

Appendix 3

Water Resources Assessment

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Tomingley Gold Operations

Modification 3

Water Resources Assessment

November 2015

Executive summary

Tomingley Gold Operations (TGO) is seeking an approval to modify the approved mining operations south of Tomingley, NSW.

The proposed modification includes:

- Filling of Wyoming Three open cut with waste rock.
- A small extension (cutback) to the eastern perimeter of Caloma One open cut.
- Development of an additional open cut pit (Caloma Two).
- Development of underground workings (stopping) below the Caloma One and Caloma Two open cuts accessed from a portal constructed within the Caloma One open cut. The approved Wyoming One underground workings would be developed via a decline continued from the Caloma underground workings.
- A lift of the Residue Storage Facility (RSF) dam wall.

All of the proposed modification components listed above are within the existing Mine boundary.

An assessment of the potential impacts of the proposed modification on the surrounding water resources was undertaken. This assessment considered the potential impacts on surface and groundwater quality and quantities, estimated water usage and discharges (via water balance modelling), and how the proposed modifications are to be incorporated into the existing water management system.

The assessment indicates that the proposed modification is not expected to have significant impacts on the local water resources, compared to the approved mining operations.

A summary of the water related assessment criteria and a reference to the relevant report sections where each is addressed is included in Table 1-1.

Table 1-1 Response to Assessment Requirements

Requirements	Section(s)
Department of Planning & Environment (SEARs)	
Details of upgrades to the surface management system and design assumptions for management of dirty water, contaminated water and diversion of clean water.	Section 1.2 and Section 5.1
Updated mine site water balance to demonstrate that water (shortage and excess) can be appropriately managed through dry and wet sequences. It is noted that the project approval conditions require an annual review of the Mine site water balance which can be used to inform the assessment of the proposed modification.	Section 5.3
Provide details of Environment Protection Licence (EPL) requirements (monitoring/discharge points) and any proposed changes required.	Section 2.1.2
It is noted that it is not intended to undertake a detailed groundwater assessment as the Caloma 2 Open Cut was considered in the original project assessment and other activities are within the zone of influence of approved mining operations. A qualitative groundwater assessment will be undertaken if the proposed Caloma 1 decline is determined to be outside the zone of influence previously assessed. You will need to consult further with NSW Office of Water on this issue and appropriateness of this approach.	Section 5.2
Additional groundwater monitoring and groundwater model verification has been completed as required under project approval	Section 5.2

Requirements	Section(s)
Schedule 3 conditions 31 (Baseline Groundwater Monitoring) and 32(c)iv (Water Management Plan - verification and refinement of the groundwater model. The modification should provide details of the monitoring and verification process to inform any changes in predictions from the original EA (inclusive of Caloma 2) following model verification.	
Identify / review any proposed changes to the groundwater monitoring program.	Section 5.2
NSW Environment Protection Authority	
Water management including the potential impact of water pollution on local watercourses (including water demand and management requirements)	Section 6.1
The impact on groundwater, including the impact on groundwater dependent ecosystems and other water users	Section 6.2
NSW Department of Primary Industries - Water	
Annual volumes of surface water and groundwater proposed to be taken by the activity (including through inflow and seepage) from each surface and groundwater source as defined by the relevant water sharing plan.	Section 2.1.4 and Section 6.2
Assessment of any volumetric water licensing requirements (including those for ongoing water take following completion of the project).	Section 5.3.1 and Section 6.2
The identification of an adequate and secure water supply for the life of the project. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased.	
A detailed and consolidated site water balance.	Section 5.3
A detailed assessment against the NSW Aquifer Interference Policy (2012) using DPI Water's assessment framework.	Section 5.2
Assessment of impacts on surface and groundwater sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Section 5.1.3 and Section 1.1
Full technical details and data of all surface and groundwater modelling, and an independent peer review.	Section 5.2
Proposed surface and groundwater monitoring activities and methodologies.	refer to Section 6.3
Proposed management and disposal of produced or incidental water.	Section 5.3.2
Details of the final landform of the site, including final void management (where relevant) and rehabilitation measures.	To be addressed in amended Mine Operations Plan (MOP)
Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.	Section 5.1.3, Section 1.1 and Section 6
Consideration of relevant policies and guidelines.	Section 2
A statement of where each element of the SEARs is addressed in the EIS (i.e. in the form of a table).	This table
NSW Department of Industry - Division of Resources and Energy	
Description of Existing Environment, Identification of Impacts and Constraints include a comprehensive description of the following activities and their impacts:	

Requirements	Section(s)
Surface and groundwater usage and management;	Section 5.1.1 and 5.2.1
Impacts associated with the operational and post closure stages of the project must also be identified in detail and control management strategies outlined. The following are the key issues to be addressed in the EA that are likely to have a bearing on rehabilitation and mine closure. Where a void is proposed to remain as part of the final landform, the assessment is to provide details in regards to the following :	
Outcomes of the surface and groundwater assessments in relation to the likely final water level in the void.	To be addressed in amended Mine Operations Plan (MOP)
Surface water flow and flooding regimes and how these will be impacted and mitigated by the project both during and after mining has ceased.	Section 6.1

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1. Introduction

1.1 Background

Tomingley Gold Mine (the Mine) is owned and operated by Tomingley Gold Operations Pty Ltd (TGO), a wholly owned subsidiary of Alkane Resources Ltd.

The Mine is located on both sides of the Newell Highway, to the south of Tomingley in central western NSW, between Dubbo and Peak Hill (refer to Figure 1-1).

Following project approval in July 2012 (PA 09_0155) and the subsequent issuing of the mining lease in February 2013, mining commenced on the site in January 2014 with three open cut pits (Wyoming One, Wyoming Three and Caloma One). The project includes a processing plant with associated residue storage facility (RSF).

Mining is carried out at the Mine in accordance with the following approvals:

- Project Approval 09_0155.
- Environmental Protection Licence (EPL) 20169.
- Mining Lease (ML) 1684.

GHD Pty Ltd (GHD) was commissioned by TGO to prepare a Water Resources Assessment for the proposed modification (Mod 3) of Project Approval 09_0155. This assessment forms part of an Environmental Assessment (EA) to support a modification to Project Approval 09_0155 under section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to facilitate the expansion of mining at the Mine.

1.2 Proposed modification

The proposed modification includes:

- Filling of Wyoming Three open cut with waste rock.
- A small extension (cutback) to the eastern perimeter of Caloma One open cut.
- Development of an additional open cut pit (Caloma Two).
- Development of underground workings (stoping) below the Caloma One and Caloma Two open cuts accessed from a portal constructed within the Caloma One open cut. The approved Wyoming One underground workings would be developed via a decline continued from the Caloma underground workings.
- A lift of the Residual Storage Facility (RSF) dam wall.

The layout of the Mine, including the approved and proposed features, is shown in Figure 1-2.

1.3 Objectives

The objective of this water resources assessment is to address the assessment requirements issued by the:

- Department of Planning & Environment (DPE) – Issue Secretary's Environmental Assessment Requirements (SEARs).
- NSW Environment Protection Authority (EPA).
- NSW Department of Primary Industries – Water (DPIW).
- Department of Industry - Division of Resources and Energy (DRE).

These assessment requirements are listed in the sections below.

1.3.1 Department of Planning & Environment

With respect to surface and groundwater resources, the DPE provided the following environmental assessment requirements:

- Details of upgrades to the surface water management system and design assumptions for management of dirty water, contaminated water and diversion of clean water.
- Updated mine site water balance to demonstrate that water (shortage and excess) can be appropriately managed through dry and wet sequences. It is noted that the project approval conditions require an annual review of the Mine site water balance which can be used to inform the assessment of the proposed modification.
- Provide details of EPL requirements (monitoring/discharge points) and any proposed changes required.
- It is noted that it is not intended to undertake a detailed groundwater assessment as the Caloma Two open cut was considered in the original project assessment and other activities are within the zone of influence of approved mining operations. A qualitative groundwater assessment will be undertaken if the proposed Caloma One decline is determined to be outside the zone of influence previously assessed. You will need to consult further with DPI Water on this issue and appropriateness of this approach.
- Additional groundwater monitoring and groundwater model verification has been completed as required under project approval Schedule 3 conditions 31 (Baseline Groundwater Monitoring) and 32(c)iv (Water Management Plan - verification and refinement of the groundwater model. The modification should provide details of the monitoring and verification process to inform any changes in predictions from the original EA (inclusive of Caloma 2) following model verification.
- Identify / review any proposed changes to the groundwater monitoring program.

1.3.2 NSW Environment Protection Authority

The EPA requested the assessment of the modification to mining operations consider the following key issues:

- Water management including the potential impact of water pollution on local watercourses (including water demand and management requirements).
- The impact on groundwater, including the impact on groundwater dependent ecosystems (GDE) and other water users.

1.3.3 NSW Department of Primary Industries - Water

DPIW provided the following advice when consulted as to the key requirements for assessment of the impact of the proposed modifications on water resources:

- Annual volumes of surface water and groundwater proposed to be taken by the activity (including through inflow and seepage) from each surface and groundwater source as defined by the relevant water sharing plan (WSP).
- Assessment of any volumetric water licensing requirements (including those for ongoing water take following completion of the project).

- The identification of an adequate and secure water supply for the life of the project. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased.
- A detailed and consolidated site water balance.
- A detailed assessment against the NSW Aquifer Interference Policy (AIP) (2012) using DPI Water's assessment framework.
- Assessment of impacts on surface and groundwater sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.
- Full technical details and data of all surface and groundwater modelling, and an independent peer review.
- Proposed surface and groundwater monitoring activities and methodologies.
- Proposed management and disposal of produced or incidental water.
- Details of the final landform of the site, including final void management (where relevant) and rehabilitation measures.
- Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.
- Consideration of relevant policies and guidelines.
- A statement of where each element of the SEARs is addressed in the EIS (i.e. in the form of a table).

1.3.4 NSW Department of Industry - Division of Resources and Energy

The interest of the DRE is primarily in the safe operation of the mine and effective rehabilitation of the Mine Site. The following provides the assessment requirements of the DRE as they relate to surface and groundwater resources:

- Description of existing environment, identification of impacts and constraints include a comprehensive description of the following activities and their impacts:
 - Surface and groundwater usage and management.
 - Impacts associated with the operational and post closure stages of the project must also be identified in detail and control management strategies outlined. The following are the key issues to be addressed in the EA that are likely to have a bearing on rehabilitation and mine closure.
- Where a void is proposed to remain as part of the final landform, the assessment is to provide details in regards to the following:
 - Outcomes of the surface and groundwater assessments in relation to the likely final water level in the void.
 - Surface water flow and flooding regimes and how these will be impacted and mitigated by the project both during and after mining has ceased.

1.4 Water Management System Overview

The water management strategy at the Mine includes separate systems for the management of clean, dirty, and process (contaminated) water.

During normal operations and weather conditions, the Mine Site is designed to be nil-discharge site - that is no discharges of dirty and process water into the surrounding environment are expected to occur. During periods of prolonged and intense rainfall however, emergency discharges may occur.

The clean water management system manages runoff generated from areas outside and upslope of the Mine, as well as areas within the Mine that have been rehabilitated or undisturbed. While some rehabilitation has been completed at the Mine, most notably the profiling and soil application to the lower lift of Waste Rock Emplacement (WRE) 2, as well as profiling, soil application and revegetation of various amenity bunds, these areas are not considered to be 'complete' and therefore remain outside the clean water management system. Only a small area of the Mine Site remains undisturbed (the site of the proposed Caloma Two open cut). The clean water system includes clean water diversion drains that intercept clean water runoff from upslope of the Mine Site, diverting the intercepted water around (and through) the Mine Site. This minimises the volume of water to be managed within the dirty and process water systems, as well as assisting in minimising the potential impacts of the Mine on the downstream surface water environment.

The dirty water management system manages sediment-laden runoff from disturbed areas, including waste rock emplacements, RSF walls and other disturbed areas within the Mine Site not within the process water system. Runoff from these areas is intercepted by dirty water catch drains and directed towards sediment basins to allow sediment to settle prior to being discharged off site (during periods of extended rainfall) or reused on site (subject the water access licence (WAL) restrictions).

The process water management system manages water associated with mining activities, including ore processing, residue storage, and groundwater inflows and runoff generated within the open cut areas. Any potentially contaminated water is managed within the process water management system. The process water management system includes water storage dams (most notably the Wyoming Central Dam between the Wyoming One and Wyoming Three open cuts), sumps, pipes and pumps, and catch drains. The reuse of process water on site, typically within the ore processing plant, reduces the potential for this contaminated water to be discharged off the Mine Site.

The Woodlands Borefield, located to the north of the Mine approximately 7 km east of Narromine, provides additional external water supplies for use across the Mine when site water storages are diminished. Water from the Woodlands Borefield is stored within the Wyoming Central Dam and Raw Water Dam.

1.5 Assessment Method

1.5.1 Surface Water

The principal surface water impacts of the proposed modification are likely to result from the construction of the Caloma Two open cut. The other components of the modification (refer to Section 1.2) are located within areas already affected by mining operations at the Mine and are therefore unlikely to result in appreciable impacts to the local surface water environment.

