.2 Waste Rock Disposal

The expansion of the Golden Bar WRS consists of an approximately 500 m southwestward extension of the existing WRS and a 120 m extension from the front (northern) face of the current WRS. The final WRS toe being located at the current silt pond (Figure 3).

- The WRS footprint has been adjusted to avoid a small ephemeral wetland located to the northeast.
- The top level of the WRS is 610 mRL, about 60 m above the current WRS.

- Storage capacity of this WRS extension is just over 30 Mt.

2.3 Water Management

- Runoff from the WRS during construction will be directed to the Clydesdale Silt Pond, Golden Bar Pit, or temporary local silt bunds or silt ponds. Any temporary local silt bunds or silt ponds will be minor and the need for these can be reviewed as part of environmental monitoring and erosion and sediment control as part of the operation of the WRS.
- Perimeter drains will be required around the extended WRS to direct runoff into the silt control structures.
- Dewatering of the current Stage 1 Golden Bar pit is outlined in GHD (2023) (Appendix B) and assumes dewatering to the nearest waterways. This will likely consist of active management of the discharge to the upper NBWR and Murphys Creek catchments as is currently undertaken to allow for sufficient dilution within the receiving environment to ensure compliance with the existing compliance limits at NB03.
- Stormwater and groundwater within the pit are intended to be pumped initially for use in dust suppression, but any excess water from the pit will need to be either pumped back to Frasers or pumped into the silt control structures for the WRS runoff.

2.4 Project Closure

- The Pit will not be backfilled. The pit void will eventually flood and drain to the south as it does currently.
- The slopes of the WRS will be shaped and revegetated progressively, using existing Macraes rehabilitation techniques.

2.5 Project Timeline

- 2026 to 2027: Mining phase
- 2028: Site rehabilitation

3. Site Setting

The environmental conditions present at Macraes have been summarised in previous reports written for the MGP MPIII resource consents. This assessment has relied solely on existing data and previous reports made available by OGNZL. The following subsections present an overview of the environmental setting across the MGP site, as has been summarised in previous reports.

3.1 Topography / Surface Water Bodies

The topography of the wider Macraes site is driven by the geologic evolution of the region. Long term weathering and erosion of the underlying rock resulted in a distinctive low relief peneplain which is bounded by NBWR to the west, Deepdell Creek to the north, and Murphys Creek to the south. Deepdell Creek has been deeply incised into this erosional surface resulting in steep valley slopes and minimal alluvial deposition. In contrast, the NBWR is characterised by shallow relief, broad valleys and alluvial deposition.

The original topography has been altered by thirty years of mining and waste deposition. Mining has been generally aligned with the orientation of the major shear zone. This has altered portions of original catchments in the main MGP site, but the primary streams and rivers surrounding the mining site remain and are ephemeral in nature.

The MGP site is located within the Shag River/Waihemo and Waikouaiti River catchments as shown in Figure 4. The Shag River flows in a south-easterly direction and enters the ocean close to Matakaea. The NBWR flows in a southerly direction from the mine site and enters the ocean near Karitane. The catchments consist primarily of agriculture and forestry.

Discharges from the Golden Bar Pit and WRS have the potential to reach the Shag River via McCormicks Creek and the NBWR (via the Clydesdale Creek (a tributary of Murphys Creek) and Golden Bar Creek respectively) as a result of pit lake spillage and/or groundwater transport. The key surface water bodies with monitoring and compliance locations notes within the NBWR referred to in this assessment are highlighted in Figure 5. The cumulative assessment of the impacts to McCormicks Creek, Murphys Creek and the NBWR are covered in GHD, 2024.

Assessing the potential impact of the proposed development at Golden Bar on the Clydesdale and Golden Bar Creeks (tributary of Murphys Creek and NBWR respectively) is the key objective of this report. The cumulative assessment of the impact (ie. that takes into account the modelled impacts from this assessment and modelled impacts from any Frasers Pit or Innes Mills Pit (IMOP) lake spill water, WRS seepage and/or groundwater discharges on the Waikouaiti North Branch are covered in GHD, 2024.

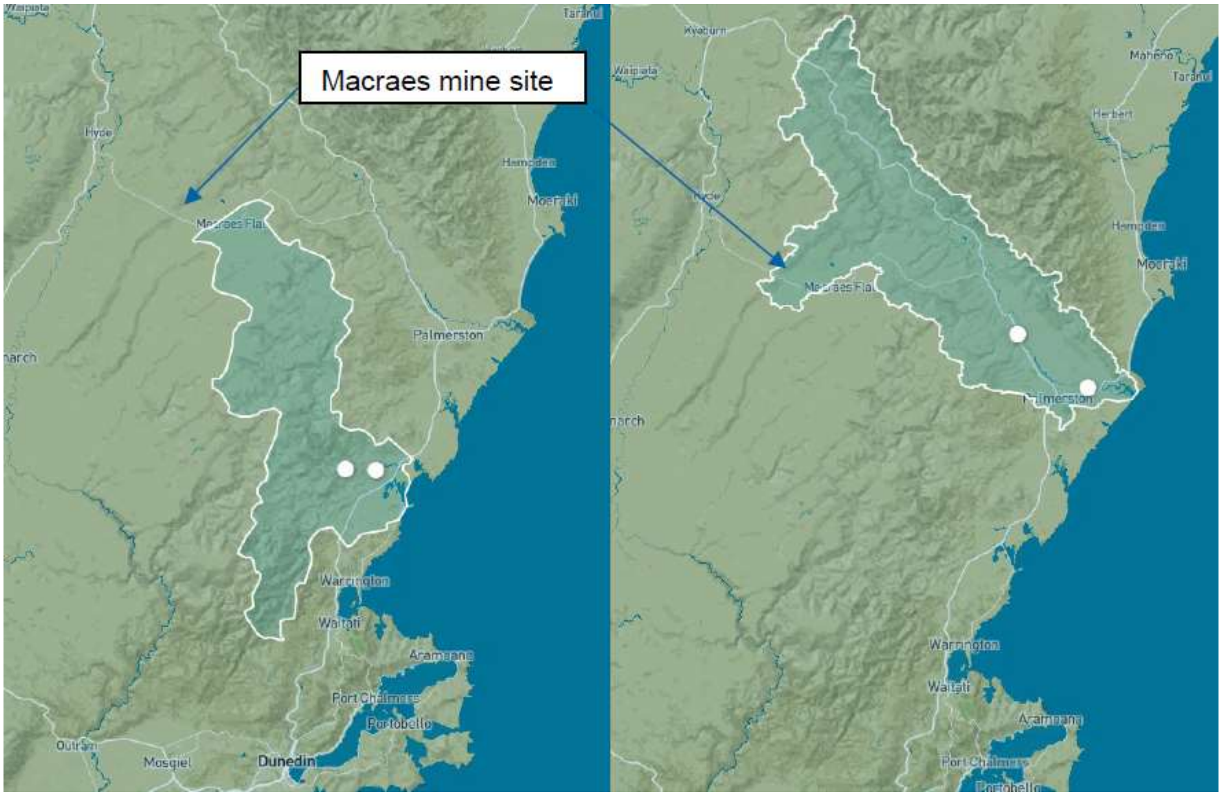
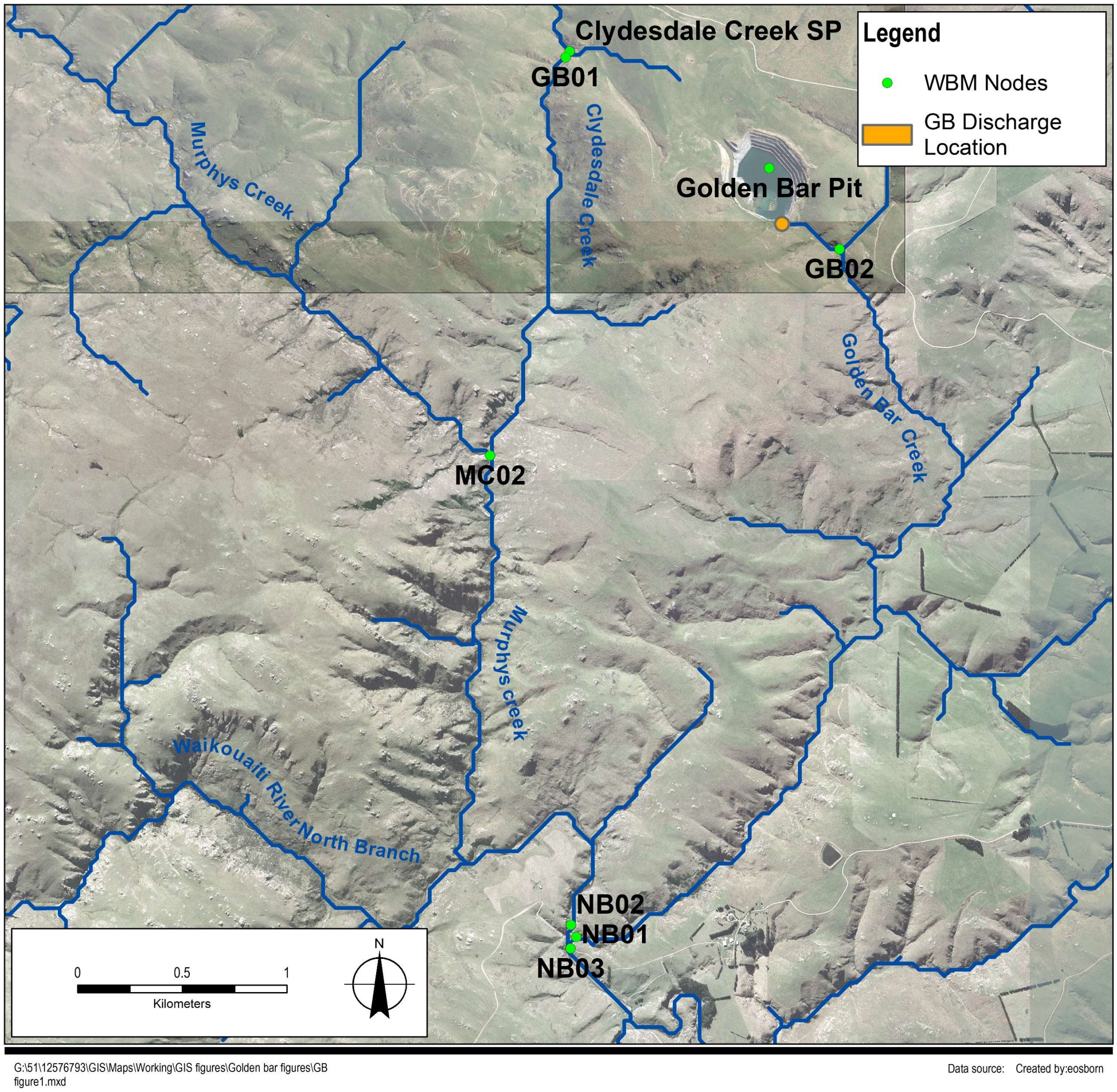


Figure 4 Waikouaiti North Branch River (left) and Shag River / Waihemo (right) catchments



*NB03, MC02, GB01 and GB02 have existing compliance criteria, while NB01 and NB02 are established water quality monitoring locations

Figure 5 Key tributaries of the Waikouaiti North Branch relating to the Golden Bar surface water assessment

3.2 Climate

The climate at Macraes is controlled predominantly by the mountains to the west of the site (Rock and Pillar Range) which act as a barrier to incoming weather systems from the west, leading to a fairly dry climate with limited precipitation. Rainfall data from the MGP are available from three locations, Glendale, Deepdell and Golden Point stations. Deepdell and Golden point stations were installed to monitor rainfall at the MGP site while Glendale is part of the national climate monitoring programme. Glendale station data spans from 1959 to 2013. Climate and climate change representation is further discussed in Section 5.3.

3.3 Background Geology

Regionally, the geology is dominated by the Mesozoic-aged crystalline metamorphic rock of the Rakaia Terrane Otago Schist (CDM Smith, 2016). Significant weathering and tectonic deposition resulted in the erosion of more recent alluvial sediments. The landscape is now dominated by widespread outcrops of Otago Schist and a very thin superficial layer or alluvium and colluvium. This alluvium and colluvium layer has generally been found at a maximum thickness of 1.8 m (Golder, 2011a) and is generally not considered to have a major impact on the groundwater flow system. Deformations and major discontinuities have been driven by the structural features described below.

3.3.1 Hyde Macraes Shear Zone (HMSZ)

The MGP began due to ore potential within the schist deformed by the HMSZ. This shear zone runs north-south through the Macraes site (aligned with Macraes Map Grid North). The shear zone comprises the Hanging Wall Shear and Footwall Shear zones which are considered to have enhanced hydraulic conductivity along the orientation of the features. The vertical separation between the top of the Hanging Wall Shear and the Footwall Fault is approximately 100 to 120 m.

3.3.2 Additional Structural Features

There are three major northeast-southwest trending faults that are present across the MGP site:

– The Deepdell Fault - aligned with Deepdell Creek
– The Macraes Fault - intersects the northern end of Frasers Pit and extends out to Top Tipperary Creek forming the northern boundary of Frasers Underground Mine (FRUG)
– Unnamed Fault – aligned with Murphys Creek, south of Frasers Pit.

3.4 Hydrostratigraphy

Due to the structural complexities present within the schist body and the manmade waste deposition that has occurred, there are a number of hydrostratigraphic units which have been incorporated into previous groundwater models. The number of hydrostratigraphic units has reduced in recent numerical groundwater modelling, opting for more simplified models (CDM,2016; GHD,2021). Throughout these simplifications, the values have not changed significantly. Units considered in previous groundwater models are listed below:

– Highly weathered schist
– Moderately weathered schist
– Slightly weathered schist
– Unweathered schist
– Footwall Fault
– Hanging Wall Shear
– Intra-shear schist
– Embankment materials
– Waste rock
– Flotation tailings
– Mixed tailings / Concentrate tailings
– Fine / coarse tailings

In 2016, CDM Smith compiled a review of all hydrogeological properties that have been applied to different groundwater models created and updated over the years. This summary has been reviewed and updated by GHD (2021) to include the values applied by CDM Smith in the groundwater model (2016) and GHD (2021). Data are presented in Appendix C. In addition, hydrogeological investigations were undertaken recently associated with the GPUG Ext. development and are detailed in WSP (2023). The primary hydrogeological units and parameters used in this assessment are discussed in further detail in the subsections below.

3.5 Schist

The Otago Schist is a crystalline metamorphic rock with effectively no primary porosity or permeability except where weathered. The permeability and porosity in this unit are primarily driven by the defects within the rock mass (fractures and faults) which create groundwater seepage routes and flow paths. The foliation dips around 15° to 30° south-southeast but rotate approaching major faults in the area. The deformities and foliation within the schist make it anisotropic with slightly higher hydraulic conductivity in the north/south direction (Ky).

The intensity of the weathering of the schist rock mass decreases with depth. However, geotechnical investigations have indicated that the moderate weathering of the schist only extends to about 5 m, while slight weathering only extends to about 35 to 50 m (Golder, 2011b). Therefore, on the scale of mining extents, the weathering is not considered to have a significant impact on the groundwater flow regime.

CDM Smith (2016) compiled a summary of historic hydraulic testing of schist undertaken at around the MGP site originally sourced from Golder, 2011a (Appendix B). The raw data were reviewed in graphical format and the geometric mean (geomean) and averages from the CDM Smith summary are presented in GHD (2021) in Table 1. Further testing, near GPUG, was undertaken by WSP (2023) and estimated hydraulic conductivity values are in the same order of magnitude (or lower) as those presented and used in previous assessments and in this report (although lower hydraulic conductivity values compared to those presented in Table 3 were estimated at depth).

Table 1 Hydraulic testing summary (Adapted from CDM Smith, 2016)

Depth (m bgl)	Average minimum (m/s)	Average maximum (m/s)	Geomean (m/s)
<10	2.2E-07	2.4E-04	6.9E-07
10 – 20	5.1E-08	1.7E-04	3.9E-07
20 – 30	1.3E-07	1.9E-05	2.7E-07
30 – 40	3.5E-07	2.3E-04	4.4E-07
40 – 50	1.2E-07	6.7E-07	9.8E-08
> 50	9.7E-08	3.7E-06	4.5E-07
250-500	1.0E-08	7.0E-07	-

3.6 Waste Rock

Waste rock is the rock that contains insufficient ore to process economically. It is typically coarse in nature (gravel to boulders <1.5 m in diameter) and angular, due to the blasting process used to break down the schist. It is typically stacked and compacted in 15 to 20 m lifts. The rock often contains sulphide minerals which have potential to oxidise and create acidic and metalliferous leachate.

3.7 Tailings

Tailings are the material left after ore processing has been undertaken. The material typically comprises a slurry of water, sediment (silt with sand and clay sized particles), and possibly leftover additives used during processing. The tailings at Macraes often contains high concentrations of arsenosulphides due to the presence of arsenopyrite in the sheared schist. After processing, tailings are deposited into the TSFs, grading out with coarse sediments settling out close to the deposition point.

4. Groundwater Assessment

4.1 Overview – Conceptual flow model

The conceptual understanding of the groundwater system in the vicinity of the Golden Bar extension is as follows:

- Recharge of the groundwater system via rainfall infiltration through fractures within the bedrock.
- Groundwater flow is generally topographically driven, with discharge via seeps and/or springs in topographic lows (streams and depressions).
- Hydraulic conductivity of the schist is primarily influenced by the degree of weathering in the schist bedrock, with variability (anisotropy) in horizonal hydraulic conductivity due to rock mass fracturing by structural features such as foliation-parallel fractures, faults and shear zones.
- Rainfall recharge into the waste rock stacks is predominantly intercepted by drainage channels at base of stacks with limited infiltration into the underlying schist bedrock.

Based on the current hydrogeological understanding of the project area the conceptual groundwater flow model for the Golden Bar site is presented in Figure 6 and Figure 7.

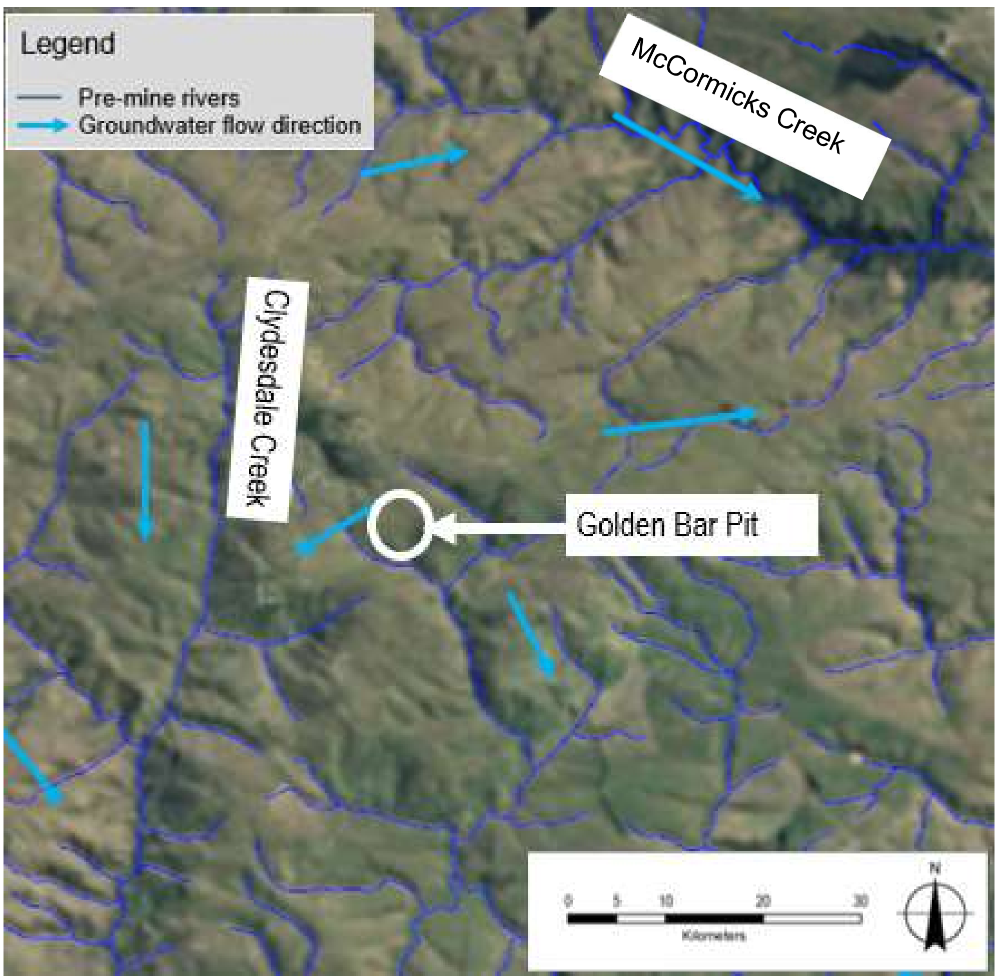


Figure 6 Golden Bar conceptual groundwater model flow diagram (pre mining)

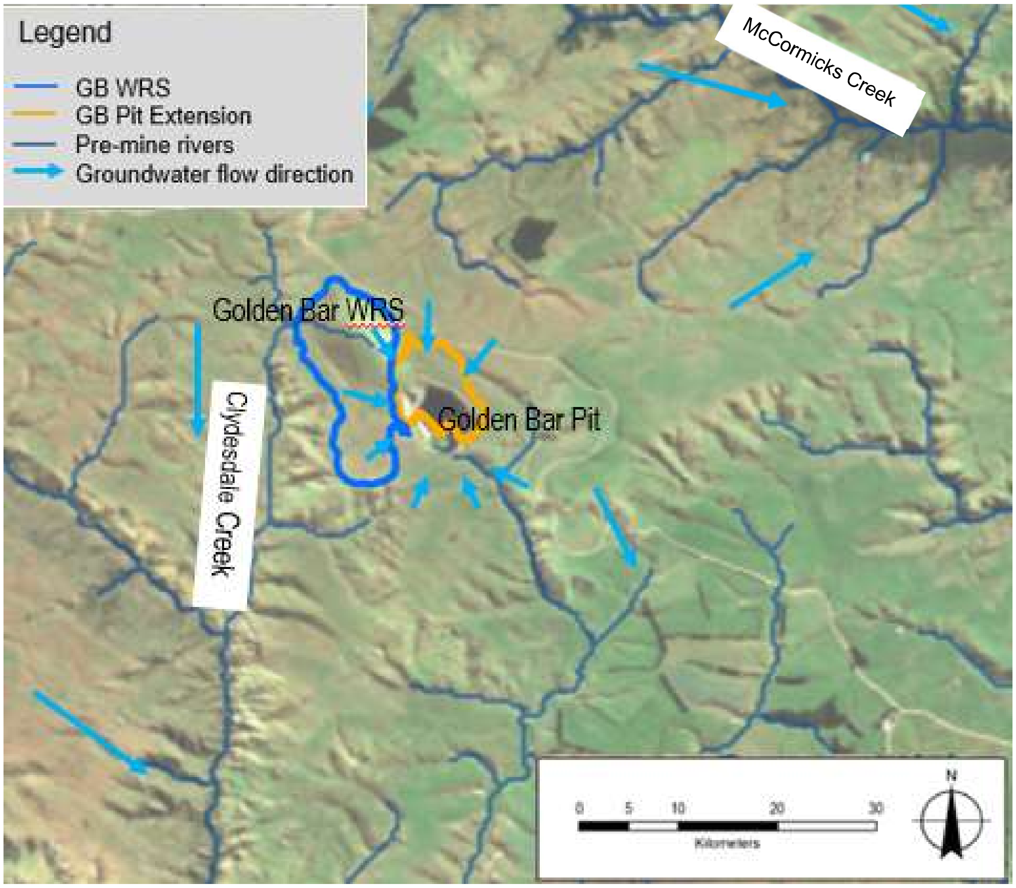


Figure 7 Golden Bar conceptual groundwater model flow diagram (existing / proposed mining)

4.2 Groundwater Model

4.2.1 Model Setup

A 3D numerical groundwater flow model of the Golden Bar pit area has been setup using Groundwater Modelling System (GMS) software using MODFLOW-USG (numerical modelling code) developed by the USGS. The objectives of the modelling are to:

– Predict pit inflow for the existing Stage 1 and proposed Stage 2 Golden Bar open pit.
– Simulate groundwater recovery after the conclusion of the proposed expansion.
– Perform solute transport modelling during recovery.

The model domain is 9 km by 9 km in east-west and north-south direction with the proposed pit extension at the centre of the model domain. The model has been setup in NZTM grid system.

Model grid size has been refined to 25 m within the proposed pit and two creeks (McCormicks and Murphys Creek), outside of that, 50 m grid size has been adopted. Vertically, 8 model layers have been setup with the first layer 30 m thick followed by 50 m thick layers (layers 2 to 8 - Table 2), which resulted in a total of 286,728 model cells. This provides enough grid resolution for pit-dewatering, recovery, and contaminant transport modelling.

The extent of the model domain is presented in Figure 8 and grid design is presented in Figure 9.

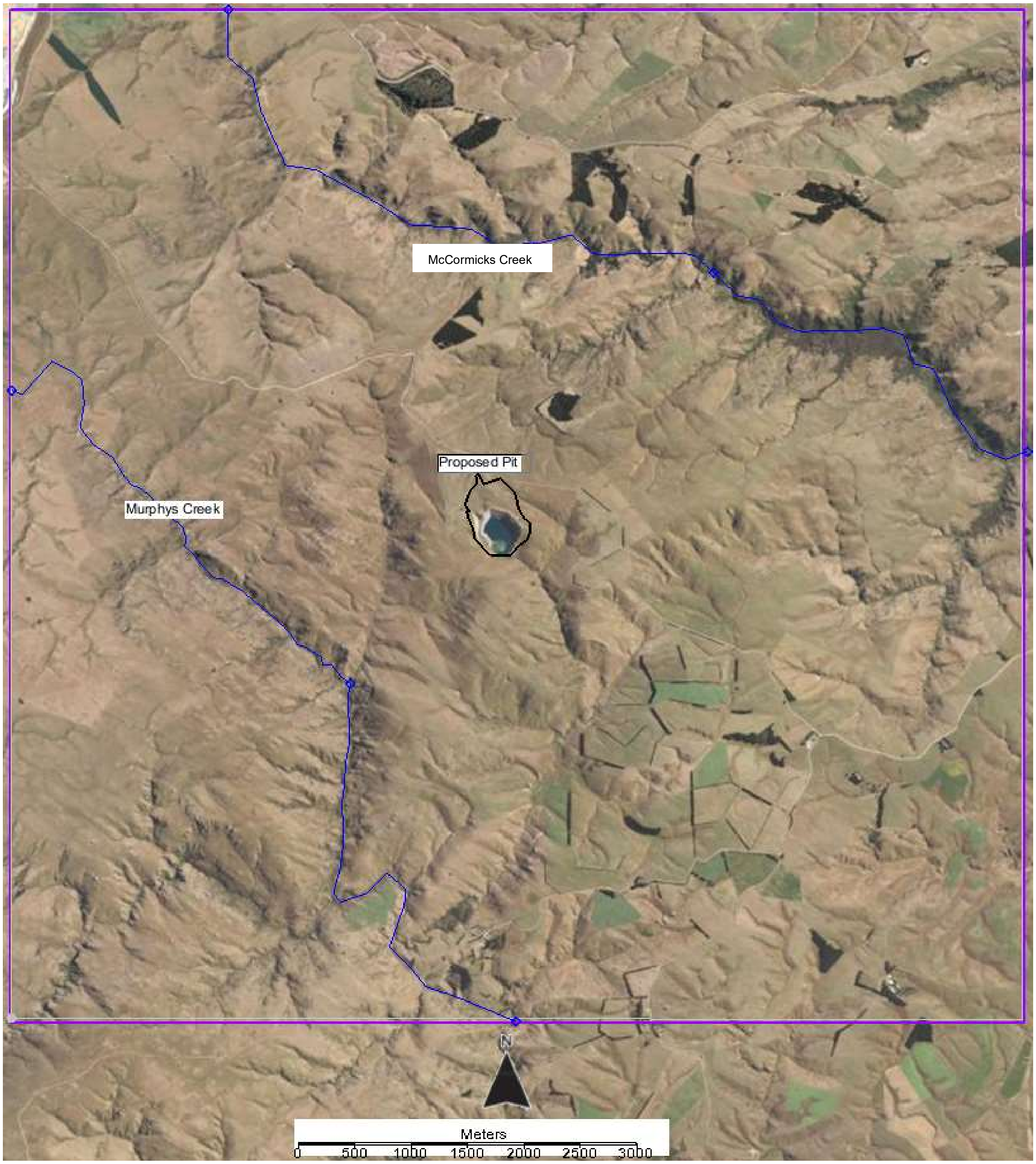


Figure 8 Golden Bar groundwater model domain

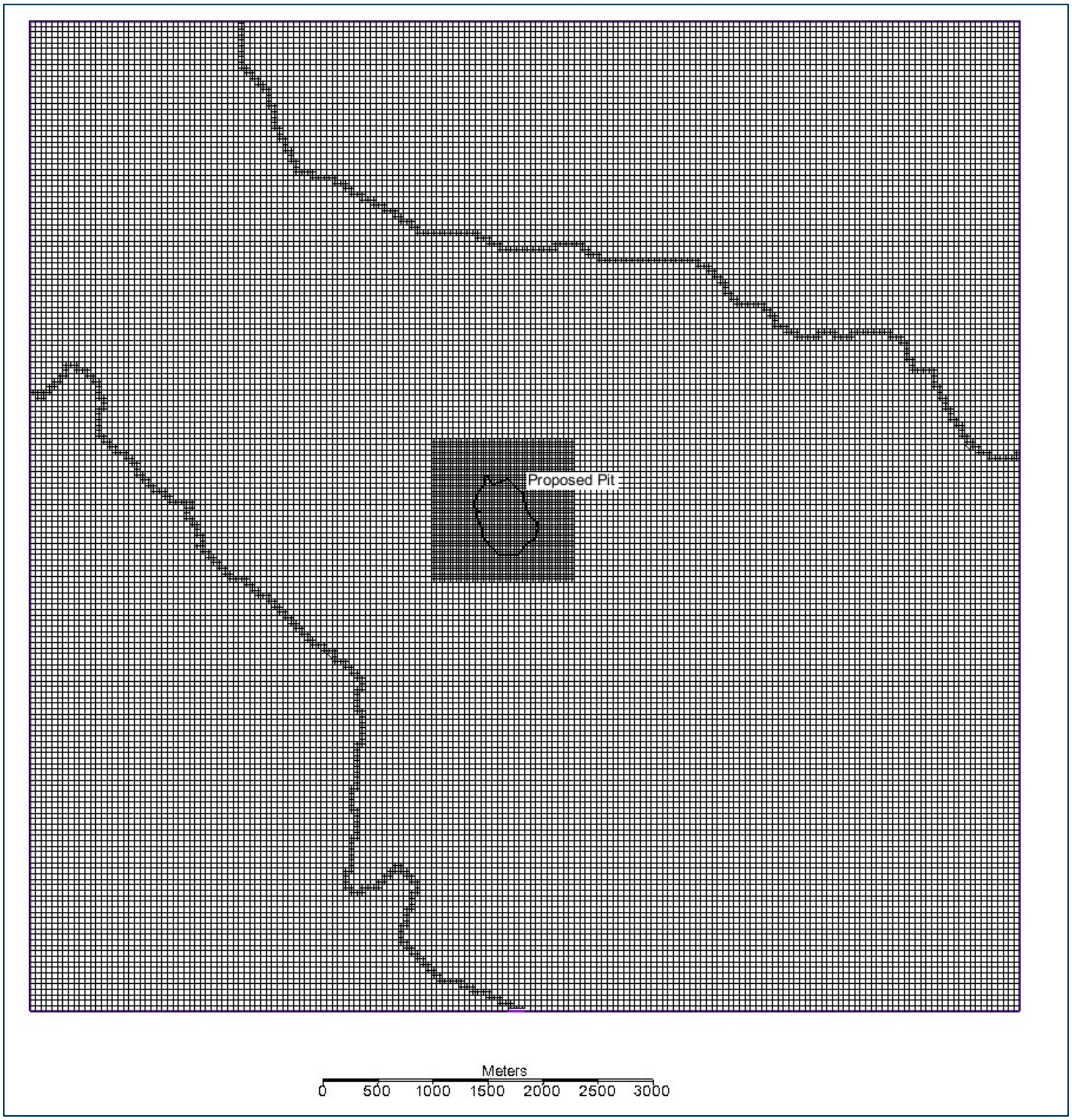


Figure 9 Grid design Golden Bar model

4.2.2 Boundary Conditions

The following boundary conditions have been applied in the model:

- **River Boundary:** The McCormicks Creek and Murphys Creek have been modelled as river boundaries (Figure 10). Riverbed conductance applied was 5 m^2/d/m with river state applied at the topographic level, river bottom elevation was applied 1 m below the river stage level.
- **Drain Boundaries:** Dewatering of the pit has been simulated using the drain boundary conditions, with drain bottom elevation corresponding to the base of the mining. Small creeks and tributaries boundaries have been modelled as drain boundary conditions (Figure 10). Drain conductance applied was 10 m^2/d/m with drain bottom elevation set at topographic level.
- **Recharge boundary**: Several reports (Kingett Mitchell, 2005a&b, Golder, 2011a, CDM Smith, 2016) have noted that the recharge rate of the wider area is around 32 mm/yr (equating to 5.3% of annual rainfall of 607 mm across the whole of the MGP site). The GHD (2021) groundwater model calibration resulted in an applied recharge of 29.2 mm/yr. This value generally reflects 4.5% of GHD’s synthetic annual rainfall average used in the Water Balance Model (GHD, 2021) and resulted in the best overall calibration under steady state conditions. In this assessment, the model was calibrated with recharge rate of 29.2 mm/yr in agreement with previous modelling.
- **No flow boundary:** Along the model edge (due to relatively low hydraulic conductivity of the material).
- **General Head Boundary**: The general head boundary is used to simulate head-dependent flux boundaries and was applied to model the recovery of water level post-mining within the pit. The location of general head boundary applied is presented in Figure 11. The head values for the boundary condition were derived from the surface water modelling results (refer Section 5.7, Figure 34).

