SOILWATER CONSULTANTS

Water Management Plan (WMP) for the Twin Bonanza Gold Project	
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A - Report issued for internal review

B - Draft report issued for client review

C - Final report issued to client

LIMITATIONS

The sole purpose of this report and the associated services performed by Soil Water Consultants (SWC) was to develop a Water Management Plan (WMP) for the Twin Bonanza Gold Project. This work was conducted in accordance with the Scope of Work presented to ABM Resources NL ('the Client'). SWC performed the services in a manner consistent with the normal level of care and expertise exercised by members of the earth sciences profession. Subject to the Scope of Work, the WMP was confined to the Twin Bonanza Project Area (exploration least number EL28322). No extrapolation of the results and recommendations reported in this study should be made to areas external to this project area. In preparing this study, SWC has relied on relevant published reports and guidelines, and information provided by the Client. All information is presumed accurate and SWC has not attempted to verify the accuracy or completeness of such information. While normal assessments of data reliability have been made, SWC assumes no responsibility or liability for errors in this information. All conclusions and recommendations are the professional opinions of SWC personnel. SWC is not engaged in reporting for the purpose of advertising, sales, promoting or endorsement of any client interests. No warranties, expressed or implied, are made with respect to the data reported or to the findings, observations and conclusions expressed in this report. All data, findings, observations and conclusions are based solely upon site conditions at the time of the investigation and information provided by the Client. This report has been prepared on behalf of and for the exclusive use of the Client, its representatives and advisors. SWC accepts no liability or responsibility for the use of this report by any third party.

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1 INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

This document describes a Water Management Plan (WMP) for the proposed Twin Bonanza Gold Project (TBGP), operated by ABM Resources NL (ABM). The primary purpose of this Plan is to monitor and mitigate site-specific risks to surface and ground waters that were identified through the Environmental Impact Statement (EIS) process. It is intended to provide the mining operation with a useful management tool that enables them to meet environmental quality targets, while also satisfying the monitoring and reporting requirements of the Northern Territory (NT) Department of Mines and Energy (DME).

1.2 SCOPE OF THIS DOCUMENT

This WMP applies to the proposed TBGP, located in the central Northern Territory (NT), and as described in Section 1.4. This mining development is currently in the planning stages, with only exploration and bulk sampling activities occurring in the area. The level of detail in this WMP reflects this early stage of development – it is intended that this plan will be updated as the site is further developed.

This document was developed using the following preliminary studies and background data:

- Preliminary Groundwater Resource Assessment (Earth Systems, 2013)
- Preliminary Surface Flow Analysis (SWC, 2013a)
- Preliminary Soils Assessment (SWC, 2013b)
- Geological drilling data provided by ABM Resources.

This document was developed according to the *Water Management Plan Template*, supplied by the NT DME as part of the *Template for the Preparation of Mining Management Plan* (August, 2012).

1.3 COMPLIMENTARY DOCUMENTS

The following complimentary documentation was produced concurrently with this document as part of the mine planning process:

- Environmental Impact Statement (EIS)
- Groundwater Sampling SOP (SWC, 2013c)
- Surface Water Sampling SOP (SWC, 2013d)
- Erosion and Sediment Control Plan (SWC, 2013e)

1.4 GENERAL SITE DESCRIPTION

The proposed TBGP is located in the Tanami Desert Region of the Northern Territory of Australia, approximately 625 km north-west of Alice Springs and 16 km east of the NT and Western Australian (WA) border (Figure 1.1). ABM hold an exploration lease (EL28322) and have submitted an application for a mineral lease (MLA29822) which encompasses the Old Pirate Deposit and surrounding prospects, including Golden Hind, Old Glory, and other ore zones that may be identified or confirmed by continued exploration and mining activity in the region. This project is still at the approvals stage, with a Notice of Intent (NOI) having been submitted to the NT Department of Lands Planning and Environment (DLPE) in January 2013.

The proposed site layout is shown in Figure 1.2, and consists of three open pits, onsite processing facilities and associated tailings dams (TD), concentrate residual dam (CRD), waste rock dumps (WRDs), and required infrastructure including accommodation, workshops, and offices.

Trial bulk sampling and on-site trial processing has occurred during 2013, to be followed by open pit mining, and potential underground mining. Life of mine is expected to be at least 3–4 years, with the expectation that further exploration activities will indicate that this can be extended significantly.

Water supply requirements for the full production phase are estimated at 350,000 m^3/yr (average of 11.1 L/s). This maximum water demand represents a processing rate of 300,000 tonnes per annum of ore, and is not expected to be required until year 4 of the project.

1.5 HYDROLOGICAL AND HYDROGEOLOGICAL SETTING

The Tanami Desert Region has a semi-arid climate, characterised by hot, wet summers and mild, relatively dry winters. Average annual rainfall in the region ranges from 400-500 mm, and approximately 85 % of this falls between November and April (Figure 1.3). Summer rainfall is characterised by infrequent, but intense rainfall events, with single events delivering > 50 mm in 24 hours on average at least once per year (Table 1.1). Average pan evaporation for the region is approximately 3,000 mm/yr, far exceeding the average annual rainfall.

The Project Area is located relatively high in the landscape, and does not intersect any regional-scale surface water features (SWC, 2013a). The majority of the main infrastructure areas are located on topographic highs or diverging slope areas, where the potential for converging local surface water flows is minimal. The shape of the landscape indicates that sheet flow will be the dominant surface water flow process, with some accumulation of flows possible in lower-lying areas after large storm events, although there are no permanent water features present within the proposed mining lease. The borefield and some sections of the main access road were given a “high” potential flood risk rating because of their location in lower-lying areas.

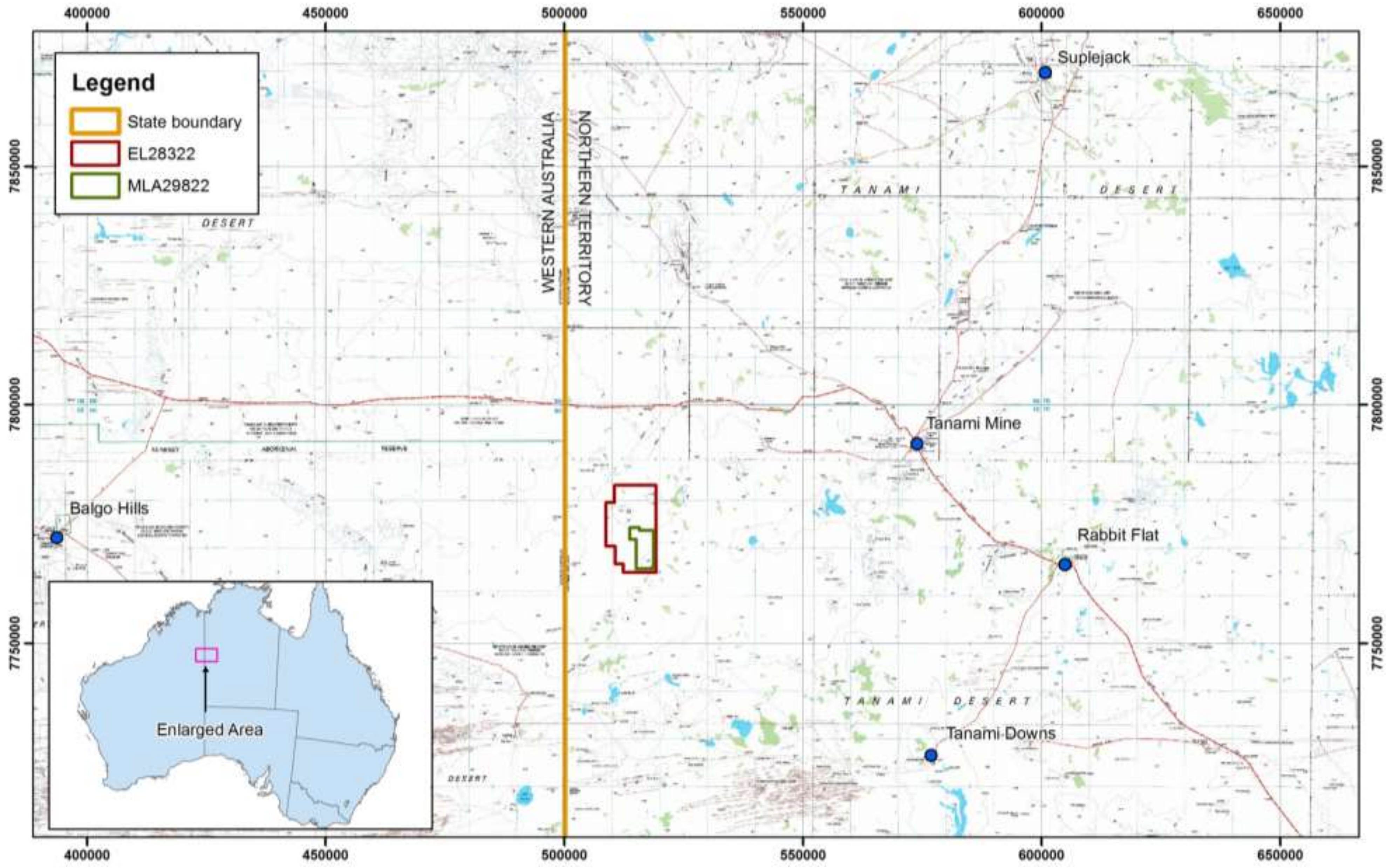
Two types of aquifers have been identified as potential groundwater resources within the Project Area, including hard-rock aquifers and an unconsolidated sedimentary aquifer hosted within Tertiary to Recent palaeochannels (Earth Systems, 2013). Initial indications are that the palaeochannel aquifers should be the primary targets for more detailed hydrogeological assessment. On that basis, a number of groundwater resource target areas within palaeochannel aquifers have been identified including locations close to the Mineral Lease as well as up to 35 km away, and this is discussed further in Section 3.1.

Initial mining as detailed in the EIS will occur above the water table. If, in the future, the deposits are deemed economically viable for underground mining, water produced as a by-product of mining will be used to augment the water supply.

Groundwater recharge is understood to generally only occur after larger rainfall events (i.e. more than 50 mm in 24-48 hours) (Earth Systems, 2013). A figure of 4.5 mm/year, or 1 % of the total annual average rainfall, was considered to be a reasonable estimate of recharge to the palaeochannels (Earth Systems, 2013). Estimates of groundwater recharge to the bedrock aquifer have not been determined.

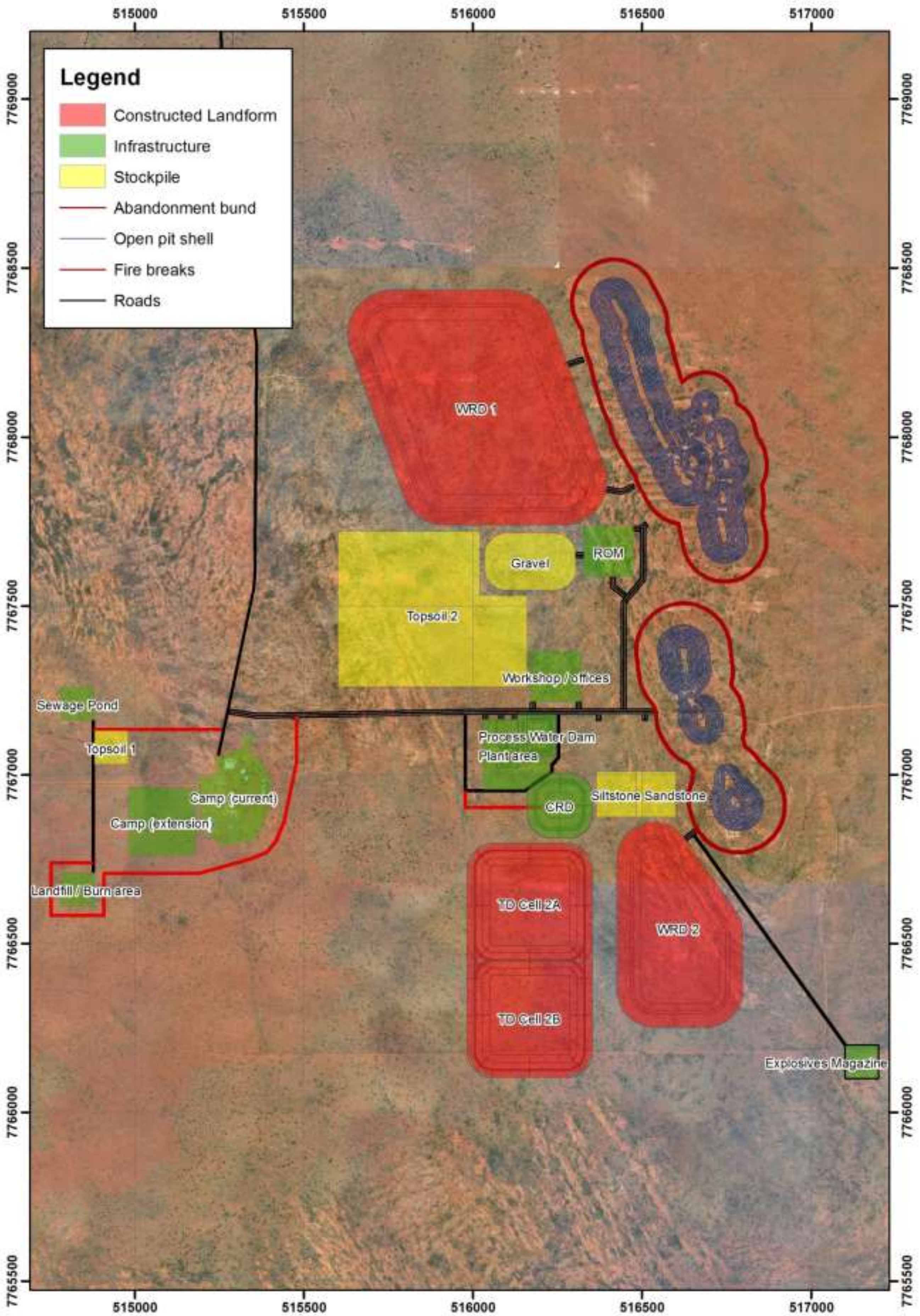
Table 1.1: Rainfall frequency data for the Project Area (depth, mm) (BOM, 2013)

Duration	1:1 yr	1:5 yr	1:10 yr	1:20 yr	1:50 yr	1:100 yr	1:1,000-yr
5Mins	6.3	10.4	11.8	13.5	15.8	17.6	23.1
10Mins	9.9	16.4	18.5	21.3	24.8	27.7	36.3
30Mins	19.4	31.9	35.9	41.3	48.2	53.5	55.3
1Hr	26.4	43.8	49.5	57.0	66.8	74.2	97.5
6Hrs	38.8	70.8	82.8	98.4	119.4	136.2	182.5
24Hrs	57.6	109.4	130.1	156.2	192.0	220.3	297.5
72Hrs	83.5	157.7	187.2	223.9	274.3	313.9	423.7

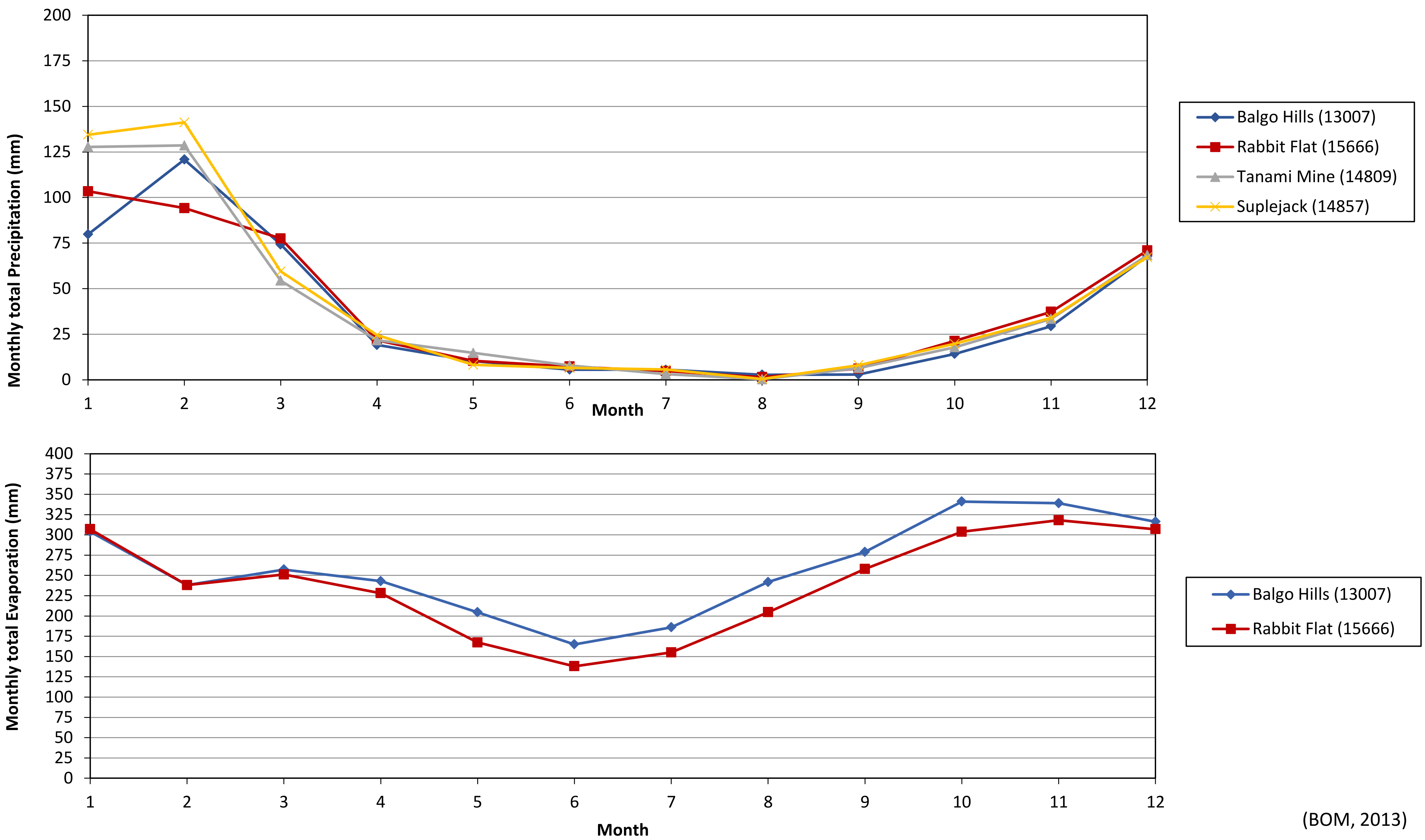


ABM Resources NL	Figure 1.1: Location of the Twin Bonanza Project Area
Water Management Plan for the Twin Bonanza Gold Project	

PN: ABM-001-01-03 Prepared by: JP Date: 5/11/13 Reviewed by: ASP Date: 05/12/13 Revision: 1



ABM Resources NL	Figure 1.2: Site Layout	soilwater GROUP
WMP for the Twin Bonanza Gold Project		



ABM Resources NL	Figure 1.3: Precipitation and Evaporation data for weather stations near the Twin Bonanza Project	soilwater GROUP
Water Management Plan for the Twin Bonanza Gold Project		

2 SURFACE WATER

2.1 SURFACE WATER INFRASTRUCTURE / FEATURES

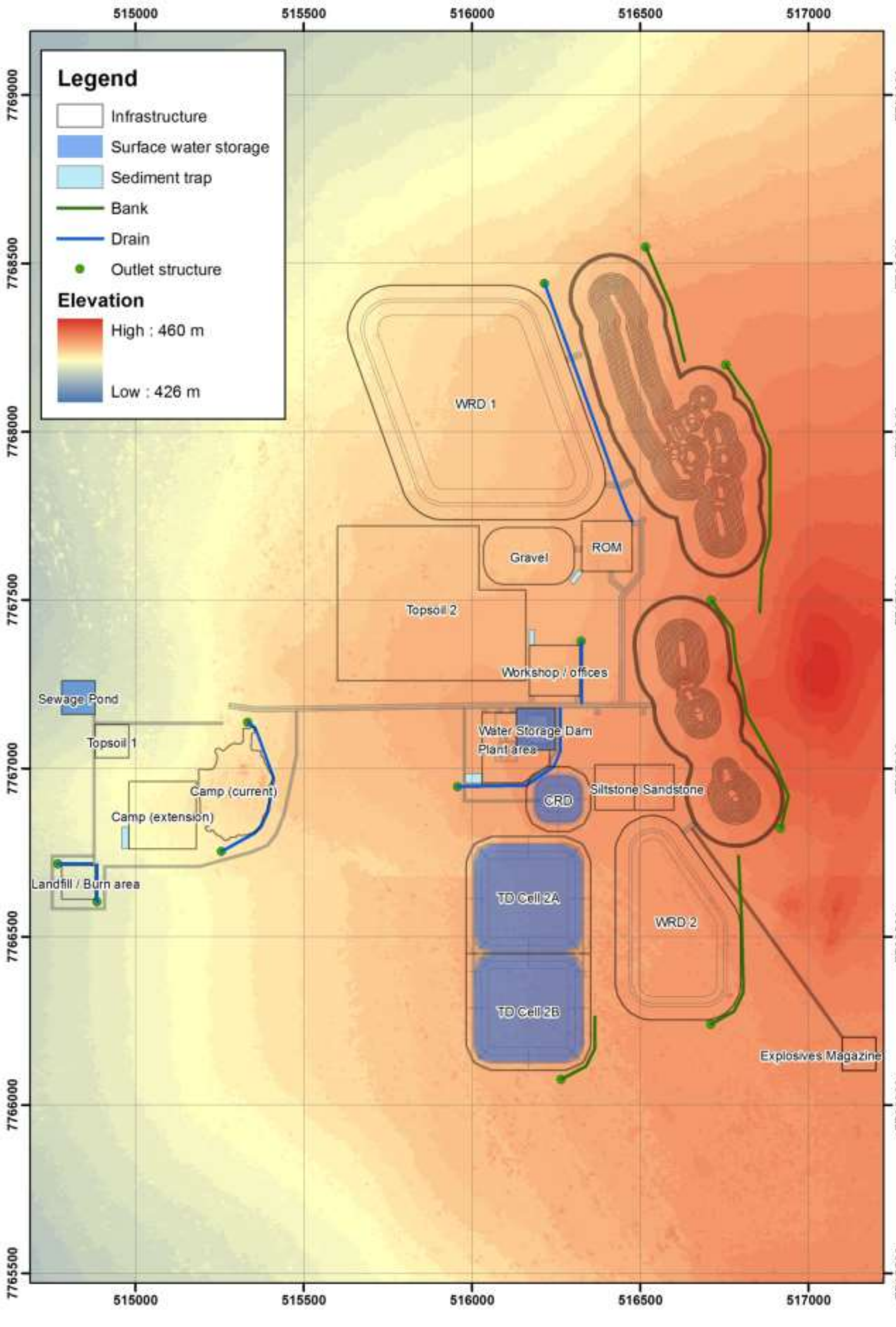
As discussed in Section 1.5, there are no permanent natural surface water features within the proposed mining lease and, as the project is still in the approvals stage, the majority of surface water infrastructure has yet to be constructed. This section will therefore discuss the existing Water Storage Dam and proposed *surface* water infrastructure, including:

- One TD, consisting of two cells
- Water Storage Dam (existing)
- The CRD
- Sewage pond
- Sediment traps
- Diversion banks / drains

The proposed location of each of these features is shown on Figure 2.1, a description of their key design features is included in Table 2.1, and some of the primary management issues are discussed in the following sections.