The assessment of the potential surface water impacts associated with the proposed Caloma Two open cut includes the assessment of:

- Changes to the site water balance.
- Changes to the local hydraulic and hydrological conditions due to changes in surface water diversion channel and loss of clean water catchment.
- Erosion and sedimentation resulting from the disturbance area.

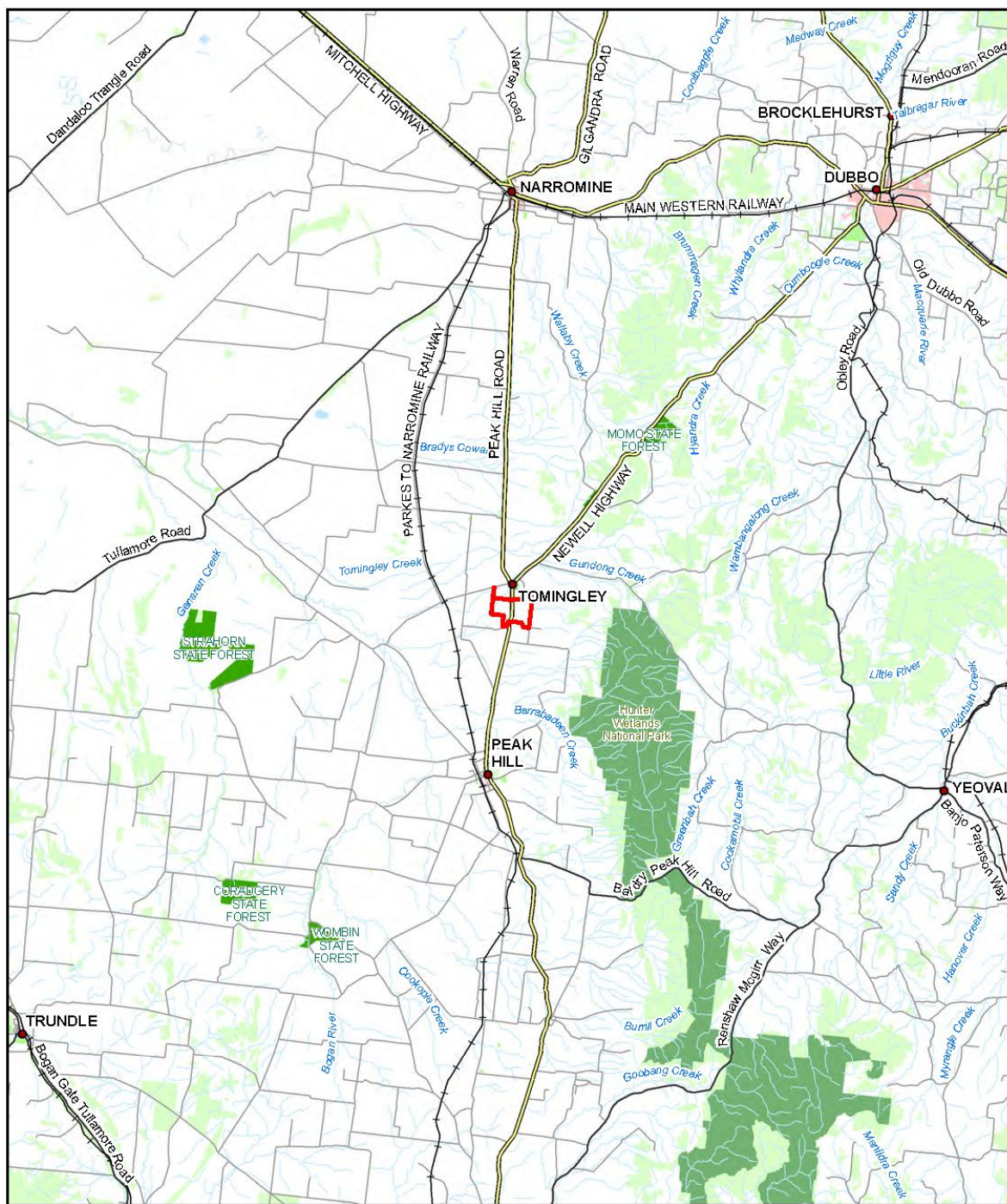
1.5.2 Groundwater

Potential groundwater impacts may arise from the development of the Caloma Two open cut and Caloma underground workings, as well as the filling of the Wyoming Three open cut with waste rock. These potential impacts have been assessed in accordance with the NSW AIP.

The AIP requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the AIP. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable.

Based on the hydrogeological environment at the Mine, outlined in Section 3.5, Level 1 minimal impact considerations for Less Productive Fractured Rock Water Sources have been adopted for the groundwater impact assessment and are defined as follows:

- Water table:
 - Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, at a distance of 40 m from any high priority GDE or high priority culturally significant site listed in the schedule of the relevant WSP. A maximum of a 2 m water table decline cumulatively at any water supply work.
 - If more than 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any high priority GDE; or high priority culturally significant site; listed in the schedule of the relevant WSP then appropriate studies (including the hydrogeology, ecological condition and cultural function) will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than 2 m decline cumulatively at any water supply work then make good provisions should apply.
- Water pressure:
 - A cumulative pressure head decline of not more than a 2 m decline at any water supply work.
 - If the predicted pressure head decline is greater than the requirement above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.
- Water quality:
 - Any change in groundwater quality should not lower the beneficial use category of the groundwater source, beyond 40 m from the activity.
 - If the above condition is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.



LEGEND

- | | | |
|----------------|-----------------|-----------------|
| Site boundary | Minor Road | National Park |
| Railway | Watercourse | State Forest |
| Principal Road | Built Up Area | Forest Or Shrub |
| Secondary Road | Recreation Area | |

Paper Size A4
0 3,500 7,000 14,000
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



Alkane - Tomingley Gold Operations
Modification 3
Water Resources Assessment

Job Number | 22-18072
Revision | A
Date | 06 Nov 2015

Locality plan

Figure 1-1

Level 3, GHD Tower, 24 Honeyuckle Drive, Newcastle NSW 2300 T 612 4979 9999 F 612 4979 9999 E entmail@ghd.com W www.ghd.com.au
© 2015. Whilst every care has been taken to prepare this map, GHD, LPI and Geoscience Australia make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Data source: Geoscience Australia: 250k Topographic Series 3, 2006; LPI: DTDB, 2012. Created by: tmorton



2. Regulatory Context

2.1 Legislation

2.1.1 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act), administered by the NSW Department of Planning and Environment (DPE), provides the statutory framework under which development proposals in NSW are assessed. This water resources assessment forms part of an Environmental Assessment (EA) to support an application to modify PA 09_0155 under section 75W of the EP&A Act.

2.1.2 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the EPA, an independent statutory authority and the primary environmental regulator within NSW. Under the POEO Act the NSW EPA regulates polluting activities (scheduled activities) to ensure the protection of the environment from potential water, air and noise pollution. Regulation is achieved via EPLs and associated conditions.

Scheduled activities currently undertaken at the Mine include crushing, grinding or separating, mineral processing and mining for minerals, as well as water, air and noise pollution generated in undertaking mining related activities.

The Mine currently holds EPL 20169, which identifies seven surface water discharge locations, two surface water monitoring locations and seven groundwater monitoring locations. Monitoring requirements for both surface and groundwater points are detailed within EPL 20169 including parameters, frequency, and sampling method. Storage freeboard requirements are also included in EPL 20169 specifically for the RSF and Process Water Dam (PWD). Concentration limits for specific surface water locations are provided in Section 4.1.5.

2.1.3 Water Act 1912

The *Water Act 1912* is administered by DPIW and has historically been the main legislation for managing water resources in NSW. The *Water Act 1912* governs access, trading and allocation of licences associated with both surface water and groundwater sources and is currently being progressively phased out and replaced by WSPs under the *Water Management Act 2000* (WM Act), discussed further in Section 2.1.4. Once a WSP commences, existing licences under the *Water Act 1912* are converted to WALs and to water supply works and use approvals under the WM Act.

The *Water Act 1912* covers the extraction of water from a river, extraction of water from groundwater sources, aquifer interference (less than 3 ML/year) and surface water diversion works (of a capacity of less than basic landholder rights).

While the surface water and groundwater systems within the vicinity of the Mine are regulated by WSPs (discussed further in Section 2.1.4), several licences are held by the Mine under the *Water Act 1912* for groundwater monitoring bores (refer to Table 2-1).

Table 2-1 Licenced Groundwater Bore Details

Licence Number	Issue Date	Expiry Date	Purpose
80BL245428	23 September 2009	Perpetuity	Groundwater Monitoring
80BL245429			
80BL245430			
80BL245431			
80BL245432			
80BL620426	27 October 2014	Perpetuity	Groundwater Monitoring

2.1.4 Water Management Act 2000

The WM Act, also administered by DPIW, is progressively being implemented throughout NSW to manage water resources, superseding the *Water Act 1912*. The aim of the WM Act is to ensure that water resources are conserved and sustainably managed for present and future water users. The WM Act also provides a formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for the protection of catchment conditions. Fresh water sources throughout NSW are managed via WSPs under the WM Act. Key rules within the WSPs specify when licence holders can access water and how water can be traded.

An amendment to the WM Act (Section 60I) came into effect on 1 March 2013. This amendment makes it an offence for a person, without a suitable access licence, to take, remove or divert water from a water source or relocate water from one part of an aquifer to another part of an aquifer in the course of carrying out a mining activity. Various activities are captured by the provisions of the amendment including mining, mineral exploration and petroleum exploration.

The Mine is located within the Macquarie Bogan Unregulated and Alluvial Water Sources (2012) WSP, within the Upper Bogan River Water Source (surface water), and the NSW Murray Darling Basin Fractured Rock Groundwater Sources (2012) WSP, within the Lachlan Fold Belt MDB Groundwater Source (groundwater).

The Mine is supported by an external water source regulated by the Lower Macquarie Groundwater Sources 2003 WSP. Table 2-2 identifies the WALs currently held by TGO under the WM Act, the annual extraction limit and the WSP covering the WAL.

Table 2-2 Water Sharing Plan Licences

Water access licence number/Reference	Extraction limit (ML/year)	Water sharing plan / Water Source	Description
Surface Water			
80CW809661	NA	NA	Controlled Works Approval (western boundary diversion structure)
80CA719513 / WAL 35321	22	Upper Bogan River Water Source	Water Supply Works and Water Use
Groundwater			
80WA705442	NA	Lower Macquarie Zone 6 Groundwater Source	Works Approval
WAL20270	1000		Aquifer (Woodlands Borefield)

Water access licence number/Reference	Extraction limit (ML/year)	Water sharing plan / Water Source	Description
WAL28643	220	NSW Murray Darling Basin Fractured Rock Water Source	Dewatering

Note: Works approval 80WA715325, 80WA715323 and 80WA715324 for dewatering of Pits all expired 5 June 2015. Expired volume equal to 151.9 ML/yr

The Lower Macquarie Groundwater Source WSP allows for use of carryover water from one water year to the next at a ratio of 0.62 ML/entitlement remaining with a maximum extraction of 1.44 ML/entitlement, plus any annual transfer of water onto a licence (known as an allocation assignment).

Controlled Activity Approvals

Any works proposed within the defined riparian zone of a creek are to be carried out in accordance with the WM Act. Works undertaken on waterfront land (i.e. near a river, lake or estuary) require a Controlled Activity Approval (CAA), unless defined as exempt. State significant developments and activities within a mining lease do not require a CAA.

Maximum Harvestable Rights

Landholders are entitled to a proportion of runoff from their property, known as a 'harvestable right'. Within the vicinity of the Mine, land holders have the right to capture up to 10% of the average regional runoff generated by the total contiguous land holdings without requiring a licence under the WM Act. The maximum harvestable right dam capacity (MHRDC) is the total dam capacity a landholder may maintain without requiring a licence. If the MHRDC is exceeded, a WAL is required for the additional water harvested from the surface water source.

The guidelines for determining the MHRDC indicate that the following dams are exempt from the calculation of the MHRDC and do not require a licence (NOW, 2010).

- Dams for the control or prevention of soil erosion (i.e. sediment basins).
- Dams for the capture, containment or recirculation of drainage (including pit sumps, and process water dams).
- Dams without a catchment ("turkey's nests").

It should be noted that while surface water captured within sediment basins does not require a licence, the captured water can only be reused for environmental purposes, typically dust control. Captured water that is used for other purposes, such as in the processing plant, are to be covered either by harvestable rights or a WAL.

The existing water storages within the Mine all fall into one of the above categories and therefore do not require licensing under the WM Act. The NSW DPIW harvestable rights calculator indicates that the Mine has a harvestable right of approximately 60 ML/yr, based on contiguous land holdings of approximately 1000 ha.

2.1.5 Dams Safety Act 1978 and Mining Act 1992

The NSW Dams Safety Committee (DSC) plays a role in determining the type and extent of mining allowed in the vicinity of prescribed dams and their storages. A 'prescribed dam' is a dam included on Schedule 1 of the Dam Safety Act 1978 (DS Act). 'Notification Areas' are defined by the DSC under Section 369 of the Mining Act 1992. Before granting leases over these areas the Minister for Primary Industries will seek the recommendations of the DSC and the DSC will usually recommend that a condition be included in the lease requiring the mining company to make a special application before mining within the Notification Area.