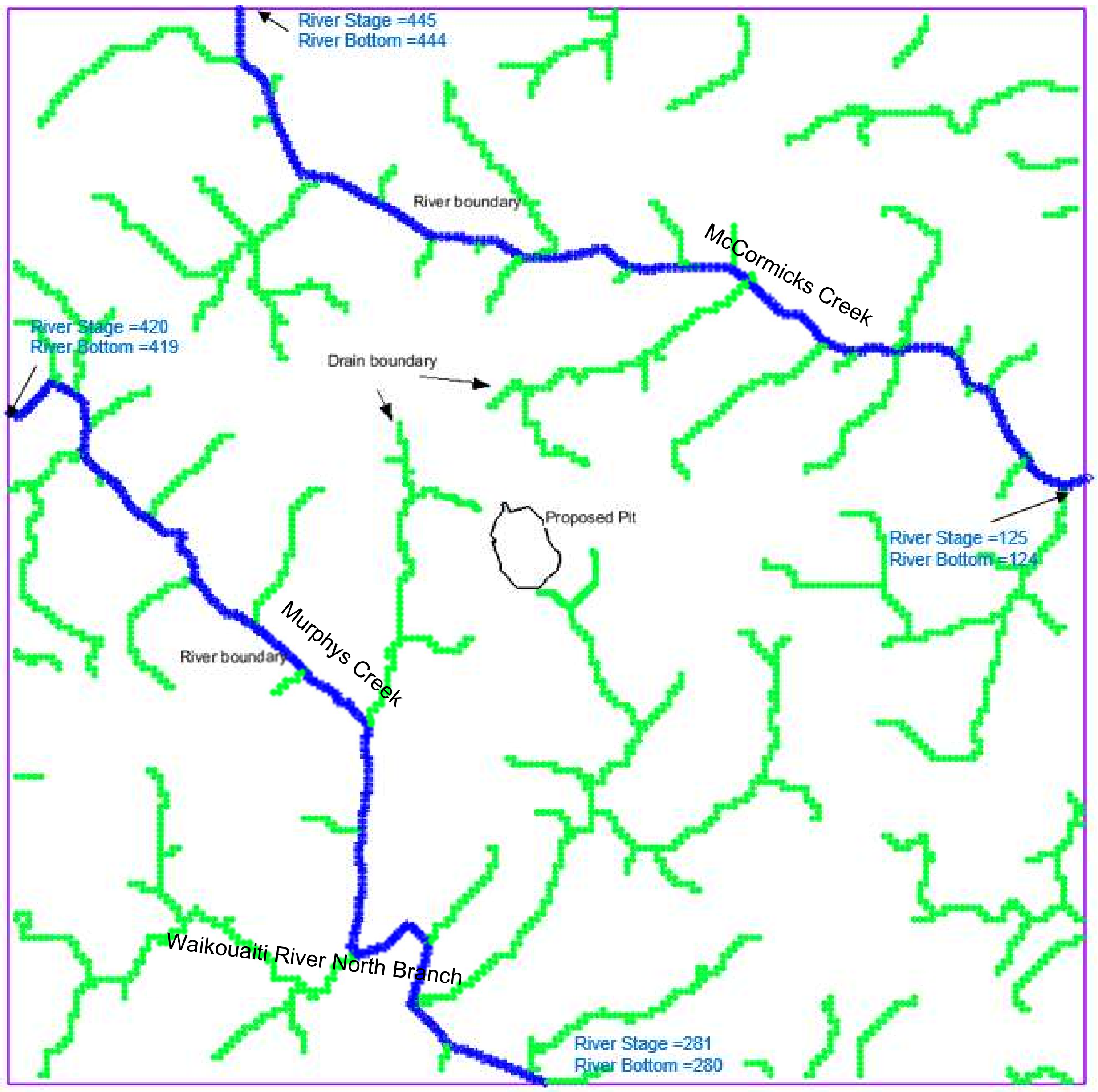


Figure 10 Boundary conditions Golden Bar model.

Blue lines (McCormicksCreek and Murphys Creek) represent river boundaries. Green lines represent drain boundaries (smaller creeks).

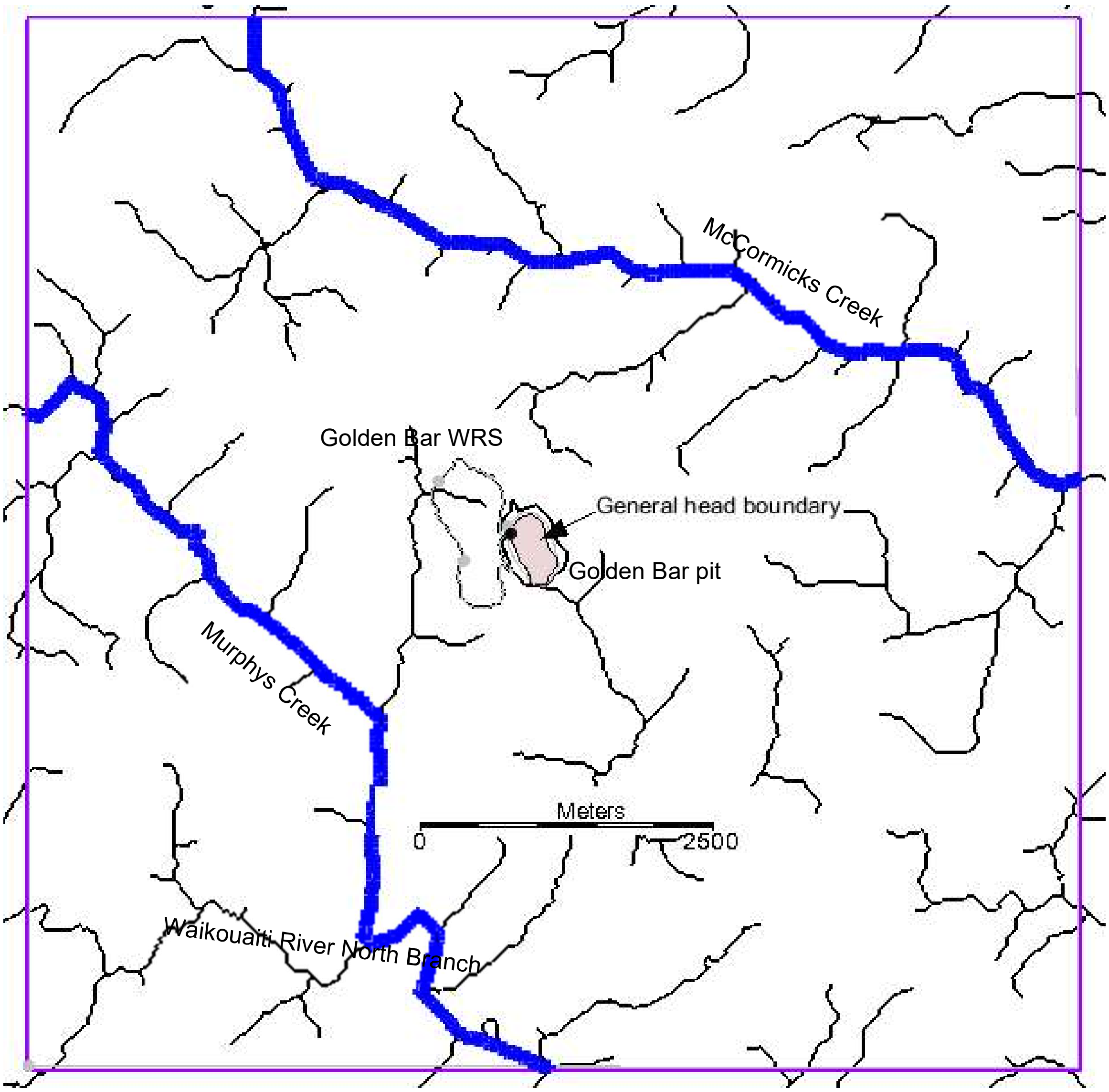


Figure 11 Location of the general head boundary at the proposed pit lake.

4.2.3 Steady-State Model Calibration

For the model calibration, initial model parameters used were based on previous studies (Golder, 2011a, Golder, 2016, GHD, 2021, WSP- Golder, 2022 and GHD, 2024) and values were adjusted during the calibration process. The final hydraulic parameters from the model calibration are presented in Table 2. As discussed above, a uniform recharge rate of 29.2 mm/year was applied in the model.

Table 2 Steady-state model parameters (Golden Bar model)

Unit Name	Model Layer (Thickness of layer)	Kx m/s (m/d)	Kz m/s (m/d)	Ky m/s (m/d)	Specific Yield *	Specific Storage 1/m*
Moderately Weathered Schist (Shallow)	1 (30 m thick)	1.0×10^{-7} (0.0086)	6.0×10^{-8} (0.0052)	2.5×10^{-7} (0.022)	0.02	1E-5
Slightly weathered shist	2 (50 m thick)	5×10^{-8} (0.0043)	5×10^{-9} (0.00043)	5×10^{-8} (0.0043)	0.01	1E-5
Slightly weathered - Unweathered Schist Bedrock	3 - 5 (50 m thick)	1.5×10^{-8} (0.0013)	1.5×10^{-9} (0.00013)	1.5×10^{-8} (0.0013)	0.01	1E-5
Unweathered Schist	6 – 8 (50 m thick each layer)	5×10^{-9} (0.000432)	5×10^{-10} (0.000043)	5×10^{-9} (0.00043)	0.01	1E-5
Waste Rock*	1 (0 to 160 m thick)	1.0×10^{-6} (0.086)	1.0×10^{-6} (0.086)	1.0×10^{-6} (0.086)	0.15	1E-5
Notes:	Kx-denotes horizontal hydraulic conductivity in x direction Ky-denotes horizontal hydraulic conductivity in y direction Kz-denotes vertical hydraulic conductivity Vertical anisotropy represents ratio of hydraulic conductivity in horizontal x (Kx) to z (Kz) directions (Kx/Kz) *Parameter used in transient model only.					

Very limited groundwater level data are available within the model domain (measured January 2016) representing pre- mining groundwater level conditions and have been used as calibration target.

Figure 12 shows the location of boreholes used as groundwater level calibration targets and residuals representing the difference between the measured and modelled groundwater levels. The boreholes are concentrated very close to the pit area. A detailed summary of the boreholes, measured, modelled and residuals are presented in Table 3.

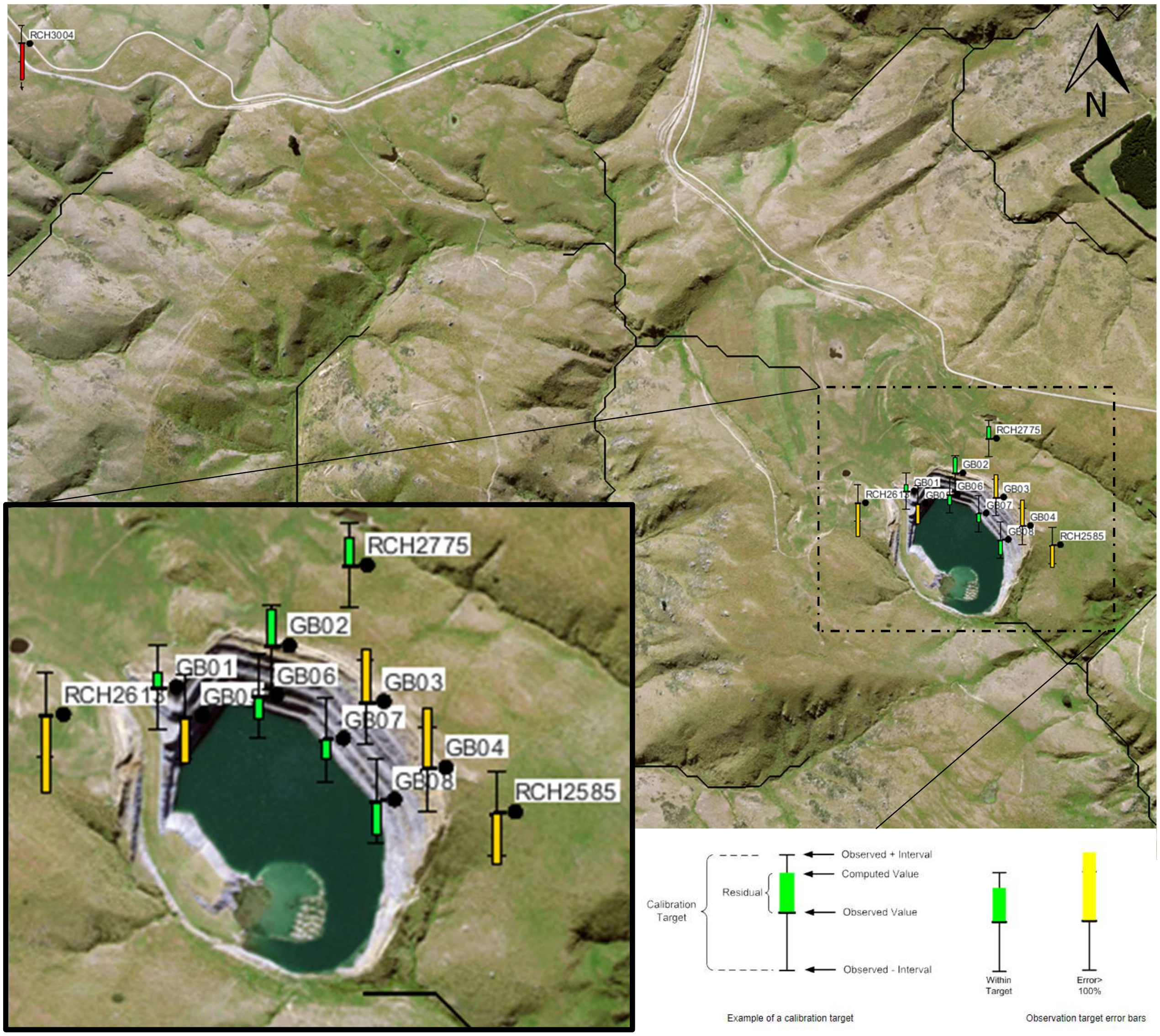


Figure 12 Boreholes used in model calibration and vertical bars showing residual statistics (difference between measured and modelled heads).

Table 3 Measured and modelled groundwater level data

Hole ID	Easting (NZTM2000)	Northing (NZTM200)	Elevation (m RL)	Depth to water (m)	Measured Groundwater level (m RL)	Modelled groundwater level (m RL)	Residual (m) (weightings of 1)
GB01	1406600	4968411	481.94	60.46	502.079	503.82	-1.7
GB02	1406743	4968463	492.02	68.61	503.914	508.38	-4.5
GB03	1406862	4968393	496.63	74.11	504.015	510.22	-6.2
GB04	1406940	4968309	502.64	81.16	501.984	509.14	-7.2
GB05	1406634	4968375	474.2	9.66	510.34	504.88	5.5
GB06	1406727	4968401	474.2	9.44	510.56	507.75	2.8
GB07	1406811	4968346	474.2	9.05	510.95	508.52	2.4
GB08	1406876	4968269	474.2	8.75	511.25	507.14	4.1
RCH2585	1407028	4968253	503.8	60.46	521.69	515.64	6.1
RCH2613	1406458	4968376	471.7	68.61	516.57	507.48	9.1
RCH2775	1406841	4968565	486	74.11	507.2	510.56	-3.4
RCH3004	1404013	4969721	470	2.44	472.44	456.55	15.9

The performance of model calibration is commonly associated with the difference between measured and modelled water levels. This measure is quantified through the scaled root mean square (SRMS) error. The SRMS is expressed as a percentage and is a more representative measure of the fit than the standard root mean squared (RMS), as it accounts for the scale of the potential range of data values. Therefore, if the ratio of the RMS error to the total head change is small, the error is only a small part of the overall model response (Barnett et al, 2012).

The steady-state calibration resulted in a scaled root mean square error (SRMS) of 11.2% when a 50% weight was applied to distant RCH3004 bore value. This bore is located away from the pit and may be recording a perched water table (as depth to water was <10 m with no bore depth data available). For high confidence model, the target SRMS is often < 5-10% (Barnet et al, 2012). The SRMS value obtained for this model is marginally higher than 10%. This is considered reasonable given the boreholes are not screened and cased, so the section of the hole that is having the most influence on the in-hole water level is not actually known.

The modelled computed vs observed head plot (scatter plot) from the steady-state model calibration (RUNID Macraes_IV_GB_SS_025) is presented in Figure 13. The relatively high value of the normalised mean calibration error is mainly due to the very small number of available (one-off) water levels, all within a very small region and with very small value range.

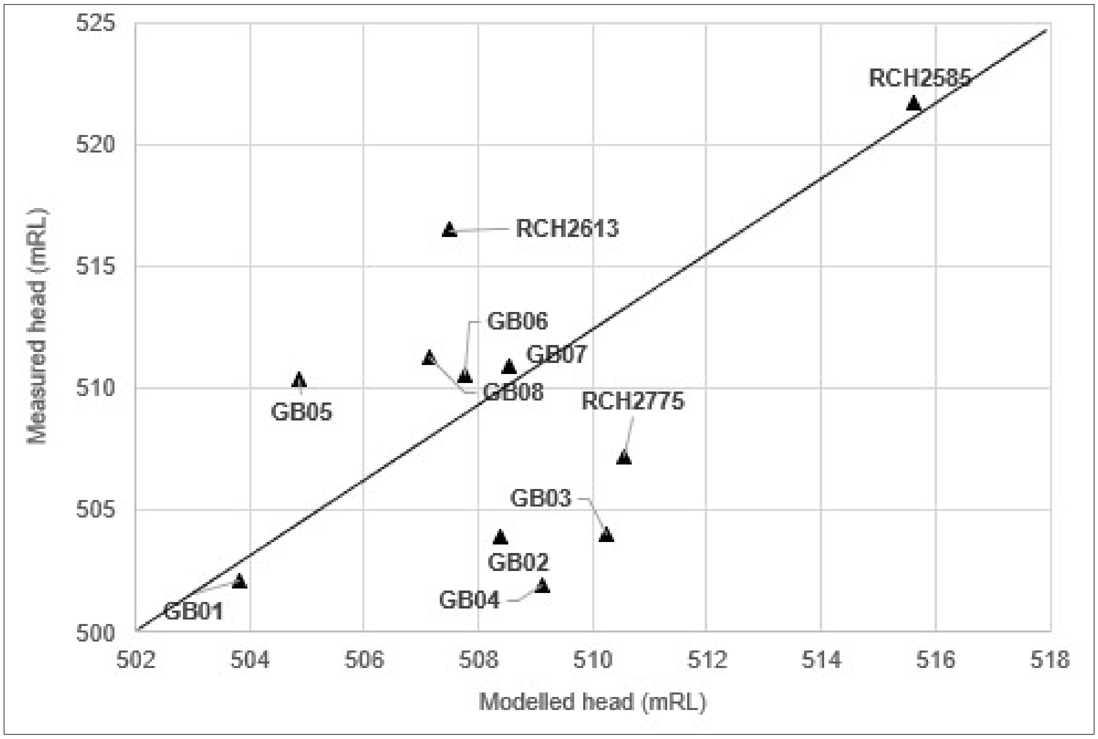


Figure 13 Steady state scatter plot (model computed vs measured head) - Golden Bar model (without the RCH3004)

Steady-state modelled head contours (in layer 1) are presented in Figure 14. Groundwater levels along the Creek and river beads are higher in this image than in Figure 14 because we are looking at layer 3 rather than layer 1. The model has upward hydraulic gradient beneath the river beds.

The overall mass balance (outflows - inflows) for the steady state model (Figure 15) is <0.01%, suggesting that the model is numerically stable. As shown in Figure 15, the main input to the groundwater system is via rainfall recharge with inflow rate of 6,480 m^3/d (or 75.0 L/s) which accouts for 66.6% of the total model inflow of 9,732 m^3/d (or 112.6 L/s). There is some localised recharge from river cells, which is due to infered river bottoms and stages, and is countered by greater drainage in nearby cells.

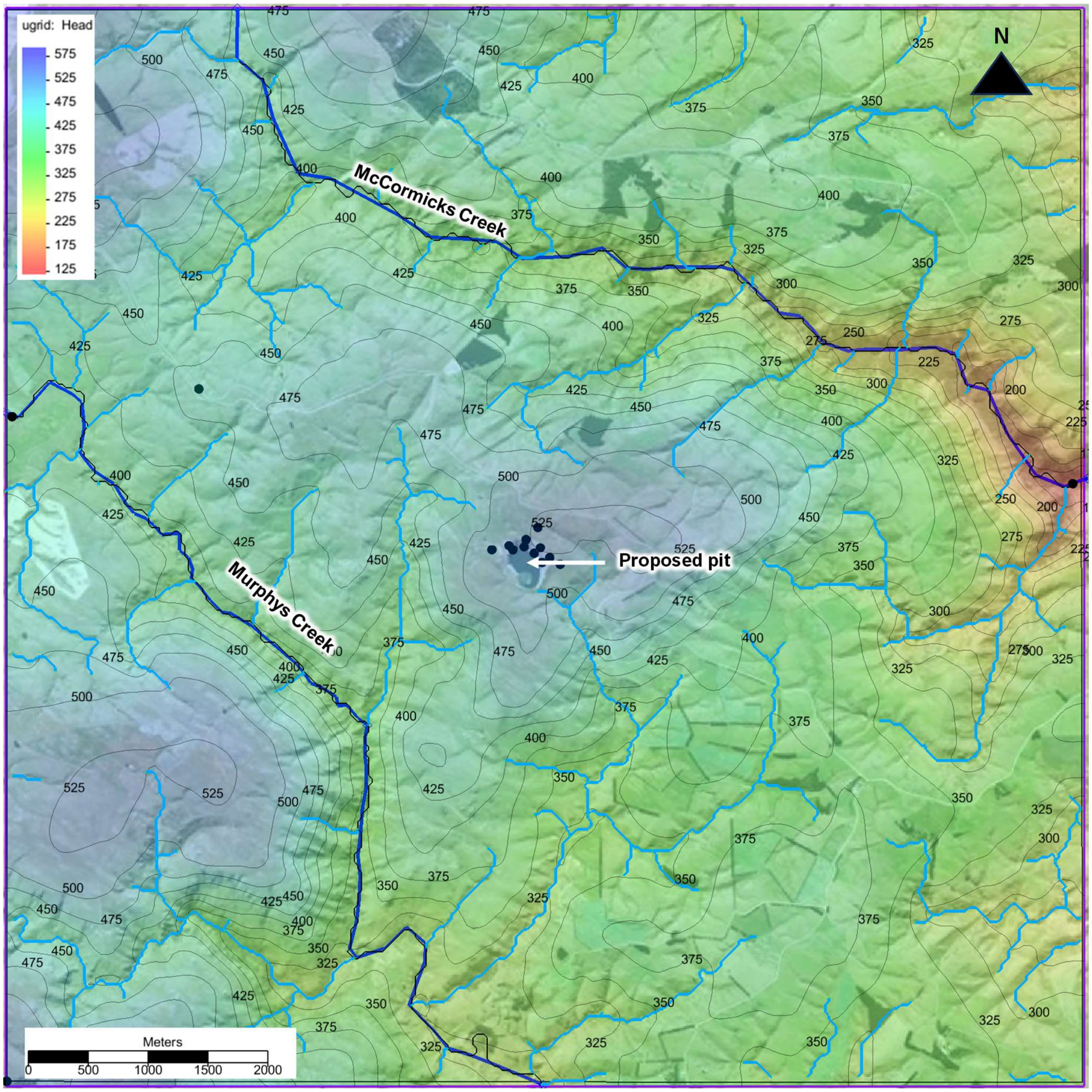


Figure 14 Pre mining steady-state modelled head contours (mRL) in model layer 1 (Golden Bar model). Black dots show the calibration head target locations.

```
 VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP       1 IN STRESS PERIOD       1
 ---------------------------------------------------------------------------------------

    CUMULATIVE VOLUMES      L**3       RATES FOR THIS TIME STEP      L**3/T
    ------------------                 ------------------------

          IN:                                     IN:
          ---                                     ---
            STORAGE =           0.0000              STORAGE =           0.0000
      CONSTANT HEAD =           0.0000        CONSTANT HEAD =           0.0000
             DRAINS =           0.0000               DRAINS =           0.0000
      RIVER LEAKAGE =        3251.8774        RIVER LEAKAGE =        3251.8774
           RECHARGE =        6479.6997             RECHARGE =        6479.6997

           TOTAL IN =        9731.5771             TOTAL IN =        9731.5771

         OUT:                                    OUT:
         ----                                    ----
            STORAGE =           0.0000              STORAGE =           0.0000
      CONSTANT HEAD =           0.0000        CONSTANT HEAD =           0.0000
             DRAINS =        8420.7836               DRAINS =        8420.7836
      RIVER LEAKAGE =        1310.7957        RIVER LEAKAGE =        1310.7957
           RECHARGE =           0.0000             RECHARGE =           0.0000

          TOTAL OUT =        9731.5793            TOTAL OUT =        9731.5793

           IN - OUT =      -2.1339E-03             IN - OUT =      -2.1339E-03

PERCENT DISCREPANCY =          -0.00     PERCENT DISCREPANCY =          -0.00
```

Figure 15 Steady state Golden Bar model water balance summary (units of cubic metres per day)

4.2.4 Predictive Analysis

4.2.4.1 Dewatering

Mining at the current Golden Bar Stage 1 pit ceased in 2005, and the water level in the pit reached the current spill level (approximately 497.5 m RL) in 2018. Existing conditions have been simulated with a transient flow model from 2005 to 2025 (a total of 20 years). Mining and associated dewatering for the proposed expansion of the pit has been simulated from 2024– 2025 (2 years of dewatering) as per the Macraes mining schedule.

Modelled head contours at the end of proposed dewatering (end of 2025) are plotted in Figure 16. Model layer 3 has been chosen because upper layer 1 is largely dry near the pit and most of dewatering occurs from within this layer 3.

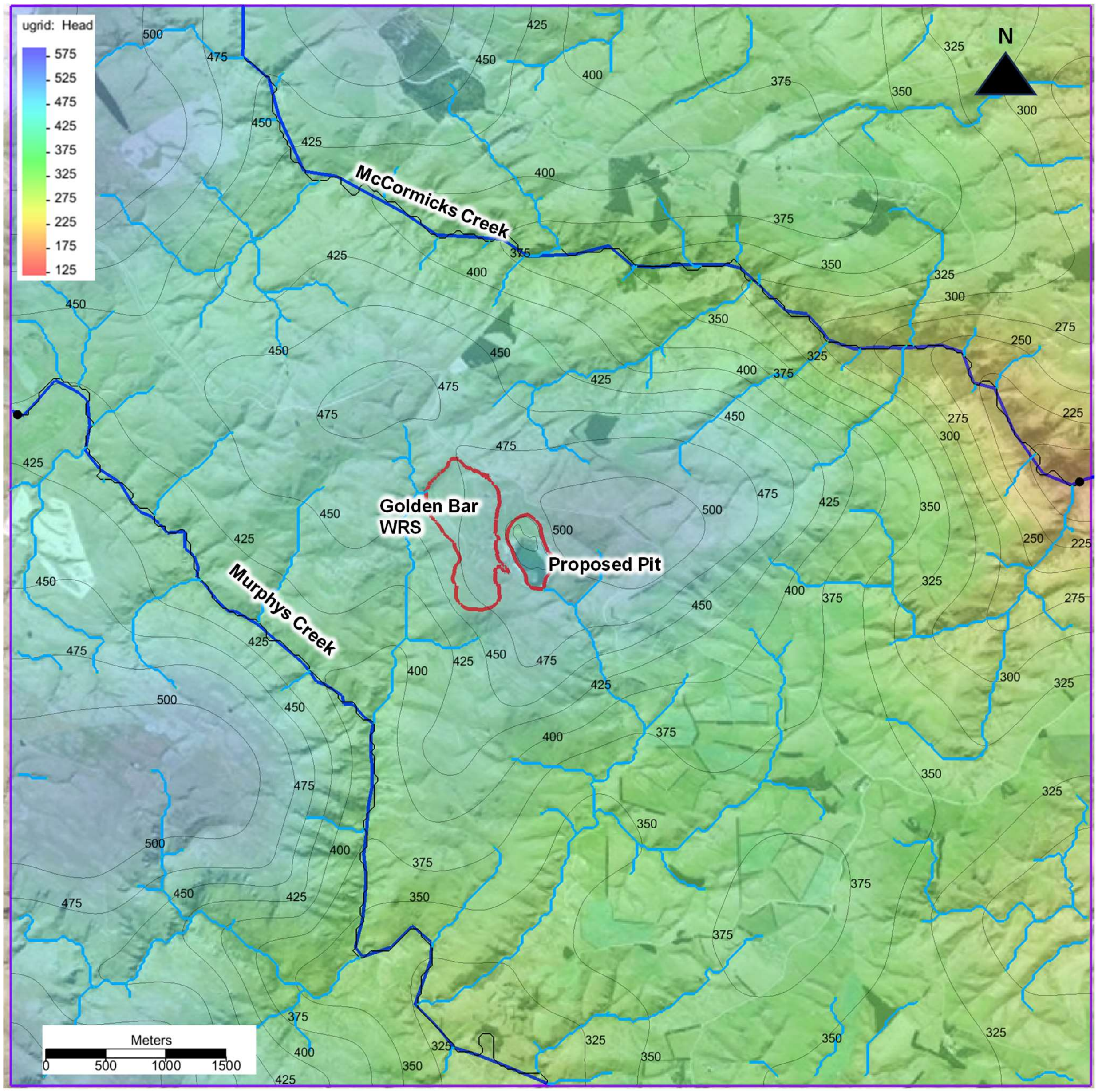


Figure 16 Hydraulic head (mRL) in model layer 3 at the end of dewatering for the pit expansion

Estimated groundwater inflow into the existing and proposed expansion of the Golden Bar pit are presented in Figure 17 and Figure 18 respectively. As presented in these figures, groundwater inflow into the existing pit is approximately 0.2 L/s and for the proposed pit expansion, inflow rate is estimated to range from 1.8 L/s (at the beginning) to 0.7 L/s (towards the end of dewatering).

The water balance at the end of proposed pit dewatering/mining is presented in Figure 19. Modelling results indicate that the river leakage inflow rate results for dewatering the pit are identical to that of the steady-state simulation (Figure 15). This indicates that the existing and proposed additional pit dewatering at the Golden Bar pit will have negligible impact to the groundwater contributions to the McCormicks Creek and Murphys Creek flows. There is a slight increase in total drain outflow at the end of proposed dewatering as shown in Figure 19, compared to the drain outflow estimated from the steady-state simulation. This increase is mainly attributed to the additional outflow from the drain boundary applied to model dewatering for the pit expansion. The modelled drain outflow rate of 8,469 m^3/d (value shown in Figure 19) is a combination of pit outflow (from dewatering) as well as outflow to the smaller surface creeks that discharge to McCormicks Creek and Murphys Creek. Reduction of the groundwater contribution to the smaller surface creeks (represented by drains outflow) from the pit dewatering is

~48 m^3/d (0.55 L/s) less than the total drain outflow estimated from the steady-state simulation (Figure 15). This reduction is less than 1% of the steady-state drain discharge of 8,421 m^3/d, suggesting that changes to the groundwater contribution to the base flow of local creeks/streams from the existing and proposed additional pit dewatering at the Golden Bar pit are expected to be negligible.

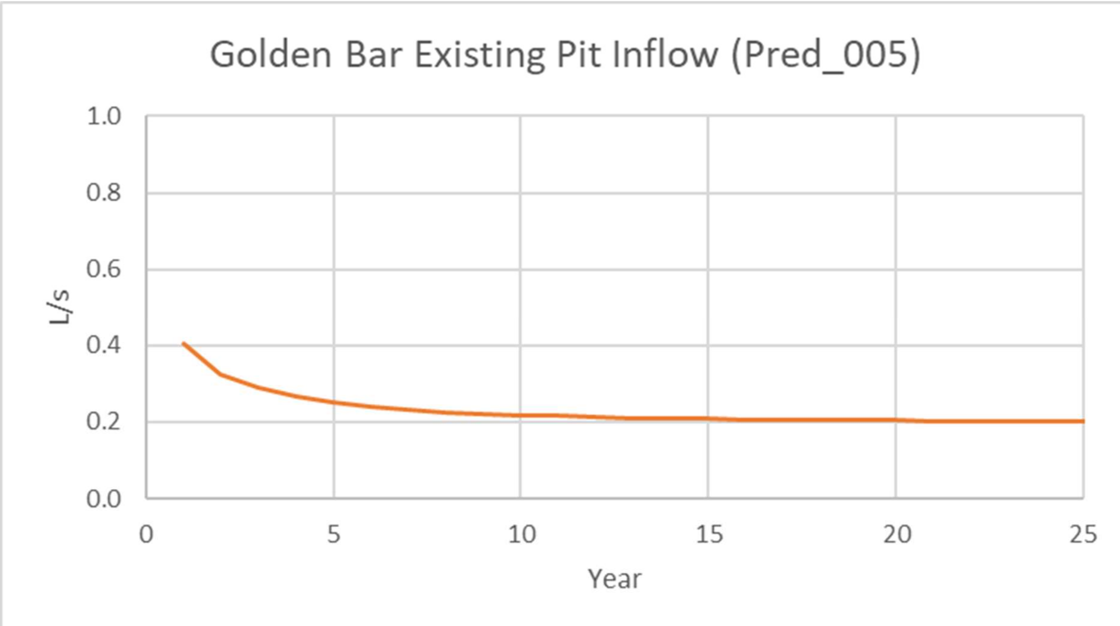


Figure 17 Existing pit inflow (Golden Bar pit)

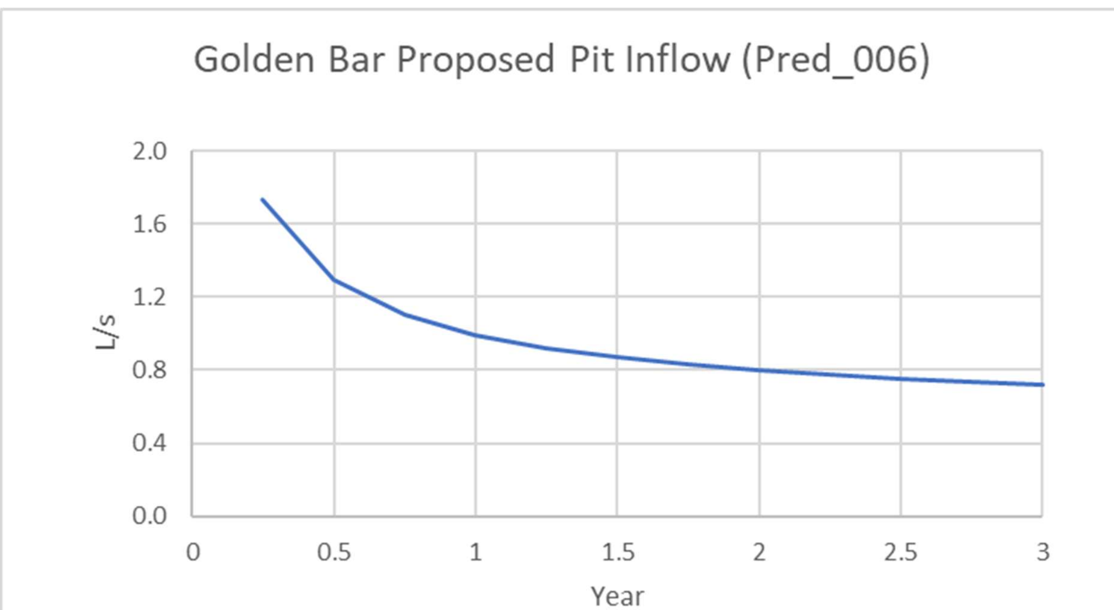


Figure 18 Modelled inflows to the pit expansion (Golden Bar pit)

```
VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP       3 IN STRESS PERIOD      12
-------------------------------------------------------------------------------------

   CUMULATIVE VOLUMES      L**3       RATES FOR THIS TIME STEP      L**3/T
   ------------------                 ------------------------

         IN:                                   IN:
         ---                                   ---
           STORAGE =      112273.2694            STORAGE =         49.0509
     CONSTANT HEAD =           0.0000      CONSTANT HEAD =          0.0000
            DRAINS =           0.0000             DRAINS =          0.0000
     RIVER LEAKAGE =     3560808.3601      RIVER LEAKAGE =       3251.8801
          RECHARGE =     7095271.0309           RECHARGE =       6479.6997

          TOTAL IN =    10768352.6604           TOTAL IN =       9780.6307

        OUT:                                  OUT:
        ----                                  ----
           STORAGE =        2331.9302            STORAGE =          0.8817
     CONSTANT HEAD =           0.0000      CONSTANT HEAD =          0.0000
            DRAINS =     9330761.4427             DRAINS =       8469.0169
     RIVER LEAKAGE =     1435259.1751      RIVER LEAKAGE =       1310.7321
          RECHARGE =           0.0000           RECHARGE =          0.0000

         TOTAL OUT =    10768352.5480          TOTAL OUT =       9780.6307

          IN - OUT =           0.1124           IN - OUT =     -1.2829E-05

 PERCENT DISCREPANCY =          0.00     PERCENT DISCREPANCY =         -0.00
```

Figure 19 Water balance summary at the end of 3 year of proposed Golden Bar pit dewatering

4.2.4.2 Groundwater Recovery

Groundwater recovery was computed for 400 years with the proposed Golden Bar pit-lake level modelled as a general head boundary condition. The head values for the boundary condition were derived from the surface water modelling results (refer Section 5.8). The head value applied with time is presented in Figure 20, with the overflow elevation at 497.5 mRL.