Table 2.1: Summary of proposed surface water management infrastructure

Infrastructure Item	Purpose	Physical Attributes
TD Cells	Receives tailings slurry from the processing plant. Decant water is collected and returned to the process circuit.	Two cells, above and below ground components, staged construction. Each above ground cell 370 x 370 m (500,000 m^3) ≥ 150 cm freeboard
Water Storage Dam (existing)	Temporary storage of water used in the processing plant. This may be groundwater, or recycled water from other areas of site.	Fully lined with HDPE 91 x 91 m (10,000 t) > 150 cm freeboard
Concentrate Residual Dam	Temporary storage of dense tailings concentrate that has undergone cyanide leaching. 1-2 tonnes deposited daily, and evaporated.	Fully lined with HDPE 190 x 190 m (50,000 m^3) ≥ 150 cm freeboard
Sewage pond	Storage and treatment of domestic waste from the accommodation camp.	Earth-lined turkeys nest pond for disposal of treated sewage effluent.
Sediment traps	Temporary storage of runoff water from the main infrastructure areas. These are designed as flow-through systems during intense rainfall.	Earth-lined ponds See SWC (2013e) for design details
Diversion banks / drains	Divert clean stormwater around the main disturbance areas.	See SWC (2013e)



ABM Resources NL	Figure 2.1: Surface water infrastructure / features	soilwater GROUP
WMP for the Twin Bonanza Gold Project		

2.2 SURFACE WATER MANAGEMENT TO DATE

Surface water management activities to date have focused on water management planning, including the development of the following surface water management-related documents:

- This Water Management Plan
- Erosion and Sediment Control Plan (SWC, 2013e)
- Surface Water Sampling SOP (SWC, 2013d)

These plans were developed as part of the mine planning and approvals process, and provide a complete package of plans and procedures to ensure that surface water will be managed and monitored appropriately throughout the life of mine.

2.3 FUTURE SURFACE WATER MANAGEMENT

Future surface water management activities will generally focus on the development of site infrastructure, and on the initial implementation and review of this WMP.

2.3.1 SURFACE WATER SOURCES AND DESTINATIONS

There are no permanent natural surface water features within the proposed mineral lease area (SWC, 2013a). All natural surface water runoff is of a temporary (ephemeral) nature, and largely consists of sheet flow over the primarily diverging slope surfaces. Any temporary 'clean water' (or upstream) surface water flows will be diverted, and therefore do not enter the site water budget (Section 6). Therefore, the majority of surface water occurring on site is either (a) the result of precipitation falling directly within a disturbance area, or (b) intentional storage of water as a resource or waste product related to mining.

As discussed in Section 1.5, average annual rainfall in the region is approximately 400-500 mm, and approximately 85 % of this falls between November and April. Summer rainfall is characterised by infrequent, but intense rainfall events, and rainfall is expected to contribute a significant volume of surface water to the constructed surface water storage facilities (TD cells, Water Storage Dam, etc.) and sediment ponds, particularly during more intense storms.

Additional surface water will also be generated from the pumping of groundwater. Groundwater will be used in the processing circuit, discharged to the TD, and recycled back to the processing circuit via the Water Storage Dam. In addition, rainfall that is captured by the mine pits has the potential to be re-used for mining and processing purposes.

The major water sink for this Project is expected to be evaporation. Average pan evaporation for the region is approximately 3,000 mm/yr, far exceeding the average annual rainfall. This volume of water can be expected to be lost from all surface water storages according to the monthly rates given in Figure 1.3. Additional water will be evaporated in the process circuit.

Some discharge of water will occur from the sediment traps, primarily during the wet season, when the basins will remain full for the majority of the time and will act as flow-through basins. As discussed in the *Erosion and Sediment Control Plan* (SWC, 2013e), the basins have been designed to remove 90% of material ≥ 0.045 mm in diameter, even during a 1:20-yr peak flow event, so only relatively clean water will be discharged.

See Section 6, *Water Account*, for further information about water sources and sinks, including estimated volumes and flow rates.

2.3.2 Management of surface water flows

The following sections describe how the *volume* and *flow rate* of surface water entering and leaving the site will be managed, under normal operating conditions, and under extreme (i.e. 1:100-yr peak flow) conditions.

2.3.2.1 Flooding potential

The majority of infrastructure areas within the TBGP were assessed as having a “low” flood risk rating because of the sites location high in the landscape, and because of the predominance of diverging flow conditions on the sloping landscape (SWC, 2013a). This means that as long as appropriately sized diversion structures are installed, it is not expected that the main site areas will be affected by significant flooding.

Some potential for flooding was identified along the lower lying areas of the main access road, and within the adjacent borefield area. The main access road is already established, and has been fitted with low pass crossings in areas with a high likelihood of seasonal flooding. This is expected to be adequate for maintaining the integrity of the road surface in these areas.

The flood potential within the borefield area has not been assessed in detail, as there will be little infrastructure installed in this area. It is anticipated that any equipment installed within the borefield area should be able to cope with seasonal flooding.

2.3.2.2 Diversion of ‘clean water’

Sheet flow occurring during large storm events has the potential to collect into concentrated flow streams wherever it comes into contact with mine site infrastructure or constructed landforms, potentially causing flooding or erosion of these features. To mitigate this, all ‘clean runoff’ will be diverted around the planned disturbance areas using diversion banks and drains (Figure 2.1). The main site diversion banks will be installed along the eastern edge of the pits and WRDs to divert the majority of surface water entering the site. In addition, smaller diversion drains will be used to manage surface water flowing into the Plant area, Workshops / Offices, Camp, and Landfill area from their respective local catchments. Alternatively, these areas may be constructed on raised pads to eliminate the need for diversion drains (this will be at the ROM pad).

Discharge from each diversion structure will be via a level spreader or rock chute, to ensure that the concentrated surface flow is transitioned back to sheet flow in a way that minimises erosion downslope of the outlet. All diversion drains and their associated outlet structures have been designed to convey a 1:100-yr peak flow event (See the ESCP for designs of the various water management structures to be implemented).

2.3.2.3 Internal site drainage

Water that falls directly within each of the infrastructure areas (i.e. Plant, workshops / offices, Camp, and ROM pad) has the potential to pond and / or runoff and cause erosion of the land surface and sedimentation of the surrounding environment. All surface flow within these areas will therefore be directed into a sediment trap, designed specifically to handle the expected peak flow rates from the infrastructure catchments (SWC, 2013e). This will be achieved by shaping the land surface in each of these areas, such that all runoff is directed into the sediment traps.

2.3.2.4 Surface water storage facilities

Water inflows and outflows from each of the surface water storage facilities (i.e. the TD cells, Water Storage Dam, CRD, and sewage pond) will be monitored carefully to minimise the potential for overtopping of these facilities. In general, water will not be pumped into any of these facilities unless there is sufficient freeboard to contain a 1:100-yr 72-hr rainfall event. The water level within each of these facilities will be monitored according to Section 4, to ensure compliance with freeboard requirements.

The majority of water being pumped out of these facilities will either be (1) reused within the processing circuit (the preferred choice), or (2) treated for subsequent disposal. No surface water will be released into the surrounding environment from the surface water storage facilities with the exception of the sewage pond, where the option for an approved sprinkler field is being sought for periods when evaporation is not expected to be adequate.

2.3.3 MANAGEMENT OF POTENTIAL CONTAMINATION

The following sections describe management measures related to the *quality* of surface water expected to enter and leave the site.

2.3.3.1 Surface water storage facilities

The constructed surface water storage facilities (i.e. the TD cells, CRD, Water Storage Dam, and sewage pond) constitute the primary contamination risk associated with surface water at the TBGP. Potential sources of contaminants for each of these surface water bodies, and their associated environmental and safety risks, are provided in Table 2.2. Surface water quality within these facilities will be monitored on an ongoing basis, according to Section 4.3, to ensure that the properties of the water are known throughout the life of mine.

Table 2.2: Potential sources of contamination and risks associated with the various surface water bodies at the TBGP

Surface water storage facility	Potential contaminants	Environmental risks	Safety risks
TD	Fine tailings material Elevated metal and metalloid contents	Smothering of vegetation if released. Vegetation toxicity and degradation of surface and groundwater quality	Drowning
CRD	Fine tailings material Elevated metal and metalloid contents Cyanide (CN)	Smothering of vegetation if released. Vegetation toxicity and degradation of surface and groundwater quality	Inhalation of CN gas. Drowning.
Water Storage Dam	NaCl (salinity) Elevated metal and metalloid contents	Vegetation toxicity	Drowning
Sewage pond	As per regulatory requirements Pathogens Nutrients	Vegetation toxicity and degradation of surface and groundwater quality	Exposure to pathogens. Drowning.

In general, all surface water storage facilities will be designed, constructed, and managed to prevent any release of water into the surrounding environment, regardless of the actual level of contamination present. In order to achieve this, the following steps will be taken:

- The Water Storage Dam has been constructed using an HDPE liner. This will prevent all seepage from these facilities. Water will primarily be removed by pumping and recycling water into to the processing circuit and by evaporation (up to approximately 3,000 mm/yr)
- The TD cells and CRD will likely utilise a conditioned earth or clay-lined layer to achieve a permeability of 1 x 10^{-8} m/s to prevent seepage into groundwater. However, the design work (including assessment of *in situ* material suitability) for these structures is still ongoing. If the local materials are not deemed suitable, then other options to prevent or minimise seepage will be explored.
- All surface water storage facilities will be designed, constructed, and monitored to maintain a minimum freeboard sufficient to hold a 1:100-yr, 72-hr rainfall event of approximately 150 cm. The water level in each of these facilities will be monitored according to Section 4.3, to ensure compliance with freeboard requirements.
- Where the freeboard requirement is discovered to be insufficient, all water additions to the surface water storage will be halted. Water will need to be evaporated or pumped out to another safely contained location prior to resuming the addition of any more water.
- All of the water being pumped out of these facilities will either be (1) reused within the processing circuit (the preferred choice), or (2) or treated for disposal. No surface water will be released into the surrounding environment from any of the surface water storage facilities.

2.3.3.2 Erosion and Sediment Control Plan (ESCP)

A detailed ESCP has been developed for TBGP which aims to minimise erosion to landforms and subsequent sediment contamination of the surrounding environment (SWC, 2013e). According to the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008), an effective erosion and sediment control strategy considers the interrelated processes of drainage control (minimising water flows through erosion prone areas), erosion control (minimising the detachment of sediment), and sediment control (trapping sediment displaced by up-slope erosion processes) . Thus, the key strategies adopted in the ESCP involve (1) diversion of water flowing into disturbance areas, (2) minimising erosion of disturbance areas by water that falls within the disturbance areas, and (3) trapping the majority of sediment-laden water and treating it before it moves offsite.

In summary, the following steps will be taken to minimise sediment fluxes during the active phase of the site:

- The site layout has been designed specifically to minimise interaction with surface water flows. The majority of the main infrastructure areas are located on local topographic highs or diverging slope areas, where the potential for converging surface water flows is minimal.
- Diversion drains and banks will be used to redirect any “clean” surface water flows around the main site areas. This minimises the potential for erosion by limiting the amount of water flowing through the disturbance areas, and also protects infrastructure from flooding during extreme events. Design of diversion structures is discussed further in the ESCP (SWC, 2013e).
- Exposed soil surfaces will be engineered to minimise erosion potential. This will be achieved through careful material selection, slope grading, and other surface treatments, as discussed in the ESCP (SWC, 2013e).

- Any sediment-laden water within the disturbance areas will be captured and treated in sediment traps to minimise the amount of sediment released into the surrounding environment. The design of sediment traps is discussed further in the ESCP (SWC, 2013e).

The key erosion and sediment control infrastructure proposed for this site includes:

- Main site diversion banks incorporated along the eastern extent of the pit abandonment bunds
- Diversion banks along the TD cells and WRD 2
- Diversion drain between the Northern pit and WRD 1
- Diversion drains for the Plant area, Workshop / Offices, Burn Area, and Camp
- Sediment traps for the Plant area, Workshop / Offices, ROM pad, and Camp

The location of these items is shown on Figure 2.1, and their design is discussed further in the ESCP (SWC, 2013e).

2.3.3.3 Spills and other potential surface water contamination

Hydrocarbons and other chemicals (e.g. ammonium nitrate) will be stored onsite, primarily in the workshop, processing plant, and explosive magazines. All tanks, fuel drums, and chemical products will be stored within self-bunded tanks, bunded/lined areas, or within portable self-bunded pallets. Permanent bunded storage areas will be located away from the accommodation site and drainage lines. Any spills of these materials have the potential to interact with surface water flows and to be carried into the surrounding environment. The following will be implemented in order to minimise any negative effects from spills:

- Fuel and chemical storage areas will be fully-bunded. The bunding will be sized to hold the entire volume of the fuel or chemical stored within, and to additionally hold a 1:100-yr, 72-hr rainfall event.
- The workshop area and any additional fuelling areas or wash-down bays will be designed to drain into a central point. A grease trap will be installed at this central point to treat the water before discharge into the sediment trap.
- An Emergency Response Plan has been developed to outline more detailed procedures for spills that occur outside of the main risk areas outlined here.

2.3.4 Planned discharges of surface water

The only planned discharge of surface water will occur from the diversion structures and sediment traps. Discharges from these structures will occur primarily during the wet season, when the majority of precipitation occurs. As discussed in the *Erosion and Sediment Control Plan* (SWC, 2013e), the sediment traps have been designed as flow-through basins, capable of removing 90% of material ≥ 0.045 mm in diameter, even during at 1:20-yr storm event, with higher removal rates of finer-sized particles achieved during lower flow rates. Therefore, only relatively clean water will be discharged. As flow-through conditions can only occur during (or shortly after) rainfall-runoff events, the volume of water released from these facilities will be proportional to natural runoff in the surrounding environment. All discharges will occur via rock lined release points onto native slopes, where the surface water regime is dominated by sheet flow. No discharges will occur into surface waterways, as none exist within the TBGP Area.

Limited release of water from the sewage pond may occur if the evaporation rate is determined to be inadequate. Release of water from this facility would only occur to an approved sprinkler field.

3 GROUNDWATER

3.1 GROUNDWATER INFRASTRUCTURE / FEATURES

The Twin Bonanza Project includes three existing groundwater extraction bores, known as “Timmy’s Bore” (or “Strezza’s”), “Corsair Bore”, and “Wilson’s Bore”. The location of these existing bores is shown on Figure 3.1, and their construction details are listed in Table 3.1. Wilson’s Bore is located within the Exploration Lease area and a Section 19 lease under the *Aboriginal Land Rights Act 1976* and Corsair Bore is located within the Mineral Lease Application area. Corsair is thought to be installed within a deep bedrock aquifer (90-150 metres below ground level (mbgl)), while Wilson’s is installed in the upper reaches of the palaeochannel system. Both of these bores are currently being utilised to provide water for the Twin Bonanza pilot processing plant, at a combined rate of approximately 2 L/s. Timmy’s Bore is located approximately 5 km to the West of the main Project Area within the Nora Palaeochannel, and a pipeline corridor has been established from the bore location to the Old Pirate mine site. This bore is not currently in use, as it has collapsed. Depth to water in Timmy’s Bore has previously been recorded at a depth of less than 6 mbgl. The three existing bores are understood to have a combined maximum yield of up 10 L/s, although this maximum extraction rate is not likely to be sustainable (Earth Systems, 2013).

A number of options are being considered for the development of additional production bores to diversify the water supply and boost the available flow rate to the estimated peak requirement of approximately 11 L/s. Earth Systems (2013) identified six potential bore field locations within palaeochannel areas surrounding the Project Area, and these are shown on Figure 3.1, and described in Table 3.1. As the project is to be developed in a staged approach the 11 L/s will not be required at start up, giving an opportunity to monitor sustainability of the current bores. Groundwater target areas #2A and #3 are the primary candidates for further exploration. Target area #2A has the advantage of being relatively close to the Project Area, and within the existing Section 19 Lease used for access to Timmy’s Bore. The existing Timmy’s Bore pipeline corridor could also be utilised to supply water from target area #2A to the processing plant. Groundwater target area #3 is considered the best candidate for a long-term sustainable supply because of its location within one of the main branches of the Tanami Palaeochannel, with a large upstream catchment area of approximately 170 km^2. However, land access rights would need to be obtained in order to explore the groundwater resource or operate production bores in target area #3.

There are currently no dedicated monitoring bores located within the Project Area, and limited monitoring data is available from Timmy’s Bore, Corsair Bore, and Wilson’s bore as well as a number of other registered bores within a 40 km radius (Figure 3.1). Installation of additional groundwater monitoring bores is planned – this is discussed further in Section 4.4.

3.1.1 GROUNDWATER ASSOCIATED WITH OPEN CUT PITS

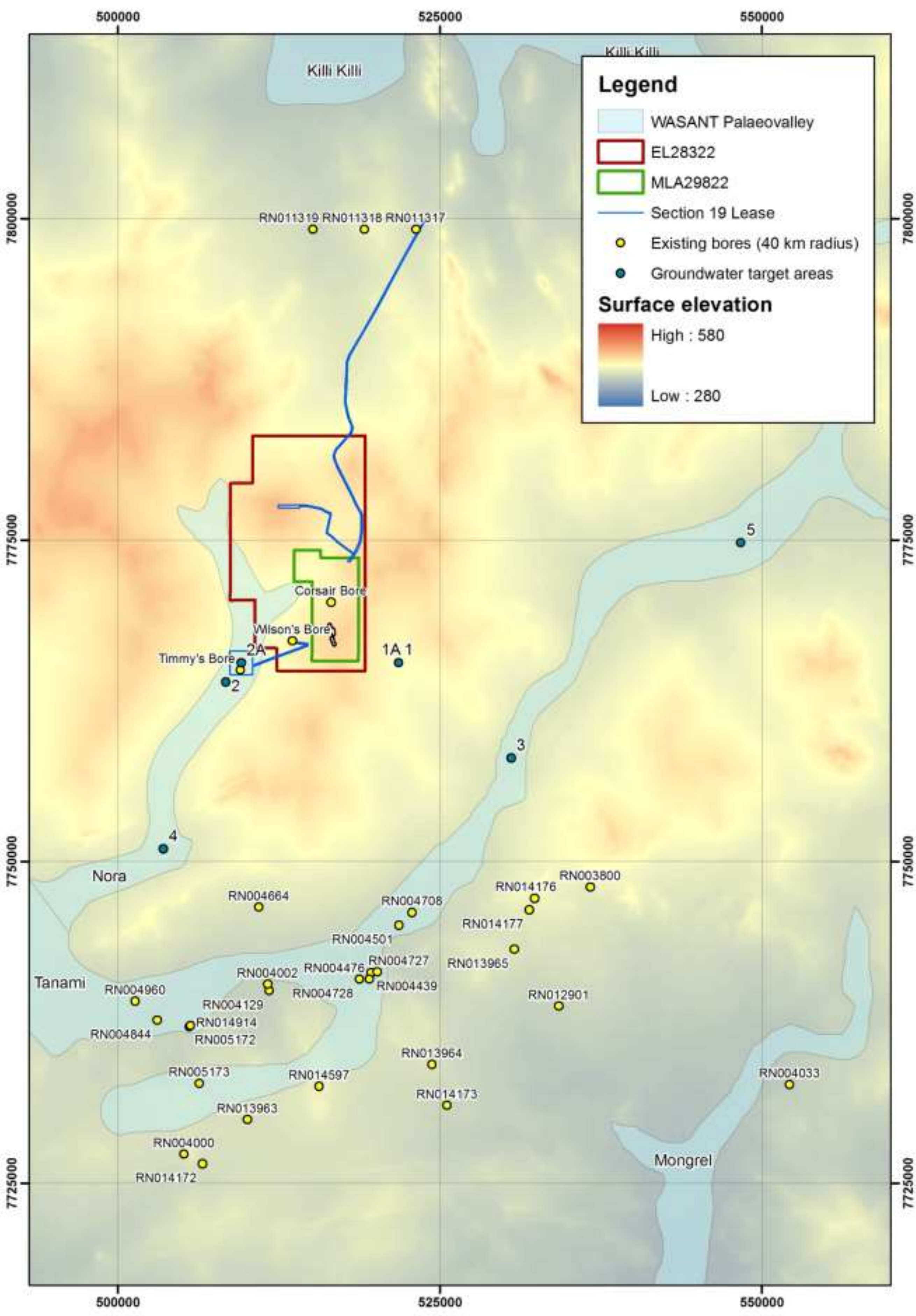
Minimal mine pit dewatering is expected in the short- to medium-term, as groundwater within the pit areas is expected to be located at approximately 100-150 mbgl, while the proposed pit shells extend to a maximum depth of 50 mbgl. Thus, no major dewatering infrastructure is likely to be required unless underground mining is eventually deemed feasible.