The extent of mining permitted near a prescribed dam depends on the mining geometry, the proximity to the dams or the stored water and the local geology.

The DSC has a statutory function to require prescribed dam owners to arrange for the following:

- Proper operation and maintenance of dams using trained personnel.
- Regular dam surveillance using trained personnel.
- Appropriate emergency planning and security precautions for dams.
- Ongoing assessment of dam behaviour by experienced personnel and regular review of compliance with current DSC requirements.
- Actions in response to these assessments to ensure that their dams are maintained in a safe condition.

In accordance with Schedule 1 of the DS Act, the 'Tomingley Residue Storage Facility' (RSF Cells 1 and 2) is defined as a prescribed dam, identified as plan number 249 gazetted 20 December 2013 (NSW DSC; 2015).

2.2 Policies

2.2.1 NSW Aquifer Interference Policy

The AIP was finalised in September 2012 and clarifies the water licensing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer in the course of carrying out mining. Many aspects of this policy will be given legal effect in the future through an Aquifer Interference Regulation. Stage 1 of the Aquifer Interference Regulation commenced on 30 June 2011.

The AIP outlines the water licensing requirements under the Water Act and WM Act. A water licence is required whenever water is taken from an aquifer, either for consumptive use or taken incidentally (such as groundwater inflows into an open cut mine). Under the WM Act, a WAL gives its holder a share of the water available for extraction from a groundwater source. Sufficient WALs must be held to cover all water taken from a water source at all stages of a mining, including closure.

The AIP requires that the potential impacts of an activity on groundwater sources, including adjacent groundwater users and GDEs, be assessed.

2.2.2 NSW State Groundwater Policy

The objective of the NSW State Groundwater Policy Framework Document (1997) is to manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW. The NSW groundwater policy has three parts:

- NSW Groundwater Quantity Protection Policy.
- NSW Groundwater Quality Protection Policy.
- NSW Groundwater Dependent Ecosystems Policy.

NSW Groundwater Quantity Protection Policy

The key principles of this policy relevant to the Mine are:

- Maintain total groundwater use within the sustainable yield of the aquifer from which it is withdrawn.
- Groundwater extraction shall be managed to prevent unacceptable local impacts.

- All groundwater extraction for water supply is to be licensed. Transfers of licensed entitlements may be allowed depending on the physical constraints of the groundwater system.

The criteria and management plan developed for the Mine will seek to follow the principles of this policy.

NSW Groundwater Quality Protection Policy

The objective of this policy is the ecologically sustainable management of the State's groundwater resources so as to:

- Slow, halt or reverse any degradation in groundwater resources.
- Direct potentially polluting activities to the most appropriate local geological setting so as to minimise the risk to groundwater.
- Establish a methodology for reviewing new developments with respect to their potential impact on water resources that will provide protection to the resource commensurate with both the threat that the development poses and the value of the resource.
- Establish triggers for the use of more advanced groundwater protection tools such as groundwater vulnerability maps or groundwater protection zones.

Groundwater triggers established as part of a Water Management Plan for the Mine will be reviewed to ensure they follow the objectives of this policy.

NSW Groundwater Dependent Ecosystems Policy

This policy was designed to protect ecosystems that are dependent on groundwater as a primary water source so that the ecological processes and biodiversity of these ecosystems are maintained (or restored).

Analysis of the application of the NSW GDEs Policy to the area within the site boundary is outlined in Section 3.5.2.

2.3 Guidelines

2.3.1 Managing Urban Stormwater: Soils and Construction

Managing Urban Stormwater: Soils and Construction Volume 1 (The 'Blue Book'; Landcom, 2004) outlines the basic principles for the design, construction and implementation of sediment and erosion control measures to improve stormwater management and mitigate the impacts of land disturbance activities on soils and receiving waters.

This document relates particularly to urban development sites, however it is relevant to the Mine as it provides guidance on the configuration of erosion and sedimentation controls required during construction.

Additional volumes of the Blue Book have been issued on the application of erosion and sediment controls to various non-urban development types. The relevant volumes of the Blue Book relevant to the Mine are:

- *Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries* (DECC 2008c) provides specific guidelines, principles and minimum design standards for good management practice in erosion and sediment control during the construction and operation of mines and quarries.

- *Managing Urban Stormwater: Source Control* (EPA 1998) provides guidance to local and state government agencies and developers, as well as community and business groups, on a range of source control (water quantity and quality) techniques that can be adopted to minimise impacts of works on surface water environments.

3. Regional Environment

3.1 Topography and Land Use

The Mine is located to the south of Tomingley within the central west region of NSW, west of the Great Dividing Range. The topography of the area is generally flat with gentle undulating rises and depressions.

Land use within and surrounding the Mine includes residential and rural residential, agriculture, transportation infrastructure (Newell Highway), commercial (Tomingley township), recreation and community facilities and former mining operations north of Tomingley (Myalls United Gold Mine).

3.2 Climate

3.2.1 Rainfall

Daily rainfall data was obtained as SILO Patched Point Data from the Queensland Climate Change Centre of Excellence. SILO Patched Point Data is based on historical data from a particular Bureau of Meteorology (BOM) station with missing data 'patched in' by interpolating with data from nearby stations. For this assessment, SILO data was obtained for the Peak Hill Post Office Station (station number 50031), which is located approximately 14 km south of the Mine. This station was chosen based on the length and quality of the data record and proximity to the Mine site.

The period of rainfall data used for this assessment extended from January 1900 to July 2015 and is summarised as annual totals in Figure 3-1. The statistics for this rainfall data set are:

- Minimum annual rainfall – 233 mm in 1944.
- Average annual rainfall – 561 mm.
- Median annual rainfall – 545 mm.
- Maximum annual rainfall – 1217 mm in 1950.

The SILO dataset was used to generate a Cumulative Rainfall Departure (CRD) curve. CRD is the monthly accumulation of the difference between the observed monthly rainfall and the long term average monthly rainfall.

The CRD over the period 1900 to 2015 is shown in Figure 3-2. Any increase in the CRD reflects above average rainfall while a decrease in CRD reflects below average rainfall. The CRD curve only deviates from zero due to atypical (above and below average) rainfall.

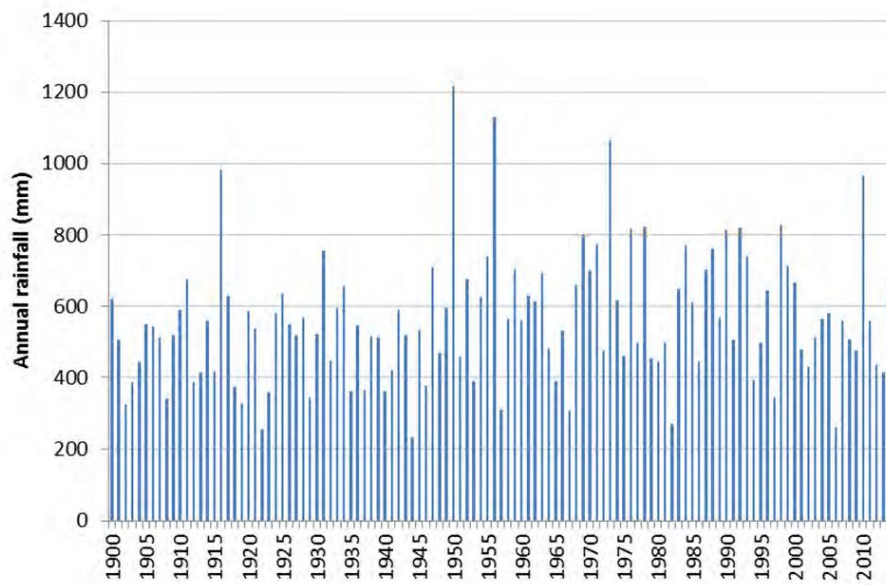


Figure 3-1 Annual Rainfall Recorded at Peak Hill Post Office Station

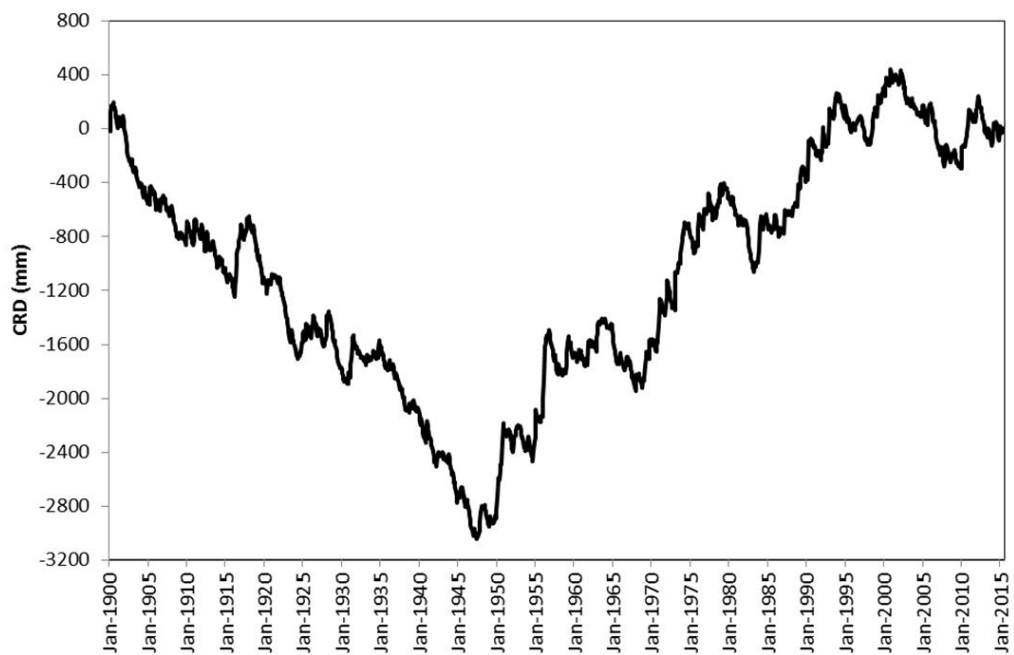


Figure 3-2 CRD Curve for Peak Hill Post Office Station

3.2.2 Rainfall Event Distribution

From the long range rainfall data, an assessment of the frequency of a range of flood events over the past 115 years, expressed as the number of days within the historical data with rainfall depths greater than the reference rainfall depth, was undertaken. A summary of the assessment is provided in Table 3-1.

Table 3-1 Historical Rainfall Frequency

ARI	IFD Rainfall Depth (mm)			Days with rainfall > IFD Rainfall Depth			Likely Waterway Conditions
	24 hr	48 hr	72 hr	24 hr	48 hr	72 hr	
1 Year	49	57	60	90	159	284	Above average conditions.
5 Year	81	97	103	18	33	52	Water ponding within the Mine water likely to remain within banks of Gundong Creek.
20 Year	108	131	141	4	4	7	Water ponding within the Mine minor flooding of Gundong Creek.
50 Year	129	150	158	1	1	3	Newell Highway inundated in sections
100 Year	145	179	193	0	0	0	Major flooding, Newell Highway inundated in sections

The analysis indicates that longer duration rainfall events are more likely to trigger water management responses.

3.2.3 Evaporation

Evaporation data was obtained from the patched point data set from SILO (2015) based on the latitude and longitudinal location of the site. The average monthly evaporation data for the site is provided in Figure 3-3, with annual average evaporation of 1779.5 mm/year.

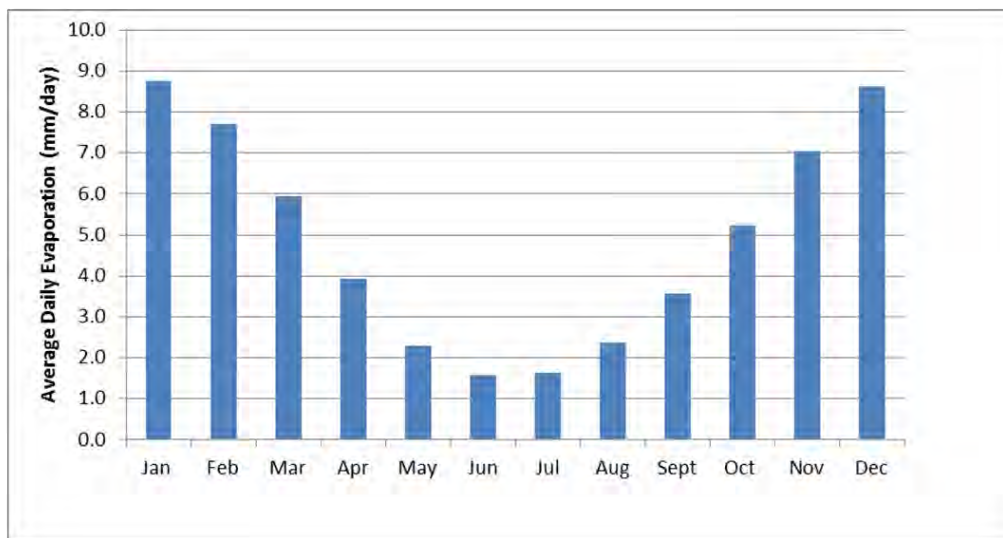


Figure 3-3 Monthly Evaporation (SILO, 2015)

3.3 Geology and Soils

As discussed by The Impax Group (2011), the Mine is located on the Junee-Narromine volcanic belt, part of the Palaeozoic Lachlan Orogen composition of sedimentary, volcanic and intrusive rock formations of early Cambrian to early Devonian age. The Ordo-Silurian sequences that comprise the Wyoming/Caloma deposits are tight to isoclinal folding, strong axial planar cleavage with green schist metamorphic assemblages.