Modelled pressure head contours at the end of the recovery run in model layer 1 are presented in Figure 21. Modelling results indicate that at the end of 400 years, groundwater levels have mostly recovered through-out the model domain other than in the immediate vicinity of the proposed pit where the water level is approximately 20 m below pre-mining steady-state conditions.

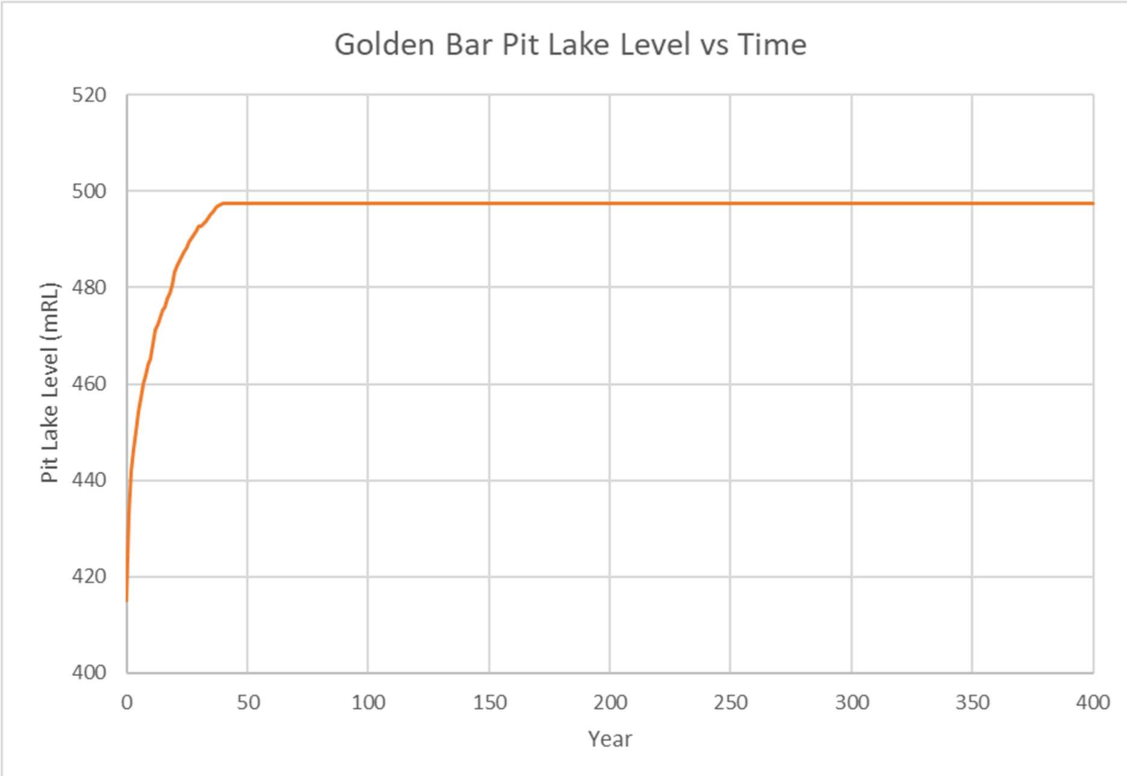


Figure 20 Golden Bar Stage 2 Pit Lake water level recovery

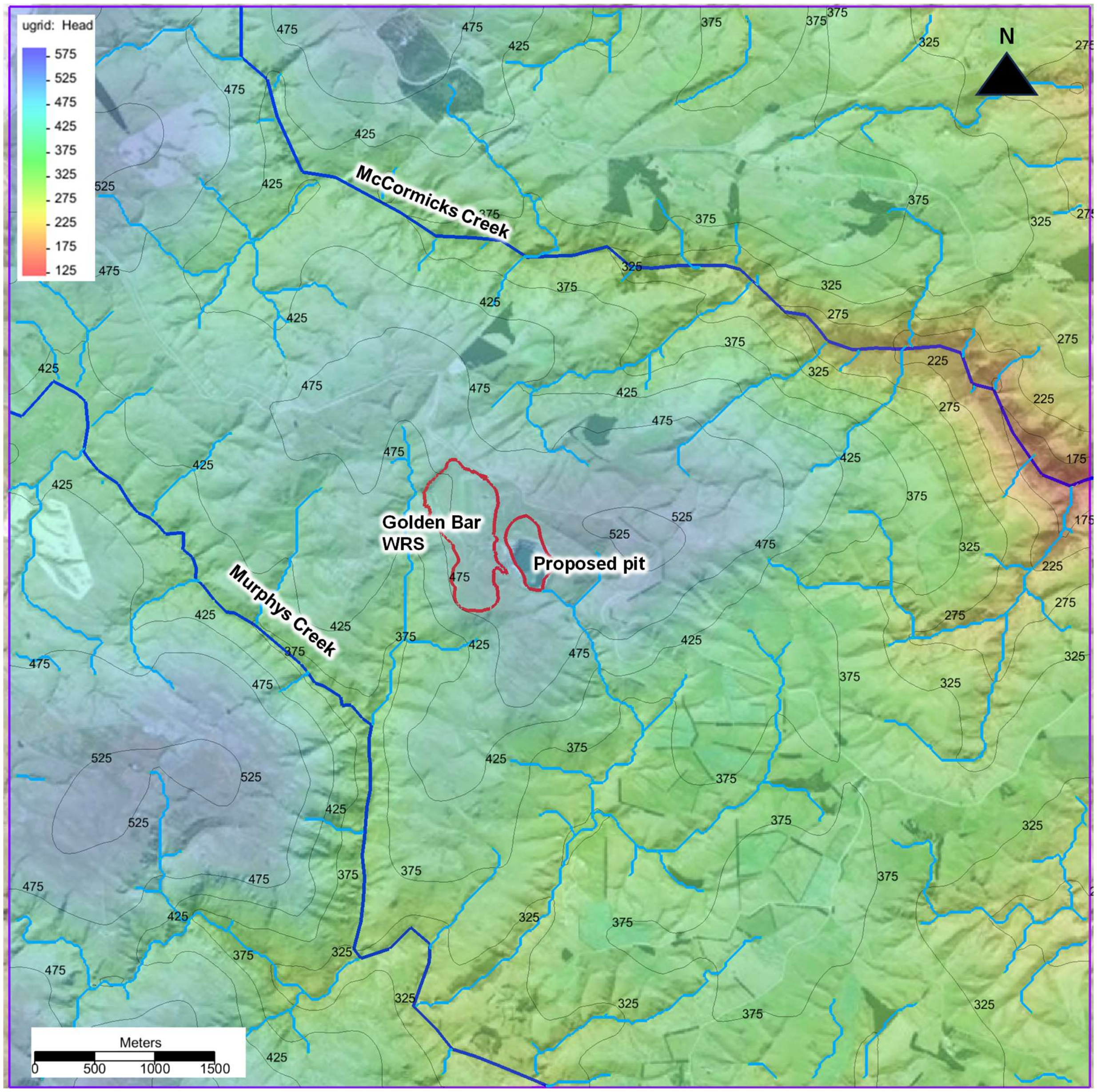


Figure 21 Hydraulic head (mRL) at the end of 400 years of recovery in model layer 1.

4.2.4.3 Contaminant Transport

Contaminant transport modelling was undertaken using solute transport modelling code (MODFLOW USG-TRANSPORT) VERSION 1.8.0 at the start of the water level recovery run for the Golden Bar Pit Lake and for a total of 400 years with the following inputs:

– Sulphate has been modelled due to its expected elevated concentration (relative to other key contaminants), its existing elevated nature in some receiving surface water bodies around the MGP site as a result of mining activity, and its limited ability to attenuate within the groundwater system, It is therefore considered a conservative element with which to assess contaminant mobilisation and transport from the backfilled waste, WRSs and subsequent pit lakes to receiving surface water bodies via the groundwater system.

– The sulphate concentration applied to the Golden Bar Pit Lake is 400 mg/L. The value applied has been based on the concentration values estimated in MWM, 2024.

- The sulphate concentration applied to the Golden Bar WRS (labelled zone 20 shown in Figure 25) is 2,048 mg/L based on an average WRS height of 29.4 m and the height / concentration relationship defined in MWM (2023b)
- Effective porosity values equal to specific yield values (Table 2)
- Longitudinal dispersivity value = 20 m (assumed 10% of plume length based on initial test run where plume was expected to migrate approximately 200 m)
- Transverse dispersivity value = 2 m (10% of the longitudinal)

Water balance error and solute transport mass balance error for this run as well as all previous model runs was <0 indicating all model runs completed were numerally stable.

The extent of the sulphate plume at the end of 400-year simulation is presented in Figure 22, Figure 23 and Figure 24 for model layers 1, 2 and 4 (L1, L2, L4) respectively. In these figures, plume is defined with the outer concentration of 10 mg/L. As presented in these figures, the maximum horizontal extent of the plume is approximately 800 m to the north-east of the source area (Golden Bar WRS) and approximately 900 m to the south-east of the source area (Golden Bar Pit Lake).

Modelling results indicate that the sulphate plume in layer 1 (Figure 22) is moving towards the Murphys Creek catchment, rather than the McCormicks Creek catchment, with the upper reaches of Murphys Creek likely to receive higher concentrations of contaminants relative to the McCormicks catchment which is expected to receive a relatively small impact from the Golden Bar area.

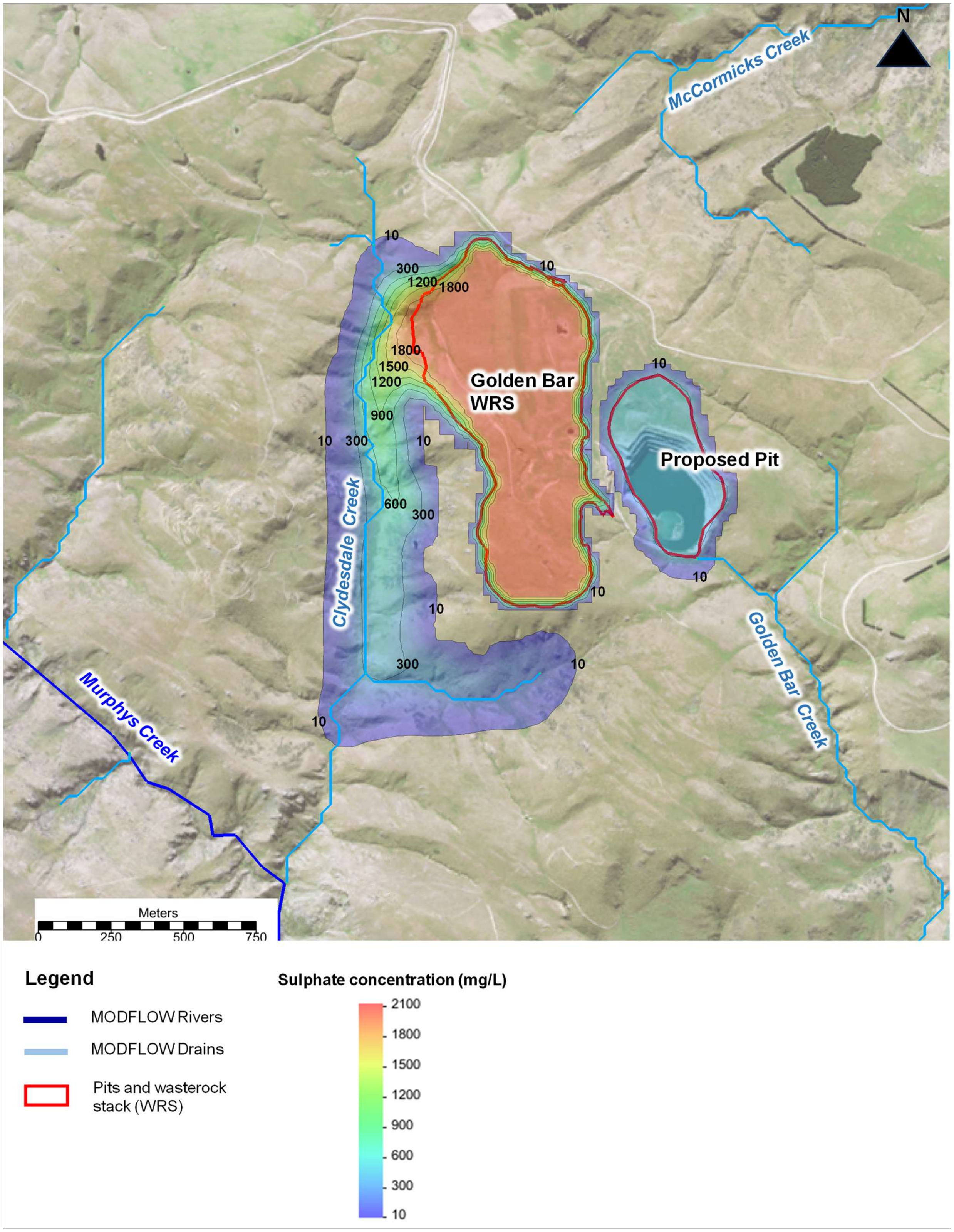


Figure 22 Contour plot showing sulphate plume extent in 400 years in model layer 1

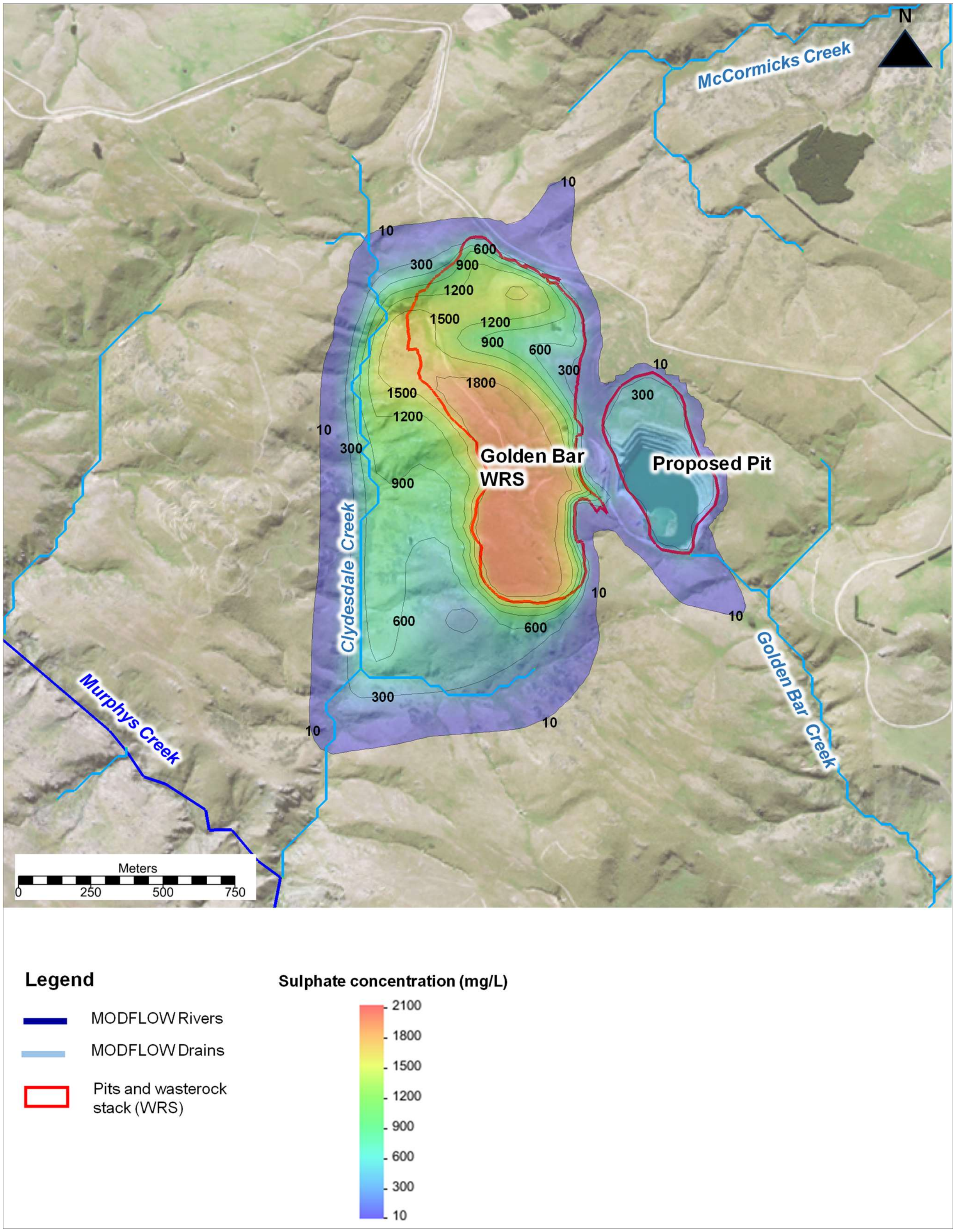


Figure 23 Contour plot showing sulphate plume extent in 400 years in model layer 2

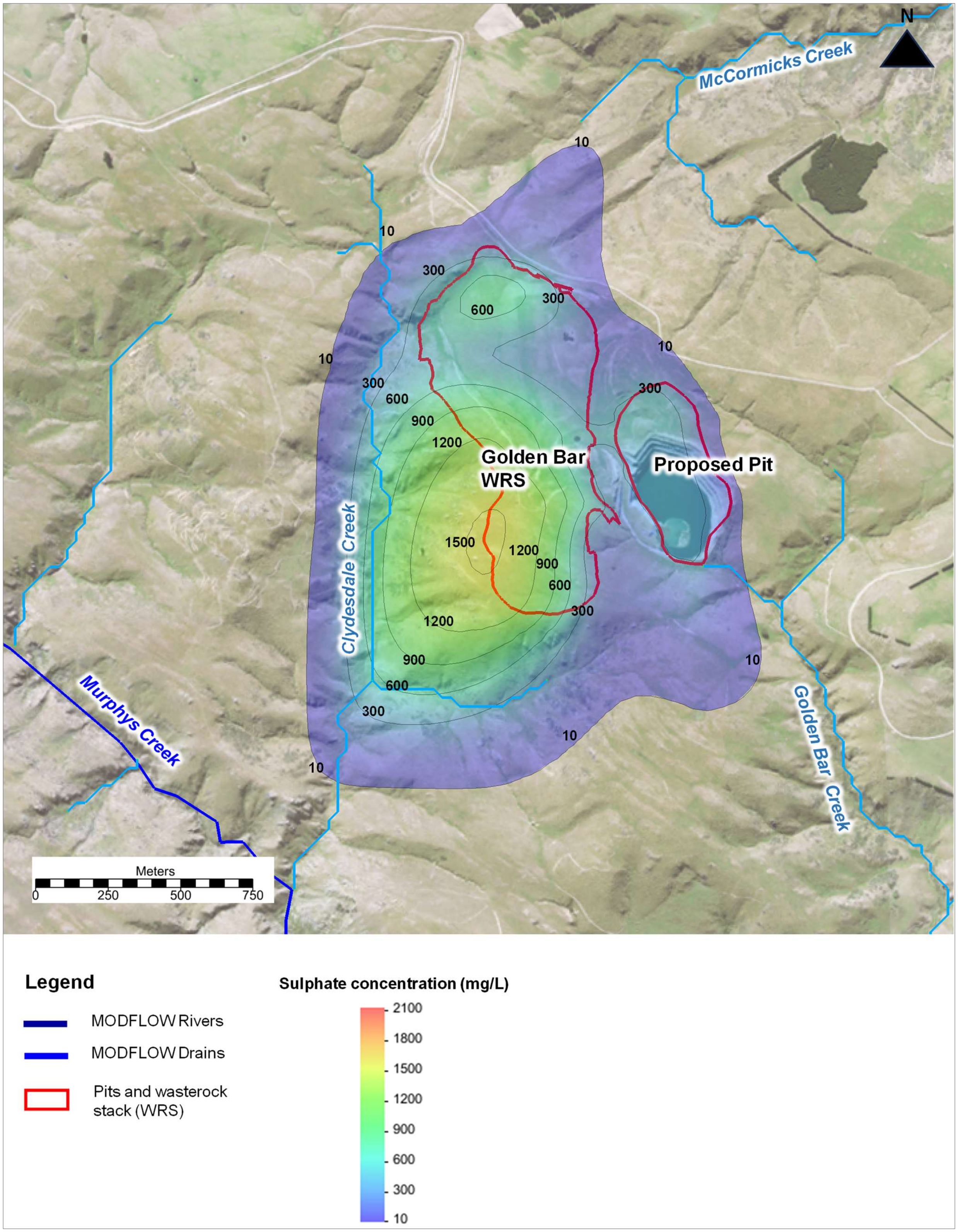


Figure 24 Contour plot showing sulphate plume extent in 400 years in model layer 4

Figure 24 shows the bulk of the modelled sulphate plume moving towards Murphys Creek catchment with a minor plume extending towards the McCormicks Creek catchment. Clydesdale Creek is likely to receive the highest contaminant concentrations. McCormicks Creek catchment is expected to have a relatively small impact from the Golden Bar area relative to the southern catchment.

Different zones were created to represent the WRS and pit lake to estimate inflows and outflows through those zones, and these are presented in Figure 25. Estimated groundwater flow rates with time from the Golden Bar WRS (zone 20) and the Golden Bar Pit Lake (zone 10) are presented in Figure 26 and Figure 27 respectively. As presented in these figures, the long-term seepage outflow from the Golden Bar WRS is estimated at 0.5 L/s, however, only 0.2 L/s is migrating via layer 1 and is likely to end up in the surface water courses.

Figure 22 specifically shows contaminants transported away from Golden Bar WRS within model Layer 2 entering Layer 1 around Clydesdale Creek to the west of the WRS and with likely discharges to the creek. Contaminants in the deeper layers will also discharge to the creeks, given the simulated upward hydraulic gradients beneath the creeks.

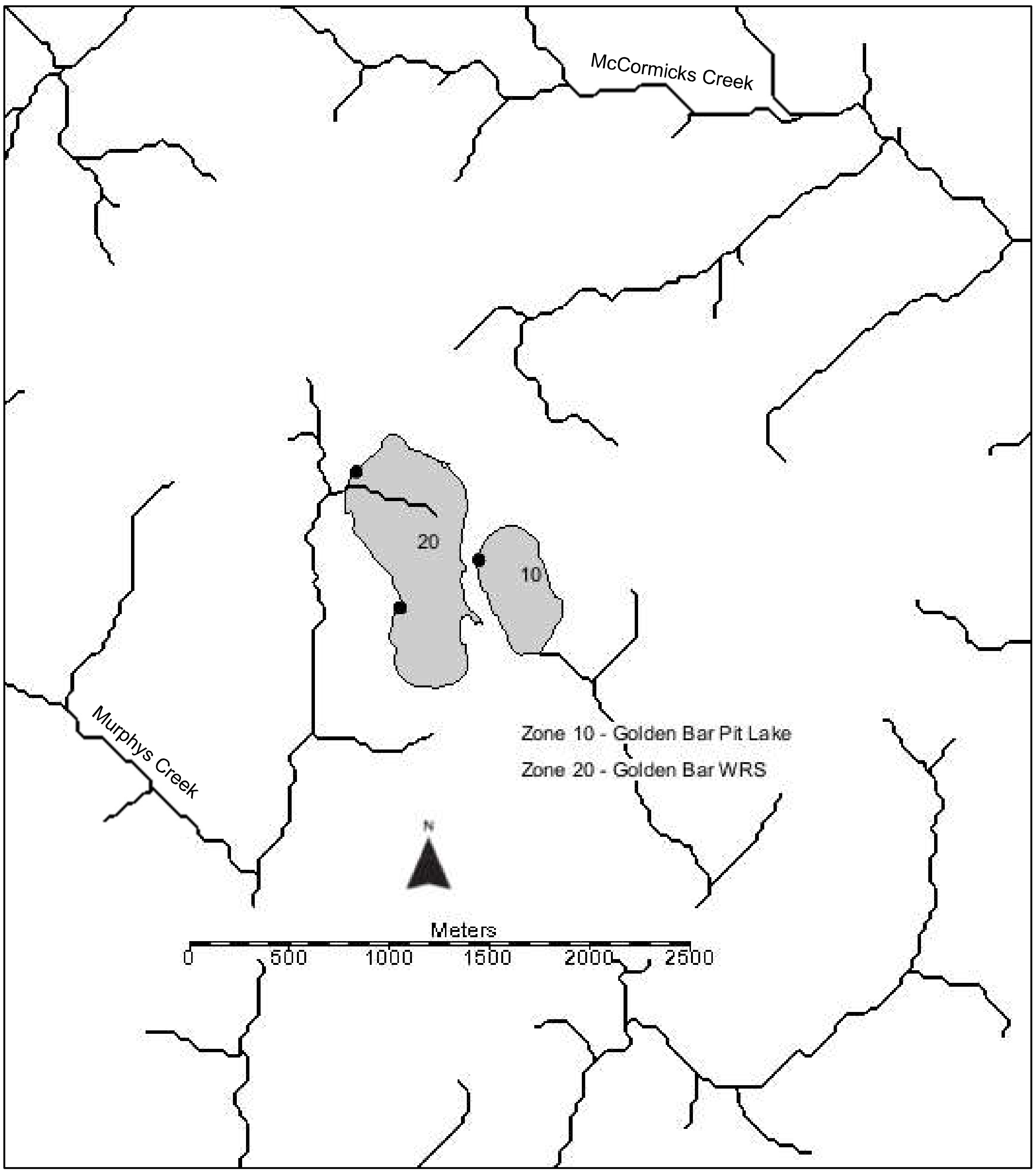


Figure 25 Location plan of zones to assess inflow and outflow during recovery.

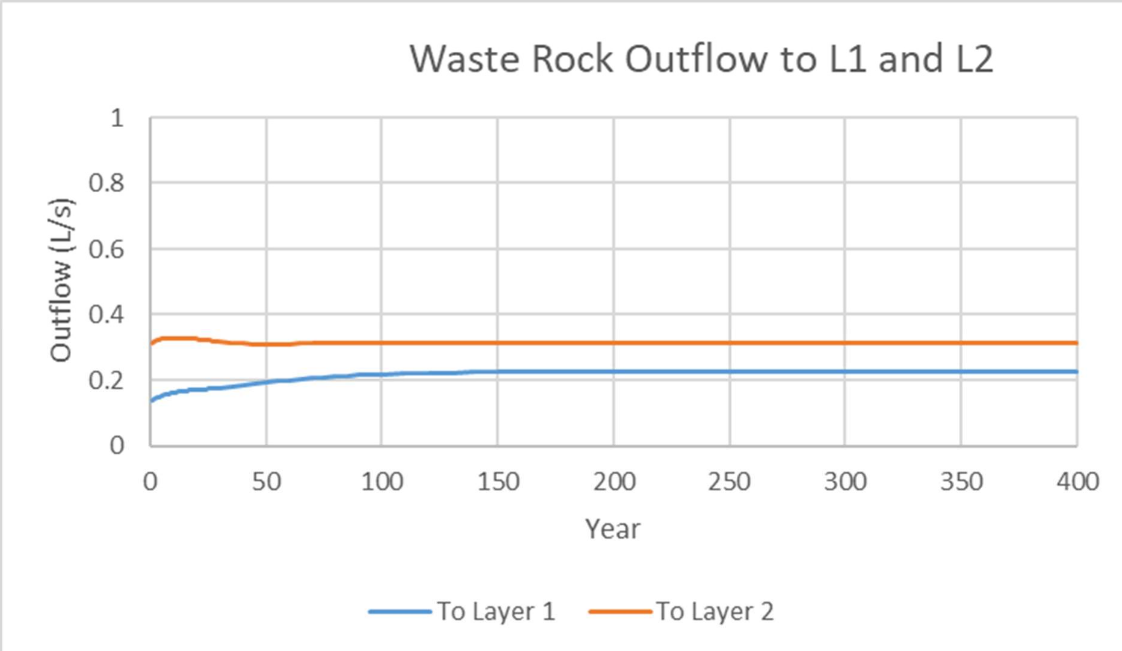


Figure 26 Seepage flow rate from Golden Bar WRS (zone 20) to Zone 1 (Layer 1) and Zone 21 (Layer 2)

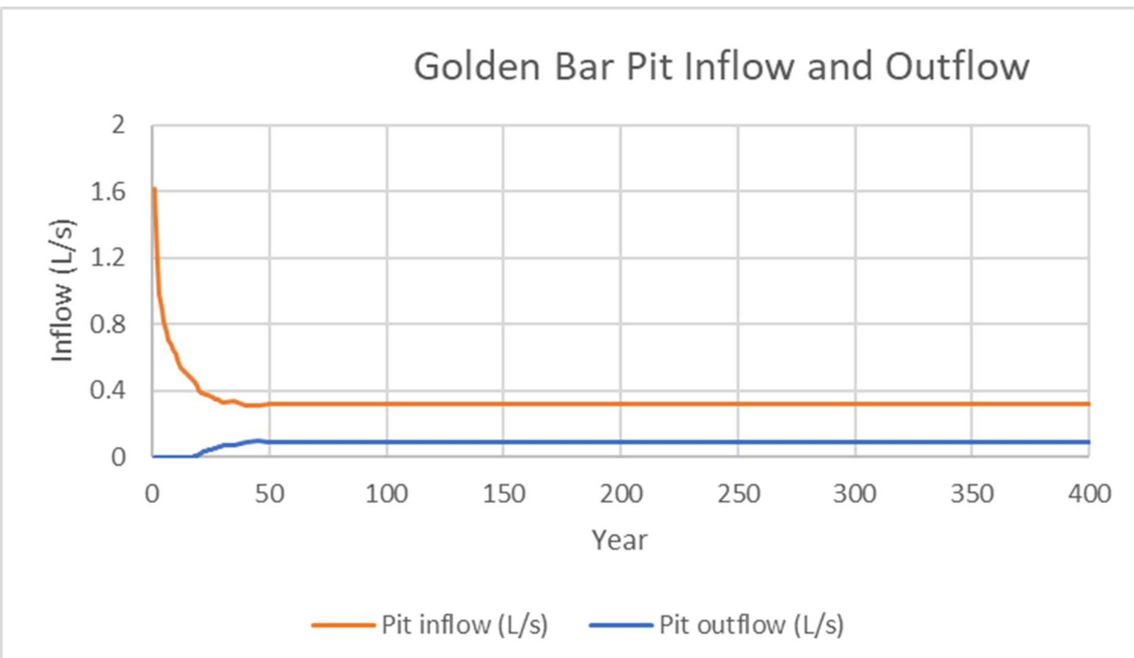


Figure 27 Groundwater in and outflow from the Golden Bar Stage 2 Pit Lake

The total modelled contaminant (sulphate) mass estimated to discharge into the creeks of the NBWR catchment has been calculated utilising the results from the contaminant transport modelling (Figure 21) and simulated flows through the surface water boundaries. The sulphate flux (of all groundwater water discharging up stream of the compliance monitoring location MC02 at Clydesdale Creek, Figure 33) is estimated to be ~26 kg/day 20 years post closure), 76 kg/day (230 years post closure) and 80 Kg/day (400 years post closure). These values represent contaminants sourced from the Golden Bar area only. The sulphate flux estimated to be discharged at Golden Bar Creek (GB02) and towards McCormicks Creek are considered minor ~0.1 Kg/day (230 years post closure).

4.3 Groundwater Summary

A numerical groundwater 3D model of the Golden Bar pit area has been developed using MODFLOW-USG and MODFLOW-USG-TRANSPORT. The 3D model has been used to assess groundwater inflow into the existing and proposed expanded pit as well as during groundwater recovery for 400 years.

Modelling results indicate that groundwater inflow rates to the proposed Golden Bar pit extension range from 1.8 L/s (at the beginning of the excavation) to 0.7 L/s (towards the end). At the end of 400 years, groundwater levels are mostly recovered through-out the model domain other than in the immediate vicinity of the proposed pit where the water levels are estimated to be approximately 20 m below modelled pre-mining steady-state conditions. Estimated changes to the groundwater contribution (less than 1%) to the base flow of local creeks/streams from the existing and proposed additional pit dewatering at the Golden Bar pit are expected to be negligible.

The contaminant plume (defined by the 10 mg/L concentration of sulphate) from the Golden Bar WRS and the Golden Bar Pit Lake is modelled to extend approximately 500 m (from the southern limit of the Golden Bar WRS) and approximately 900 m (from the southeastern limit of the pit lake) to the south-east direction in 400 years. Results indicate that the McCormicks Creek catchment to the north of the Golden Bar area is expected to receive a relatively minor component of the contaminants from the Golden Bar area, with the majority of the surface water impacts constrained to the upper reaches of the Clydesdale Creek (a tributary of the NBWR). The sulphate flux (of all groundwater water discharging up stream of the compliance monitoring location MC02 at Clydesdale Creek, Figure 33) is estimated to be ~26 kg/day 20 years post closure), 76 kg/day (230 years post closure) and 80 Kg/day (400 years post closure). These values represent contaminants sourced from the Golden Bar area only. The sulphate flux estimated to be discharged at Golden Bar Creek (GB02) and towards McCormicks Creek are considered minor ~0.1 Kg/day (230 years post closure).