3.1.2 GROUNDWATER ASSOCIATED WITH THE TD

The TD cells, once constructed, will likely utilise a conditioned earth or clay-lined layer to achieve a permeability of 1 x 10^{-8} m/s to prevent seepage into groundwater. Design work (including assessment of *in situ* material suitability) for these structures is still ongoing.

3.1.3 SUSTAINABLE GROUNDWATER YIELDS

The staged development of the project will not require the full allocation of 11 L/s at start up, this allows for monitoring and a thorough assessment of the sustainable yields and recharge rates at the existing bores. Also the staged ramp up will allow time to access and test the additional groundwater targets.



ABM Resources NL	Figure 3.1: Groundwater infrastructure / features	soilwater GROUP
WMP for the Twin Bonanza Gold Project		

Table 3.1: Existing and proposed production bore construction (adapted from Earth Systems, 2013).

Bore	Easting	Northing	Casing Elevation (mAHD)	Geology	Depth (m) (approximate)	Approximate Water Level (mbgl)	Notes
Timmy's Bore (Strezza's)	509507	7764901	424	Palaeochannel	10	6	Borehole was 34.7m deep in earlier assessment, but has since collapsed Borehole is registered (RN016568). Also known as Strezza's Bore.
Corsair Bore	516550	7770180	438	Fractured bedrock	150	95	Drilled in 2010 near high yielding exploration borehole. Yield understood to be 2-3 L/s (possibly up to 4 L/s) but sustainability of this is unknown. Previous water level recorded as 110 mbgl.
Wilson's Bore	513529	7767170	430	Unknown (palaeochannel branch?)	92	40	Understood to have run dry in 2012 after 2.5 years of use in previous operation. Yielded up to 4L/s. Further onsite investigation discovered the pump was poorly positioned in a mud layer at the base of the bore resulting in pumping issues. Pumping resumed in 2013 for pilot processing operation.
Target Area 1	521800	7765470	432	Palaeochannel sub-catchment	(40)	unknown	Closest potential catchment to the Project area. Relatively small catchment area may limit sustainability of groundwater supply.
Target Area 1A	521800	7765470	432	Palaeochannel Sub-catchment	(40)	unknown	Closest potential catchment to the Project area. Limited catchment size and narrow width may restrict size of potential well field.
Target Area 2	508360	7763970	424	Palaeochannel	(40)	6	Close to Timmy's Bore (Strezza's), which was recorded to yield approx. 2 L/s, prior to its collapse. Water quality is likely to be good. 8.5 km from site, with an established pipeline corridor.
Target Area 2A	514880	7767030	424	Palaeochannel	(40)	6	Similar to Target Area 2, but falling within the Section 19 Lease area.
Target Area 3	530520	7758060	404	Palaeochannel	(40)	unknown	Within the main branch of the Tanami Palaeochannel – i.e., has a large catchment area (170 km^2), and likely more sustainable yield. 17 km from site.

Bore	Easting	Northing	Casing Elevation (mAHD)	Geology	Depth (m) (approximate)	Approximate Water Level (mbgl)	Notes
Target Area 4	503520	7751000	410	Palaeochannel	(40)	unknown	Within the main branch of the Nora Palaeochannel. Has a large catchment area (83 km^2), and likely sustainable yield. 20 km from site.
Target Area 5	548370	7774790	397	Palaeochannel	(40)	unknown	Within a relatively wide section of the main branch of the Tanami Palaeochannel, potentially allowing for a larger borefield. 33 km from site.

3.2 GROUNDWATER MANAGEMENT TO DATE

Groundwater management activities to-date have focused on water management planning, including the commissioning of the following studies and groundwater management documents:

- Preliminary groundwater study (Earth Systems, 2013)
- Groundwater monitoring SOP (SWC, 2013c)
- This *Water Management Plan*

Some monitoring of water levels was conducted as part of a baseline groundwater study (Earth Systems, 2013), but no other significant groundwater-related activities have occurred to-date.

3.3 FUTURE GROUNDWATER MANAGEMENT

Groundwater management in the upcoming period will focus on the development of new groundwater resource areas (including obtaining land access rights, test drilling, and test pumping), and on the initial implementation and review of this WMP.

3.3.1 GROUNDWATER SOURCES AND DESTINATIONS

The Wilson's and Corsair Bores are currently being utilised in a limited capacity to provide water for the Twin Bonanza pilot processing plant, at a rate of approximately 2 L/s. While the maximum yield from these two bores has been reported as 8 L/s (Earth Systems, 2013), this is not expected to be sustainable, and additional groundwater sources will need to be developed in order to meet the expected maximum demand of 11 L/s. Because the site will be developed in stages, this maximum demand is not expected to be required for up to 4 years, giving sufficient time for testing and development of new sustainable sources of water.

Testing and development of additional new production bores is planned for the upcoming period, with target areas #2A and #3 (Figure 3.1) being given priority. Timmy's Bore ("Strezza's") will first be redeveloped, as the required infrastructure for pumping to site is already in place at this location. Additional test bores, and a number of monitoring bores may then be drilled within target area #2A, if necessary. The test bores will be located according to the results of an ongoing geophysical groundwater survey, and are likely to be installed to a depth of approximately 30-40 m. Monitoring bores will be placed at a distance of 10 and 100 m upstream and downstream of the test bore. Pumping tests (both a step test and a constant rate test) will be completed to determine aquifer properties and long-term sustainable yields prior to commissioning of any full-scale production bores (including the redeveloped Timmy's Bore). If the results of the testing in target area #2A show a need to develop an additional water source, access agreements will be sought with land holders in target area #3, and an additional similar testing program will be initiated

No discharges will occur from the TBGP to the groundwater system, with all pumping test water to be captured within pre-excavated sumps and evaporated. Throughout the course of mining, the majority of extracted groundwater will be used within the processing plant, with a minor volume of water also being used for site activities, including dust suppression and domestic uses at the accommodation camp and office / workshop facilities. Prior to domestic use water will be treated by a Reverse Osmosis Plant.

3.3.2 MANAGEMENT OF GROUNDWATER FLOWS

Groundwater extraction rates will be managed so that a sustainable yield is maintained, and so that the extraction will not negatively affect other groundwater users. At this stage, sustainable extraction rates have not been characterised in the palaeochannel aquifers within groundwater target areas #2A and #3, as these areas have been largely undeveloped to-date. Only limited groundwater testing and monitoring data is available.

As part of the staged mine development, activities during the early period of operations will primarily focus on filling information gaps, particularly around defining aquifer depth and extent, and measuring key aquifer properties such as transmissivity and storativity. Test bores will be installed in a staged manner as the project develops, and these will undergo pump testing to determine aquifer properties and long-term sustainable yields within the target areas. Appropriate production bores and pumping equipment will then be installed according to the calculated sustainable yield. It is proposed to initially redevelop Timmy's Bore (Strezza's) within target area #2A, with additional test bores and pump testing being completed in other target areas if necessary to achieve the required yield.

During the active mine phase, groundwater extraction rates will be managed primarily by measuring flow rates (and volumes) from the production bores and monitoring drawdown within the pumped aquifer(s). A monitoring bore network will be developed as the water demand increases to allow for "background" data to be collected prior to the start of production pumping. This is discussed further in Section 4.4.

The potential effect of groundwater extractions on 'downstream' water users will also be assessed. Based on a review conducted by Earth Systems (2013), there are currently no registered bores within the Nora Palaeovalley, downstream of groundwater target area #2A (Figure 3.1), indicating minimal potential for any impact on these other bores. Similarly, all registered bores within the Tanami Palaeovalley are located at least 2 km upstream of target area #3, also indicating minimal potential impact from pumping in this area. Pump testing will confirm the expected extent of drawdown effects.

3.3.3 MANAGEMENT OF POTENTIAL CONTAMINATION

The chemical makeup of existing groundwater in the region is not well established (Earth Systems, 2013), with the majority of available water quality data having been collected in the 1960's and 1970's, primarily from locations > 10 km down-gradient from the TBGP. The existing data set does not indicate a clear difference in chemistry between the bedrock and palaeovalley aquifer systems (see Table 3.2), with both systems being generally moderately alkaline (pH = 7.3 – 8.1), moderately fresh to brackish (TDS = 420 – 9,710 mg/L), and with a moderate to high total hardness (201 – 6,360 mg/L as $CaCO_3$). Elevated levels of Arsenic (As) and Selenium (Se) have been detected in the bedrock aquifer, although these elements have not been assessed in any of the available data sets for the palaeochannel bores.

Therefore, a groundwater monitoring network is to be developed, in a staged manner, to begin collecting a relevant set of "background" water quality data. In addition to background measurements in the pre-mine period, the placement of the monitoring points will ensure that there are suitable bores available for (1) ongoing monitoring of groundwater flowing into the TBGP from up-gradient, (2) monitoring of groundwater in the immediate vicinity of the TBGP to detect any contamination originating within the disturbance area, and (3) monitoring of groundwater down-gradient of the TBGP. The groundwater monitoring program, including monitoring bore location selection, is discussed further in Section 4.4.

Contamination of groundwater from surface activities is considered very unlikely, as the groundwater within the TBGP Area is thought to exist at ≥ 100 m depth. However, a conservative approach will be taken to prevent any contamination of the surface soils and therefore not allow for any potential leaching into the groundwater system. As previously discussed, a range of potential contaminants have been identified for the various surface water bodies (Table 2.2), and these are generally associated with the hypersaline water sources and processing byproducts (i.e. tailings material elevated in metals and CN). In general, all surface water storage facilities will be designed, constructed, and managed to prevent any release of water into the groundwater system, regardless of the actual level of contaminants within these facilities. Specific tasks intended to achieve this are discussed in Section 2.3.3.1.

The potential for Acid and Metaliferous Drainage (AMD) from the WRD has been previously assessed, and is considered to be negligible, as the majority of material to be extracted from the pits has been classified as Non-Acid-Forming (NAF) (ABM, 2013). Some materials, however have been identified with limited potential to leach arsenic (e.g. arsenopyrite, pyrite, and galena) and lead under certain conditions. Therefore, the proposed construction of the WRD has been designed specifically to manage pH and availability of oxygen to reduce the risk of these elements leaching into the environment. In general, the most benign and stable waste materials (i.e. sandstone) will be used as the outer embankment of the waste dump, and those with the highest sulfide concentrations will be isolated in the centre of the landform and surrounded by more inert material (i.e. sandstone) (Figure 3.2).

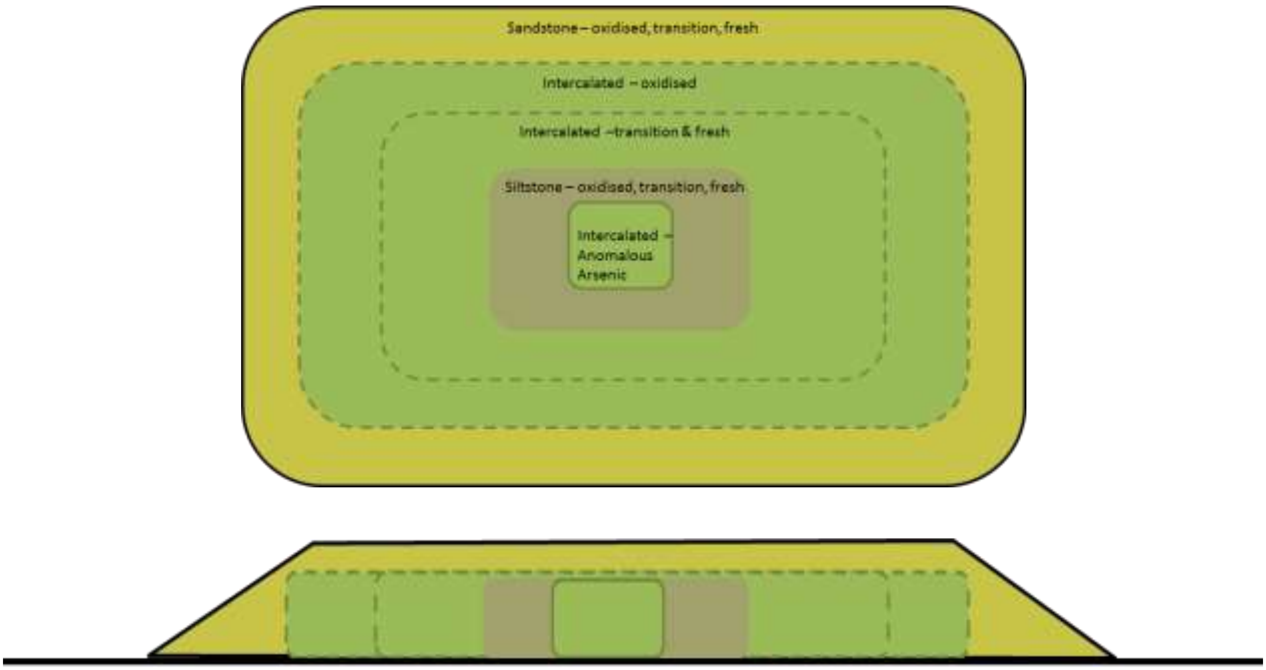


Figure 3.2: Conceptual diagrams of the Waste Rock Dump construction

The open pit walls are expected to contain minor veins of partially oxidized sulphides (ABM, 2013). The open pit walls are expected to contain minor veins of partially oxidized sulphides (ABM, 2013). The presence of small quantities of sulphides is unlikely to have an effect on water quality as the mine pit is not likely to intersect the groundwater (> 100 m bgl) and any surface water body that forms following high rainfall events will rapidly evaporate with minimal infiltrate and seepage into the underlying deep regolith. In addition, the potential for exposed sulfide oxidation to occur on the mine pit walls is reduced by the semi-arid climate and the likely armouring and weathering rind that typically occurs in response to oxidation, which will further reduce the ingress of water into the pit walls.

3.3.4 Planned discharges to groundwater

There are no planned discharges from the TBGP to the groundwater system.

Table 3.2: Summary of available groundwater quality data

Analyte	Registered bores		Wilson's	Corsairs	Timmy's	NRMMC
	Bedrock	Palaeovalley	Palaeovalley	Bedrock	Palaeovalley	(2011)[1]
pH	7.3 – 7.6	7.6 – 8.1	7.8	7.9	7.8	n/a
EC (µS/cm)	1,570 – 9,860	9,100 – 14,070	13,000	3,670	574	n/a
TDS (mg/L)	955 – **7,610**	**4,700 – 9,710**	**7,330**	**2,140**	421	1,200
Total hardness (mg/L)	421 – **6,360**	**939 – 2,100**	**1,830**	**1,030**	201	500
Total alkalinity (mg/L)	210 – 462	221 – 424	590	237	230	n/a
Na (mg/L)	148 – 1,435	1,204 – 2,135	1,680	305	27	n/a
K (mg/L)	26 – 128	163 – 330	192	44	33	n/a
Ca (mg/L)	76 – 948	100 – 173	233	172	41	n/a
Mg (mg/L)	49 – 1,019	143 – 339	303	145	24	n/a
Fe (mg/L)	0.2 – 1.3	< 0.1 – 5.3	<0.05	<0.05	<0.1	n/a
SiO_2 (mg/L)	13 – 38	76 – 80	-	-	106	n/a
Cl (mg/L)	**260 – 8,260**	**400 – 3,724**	**2,480**	**807**	**24**	5
SO_4 (mg/L)	103 – **4,464**	428 – **1,690**	**1,760**	360	21	500
NO_3 (mg/L)	0 – **53**	**158 – 252**	-	-	23	50
HCO_3 (mg/L)	243 – 431	269 – 517	-	-	281	n/a
CO_3 (mg/L)	0 – 31	-	-	-	0	n/a
F (mg/L)	0.7 – 1.8	1.5 – 2.3	-	-	1.3	n/a
PO_4 (mg/L)	< 1	< 1	-	-	-	n/a
NaCl (mg/L)	-	659 – 6,137	-	-	40	n/a
Al (mg/L)	-	-	0.04	<0.01	-	0.2
As (mg/L)	-	-	0.002	**0.197**	-	0.01
Be (mg/L)	-	-	<0.001	<0.001	-	0.06
Ba (mg/L)	-	-	0.017	0.03	-	2
Cd (mg/L)	-	-	<0.0001	0.0013	-	0.002
Cr (mg/L)	-	-	0.012	<0.001	-	0.05
Co (mg/L)	-	-	<0.001	0.001	-	n/a
Cu (mg/L)	-	-	0.006	0.001	-	2
Pb (mg/L)	-	-	<0.001	<0.001	-	0.01
Mn (mg/L)	-	-	0.001	0.28	-	0.5
Mo (mg/L)	-	-	<0.001	<0.001	-	0.05
Ni (mg/L)	-	-	0.004	<0.001	-	0.02
Se (mg/L)	-	-	**0.02**	<0.01	-	0.01
Sr (mg/L)	-	-	4.5	2.88	-	n/a
Ti (mg/L)	-	-	<0.01	<0.01	-	n/a
V (mg/L)	-	-	<0.01	<0.01	-	n/a
Zn (mg/L)	-	-	0.041	0.016	-	3
B (mg/L)	-	-	1.32	<0.05	-	4

Notes: [1] Australian Drinking Water Guidelines (bolded values exceed the guidelines)

4 MONITORING

4.1 MONITORING PROGRAMS

The surface water and groundwater monitoring programs described in the following sections have been developed with the aim of:

- Ensuring water is available for ongoing production
- assessing the impacts of the operation on water resources
- providing early warning capability by identifying environmental changes
- validating modelling (actual vs. predicted)
- contributing to reviews of environmental management procedures and performance, and
- demonstrating compliance with permits and licences

In general, most monitoring activities will be conducted monthly, by following the relevant Standard Operating Procedure (SOP) (see APPENDIX A and APPENDIX A). Monitoring results will be compared against trigger values to determine if any contingency measures are necessary. Monitoring results will be reported annually, as described in Section 5, *Water Quality Reporting*.

4.2 MONITORING PERMITS AND AGREEMENTS

At this early stage of the development, there is an existing monitoring agreement with the Central Land Council who represent the traditional owners of the area. The Agreement requires monitoring of the palaeochannels as water is extracted from these areas.

This section will eventually include a list of all access agreements obtained for monitoring purposes which are not confidential (e.g. with land holders, traditional owners, or third-party bore owners). Where relevant, operating permit conditions may also be included after final lease conditions are granted.

4.3 SURFACE WATER MONITORING

4.3.1 MONITORING LOCATIONS

Monitoring of surface water storages, sediment traps, and other surface water infrastructure will be conducted at the locations specified in Table 4.1 and shown on Figure 4.1. These locations are expected to represent all of the potential surface water sources within the TBGP. As previously discussed, there are no natural surface water features within or within an appreciable distance of the TBGP, and thus no natural features were selected for monitoring.

Table 4.1: Summary of surface water monitoring program

ID	Description	Easting	Northing	Type(s)	Frequency
1	TD supernatant pond	516015	7766760	Water quality Water levels	Monthly Daily
2	Water Storage Dam	516180	7767160	Water quality Flow rates (in/out) Water level	Monthly Continuous Continuous
3	CRD Dam	516254	7766932	Water quality Water level	Monthly Continuous
4	Sewage pond	514830	7767239	Flow rates (in/out) Water level	Continuous Continuous
5	Sediment trap (inflow and outflow)	516295 516177 515973 514970	7767548 7767419 7766984 7766823	Water quality Visual inspections	Opportunistic See ESCP (SWC, 2013e)
6	Surface water diversions and outlets (outlet coordinates given)	516754 516711 516917 516516 516709 516264 516216 516324 515957 515333 515255 514886 514769	7768199 7767499 7766821 7768549 7766239 7766076 7768441 7767377 7766946 7767137 7766753 7766602 7766716	Visual inspections See ESCP (SWC, 2013e)	Weekly during wet season Monthly during dry season See ESCP (SWC, 2013e)

4.3.2 PARAMETERS TO BE MEASURED

Table 4.2 summarises the chemical analysis to be completed for each of the monitoring locations. The analysis for the TD, Water Storage Dam, and CRD focuses primarily on metals and cyanide content, as this is aimed at characterising water that has been used within the gold processing circuit. The analysis of sediment trap discharge water is aimed at quantifying suspended solids and testing the effectiveness of the upstream oil and grease traps, while the monitoring of the diversion structures and sewage evaporation pond is aimed primarily at assessing the structural integrity of the infrastructure and maintaining freeboard requirements.