The area is dominated by alluvial sequences of clays, sands and gravel of Quaternary to Tertiary age, up to 50 m thick. The alluvial material dissipates to the south and north with basement outcropping. There is a well-developed weathering profile which can extend down to 70 m below ground level (bgl) (The Impax Group, 2011). The weathered zone is underlain by fractured siltstone, sandstone and shale extending beyond 100 m bgl. Geological structural features are evident from inspection of the open cut faces, however there is no evidence of extensive zones of higher permeability strata.

Soil erodibility values (K factors) for the Mine Site are moderate to high at 0.04 to 0.05 (SEEC, 2011). Typically the worst soils are located to the east of the Newell Highway in the sodic Gilgaied Dermosol soils (SEEC, 2011). This assessment of SEEC (2011) has been confirmed by observations of the dispersive and erodible nature of soils on the Mine Site with soil and water management measures refined to reflect this.

As part of the site Mining Operations Plan (MOP), topsoils (not included those of the Gilgaied Dermosol soils) are stripped to a depth of approximately 30 cm below natural surface with the most ideal for stripping and stockpiling being the red (non-Gilgaied) Dermosol soils. Subsoils are defined from 30 cm to 70 cm below natural surface with sodic tendencies. The typical emersion value for the subsoil material has been reported to be Class 1.

3.4 Hydrology and Waterways

The Mine is located within the Macquarie-Bogan catchment and is part of the Murray-Darling Basin in the central west of NSW.

The Mine is located within the catchment of Gundong Creek with this creek contributing to the Bogan River approximately 10 km to the west of the Mine's boundary. The creek has been diverted historically as part of the Tomingley township development and has limited crossing structures affecting its hydraulic operation.

Gundong Creek is a third order stream with a core riparian zone of approximately 62 m wide. Gundong Creek includes reaches of irregular form with eroding banks likely to be caused by historical agricultural stock movements. Vegetation within the creek appears to be increasing following the removal of stock however there remains only limited riparian vegetation characterised by low growing grasses.

All of the watercourses and drainage lines within and surrounding the Mine are ephemeral with flows only occurring following large storm events and during extended wet periods. The watercourses are typically well-defined valley fill channels.

3.5 Hydrogeology

The Impax Group (2011) defined three distinct groundwater systems within the vicinity of the mining leases held by TGO for the Mine:

- Shallow alluvium – discrete, shallow alluvium (less than 10-20 m deep) dissects the plains surrounding the Mine Site along creek flow paths. These perched shallow groundwater sources are believed to be recharged from rainfall infiltration. Groundwater within these systems is of relatively good quality, however the groundwater is generally not continuous across the Mine and yields are relatively low due to the clayey strata.
- Deep alluvium – up to 100 m deep and located approximately 10 km to the northwest and west of the Mine. Groundwater yields are believed to be low and of poor quality. These systems may have some interaction with underlying bedrock however are believed to be primarily recharged from rainfall.
- Fractured rock – the area surrounding the Mine is typically underlain by discontinuous fractured siltstone and sandstone groundwater sources. Groundwater yields range from 0-3 L/s, generally less than 1.5 L/s, and water quality is poor with high salinity (EC levels up to approximately 30,000 $\mu\text{S}/\text{cm}$).

The hydraulic conductivity of the shallow alluvial clay is generally low to very low. Falling head tests on clayey strata between 1.55 and 42.5 m bgl at the RSF area (to the southwest of the Wyoming Three open cut) indicate hydraulic conductivities of 0.0002 to 0.002 m/d or 2.3×10^{-8} to 10^{-9} m/s (DE Cooper & Associates, 2011). In addition, overburden clay from the Wyoming One open cut was tested for its potential use in the RSF embankment and found to have a compacted hydraulic conductivity of less than 10^{-10} m/s (8.6×10^{-6} m/day) (DE Cooper & Associates, 2011).

The saline fractured rock groundwater most likely occurs at a depth of greater than 100 m bgl in the vicinity of the Mine, as indicated by the lack of groundwater inflow recorded during pit development to date. During exploration drilling at the Wyoming Three open cut pit site, there was no record of water flows into the drill hole at less than 50 m bgl. At 50 to 100 m depth there was some water recorded during rod changes but no flow during drilling. At greater than 100 m depth, some weak flow during drilling was recorded. The deep groundwater is most likely to be confined.

Based on groundwater monitoring data, the hydraulic gradient of the deep groundwater system is approximately 0.01 to the north. Adopting a hydraulic conductivity of 0.07 m/day, the deep groundwater moves to the north at a rate of approximately 0.0007 m/day or 0.3 m/year.

Slug testing undertaken within monitoring bores of the Mine report hydraulic conductivities in the fractured rock water source ranging from 0.002 to 0.11 m/d (Coffey, 2007). Additional pumping tests at WYMB001, WYMB002 and WYMB003 were undertaken by the Impax Group (2011) and interpreted by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE). The additional pumping tests reported hydraulic conductivity between 0.0001 and 0.06 m/d (Impax Group, 2011). Reported hydraulic conductivities are summarised in Table 3-2.

Table 3-2 Reported Hydraulic conductivity – fractured rock

Bore	Calculated conductivity (Coffey, 2007) (m/d)	Calculated conductivity (Impax Group, 2011) (m/d)
WYMB001	0.02	0.0001
WYMB002	0.07	0.01
WYMB003	0.08	0.06
WYMB004	0.002	-
WYMB006	0.11	-

3.5.1 Groundwater Bore Search

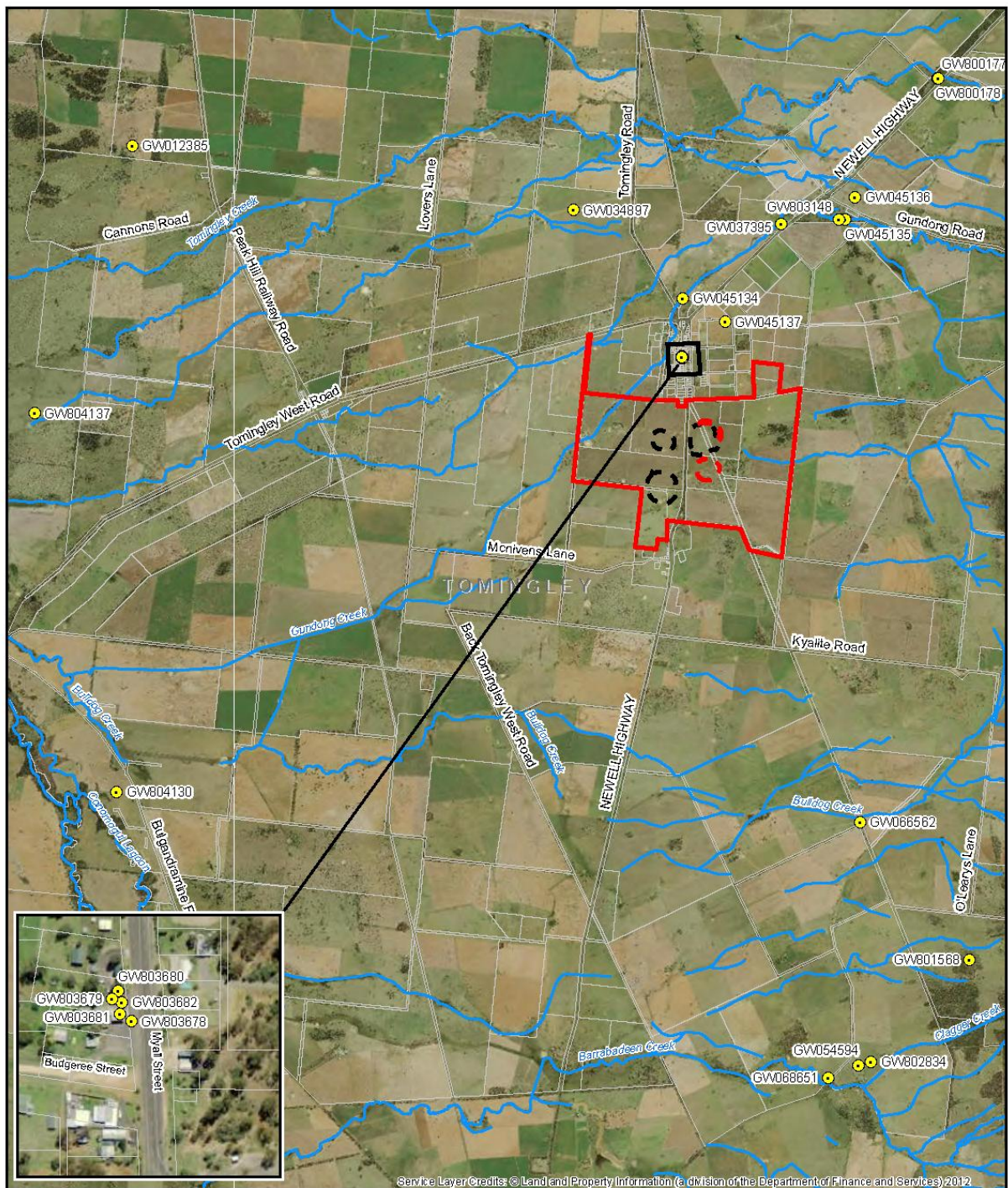
A search of the NSW Groundwater Bore Database (DPIW, 2015) was undertaken to identify registered bores in the vicinity of the Mine. The search identified 22 bores within a 10 km radius of the Mine. Licences for a number of these 22 bores were reported as cancelled, lapsed or abandoned. Of the 22 bores the majority (15) were licensed as a test bore or monitoring bore. Of the remaining bores, three were registered as stock and domestic (at depths 1.8 m to 81 m bgl), while one was registered as irrigation (within unconsolidated sand clay at depth 4.5 m bgl) and one as town water supply (5.8 m bgl). The remaining two bores were registered as groundwater exploration and mining. All reported yields were less than 1.5 L/s.

Licensed groundwater bores in the vicinity of the Mine are shown in Figure 3-4. Details regarding licensed groundwater bores are summarised in Appendix A. The closest active production bores (i.e. non test or monitoring bores), are over 3 km to the north of the mining lease area within shallow alluvium (GW034897, GW037395 and GW803148).

3.5.2 Groundwater Dependant Ecosystems

The closest high priority GDEs listed in the NSW Murray Darling Fractured Rock Groundwater Sources WSP are Dilladerry Spring, located approximately 18.5 km east of the Mine, and Hyandra Hill Spring located approximately 28 km north east of the Mine. There are a number of isolated areas of vegetation that occurs within and surrounding the Mine that are potential GDEs. The Impax Group (2011) found that while these areas of vegetation may use groundwater in the shallow strata they are not considered to be solely dependent on groundwater for their survival.

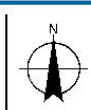
Various tributaries of the Bogan River that lie to the north of the Mine are also potential GDEs.



LEGEND

- Cadastral
- Site boundary
- Groundwater bore
- Watercourse
- Existing Open Cut
- Proposed Open Cut

Paper Size A4
0 325 650 1,300 1,950 2,600
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



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NSW Groundwater
Bore Search

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Figure 3-4

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Data source: LPI: DTB/D/C DB, 2012. LPI: Imagery, 2015. Created by: tmorton

4. Approved Water Management System

4.1 Surface Water Management

The approved surface water management system includes a range of clean and dirty water channels, sediment basins, water storage dams and sumps. The approved surface water management system is intended to manage clean, dirty (sediment laden) and process (contaminated) water separately, thereby minimising the volume of clean water captured within the dirty and process water systems.

The approved surface water management system is summarised in Figure 4-1.

4.1.1 Clean Water Management System

The clean water management system at the Mine includes:

- Clean water diversion channels that divert runoff from external and undisturbed catchments away from disturbed areas within the Mine.
- Clean water storages (refer to Table 4-1).
- Flood protection measures to protect the Mine from Gundong Creek flooding.
- The preservation of riparian zones associated with Gundong Creek to assist in maintaining watercourse and ecosystem health.
- An external water supply from the nearby Woodlands Borefield.

Table 4-1 Approved Clean Water Structures

Storage	Constructed Volume (ML)
Potable Tanks	0.05
Raw Water Dam	10.7
Wyoming Central Dam - Small Cell	17.4

Clean water diversions

Clean water diversions located on the northern, eastern and western boundaries, as well as through the centre of the Caloma portion of the Mine (refer to Figure 4-1), are designed to manage clean runoff generated within undisturbed areas upslope of and within the Mine. The central clean water diversion channel passes through the Caloma portion (to the east of the Newell Highway) of the Mine Site, and is therefore designed to safely convey the 100 year ARI critical duration design storm event (plus a freeboard of 0.5 m) to minimise the risk of flooding Caloma One open cut.

Raw Water Dam

The Raw Water Dam (RWD: refer to Figure 4-1) is the point of storage for the majority of water transferred from the Woodlands Borefield and any other additional external clean water transfers (tankered). The Raw Water Dam supplies the processing plant and other raw water demands on site.