The model was calibrated in the steady-state conditions using very limited available pre-mining water level data very close to and within the pit before undertaking model predictions. Monitoring (both water level and water quality) of existing and additional groundwater monitoring wells in the wider vicinity of the proposed pit extension and the WRS as well as near McCormicks Creek and Murphys Creek prior to and during mining will assist to a better model calibration (representing the existing stage) and to confirm the envelope of effects presented in this assessment.

5. Surface Water Assessment

5.1 Introduction

GHD have previously developed a site wide water balance model (WBM) for OGNZL operations at the Macraes Gold Mine in 2018. This WBM later incorporated the Deepdell North Stage III Project and assessed the potential impact on downstream water quality associated with the project. The combined analysis showed a low potential for future non-compliance in Deepdell Creek and Shag River receiving water bodies and is reported in GHD, 2019. This WBM has since been optimised and updated to incorporate subsequent site changes, additional monitoring data and to assess surface water quality impacts of specific mining projects at Macraes with the results of the later documented in following reports, each of which have been utilised to support the consenting of the specific projects:

– GHD 2020. GPUG Cumulative Effects Assessments. Report prepared for Oceana Gold (New Zealand) Ltd
– GHD 2021. TTTSF Crest Raise. [RL 560-568 m RL] Surface and Groundwater Assessment. Report prepared for Oceana Gold (New Zealand) Ltd
– GHD 2022a. TTTSF Crest raise. [RL 568-570 m RL] Surface Water and Groundwater Assessment. Report prepared for Oceana Gold (New Zealand) Ltd.
– GHD 2022b. Frasers Co-disposal Surface Water and Groundwater Assessment. Report prepared for Oceana Gold (New Zealand Ltd, 10 November 2022.

The construction, calibration, and input data of the current Goldsim WBM are well documented throughout the above assessments and can be used to estimate future impacts of receiving water quality as a result of site activities and rehabilitation activities.

Updates to the WBM which have been implemented include:

– Revised WRS seepage quantity and quality estimates. The WBM now estimates sulphate concentrations in seepage water based on correlations with WRS height as presented in Mine Waste Management (2022). This also applies a sulphate ceiling in which geochemical equilibrium would limit forever increasing concentrations and correlations of other contaminants to sulphate concentrations to capture the key consenting parameters.
– Recalibration at key compliance and monitoring points utilising revised catchment boundaries and up to date water quality monitoring data.

Inclusion of ground water interactions within the pits based on inflow/outflow relationships presented in Section 4.2.4 of this report.

5.2 Model Schematisation

An overview schematic of the WBM related to the Golden Bar area is shown in Figure 28 indicating key nodes represented in the model and direction of surface water flows. Not shown in the figure is the surface water catchments areas, WRSs and ground water / WRS seepage flows. Catchment maps defining surface types and contributing areas to these nodes are provided in Appendix A (Figure 48 to Figure 53).

Key stage volume inputs and catchment areas are outlined in Appendix A.

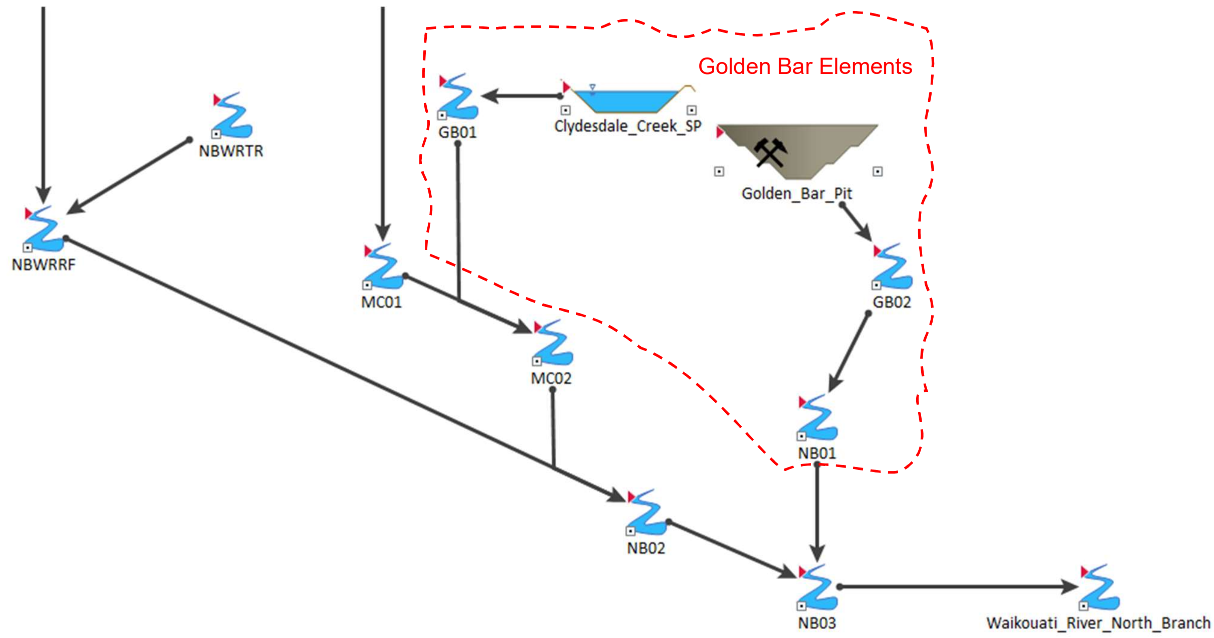


Figure 28 Schematic of the Golden Bar elements of the Macraes Water Balance Model.

5.3 Climate and climate change Representation

Climate data are applied to the model based on historical measurements, from which a synthetic rainfall time series is generated, and monthly evaporation statistics are derived. Where the model is applied for long term predictive modelling of flows and contaminant concentrations climate change adjustments are applied to the rainfall and evaporation inputs.

Van Vuuren et al (2011) set representative concentration pathways (RCPs) defining approximate total radiative forcing through to the year 2100. The paper presents an RCP8.5 scenario that represents a 'business as usual' response to climate change resulting in high greenhouse gas concentrations by 2100. Given the uncertainty of the global response to climate change and the subsequent effects to long-term water management at the Macraes Mine site, the RCP8.5 scenario is seen as the conservative approach to accounting for climate change and it is expected to lead to the following key outcomes:

- increased mean and maximum temperatures,
- increased dry days (no precipitation) and evaporation with more severe and frequent droughts,
- decrease in summer precipitation (December – February),
- increase in winter precipitation (June – August),
- increased mean precipitation concentrated on the extreme events.

5.3.1 Rainfall

Rainfall is represented in the WBM based on a stochastic synthetic data series produced for statistical similarity with recorded rainfall data. The algorithm producing the stochastic rainfall seeks to represent seasonal variation, daily rainfall depth distributions and antecedent rainfall conditions. This makes the extended synthetic rainfall series suitable for representing an increased range of scenarios than what could be achieved with a historic data series alone. The recorded rainfall includes daily rainfall data from Glendale Station (agent number 5370) between 1959 and 2008, and the Golden Point Station on the Macraes site between 1991 and 2018. The synthetic data represents daily rainfall depths for 1,000 years and has a mean annual depth of 664 mm with a range between 355 mm and 1155 mm (Table 4).

Table 4 Rainfall statistics

	Synthetic Record (1,000 years)	Golden Point Station (1991-2022)	Glendale Station No. 5370 (1959-2008)
Mean annual rainfall (mm)	664	665	634
Minimum annual rainfall (mm)	355	414	395
Maximum annual rainfall (mm)	1155	1034	950
Dry days	59%	59%	68%

Seasonal rainfall variations under the RCP8.5 scenario are expected to follow the trends as outlined in Table 5. Typically, this results in dryer summer periods and wetter winters than historical means. The net result is an overall annual increase in precipitation.

Table 5 Mean rainfall changes for RCP8.5 at Macraes Mine (Data extracted from NIWA, 2016)

Future Year	2055		2090	
	Lower	Upper	Lower	Upper
Summer	-10%	-5%	-10%	-5%
Autumn	5%	10%	10%	15%
Spring	-5%	0%	10%	15%
Winter	10%	15%	20%	25%
Annual	-5%	0%	10%	15%

5.3.2 Evaporation

Evaporation is represented in the model based on monthly statistics derived from pan evaporation data collected from site between 1991 and 2018 as shown in Figure 29. Mean annual evaporation is 952 mm and this is represented in the WBM as a monthly normal distribution with cut-offs applied as per the minimum and maximum valves.

An evaporation reduction factor of 0.7 is applied to evaporation from the pit lakes to account for differences between pan evaporation rates and evaporation rates expected from large water bodies.

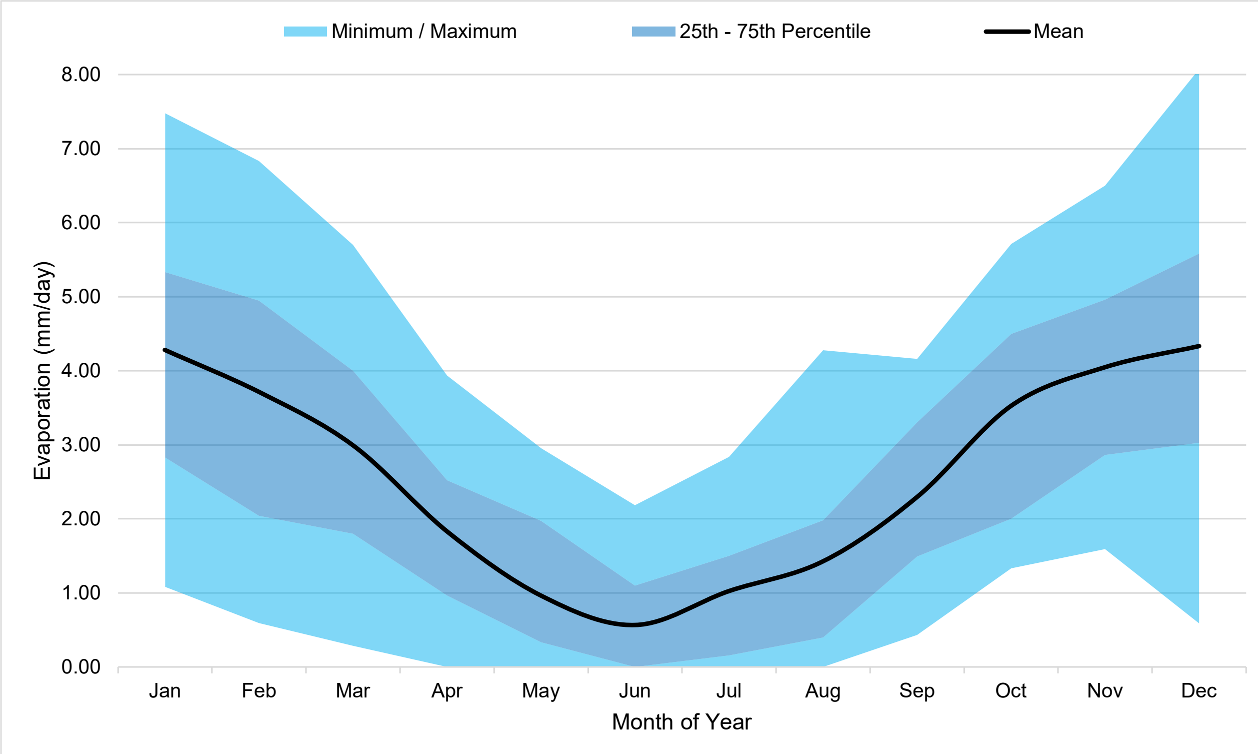


Figure 29 Evaporation statistics applied in WBM

Under the RCP8.5 scenario an increase in potential evaporation deficit (PED) of approximately 120 mm could be expected by 2110 (Figure 30). At the Macraes Mine site this translates to an increase in mean evaporation potential of approximately 12.5 %. This evaporation potential is applied to the model as a multiplier of the existing evaporation rates, linearly increasing to 12.5 % by the year 2110. From the year 2110 evaporation is fixed to 1.125 times the historical statistics.

The net result from the applied evaporation and rainfall adjustments in the long term is a typical increase in annual runoff, with seasonal decreases in summer periods and increases in winter.

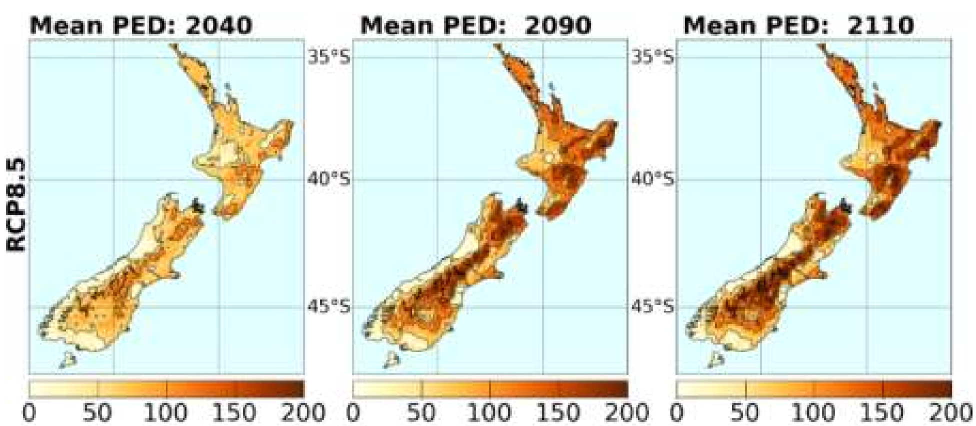


Figure 30 PED projections (exert from MfE 2018, Figure 55)

5.3.3 Runoff

Runoff is represented in the WBM by two methods, the rational method is applied to areas impacted by mining and WRS runoff, and a calibrated Australian Water Balance Model (AWBM) (Boughton 2004) is applied to all other areas.

Table 6 outlines the runoff coefficients applied to impacted and WRS surfaces. Runoff coefficients are interpolated from these given values based on the daily rainfall depth. These coefficients increase with rainfall depth to represent the higher runoff rates from more wetted soils. Runoff coefficients are specifically derived for the catchment reporting to the Golden Bar Pit based on a model calibration as presented in Appendix A-3. Given the relatively small size of these catchments they are modelled using the rational method approach rather than the AWBM.

Table 6 Runoff coefficients for application of the rational method.

Daily rainfall (mm)	Impacted Areas	Waste Rock Stacks	Golden Bar Pit Catchments[1]	Golden Bar Pit Walls[1]
0	0.05	0	0.1	0.1
10	0.2	0.05	0.3	0.5
50	0.4	0.15	0.5	0.8
90 +	0.7	0.4	0.7	0.9

[1]. Runoff coefficients determined from calibration to the existing Golden Bar Pit Lake.

Runoff to water body surfaces is modelled with a runoff coefficient of 1.0 and the surface area of these water bodies are adjusted based on the defined volume-area relationships, with a corresponding reduction in adjacent catchment area.

For flows from natural catchments a catchment runoff model based on the Australian Water Balance Model (AWBM) (Boughton 2004) is calibrated to gauging undertaken on the NBWR at Golden Bar Road and Griffin Road gauges (NBGR) between 1991 and 1998. This calibration is presented in Appendix A-2.

5.4 Surface Water Quality

The surface water quality parameters applied to the water balance model are listed in Table 5.4. These values have been derived based on the water quality data provided by OGNZL and based on analysis of typical distributions of the data, a ±30% distribution is applied to the values within the Monte-Carlo simulations.

These source terms are applied in the model based on the following definitions:

– **Natural** is used to define areas that have not been affected by modern mining operations. This may include native/non-native forestry, farmed land and wetlands among other land uses.

– **Impacted** areas are influenced by mine operations and disturbance is typically near the natural surface only, for example, haul roads, workshop areas and exploration activities.

– **Impacted-Rehabilitated** includes areas that have been impacted, then rehabilitated through establishing vegetation. This surface type is nominally considered to be equivalent to ‘natural’ surfaces once rehabilitated.

– **WRS** (Waste Rock Stack) is surface areas of mined rock placed for purpose of stockpiling or producing a WRS and does not have established vegetation.

– **WRS-Rehabilitated** includes areas that have been WRS, then rehabilitated through establishing vegetation. Typically, this is grass cover suitable for grazing stock.

Table 7 Surface Water quality source terms – mean value inputs

Parameter (g/m^3)	Natural	Impacted	Impacted Rehabilitated	WRS	WRS Rehabilitated
Ammoniacal N	0.01	0.120	0.01	0.500	0.010
Arsenic	0.0025	0.037	0.0025	0.011	0.011
Copper	0.001	0.0012	0.001	0.0018	0.0011
Hardness	100	1000	100	200	220
Iron	0.2	0.2	0.2	0.079	0.079
Lead	0.00015	0.0002	0.00015	0.00015	0.00015
Nitrate N	0.15	0.015	0.15	1.0	0.4
Sulphate	10	930	10	470	150
Zinc	0.0015	0.0015	0.0015	0.0012	0.0012

Golden Bar Pit Lake surface water quality utilised in the model is as presented in MWM 2024. The pit lake water quality has been derived by developing source terms for each component of the GHD pit water balance and modelling of the annualised pit lake concentrations in a hydrogeochemical pit lake model. Timeseries plots of sulphate and Nitrate N are presented in Figure 31 and Figure 32.

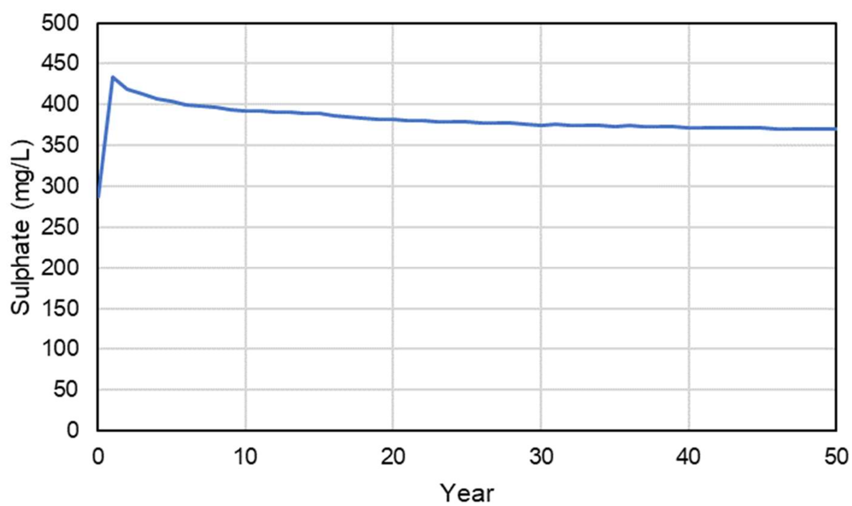


Figure 31 Golden Bar Stage 2 Pit Lake sulphate concentration (MWM, 2024)

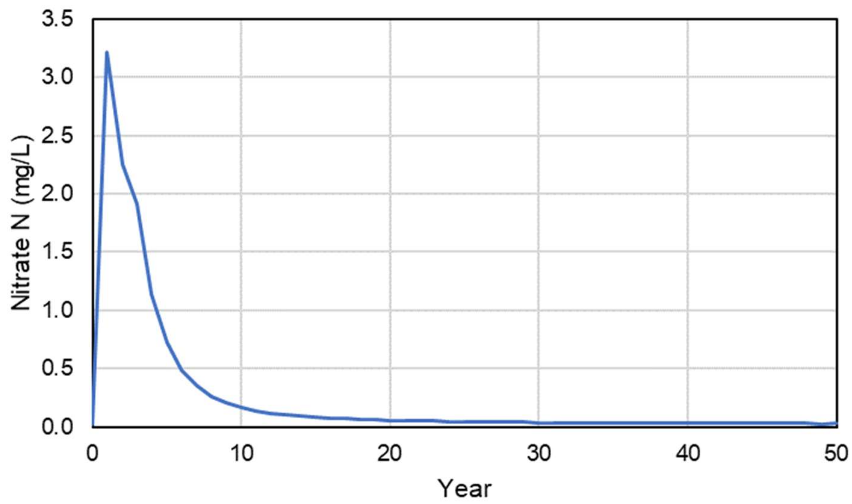


Figure 32 Golden Bar Stage 2 Pit Lake Nitrate N concentration (MWM, 2024)

5.5 Model Domain

The model domain includes the Clydesdale Creek catchment upstream of the confluence with Murphys Creek and the Golden Bar catchment upstream of the confluence with the NBWR as shown in Figure 33. The proposed expansion to the Golden Bar WRS is predominantly within the Clydesdale Creek catchment, with some surface runoff directed towards the Golden Bar Pit. The proposed expansion to Golden Bar Pit sits within the catchment of the un-named tributary of the NBWR (referred to throughout this report as the Golden Bar Creek) with future overflow entering this tributary. The modelling results presented in this report focus on the outcomes associated with the Clydesdale Creek catchment at GB01 and the Golden Bar Creek catchment reporting to GB02 and NB01 before the confluence with the NBWR. Mining influences from the Frasers Pit area and associated WRSs influence water quality outcomes within Murphys Creek (MC02) and the NBWR (NB02 and NB03) and these are reported on separately where the upstream activities and mitigation strategies are covered in detail (GHD, 2024).

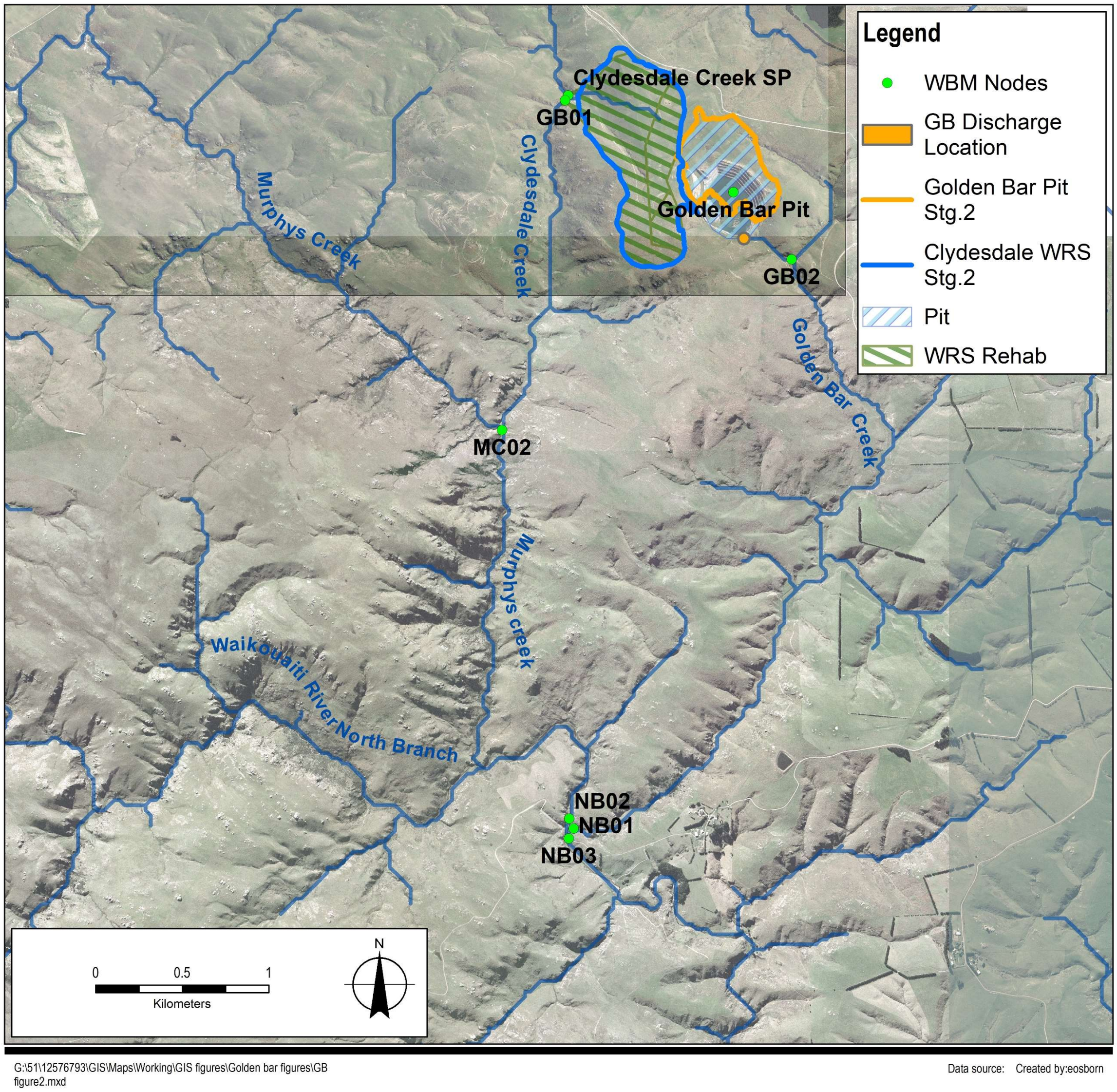


Figure 33 Golden Bar model domain

5.6 Existing Water Quality Compliance Criteria

The proposed Golden Bar Pit Stage 2 extension will influence waters discharging to the NBWR, via the Clydesdale Creek and Golden Bar sub-catchments. There are established water quality monitoring locations on the NBWR including the aforementioned sub-catchments (GB01, GB02 and NB01, refer Figure 33). These were established in previous phases of the Golden Bar development. The compliance locations where the proposed Golden Bar Stage 2 development has an impact on water quality are summarised in Table 8. NB03 is located within the NBWR downstream of the confluence of Golden Bar Creek with NBWR; GB01 is located immediately downstream of the Clydesdale Silt Pond; GB02 is downstream of the Golden Bar Pit discharge; and MC02 is located downstream of the confluence of Murphys Creek and Clydesdale Creek. The effects of the proposed Golden Bar Stage 2 development on water quality at NB03 and MC02 (inclusive of upstream influences from other aspects of the MPIV project) at are covered in GHD (2024). This report addresses water quality effects at compliance locations that are only influenced by the Golden Bar development (ie. at GB01/GB02) and monitoring location NB01.

Table 8 Summary of existing consented water quality criteria

Parameter	NB03	GB01/GB02	MC02
Resource Permit	RM10.351.08, RM10.351.11, RM10.351.12, RM2002.491, RM2002.759, RM2002.763	RM2002.763	RM2002.491, RM2002.759, RM2002.763
Arsenic (g/m^3)	0.01	0.15	0.15
Copper (g/m^3)*	0.009	0.009	0.009
Iron (g/m^3)	0.2	1.0	1.0
Lead (g/m^3)*	0.0025	0.0025	0.0025
Zinc (g/m^3)*	0.12	0.12	0.12
Sulphate (g/m^3)	250		
pH (range)	6.0-9.5	6.0-9.5	6.0-9.5
Nitrate-N, NO_3-N (g/m^3)	NA		
Ammoniacal Nitrogen NH_4-N (g/m^3)	NA		

* Copper, lead and zinc standards shall be hardness related limits. Values given in the tables above assume a hardness of 100g/m3 $CaCO_3$.

Modelling covers the full time-domain from present day to long-term operation following spill from the pit lake. Within this time frame three key phases (with the addition of a climate change scenario) of the project are considered, these are:

1. **Mining** – During active mining where waste rock stacks are under construction and pits are being dewatered and excavated. Active management of mine water is in place.
2. **Closure** – All surfaces are rehabilitated (other than pit walls), most pits not yet overflowing, seepage from WRSs may not have reached peak predicted water quality and flow rates, active return pumping of TSF underdrains maintained.
3. **Long-term** – Pits that are projected to overflow have reached the overflow, all surfaces are rehabilitated (other than pit walls), seepage from WRSs have reached peak predicted values, all mine waters discharging to the environment other than where in-perpetuity pumping and treatment provisions are made.
4. **Long-term + Climate Change** – Equivalent to Phase 3 with the addition of climate change effects on rainfall and evaporation.

Table 9 Summary of modelling scenarios

Reference	Phase	Dates	Description
1	Mining	2026-2027	During active mining of Golden Bar Pit
2	Closure	2045-2050	Following full rehabilitation
3	Long-term	~2125 +	Following overflow of the Pit Lake
4	Long-term + CC	~2125 +	Following overflow of the Pit Lake with climate change allowance

5.6.1 Key water management assumptions

– Dewatering of the Golden Bar pit lake during mining operations is not represented in the water quality outcomes and is covered in a separate assessment investigating dewatering timeframes and effects (GHD, 2023) (Appendix B). These operations are undertaken with a degree of manual control and could be inaccurately reflected in a predictive model. It is assumed that these discharges are undertaken based on existing consent requirements and done in a manner that does not negatively impact water quality within the receiving environment. Alternatively, these waters are recycled within the mine water management system and reused on site.

- Rehabilitation of waste rock surfaces is undertaken and completed promptly on completion of mining.
- TSS levels discharging to the receiving environment are managed using appropriately sized silt ponds and other sediment and erosion protection measures.
- During the mining phase all operational waters are managed on site and remain within a closed system. For example, water from the tailing's impoundments (including captured seepage) is recirculated and re-used for mine operations. Losses of these waters to the environment is through either uncaptured seepage to ground or evaporation.
- Seepage from WRSs is modelled based on an increase with time to a maximum predicted value. The potential for seepage concentrations to reduce from this maximum due to depletion of contaminant sources is not accounted for.
- All contaminants are assumed to be conservatively transported within both the groundwater and surface water environments on a mass balance basis.

5.7 Groundwater and WRS Seepage Inputs

Groundwater interaction with the Golden Bar Pit Lake is applied based on the net groundwater inflow as outlined in Section 4.2.4. Groundwater modelling shows that there is a net positive groundwater inflow at all stages of pit lake development.

Groundwater contaminant flux from the groundwater model is not explicitly replicated in the WBM, however the seepage fluxes from the WRS are derived from measured flow data and water quality concentrations. A mean seepage flow rate of 92 mm/yr (applied across the WRS surface area) is determined from measured flows and the existing extents of the WRS. A normal distribution with limits of ±30% of this mean value is stochastically applied in the probabilistic assessment. The seepage contaminant mass flux is then given by:

$$Mass\ Flux\ \left(\frac{g}{yr}\right) = Seepage\ Flow\ Rate\left(\frac{m}{yr}\right) \times WRS\ Area\ (m^2) \times Concentration\left(\frac{mg}{L}\right) \qquad \text{(Eqn. 1)}$$

Seepage concentrations are represented in the WBM by the relationships described in MWM, 2023, where the sulphate concentration derived from measured site data is calculated as:

$$\begin{aligned} Maximum\ Sulphate\ \left(\frac{mg}{L}\right) &= \begin{cases} 850e^{(0.025 \times Average\ Heigth\ (m))} & Average\ Height < 27.5\ m \\ 120e^{(0.0965 \times Average\ Heigt\ \ (m))} & Average\ Height \geq 27.5\ m \end{cases} \\ Medium\ Sulphate\ \left(\frac{mg}{L}\right) &= \begin{cases} 625e^{(0.025 \times Average\ Heigt\ \ (m))} & Average\ Height < 27.5\ m \\ 66e^{(0.1075 \times Average\ Heigth\ (m))} & Average\ Height \geq 27.5\ m \end{cases} \end{aligned} \qquad \text{(Eqn. 2)}$$

Concentrations for the other water quality parameters presented are applied as relationships to these Sulphate concentrations, where MWM 2023b presents relationships specific to the Clydesdale WRS and generic relationships for other proposed WRSs.

The contour plots from the groundwater modelling presented in Figure 22, Figure 23 and Figure 24, show the extent of the predicted plume is largely confined to an area within the upper reaches of the Clydesdale Creek catchment and upper reach of the Golden Bar catchment with the flux largely confined to the upper weathered schist layers. This flux is considered to be conservatively represented within the WBM utilising the relationships (on WRS seepage flux generation) as defined in MWM, 2023. The estimated sulphate flux from the groundwater modelling is 26 kg/day (20 years post closure) and 80 kg/day (400 years post closure) at MC02. This is conservatively represented by the WBM which represents a mean groundwater seepage of 200 kg/day based on discharge estimates from the Golden Bar WRS. The estimated sulphate flux into the McCormicks Creek catchment and to Golden Bar Creek is considered small (~0.1 Kg/day) and these are not accounted for in the WBM.

5.8 Results – Golden Bar Water Balance

The WBM has been applied to estimate filling rates for the Golden Bar Pit Lake and estimate the long-term equilibrium level. Modelling projections (Figure 34) have the pit initially at or near overflow level as its current status, this continues until dewatering is assumed to commence in Q4 2024 / Q1 2025 in preparation for mining Stage 2 of Golden Bar Pit. Following the end of mining in 2027 the pit lake water level rises so that overflow level could be reached after a period of approximately 35 to 42 years post closure (90th percentile confidence interval), following which water accumulated within the Golden Bar Pit Lake spills into the NBWR via the Golden Bar tributary and the pit low point to the spillway at southeast end of the lake. The mean overflow from the pit is estimated to be approximately 3.2 L/s. During dry periods overflow from the lake may temporarily cease.

The key drivers in the Golden Bar water balance are total surface runoff and direct rainfall with groundwater inflow a relatively minor contributor in comparison (Figure 35). An additional input to the pit lake is seepage from the Golden Bar WRS which is to the immediate west of the Golden Bar pit. Rainfall falling onto this WRS provides a consistant source of seepage to the pit lake. This seepage is a relatively minor contributor as the natural contours indicate only a small section of the WRS seepage is directed into the pit lake while the majority is directed into Clydesdale Silt Pond. The average height of the section of WRS seeping into the pit lake was estimated to be 29.4 m. Seepage and evaporation (not shown) provide losses of water from the pit lake throughout its development.