In addition to chemical analysis, water depth / level and inflow and outflow rates will be monitored in the surface water storage facilities. This will be achieved by installing flow meters and depth measuring devices, ideally capable of logging the information automatically. This will allow for the continuous and accurate recording of process flow data, and will provide early warning for freeboard exceedances. Flow totals and water depths will be recorded manually during monitoring events.

The ESCP (SWC, 2013e) outlines an *Infrastructure Test Plan* (ITP) that will be incorporated as part of site monitoring activities. The ITP describes a procedure for inspection of all surface water diversions and outlet structures to ensure an acceptable level of performance throughout the life of mine.

4.3.3 Sampling frequency

In general, surface water monitoring activities will take place monthly. As previously discussed, inflow and outflow rates from the surface water storage facilities will be recorded automatically and on an ongoing basis; however, this information should be summarised monthly along with the rest of the monitoring data. Measurements of sediment trap discharge will be collected opportunistically, as the sediment traps are only expected to act as flow-through basins during larger storm events.

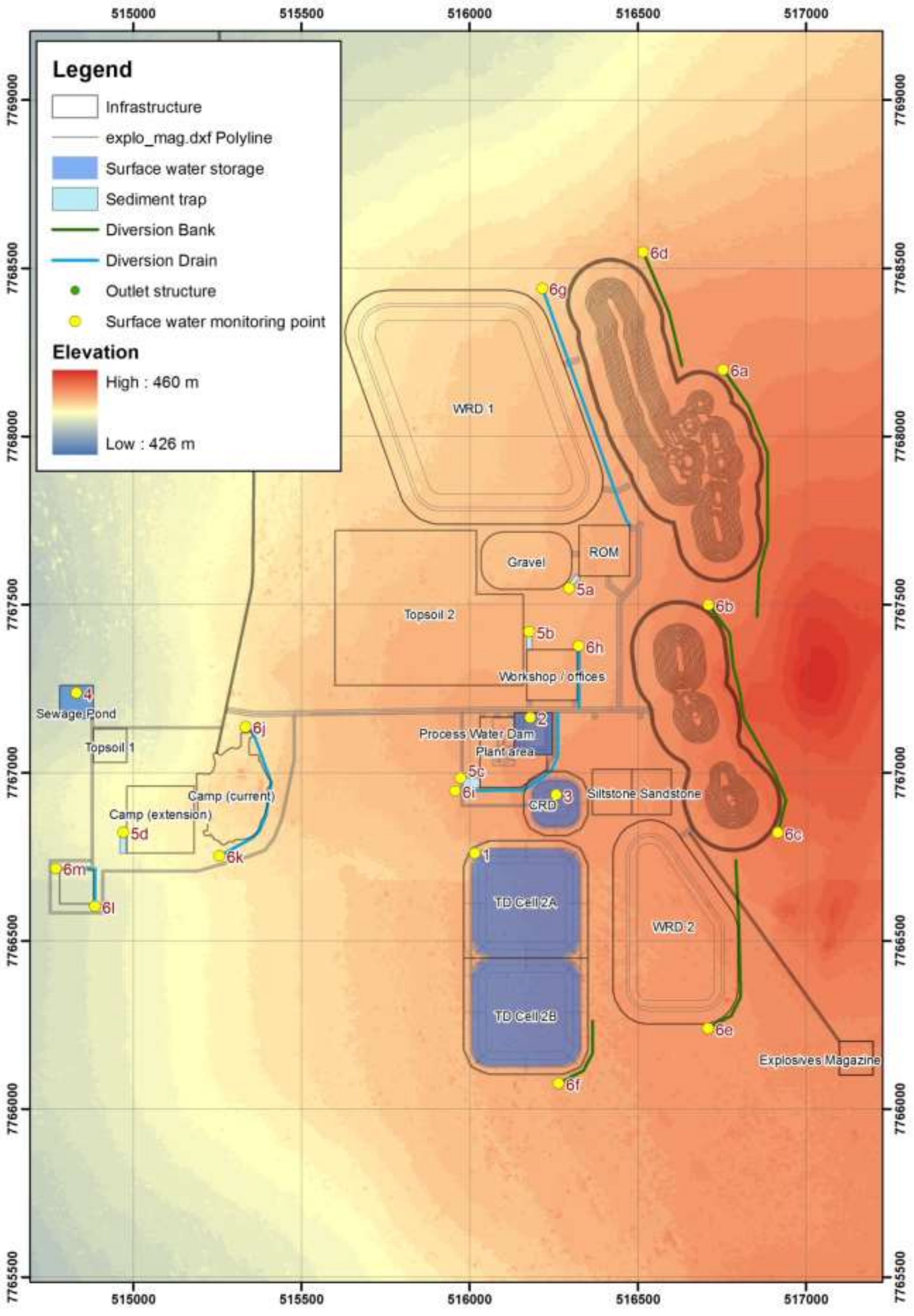
The frequency of inspection and monitoring of surface water diversions and outlet structures is governed by the ITP (SWC, 2013e).

4.3.4 Sampling methodology

The collection of surface water quality samples is described in detail in the *Standard Operating Procedure for Surface Water Monitoring* (SWC, 2013d).

Table 4.2: Analytes for surface water quality monitoring

Analyte	Location ID (Table 4.1)					
	1	2	3	4	5	6
pH	✓	✓	✓	-	✓	-
Electrical conductivity (EC)	✓	✓	✓	-	✓	-
Total Dissolved Solids (TDS)	✓	✓	✓	-	✓	-
Dissolved organic carbon (DOC)	-	-	-	-	-	-
Total organic carbon (TOC)	-	-	-	-	-	-
Ionic balance	✓	✓	✓	-	-	-
Major Cations (Ca, Mg, Na, K)	✓	✓	✓	-	-	-
Major Anions (Cl, SO_4, F)	✓	✓	✓	-	-	-
Total Alkalinity	✓	✓	✓	-	-	-
Dissolved metals (Al, As, B, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Sb, Se, Zn, Hg)	✓	✓	✓	-	✓	-
Free cyanide (CN^-)	✓	✓	✓	-	-	-
WAD cyanide	✓	✓	✓	-	-	-
Total cyanide	✓	✓	✓	-	-	-
Total petroleum hydrocarbons (TPH)	-	-	-	-	✓	-



ABM Resources NL	Figure 4.1: Surface water monitoring locations	soilwater GROUP
WMP for the Twin Bonanza Gold Project		

4.4 GROUNDWATER MONITORING

4.4.1 MONITORING LOCATIONS

Groundwater monitoring sites have been selected according to the *Australian Guidelines for Water Quality Monitoring and Reporting* (ARMCANZ, 2000) so that representative samples of the un-impacted (native or control) and potentially impacted groundwater may be collected both in the pre-mine period and throughout the life of mine. The monitoring program has been designed as a "Before-After, Control-Impact" (BACI) program, with priority applied to early detection, and assessment of biodiversity or ecosystem level response.

Because the majority of the proposed disturbance has not occurred, true pre-mine or "background" data may still be collected from the proposed monitoring bores in the period prior to full-scale mining activity. In addition, several continuous control sites (or "analogues") will be established in areas outside of the potential influence of site activities to monitor background levels throughout the life of mine. Therefore, the monitoring program is considered a BACI-style program according to ARMCANZ (2000), (Figure 4.2). This type of program design allows for the same parameters to be monitored at the control sites and the potentially impacted sites to determine whether or not any observed patterns of behaviour are likely to be due to natural variations or the impacts of site activities.

The proposed groundwater monitoring locations are specified in Table 4.3 and shown on Figure 4.3, and each of these falls into one of the following categories:

- The existing production bores (Wilson's and Corsair), Timmy's Bore (which is planned to be redeveloped), and any future production bores within groundwater Target Area #2A. The production bores will be used to monitor groundwater quality within the areas surrounding the mine site. Corsair Bore will be used to monitor the bedrock aquifer north of the mine site, and Wilson's and Timmy's Bore will be used to monitor palaeovalley water quality down-gradient of the mine site.
- Four monitoring Bores (M01-M04) are intended to intercept the primary potential contaminant pathways down-gradient from the site. These will be installed in the surficial aquifer, which constitutes the upper catchment of palaeochannel system. The properties and extent of this surficial aquifer are not well known at this stage, and these locations are therefore preliminary; they have been proposed within the intended mineral lease area, and as far downslope as possible. If it is determined that no surficial aquifer system is present this far up-slope, then these monitoring locations may be moved down-slope and additional access agreements may be necessary.
- Five deep bores within the vicinity of the site will also be monitored (M05-M09). One of these monitoring bores (M07) will be installed central to the site (adjacent to the Plant and CRD), while the other four will be installed around all four sides of the infrastructure to enable monitoring of groundwater flow in all directions.
- Three "background" or "analogue" sites (A01 – A03) are intended to provide monitoring data for areas similar to those being monitored within the TBGP. These are located in areas outside of the potential influence of site activity, and will provide a means of distinguishing measured changes in the primary monitoring bores (M01 – M04) from natural fluctuations or variability. Bore A01 will be installed into the bedrock aquifer, while bores A02 and A03 will be installed within the palaeochannel aquifer at similar landscape positions to the monitoring bores.
- Four monitoring bores (BF01 – BF04) are proposed for the palaeochannel borefield, in the vicinity of Timmy's Bore, with another located adjacent to Wilson's Bore (M10). These will be used primarily to monitor water levels within the palaeochannel aquifer. These are likely to be installed at the time of exploration pump-testing, and will remain in place if the pump testing returns favourable results.

As further information and data becomes available the bore locations may be modified to ensure data is gathered from the most suitable structural, geomorphological and geological locations.

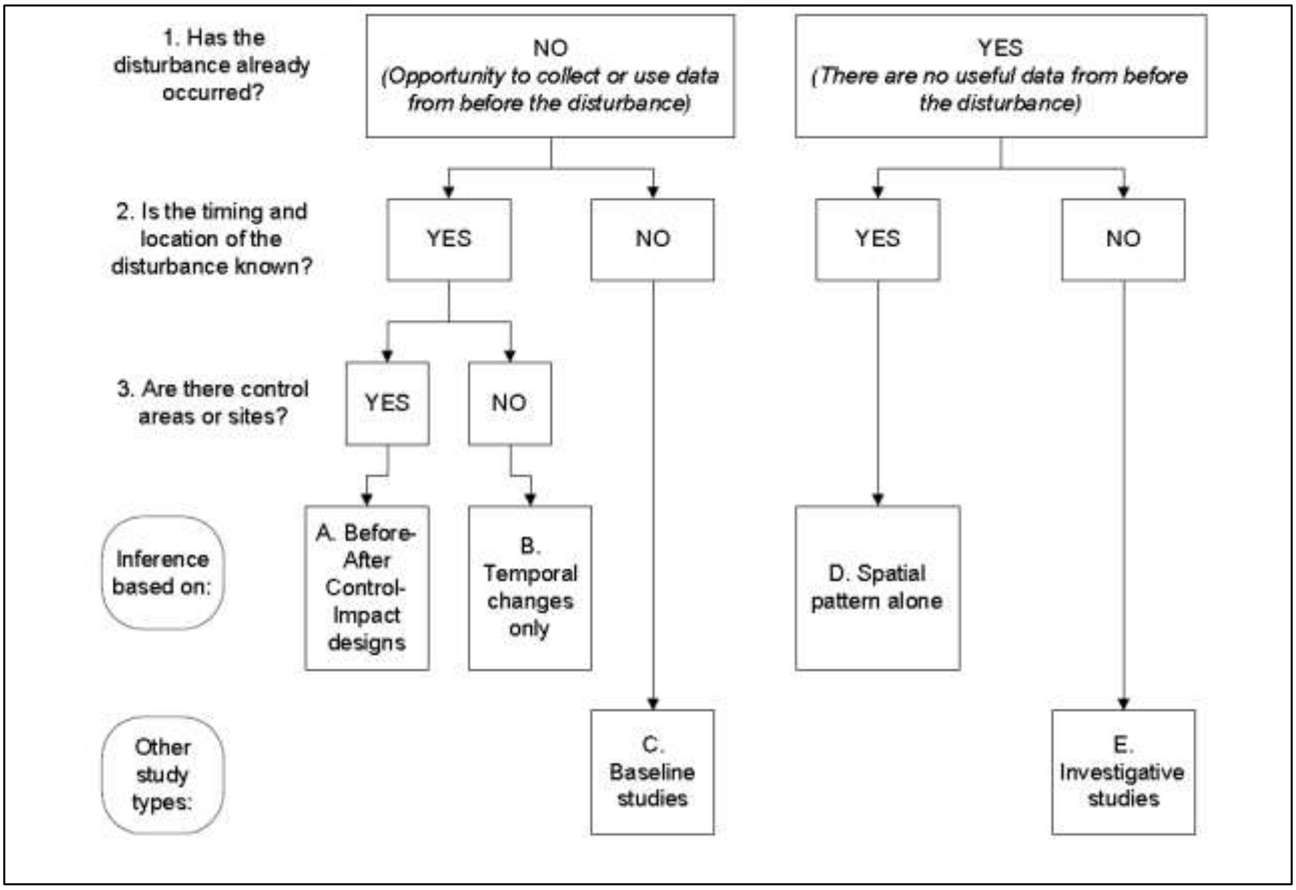


Figure 4.2: Monitoring program selection (ARMCANZ, 2000)

Table 4.3: Proposed groundwater monitoring locations

ID	General Location	Easting	Northing	Type	Aquifer
CB	Corsair's Bore	516550	7770180	Production bore	Bedrock
WB	Wilson's Bore	513529	7767170	Production bore	Palaeochannel
TB	Timmy's Bore	509507	7764901	New production bore	Palaeochannel
A01	4.1 km north of site	517374	7772534	Analogue	Bedrock
A02	3.7 km north of site	516995	7772128	Analogue	Palaeochannel
A03	3.7 km northwest of site	514335	7772882	Analogue	Palaeochannel
BF01	1 km up-gradient of TB	509830	7765915	Monitoring bore	Palaeochannel
BF02	200 m up-gradient of TB	509559	7765126	Monitoring bore	Palaeochannel
BF03	200 m adjacent to TB	509726	7764848	Monitoring bore	Palaeochannel
BF04	200 m down-gradient of TB	509444	7764705	Monitoring bore	Palaeochannel
M01	Down-gradient of WRD1	515432	7768610	Monitoring bore	Palaeochannel
M02	Down-gradient of WRD1	515115	7767679	Monitoring bore	Palaeochannel
M03	Down-gradient of TD / WRD2	515115	7766395	Monitoring bore	Palaeochannel
M04	Down-gradient of TD / WRD2	515525	7765687	Monitoring bore	Palaeochannel

ID	General Location	Easting	Northing	Type	Aquifer
M05	Northwest of WRD 1	515417	7768518	Monitoring bore	Bedrock
M06	Southwest of TD	515794	7765681	Monitoring bore	Bedrock
M07	Central to the site	516269	7767033	Monitoring bore	Bedrock
M08	Northeast of pits	516738	7768477	Monitoring bore	Bedrock
M09	Southeast of WRD 2	516951	7766088	Monitoring bore	Bedrock
M10	200 m down-gradient of WB	513277	7767141	Monitoring bore	Palaeochannel

4.4.2 PARAMETERS TO BE MEASURED

A standard set of monitoring parameters will be implemented for all monitoring locations (see Table 4.4). The list of analytes applies to all “production”, “analogue”, and “monitoring” bores described in Table 4.3, with the exception of BF01-BF04, which will be used primarily for monitoring water levels in the palaeochannel aquifer.

In addition to the chemical analysis, groundwater elevations and extraction rates will also be monitored. Depth to groundwater will be recorded at all “analogue”, and “monitoring” bores described in Table 4.3, with water depth also being recorded in the “production” bores where practicable. All “production” bores will be fitted with a flow metering device capable of continuous recording of the extracted flow rate and volume.

The collection of groundwater monitoring data is described in detail in the *Standard Operating Procedure for Groundwater Monitoring* (SWC, 2013c).

4.4.3 SAMPLING FREQUENCY

In general, groundwater monitoring activities will take place monthly. As previously discussed, groundwater extraction rates and volumes will be recorded automatically and on an ongoing basis; however, this information will be summarised monthly along with the rest of the monitoring data.

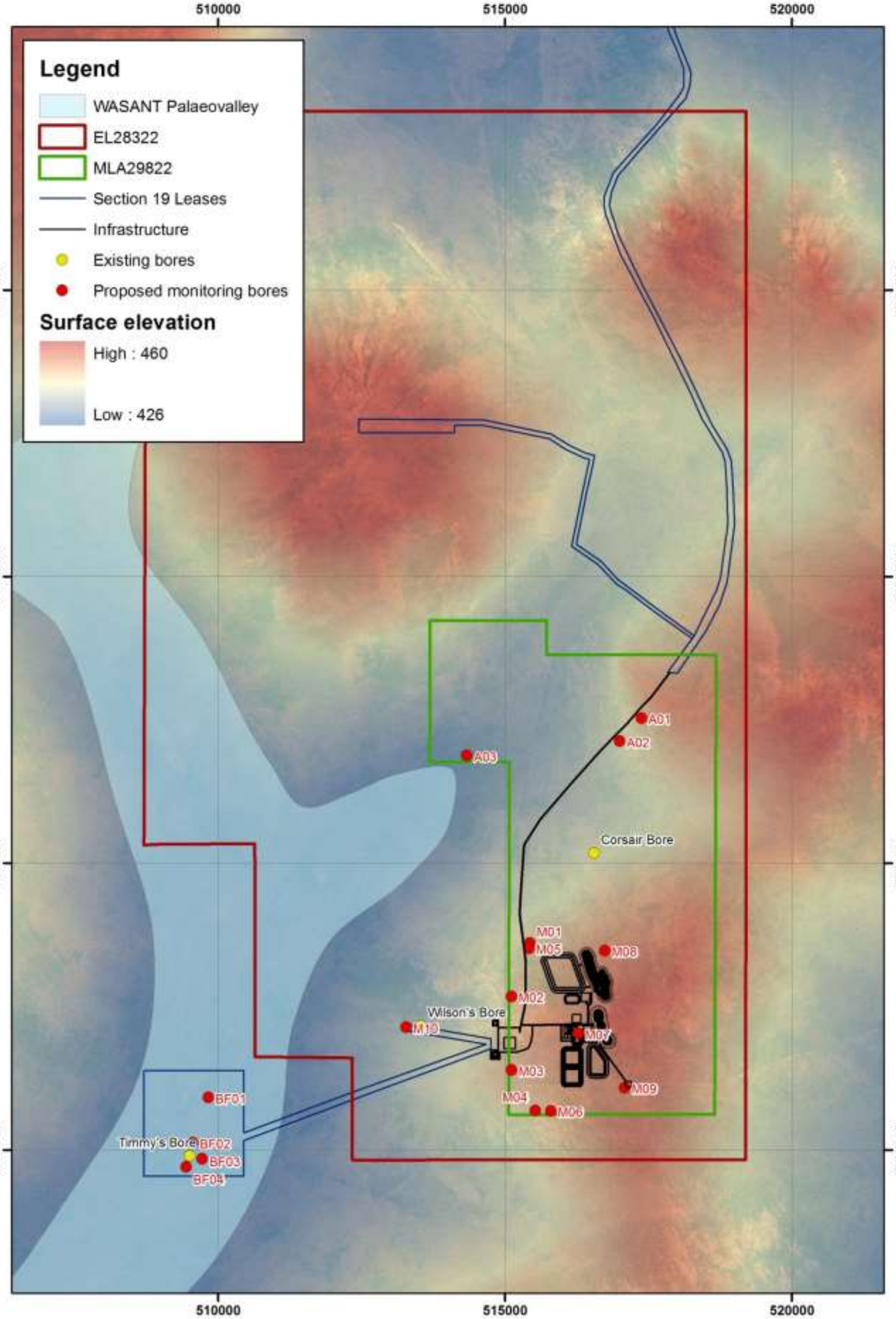
4.4.4 SAMPLING METHODOLOGY

The collection of groundwater monitoring data is described in detail in the *Standard Operating Procedure for Groundwater Monitoring* (SWC, 2013c).