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Figure 4-1
Approved and modified surface
water management system

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Wyoming Central Dam – Small Cell

The small cell of Wyoming Central Dam (refer to Figure 4-1) is utilised as a secondary raw water storage, providing additional storage capacity when the RWD is full.

Water stored within the Wyoming Central Dam small cell is typically used as a reserve supply for dust suppression during extended dry periods when the water storages within the Wyoming Central Dam large cell are depleted.

Woodlands Borefield

The pipeline from the Woodlands Borefield supplies clean water to a potable water tank and the RWD. The Woodlands Borefield supplies clean water for potable use, as well as providing additional water for the processing plant and dust suppression during extended dry periods.

4.1.2 Dirty Water Management System

The dirty water management system consists of dirty water catch drains and sediment basins. Dirty water catch drains are located at the toe of the RSF walls, surrounding WREs and along internal haul roads (refer to Figure 4-1). The dirty water catch drains intercept sediment laden runoff from disturbed areas (not located within the process water system: refer to Section 4.1.3), conveying the intercepted water into a series of sediment basins (refer to Figure 4-1). The sediment basins provide allow sediment to settle out of the intercepted water prior to reuse on site (subject to WAL restrictions) or discharge off the Mine Site (subject to EPL requirements) during periods of extended rainfall.

Dirty water catch drains

Dirty water catch drains are designed to safely convey sediment laden runoff from disturbed areas of the Mine Site, including RSF dam walls, WREs and haul roads, for design storm events up to the 20 year ARI event.

Dirty water catch drains do not intercept water generated within the process water areas of the Mine Site, including the open cut areas, which have the potential to be contaminated with metals, have elevated salinity levels and other pollutants that require additional treatment.

Sediment Basins

Sediment basins provide temporary storage of sediment laden runoff water, providing an opportunity for sediment to settle (typically with the addition of a flocculating agent) prior to reuse on Mine Site or discharge off the Mine Site. The capacity of each sediment basin is dependent on the associated catchment area. The approved capacity of each sediment basin (plus Wyoming Central Dam – large cell – Large Cell), is included in Table 4-2.

Table 4-2 Approved Dirty Water Structures

Storage	Design Volume (ML) *	Reuse
Sediment Basin 1	20.8	Dust suppression and process water (subject to water access licensing)
Sediment Basin 2	3.20	
Sediment Basin 3	7.4	
Sediment Basin 4	15.9	
Sediment Basin 5	2.2	
Wyoming Central Dam – Large Cell	78.2	Process Demand

* Determined from maximum of design volume and site 'works as executed' survey

Dirty water from the sediment basins that is to be reused on the Mine Site is transferred to the Wyoming Storage – Large Cell (refer to Figure 4-1).

Wyoming Central Dam – Large Cell

The Wyoming Central Dam – Large Cell (refer to Figure 4-1) provides a central point for the transfer of dirty water for reuse across the Mine Site. Wyoming Central Dam – Large Cell provides a dewatering point for water captured within the open cuts.

4.1.3 Process Water Management System

Process water is that which has likely been exposed to elevated levels of pollutants (other than sediment). This includes runoff generated within the open cut pits, as these areas typically result in elevated salinity levels, as well as other contaminants. Isolating the process water system from the dirty water system reduces the treatment requirements for discharges off site, as well as providing water for reuse within the processing plant.

The process water system includes:

- Process Water Dam (PWD).
- RSF.
- Open cut sumps.

The capacities of each of these storages is summarised in Table 4-3.

Table 4-3 Approved Process Water Structures

Storage	Volume (ML)
Process Water Dam	9.2
Residue Storage Facility Decant Ponds	8.0
Wyoming Three Open Cut	1.0 to 5.0
Caloma One Open Cut	1.0 to 5.0

Process Water Dam

The PWD (refer to Figure 4-1) provides a central storage of process water generated throughout the Mine Site and is the primary water supply to the processing plant.

The PWD includes a small sediment basin to provide pre-treatment to transfers to minimise the sediment loads entering the PWD. This improves the quality of the feed water to the plant and reduces the siltation of the PWD.

Residue Storage Facility

The RSF is comprised of two cells, each approximately 22 ha in area (refer to Figure 4-1). The RSF receives slurry from the Processing Plant which is deposited in the active cell. Water recovered from the RSF is captured within the decant ponds prior to returning to the PWD for reuse in the Processing Plant. A proportion of moisture is retained within the RSF with some loss through evaporation.

The RSF is a prescribed dam under the NSW Dam Safety Committee and has a rainfall capture capacity equivalent to the 10,000 year ARI design storm event.

Open Cut Sumps

The open cuts (refer to Figure 4-1) are operated with a small sump located within the base of the open cut. These sumps serve as a point of dewatering for water used in the processing of mined ore, or a collection point for any groundwater that may be encountered during mining. Typically the volume of these sumps will depend on the stage of the open cut development, working areas, and groundwater inflow volumes. The volume will vary over the life of the Mine but are expected to be between approximately 1 and 5 ML. Due to the high salinity of the

groundwater inflow, the water from the sumps has been defined as process water and should be reused in process water demand primarily.

Opportunities for dewatering sumps transferring water back to the Wyoming Central Dam – Large Cell should be evaluated based on site monitoring and water demands.

4.1.4 Potable and Wastewater Systems

Potable Supply

Water for potable supply is sourced from the Woodlands Borefield and stored within a small 50,000 L tank. Water from this system is appropriate for use in office, bathhouse and drinking water.

Wastewater Systems

All effluent generated at the Mine is managed on site. An aerated wastewater treatment system provides primary and secondary treatment of sewage with water to be reused as irrigation on site. Water is disinfected through chlorination.

The capacity of the treatment system is 4000 L with all water reused in evaporative sprays along the Mine access road. The treatment system can be expanded to meet increased demand.

The management of this system is covered within a specific management plan and the quality of this water is assessable against the National Water Quality Management Strategy (NWQMS) for reuse of effluent.

4.1.5 Surface Water Quality

Monitoring

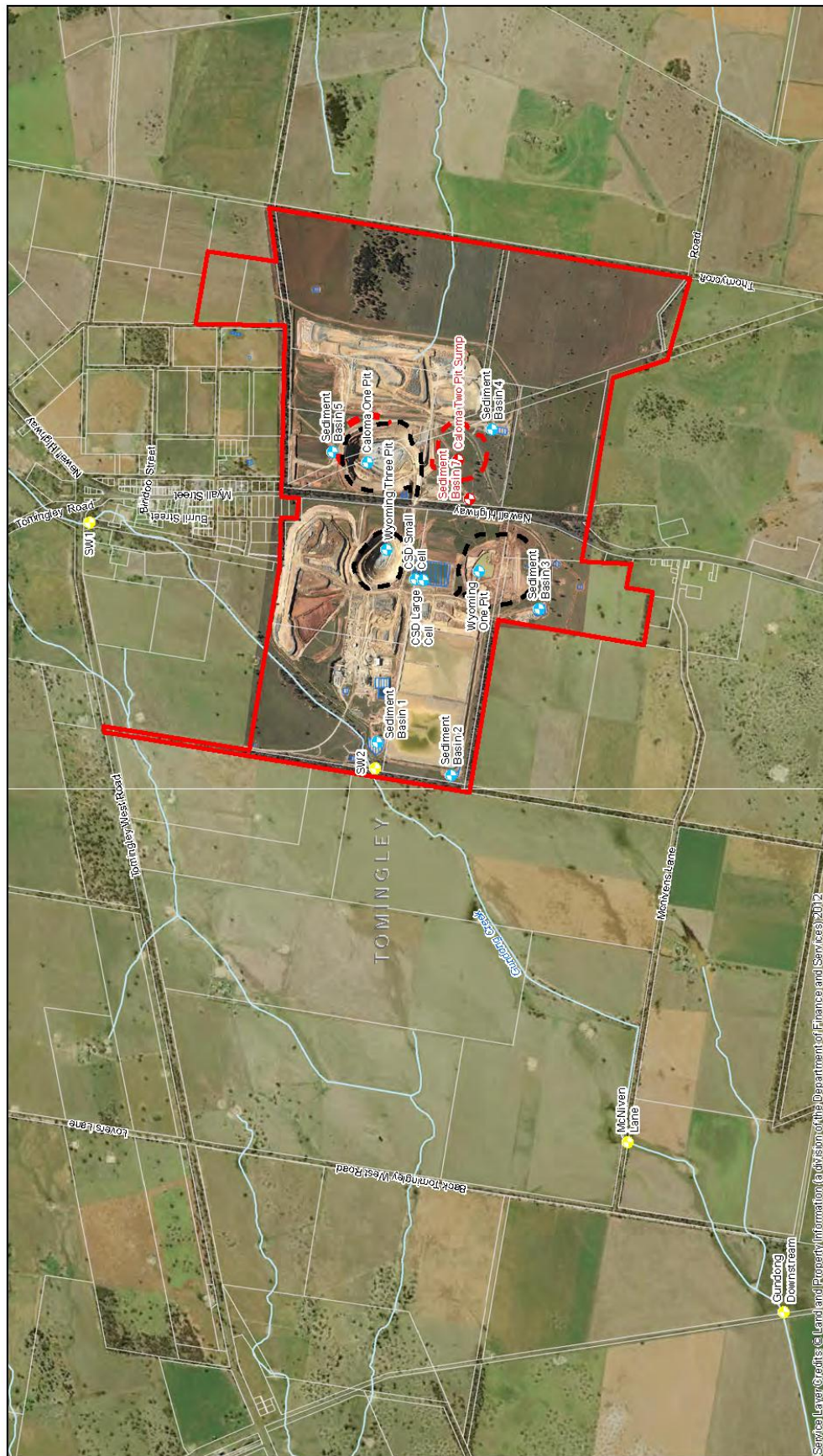
TGO undertakes surface water quality monitoring at several locations within and surrounding the Mine, including those locations specified in EPL 20169. EPL 20169 requires that surface water quality be monitored at one location within the process water system (EPA 2), five locations within the dirty water system (EPA 4 to EPA 8) and two locations within the surrounding clean water system (i.e. Gundong Creek: EPA 16 and EPA 17). Water quality monitoring locations are listed in Table 4-4 and shown in Figure 4-2.

Table 4-4 Surface Water Quality Monitoring Locations

Monitoring Location	EPA Identification Number	Water Management System	Monitoring Period	Notes
CSD Large Cell	-	Process	May 2015 to present	Wyoming Central Dam – Large Cell
CSD Small Cell	-	Process	May 2015 to present	Wyoming Central Dam – Small Cell
Caloma One Pit	-	Process	-	-
Wyoming Three Pit	-	Process	April 2015 to present	-
Sediment Basin 1	4	Dirty	October 2013 to present	Discharges to Gundong Creek catchment
Sediment Basin 2	5	Dirty	October 2013 to present	Discharges to Gundong Creek catchment
Sediment Basin 3	6	Dirty	October 2013 to present	Discharges to Gundong Creek

Monitoring Location	EPA Identification Number	Water Management System	Monitoring Period	Notes
				catchment
Sediment Basin 4	7	Dirty	October 2013 to present	Discharges to Gundong Creek (via the Central Clean Water Diversion Channel)
Sediment Basin 5	8	Dirty	March 2014 to present	Discharges to Gundong Creek (via the Central Clean Water Diversion Channel)
SW1	16	Clean	June 2014 to present	Upstream of the Mine; west of Tomingley township.
SW2	17	Clean	June 2014 to present	West of the Mine; adjacent to SP1
McNiven Lane	-	Clean	July 2015 to present	Downstream of the Mine; McNiven Lane crossing of Gundong Creek
Gundong Downstream	-	Clean	July 2015 to present	Downstream of the Mine; Peak Hill Railway underbridge at Gundong Creek.

Water quality monitoring within the process water system is undertaken on an approximately fortnightly basis. Water quality monitoring within the dirty water system commenced as each sediment basin was constructed. Water quality monitoring of the dirty water systems is undertaken on a monthly basis as of 2015. Water quality within Gundong Creek is monitored infrequently due to the ephemeral nature of the Gundong Creek system.



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Figure 4-2
Surface water monitoring locations

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Data source: Google Earth Pro; Imagery, 2015; LPI; DTDB, 2012. Created by: tmonlon

LEGEND

Paper Size A4 0 125 250 500 750 1000 Metres Map Projection: Transverse Mercator Horizontal Datum: GDA 1994 Grid: GDA 1994 MGA Zone 55	N	Cadastral Site boundary Watercourse Surface water feature	Existing Pit Proposed Pit Surface water monitoring locations Proposed surface water monitoring locations
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EPL Pollutant Concentration Limits

EPL 20169 requires that discharges from the sediment ponds do not exceed the concentration limits summarised in Table 4-5. The EPL limits are generally equivalent to default water quality trigger values specified within *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 3: Primary Industries – Rationale and Background Information* (ANZECC/ARMCANZ, 2000).