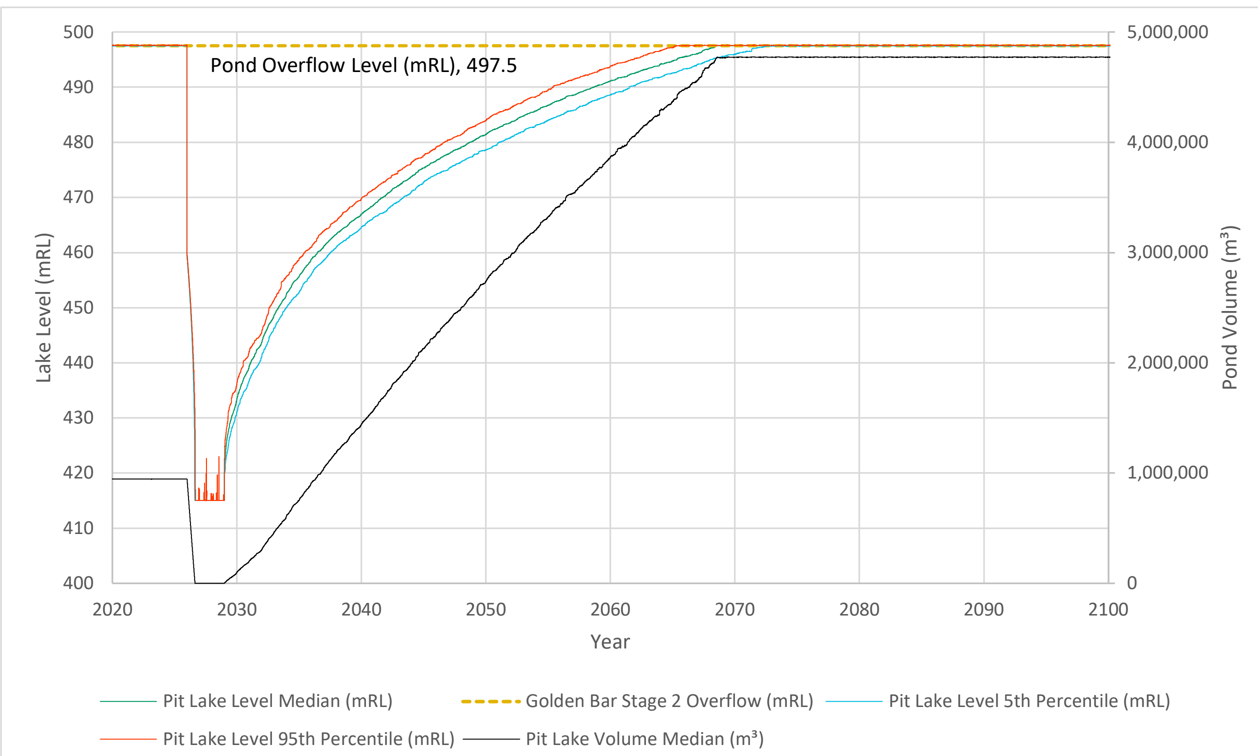


Figure 34 Golden Bar Stage 2 Pit Lake filling assessment full model period

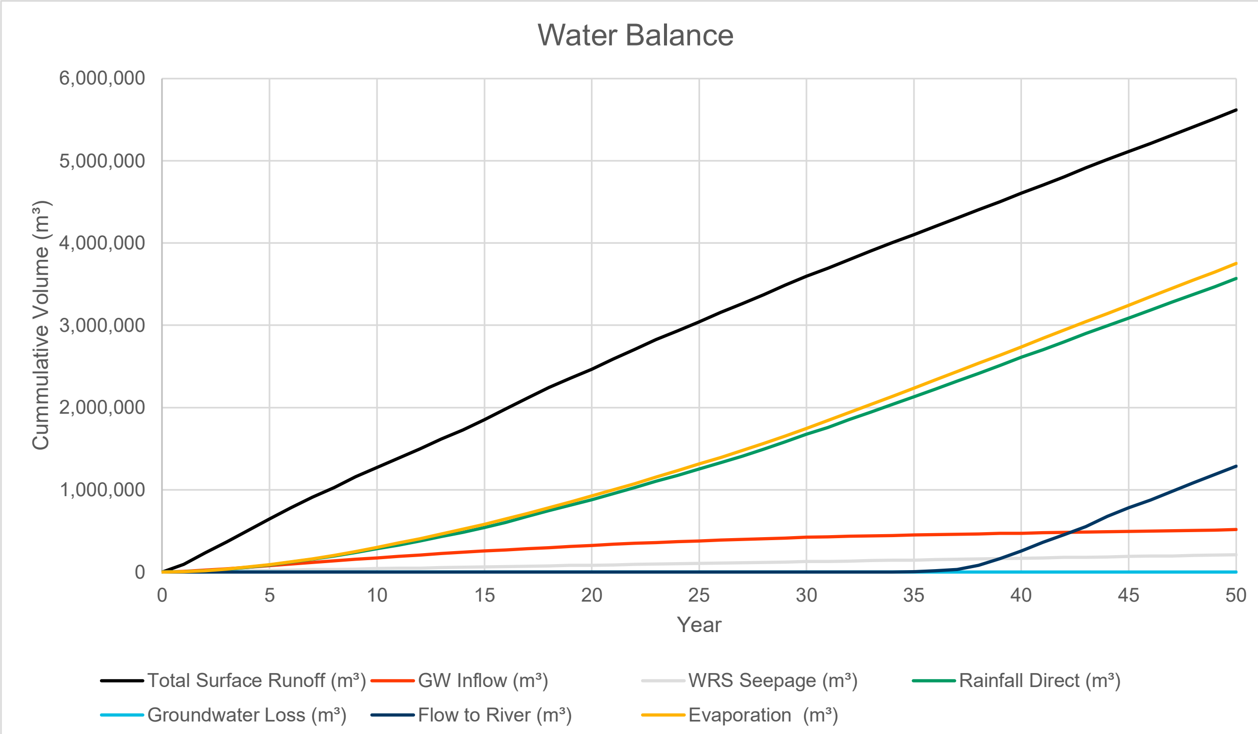


Figure 35 Golden Bar Stage 2 Pit Lake cumulative water balance once filling commences.

5.9 Results – Water Quality

The water quality results are presented at locations GB01, GB02 and NB01. The cumulative effects of the Stage 2 Golden Bar development and the MPIV development within the Frasers Pit area on the NBWR are covered in GHD, 2024.

For compliance monitoring locations GB01 and GB02 and monitoring location NB01, Sulphate, Nitrate N and Ammoniacal N predictions are presented as they are considered key elements in terms of the current and predicted future impacts and the modelled results are within the range of consented limits applied to other surface water bodies within the wider MGP area. For consented parameters (arsenic, copper, iron, lead and zinc), modelling suggests they are unlikely to reach the compliance limits (at GB01 and GB02) or significantly increase in concentration throughout both the duration of the operational period and post closure period based on the assumptions and considerations as outlined in this report. Modelled results for these elements are presented in Section 5.9.5.

5.9.1 Golden Bar Compliance Monitoring Location GB01

Compliance monitoring location GB01 is within the Clydesdale Creek catchment and is down stream of the Golden Bar WRS and the Clydesdale silt pond. GB01 receives surface water and groundwater influenced by operations within the Golden Bar WRS and the associated natural catchment. The summarised WBM results for sulphate, Nitrate N and Ammoniacal N are presented in Figure 36, Figure 37 and Figure 38 respectively.

In general, sulphate is predicted to increase in the closure and long term scenarios relative to the mining period. This increase in sulphate concentrations is due to the increased size of the Golden Bar WRS and therefore, increased seepage flows and concentrations. The sulphate mass loads are expected to increase from the start of the Stage 2 WRS expansion and to have reached a steady state by the end of the defined closure period (2045-2050). Climate change may result in a small reduction in long-term concentrations as the balance of seepage water and runoff shifts. Ammoniacal N concentrations are modelled to have little change with time and no notable increases from current levels at the monitoring location. Nitrate N concentrations are modelled to increase following construction of the expanded WRS and the subsequent increase in seepage flow rates. This will be subject to good practice being applied in construction and progressive rehabilitation of the WRS expansion.

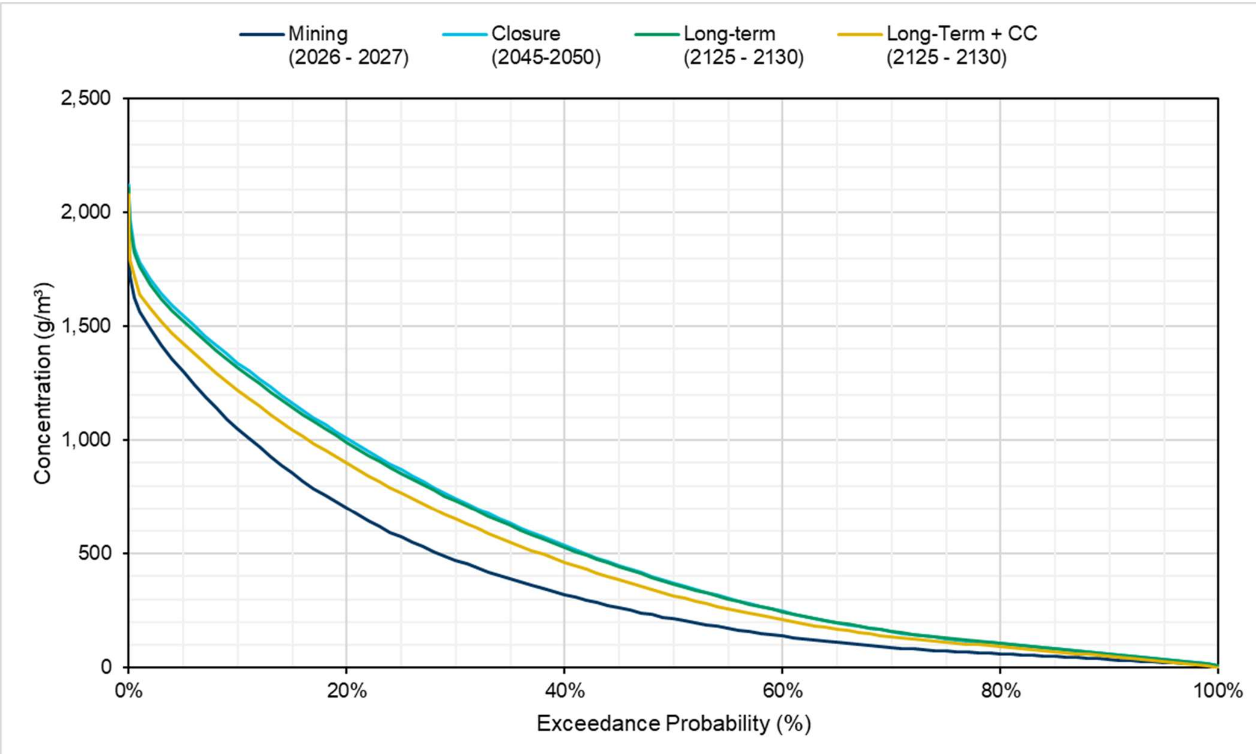


Figure 36 GB01 Sulphate – Modelled probability exceedance

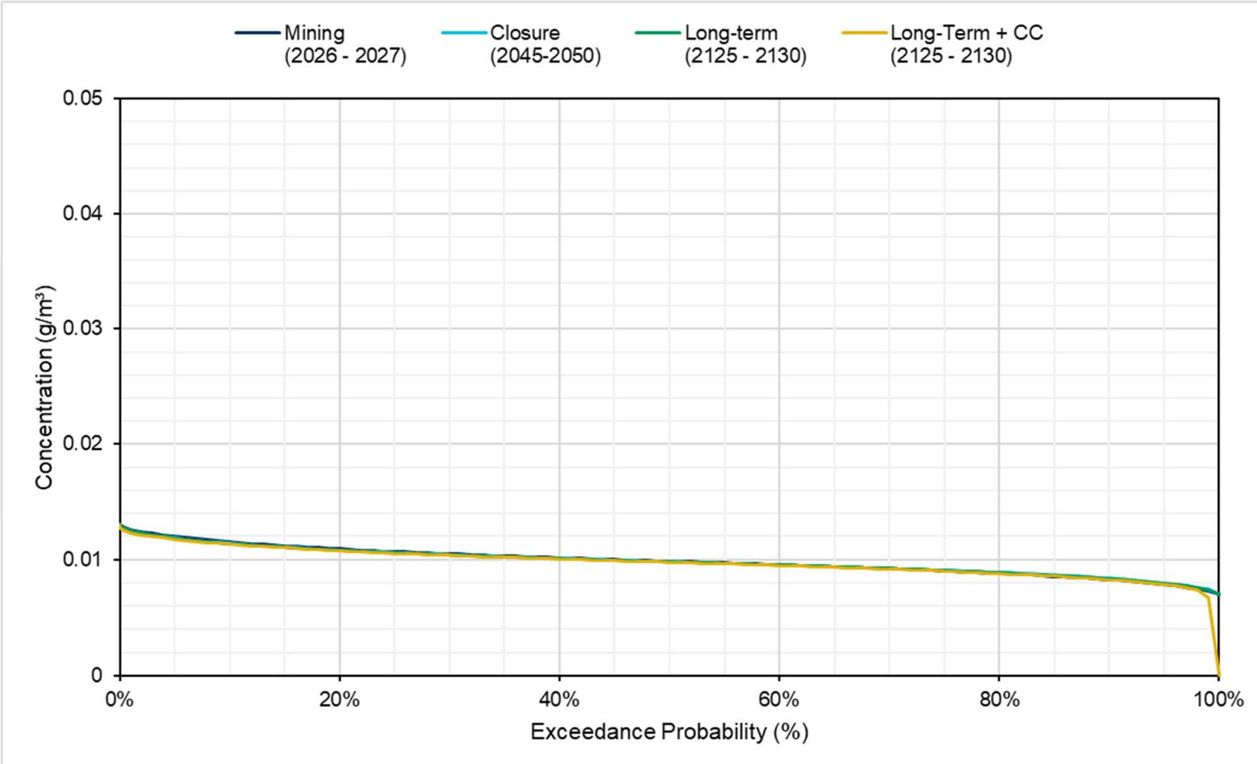


Figure 37 GB01 Ammoniacal N – Modelled probability exceedance

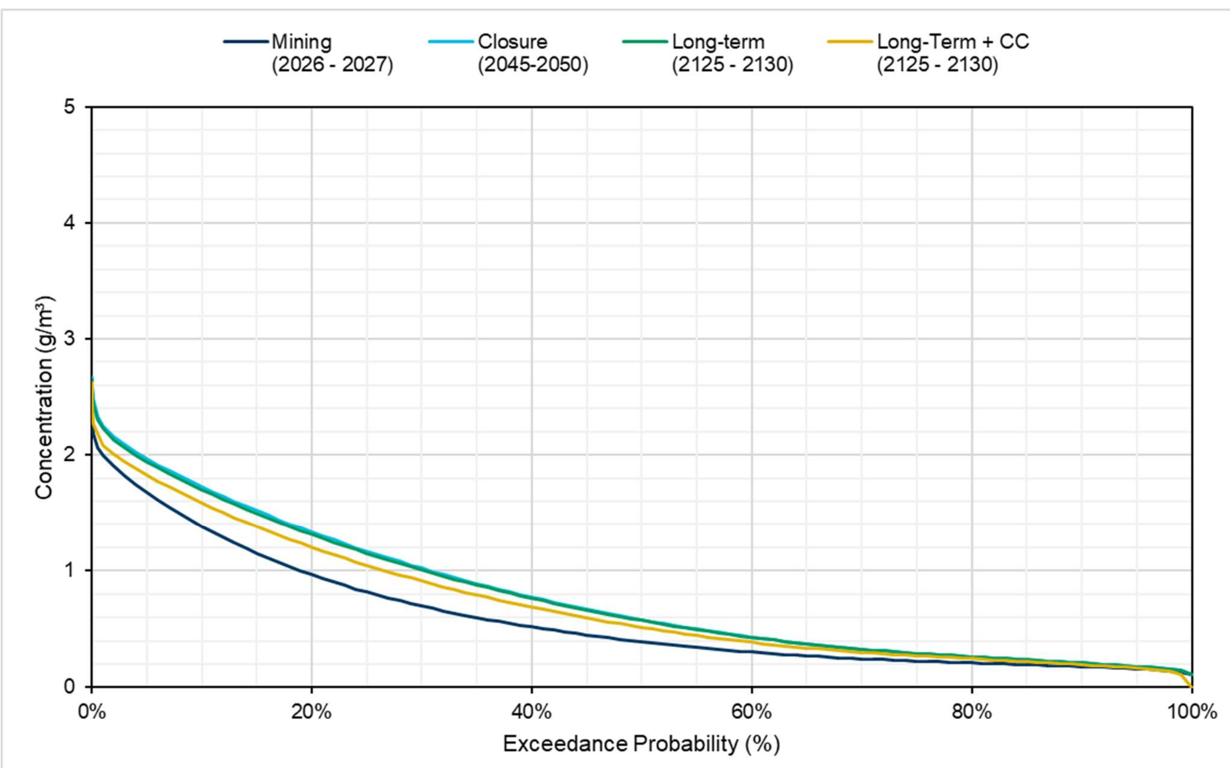


Figure 38 GB01 Nitrate N – Modelled probability exceedance

5.9.2 Golden Bar Compliance Monitoring Location GB02

Compliance monitoring location GB02 is within the Golden Bar catchment and is located immediately down stream of the Golden Bar Stage 2 pit Lake spill location (Figure 33). GB02 receives surface water and groundwater influenced by operations within the Golden Bar Pit. The summarised WBM results for sulphate, Nitrate N and Ammoniacal N are presented in Figure 39, Figure 40 and Figure 41 respectively.

Sulphate concentrations at GB02 are predicted to be low during the mining and closure phases as flows within the tributary are from natural catchment runoff and groundwater recharge only prior to overflow from the pit lake as illustrated in Figure 39. Long-term, water spilling from the Golden Bar Pit Lake will influence water quality at this location with sulphate concentrations predicted to increase as elevated sulphate pit lake water spills into the upper reaches of this catchment. Sulphate concentrations at GB02 are expected to remain below 400 g/m^3 during this period which is reflective of the maximum predicted Golden Bar Pit Lake sulphate concentrations as reported by MWM 2024 (434 mg/l). Ammoniacal N and Nitrate N concentrations are expected to reduce once regular overflow from the pit lake begins due to the diluting effect from the pit lake water.

Note that the effects of pit dewatering before and during expansion of the pit are not represented within the results and are covered separately in GHD, 2023 (Appendix B). It is expected that this will be actively managed on site maintaining acceptable contaminant concentrations to the receiving surface waters.

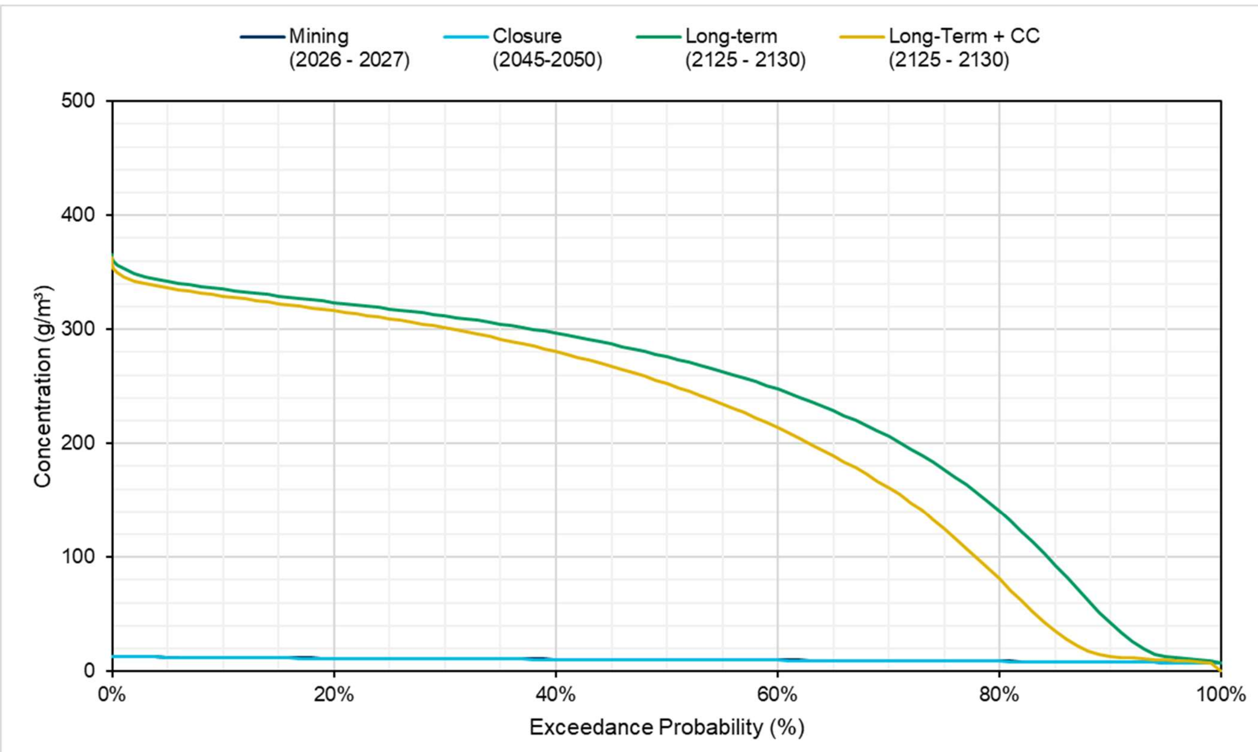


Figure 39 GB02 Sulphate – Modelled probability exceedance

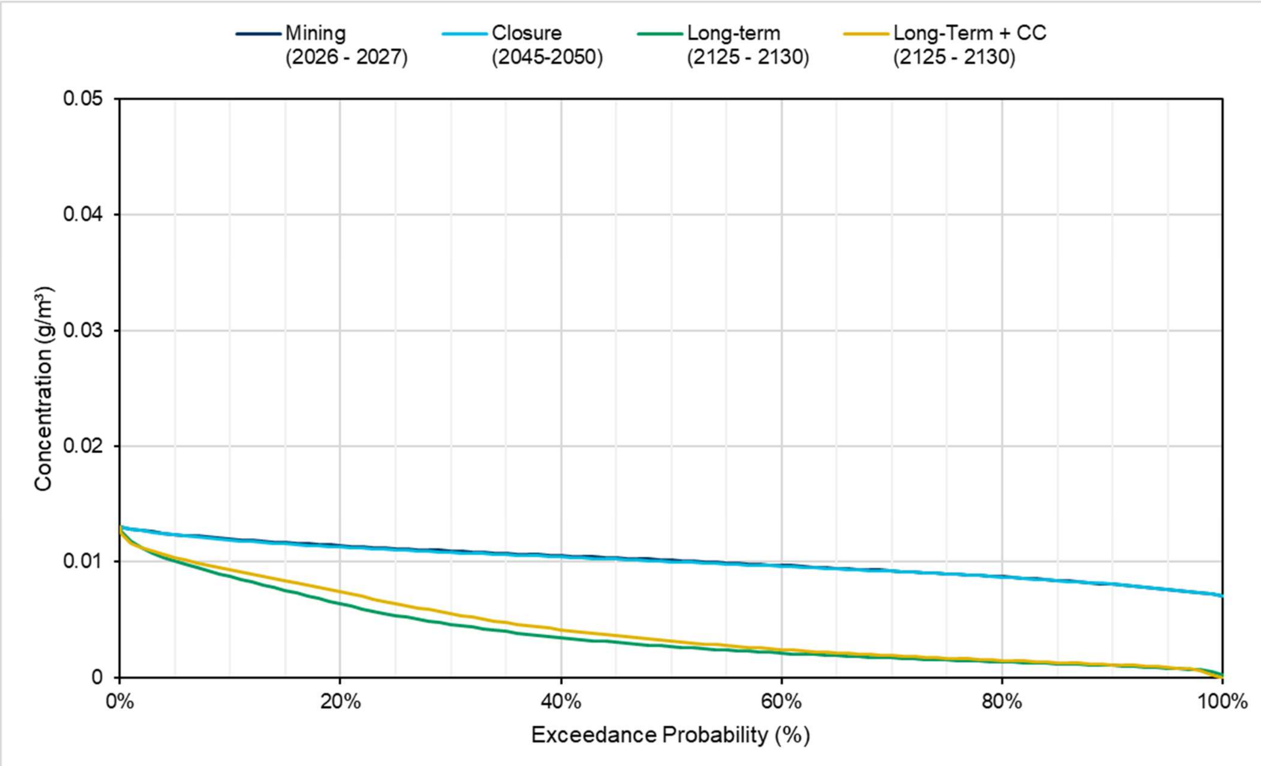


Figure 40 GB02 Ammoniacal N – Modelled probability exceedance

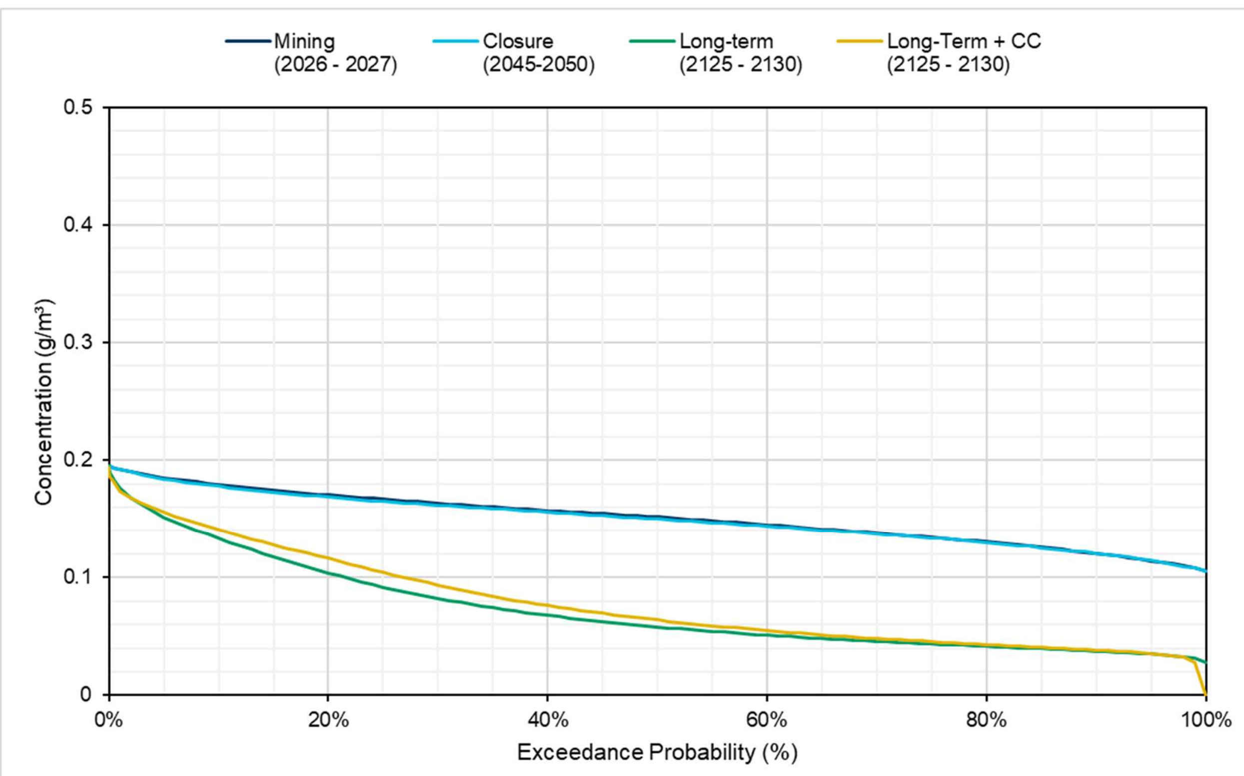


Figure 41 GB02 Nitrate N - Modelled probability exceedance

5.9.3 Golden Bar Monitoring Location NB01

An existing monitoring location (NB01) is established on the waterway downstream of the Golden Bar Pit in Golden Bar Creek, just before the confluence with the NBWR. Flows and water quality at NB01 are influenced by surface water runoff and groundwater associated with operations within the Golden Bar Pit and the surrounding natural catchment. The summarised WBM results for sulphate, Nitrate N and Ammoniacal N are presented in Figure 42, Figure 43 and Figure 44 respectively. None of these parameters currently have consented limits at NB01.

The water quality at NB01 is only affected by non-mined areas unless the Golden Bar pit is overflowing (as per current) resulting in only natural catchment water quality being predicted in the stated mining and closure phases at NB01. The long term and closure scenarios show it is unlikely for a sulphate concentration of 400 g/m^3 to be exceeded at NB01 during this period which is reflective of the maximum predicted Golden Bar Pit Lake sulphate concentrations as reported by MWM 2024. As for the GB02 monitoring location, the Ammoniacal N and Nitrate N values at NB01 during the mining and closure stages have higher concentrations than the post closure stage. This is due to the modelled natural Ammoniacal N and Nitrate N values being higher than the predicted concentrations in the pit lake water.

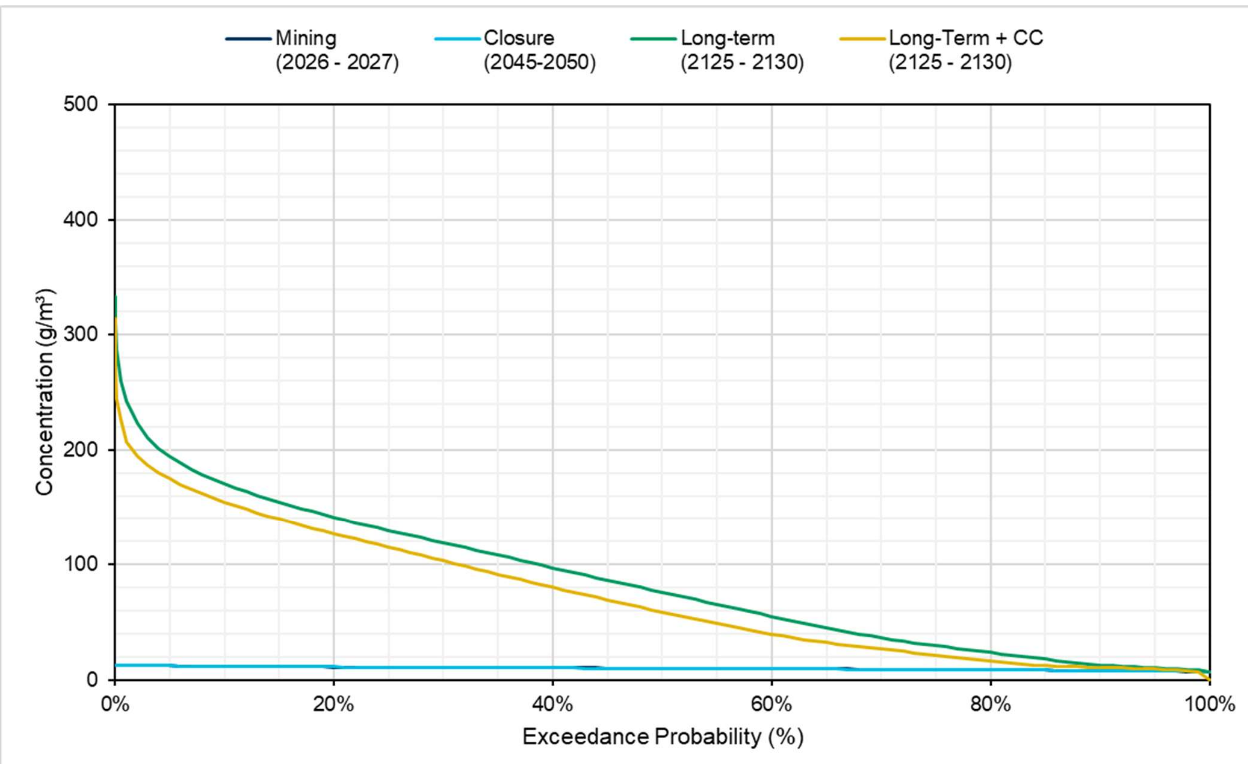


Figure 42 NB01 Sulphate - Modelled probability exceedance

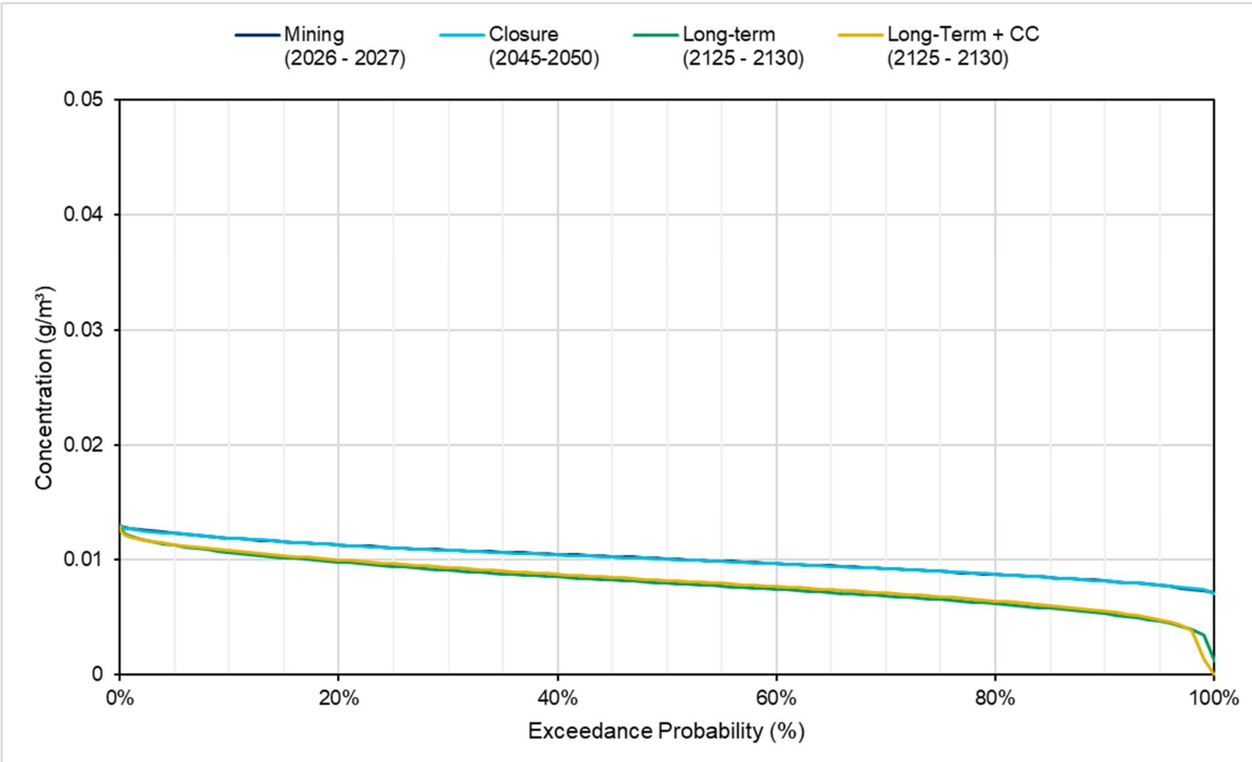


Figure 43 NB01 Ammoniacal N - Modelled probability exceedance

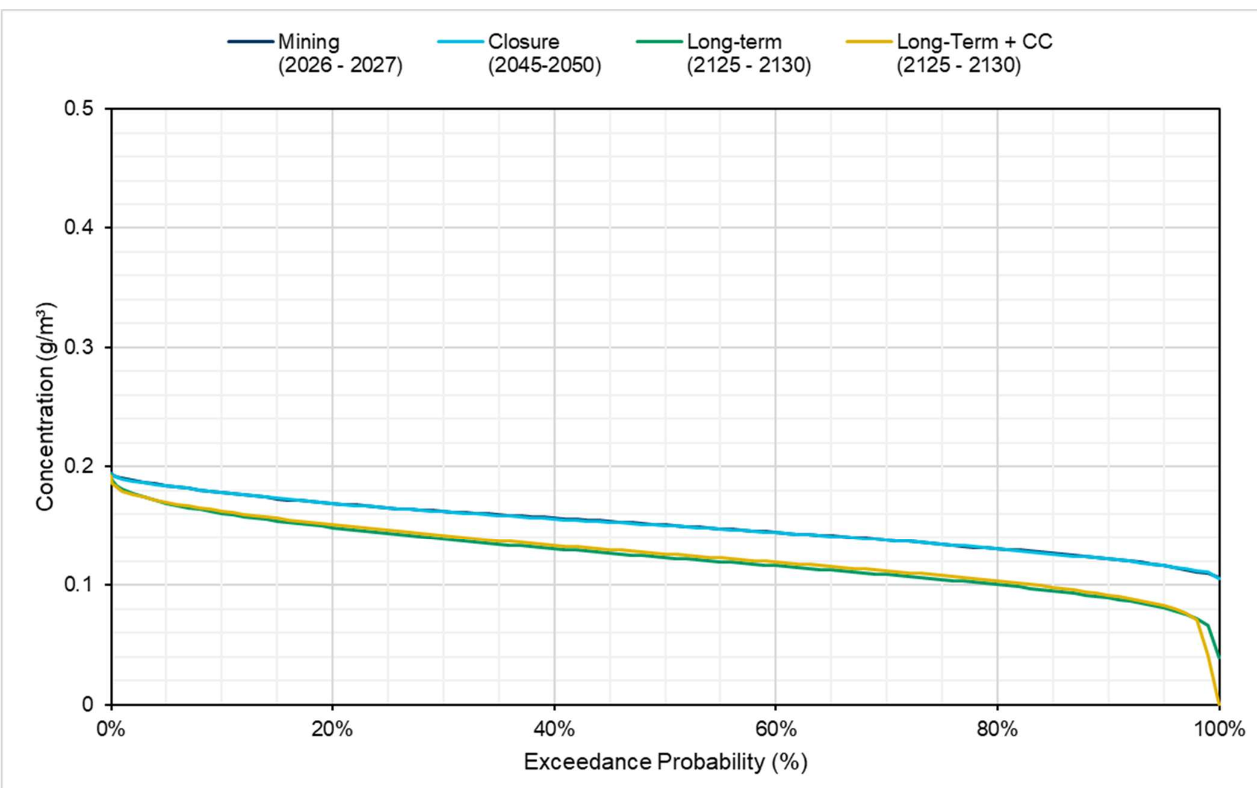


Figure 44 NB01 Nitrate N - Modelled probability exceedance

5.9.4 NBWR Compliance Location NB03

The compliance monitoring location downstream of the proposed Stage 2 Golden Bar development within the NBWR is NB03. An assessment of compliance against these water quality criteria is made in GHD, 2024 and considers both the modelled impacts from the proposed Stage 2 Golden Bar development and the modelled impacts from further up catchment. These predictions are not repeated here.