Table 4.4: Analytes for groundwater quality monitoring

Parameter	Units	Limit of Detection	Method Reference	Method
Field Parameters				
pH	-	0.01	APHA 4500-H^+ B	Electrometry
Electrical Conductivity (EC)	µS/cm	1	APHA 2510 B	Electrode
Temperature	°C	0.1		Electrode
Oxidation-reduction potential (ORP)	mV	1		Photometry
General Parameters				
pH	-	0.01	APHA 4500-H^+ B	Electrometry
Electrical Conductivity (EC)	µS/cm	1	APHA 2510 B	Electrode
Total Dissolved Solids (TDS)	mg/L	10	APHA 2540 C	Gravimetry
Alkalinity – Total (as $CaCO_2$)	mg/L	1	APHA 2320 B	Titration
Ionic balance	Ratio (mg/L:mg/L)	1 mg/L		ICP-AES
Major Ions & Ligands				
Calcium (Ca^{2+})	mg/L	1	APHA 3210	ICP-AES
Potassium (K^+)	mg/L	1	APHA 3210	ICP-AES
Magnesium (Mg^{2+})	mg/L	1	APHA 3210	ICP-AES
Sodium (Na^+)	mg/L	1	APHA 3210	ICP-AES
Chloride (Cl^-)	mg/L	1	APHA 4500-Cl^-B	Titration
Fluoride (F^-)	mg/L	0.1	APHA 4500-F^- C	Ion-selective electrode
Sulfur Species				
Sulfate ($SO4^-$)	mg/L	1	APHA 4500-SO_4^- E	Turbidimetry
Nutrients				
Nitrate (NO_3^- as N)	mg/L	0.01	APHA 4500-NO_3^- I	FIA-Photometry
Ammonia (as N)	mg/L	0.01	APHA 4500-NH_3^- H	FIA-Photometry
Reactive Phosphorus as P	mg/L	0.01	APHA 4500 P–G	FIA-Photometry
Phosphorus – Total	mg/L	0.01	APHA 4500 P–H	FIA-Photometry
Total Kjeldahl nitrogren (TKN as N)	mg/L	0.1	APHA 4500-N_{org} D	FIA-Photometry
Chemical Oxygen Demand (COD)	mg/L	5	APHA 5220 B	Titration

Parameter	Units	Limit of Detection	Method Reference	Method
Carbon				
Total Organic Carbon (TOC)	mg/L	1	APHA 5310 B	IR Spectrometry or titration
Dissolved Organic Carbon (DOC)	mg/L	1	APHA 5310 B	IR Spectrometry or titration
Cyanide				
Free Cyanide (CN-)	mg/L	0.004	APHA 4500-CN- C&N	FIA-Photometry
Weak Acid Dissociable (WAD) Cyanide (CN-)	mg/L	0.004	APHA 4500-CN- I&N	FIA-Photometry
Total Cyanide (CN-)	mg/L	0.004	APHA 4500-CN- C&N	FIA-Photometry
Metals - Dissolved				
Aluminium (Al)	mg/L	0.01	USEPA 6020	ICP-MS
Antimony (Sb)	mg/L	0.001	USEPA 6020	ICP-MS
Arsenic (As)	mg/L	0.001	USEPA 6020	ICP-MS
Boron (B)	mg/L	0.05	USEPA 6020	ICP-MS
Cadmium (Cd)	mg/L	0.0001	USEPA 6020	ICP-MS
Chromium (Cr)	mg/L	0.001	USEPA 6020	ICP-MS
Copper (Cu)	mg/L	0.001	USEPA 6020	ICP-MS
Lead (Pb)	mg/L	0.001	USEPA 6020	ICP-MS
Nickel (Ni)	mg/L	0.001	USEPA 6020	ICP-MS
Manganese (Mn)	mg/L	0.001	USEPA 6020	ICP-MS
Selenium (Se)	mg/L	0.01	USEPA 6020	ICP-MS
Uranium (U)	mg/L	0.001	USEPA 6020	ICP-MS
Vanadium (V)	mg/L	0.01	USEPA 6020	ICP-MS
Zinc (Zn)	mg/L	0.005	USEPA 6020	ICP-MS
Mercury (Hg)	mg/L	0.0001	APHA 3112-Hg B	CV/FIMS
Hydrocarbons				
Total Petroleum Hydrocarbons (TPH) TPH (C6-C9) plus TPH (C10-C36)	µg/L	20	USEPA 5030	P&T/GC/MS
Biological indicators				
E. Coli	cfu/100 mL	1	-	-



ABM Resources NL	Figure 4.3: Groundwater monitoring locations	soilwater GROUP
WMP for the Twin Bonanza Gold Project		

4.5 QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance and quality control (QA/QC) procedures related to water monitoring are prescribed within the Standard Operating Procedures (SOPs) for surface water monitoring (SWC, 2013d) and groundwater water monitoring (SWC, 2013c) (included as APPENDIX A and APPENDIX A). In general, the SOPs describe how to collect sample blanks and replicates, including calculations for determining an appropriate number of QA/QC samples for each sampling event, and guidance for interpreting QA/QC sample results.

4.6 WATER QUALITY TRIGGER VALUES

4.6.1 LEVEL OF PROTECTION

Trigger levels for water quality are set to protect the natural hydrogeological and biological environment against undue stress, and to protect water quality for potential future uses. In general, the level of protection proposed for the TGBP is intended to maintain a similar level of water quality as was present in the pre-mine environment, and accounting for natural fluctuations in constituent concentrations.

Specific trigger vales and monitoring solutions for surface water and groundwater have been developed according to the the ANZECC & ARMCANZ Procedural Framework for the monitoring and assessment of water quality (ANZECC and ARMCANZ, 2000), and these are discussed further in the following sections.

4.6.2 SURFACE WATER TRIGGER VALUES

The concept of trigger values does not readily apply to the majority of the monitored surface water within the TBGP. Due to the nature of the water that will be present in the TD, Water Storage Dam, and CRD (i.e. this water is likely to have elevated concentrations of arsenic), these facilities have been designed to be fully contained, and no releases of surface water to the environment are planned or expected. Thus, setting specific threshold values for particular constituents is not warranted. Monitoring of these facilities is instead conducted with the purpose of identifying the relevant properties of the water for use within the processing circuit, and so that constituents of particular concern can be identified in the highly unlikely case of unexpected releases to the environment.

Specific trigger values can, however, be set for the sediment traps. As these facilities have been designed to remove 90 % of material ≥ 0.045 mm in diameter (SWC, 2013e), measurements of sediment trap inflow and outflow will demonstrate this level of removal efficiency, when averaged over 12 rainfall events each year.

The current *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000) do not provide any guidance for acceptable levels of oil/grease or petroleum hydrocarbons in surface water. Therefore, an alternative two-tiered trigger value system is proposed for monitoring total petroleum hydrocarbons (TPH) in the sediment traps):

1. If concentrations of TPH > 15 mg/L are detected, the efficiency of the oil/grease traps is to be assessed, and improvements made, where necessary.
2. If concentrations of TPH > 30 mg/L are detected, the oil/grease traps are considered not to be functioning properly, and improvements to their functioning will be made.

4.6.3 GROUNDWATER TRIGGER VALUES

The generic trigger levels presented in the current *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000) do not readily apply to groundwater. However, the guidelines recommend the development of site-specific trigger values, determined in consultation with relevant stakeholders.

In order to determine if site activities are affecting the groundwater quality, the pre-disturbance, or “background”, groundwater quality must first be known. It is anticipated that the first 6-12 months’ worth of data collected from the “monitoring” and “analogue” bores will initially be used to set background levels, and this will be analysed and updated according to the *Australian Guidelines for Water Quality Monitoring and Reporting* (ARMCANZ, 2000) to develop a 24 month running average as further data is collected in subsequent sampling events. During site operation, the “analogue” bores will be used to track natural fluctuations in the background levels in both the bedrock and palaeochannel aquifer systems (i.e. a BACI analysis).

Once enough background data has been collected, trigger levels will be set according to appropriate statistical procedures, as outlined in ARMCANZ (2000). To allow for a high level of certainty that a trigger level has been exceeded, a value greater than the trigger level must be detected for three consecutive readings prior to initiating a response (e.g. arsenic detected at an elevated level in monitoring bore M05 for three consecutive months).

4.6.4 RESPONSES AND INCIDENT REPORTING

Exceedance of trigger values for sediment removal in the sediment traps will initiate a review of the sediment trap design, including the input assumptions used (e.g. catchment areas, surface materials, and erosion rates may be different than originally assumed). Modifications to the design of the basins will be made, where the design is found to be inappropriate. The design modifications should be reported in the next annual water quality report which will be incorporated in to the company’s annual Mine Management Plan (MMP).

As discussed in Section 4.6.2, a two-tiered trigger value system is proposed for monitoring total petroleum hydrocarbons (TPH) in the sediment traps:

1. If concentrations of TPH > 15 mg/L are detected, the efficiency of the oil/grease traps is to be assessed, and improvements made, where necessary.
2. If concentrations of TPH > 30 mg/L are detected, the oil/grease traps are considered not to be functioning properly, and improvements to their functioning will be made.

If background groundwater levels are exceeded for three consecutive monitoring periods, an investigation of the likely causes (i.e. potential contaminant sources), and an assessment of the likely significance of this in terms of future water uses will be conducted, and appropriate recommendations for action made. A review of the groundwater monitoring network should also be conducted, to ensure adequate contaminant tracking and source identification is possible in the future. This technical review and reporting will be conducted within one month after exceeding the trigger value.

5 WATER QUALITY REPORTING

5.1 REPORTING REQUIREMENTS

Water Quality will be reported annually in the MMP in accordance with the *Mining Management Act 2001*. Reporting to regulatory authorities (through the MMP) and stakeholders at the appropriate level of detail is important to demonstrate the effective implementation of an environmental management system on site. The MMP will incorporate an annual water quality report, summarising the water quality data for the previous period, and discussing the implications for the continued management of the site and the potential risks to the environment. This report will include:

- Graphs summarizing water quality data
- Where applicable graphs should indicate:
  - site specific trigger values
  - “total” and “filtered” sample analysis results
- An interpretation and discussion of this data including:
  - identification of any issues (e.g. degrading water quality in a specific site/area);
  - actual and / or potential causes of issues and
  - conclusions drawn from the results.
- Details of any incidents affecting water quality;
- Details of actions taken to address any water quality issues;
- Commitments to specific areas for improvement in the next reporting period
- A list of water quality reporting requirements for wastewater discharge licence purposes if applicable (e.g. bi-monthly reporting due dates, annual report due date etc.).

All the raw data for the previous reporting period is to be presented as appendices to Part B (confidential section) of the MMP.

5.2 SURFACE WATER QUALITY REPORT FOR THE PREVIOUS PERIOD

Because active mining (and thus monitoring) has not yet started, no detailed monitoring data is available. All available background data is presented in Section 2.

5.3 GROUNDWATER QUALITY REPORT FOR THE PREVIOUS PERIOD

Because active mining (and thus monitoring) has not yet started, no detailed monitoring data is available. All available background data is presented in Section 3.

6 WATER ACCOUNT

6.1 REPORTING REQUIREMENTS

The term "Water Account" refers to the system for quantifying, qualifying and reporting inflows, outflows, diversions and use of surface water and groundwater on a site. The Water Account must take into account inputs (e.g. rainfall, surface flows, groundwater inflows, etc.), outputs (e.g. evaporation, evapotranspiration, controlled/uncontrolled discharges, etc.), water use in production, diversions and interactions between surface and groundwater.

A Water Account must include the following components:

- Site Flow Diagram representing significant water flows associated with the site
- Input-Output Statement (as per MCA framework)
- Accuracy Statement (as per MCA framework)
- Statement of Operational Efficiencies (as per MCA framework)
- Summary of Water Stores

Water Management Plans should include Water Accounts for:

- the previous authorization period that has just passed
- the upcoming authorization period, and
- any envisaged scenarios that are likely to adversely impact the operations.

To improve the efficiency of Water Account preparation and assessment, refer to the Minerals Council of Australia (MCA) website at: http://www.minerals.org.au/focus/sustainable_development/water_accounting.

6.2 WATER ACCOUNT FOR THE PREVIOUS PERIOD

No water account has been prepared for the previous period, as the infrastructure for this project is not yet in place, and no mining activity has occurred.

6.3 WATER ACCOUNT FOR THE UPCOMING PERIOD

A preliminary conceptual Water Account has been prepared for the TBGP, which outlines all of the major water inflows and outflows. The level of detail in this Water Account reflects the early stage of development of the Project, and it is intended that this will be updated as the site water requirements and available resources (i.e. groundwater supply) are further developed.

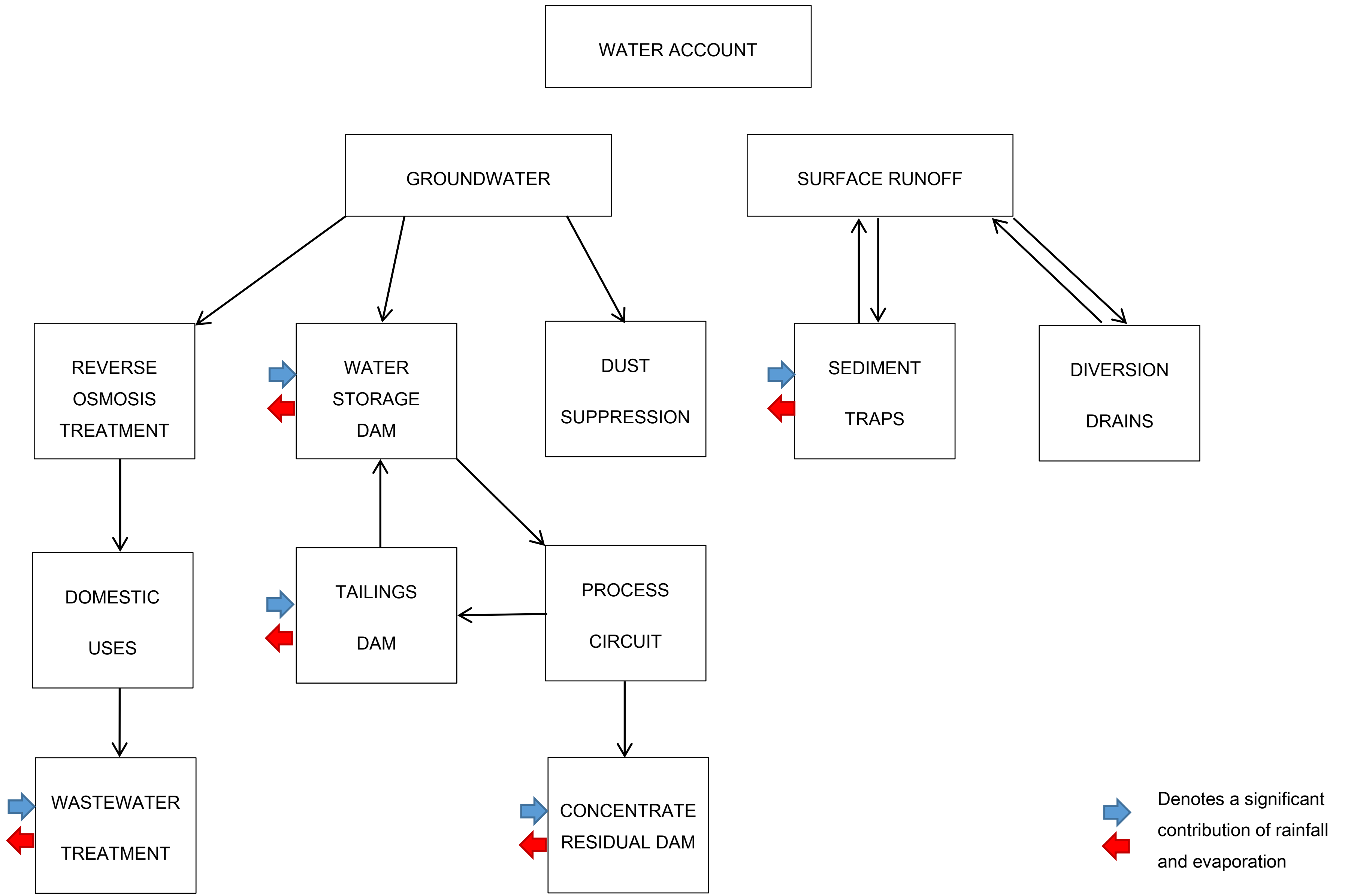
A conceptual site flow diagram is shown in Figure 6.1, and the major water inflows and outflows have already been described in Sections 2.3.1 and 3.3.1. In summary, the majority of water supplied to the site will be made up of groundwater, with a significant contribution to the water storages from rainfall during the wet season. All surface water runoff will either be diverted around the main disturbance areas, or directed into one of the four sediment traps to be installed within the infrastructure areas. Evaporation will likely account for a major proportion of water outflows, with the majority of the remainder being used in the processing circuit. Water that is not consumed in the processing circuit will be recycled back into the Water Storage Dam, and subsequently reused in the processing plant.

6.4 WATER ACCOUNT FOR A 1:100 YR PEAK RAINFALL SCENARIO

Once a detailed Water Account has been prepared for the average site conditions, a Water Account should be prepared for an extremely wet year (i.e. the 1:100-yr peak rainfall scenario). This will demonstrate that the site infrastructure is capable of handling the additional water input.

6.5 STATUS OF WATER STORES DURING PREVIOUS PERIOD

Once the site is operational, graphs of water surface levels and volumes for all significant water stores will be included here. Graphs will show how the storage levels changed through the reporting period (e.g. show the values recorded during each of the monthly monitoring events, or show continuously logged water level data), and will be presented relative to the maximum operating volume and crest level to demonstrate compliance with freeboard requirements.



ABM Resources NL	Figure 6.1: Water Account flow diagram
WMP for the Twin Bonanza Gold Project	

7 STRATEGIC PLANNING

7.1 CURRENT STATUS OF THE WMP

The TBGP is currently in the planning stages; mining has not yet commenced, and the majority of infrastructure has not yet been built. The level of detail in this WMP reflects this early stage of development – it is intended that this plan will be updated as the site is further developed.

7.2 OBJECTIVES, PRIORITY ACTIONS, AND INITIATIVES

The primary purpose of this Plan is to provide the TBGP with a useful management tool that enables them to meet environmental quality targes while also satisfying the monitoring and reporting requirements of the Northern Territory (NT) Department of Mines and Energy (DME).

Priority actions for the upcoming period include:

- Establishment of a groundwater monitoring network, and commencement of “background” data collection
- Establishment of an additional groundwater production bore, including test pumping of the bore
- Installation of site infrastructure

7.3 PROPOSED WORKS FOR THE UPCOMING PERIOD

The following works are proposed for the upcoming period:

- Drill test water source targets based on compiled data and ground surveys.
- Re-establishment of Timmy’s Bore (Strezza’s), and installation of a test bore within groundwater target area #2A (Figure 3.1)
- Installation of monitoring bores within groundwater target area #2 (Figure 3.1)
- Pump testing to determine likely long-term sustainable yields
- Establishment of monitoring bore network (Figure 4.3)
- Installation of site infrastructure
- Conduct initial water monitoring activities
- Review and update this WMP

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APPENDICES

APPENDIX A

STANDARD OPERATING PROCEDURE (SOP) FOR SURFACE WATER MONITORING

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			Originator	Reviewer	Approved
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B1	21/08/13	Draft SOP issued for client review	JP	ASP	ASP
C1	10/12/13	Final document issued to client	JP	ASP	ASP

Revision Code*

A - Report issued for internal review

B - Draft report issued for client review

C - Final report issued to client

LIMITATIONS

The sole purpose of this report and the associated services performed by Soil Water Consultants (SWC) was to undertake prepare a Surface Water Sampling Standard Operating Procedure (SOP) for the proposed Twin Bonanza Gold Project. This work was conducted in accordance with the Scope of Work presented to ABM Resources ('the Client'). SWC performed the services in a manner consistent with the normal level of care and expertise exercised by members of the earth sciences profession. Subject to the Scope of Work, the Surface Water Sampling SOP was confined to Twin Bonanza Gold Project. No extrapolation of the results and recommendations reported in this study should be made to areas external to this project area. In preparing this study, SWC has relied on relevant published reports and guidelines, and information provided by the Client. All information is presumed accurate and SWC has not attempted to verify the accuracy or completeness of such information. While normal assessments of data reliability have been made, SWC assumes no responsibility or liability for errors in this information. All conclusions and recommendations are the professional opinions of SWC personnel. SWC is not engaged in reporting for the purpose of advertising, sales, promoting or endorsement of any client interests. No warranties, expressed or implied, are made with respect to the data reported or to the findings, observations and conclusions expressed in this report. All data, findings, observations and conclusions are based solely upon site conditions at the time of the investigation and information provided by the Client. This report has been prepared on behalf of and for the exclusive use of the Client, its representatives and advisors. SWC accepts no liability or responsibility for the use of this report by any third party.

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9 INTRODUCTION

9.1 PURPOSE OF THIS DOCUMENT

This document aims to provide standard procedures for trained staff at the Twin Bonanza Gold Project engaged in surface water sampling. This document is designed to work in conjunction with the Water Management Plan (WMP) to ensure a high standard of surface water monitoring data collection, analysis, and reporting. This document was prepared in accordance with the Northern Territory (NT) Department of Mines and Energy (DME) Advisory Note on the '*Methodology for the Sampling of Surface Waters*', and with reference to the requirements of the *Minerals Titles Act 2010* the *Mining Management Act 2001*, the appropriate Australian Standards (e.g. AS 5667.1:1998; 5667.4:1998; 5667.6:1998; and 5667.11:1998) and the *Mine Site Water Management Handbook* (Mineral Council of Australia, 1997).

9.2 SCOPE OF THIS DOCUMENT

This document details surface water monitoring procedures for field staff at the Twin Bonanza Gold Project, from initial preparation for sampling through to field collection and measurement and final data analysis and Quality Assurance / Quality Control (QA/QC). Details of the overall monitoring programme, including the selection of sampling sites and the selection of particular analytes are covered in the WMP.

9.3 UPDATES TO THIS DOCUMENT

This is designed to be a "living document", and is expected to change as accepted sampling methodology and the site sampling program evolves. More site-specific information may also be incorporated to replace generic descriptions as the operation develops (e.g. a field sampling sheet should be attached in place of the generic information in Section 17.2.4), and the locations of monitoring points should be updated as they are added or removed.

9.4 OVERVIEW OF THE SURFACE WATER MONITORING PROGRAMME

9.4.1 SAMPLING LOCATIONS

Monitoring of surface water storages, sediment traps, and other surface water infrastructure will be conducted at the locations specified in Table 4.1 and shown on Figure 4.1. These locations are expected to represent all of the potential surface water sources within the TBGP. There are no natural surface water features within an appreciable distance of the Project Area, and thus no natural features were selected for monitoring.

9.4.2 SAMPLING FREQUENCY

In general, surface water monitoring activities will take place monthly. As previously discussed, inflow and outflow rates from the surface water storage facilities will be recorded automatically and on an ongoing basis; however, this information should be summarised monthly along with the rest of the monitoring data. Measurements of sediment trap discharge will be collected opportunistically, as the sediment traps are only expected to act as flow-through basins during larger storm events.