Table 4-5 EPL 20169 pollutant concentration limits

Pollutant	EPL Limits
Arsenic (mg/L)	0.024
Cadmium (mg/L)	0.0002
Copper (mg/L)	0.0014
EC (µS/cm)	350
Lead (mg/L)	0.0034
Nickel (mg/L)	0.011
Nitrogen (total) (µg/L)	250
pH (pH units)	6.5 to 8.5
Phosphorous (total) (µg/L)	20
TSS (mg/L)	50
Zinc (mg/L)	0.008

Exceedance Management

Ongoing water quality monitoring of Gundong Creek, at multiple locations upstream and downstream of the Mine and in particular during large storm events or extended periods of wet weather, will assist in identifying whether instances of pollution within Gundong Creek are the result of discharges from the Mine or the result of other processes (natural or human) within the catchment.

Where exceedances of water quality trigger values occur within Gundong Creek that are the result of discharges (uncontrolled or otherwise), TGO implements the following protocols.

- If a controlled discharge, cease to discharge and undertake testing of the discharge water to ensure that it meets the requirements of EPL 20169.
- If an uncontrolled discharge, notify the EPA immediately, and, if safe to do so, commence emergency pumping measures to alternative water storages to minimise the volume of uncontrolled discharges off-site.

4.2 Groundwater Management

Due to the limited interception of groundwater to date, groundwater management at the Mine has focussed on monitoring only.

4.2.1 Groundwater Monitoring Network

The existing groundwater monitoring network has been progressively established at the Mine since 2006. The Mine undertakes quarterly groundwater monitoring of deep bores (WYMB01, WYMB02, WYMB03, WYMB04 and WYMB06) and a shallow alluvial bore GDCMP01 in accordance with EPL 20169. In addition, the Mine undertakes monthly monitoring of shallow bores in the vicinity of the RSF (RSFMP01, RSFMP02, RSFMP03, RSFMP04, RSFMP05, RSFMP06, RSFMP07, RSFMP08, RSFMP09, RSFMP10 and RSFMP11) and PWD (PWMP01 and PWMP02). Six additional shallow monitoring bores were installed in 2015 to monitor

potential impacts from the PWD and associated process water pipelines (PWMP03, PWMP04, PWMP05, PWMP06, PWMP07 and PWMP08).

Groundwater bore locations are shown in Figure 4-3. Monitoring bore details are summarised in Table 4-6.

Table 4-6 Groundwater Monitoring Bore Details

Bore	Depth (m)	Top of Casing Level (m AHD)	Monitoring Period	Lithology
WYMB001	90	270.424 ^(a)	April 2007 – present	Fractured rock
WYMB002	114	268.515 ^(a)	April 2007 – present	Fractured rock
WYMB003	84	275.472 ^(a)	April 2007 – present	Fractured rock
WYMB004	78	272.07 ^(a)	April 2007 – present	Fractured rock
WYMB006	90	268.43 ^(a)	April 2007 – present	Fractured rock
WYMB10	150	272.62 ^(b)	November 2012 – present	Fractured rock
GDCMB01	3.5	273.44 ^(b)	November 2012 – present	Gundong Creek Alluvium
RSFMP01	10.95	268.9 ^(c)	March 2014 – present (dry since installation)	Shallow strata
RSFMP02	10.58	268.3 ^(c)	March 2014 – present (dry since installation)	Shallow strata
RSFMP03	11.88	267.25 ^(c)	March 2014 – present	Shallow strata
RSFMP04	5.28	266.1 ^(c)	March 2014 – present	Shallow strata
RSFMP05	13	265.8 ^(c)	March 2014 – present	Shallow strata
RSFMP06	4.08	264.85 ^(c)	March 2014 – present	Shallow strata
RSFMP07	5.5	265.15 ^(c)	March 2014 – present	Shallow strata
RSFMP08	4.43	265.9 ^(c)	March 2014 – present (dry since installation)	Shallow strata
RSFMP09	5	266.65 ^(c)	March 2014 – present (dry since May 2014)	Shallow strata
RSFMP10	5.5	267.75 ^(c)	March 2014 – present (dry since August 2014)	Shallow strata
RSFMP11	5.74	269 ^(c)	March 2014 – present (dry since installation)	Shallow strata
PWMP01	11.49	267.85 ^(c)	January 2015 – present	Shallow strata
PWMP02	12	267.95 ^(c)	January 2015 – present	Shallow Strata
PWMP03	12	To be surveyed	July 2015 – present	Shallow Strata
PWMP04	11.56	To be surveyed	July 2015 – present	Shallow Strata
PWMP05	11.59	To be surveyed	July 2015 – present	Shallow Strata
PWMP06	12.91	To be surveyed	July 2015 – present	Shallow Strata
PWMP07	11.82	To be surveyed	July 2015 – present	Shallow Strata
PWMP08	9.56	To be surveyed	July 2015 – present	Shallow Strata

(a) Casing surveyed

(b) Casing elevation estimated using natural surface survey and measuring stick up of casing

(c) Level estimated using natural surface survey

Bore construction details of WYMB001, WYMB002, WYMB003, WYMB004, WYMB006 and WYMB10, that screen the fractured rock water source, are summarised in Table 4-7. Each of these bores feature a bentonite seal between 30 m and 71.2 m bgl. Below the bentonite seal the bore is surrounded by a gravel pack that extends to the base of the bore. Within the gravel pack each bore is screened in 3 to 6 m intervals.

Table 4-7 Fractured Rock Water Source Monitoring Bores Construction Details

Bore	Hole depth (m bgl)	Depth of casing (m bgl)	Screened interval (m bgl)	Bentonite seal (m bgl)	Gravel pack length (m)
WYMB001	90	90	84-90, 78-81	60	30
WYMB002	114.5	114	108-114, 102-105, 96-99	71.2	43
WYMB003	84	84	78-84, 69-72, 60-63	42	42
WYMB004	96	78	72-78	30	66
WYMB006	90	90	84-90, 75-81	60	30
WYMB10	150				

4.2.2 Groundwater Levels

Hydrographs of all fractured rock groundwater monitoring bores have been plotted and compared with the CRD (Appendix E).

Pre-mining groundwater levels at WYMB001 were generally rising over the pre-mining period while groundwater levels at WYMB002 and WYMB003 were generally constant. Comparing long term average groundwater levels to the depth of the bentonite seal for several of the bores in Table 4-7, the groundwater level extends above the bentonite seal indicating that the fractured rock water source is confined and under pressure.

The groundwater hydrographs in Appendix E for WYMB004 and WYMB006 indicate that groundwater levels at these monitoring locations are generally constant with the exception of a spike in groundwater levels in early 2008. Coffey (2008) found this observed rise in groundwater levels at WYMB004 and WYMB006 followed a significant month of above average rainfall of approximately 150 mm in December 2007. WYMB004 and WYMB006 are located near McPhail's historical workings and Coffey (2008) concluded that the response in groundwater levels following rainfall may be related to filling of McPhail's historical workings.

However there is no similarly strong response in groundwater levels at WYMB004 following wet periods in early 2014 and December 2014. Similarly, the response in groundwater levels at WYMB006 to wet periods in early 2014 and December 2014 is not as strong as the response to rainfall observed in early 2008.

Baseline and operational groundwater levels are summarised in Table 4-8.

Table 4-8 Groundwater Level Summary

Location	Baseline (pre-January 2014) groundwater level (m AHD)		Operational groundwater level (m AHD)	
	Minimum	Maximum	Minimum	Maximum
WYMB001	209.97	233.82	230.79	232.25
WYMB002	208.91	209.37	208.17	209.49
WYMB003	220.19	221.74	221.20	222.29
WYMB004	208.62	242.32	208.23	209.55

Location	Baseline (pre-January 2014) groundwater level (m AHD)		Operational groundwater level (m AHD)	
	Minimum	Maximum	Minimum	Maximum
WYMB006	231.13	240.31	230.98	236.42
WYMB10	200.30	200.42	196.85	200.55

During the operational phase at the Mine, groundwater levels have typically remained within pre-mining minimum and maximum groundwater levels. The hydrographs for WYMB002, WYMB003, WYMB006 and WYMB10 shown in Appendix E indicate some variation in groundwater levels for the December 2014 monitoring round, however groundwater levels returned to typical levels by the following March 2015 monitoring round.

4.2.3 Groundwater Quality

Background water quality data is available at deeper bores WYMB001, WYMB002, WYMB003, WYMB004, WYMB006 and WYMB10 and at alluvial monitoring bore GDCMB01. Groundwater quality plots are presented in Appendix F.

pH was generally between 7 and 8.5 for all deep bores, indicating that all sites are slightly alkaline. Background EC at WYMB02, WYMB03, WYMB04 and WYMB10 was over 20,000 $\mu\text{S}/\text{cm}$ indicating saline water. Background EC at WYMB01 and WYMB06 was lower however still saline at typically 12,000 to 13,000 $\mu\text{S}/\text{cm}$. Due to the high salinity of the deep groundwater it is considered to have low beneficial use, which is reflected in the lack of deep production bores in the area.

A piper diagram for all groundwater monitoring locations is shown in Appendix D. The piper diagram allows comparison of water chemistry between monitoring locations. The piper diagram indicates that the saline groundwater at each deep monitoring location within the fractured rock water source is of sodium chloride type. The groundwater at the Wyoming Three sump and the Caloma One sump is of similar chemistry to the deep groundwater. The piper diagram also indicates that groundwater in the Gundong Creek alluvium is of differing chemistry to the deep groundwater within the fractured rock water source, having both chloride and bicarbonate dominance. The differing chemistry indicates a low degree of connectivity between the alluvium and the deep fractured rock water source.

Water quality parameters at GDCMB01 have been compared to Default Trigger Values (DTVs) for 95% species protection recommended by ANZECC and ARMCANZ (2000a) due to the likely hydraulic connection between the alluvium and Gundong Creek. Water quality at GDCMB01 has been plotted against DTVs with time series graphs shown in Appendix F. Water quality at GDCMB01 is below DTVs for dissolved arsenic, cadmium, mercury, and ammonia. EC at GDCMB01 is typically above the DTV. Groundwater at GDCMB01 has also exceeded DTVs for pH, TSS and for dissolved chromium, copper, lead, nickel, zinc and iron on one or more occasions.

Limited groundwater quality data is available at shallow groundwater monitoring locations associated with the RSF and the PWD. This lack of data is due to a number of these locations being dry or almost dry for the majority of monitoring periods.

Available groundwater quality data at RSF and PWD monitoring locations indicates that pH was generally between 7 and 8.5 indicating slightly alkaline groundwater. EC at monitoring location RSFMP03 typically varied between 10,000 and 15,000 $\mu\text{S}/\text{cm}$ while at all other RSF and PWD monitoring locations available data indicated that EC varied between 1,000 and 4,000 $\mu\text{S}/\text{cm}$.

Available groundwater quality data at RSF and PWD monitoring locations has been plotted against DTVs for 95% species protection recommended by ANZECC and ARMCANZ (2000a)

with water quality graphs in Appendix F. Monitoring locations associated with the RSF and the PWD exceeded DTVs on one or more locations for EC, pH and dissolved cadmium, chromium, copper, lead, nickel and zinc. These exceedances are likely to be attributable to the natural geochemistry of the shallow groundwater source.

4.2.4 Existing Groundwater Impacts

Open cut extraction has commenced in Caloma One, Wyoming Three and Wyoming One pits. Extraction details are summarised in Table 4-9.

Table 4-9 Existing Open Cut Extraction

Open Cut	Level in Oct 2015 (m AHD)	Start Level (m AHD)	Final Level (m AHD)	Inflow Observations
Caloma One	193.5	271	95	No inflow observed
Wyoming One	247.5	268	80	No inflow observed
Wyoming Three	165	271	155	Experiences a short inflow for 12-24 hours following blasting (generally less than 0.5 ML) then inflow reduces to negligible flow until the next flitch comes out.

Note: Pit level and observed inflow current as of October 2015.