5.9.5 WBM Predictions

The modelled statistical predictions for the modelled water quality parameters are outlined in Table 10, Table 11 and Table 12 for compliance monitoring locations GB01 and GB02 and the monitoring location NB01 respectively. There are no modelled exceedances of the existing water quality criteria at GB01 and GB02.

Table 10 Predicted GB01 Water Quality Statistics

		Mining (2026 - 2027)	Closure (2045-2050)	Long-term (2125 - 2130)	Long-Term + CC (2125 - 2130)	Current (2022 - 2025)
GB01	Sulphate median	213	371	368	329	214
	Sulphate 95 percentile	1300	1547	1522	1471	1277
	Sulphate Max	1840	2122	2108	2091	1903
	Nitrate N Median	0.4	0.6	0.6	0.5	0.4
	Nitrate N 95 percentile	1.7	2.0	1.9	1.9	1.7
	Nitrate N Max	2.3	2.7	2.7	2.6	2.4
	Ammoniacal N Median	0.010	0.010	0.010	0.010	0.010
	Ammoniacal N 95 percentile	0.012	0.012	0.012	0.012	0.012
	Ammoniacal N Max	0.013	0.013	0.013	0.013	0.013
	Arsenic median	0.002	0.002	0.002	0.002	0.002
	Arsenic 95 percentile	0.003	0.003	0.003	0.003	0.003
	Arsenic Max	0.005	0.006	0.005	0.006	0.004
	Copper Median*	0.01	0.02	0.02	0.01	0.01
	Copper 95 percentile*	0.05	0.06	0.06	0.06	0.05
	Copper Max*	0.07	0.09	0.09	0.09	0.08
	Iron Median	0.17	0.15	0.16	0.16	0.17
	Iron 95 percentile	0.23	0.23	0.22	0.23	0.23
	Iron Max	0.26	0.26	0.26	0.26	0.26
	Lead Median	0.0002	0.0002	0.0002	0.0002	0.0002
	Lead 95 percentile	0.0004	0.0005	0.0005	0.0005	0.0004
	Lead Max	0.0005	0.0006	0.0006	0.0006	0.0006
	Zinc Median	0.01	0.01	0.01	0.01	0.01
	Zinc 95 percentile	0.02	0.02	0.02	0.02	0.02
	Zinc Max	0.02	0.03	0.03	0.03	0.02

#All results in mg/L

*The copper compliance concentration for GB01 is 0.009 mg/L based on a hardness of 100 mg/L. Elevated modelled copper concentrations given at GB01 are all associated with elevated hardness. Taking the associated hardness adjusted compliance criteria into account, all the provided statistics are in compliance with the relevant hardness adjusted compliance value.

Table 11 Predicted GB02 Water Quality Statistics

		Mining (2026 - 2027)	Closure (2045-2050)	Long-term (2125 - 2130)	Long-Term + CC (2125 - 2130)	Current (2022 - 2025)
GB02	Sulphate median	10	10	276	256	189
	Sulphate 95 percentile	12	12	342	338	251
	Sulphate Max	13	13	366	364	309
	Nitrate N Median	0.2	0.1	0.1	0.1	0.1
	Nitrate N 95 percentile	0.2	0.2	0.2	0.2	0.1
	Nitrate N Max	0.2	0.2	0.2	0.2	0.2
	Ammoniacal N Median	0.010	0.010	0.003	0.003	0.010
	Ammoniacal N 95 percentile	0.012	0.012	0.010	0.011	0.011
	Ammoniacal N Max	0.013	0.013	0.013	0.013	0.013
	Arsenic median	0.003	0.002	0.108	0.100	0.089
	Arsenic 95 percentile	0.003	0.003	0.135	0.133	0.117
	Arsenic Max	0.003	0.003	0.144	0.143	0.140
	Copper Median	0.001	0.001	0.001	0.001	0.001
	Copper 95 percentile	0.001	0.001	0.001	0.001	0.001
	Copper Max	0.001	0.001	0.001	0.001	0.001
	Iron Median	0.20	0.20	0.05	0.064	0.09
	Iron 95 percentile	0.25	0.25	0.20	0.212	0.27
	Iron Max	0.26	0.26	0.26	0.260	0.63
	Lead Median	0.0002	0.0001	0.0001	0.0001	0.0001
	Lead 95 percentile	0.0002	0.0002	0.0002	0.0002	0.0003
	Lead Max	0.0002	0.0002	0.0002	0.0002	0.0005
	Zinc Median	0.002	0.001	0.005	0.005	0.001
	Zinc 95 percentile	0.002	0.002	0.006	0.006	0.002
	Zinc Max	0.002	0.002	0.007	0.007	0.002

[#]All results in mg/L

Table 12 Predicted NB01 Water Quality Statistics

		Mining (2026 - 2027)	Closure (2045-2050)	Long-term (2125 - 2130)	Long-Term + CC (2125 - 2130)	Current (2022 - 2025)
NB01	Sulphate median	10	10	76	61	46
	Sulphate 95 percentile	12	12	194	180	113
	Sulphate Max	13	13	334	320	259
	Nitrate N Median	0.2	0.2	0.1	0.008	0.1
	Nitrate N 95 percentile	0.2	0.2	0.2	0.011	0.2
	Nitrate N Max	0.2	0.2	0.2	0.013	0.2
	Ammoniacal N Median	0.010	0.010	0.008	0.008	0.010
	Ammoniacal N 95 percentile	0.012	0.012	0.011	0.011	0.012
	Ammoniacal N Max	0.013	0.013	0.013	0.013	0.013
	Arsenic median	0.003	0.003	0.029	0.023	0.020
	Arsenic 95 percentile	0.003	0.003	0.076	0.070	0.052
	Arsenic Max	0.003	0.003	0.131	0.126	0.127
	Copper Median	0.001	0.001	0.001	0.001	0.001
	Copper 95 percentile	0.001	0.001	0.001	0.001	0.001
	Copper Max	0.001	0.001	0.001	0.001	0.001
	Iron Median	0.20	0.20	0.16	0.165	0.18
	Iron 95 percentile	0.25	0.25	0.22	0.228	0.24
	Iron Max	0.26	0.26	0.26	0.257	0.55
	Lead Median	0.0002	0.0002	0.0001	0.0001	0.0001
	Lead 95 percentile	0.0002	0.0002	0.0002	0.0002	0.0002
	Lead Max	0.0002	0.0002	0.0002	0.0002	0.0005
	Zinc Median	0.002	0.002	0.002	0.002	0.001
	Zinc 95 percentile	0.002	0.002	0.004	0.004	0.002
	Zinc Max	0.002	0.002	0.006	0.006	0.002

#All results in mg/L

5.10 Surface Water Summary

The WBM indicates that the Golden Bar Stage 2 Pit Lake overflow level could be reached after a period of approximately 35 to 42 years post closure, following which water from Golden Bar Stage 2 Pit Lake would spill into the NBWR Catchment. The mean overflow rate to the NBWR Catchment is estimated to be approximately 3.2 L/s.

Water Balance Modelling has shown that in general, sulphate concentrations within the receiving environment are predicted to increase post closure relative to the mining phase. The catchment draining to GB01 shows a small increase in predicted sulphate concentrations due to the relative greater increase in sulphate concentration and mass from seepage (from the Golden Bar WRS) with time. The catchment draining to GB02 and NB01 show an increase in predicted sulphate concentrations due to spill water from the Golden Bar Pit Lake which is elevated in sulphate in the long term compared to present levels. Ammoniacal N and Nitrate N concentrations are predicted to reduce in the long term relative to the mining phase due to the increased presence of rehabilitated surfaces (compared to non-rehabilitated surfaces which provide a higher relative contribution of these parameters before the closure period).

There are no modelled exceedances of the existing water quality criteria at the current compliance monitoring locations GB01 and GB02.

6. Conclusions

Groundwater modelling results indicate that groundwater flow into and out of the existing and proposed Golden Bar Pit, as well as groundwater seepage from Golden Bar WRS and Golden Bar Stage 2 Pit Lake (with the majority of seepage) are expected to move laterally within the weathered schist and be captured in silt ponds and/or report to the receiving surface water catchment.

The groundwater contaminant plume is modelled to reach a maximum extent of approximately 800 m (from the Golden Bar WRS) to the south-west and 900 m (from the pit lake) to the south-east direction over a period of 400 years. The majority of the modelled plume reporting to the surface water catchments is expected to impact the NBWR catchment to the south. The McCormicks catchment to the north is not expected to be significantly impacted in terms of water quality from groundwater seepage as a result of the proposed development.

The WBM indicates that the Golden Bar Pit Lake overflow level could be reached after a period of approximately 35-42 years post closure, following which water from the Golden Bar Pit Lake would spill into Golden Bar Stream via the low point in the pit wall to the south east and ultimately the NBWR.

The WBM shows that in general, sulphate concentrations within the receiving environment are predicted to increase post closure relative to the mining phase due to the relative greater increase in sulphate concentration and mass from seepage water (from the expanded Golden Bar WRS) and the Golden Bar Stage 2 Pit Lake overflow. Ammoniacal N and Nitrate N concentrations are predicted to reduce post closure relative to the mining phase due to the increased presence of rehabilitated surfaces (compared to non-rehabilitated surfaces which provide a higher relative contribution of these parameters before the closure period) and rapid biochemical decay. The exception to this is Nitrate N concentrations in Clydesdale Creek which are predicted to increase following construction of the expanded WRS and the subsequent increase in seepage flow rates. Modelling of other parameters of interest (arsenic, copper, iron, lead and zinc) suggest that they are unlikely to reach the compliance limits (at GB01 and GB02) or significantly increase in concentration at either GB01, GB02 or NB01 throughout both the duration of the operational period and post closure period.

In summary the development of the Golden Bar Stage 2 development project as outlined will likely impact surface water qualities within tributaries of the NBWR catchment by increasing instream sulphate concentrations. Water quality is expected to remain within the current compliance limits at Clydesdale Creek and Golden Bar Creek throughout both the duration of the operational period and/or post closure period. No measurable impact is expected within the McCormicks catchment to the north. The cumulative impact and effects on water quality compliance at monitoring locations further down catchment are included within GHD, 2024.

7. References

Barnett B, Townley L. R., Post V., Evans R. E., Hunt R. J., Peeters L, Richardson S., Wernere A. D., Knapton A. and Borokay A., (2012). Australian Groundwater modelling guidelines, June 2012.

Boughton, W. (2004). The Australian water balance model, Environmental Modelling & Software. 19(10), 943-956.

CDM Smith (2016). Macraes Gold-Tungsten Project – Hydrological Data and Conceptualisation

GHD (2019). Deepdell North Stage III Project Receiving Water Quality Analysis. Report prepared for Oceana Gold (New Zealand) Ltd, November 2019.

GHD (2021). Round Hill Open Pit Pre-Feasibility Study –Groundwater Modelling Report. Prepared for Oceana Gold New Zealand Limited.

GHD (2022a). TTTSF 570 Crest Raise. Surface Water and Groundwater Assessment. Prepared for Oceana Gold New Zealand Limited.

GHD (2022b). Frasers Co-disposal Surface Water and Groundwater Assessment. Report prepared for Oceana Gold (New Zealand Ltd, 10 November 2022.

GHD (2023). Macraes Phase 4. Golden Bar Dewatering Assessment. Report prepared for Oceana Gold, New Zealand Ltd.

GHD (2024). Macraes Mine. Phase IV. Stage 3. Surface Water and Groundwater Assessment. Report prepared for Oceana Gold, New Zealand Ltd.

Mine Waste Management (2022). Frasers Open Pit Tailings Co-Disposal: Geochemistry

Mine Waste Management (2023). Waste Rock Stack Seepage Quality. Report prepared for Oceana Gold (New Zealand Ltd, 23 February 2023.

Mine Waste Management (2024). Macraes Phase 4.3: Golden Bar Pit Lake Water Quality Analogue Model. 6 June 2023

Golder Associates (2011a). Macraes Phase III Project, Top Tipperary Tailings Storage Facility Hydrogeological Assessment.

Golder Associates (2011b). Macraes Phase III Project, Groundwater Contaminant Transport Assessment – Deepdell Creek, North Branch Waikouaiti River and Murphys Creek Catchments.

Golder Associates (2016). Coronation North Project, Groundwater Assessment

Kingett Mitchell Ltd (2005a). Macraes Gold Project Groundwater Modelling Technical Report.

Kingett Mitchell Ltd (2005b). Macraes Gold Project Groundwater and Contaminant Transport Assessment.

Van Vuuren DP, Edmonds J, Kainuma M, Riahi K, Thomson A, Hibbard K, Hurtt GC, Kram T, Krey V, Lamarque JF, Masui T, Meinshausen M, Nakicenovic N, Smith S, Rose SK. (2011). The representative concentration pathways: an overview. Climatic Change 109: 5–31.

WSP (2023). Golden Point Underground Mine (GPUG). GPUG Extension Hydrogeological Assessment (GPUG ext). April 2023.

WSP Golder (2022). Golden Point Underground Mine (GPUG) Extension Hydrogeological Assessment.

Appendices

Appendix A

Water Balance Model Build Report

A-1 Model Inputs

Key inputs into the Water Balance Model as outlined as provided.

- Stage volume area table for Golden Bar current and Stage 2
- Measured site data
- Mine area and waste rock stack plans – current / closure
- Catchment runoff plans – current / closure

The stage pit volume curve data for the current golden Bar Pit is shown in Table 13. Table 14 shows the stage 2 Golden Bar Pit stage volume curve provided by OGNZL.

Table 13 Stage volume curve for current Golden Bar Pit

RL	Volume (m^3)	Area (m^2)
455.0	0	0
460.0	2,018	114
465.0	16,230	914
470.0	53,047	2,987
475.0	121,587	6,846
480.0	235,570	13,264
485.0	384,522	21,651
490.0	566,795	31,915
495.0	804,829	45,318
500.0	1,083,330	61,000

Table 14 Stage 2 Golden Bar pit Stage Volume Curve

RL	Volume(m^3)	Area(m^2)
420.0	2,162	900
422.5	6,798	1,900
425.0	17,538	4,300
427.5	33,975	6,600
430.0	54,606	8,300
432.5	85,596	12,400
435.0	123,228	15,100
437.5	165,227	16,800
440.0	214,607	19,800
442.5	273,636	23,600
445.0	339,939	26,500
447.5	423,560	33,400
450.0	512,119	35,400
452.5	610,186	39,200
455.0	723,842	45,500
457.5	843,508	47,900
460.0	973,148	51,900
462.5	1,130,133	62,800
465.0	1,301,276	68,500
467.5	1,483,324	72,800
470.0	1,679,742	78,600
472.5	1,884,572	81,900
475.0	2,096,683	84,800
477.5	2,336,623	96,000
480.0	2,589,038	101,000
482.5	2,850,700	104,700
485.0	3,127,479	110,700
487.5	3,413,583	114,400
490.0	3,711,488	119,200
492.5	4,054,158	137,100
495.0	4,406,772	141,000
497.5	4,768,230	144,600

A-2 Australian Water Balance Model (AWBM) Calibration

A-2-1 Deepdell Creek

For flows from un-effected catchments an AWBM is calibrated to gauging undertaken on Deepdell Creek at DC03 (immediately upstream of DC04 and the haul road crossing Deepdell Creek) between 1991 and 2018. This gauging site has a contributing catchment area of 4,200 ha. Golden Point rainfall and evaporation records are applied in calibration of the AWBM. The calibrated runoff model predicts both surface runoff and total runoff including base flow recharge, where total runoff is applied to model stream flows. The statistical comparison between gauge and calculated flows is shown in Figure 45. The model calibration has a slight bias for underestimating natural catchment flows which is seen as conservative for assessing water quality effects following mass load contributions. This is not true for the driest 1% of flows (i.e. measured flows below 1 L/s), where measured data indicates that flow reduces at a relatively higher rate than predicted.

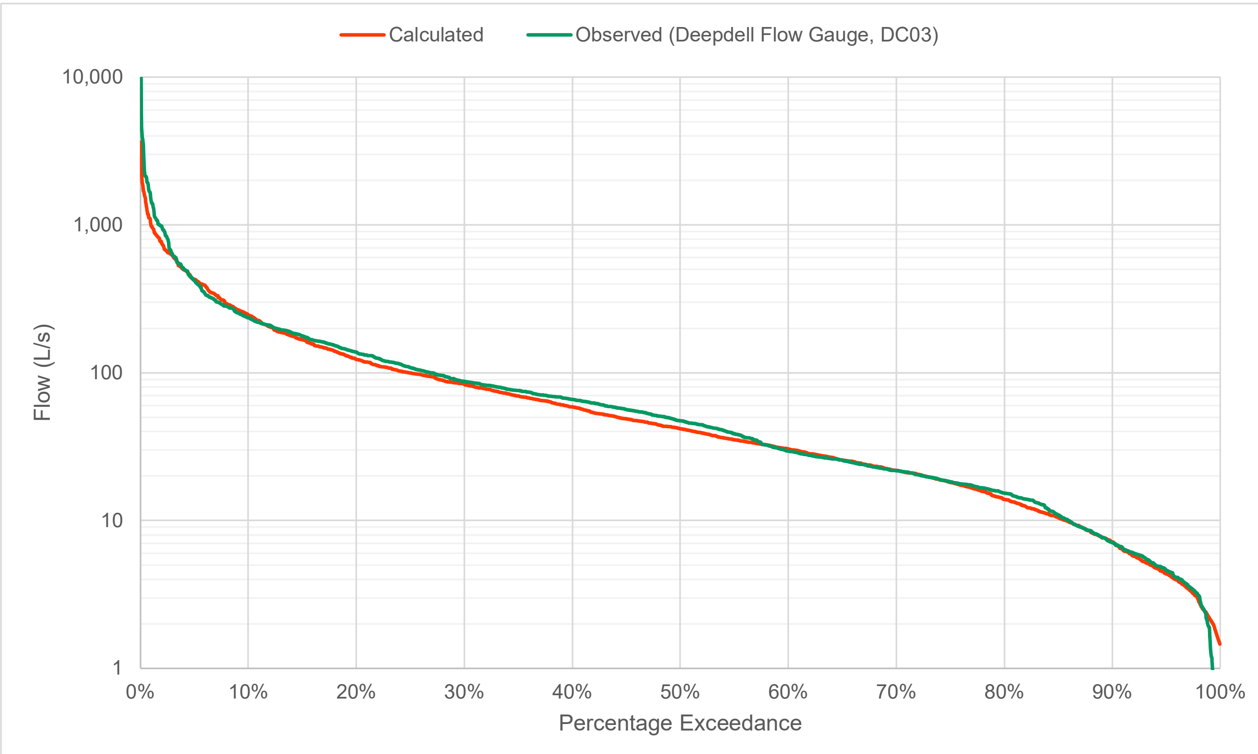


Figure 45 Calibration of the Deepdell Creek AWBM

A-2-2 Waikouaiti River North Branch

For flows from un-effected catchments an AWBM is calibrated to gauging undertaken on the NBWR at Golden Bar Road and Gifford Road gauges (NBGR) between 1991 and 1998. These two gauging sites are estimated to have reporting catchments of 250 ha and 640 ha respectively. Golden Point rainfall and evaporation records are applied in calibration of the AWBM. The calibrated runoff model predicts both surface runoff and total runoff including base flow recharge as shown in Figure 46, with these two outputs closely representing the statistical flows at the respective gauging sites. Given the specific runoff calculated at the lower gauging site – (NBGR) is lower and potentially unconservative, the total specific runoff model output is applied to the WBM for the purpose of pit lake filling projections.

Gauged flows above 10 L/s are estimates only, equivalent to a specific flow of 0.35 mm/d at Gifford Road and 0.135 mm/d at NBGR, corresponding to approximately the highest 15% of flows.

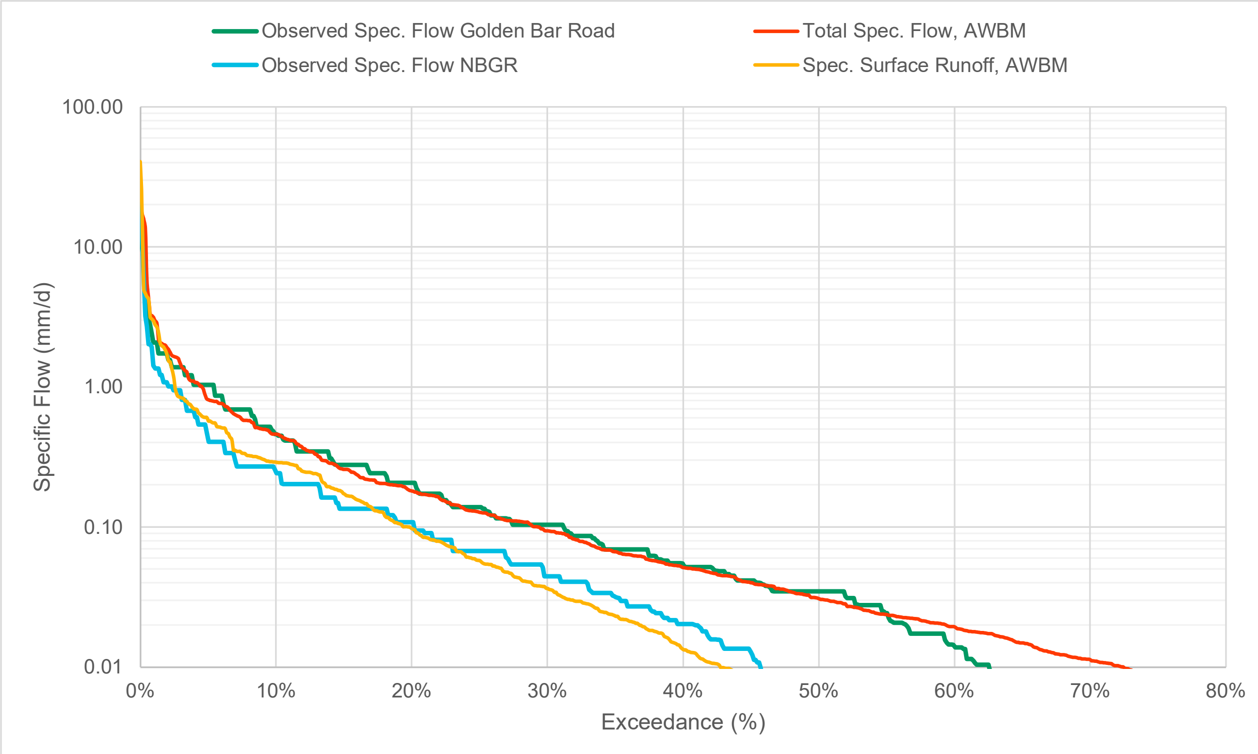


Figure 46 Calibration of the NBWR AWBM

A-3 Golden Bar Pit Lake Model Calibration

Historic measured site data at Golden Bar Pit allowed for the model calibration of the Golden Bar Pit Lake. Figure 47 Golden Bar Pit Lake calibration based on measured data from the existing pit lake indicates the closeness between the model calibration water level and the measured site data for the period around 2011. This provides a good indication that the model calibration is reasonable. The overflow level of the pit lake is likely to be closer to 497.5 mRL, aligning closer to the calibration results compared to the anecdotal first overflow value.

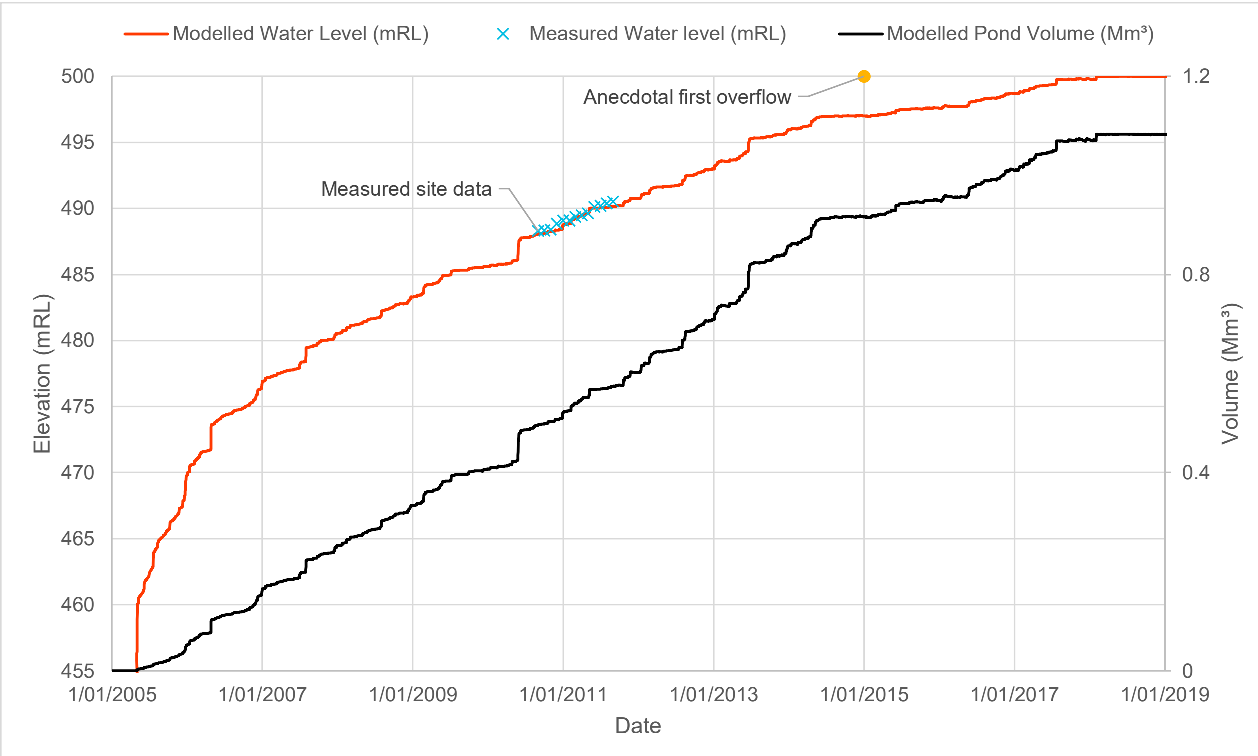
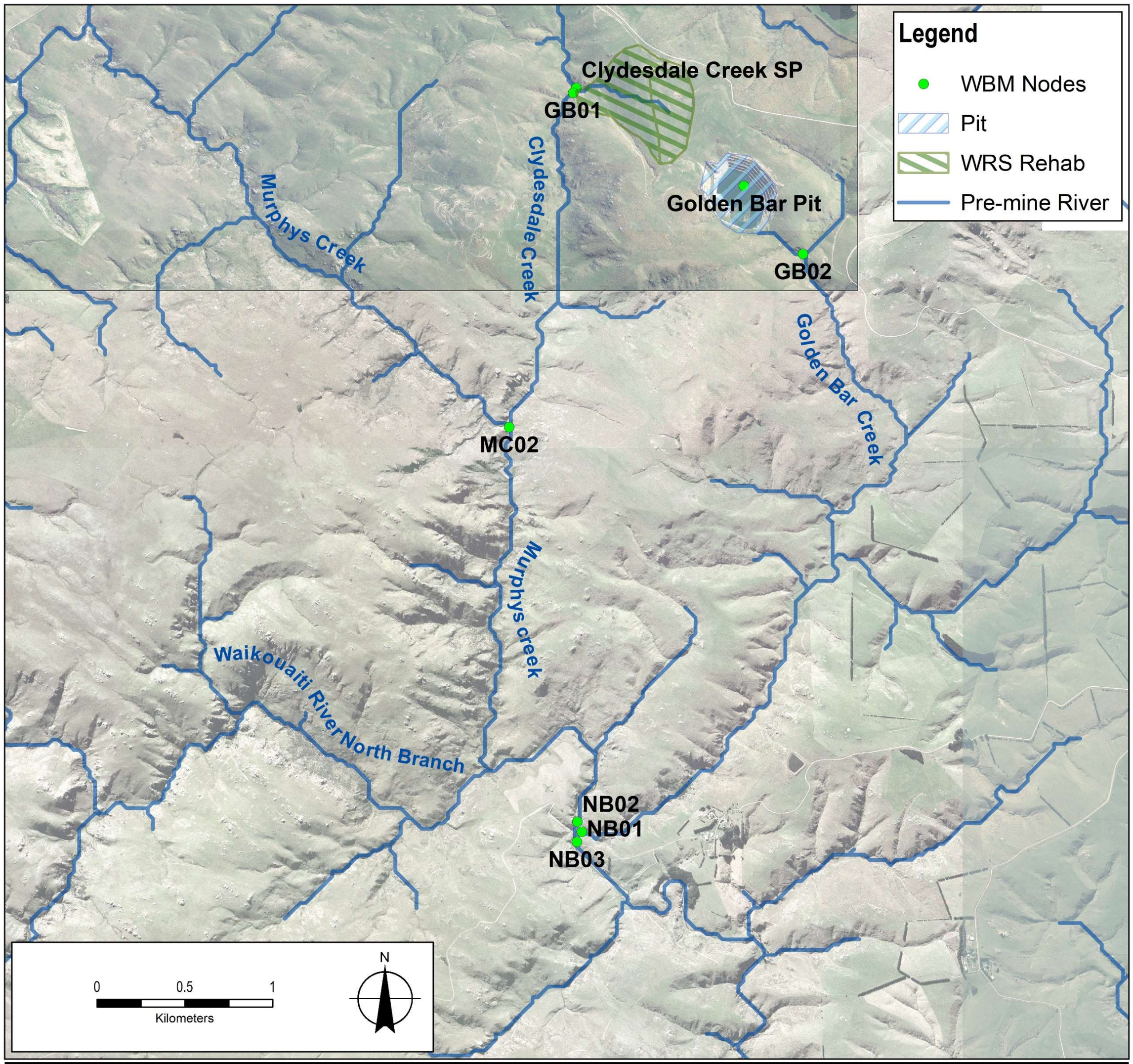


Figure 47 Golden Bar Pit Lake calibration based on measured data from the existing pit lake