9.4.3 PARAMETERS TO BE MEASURED

Table 4.2 summarises the chemical analysis to be completed for each of the monitoring locations. The analysis for the TD, Water Storage Dam, and CRD focuses primarily on metals and cyanide content, as this is aimed at characterising water that has been used within the gold processing circuit. The analysis of sediment trap discharge water is aimed at quantifying suspended solids and testing the effectiveness of the upstream oil and grease traps

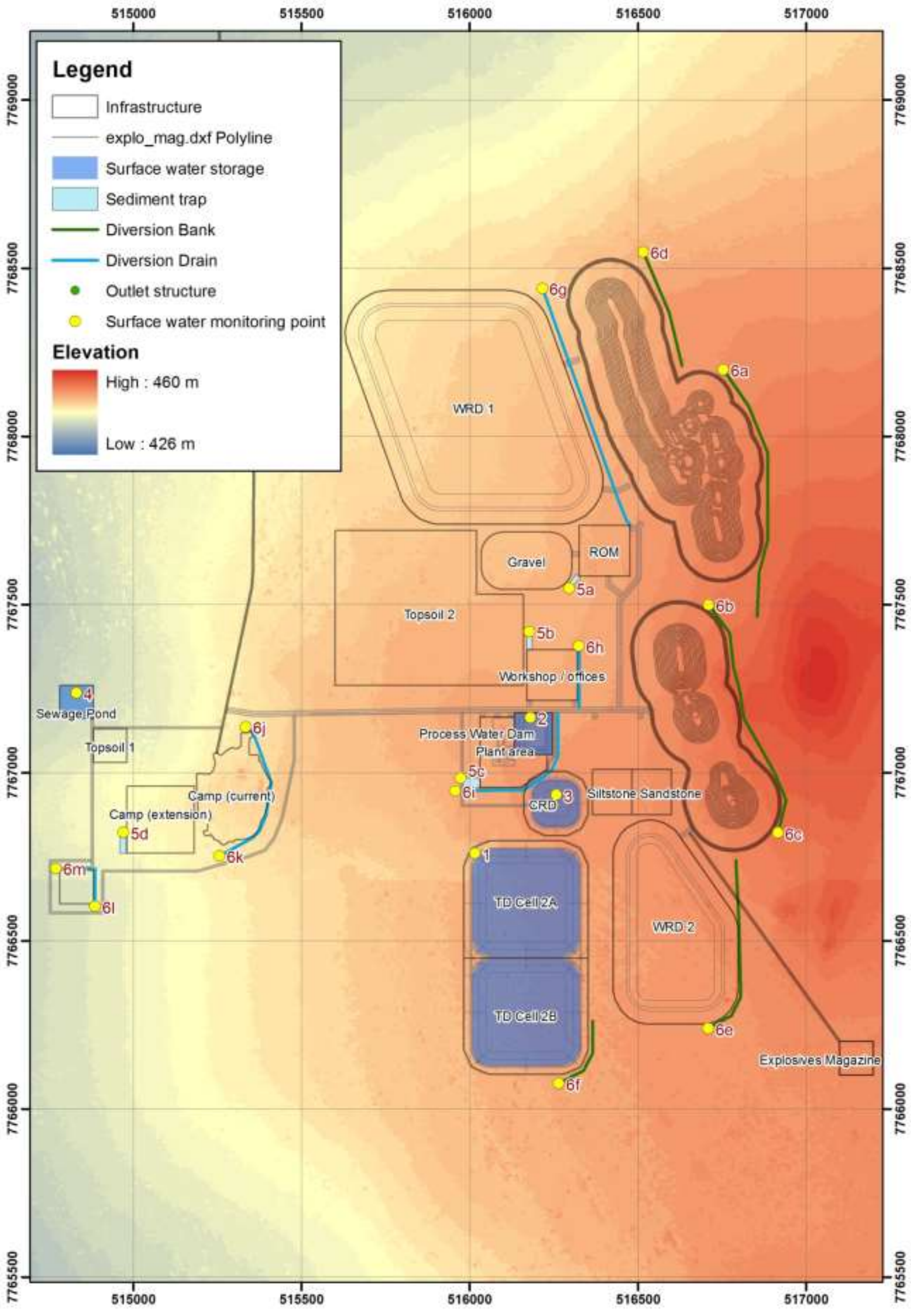
No regular sampling will occur in the diversion structures and sewage evaporation pond, and monitoring will be limited to visual inspections. These inspections are outlined in the *Erosion and Sediment Control Plan* (ESCP), and this information is not repeated in this SOP.

Table 5: Summary of surface water monitoring locations

ID	Description	Easting	Northing	Type(s)	Frequency
1	TD supernatant pond	516015	7766760	Water quality Water levels	Monthly Daily
2	Water Storage Dam	516180	7767160	Water quality Flow rates (in/out) Water level	Monthly Continuous Continuous
3	CRD Dam	516254	7766932	Water quality Water level	Monthly Continuous
4	Sewage pond	514830	7767239	Flow rates (in/out) Water level	Continuous Continuous
5	Sediment trap (inflow and outflow)	516295 516177 515973 514970	7767548 7767419 7766984 7766823	Water quality Visual inspections	Opportunistic
6	Surface water diversions and outlets (outlet coordinates given)	516754 516711 516917 516516 516709 516264 516216 516324 515957 515333 515255 514886 514769	7768199 7767499 7766821 7768549 7766239 7766076 7768441 7767377 7766946 7767137 7766753 7766602 7766716	Visual inspections	Weekly during wet season Monthly during dry season

Table 6: Analytes for surface water quality monitoring

Analyte	Location ID (from Table 4.1)					
	1	2	3	4	5	6
pH	✓	✓	✓	-	✓	-
Electrical conductivity (EC)	✓	✓	✓	-	✓	-
Total Dissolved Solids (TDS)	✓	✓	✓	-	✓	-
Dissolved organic carbon (DOC)	-	-	-	-	-	-
Total organic carbon (TOC)	-	-	-	-	-	-
Ionic balance	✓	✓	✓	-	-	-
Major Cations (Ca, Mg, Na, K)	✓	✓	✓	-	-	-
Major Anions (Cl, SO_4, F)	✓	✓	✓	-	-	-
Total Alkalinity	✓	✓	✓	-	-	-
Dissolved metals (Al, As, B, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Sb, Se, Zn, Hg)	✓	✓	✓	-	✓	-
Free cyanide (CN^-)	✓	✓	✓	-	-	-
WAD cyanide	✓	✓	✓	-	-	-
Total cyanide	✓	✓	✓	-	-	-
Total petroleum hydrocarbons (TPH)	-	-	-	-	✓	-



ABM Resources NL	Figure 1: Surface water monitoring locations	soilwater GROUP
WMP for the Twin Bonanza Gold Project		

10 PREPARATION FOR SAMPLING

Being prepared for a surface water monitoring event means having the right equipment, sample bottles, safety gear, and a sampling plan in place before setting out. This section outlines standard procedures to ensure that field staff are well-prepared and able to collect high-quality monitoring data.

10.1 EQUIPMENT PREPARATION

Any equipment that will come into contact with water samples (e.g. pumps, bails, scoops) must be appropriately cleaned and decontaminated prior to each use. Sampling equipment should be washed using detergent and tap water, and then rinsed thoroughly with deionised (DI) water. Sampling equipment should be rinsed with DI water again in between collection of each sample. Cleaning and preparation of sample bottles is discussed in Section 17.2.

Field meters (e.g. pH and conductivity meters) must be calibrated according to the manufacturer's instructions at the start of each day of monitoring. Calibration checks should also be performed periodically throughout the day. Calibration should be performed using standards of a known concentration appropriate to the anticipated range of values in the water to be sampled. Calibration standards should be stored appropriately (e.g. keep refrigerated and do not exceed 'use by' dates) to ensure their accuracy. The required volume of standard should always be decanted into a suitable receptacle for calibration purposes and then discarded.

After all equipment is cleaned and calibrated, a field kit with the following items should be prepared to take out on the sampling round.

- Field data sheets
- Completed sample labels
- Chain of custody forms
- Container for field measurements
- Sample bottles for dispatch to laboratory (as detailed in Section 17.2)
- If necessary, equipment for collection of samples from a safe distance (e.g. sample pole)
- Filtration equipment and syringe (if necessary)
- Field parameter meters or test kits (e.g. alkalinity/acidity test kit)
- Powder-less nitrile gloves
- Esky and ice packs for preserving samples
- If required, appropriate preservative (e.g. nitric acid)
- Personal Protective Equipment (PPE), first aid, and communication equipment

A list of all equipment to be taken into the field is provided in Attachment 1.

10.2 SAMPLE BOTTLE PREPARATION

The chemical elements of interest dictate the type of bottle to be used for sampling (e.g. glass or plastic), and the method of preservation required (e.g. filtered, acid preserved, chilled / frozen). It is best to contact the analysing laboratory to determine preservation requirements prior to undertaking sampling, and to have sufficient pre-prepared sample bottles despatched to site.

10.2.1 NUMBER OF BOTTLES REQUIRED

Colour coded bottles are provided to make it easier for people to differentiate them. The colour coding scheme is summarised in Table 12. The number of bottles required for a standard sampling event is summarised in Table 13

Table 12. Sample bottle colour coding scheme

Test Parameter	Label Colour	Container Type (Preservation)
Alkalinity, EC, pH, Cations, Chloride, Sulphate, Fluoride, TDS, Acidity	Green	1 x 500mL plastic (none)
Total Phosphorus	Purple	1 x 125mL plastic (Sulfuric acid)
DOC (Field Filtered)	Purple*	1 x 40mL Amber vials (Sulfuric acid)
TOC	Purple*	1 x 40mL Amber vials (Sulfuric acid)
Dissolved Heavy Metals (Field Filtered)	Red & Green Stripe	1 x 60mL plastic (none) AIRFREIGHT OPTION
TPH(C6-C9)	Purple*	2 x 40mL Amber vials (Sulfuric Acid)
TPH (C10-C36)	Orange*	1 x 100mL Amber glass (none) for primary analysis.

Note: * These samples are for organics, and are supplied with Teflon lids

Table 13: Number of bottles required for normal sampling round

Bottle	Number required per sampling round
Green	TBD
Purple	TBD
Purple *	TBD
Orange *	TBD
Red & Green Stripe	TBD

Note: * These samples are for organics, and are supplied with Teflon lids

10.2.2 FIELD AND TRANSPORT BLANKS

In addition to the bottles required for sampling, one field blank and one transport blank are required for sampling every 6 months per analyte per day of sampling (i.e. one blank for metals, one for sulfate, etc.). Field and transport blanks are required as part of the QA/QC of the sampling programme (see Section 20). A field blank is used to estimate contamination of a sample during the collection procedure, and transport blank is used to estimate the contamination introduced during transport of the sample bottles to and from the field.

To obtain both a field and transport blank, the following procedure should be followed:

3. In the site laboratory, divide a water sample of appropriate quality into two parts.
4. Retain portion A at the site laboratory and transport portion B to the sampling site.
5. Divide portion B into two parts:
    a. portion B1 is used as a field blank, and
    b. portion B2 is used as a transport blank.
6. Process portion B1 using the same procedures used for sampling (e.g. pour it into the sample bottles using same sampling pump or scoops used for collection of the actual samples)
7. Return portions B1 and B2 to the laboratory using the same preservation and transport methods as the monitoring samples.
8. Portions A, B1 (field blank), and B2 (transport blank) can be analysed and results compared.

10.2.3 Replicate samples

Replication is the collection and analysis of more than one sample from the same location at the same time. This provides the experimental sampling error and thus a measure of the sampling precision. One replicate sample should be collected every 6 months per analyte, per day of sampling (i.e. one blank for metals, one for sulfate, etc.).

10.2.4 Bottle washing

ALS provides prepared bottles (i.e. washed and dosed with preservatives) for each of the required analysis, thus saving time prior to and during the sampling campaign. In the event that pre-preserved bottles cannot be obtained from the analysing laboratory the following guidelines may be followed.

All sample bottles must be washed prior to use. Unless otherwise prescribed, it is sufficient to wash both plastic and glass bottles using a standard detergent, according to the following procedure:

9. Wash container and cap with detergent and tap water.
10. Rinse thoroughly with tap water.
11. Rinse twice with DI water.
12. Drain thoroughly and replace cap.

For bottles requiring a solvent wash, use the following procedure:

13. Wash container and cap with detergent and tap water.
14. Rinse thoroughly with tap water.
15. Rinse twice with DI water and dry.
16. Rinse with acetone of an appropriate quality and drain
17. Rinse with a suitable solvent of an appropriate quality, dry and immediately replace cap.

NOTE: The solvent should be compatible with the analytes of interest and the analytical method to be used.

WARNING: Organic solvents may be hazardous. Provide suitable handling facilities and handle with care.

For bottles requiring acid-washing, use the following procedure:

18. Wash container and cap with detergent and tap water.
19. Rinse thoroughly with tap water.

20. Rinse with 10 % nitric acid.
21. Drain and fill with 10 % nitric acid.
22. Cap and store for at least a week.
23. Empty, rinse with DI water and immediately replace cap.

10.3 FIELD SHEETS

Field sheets should be used to record any details relevant to the subsequent analysis and interpretation of the results. This should include all the information necessary to assist in data interpretation and repeatability of sampling efforts, and should include:

- Name and location of sampling point
- Date and time of sample collection
- Sampler name (or initials)
- Any relevant descriptive information (e.g. water level)
- Sample appearance at the time of collection (e.g. colour, clarity, odour)
- Field parameters measured, or results of any on site analysis (e.g. pH, EC, alkalinity)
- Sample treatment post collection (e.g. filtration, acidification)

An example of a field sheet is provided in Attachment 2.

10.4 HEALTH AND SAFETY CONSIDERATIONS

A risk assessment should be conducted prior to each sampling event to identify hazards and implement appropriate controls to reduce risks to safety and the environment. General guidance on safety matters is provided in the site Occupational Health and Safety Plan. All personnel involved in the surface water sampling and field analysis should also be familiar with the relevant Material Safety Data Sheets (MSDS).

A generic Job Safety Analysis (JSA) form is provided in Attachment 4.

11 FIELD MEASUREMENTS

The following field measurements should be taken at each sampling location and recorded on the Field Sampling Sheet (Attachment 2):

- pH
- Electrical conductivity (EC)
- Redox potential (Eh)
- Temperature
- Turbidity

Where possible, samples are to be collected directly from the water body. Where a risk assessment deems that it is unsafe to take samples directly from the water source, a sampling device (i.e. a sampling pole) must be used, and the reading taken from a container. Care must be taken to ensure that any containers coming into contact with the sample have been properly decontaminated and rinsed with sample water prior to taking any readings.

Sensors should be kept in gentle motion through the water column while a reading is being taken. Allow up to several minutes for the meter to stabilise

11.1 PH

The pH of a solution is the concentration of hydrogen ions, expressed as a negative logarithm. It reflects the acidity or alkalinity of a solution. Water with a pH of 7 is neutral; lower pH levels indicate increasing acidity, while pH levels higher than 7 indicate increasing alkalinity.

11.2 ELECTRICAL CONDUCTIVITY

Electrical conductivity is the measure of the ability of water to conduct an electric current and depends upon the number of ions or charged particles in the water. It is measured by passing a current between two electrodes (a known distance apart) that are placed into a sample of water. The unit of measurement for electrical conductivity is expressed in either micro-Siemens per centimetre (µS/cm) or milli-Siemens per centimetre (mS/cm).

11.3 REDOX POTENTIAL (EH)

The redox potential of a surface water body is a measure of its oxidising or reducing status (related to dissolved oxygen). Well aerated and circulated water will be oxidising in nature, which facilitates metals precipitation and immobilisation. In contrast, stagnant or reducing conditions promote metal dissolution and mobilisation. Redox potential is measured direct using a standard Eh probe (similar to a pH and EC probe), with the results reported in Volts (V) or millivolts (mV).

11.4 TEMPERATURE

The temperature of the water to be sampled will change throughout the day and influence parameters such as pH and Dissolved Oxygen. Temperature can be measured using a thermometer with a range of 0–50°C or a suitable electronic thermometer.

11.5 TURBIDITY

Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms. Turbidity is a measure of the clarity of a water body and is an optical measurement that compares the intensity of light scattered by a water sample with the intensity of light scattered by a standard reference suspension. It is commonly recorded in nephelometric turbidity units (NTUs).

12 COLLECTING SAMPLES FOR LABORATORY ANALYSIS

Where possible, samples are to be collected directly from the water body. Where a risk assessment deems that it is unsafe to take samples directly from the water source, a sampling device (i.e. a sampling pole) must be used, and the sample bottles filled from the sampling container. Care must be taken to ensure that any containers coming into contact with the sample have been properly decontaminated and rinsed with sample water prior to collection of samples. A clean pair of nitrile gloves should be worn at each sample site to minimise potential contamination problems.

Note: ALS sample bottles contain preservatives and therefore should not be rinsed or submerged in the water body.

12.1 DIRECT SAMPLING

To collect a grab sample directly from a shallow water body:

- Arrive at sample location.
- Ensure that labelling on the bottle to be filled is correct and that the sample number matches the number on the paperwork.
- Sort out the bottles.
- Select the 500ml bottle and fill it with water from the Dam – this may be done with a grab pole if required (See Section 12.2).
- Find the 'Field Filtered' bottles. These have a TOC / DOC check box on them. Ensure you have the Red and Green Stripe and one of the Purple. 'Check' the Field Filtered box on these bottles.
- Take the syringe, draw water from the recently filled 500ml bottle, attach the filter (yellow disc, it has a screw fitting on the clear side that matches the syringe) and squeeze the water into the smaller vials.
- Remove the filter, then repeat above, until the smaller bottle is full.
- It is important to ensure you fill the small vials until there is a strong positive meniscus on the top – this will ensure there is no air ('head space') caught in the bottle.
- After filling the first bottle, and screwing on the lid, complete the sample details, noting date and time, and invert the bottle to ensure there is only a tiny air bubble.
- Then do the same for the second Field Filtered bottle.
- If you notice the white membrane in the filter turning brown, replace it.
- Once the Field filtering is done, you can put the syringe and filters aside (keep the unused filters so that we have them as reserves if the tails water gets really dirty, throw the used ones out).
- Then fill the syringe again, and set it to one side (lay it on one of the plastic bags to keep it relatively clean).
- Take any of the remaining non filtered bottles. Check the label to see if it has an acid preservative, just so you know how careful you need to be in filling. Note also that there will be one Purple bottle that will require a 'check' against the TOC (not field filtered)
- Carefully fill the small bottle almost brimful from the 500ml bottle
- Then use the syringe to carefully fill, so that you have a positive meniscus, and screw on the cap – invert and check for the air bubble, and then complete the label.
- Then repeat for the remaining bottles
- When you have filled the last small vial, you should have an almost empty 500ml bottle.

- The last step in the field is to refill the 500ml bottle, ensuring it has minimal headspace. (it is possible to fill the syringe direct from the dam to top up the big bottle.

12.2 GRAB POLE SAMPLING

To collect a grab sample using a sampling pole:

- Ensure that labelling on the bottle to be filled is correct and that the sample number matches the number on the paperwork.
- Check that the grab pole sampler is clean; rinse with DI water, if necessary.
- Extend the grab pole sampler and immerse it into the water with the opening pointing directly down to maintain a volume of air in the container, thereby avoiding the collection of any surface films.
- If sampling from a flowing water source, point the mouth of the grab sampler up stream so that gloved hands, sample container and/or sample collection device is downstream of the sample being collected.
- If sampling from a stationary water body, move the grab sampler forward away from the sampler and any equipment to collect a continuous uncontaminated sample.
- Fill grab sampler, rinse, and then empty the rinse water at a sufficient distance (or downstream) from the sample site to prevent mixing of rinse water with the water to be sampled. Repeat 2 more times.
- Fill the grab sampler and bring back to the shore.
- Use this sample to rinse the labelled sample bottles three times using the same procedure as for taking a direct sample.
- Fill the sample bottle from the grab sampler, up to the desired level (generally the shoulder of the bottle, but always check the sampling and analysis plan).
- If samples require field filtration (i.e. for nitrate analysis), feed the filtration device from the grab sampler and fill the required sample bottles with the filtered water.
- If the sample container contains a preservative, be careful when filling to prevent any splash back.
- Cap, and store the sample container as required for transport to the laboratory.

12.3 FIELD FILTRATION

There are two main methods employed in the field filtration of water samples: pressure systems employing syringe, or gravitational pressure and vacuum filtration systems.

The standard procedure for syringe filtration is as follows:

- Draw an aliquot of the sample into the syringe from the sample collection container taking care to maintain an air gap between the base of the plunger and the sample to minimise contact and potential contamination.
- Dispense aliquot to waste to rinse syringe. Repeat.
- Draw an aliquot of the sample into the syringe taking care to maintain an air gap between the base of the plunger and the sample to minimise contact and potential contamination.
- Affix appropriate filter unit to syringe (between 0.4 and 0.5 μm) and dispense into laboratory sample container.
- Add any preservative to be used, re-seal laboratory sample container, and invert to mix thoroughly.