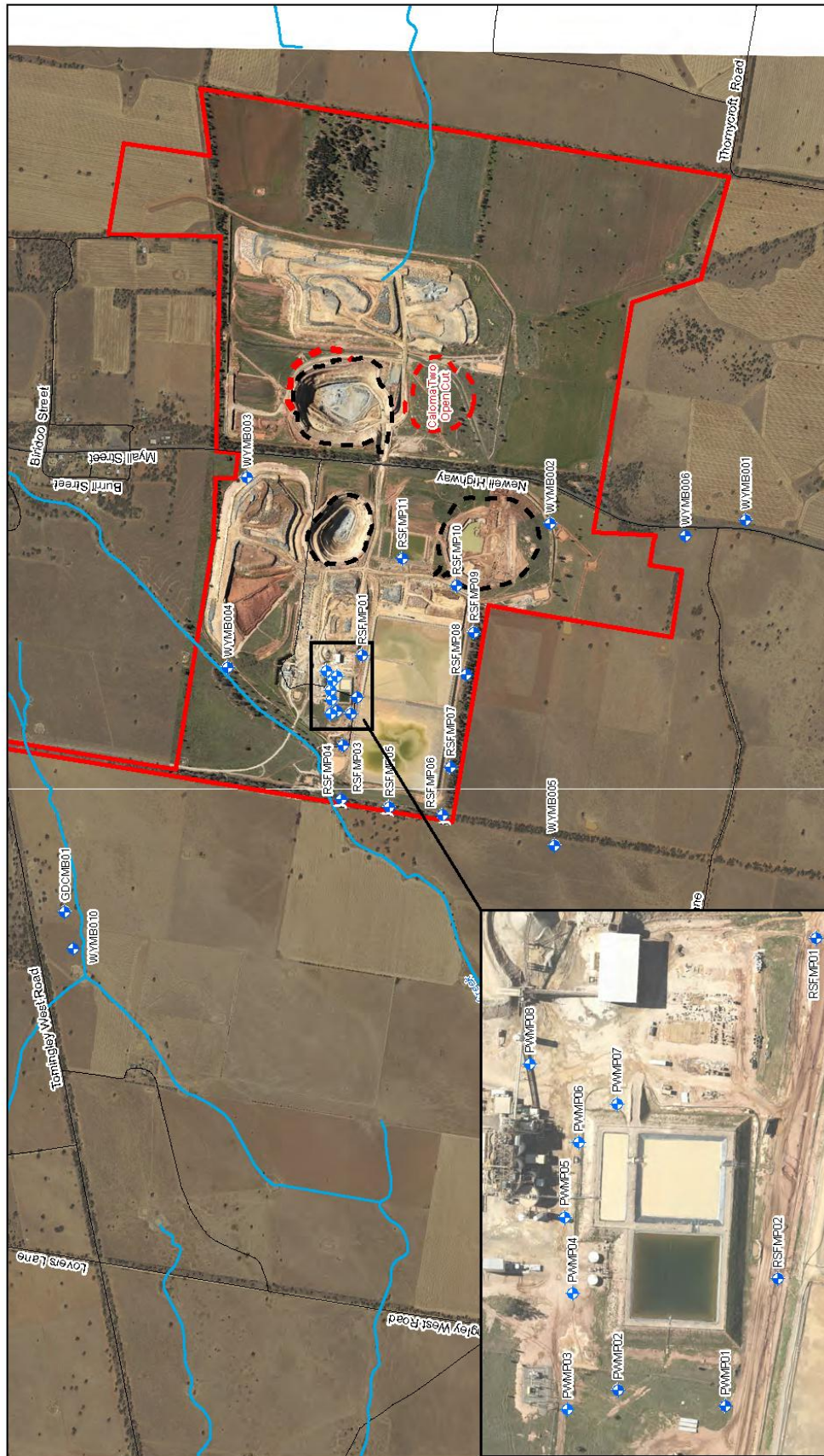
As shown in Table 4-9 groundwater interception by the existing open cut pits has been limited. The groundwater inflow observations indicate that only Wyoming Three has extended into the water bearing zone of the fractured rock water source.

The level of the existing Caloma One open cut and the lack of observed groundwater inflows indicate that the water bearing zone of the fractured rock water source is below a level of 190 m AHD, which is below the groundwater level recorded in the deep monitoring bores.

Review of the groundwater hydrographs shown in Appendix E indicates that there has been no long term drawdown in groundwater levels in the fractured rock water source. This indicates that the radius of influence of the groundwater interception in Wyoming Three open cut pit is lower than predicted in the EIS.

4.2.5 Conceptual Groundwater Model

The original conceptual groundwater model developed for the EIS has been modified based on monitoring data and site observations and is presented in Figure 4-4. The revised conceptualisation of site hydrogeology assumes that the fractured rock water source is confined at an elevation below 190 m AHD. The groundwater is under pressure as indicated by monitoring bore data showing groundwater levels ranging between approximately 200 m and 240 m AHD.



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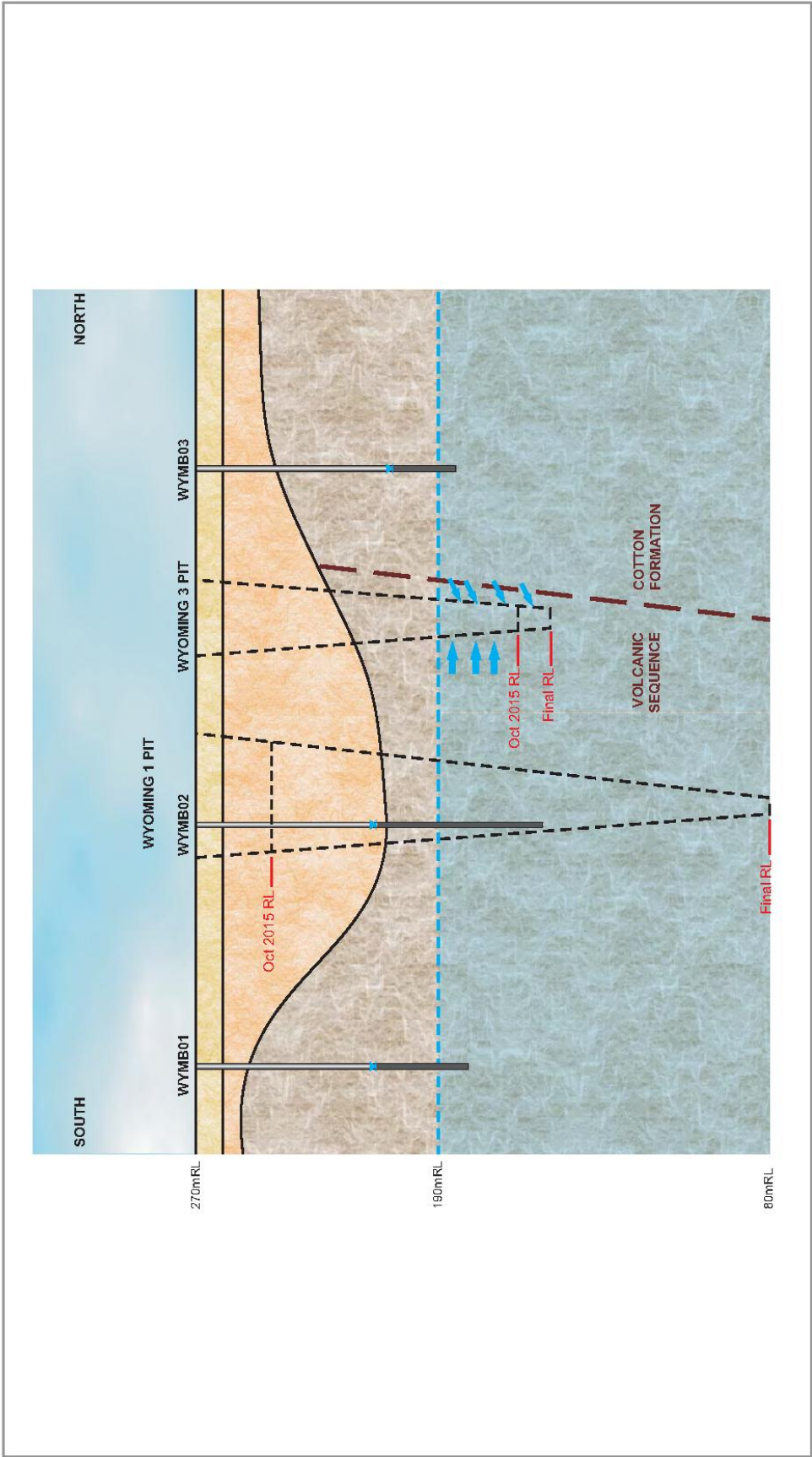


Alkane - Tomingley Gold Mine
Modification 3
Water Resources Assessment

Groundwater monitoring network

Figure 4-3

Level 3: GHD Tower, 24 Homersuckle Drive, Newcastle NSW 2300 T61 2 4070 0000 F61 2 4070 0000 E nfm@alk.com.au www.alk.com.au
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Data source: Google Earth Pro Imagery, 2016; LPI, DT06, 2012. Created by: Irontron



Conceptual diagram only - not to scale

LEGEND

Sandy Clay

Saponillite Clay

Fractured Siltstone/Sandstone

Fractured Confined Aquifer

Groundwater Inflow

Tomingley Gold Operations
Modification 3 Water Resources Assessment

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Revision A
Date 23 Oct 2015

Figure 4-4

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5. Impact Assessment

5.1 Surface Water Management

5.1.1 Clean Water Management System

The eastern cutback of the Caloma One open cut and construction of proposed Caloma Two open cut requires the realignment of the central clean water diversion channel and the adjacent WRE 3 dirty water catch drain (refer to Figure 4-1).

The principal risks associated with the realignment of the clean water diversion channel are:

1. Overtopping of the central clean water diversion channel, resulting in an increased water volume to be managed within the dirty water system and therefore an increased risk of the uncontrolled discharge of sediment laden water from Sediment Basin 4 (refer to Figure 4-1).
2. Overtopping of the adjacent dirty water catch drain into the central clean water diversion channel, resulting in the uncontrolled discharging of sediment laden water into Gundong Creek.
3. Erosion of the bed and banks of the central clean water diversion channel due to flow velocities exceeding the stability threshold of the channel surface material, resulting in the discharge of sediment laden water into Gundong Creek.

To minimise these risks, the proposed realignment of the central clean water diversion channel has been sized to safely convey the peak runoff generated by the 100 year ARI critical duration design storm event (based on the probabilistic rational method as described in ARR87: Engineers Australia, 1987). The analysis indicates that a trapezoidal channel with a base width of approximately 10 m and a minimum depth of approximately 1.6 m results in a maximum flow depth of approximately 1.1 m with a minimum freeboard of 0.5 m (refer to Figure 5-1). It should be noted that an extended separation levee between the central clean water diversion channel and the adjacent dirty water catch drain of 1 m above the maximum estimated flood level (i.e. 2.1 m above the central clean water diversion channel) is recommended to minimise the chance of overflows occurring into (and out of) the adjacent dirty water catch drain (refer to Figure 5-1). The modelling indicates that peak flow velocities within the proposed central clean water diversion channel for the 100 year ARI critical duration design storm event are approximately 1.7 m/s. As a result, it is recommended that the turf lining be reinforced with a flexible mesh to provide additional resilience during flood events.



Figure 5-1 Central Clean Water Diversion - Typical Cross Section

5.1.2 Dirty Water Management System

The realignment of the central clean water diversion channel requires the modifications of the dirty water catch drain that currently flows along the western edge of WRE 3 (refer to Figure 4-1). The realigned WRE 3 dirty water catch drain will continue to direct sediment laden runoff generated within WRE 3 towards Sediment Basin 4, and will continue to flow parallel to the relocated central clean water diversion channel (refer to Figure 4-1).

The relocated WRE dirty water catch drain is to be sufficient to safely convey the peak runoff generated during the 20 year ARI critical duration design storm event (based on the probabilistic rational method as described in ARR87: Engineers Australia, 1987). The analysis indicates that a trapezoidal channel with a base width of approximately 6 m and a minimum depth of approximately 1.1 m results in a maximum flow depth of approximately 0.9 m with a minimum freeboard of 1 m to the adjacent clean water diversion channel (refer to Figure 5-2).

The modelling indicates that for the 20 year ARI critical duration design storm event, peak flow velocities within the dirty water catch drain are approximately 1.8 m/s. To provide additional stability and longevity to the drain, it is therefore recommended that a mesh reinforced turf lining be established. This lining will also assist in reducing the sediment load within the conveyed water, thereby reducing the treatment requirements within the sediment basin necessary to allow offsite discharges to occur.

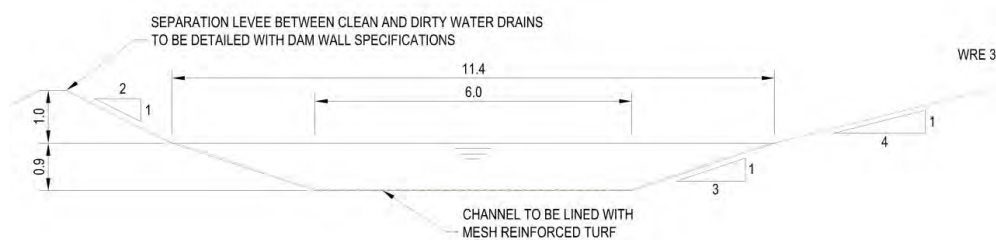


Figure 5-2 WRE 3 Dirty Water Catch Drain - Typical Cross Section

The proposed modification will also result in the modifications to other dirty water catchments at the Mine. The increased and redistributed dirty catchment areas will require some modifications to the existing sediment basins, as well as the construction of two new sediment basins (6 and 7: refer to Figure 4-1). The proposed sediment basins are designed to treat the runoff generated by the 90th percentile 10 day rainfall event, with a sediment storage zone equivalent to the total sediment volume generated over a year (estimated using the revised universal soil loss equation). A comparison of the approved and proposed sediment basin capacities is included in Table 5-1. From Table 5-1 it can be seen that the approved capacities of Sediment Basins 4 and 5 will require modification to provide adequate protection to the downstream environment from sediment laden discharges.