A-4 Catchment Maps for the Proposed Stage 2 Golden Bar Development



G:\51\12576793\GIS\Maps\Working\GIS figures\Golden bar figures\GB figure3.mxd

Data source: Created by:eosborn

Figure 48 Golden Bar Pit and WRS - Current

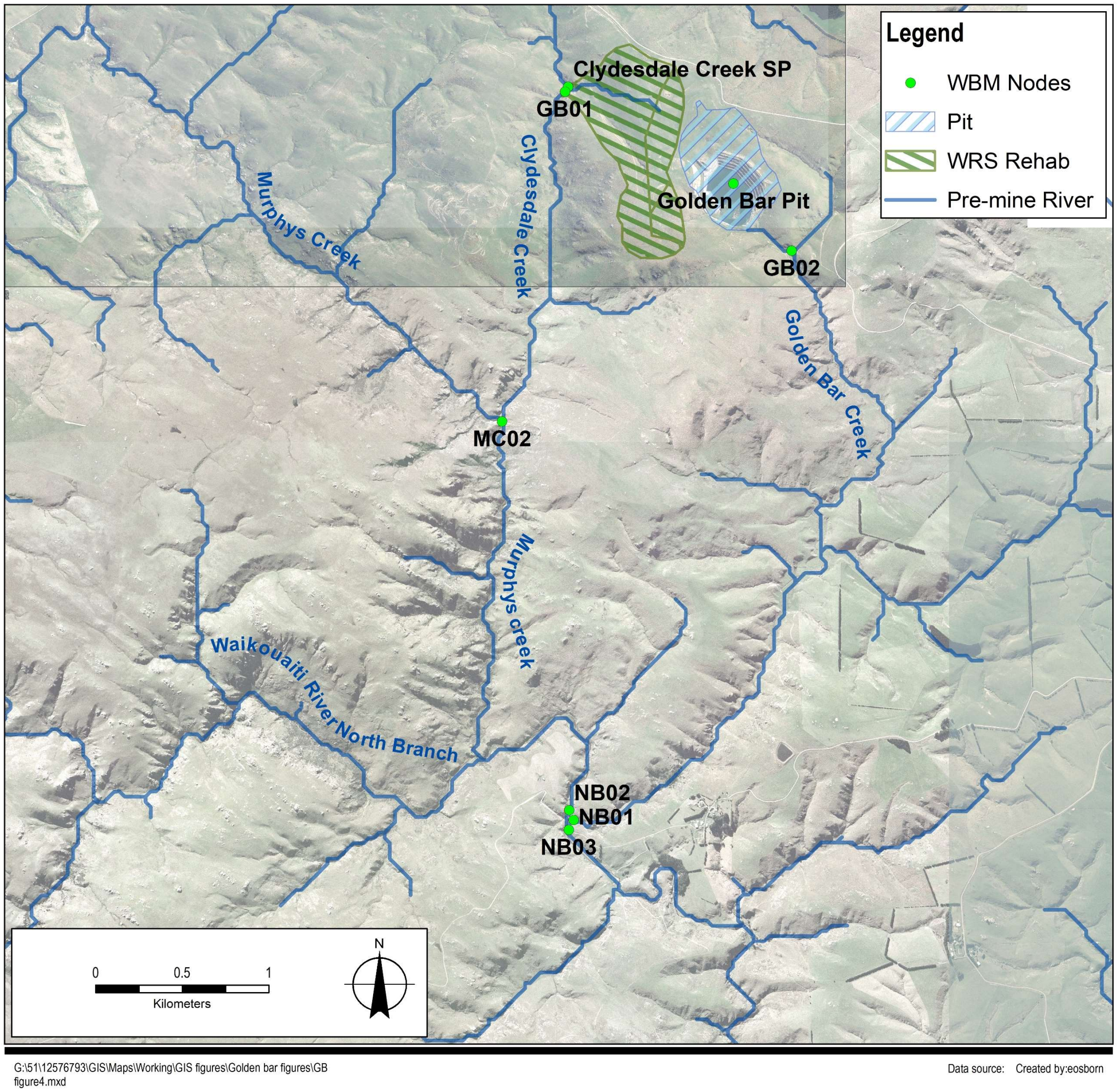


Figure 49 Golden Bar Pit and WRS – Closure

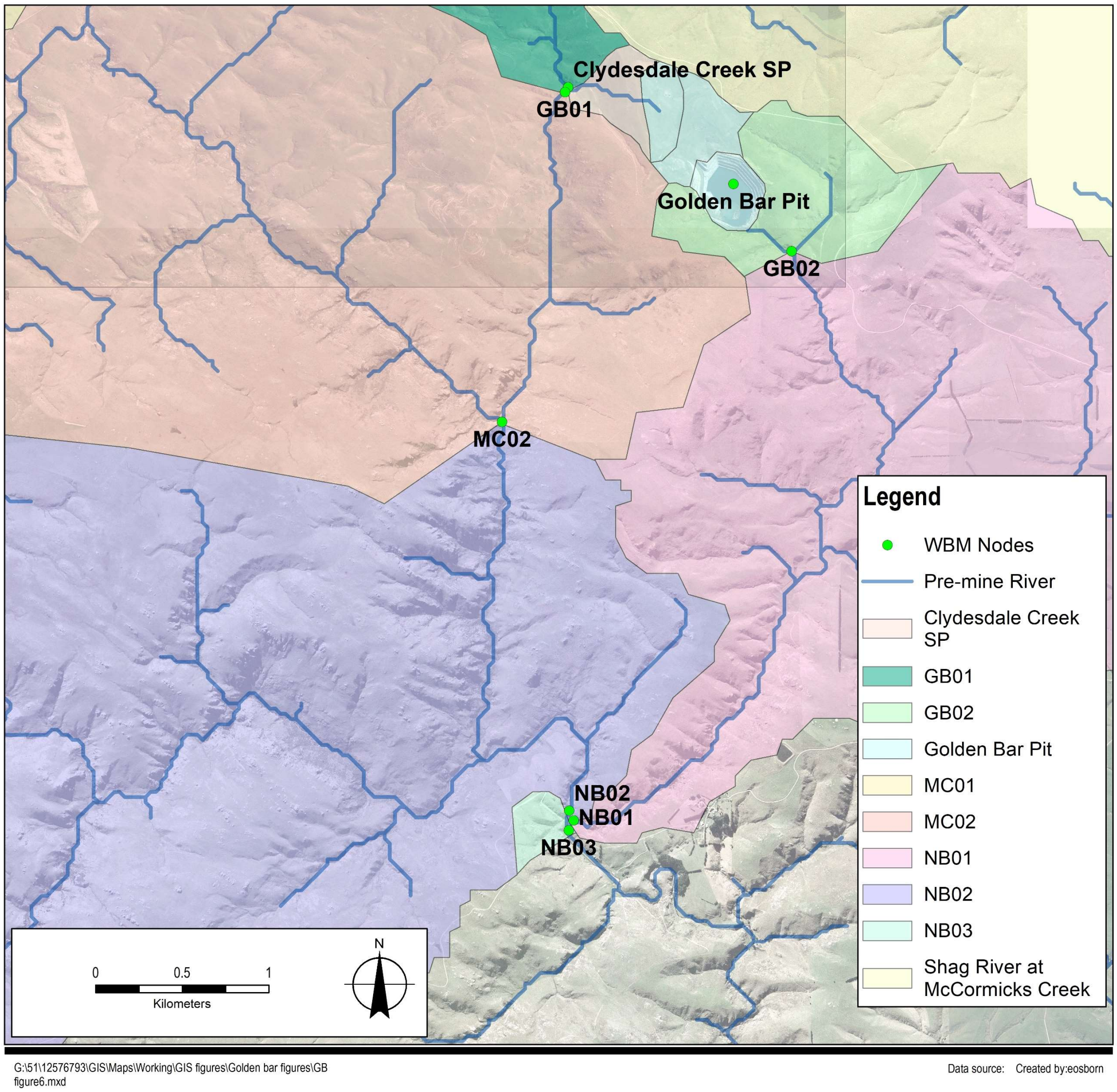


Figure 50 Golden Bar Catchment Map - Current

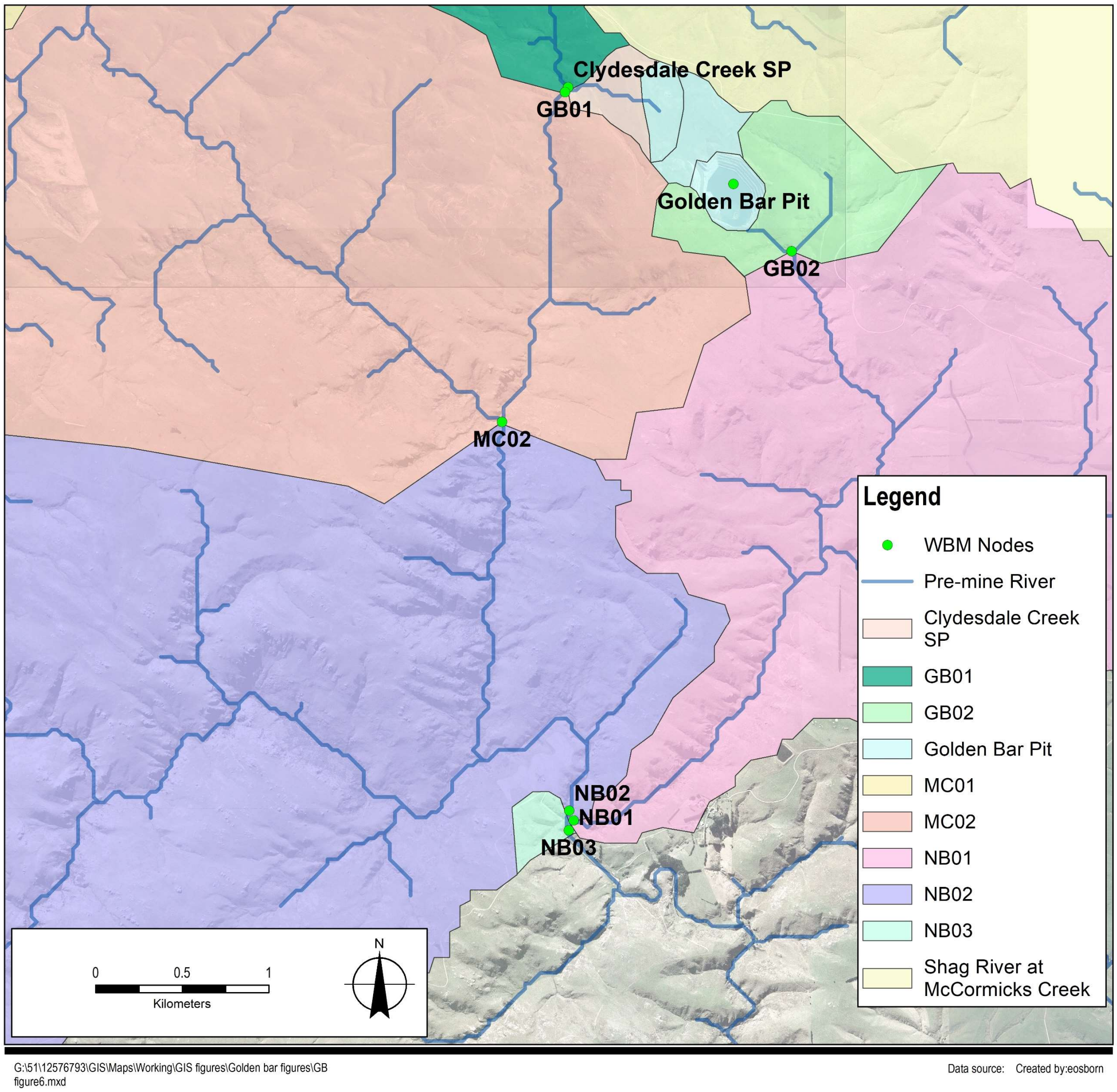
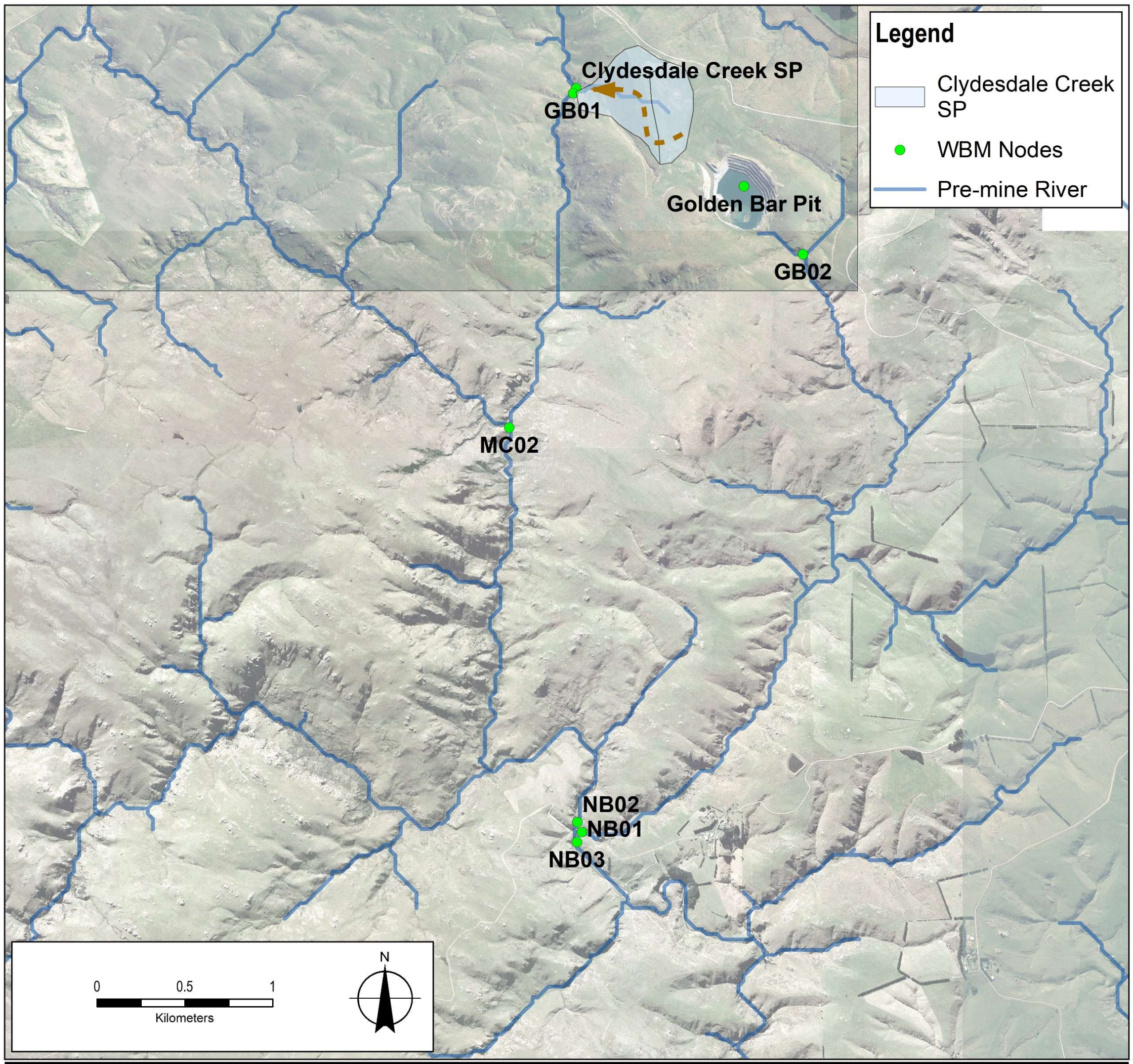


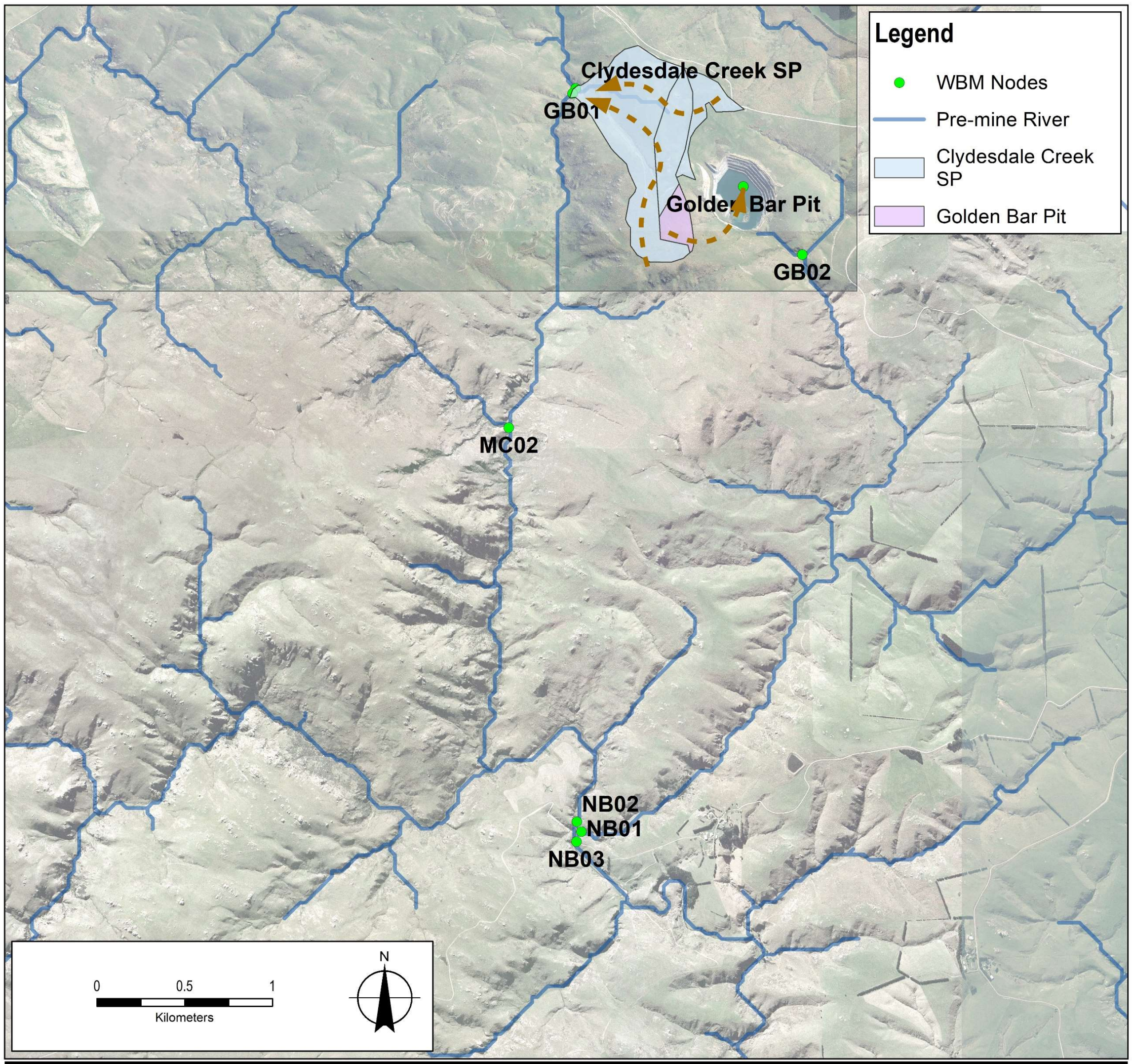
Figure 51 Golden Bar Catchment Map - Closure



G:\51\12576793\GIS\Maps\Working\GIS figures\Golden bar figures\GB figure8.mxd

Data source: Created by:eosborn

Figure 52 Golden Bar WRS Seepage Flow Map - Current



G:\51\12576793\GIS\Maps\Working\GIS figures\Golden bar figures\GB figure7.mxd

Data source: Created by:eosborn

Figure 53 Golden Bar WRS Seepage Flow Map - Closure

Appendix B

Golden Bar Dewatering Assessment

Report

21 July 2023

To	Oceana Gold New Zealand Ltd.	**Contact No.**	03 378 0900
Copy to	Dean Fergusson	**Email**	Liz.Osborn@ghd.com
From	Liz Osborn, Jeff Tuck	**Project No.**	12576793
Project Name	Macraes Phase 4		
Subject	Golden Bar Dewatering Assessment		

1. Introduction

Golden Bar Stage 2 Open Pit (GB Stg.2) is proposed to be mined between 2029 and 2031 with the proposed GB Stg. 2 pit shown in Figure 1. To enable mining of the open pit, dewatering of the existing Golden Bar Open Pit will be required as this began filling once mining concluded in 2005 and reached overflow in 2015. Dewatering of the open pit will remove water accumulated within the pit and draw down the surrounding groundwater table with discharge directed to the Golden Bar Creek (tributary of the North Branch Waikouaiti River, downstream of Golden Bar Pit).

This report provides an estimate of the time required to dewater the pit at defined pumping rates and resultant water quality outcomes in the receiving environment.

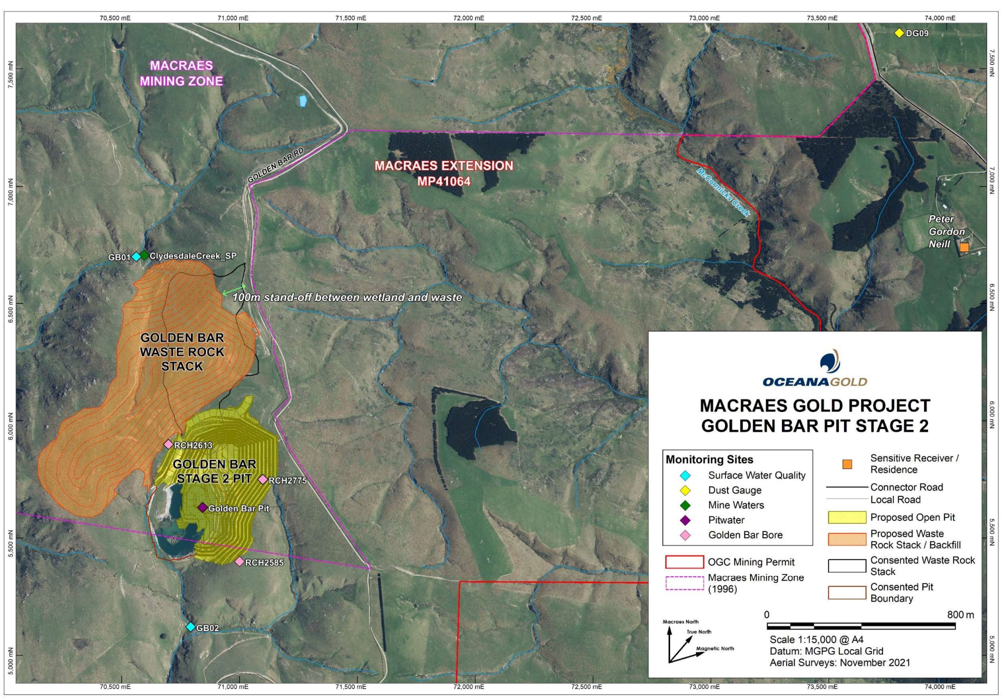


Figure 1 Proposed Golden Bar Stage 2 Elements (Source: OGNZL)

1.1 Purpose of this report

The purpose of this report is to present the results from surface water modelling for proposed dewatering of Golden Bar Pit prior to the mining the next stage. It provides estimates of the rate at which the Golden Bar pit lake level could be drawn down at given pumping rates and assesses the likely change in water quality within the receiving environment.

2. Scope and limitations

2.1 Scope of work

OGNZL have engaged GHD to assess potential rates of dewatering of Golden Bar Pit and the change in water quality within the receiving environment during dewatering. The scope of this work is to apply the site water balance model and investigate the following:

- Assess pumping rates and the resulting dewatering time for the pit,
- Determine the change in water quality at the existing monitoring points GB02, NB01 and NB03 with a focus on sulphate and arsenic as key contaminants of consideration compared to other contaminants controlled by the existing NB03 compliance point.

2.2 Limitations

This report: has been prepared by GHD for Oceana Gold Ltd and may only be used and relied on by Oceana Gold Ltd for the purpose agreed between GHD and Oceana Gold Ltd as set out in this report.

GHD otherwise disclaims responsibility to any person other than Oceana Gold Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Oceana Gold Ltd and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

3. Hydrology and model

The existing Golden Bar Pit is proposed to be dewatered by pumping to a discharge point within Golden Bar Creek before feeding into the North Branch Waikouaiti River (NBWR). Figure 2 provides an indicative location for the discharge upstream of the GB02 monitoring point as assessed in the WBM. Also shown are the established monitoring and compliance locations in the area. The Golden Bar Pit Lake currently overflows to the Golden Bar Creek upstream of the GB02 and NB01 monitoring and compliance points, and before the confluence with the North Branch Waikouaiti River and NB03 compliance point. NB03 also receives water influenced by mine operations related to Frasers Pit and Frasers Waste Rock Stacks (WRS) via Murphys Creek and upper reaches of NBWR.

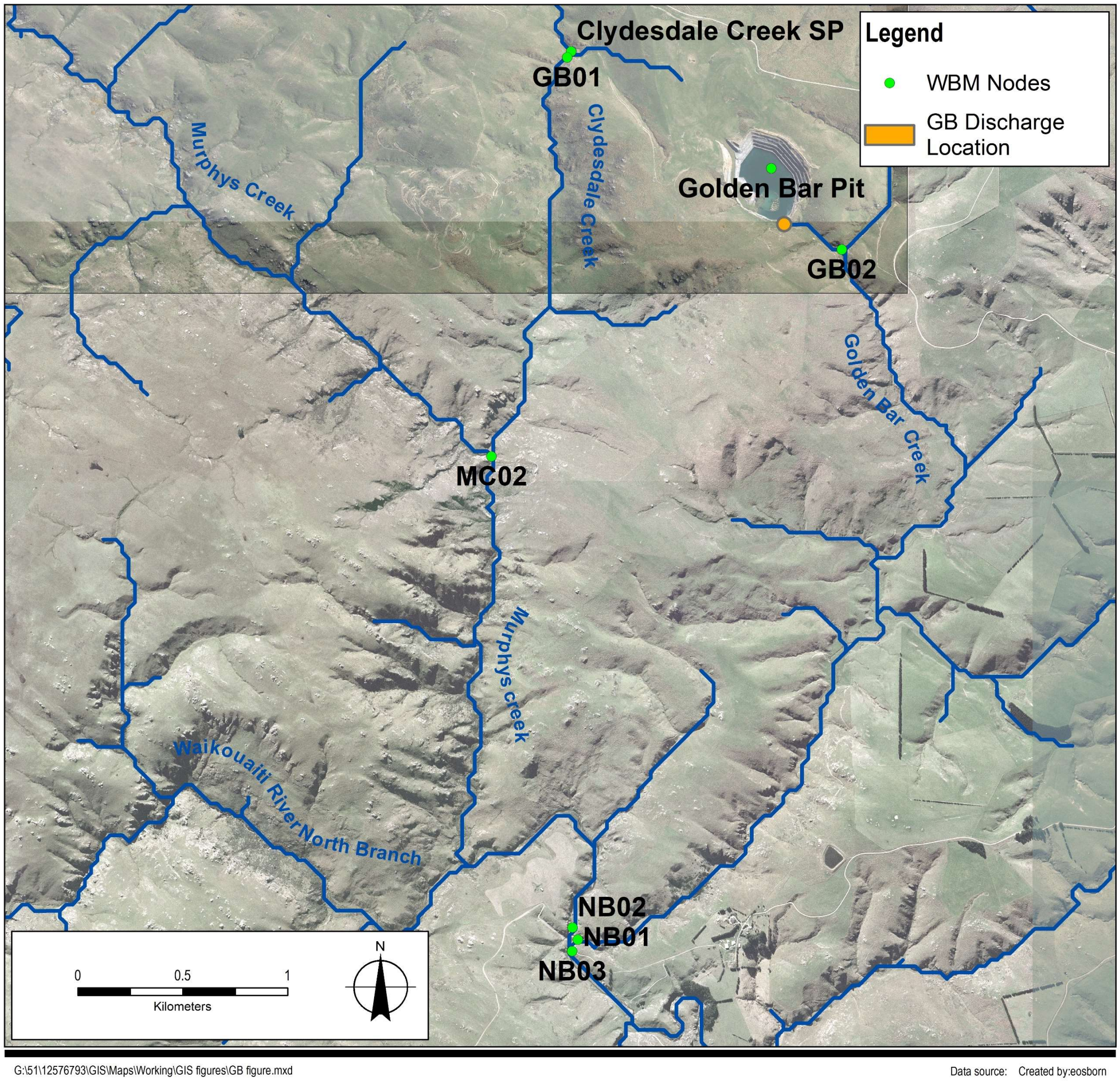


Figure 2 *Locations of monitoring points*

Flow and water quality modelling was undertaken using a WBM developed for the wider Macraes mine site and further details of this model can be found in GHD 2023[1]. As a brief overview of the model hydrological inputs:

- Rainfall applied in the WBM for predictive analysis is based on a synthetic stochastic data series produced for statistical similarity with recorded rainfall data. Calibration of the model applies daily site rainfall data from the Golden Point Weather Station.
- Evaporation is represented in the model based on monthly statistic derived from pan evaporation data collected from site between 1991 and 2018.
- Runoff is represented in the WBM by two methods, the rational method is applied to areas impacted by mining (e.g. pit walls and WRSs), and a calibrated Australian Water Balance Model (AWBM) is applied to all other areas.
- The Golden Bar Pit is represented by a relationship defining volume and surface area with water elevation for the current as-mined pit geometry.

[1] GHD 2023. Golden Bar – Surface and Groundwater Assessment

- Groundwater inflows are determined by groundwater modelling and show increasing groundwater inflow rates with depth. The model inputs are based on a mean expected inflow, and do not have an uncertainty defined.

A secondary reference point for river flow mean and median flow estimates are considered as defined by NIWA's New Zealand River maps[2]. Table 1 shows the corresponding flow estimates for the three monitoring points.

Table 1 NIWA New Zealand River Maps flow statistics

Shape	GB02 (L/s)	NB01 (L/s)	NB03 (L/s)
Catchment Area (km^2)	1.82	9.30	85.9
Median	5.199	24.17	334.5
Mean	12.44	57.3	628.8
MALF	1.81	10.3	137.0

4. Calibration

The WBM is calibrated against measured water quality data at mine water sources and monitoring points across the model domain. Comparisons between measured sulphate data from 2015 – 2020 and model outputs can be shown through constraining the model to actual rainfall data from the same period. Figure 3 shows the measured NB03 sulphate concentrations versus modelled outputs. At this location the modelled sulphate concentrations are shown to offer a conservative representation of the measured data for this time period.

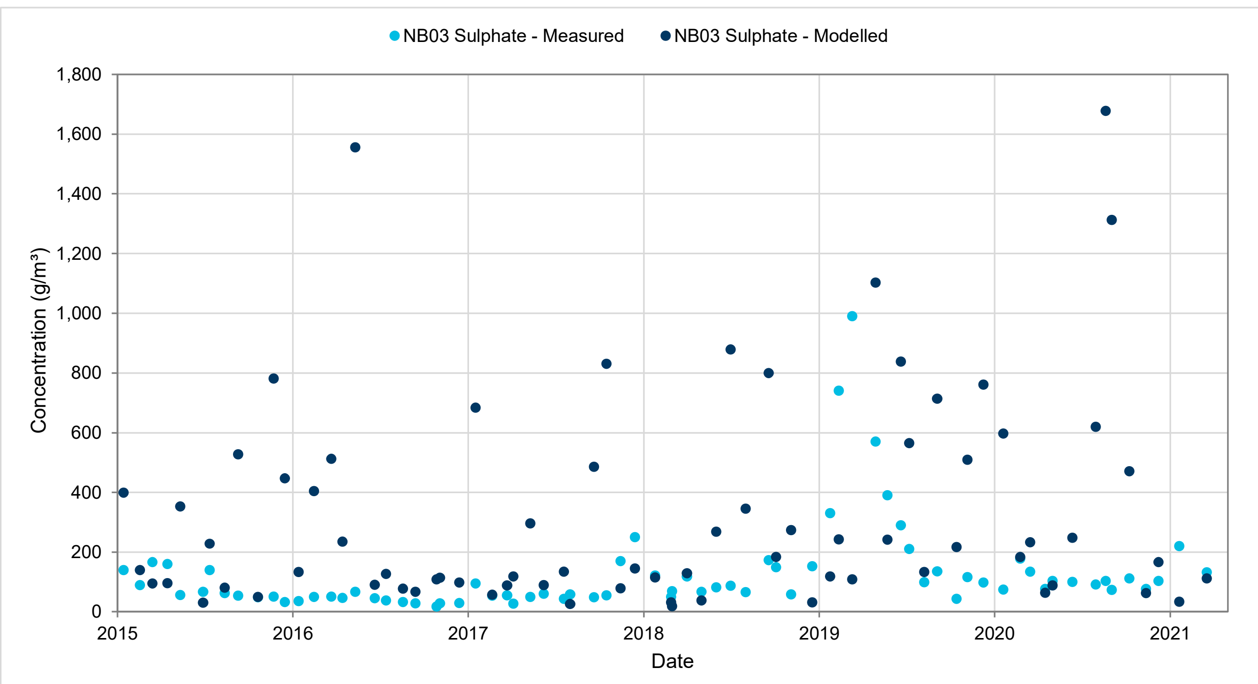


Figure 3 Historical rainfall calibration at NB03

[2] Whitehead, A.L., Booker, D.J. (2020). NZ River Maps: An interactive online tool for mapping predicted freshwater variables across New Zealand. NIWA, Christchurch. https://shiny.niwa.co.nz/nzrivermaps/

A statistical comparison for NB01 and NB03, shown in Figure 4, indicates that the median concentrations agree and the modelled data represents a greater spread near the extremes of the data ranges. Differences in the upper and lower flow estimates (compared to the measured data) are likely due to:

- The model does not allow for active management of silt pond discharges (Murphys Creek and Frasers West Silt Ponds) to be applied and this is likely a factor contributing to the difference between modelled and measured results. It would typically be beneficial to discharge higher concentration water where flows in the receiving environment are high allowing for dilution and to avoid discharges when flows are low. The consequence is that modelled result will show higher peaks and lower lows than actual as seen in Figure 4.
- It is also likely that there is a higher base flow contribution to the river (less affected by seasonal variation) than that represented by the AWBM calibrated to a flow gauge on Deepdell Creek (with the calibration focussed on low flow periods) - there is no stream flow gauging data available in the lower reaches of the NBWR. The flow estimates given in Table 1 are higher than those represented by the model by a factor of two to three, indicating a possibility that the modelled flow underrepresents baseflow.