When using vacuum filtration, the pressure difference across the filter material is supplied via the application of a vacuum between the collected sample and the laboratory sample container. The standard procedure for vacuum filtration is as follows:

- Thoroughly clean filtration unit employing a method appropriate for the analyte of interest. For example, a filtration unit that is to be used for the collection of samples for metals analysis should be rinsed using a solution of 10% Hydrochloric acid followed by water of appropriate quality.
- Agitate sample bottle to thoroughly mix sample.
- Rinse the filter unit with the water to be sampled.
- Assemble filter unit taking care to not touch filter unit components that will be in contact with the sample or introduce small tears to the filter membrane.
- Apply vacuum
- Collect sample and distribute to laboratory sample containers.
- Add any preservative to be used, re-seal laboratory sample container, and invert to mix thoroughly.

12.4 STORAGE AND TRANSPORT

Samples should be stored according to the preservation procedures summarised from AS/NZS 5667.1:1998 (or Table 14). Generally, samples are stored on ice (or ice-bricks) in an esky for transport to the laboratory. However, depending on holding times and how long it will take you to get your samples to the lab, you may need to freeze some of them (note that some samples should never be frozen). The appropriate method and period of storage is dependent on the analyte of interest and must be adhered to so that representative results from analysis are obtained.

While sample preservation will limit degradation, dispatch to the laboratory should occur as soon as practicable.

The specific procedure for transporting samples is outlined as follows:

- Take the esky and wrap it in the bubble wrap provided, ensuring that all the sample details are complete. Double check to ensure you have ticked the right boxes on the Red / Green and two of the Purple bottles.
- Take the sample back to the camp, and place the esky in the fridge or in the cold room. Hopefully you will have found some form of ice brick for transport.
- Fill in the Chain of Custody Form (see Attachment 3). As well as being the Sample Submission Form, this is a way of tracking who has been responsible for the sample. The person travelling with the sample should typically sign on in the initial position.
- If you are using the small foam esky use some tape to hold the lid on strongly, and make sure the Fragile sticker is in an obvious position.
- Remember to remove the sample from the fridge and take it with you to the sample drop off point of flight, along with the Chain of Custody form.

Table 14: Summary of water sample storage and preservation procedures

Analyte	Container	Preservation requirements	Maximum holding time
Acidity and alkalinity	Plastic	Fill container completely to exclude air, refrigerate	14 days @ 4°C

Ammonia	Plastic	Refrigerate	28 days acidified
Metals	Acid-washed plastic	Filtration required * Acidify with nitric acid to pH = 1 – 2, refrigerate.	6 months acidified
Major cations	Plastic	Chilled	Ca, Mg: 7 days Na, K: 28 days
Chloride	Plastic	None required	1 month @ 4°C or frozen
Cyanide	Opaque plastic	Add sodium hydroxide to pH > 12 **	14 days
Nitrate	Plastic	Filter on site and chill / freeze	2 days @ 4°C 30 days @ -20°C
Nitrite or Total nitrogen	Plastic	Chill / Freeze	2 days @ 4°C 30 days @ -20°C
Dissolved Phosphorus	Plastic	Filter on site, chill / freeze	2 days @ 4°C 30 days @ -20°C
Total Phosphorus	Plastic	Chill / Freeze	2 days @ 4°C 30 days @ -20°C
Sulfate	Plastic	Refrigerate	1 week @ 4°C 28 days frozen
Hydrocarbons	Amber glass	Do no fill completely. Acidify with sulphuric or hydrochloric acid to pH 1 – 2, refrigerate.	14 days @ 4°C

* Filter through 0.45 µm cellulose acetate membrane filter. Total metals analysis does not require filtration

** If interfering compounds are present, alternative preservation techniques may be required – liaise with the laboratory to determine appropriate sample treatment.

13 DATA INTERPRETATION AND REPORTING

13.1 OBLIGATIONS

The obligation of an operator of a mining site in the Northern Territory is stipulated in the Mining Management Act Part 3, Division 1 s 16 (2) as:

> *...ensuring that the environmental impact of mining activities is limited to what is necessary for the establishment, operation and closure of the site. Further, the operator must establish, implement and maintain an appropriate environment protection management system and ensure by regular assessment of that system that it operates effectively. This can be adequately demonstrated by the regular submission of a report detailing the analysis and interpretation of monitoring data, and comparison with background or pre operation data*.

13.2 INTERPRETATION OF RESULTS

Water quality data should be analysed and interpreted on an ongoing basis to identify potential impacts and/or assess the status of existing known impacts. Surface water quality data are to be reviewed monthly, as they are obtained from the field or laboratory. These should be compared with all previous data to assess trends.

The concept of trigger values does not readily apply to the majority of the monitored surface water within the TBGP. Due to the nature of the water that will be present in the TD, Water Storage Dam, and CRD (i.e. this water is likely to have elevated concentrations of arsenic), these facilities have been designed to be fully contained, and no releases of surface water to the environment are planned or expected. Thus, setting specific threshold values for particular constituents is not warranted. Monitoring of these facilities is instead conducted with the purpose of identifying the relevant properties of the water for use within the processing circuit, and so that constituents of particular concern can be identified in the highly unlikely case of unexpected releases to the environment.

Specific trigger values can, however, be set for the sediment traps. As these facilities have been designed to remove 90 % of material ≥ 0.045 mm in diameter, measurements of sediment trap inflow and outflow will demonstrate this level of removal efficiency, when averaged over 12 rainfall events each year.

The current Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000) do not provide any guidance for acceptable levels of oil/grease or petroleum hydrocarbons in surface water. Therefore, an alternative two-tiered trigger value system is proposed for monitoring total petroleum hydrocarbons (TPH) in the sediment traps):

- If concentrations of TPH > 15 mg/L are detected, the efficiency of the oil/grease traps is to be assessed, and improvements made, where necessary.
- If concentrations of TPH > 30 mg/L are detected, the oil/grease traps are considered not to be functioning properly, and improvements to their functioning will be made.

13.3 QUALITY ASSURANCE / QUALITY CONTROL

The collection of field and transport blanks (see Section 17.2.1) enables the identification of any deficiencies in the methodology employed in sample collection or any further training required by the environmental officers collecting the sample. Sample blanks that return greater than anticipated values for analytes may indicate exposure to atmospheric contaminants or introduction of contaminants to the sample by the operator during collection and treatment of the sample.

Replicate samples should return results within a determined acceptable relative percentage difference (RPD). This acceptable difference between results can be determined using the detection limits of the analytical procedure employed by the testing laboratory. For example, replicate samples that return a large RPD (≥20%) for high concentrations of analytes when compared with the detection limits are potentially indicative of a problem with sampling methodology and warrant further investigation and/or training. The converse is true when samples return a large RPD for low concentrations of analytes that are close to the detection limits of the analytical procedures employed. In these situations the large RPD is less indicative of potential methodological problems but does warrant further scrutiny with future sampling efforts. To calculate RPD the following equation is used:

$$\text{RPD}=\left[(C_1 - C_2) \div \frac{(C_1 + C_2)}{2}\right]\times 100$$

Where C1 = Concentration of analyte in sample 1 and C2 = Concentration of analyte in sample 2.

13.4 REPORTING

Surface water monitoring data should be recorded monthly and reported annually in the *Mining Management Plan* (MMP) in accordance with the *Mining Management Act 2001*. Reporting to regulatory authorities (through the MMP) and stakeholders at the appropriate level of detail is important to demonstrate the effective implementation of an environmental management system on site. The MMP will incorporate an annual water quality report, summarising the water quality data for the previous period, and discussing the implications for the continued management of the site and the potential risks to the environment. This report will include:

- Graphs summarizing water quality data
- Where applicable graphs should indicate:
  - site specific trigger values
  - “total” and “filtered” sample analysis results
- An interpretation and discussion of this data including:
  - identification of any issues (e.g. degrading water quality in a specific site/area);
  - actual and / or potential causes of issues and
  - conclusions drawn from the results.
- Details of any incidents affecting water quality;
- Details of actions taken to address any water quality issues;
- Commitments to specific areas for improvement in the next reporting period

- A list of water quality reporting requirements for wastewater discharge licence purposes if applicable (e.g. bi-monthly reporting due dates, annual report due date etc.).

All the raw data for the previous reporting period is to be presented as appendices to Part B (confidential section) of the MMP.

14 REFERENCES

ANZECC and ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand. Canberra, ACT.

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Standards Australia 1998a, AS/NZS 5667.1:1998: Water quality – sampling. Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples. Standards Australia, New South Wales.

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Standards Australia 1998c, AS/NZS 5667.6:1998: Water quality – Sampling. Part 6: Guidance on sampling of rivers and streams. Standards Australia, New South Wales.

Western Australia Department of Water (2009a): Field sampling guidelines: A guideline for field sampling for surface water quality monitoring programs. Perth.

Western Australia Department of Water (2009b): Surface water sampling methods and analysis – technical appendices: Standard operating procedures for water sampling methods and analysis. Perth.

15 ATTACHMENTS

Attachment 1: Field equipment list

ALS Sampling Pack

- ☐ Foam Esky
- ☐ Security Labels
- ☐ 1 x 500mL plastic (*none*) (green)
- ☐ 1 x 125mL plastic (*Sulfuric acid*) (purple)
- ☐ 1 **x 40mL Amber vials** (*Sulfuric acid*) (purple)
- ☐ 1 x **40mL** Amber vials (*Sulfuric acid*) (purple)
- ☐ 1 x **60mL** plastic (*none*) **(**red and green stripe)
- ☐ 2 x **40mL** Amber vials (*Sulfuric Acid)* (purple)
- ☐ 1 x **100mL** Amber glass (*none*) for primary analysis (orange)
- ☐ Syringes
- ☐ Filters

Field Gear

- ☐ Calibrated probe for measurement of *in situ* parameters (whatever you need or have available to you, e.g. Minisonde, Hydrolab, Quanta or WTW instruments), probe cover, protection cap, surveyor.
- ☐ Field filtering gear (e.g. hand pump, filter tower, filter papers and tweezers) if required.
- ☐ Laboratory deionised (DI) water for field blanks (and quality control samples) if required.
- ☐ Deionised water in a spray bottle for cleaning filter tower (and spare deionised water for refills).
- ☐ Tap water for filling the probe protection cap and drinking water – in separate bottles.
- ☐ Bucket for measurement probes/surveyor.
- ☐ A copy of the sampling and analysis plan (SAP).
- ☐ A copy of the safety plan (includes emergency numbers and routes to nearest hospitals).
- ☐ Chain of custody (COC) forms.
- ☐ Field observation forms (FOF).
- ☐ Plastic lunch bag for COC/FOF to go into in eskies.
- ☐ Courier (or laboratory) information (where do you drop the samples off? e.g. road or air freight couriers; the office address; information to attach to esky with samples to ensure that they are couriered correctly and arrive at the laboratory).
- ☐ Eskies with ice bricks – make sure you have enough!
- ☐ Extendable grab pole sampler.
- ☐ Masking tape (always useful).
- ☐ Nitrile gloves, gumboots, waders, coveralls, safety glasses, sunscreen, hat, and any other personal protective equipment (PPE)
- ☐ Map of sites.
- ☐ A GPS, if sampling at a new site.
- ☐ Permanent marker and pens.
- ☐ Extra labels.
- ☐ Extra sample containers.
- ☐ Spare bucket to carry bottles to and from vehicle.

Attachment 2: Field sampling sheet

ABM	Field sampling sheet	ABM Twin Bonanza Mine Sample

Sampler/s: ____________ Station ID: ____________
Time: ____________
Location of sample: ____________ Water depth: ____________
Weather: ____________

Surface Water Sample ID: Sample depth (below surface m) ____________
Sample Time: ____________
Wet or Dry Weather event:
Number of Sampling Attempts:
Problems during collection:

QC SAMPLE DATA

QA/QC Sample IDs:

NONE DUP ____________ BLANK ____________

SURFACE WATER DATA & CONDITIONS

pH	EC	EH	TEMP	DO	Turbidity	Salinity	Comments

Floating debris (describe): ____________
Water colour: ____________
Clarity: ____________
Turbidity: ____________
Odour: ____________

Sample Analytical Parameters:		Bottleware/ Preservation:	Label Colour of bottle:
INORGANICS			
Alkalinity, EC, pH, Cations, Chloride, Sulphate, Fluoride, TDS, Acidity		1 x 500mL plastic (*none*)	Green
Total Phosphorus		1 x 125mL plastic (*Sulfuric acid*)	Purple
DOC (Field Filtered)		1 x 40mL Amber vials (*Sulfuric acid*)	Purple*
TOC		1 x 40mL Amber vials (*Sulfuric acid*)	Purple*
METALS			
Dissolved Heavy Metals (Field Filtered)		1 x 60mL plastic (*none*) AIRFREIGHT OPTION	Red & Green Stripe
ORGANICS			
TPH(C_6-C_9)		2 x 40mL Amber vials (*Sulfuric Acid)*	Purple*
TPH (C_{10}-C_{36})		1 x 100mL Amber glass (*none*) for primary analysis.	Orange *

Coments / Observations:

Attachment 3: Chain of Custody form

CHAIN OF CUSTODY

*ALS Laboratory: **please tick** →*

☐ **Sydney**: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com

☐ **Newcastle:** 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com

☐ **Brisbane**: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com

☐ **Townsville:** 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com

☐ **Melbourne**: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com

☐ **Adelaide:** 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com

☐ **Perth**: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com

☐ **Launceston:** 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:

OFFICE:

PROJECT: **PROJECT NO.:**

ORDER NUMBER: **PURCHASE ORDER NO.:**

PROJECT MANAGER: **CONTACT PH:**

SAMPLER: **SAMPLER MOBILE:**

COC Emailed to ALS? (YES / NO) **EDD FORMAT (or default):**

Email Reports to (will default to PM if no other addresses are listed):

Email Invoice to (will default to PM if no other addresses are listed):

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)

☐ Standard TAT **(List due date):**

☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.:

COUNTRY OF ORIGIN:

COC SEQUENCE NUMBER (Circle)

COC: 1 2 3 4 5 6 7

OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact?	Yes	No	N/A
Free ice / frozen ice bricks present upon receipt?	Yes	No	N/A
Random Sample Temperature on Receipt:	°C		
Other comment:			

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
DATE/TIME:	DATE/TIME:	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where **Metals** are required, specify **Total** (unfiltered bottle required) or **Dissolved** (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES									Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
					TOTAL									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Gl
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

Attachment 4: Field sampling health and safety forms

JOB SAFETY ANALYSIS

JSA Number :		**Supervisor:**	**Date of issue:**		**Time of issue:**	
JSA Team	**Scribe:**					
	Facilitator:					
Description of Work/Task:			**Work Location:**			
Qualifications & Training Requirements:			**Tools, Equipment & Substances Required:**			
Isolation Requirements: *(Please List)*						

PERSONAL PROTECTIVE EQUIPMENT - Place a cross in the box of the PPE required to do the task

WORK PERMITS REQUIRED - Place a cross in the box of the required permit

Confined Space Entry		Work Box		HV Electrical Permit		Excavation / Penetration		Floor Roof Wall Opening		O/Side Vessel – Platform		Other	
Live Electrical Work		Non Standard Lift		ATWP Permit		Hot Work		Work at Height		Power Vicinity / Corridor Access		Other	

JOB SPECIFIC RESOURCES – Place a cross in the box of resources required

Barricading		Sentry & Sentry Board		Fire Blankets		Phones		Other					
Drinking Water		Running Water		Voltage Reducer		Extinguishers		Other					
Warning Signs		Fire Watch		Radio		First Aid Kit							

Step No	**Job Step** (Break the job into logical stages)	**Existing & Potential Hazards** (associated with this step)	**Initial Risk**	**Control Measures** (implemented to reduce the level of risk to acceptable levels)	**Residual Risk**	**Controls in place prior to commencement of task**

JOB SAFETY ANALYSIS

						Whom responsible	Initial

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JOB SAFETY ANALYSIS

Step No	Job Step (Break the job into logical stages)	Existing & Potential Hazards (associated with this step)	Initial Risk	Control Measures (implemented to reduce the level of risk to acceptable levels)	Residual Risk	Controls in place prior to commencement of task	
						Whom responsible	Initial

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JOB SAFETY ANALYSIS

Sign Off By Persons Conducting the Work:					
Name	***Signature***	***Position***	***Signature***	***Name***	***Position***
Authorised By:					
Name	***Signature***	***Position***	***Signature***	***Name***	***Position***

Situations to consider

Work Environment	**Human Factors**	**Skills required**	**Can anyone be:**
Illumination/ Lighting	Pace, stamina	Truck operator	Crushed, sheered or cut
Noise	Complexity	Machine operator	Injured by ejected objects or substances under pressure – compressed air or hydraulic fluid
Temperature / Humidity	Familiarity, Job knowledge, Repetition	Boiler maker / Mechanic	Electrocuted
Vibration	Concentration, Alertness	Dogman	Slip or trip or fall
Dust	Resources available to do the job	Crane driver	Fall from heights - unprotected edges, brittle surfaces, fall from ladder
Space available	Manual handling	Forklift operator	Strain from pulling, pushing, lifting
Tools, Equipment	Time	Engineer	Exposure to a substance - inhalation, ingestion, skin or eye exposure
Facilities to be used	Existing Work Instructions	Electrician	Exposed to excessive noise, heat or cold
	Supervision	Observer/Spotter	Risk of fire, explosion or major spill

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JOB SAFETY ANALYSIS

Risk Calculator – use this methodology for both initial and residual risk

Step 1 – Consider the consequences
What are the consequences of this incident occurring? Consider what could reasonably have happened as well as what actually happened. Look at the descriptions and choose the most suitable Consequence

Step 2 – Consider the likelihood
What is the likelihood of the consequences identified in step 1 happening? Consider this without new or interim controls in place. Look at the description and choose the most suitable Likelihood.

Step 3 – Calculate the risk
1. Take Step 1 rating and select the correct column
2. Take Step 2 rating and select the correct line.
3. Circle the risk score where the two ratings cross on the matrix:

Hierarchy of control

Elimination	Eliminate the risk altogether. *eg. stop the activity altogether.*
Substitution	Substitute a hazardous item with a safer alternative. *eg. use water based chemicals rather than solvent based chemicals*
Isolation / Engineering	Isolate the hazard from workers and/or install equipment to counteract the hazard. *eg.Install machine guarding, mechanical lifting aids, exhaust ventilation.*
Administrative	Procedures and work practices to control the hazard. *eg. Training / Procedures / Job rotation for repetitive tasks.*
PPE	Specialised clothing to protect workers from the hazard. *eg. ear plugs / safety glasses / gloves / high-visibility clothing.*

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Risk Matrix

CONSEQUENCE		Insignificant	Minor	Moderate	Major	Catastrophic
LIKELIHOOD	Almost Certain	11	16	20	23	25
	Likely	7	12	17	21	24
	Possible	4	9	13	18	22
	Unlikely	2	5	10	14	19
	Rare	1	3	6	8	15

SEVERITY RANKING	RESPONSE
Extreme	Immediately stop the job
High	Immediate risk controls required, including instruction and training to exposed persons
Medium	Risk controls required as soon as possible
Low	Maintain Risk Awareness – introduce additional controls if practicable

CONSEQUENCE	PRIMARY INCIDENT TYPE			
	INJURY, ILLNESS, DISEASE	SYSTEM OR PROCESS FAILURE	ENVIRONMENTAL EFFECTS	PROPERTY DAMAGE
INSIGNIFICANT	Low-level short-term subjective inconvenience or symptoms. No measurable physical effects. No medical treatment.	Immediate corrective action. No loss of production. No damage to equipment	No lasting detrimental impacts. Little impact on environment. Minor repairable damage. Minor infringement of cultural values.	> $1,000
MINOR	Nature and severity of the injury determines the classification, not who delivers the treatment: Any one-time treatment & any follow-up visit for observation	Minor damage to equipment and/or facility. No loss of production.	Short-term impact with no lasting detrimental effects. Minor permanent disturbance or damage to significant structures or sites.	> $10,000
MODERATE	Any work injury/illness incurred which results in a modified or alternate work program being established. No lost time.	Serious service deficit. Moderate damage to equipment and/or facility. Loss of production < one day	Significant general impact or damage. Significant impact on environment. Moderate permanent damage to significant structures or sites.	> $100,000
MAJOR	Any incident where the employee is affected to such an extent that they are required to take time off from work.	Potential loss of business. Major system failure. Loss of production < one week	Widespread impact. Destruction with long-term effects to environment, endangered species, flora and fauna. Significant damage to structures, sites or items of cultural significance.	> $1,000,000
CATASTROPHIC	Fatality and/or severe irreversible disability or impairment(>%30)	Loss or major client due to service deficit. Urgent corrective or remedial action. Loss of production >one week.	Extensive long-term detrimental impacts on the environment, community, public health. Total destruction of highly valued structures, sites or items of cultural significance or sacred value.	>$10,000,000

Rating/Level	Measure – What is the likelihood of the hazard resulting in an incident?
Almost Certain	The event will occur more than once per year
Likely	The event will occur once every 3 years
Possible	The event will occur once every 10 years
Unlikely	The event does occur somewhere from time to time.
Rare	Have heard of the event occurring elsewhere

APPENDIX A

STANDARD OPERATING PROCEDURE (SOP) FOR GROUNDWATER MONITORING

SOILWATER CONSULTANTS

Standard Operating Procedure for Groundwater Monitoring	
Prepared for:	**Twin Bonanza Gold Project**
Date of Issue:	11 December 2013
Project No.:	ABM-001-01-03
Document Ref:	Groundwater SOP_RevC1_131210

Distribution:

Electronic Copy – Justin Robins (ABM Resources)

SWC

DOCUMENT STATUS RECORD

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Project No.:	ABM-001-01-03
Client:	Twin Bonanza Gold Project

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Revision Code*	Date Revised	Revision Comments	Signatures		
			Originator	Reviewer	Approved
A1	21/08/13	Internal review of report	JP	ASP	-
B1	21/08/13	Draft SOP issued for client review	JP	ASP	ASP
C1	10/12/13	Final document issued to client	JP	ASP	ASP

Revision Code*

A - Report issued for internal review

B - Draft report issued for client review

C - Final report issued to client

LIMITATIONS

The sole purpose of this report and the associated services performed by Soil Water Consultants (SWC) was to prepare a Groundwater Monitoring Standard Operating Procedure (SOP) for the Twin Bonanza Gold Project. This work was conducted in accordance with the Scope of Work presented to ABM Resources ('the Client'). SWC performed the services in a manner consistent with the normal level of care and expertise exercised by members of the earth sciences profession. Subject to the Scope of Work, the Groundwater Monitoring SOP was confined to Twin Bonanza Gold Project Area. No extrapolation of the results and recommendations reported in this study should be made to areas external to this project area. In preparing this study, SWC has relied on relevant published reports and guidelines, and information provided by the Client. All information is presumed accurate and SWC has not attempted to verify the accuracy or completeness of such information. While normal assessments of data reliability have been made, SWC assumes no responsibility or liability for errors in this information. All conclusions and recommendations are the professional opinions of SWC personnel. SWC is not engaged in reporting for the purpose of advertising, sales, promoting or endorsement of any client interests. No warranties, expressed or implied, are made with respect to the data reported or to the findings, observations and conclusions expressed in this report. All data, findings, observations and conclusions are based solely upon site conditions at the time of the investigation and information provided by the Client. This report has been prepared on behalf of and for the exclusive use of the Client, its representatives and advisors. SWC accepts no liability or responsibility for the use of this report by any third party.