Table 5-1 Approved and Proposed Sediment Basin Capacities

Sediment Basin	Existing		Proposed	
	Catchment Area (ha)	Capacity (ML)	Catchment Area (ha)	Capacity (ML)
1	103.4	20.8	103.4	20.8
2	7.7	3.0	7.7 ^A	3.0
3	84.4	7.4	84.4	7.4
4	83.6	15.5	84.0	21.6 ^B
5	17.4	1.6	23.2	6.0 ^B
6	-	-	1.9	4.2

Sediment Basin	Existing		Proposed	
	Catchment Area (ha)	Capacity (ML)	Catchment Area (ha)	Capacity (ML)
7	-	-	9.1	2.3

- A The capacity of Sediment Basin 2 is proposed to be increased, however the current capacity of Sediment Basin 2 exceeds the required capacity to treat local catchment runoff. Therefore the existing capacity of Sediment Basin 2 was adopted for this assessment.
- B The Water Management Plan (GHD 2015) identified that Sediment Basins 4 and 5 were likely to be undersized. TGO are currently considering increasing the capacity of Sediment Basins 4 and 5, and this has been included as part of this assessment. Similarly the surface water storages of Sediment Basin 1 and 3 require increases however these were not included as part of this assessment as they are still under consideration by TGO

5.1.3 Surface Water Impact Assessment

The construction of Caloma Two open cut is predicted to result in a reduction in the local clean water catchment area of approximately 26.5 ha (refer to Table 5-2). The increased dirty water catchment (principally due to the proposed Sediment Basin 7 and increased catchment area draining to Sediment Basin 5: refer to Table 5-2) is estimated to account for approximately 16.3 ha, whilst the increased process water system (primarily water draining to the proposed Caloma Two pit) accounts for approximately 10.2 ha.

Table 5-2 Surface Water Catchment Changes

Diversion / Channel / Dam	Approved Catchment Area (ha)	Proposed Catchment Area (ha)	Change (ha)
Clean Water System			
Central Clean Water Diversion	511.2	493.4	-17.8
Farm Dam	8.7	0.0	-8.7
<i>Total – Clean Water Catchments</i>	<i>519.9</i>	<i>493.4</i>	<i>-26.5</i>
Dirty Water System			
Sediment Basin 1	103.4	103.4	0.0
Sediment Basin 2	7.7	7.7	0.0
Sediment Basin 3	84.4	84.4	0.0
Sediment Basin 4	83.6	84.0	+0.4
Sediment Basin 5	17.4	23.2	+5.8
Sediment Basin 6	0.7	1.8	+1.1
Sediment Basin 7	-	9.0	+9.0
<i>Total – Dirty Water Catchments</i>	<i>297.2</i>	<i>313.3</i>	<i>+16.3</i>
Process Water System			
Wyoming Three Pit	11.7	11.7	0.0
Wyoming One Pit	16.7	16.7	0.0
Caloma One Pit	28.2	24.4	-3.8
Caloma Three Pit	-	14.0	+14.0
RSF	42.7	42.7	0.0
<i>Total – Process Water System</i>	<i>93.3</i>	<i>109.5</i>	<i>+10.2</i>

A 26.5 ha reduction in clean water catchment (approximately 5% of the existing clean water catchment area) is unlikely to have an appreciable impact on downstream flows. In addition, given the ephemeral nature of Gundong Creek, it is unlikely that its flows are to be utilised as a primary water source for downstream water users this further reduces the potential impact to downstream water users (including basic landholder rights and licensed water users).

As the proposed modifications are located within the existing Mine disturbance boundary, no further impacts to surrounding watercourses and associated riparian zones are expected.

5.2 Hydrogeology

Groundwater impacts from the development of the Caloma Two open cut pit and Caloma underground and the filling of the Wyoming Three open cut pit with waste rock have been assessed in accordance with the AIP. The criteria for less productive fractured rock groundwater sources have been used for this assessment and are outlined below.

5.2.1 Water Table

This criterion is relevant only if high priority GDEs may be impacted by the project. As discussed in Section 3.5.2, the closest high priority GDEs listed in the NSW Murray Darling Fractured Rock Groundwater Sources WSP are Dilladerry Spring located approximately 18.5 km east of the Mine and Hyandra Hill Spring located approximately 28 km north east of The Mine. Therefore the proposed and existing activities at the Mine are predicted to have no impact on any high priority GDEs listed in the relevant WSPs and therefore meet the Level 1 impact level for this criterion.

5.2.2 Water Pressure and Licensing

The cumulative pressure head decline at registered bores in the vicinity of the Mine has been predicted by calculating the radius of influence of the interception of the fractured rock water source by the open cut pits and underground workings.

The Impax Group (2011) predicted that the cumulative radius of influence of the Wyoming One, Wyoming Three and Caloma One pits, as well as the Wyoming One underground, would extend up to 2,300 m to 5,600 m from the Wyoming One open cut. The methodology used to calculate the radius of influence and groundwater inflows (based on the Marinelli and Niccoli (2000) equation) was conservative since it assumed unconfined saturated groundwater conditions below 60 m bgl. The predicted radius of drawdown from each open cut pit and the Wyoming One underground (each assessed individually), reported by The Impax Group (2011), is shown in Table 5-3. Predicted groundwater inflows, reported by The Impax Group (2011), are shown in Table 5-4.

Table 5-3 Predicted radius of drawdown, Impax Group (2011)

Mining Area	Radius of Drawdown (m)
Caloma One	1,700 - 3,900
Wyoming One	1,700 - 3,900
Wyoming One Underground Extension	2,300 - 5,600
Wyoming Three	650 - 1,450

Table 5-4 Predicted groundwater inflows, Impax Group (2011)

Mining Area	Inflow (L/s)	Inflow (kL/day)
Caloma One	2 - 12	173 – 1,037
Wyoming One	2 - 11	173 - 950
Wyoming One Underground Extension	3 - 20	259 - 1728
Wyoming Three	0.3 – 1.5	26 - 130

Observed groundwater inflow into Wyoming 3 open cut is minimal even though the pit is almost complete and deeper than 60 m bgl, and it has not resulted in drawdown in groundwater levels at the surrounding monitoring bores as discussed in Section 4.2.4. This indicates that the radius of influence of Wyoming 3 is less than 765 m which is the approximate distance from the centre of the Wyoming 3 pit to the closest monitoring bore WYMB003.

Since actual groundwater impacts are less than originally predicted, the methodology to calculate the radius of influence and groundwater inflows has been modified for this assessment in accordance with the conceptual model outlined in Section 4.2.5.

Modified Calculation Methodology

The modified calculation methodology is based on the transient point-sink equation for discharge from the confined groundwater source (after Lohman, 1972). The calculation and calibration methodology is summarised in Appendix B. Based on the calibration of hydraulic conductivity and storativity values, a storativity of 0.001 was adopted for the impact assessment and two hydraulic conductivity scenarios were considered:

- Scenario 1 - hydraulic conductivity of fractured rock water source equal to 0.005 m/day.
- Scenario 2 - hydraulic conductivity of fractured rock water source equal to 0.01 m/day.

Groundwater Inflows

Average groundwater inflows into the open cut pits and underground workings have been re-calculated using the modified methodology to clarify licensing requirements and to provide a transient input into the water balance model. Groundwater inflows have been calculated up to the completion of mining in September 2021. Predicted groundwater inflows for each open cut pit and underground mine (for Scenarios 1 and 2) are shown over time in Figure 5-3.

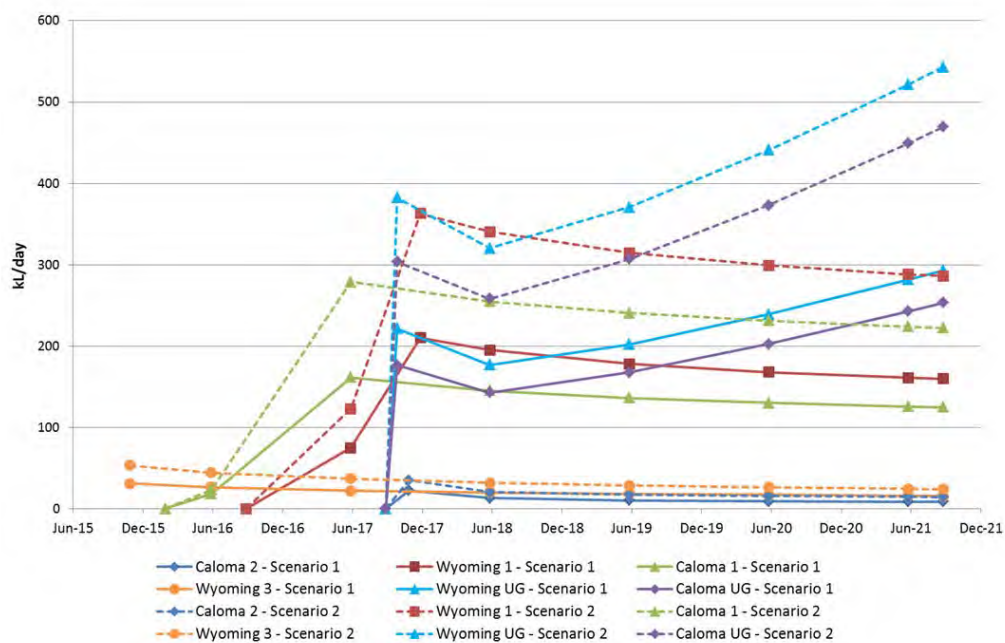


Figure 5-3 Predicted Groundwater Inflows

It is assumed that groundwater inflows will commence when each pit extends below a level of 190 m AHD, the assumed top of the confined water bearing zone. Groundwater inflows are

assumed to continue until mining has ceased and groundwater levels have reached equilibrium – that is pre-mining groundwater levels.

Using the modified calculation methodology, groundwater inflows are predicted to peak in 2017 for each pit (excluding Wyoming Three which is complete) and peak in 2021 for each underground mine. Table 5-5 compares the original groundwater inflow predictions against the modified peak inflows for Scenarios 1 and 2. Modified inflows are generally less than the original groundwater inflow predictions. Note that modified inflows have been calculated for each pit and underground mine separately and therefore the assessment retains an element of conservativeness.

Table 5-5 Predicted groundwater inflows - modified methodology

Mining Area	Peak Inflow (kL/day), Impax Group (2011)	Modified Peak Inflows (kL/day)
Caloma One	173 – 1,037	161 - 279
Wyoming One	173 - 950	177 - 320
Wyoming One Underground	259 - 1728	293 - 543
Wyoming Three	26 - 130	31 - 53
Caloma Two	Not predicted	20 - 32
Caloma Two Underground	Not predicted	253 - 469

Groundwater Licensing

Predicted groundwater inflows (using the modified calculation methodology) have also been calculated annually (by water year, from 1 July to 30 June) for each pit and underground mine to clarify the increase in licensing requirement due to the Caloma Two open cut and Caloma underground. Results for each scenario are shown in Table 5-6.

Table 5-6 Predicted groundwater inflows by water year (ML/year)

Date	Wyoming One	Caloma One	Wyoming Three	Caloma Two	Caloma UG	Wyoming UG	Total
Scenario 1 – Hydraulic conductivity $k = 0.005$; Storativity $S = 0.001$							
2015 – 2016	0	2.0	9.9	0	0	0	11.9
2016 – 2017	10.2	32.8	8.9	0	0	0	51.9
2017 – 2018	62.9	55.9	7.7	4.4	41.4	51.7	224.1
2018 – 2019	68.1	51.4	7.0	4.2	56.6	69.1	256.4
2019 –	63.3	48.7	6.5	3.6	67.7	80.7	270.5

Date	Wyoming One	Caloma One	Wyoming Three	Caloma Two	Caloma UG	Wyoming UG	Total
2020							
2020 – 2021	60.0	46.7	6.0	3.3	81.2	95.0	292.1
Scenario 2 – Hydraulic conductivity k = 0.01, Storativity S = 0.001							
2015 – 2016	0	2.5	17.0	0	0	0	19.5
2016 – 2017	16.7	55.2	14.9	0	0	0	86.8
2017 – 2018	108.5	97.4	12.6	7.0	72.8	91.1	389.2
2018 – 2019	119.6	90.4	11.0	6.9	103.1	126.1	457.1
2019 – 2020	112.3	86.3	10.0	6.0	124.4	148.5	487.6
2020 – 2021	107.2	83.1	9.3	5.5	150.0	175.6	530.7

Note: Volumes calculated for each water year from 1 July to 30 June.

The total intercepted groundwater volume is predicted to increase from a maximum of between 208 and 375 ML/year in the 2020 – 2021 water year (for existing approved conditions) up to between 292 and 531 ML/year in the 2020 – 2021 water year with the addition of the Caloma Two open cut and Caloma underground mine. Although an increase in groundwater inflow is predicted, the total volume of groundwater intercepted will be less than that originally calculated (The Impax Group, 2011).

As shown in Table 2-2, TGO currently holds a licence allocation of 220 ML/year from the NSW Murray Darling Basin Fractured Rock Groundwater Sources WSP. This analysis indicates that additional water access entitlement will need to be purchased by TGO at some point in the future.

There was 73,599 ML of tradeable water access entitlement in the Lachlan Fold Belt Murray Darling Basin Fractured Rock Groundwater Source as at January 2012 (DPIW, 2012). This indicates that there is sufficient tradeable water available within the water source to meet the requirements of TGO. Based on data from DoE (2015), 280 ML was traded within this water source over the period March to August 2015 indicating that there is active trading within the water source similar to the volumetric requirement of TGO.

Radius of Influence

The maximum radius of drawdown from each open cut and underground mine has been predicted using the modified calculation methodology. Predicted radius of drawdown is presented in Figure 5-4 and Table 5-7. Modified radius of influence predictions are generally less than the original calculations reported by The Impax Group (2011).