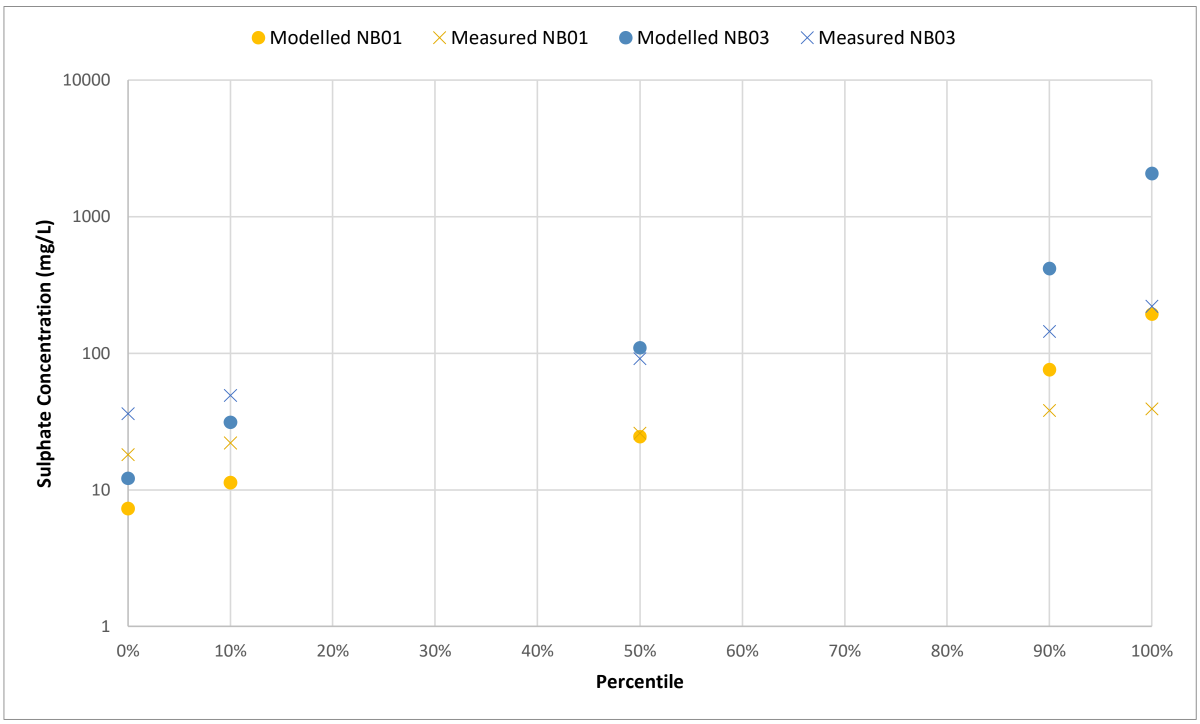


Figure 4 Synthetic statistical rainfall calibration at NB01 and NB03

5. Dewatering assessment

5.1 Assessment rational

The current monitoring points downstream of Golden Bar Pit (GB02, NB01 and NB03. NB01 and NB03) are established compliance points and have limits set for water quality as shown in Table 2. For comparison, mean and maximum statistics for Golden Bar Pit water quality are included to identify constituents of concern for this assessment. Two constituents within the pit water exceed the existing NB03 compliance criteria - Arsenic and Sulphate, while the other constituents are an order of magnitude less. pH values fall within the defined range. Recent sampling (data provided by OGNZL) has investigated water quality variation with depth and results from this sampling are presented in Table 3. These two discrete sampling events indicate that the constituents considered are either maintaining or improving since the end of the data set presented in Table 2. For the latest sampling round it can be seen that Arsenic increases with depth, reaching 0.167 g/m^3 at the lower depth of 35 m.

Nitrate N and Ammoniacal N are not included within the existing consent constituents, however, are of growing interest. The National Policy Statement for Freshwater Management (2023)[3] (NPSFM) defines the highest attribute band (A) to have an annual median of ≤1.0 g/m^3 for Nitrate N and ≤0.03 g/m^3 for Ammoniacal N and these standards are currently met by water discharging from the lake. Based on this consideration these constituents are not assessed in further detail in this report.

Table 2 Current water quality compliance criteria at NB01 and NB03 and Golden Bar Pit water quality

Constituent (g/m^3)	NB01 Compliance	NB03 Compliance	Golden Bar Pit Mean[1]	Golden Bar Pit Max[1]
pH	6.0-9.5	6.0-9.5	8.38 – 8.5 (range)	
Arsenic	0.15	0.01	0.15	0.19
Cyanide	-	0.1	-	-
Copper	0.009	0.009	0.0006	0.0007
Iron	1	0.2	0.02	0.02
Lead	0.0025	0.0025	0.0001	0.0002
Zinc	0.12	0.12	0.001	0.002
Sulphate	-	250	287	320
Nitrate – N	-	-	0.008	0.023
Ammoniacal Nitrogen	-	-	0.016	0.1

[1]. Calculated based on measured water quality data between 2015 and April 2022

Table 3 Golden Bar Pit Lake water quality sampling with depth

Depth (m)	pH (pH Units)	Arsenic g/m³	Copper g/m³	Iron g/m³	Lead g/m³	Zinc Tot. g/m³	Ammoniacal-N Tot. g/m³	Nitrate-N g/m³	Sulphate g/m³
Sampled: 31/03/2023									
1	8.4	0.127	< 0.0005	< 0.02	< 0.00010	< 0.0011	< 0.010	< 0.002	260
5	8.4	0.128	0.0005	< 0.02	< 0.00010	0.0014	< 0.010	< 0.002	260
10	8.4	0.127	< 0.0005	< 0.02	< 0.00010	< 0.0011	< 0.010	< 0.002	260
15	8.2	0.114	< 0.0005	< 0.02	< 0.00010	< 0.0011	< 0.010	< 0.002	260
20	8.1	0.115	< 0.0005	< 0.02	< 0.00010	< 0.0011	< 0.010	< 0.002	260
30	8	0.147	< 0.0005	< 0.02	< 0.00010	0.0014	0.029	0.081	260
35	8	0.167	< 0.0005	< 0.02	< 0.00010	0.0015	0.072	0.047	260
Sampled: 25/10/2022									
1	8.5	0.114	0.0006	< 0.02	< 0.00010		< 0.010	< 0.002	270
5	8.5	0.115	< 0.0005	< 0.02	< 0.00010		< 0.010	0.002	260
10	8.5	0.116	< 0.0005	< 0.02	< 0.00010		< 0.010	< 0.002	260
15	8.5	0.117	< 0.0005	< 0.02	< 0.00010		< 0.010	< 0.002	270
20	8.4	0.113	< 0.0005	< 0.02	< 0.00010		< 0.010	< 0.002	260
30	8.3	0.11	< 0.0005	< 0.02	< 0.00010		0.032	0.038	270
35	8.3	0.107	< 0.0005	< 0.02	< 0.00010		0.054	0.045	270

[3] NPSFW 2023. National Policy Statement for Freshwater Management 2000. Ministry for the Environment. February 2023.

5.2 Water balance modelling

Dewatering pumping scenarios are defined with the intent to dewater the pit within a timeframe of approximately 1 to 3 years. To achieve this, three scenarios are represented with dewatering pump rates of 30 L/s, 20 L/s and 15 L/s. Figure 5 shows the mean modelled Golden Bar pit pond levels for the three dewatering rates. Year 0 indicates the start of dewatering.

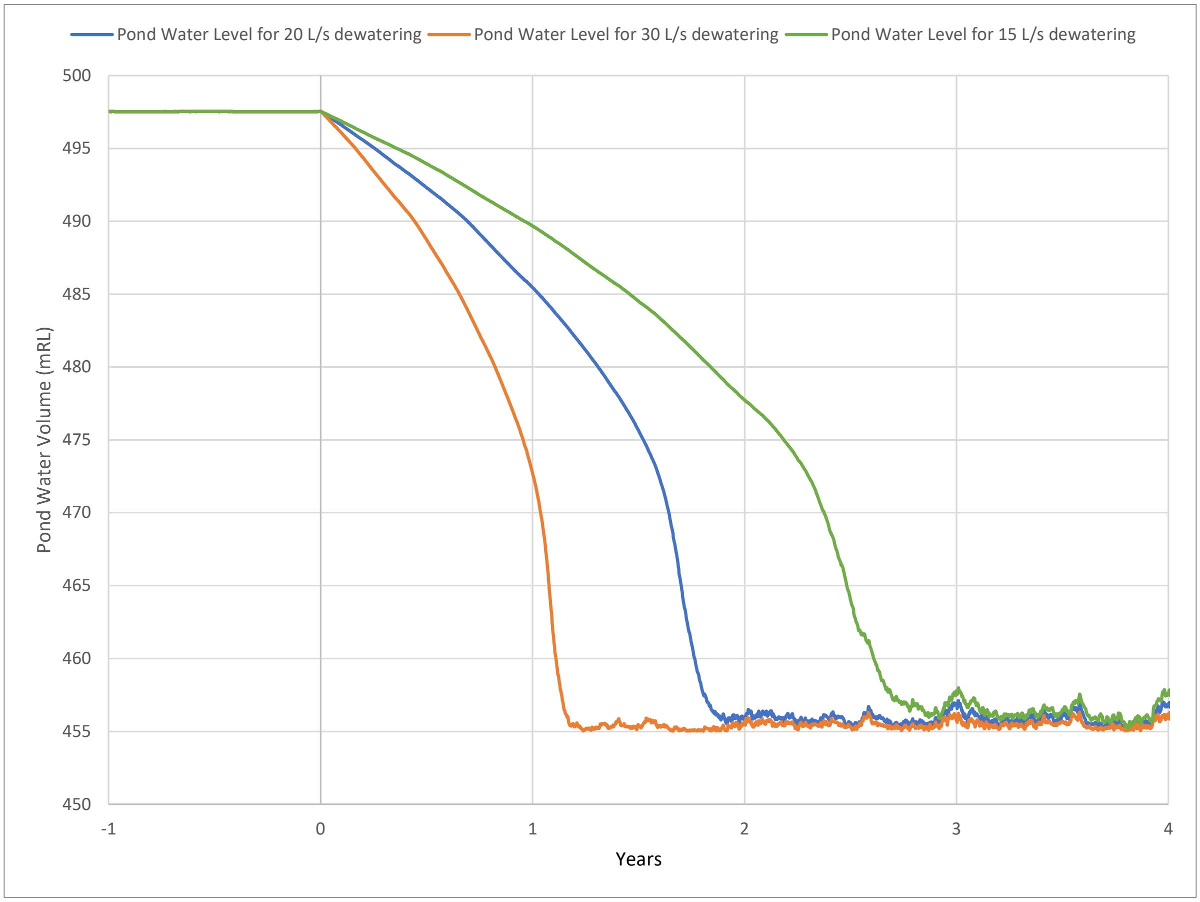


Figure 5 ***Pit water level over time with the proposed dewatering rates***

Figure 6 shows the mean, 5th and 95th percentile pit water levels with a dewatering rate of 30 L/s. This is shown to allow for Golden Bar Pit to be dewatered in approximately 1 year. There is uncertainty with the dewatering duration based on the potential for different rates of rainfall and evaporation to occur during the chosen dewatering years.

There is not a large variation between the mean and the 95th percentile dewatering duration estimates, however uncertainty in groundwater inflow rates may affect this expected drawdown rate. On completion of the initial dewatering phase, modelling allows dewatering to continue to manage surface and groundwater flows entering the pit and fluctuations associated with this can be seen in the years following dewatering. It is noted that this does not represent the proposed Golden Bar Stage.2 pit expansion, and hence, the deepening of the pit (dewatering of the Stage 2 pit expansion is covered in GHD, 2023[4]).

[4] GHD 2023. Macraes Phase IV. Golden Bar – Surface and Groundwater Assessment. Draft Report 18 May 2023

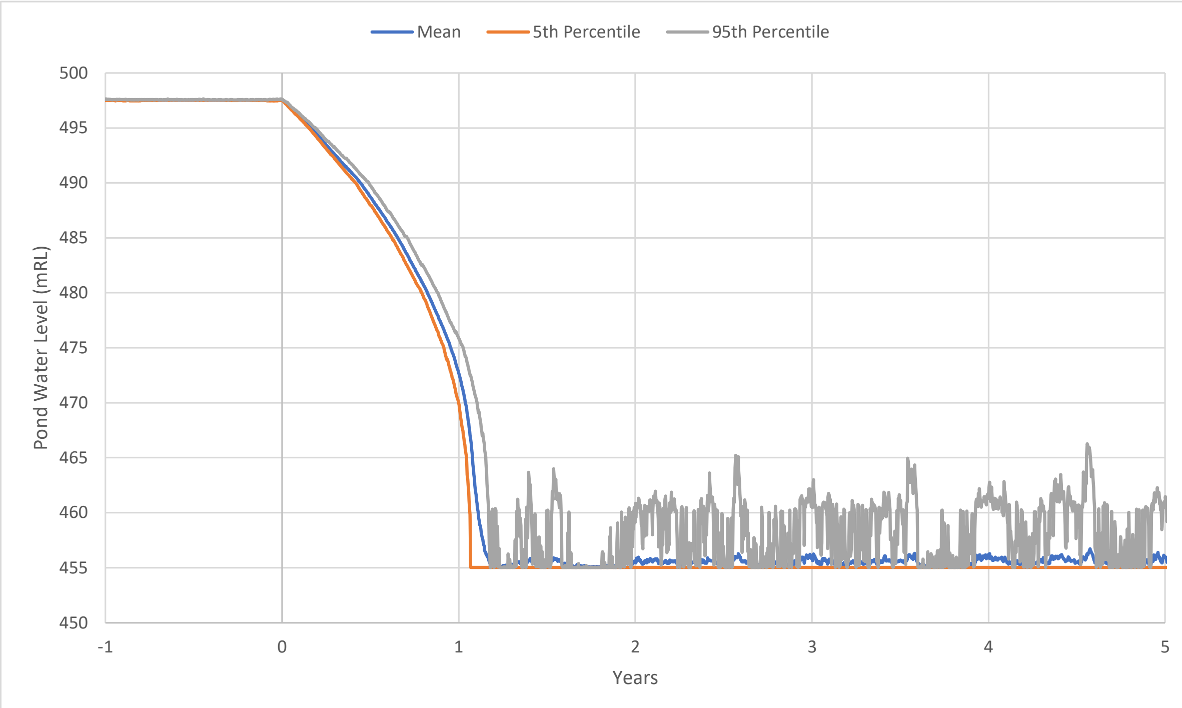


Figure 6 ***Pit water level over time for a dewatering rate of 30 L/s***

A dewatering rate of 20 L/s is estimated to allow for Golden Bar Pit to be dewatered in approximately 1.75 years as shown in Figure 7. There is a 3 month spread between the 5th and 95th percentile dewatering durations in this scenario. There is a larger variation between the average dewatering time and the 95th percentile dewatering time during the dewatering period compared to the 30 L/s dewatering rate. As dewatering occurs over a longer period it poses more opportunity for unpredictable weather events to affect the inflow volume into the pit during dewatering.

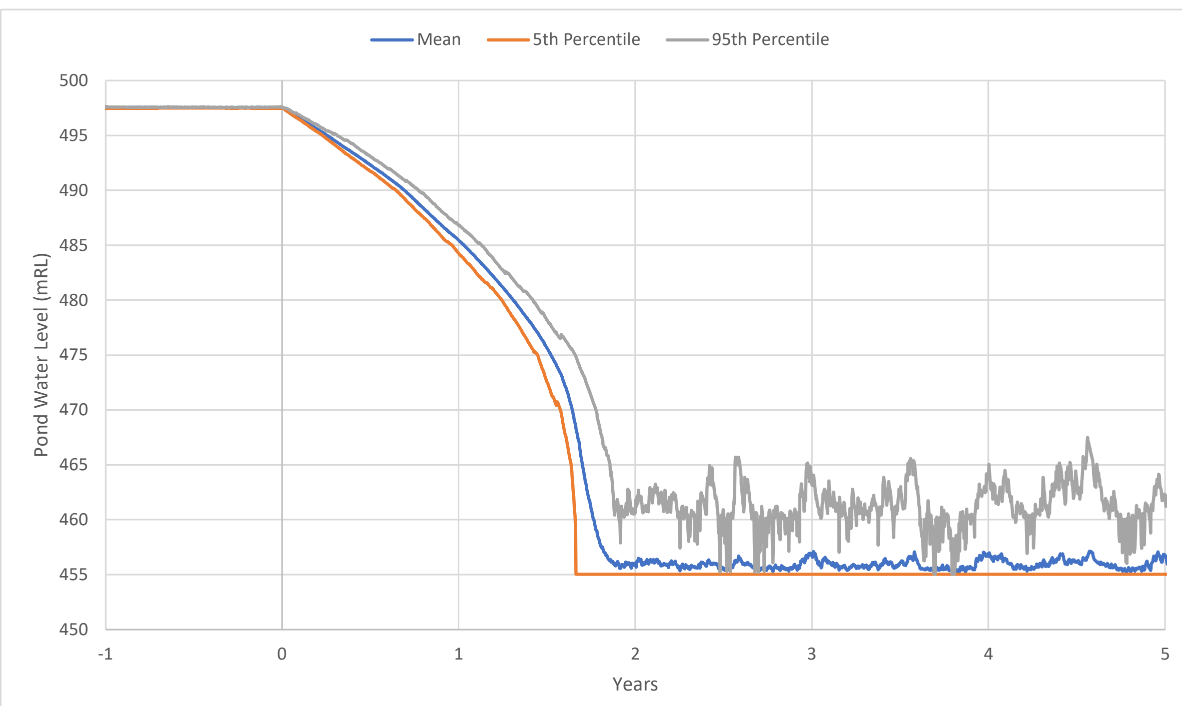


Figure 7 ***Pit water level over time for a dewatering rate of 20 L/s***

A dewatering rate of 20 L/s is estimated to allow for Golden Bar Pit to be dewatered in approximately 2.5 years as shown in Figure 8. The 5th to 95th percentile estimates have a spread of approximately 6 months, giving greater uncertainty when compared with higher dewatering rates. This follows the trend that shows greater uncertainties in dewatering time as the dewatering rate decreases.

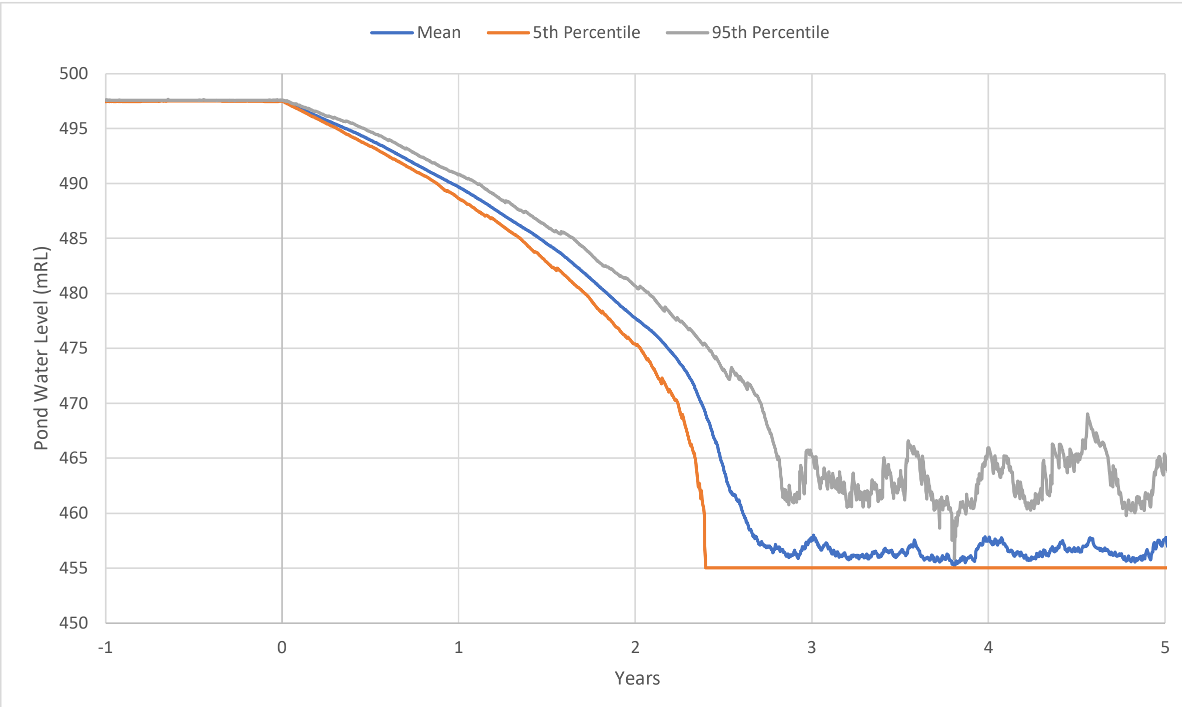


Figure 8 ***Pit water level over time for a dewatering rate of 15 L/s***

The modelled flow statistics at GB02, NB01 and NB03 are presented in **Error! Reference source not found.**. The mean and median values are based on a representative hydrological year taken before dewatering commences (i.e. current conditions) and during dewatering for each of the proposed dewatering rates.

Table 4 ***Modelled flow rates at GB02, NB01 and NB03***

Dewatering Scenario	GB02 Flow (L/s)		NB01 Flow (L/s)		NB03 Flow (L/s)	
	Median	Average	Median	Average	Median	Average
GB Pit overflowing (current)	2	5	11	29	89	229
Dewatering (30 L/s)	31	33	40	58	118	258
Dewatering (20 L/s)	21	23	30	48	108	248
Dewatering (15 L/s)	16	18	25	43	103	243

5.3 Water Quality

5.3.1 Sulphate

The yearly average, median and 95th percentile Sulphate concentrations at GB02, NB01 and NB03 have been calculated for each stage of dewatering and presented in Table 5. The modelling indicates that the established compliance limit for sulphate of 250 g/m³ would be exceeded by the 95th percentile water quality statistic for each of the scenarios. However, as discussed in Section 4 with the model calibration active management of discharges may play a role in this compliance limit being meet more regularly.

The modelling indicates that at the 95th percentile, water quality is likely to improve while dewatering is being undertaken. This is due to the pit water sulphate concentration being lower than the modelled inflows to NB03 via the NBWR upstream catchment. The effect of this can be seen in Figure 9 where dewatering at a rate of 30 L/s could reduce concentration above the 80th percentile while increasing the lower percentile concentrations. Similar is true at the lower dewatering rates with the cross over being at a higher percentile.

Table 5 Sulphate concentration statistics at GB02, NB01 and NB03

Dewatering Scenario	GB02 Sulphate (mg/L)			NB01 Sulphate (mg/L)			NB03 Sulphate (mg/L)		
	Median	Average	95th	Median	Average	95th	Median	Average	95th
GB Pit overflowing (current)	108	115	238	25	35	91	109	180	572
Dewatering (30 L/s)	273	264	283	213	195	271	154	174	377
Dewatering (20 L/s)	273	260	284	191	178	268	141	170	402
Dewatering (15 L/s)	270	255	284	173	164	263	133	168	419

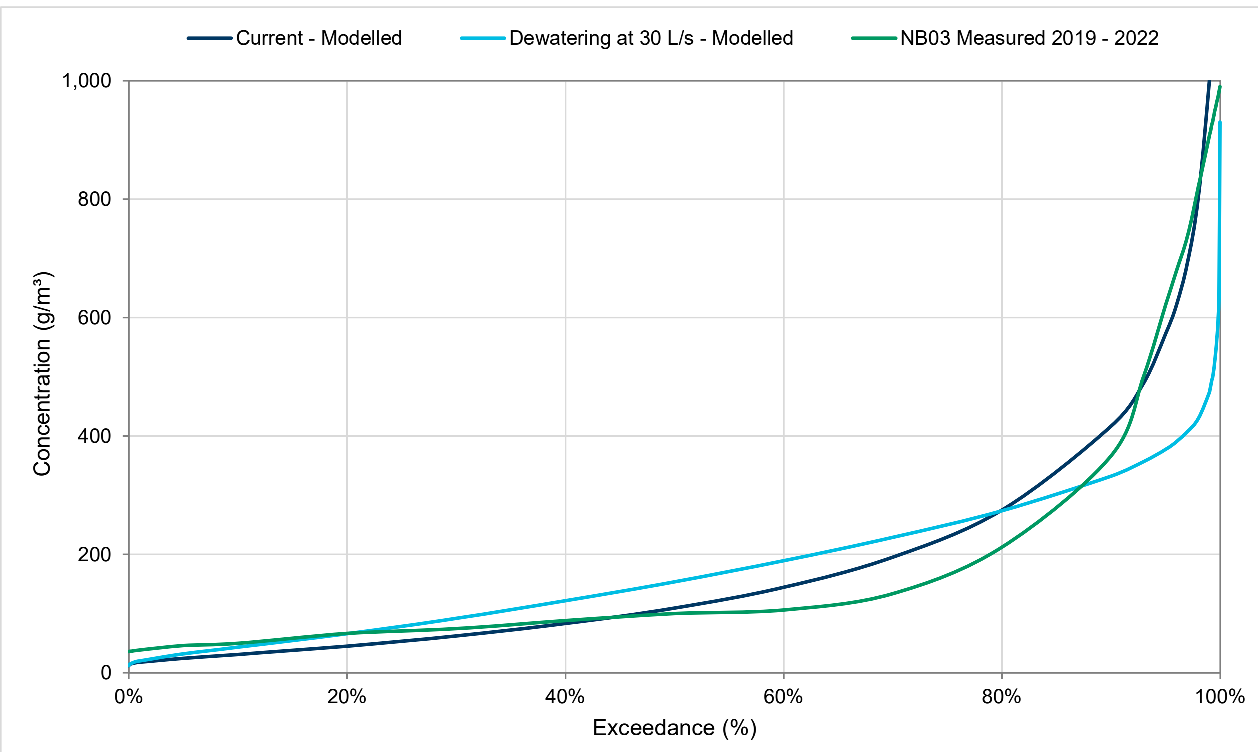


Figure 9 Modelled and measured sulphate concentrations at NB03 for a dewatering rate of 30 L/s

5.3.2 Arsenic

Arsenic levels within the pit lake are currently just below the compliance criteria of 0.15 g/m³ at GB02, however, exceed the NB03 criteria of 0.01 g/m³. Using dilution alone is unlikely to consistently allow discharge from the pit at the proposed dewatering rates while meeting the existing compliance levels defined at NB03 as outlined in this section. However, interventions could be made to improve the discharge regime or reduce Arsenic loads at the source.

The yearly average, median and 95th percentile Arsenic concentrations at GB02, NB01 and NB03 have been calculated for each stage of dewatering and presented in Table 6. The modelling indicates that the established compliance limit for Arsenic of 0.01 g/m³ would be exceeded regularly for each of the scenarios without other interventions being applied and, on this basis, the constant discharge may not be a suitable approach. Possible interventions to maintain Arsenic concentrations below 0.01 g/m³ at NB03 could include:

When operating under the 15 L/s dewatering scenario, modelling indicates that the compliance for Arsenic at NB03 would be met approximately 20% of the time. Dewatering rates would need to be reduced or ceased for the remaining 80% of days to meet the existing compliance limit. This would likely prolong the dewatering timeline significantly. Treatment of Golden Bar Pit Lake prior to commencing dewatering could be undertaken. OGLNZ has successfully carried out ferric dosing (utilising ferric chloride) at the Globe Pit Lake near Reefton to reduce Arsenic concentrations prior to the lake reaching overflow. A similar method could potentially be deployed at Golden Bar Pit Lake to reduce Arsenic concentrations to near or below the 0.01 g/m³ value which could reduce the influence this has on the dewatering regime.

Table 6 Arsenic concentration statistics at GB02, NB01 and NB03

Dewatering Scenario	GB02 Arsenic (mg/L)			NB01 Arsenic (mg/L)			NB03 Arsenic (mg/L)		
	Median	Average	95th	Median	Average	95th	Median	Average	95th
GB Pit overflowing (current)	0.054	0.058	0.123	0.010	0.015	0.045	0.004	0.005	0.009
Dewatering (30 L/s)	0.143	0.138	0.148	0.111	0.101	0.142	0.039	0.045	0.103
Dewatering (20 L/s)	0.143	0.136	0.148	0.099	0.092	0.140	0.030	0.037	0.090
Dewatering (15 L/s)	0.141	0.133	0.148	0.089	0.085	0.137	0.024	0.031	0.080

6. Recommendations and conclusion

This modelling has shown that through applying scenarios with constant dewatering rates of 30 L/s, 20 L/s and 15 L/s the Golden Bar Pit could be dewatered in 1.25, 1.75 and 2.5 years respectively, with an uncertainty of approximately ± 3 months at the lower dewatering rate. Under these dewatering scenarios the constituents Sulphate and Arsenic are at concentrations within the pit that could pose a risk of exceedance to the established consent criteria downstream of the pit. This work does not seek to define water quality compliance exceedance risks at established compliance points while the site is under active management as silt pond discharge controls can result in better outcomes than those modelled. However, it has identified how the proposed discharges may change the water quality in the receiving environment. With respect to Sulphate and Arsenic, management options that would enable the proposed dewatering to be undertaken include:

- Manage discharge to reduce the risk of exceeding the existing compliance criteria for Sulphate at the NB03 monitoring point. This would include active management of discharges to the upper North Branch Waikouaiti River and Murphys Creek catchments as is currently undertaken, then ceasing or reducing dewatering where concentrations upstream of the Golden Bar Creek and/or North Branch Waikouaiti River confluence do not allow for some level of dilution at NB03. Applying this strategy would likely increase the dewatering times by 20% or more depending on the efficiency of the operation and climatic conditions at the time.

- Manage discharge to reduce the risk of exceeding the existing compliance criteria for Arsenic as described previously outlined for Sulphate. This would require more active intervention than for Sulphate as a greater level of dilution is required and would likely increase the dewatering timeline significantly.
- Manage in pit Arsenic concentrations through treating pit lake waters prior to commencing dewatering operations. This would be done with the aim of reducing in pit lake concentrations to a point where a similar dilution is required to achieve Arsenic compliance in the receiving environment as required for Sulphate compliance.

Project name	Macraes Phase 4
Document title	Report
Project number	12576793
File name	12576793-RPT-Golden Bar Dewatering Assessment.docx

Status Code	**Revision**	**Author**	**Reviewer**		**Approved for issue**		
			Name	**Signature**	**Name**	**Signature**	**Date**
S4	A	Liz Osborn	Jeff Tuck		Tim Mulliner		21/06/2023

GHD Limited 2079

138 Victoria Street, Level 3

Christchurch Central, Canterbury 8013, New Zealand

T +64 3 378 0900 | **F** +64 3 377 8575 | **E** chcmail@ghd.com | **ghd.com**

Appendix C

Summary of Hydraulic Properties

Appendix C- Table A-1 Summary of Hydrogeological properties applied in previous groundwater models

Report	Property zone	Hydraulic conductivity (m/s)			Specific yield	Specific storage	Porosity (n)	
		Kx	Ky	Kz	Sy	Ss	Effective ne	Total pt
Kingett Mitchell Ltd 2002 Kingett Mitchell Ltd 2005a	Highly weathered schist	1.0E-06	1.0E-05	1.0E-06	-	-	0.02	-
	Moderately weathered schist	5.0E-08	1.0E-06	1.0E-07	-	-	0.02	-
	Slightly weathered schist	1.0E-08	5.0E-08	5.0E-08	-	-	0.004	-
	Unweathered schist	1.0E-09	1.0E-08	1.0E-8	-	-	0.004	-
	Footwall Fault	1.0E-08	1.0E-07	1.0E-09	-	-	-	-
	Hanging Wall Shear	1.0E-08	1.0E-07	1.0E-09	-	-	-	-
	Intra-shear schist	1.0E-09	1.0E-08	1.0E-08	-	-	-	-
	Embankment material	1.0E-07	5.0E-06	1.0E-07	-	-	-	-
	Waste rock	1.0E-06	1.0E-06	1.0E-06	0.25	-	-	-
	Flotation tailings	1.0E-07	1.0E-06	5.0E-08	-	-	-	-
	Mixed tailings	1.0E-07	1.0E-06	5.0E-08	-	-	-	-
	Concentrate tailings	1.0E-06	1.0E-06	1.0E-06	-	-	-	-
	HMSZ movement area	5.0E-06	5.0E-06	5.0E-06	-	-	-	-
Kingett Mitchell Ltd 2005b	Highly weathered schist	3.5E-07	1.0E-06	2.5E-07	0.01	0.00001	0.01	0.01
	Moderately weathered schist	1.0E-07	2.5E-07	6.0E-08	0.01	0.00001	0.01	0.01
	Slightly weathered schist	9.0E-09	9.0E-09	1.0E-09	0.004	0.00001	0.004	0.005
	Unweathered schist	1.0E-09	5.0E-09	5.0E-10	0.004	0.00001	0.004	0.005
	Shear zones of the HMSZ	8.0E-08	8.0E-08	1.0E-08	-	-	-	-
	Embankment material	1.0E-06	1.0E-06	1.0E-06	-	-	-	-
	Waste rock	1.0E-06	1.0E-06	1.0E-06	0.2	0.00001	0.15	0.2
	Fine tailings	1.0E-07	5.0E-07	1.0E-07	0.01	0.00001	0.01	0.02
	Coarse tailings	5.0E-06	5.0E-06	5.0E-06	0.01	0.00001	0.01	0.02
	Schist movement area	5.0E-06	5.0E-06	5.0E-06	-	-	-	-
	Highly weathered schist	3.5E-07	1.0E-06	2.5E-07	0.02	0.00001	0.02	0.03
	Moderately weathered schist	1.0E-07	2.5E-07	6.0E-08	0.02	0.00001	0.02	0.03

Golder Associates 2011a	Slightly weathered schist	5.0E-09	9.0E-09	1.0E-09	0.005	0.00001	0.005	0.006
	Unweathered schist	1.0E-09	5.0E-09	5.0E-10	0.005	0.00001	0.005	0.006
	Embankment Zone A	1.0E-07	1.0E-07	1.0E-07	-	-	-	-
	Embankment Zone B	5.0E-06	5.0E-06	5.0E-06	-	-	-	-
	Embankment Zone C and WRS	1.0E-06	1.0E-06	1.0E-06	0.2	0.00001	0.2	0.25
	Fine tailings	2.0E-07	2.0E-07	2.0E-07	0.38	0.00001	0.38	0.4
	Coarse tailings	5.0E-06	5.0E-06	5.0E-06	0.38	0.00001	0.38	0.4
Golder Associates 2011b	Highly weathered schist	3.5E-07	1.0E-06	2.5E-07	0.02	0.00001	0.01	0.02
	Moderately weathered schist	1.0E-07	2.5E-07	6.0E-08	0.02	0.00001	0.01	0.02
	Slightly weathered schist	9.0E-09	9.0E-09	1.0E-09	0.005	0.00001	0.004	0.005
	Unweathered schist	1.0E-09	5.0E-09	5.0E-10	0.005	0.00001	0.004	0.005
	Embankment material	1.0E-06	1.0E-06	1.0E-08	-	-	-	-
	Waste rock	1.0E-06	1.0E-06	1.0E-06	0.2	0.00001	0.15	0.2
	Fine tailings	1.0E-07	5.0E-07	1.0E-06	0.38	0.00001	0.35	0.4
	Coarse tailings	5.0E-06	5.0E-08	1.0E-07	0.38	0.00001	0.35	0.4
Golder Associates 2011d	Schist	1.0E-07	-	-	-	-	-	-
	Hanging Wall Shear	5.0E-08	-	-	-	-	-	-
	Backfill	3.0E-05	-	-	-	-	-	-
	Pit Liner	1.0E-07	-	-	-	-	-	-
CDM Smith 2016	Schist	5.8E-08	5.8E-08	5.8E-09	-	0.00001	-	0.01
	Waste rock	5.8E-07	5.8E-07	5.8E-07	-	0.00001	-	0.1
	Tailings	1.2E-08	1.2E-08	1.2E-09	-	0.00001	-	0.1
GHD, 2021	Schist	5.8E-08	1E-07	6.9E-09	-	0.00001	0.01	
	Schist (Frasers pit surfaces)	5.8E-07	5.8E-07	5.8E-08	-	0.00001	0.01	
	Waste rock	1E-06	1E-06	1E-06	-	0.00001	0.15	
	Tailings	2E-07	2E-07	2E-07	-	0.00001	0.35	
	FRUG	1E-05	1E-05	1E-05	-	0.00001	0.1	