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16 INTRODUCTION

16.1 PURPOSE OF THIS DOCUMENT

This document aims to provide standard procedures for trained staff at the Twin Bonanza Gold Project engaged in groundwater sampling. This document is designed to work in conjunction with the Water Management Plan (WMP) to ensure a high standard of monitoring data collection, analysis, and reporting. This document was prepared in accordance with the Northern Territory (NT) Department of Mines and Energy (DME) Advisory Note on the '*Methodology for the Sampling of Ground Waters*', and with reference to the requirements of the *Minerals Titles Act 2010*, the *Mining Management Act 2001*, the appropriate Australian Standards (e.g. AS 5667.1:1998; 5667.4:1998; 5667.6:1998; and 5667.11:1998) and the *Mine Site Water Management Handbook* (Mineral Council of Australia, 1997).

16.2 SCOPE OF THIS DOCUMENT

This document details groundwater monitoring procedures for field staff at the Twin Bonanza Gold Project, from initial preparation for sampling through to field collection and measurement and final data analysis and Quality Assurance / Quality Control (QA/QC). Details of the overall monitoring programme, including the selection of sampling sites and the selection of particular analytes are covered in the Water Management Plan.

16.3 UPDATES TO THIS DOCUMENT

This is designed to be a "living document", and is expected to change as accepted sampling methodology and the site sampling program evolves. More site-specific information may also be incorporated to replace generic descriptions as the operation develops (e.g. a field sampling sheet should be attached in place of the generic information in Section 17.3), and the locations of monitoring points should be updated as they are added or removed.

16.4 OVERVIEW OF THE GROUNDWATER MONITORING PROGRAMME

16.4.1 SAMPLING LOCATIONS

Groundwater monitoring sites have been selected according to the Australian Guidelines for Water Quality Monitoring and Reporting (ARMCANZ, 2000) so that representative samples of the un-impacted (native or control) and potentially impacted groundwater may be collected both in the pre-mine period and throughout the life of mine. The monitoring program has been designed as a "Before-After, Control-Impact" (BACI) program, with priority applied to early detection, and assessment of biodiversity or ecosystem level response.

Because the majority of the proposed disturbance has not occurred, true pre-mine or "background" data may still be collected from the proposed monitoring bores in the period prior to full-scale mining activity. In addition, several continuous control sites (or "analogues") will be established in areas outside of the potential influence of site activities to monitor background levels throughout the life of mine. Therefore, the monitoring program is considered a BACI-style program according to ARMCANZ (2000), (Figure 4.2). This type of program design allows for the same parameters to be monitored at the control sites and the potentially impacted sites to determine whether or not any observed patterns of behaviour are likely to be due to natural variations or the impacts of site activities.

The proposed groundwater monitoring locations are specified in Table 4.3 and shown on Figure 4.3

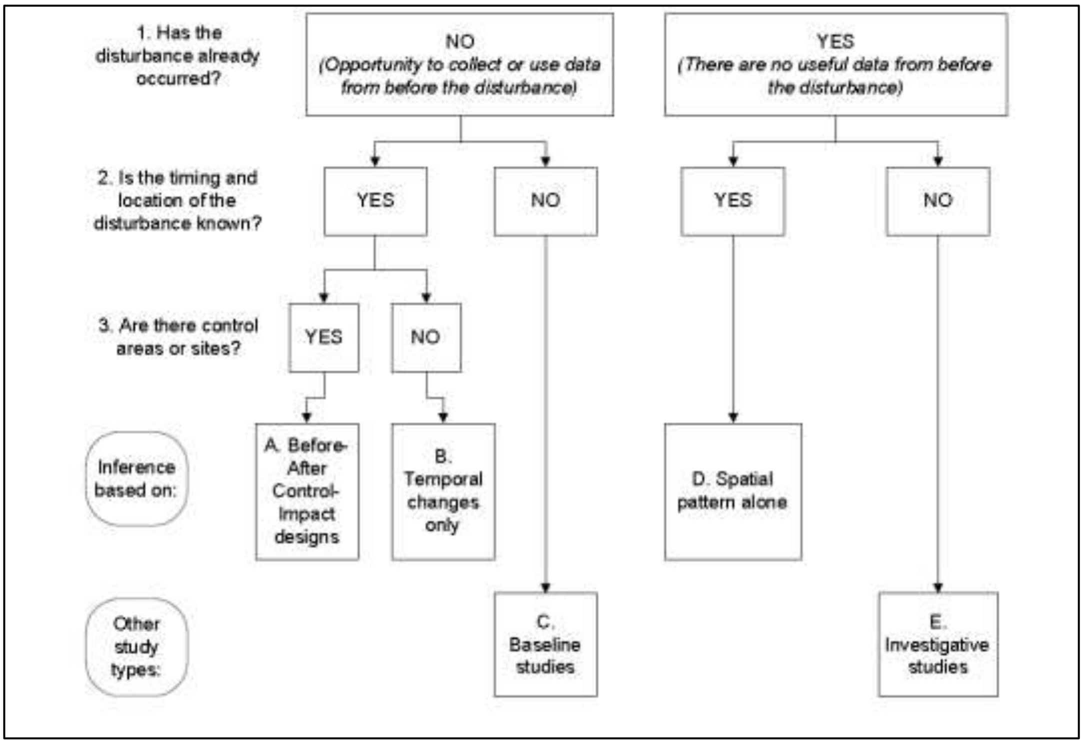
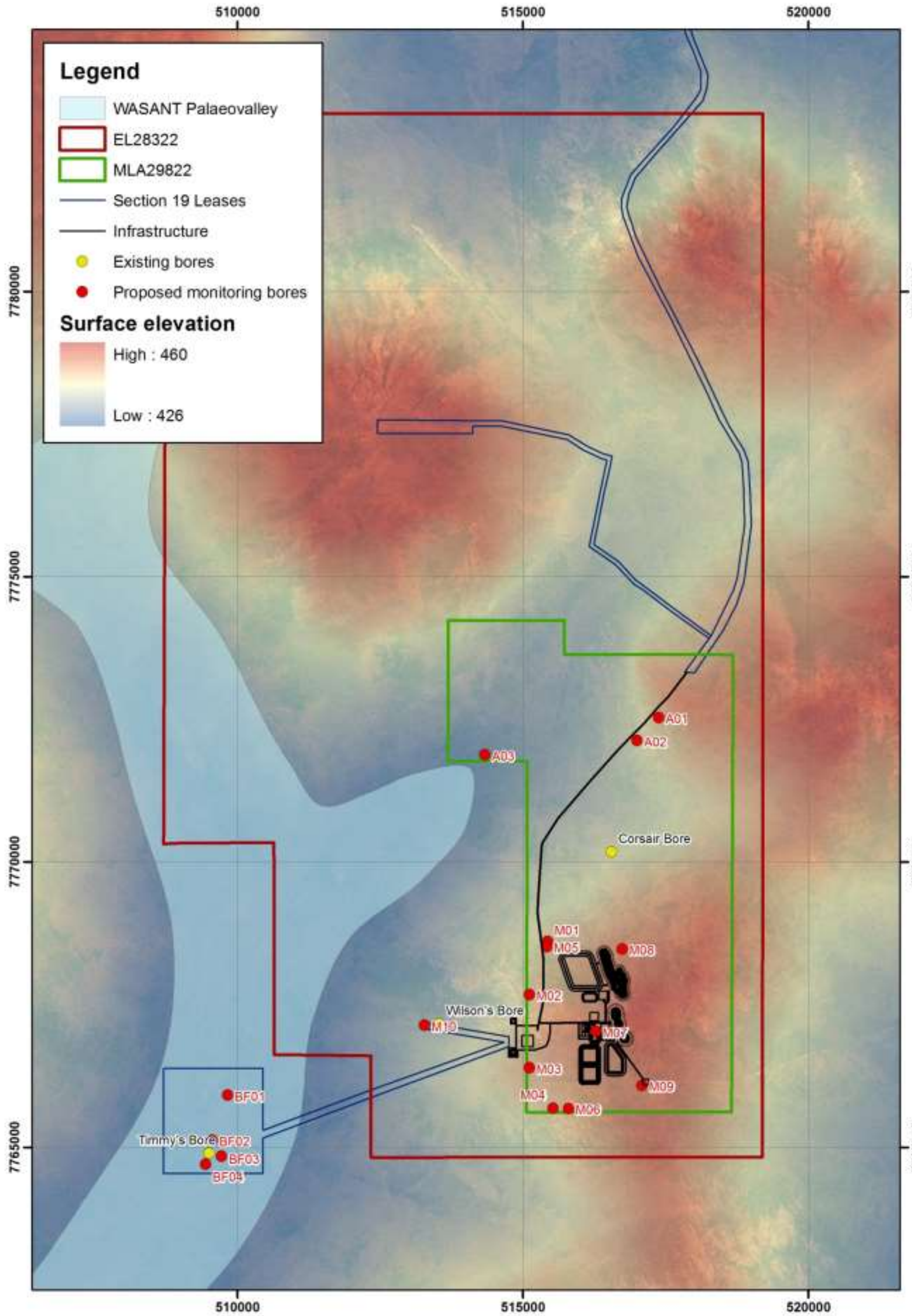


Figure 1: Monitoring program selection (ARMCANZ, 2000)

Table 1: Proposed groundwater monitoring locations

ID	General Location	Easting	Northing	Type	Aquifer
CB	Corsair's Bore	516550	7770180	Production bore	Bedrock
WB	Wilson's Bore	513529	7767170	Production bore	Palaeochannel
TB	Timmy's Bore	509507	7764901	New production bore	Palaeochannel
A01	4.1 km north of site	517374	7772534	Analogue	Bedrock
A02	3.7 km north of site	516995	7772128	Analogue	Palaeochannel
A03	3.7 km northwest of site	514335	7772882	Analogue	Palaeochannel
BF01	1 km up-gradient of TB	509830	7765915	Monitoring bore	Palaeochannel
BF02	200 m up-gradient of TB	509559	7765126	Monitoring bore	Palaeochannel
BF03	200 m adjacent to TB	509726	7764848	Monitoring bore	Palaeochannel
BF04	200 m down-gradient of TB	509444	7764705	Monitoring bore	Palaeochannel
M01	Down-gradient of WRD1	515432	7768610	Monitoring bore	Palaeochannel
M02	Down-gradient of WRD1	515115	7767679	Monitoring bore	Palaeochannel
M03	Down-gradient of TD / WRD2	515115	7766395	Monitoring bore	Palaeochannel
M04	Down-gradient of TD / WRD2	515525	7765687	Monitoring bore	Palaeochannel
M05	Northwest of WRD 1	515417	7768518	Monitoring bore	Bedrock
M06	Southwest of TD	515794	7765681	Monitoring bore	Bedrock
M07	Central to the site	516269	7767033	Monitoring bore	Bedrock
M08	Northeast of pits	516738	7768477	Monitoring bore	Bedrock
M09	Southeast of WRD 2	516951	7766088	Monitoring bore	Bedrock
M10	200 m down-gradient of WB	513277	7767141	Monitoring bore	Palaeochannel



ABM Resources NL	Figure 2: Groundwater monitoring locations	soilwater GROUP	
WMP for the Twin Bonanza Gold Project			

16.4.2 Sampling frequency

In general, groundwater monitoring activities will take place monthly. Groundwater extraction rates and volumes will be recorded automatically and on an ongoing basis by the flow meters; however, this information will be summarised monthly along with the rest of the monitoring data.

16.4.3 Parameters to be measured

A standard set of monitoring parameters will be implemented for all monitoring locations (see Table 4.4). The list of analytes applies to all “production”, “analogue”, and “monitoring” bores described in Table 4.3, with the exception of BF01 BF04, which will be used primarily for monitoring water levels in the palaeochannel aquifer.

In addition to the chemical analysis, groundwater elevations and extraction rates will also be monitored. Depth to groundwater will be recorded at all “analogue”, and “monitoring” bores described in Table 4.3, with water depth also being recorded in the “production” bores where practicable. All “production” bores will be fitted with a flow metering device capable of continuous recording of the extracted flow rate and volume.

Table 2: Analytes for groundwater quality monitoring

Parameter	Units	Limit of Detection	Method Reference	Method
Field Parameters				
pH	-	0.01	APHA 4500-H^+ B	Electrometry
Electrical Conductivity (EC)	μS/cm	1	APHA 2510 B	Electrode
Temperature	°C	0.1		Electrode
Oxidation-reduction potential (ORP)	mV	1		Photometry
General Parameters				
pH	-	0.01	APHA 4500-H^+ B	Electrometry
Electrical Conductivity (EC)	μS/cm	1	APHA 2510 B	Electrode
Total Dissolved Solids (TDS)	mg/L	10	APHA 2540 C	Gravimetry
Alkalinity – Total (as $CaCO_2$)	mg/L	1	APHA 2320 B	Titration
Ionic balance	Ratio (mg/L:mg/L)	1 mg/L		ICP-AES
Major Ions & Ligands				
Calcium (Ca^{2+})	mg/L	1	APHA 3210	ICP-AES
Potassium (K^+)	mg/L	1	APHA 3210	ICP-AES
Magnesium (Mg^{2+})	mg/L	1	APHA 3210	ICP-AES
Sodium (Na^+)	mg/L	1	APHA 3210	ICP-AES

Parameter	Units	Limit of Detection	Method Reference	Method
Chloride (Cl^-)	mg/L	1	APHA 4500-Cl^-B	Titration
Fluoride (F^-)	mg/L	0.1	APHA 4500-F^- C	Ion-selective electrode
Sulfur Species				
Sulfate ($SO4^-$)	mg/L	1	APHA 4500-SO_4^- E	Turbidimetry
Nutrients				
Nitrate (NO_3^- as N)	mg/L	0.01	APHA 4500-NO_3^- I	FIA-Photometry
Ammonia (as N)	mg/L	0.01	APHA 4500-NH_3^- H	FIA-Photometry
Reactive Phosphorus as P	mg/L	0.01	APHA 4500 P–G	FIA-Photometry
Phosphorus – Total	mg/L	0.01	APHA 4500 P–H	FIA-Photometry
Total Kjeldahl nitrogren (TKN as N)	mg/L	0.1	APHA 4500-N_{org} D	FIA-Photometry
Chemical Oxygen Demand (COD)	mg/L	5	APHA 5220 B	Titration
Carbon				
Total Organic Carbon (TOC)	mg/L	1	APHA 5310 B	IR Spectrometry or titration
Dissolved Organic Carbon (DOC)	mg/L	1	APHA 5310 B	IR Spectrometry or titration
Cyanide				
Free Cyanide (CN-)	mg/L	0.004	APHA 4500-CN- C&N	FIA-Photometry
Weak Acid Dissociable (WAD) Cyanide (CN-)	mg/L	0.004	APHA 4500-CN- I&N	FIA-Photometry
Total Cyanide (CN-)	mg/L	0.004	APHA 4500-CN- C&N	FIA-Photometry
Metals - Dissolved				
Aluminium (Al)	mg/L	0.01	USEPA 6020	ICP-MS
Antimony (Sb)	mg/L	0.001	USEPA 6020	ICP-MS
Arsenic (As)	mg/L	0.001	USEPA 6020	ICP-MS
Boron (B)	mg/L	0.05	USEPA 6020	ICP-MS
Cadmium (Cd)	mg/L	0.0001	USEPA 6020	ICP-MS
Chromium (Cr)	mg/L	0.001	USEPA 6020	ICP-MS
Copper (Cu)	mg/L	0.001	USEPA 6020	ICP-MS
Lead (Pb)	mg/L	0.001	USEPA 6020	ICP-MS
Nickel (Ni)	mg/L	0.001	USEPA 6020	ICP-MS
Manganese (Mn)	mg/L	0.001	USEPA 6020	ICP-MS
Selenium (Se)	mg/L	0.01	USEPA 6020	ICP-MS
Uranium (U)	mg/L	0.001	USEPA 6020	ICP-MS
Vanadium (V)	mg/L	0.01	USEPA 6020	ICP-MS
Zinc (Zn)	mg/L	0.005	USEPA 6020	ICP-MS
Mercury (Hg)	mg/L	0.0001	APHA 3112-Hg B	CV/FIMS

Parameter	Units	Limit of Detection	Method Reference	Method
Hydrocarbons				
Total Petroleum Hydrocarbons (TPH) TPH (C6-C9) plus TPH (C10-C36)	µg/L	20	USEPA 5030	P&T/GC/MS
Biological indicators				
E. Coli	cfu/100 mL	1	-	-

17 PREPARATION FOR SAMPLING

Being prepared for a groundwater monitoring event means having the right equipment, sample bottles, safety gear, and a sampling plan in place before setting out. This section outlines standard procedures to ensure that field staff are well-prepared and able to collect high-quality monitoring data.

17.1 EQUIPMENT PREPARATION

Any equipment that will come into contact with water samples (e.g. pumps, bails, scoops) must be appropriately cleaned and decontaminated prior to each sampling round. Sampling equipment should be washed using detergent and tap water, and then rinsed thoroughly with deionised (DI) water. Sampling equipment should be rinsed with DI water again in between collection of each sample. Cleaning and preparation of sample bottles is discussed in Section 17.2.

Field meters (e.g. pH and conductivity meters) must be calibrated according to the manufacturer's instructions at the start of each day of monitoring. Calibration checks should also be performed periodically throughout the day. Calibration should be performed using standards of a known concentration appropriate to the anticipated range of values in the water to be sampled. Calibration standards should be stored appropriately (e.g. keep refrigerated and do not exceed 'use by' dates) to ensure their accuracy. The required volume of standard should always be decanted into a suitable receptacle for calibration purposes and then discarded.

After all equipment is cleaned and calibrated, a field kit with the following items should be prepared to take out on the sampling round

- Field data sheets
- Completed sample labels
- Chain of custody forms
- Sampling pump and tubing
- Flow-through container
- Sample bottles for dispatch to laboratory (as detailed in Section 17.2)
- Filtration equipment and syringe (if necessary)
- Field parameter meters or test kits (e.g. alkalinity/acidity test kit)
- Groundwater level probe
- Powder-less nitrile gloves
- Esky and ice packs for preserving samples
- If required, appropriate preservative (e.g. nitric acid)
- Personal Protective Equipment (PPE), first aid, and communication equipment

A list of all equipment to be taken into the field is provided in Attachment 1.

17.2 SAMPLE BOTTLE PREPARATION

The chemical elements of interest dictate the type of bottle to be used for sampling (e.g. glass or plastic), and the method of preservation required (e.g. filtered, acid preserved, frozen). It is best to contact the analysing laboratory to determine preservation requirements prior to undertaking sampling, and to have sufficient pre-prepared sample bottles despatched to site.

17.2.1 NUMBER OF BOTTLES REQUIRED

Colour coded bottles are provided to make it easier for people to differentiate them. The colour coding scheme is summarised in Table 12. The number of bottles required for a standard sampling event is summarised in Table 13

Table 12. Sample bottle colour coding scheme

Test Parameter	Label Colour	Container Type (Preservation)
Alkalinity, EC, pH, Cations, Chloride, Sulphate, Fluoride, TDS, Acidity	Green	1 x 500mL plastic (none)
Total Phosphorus	Purple	1 x 125mL plastic (Sulfuric acid)
DOC (Field Filtered)	Purple*	1 x 40mL Amber vials (Sulfuric acid)
TOC	Purple*	1 x 40mL Amber vials (Sulfuric acid)
Dissolved Heavy Metals (Field Filtered)	Red & Green Stripe	1 x 60mL plastic (none) AIRFREIGHT OPTION
TPH(C6-C9)	Purple*	2 x 40mL Amber vials (Sulfuric Acid)
TPH (C10-C36)	Orange*	1 x 100mL Amber glass (none) for primary analysis.

Note: * These samples are for organics, and are supplied with Teflon lids

Table 13: Number of bottles required for normal sampling round

Bottle	Number required per sampling round
Green	TBD
Purple	TBD
Purple *	TBD
Orange *	TBD
Red & Green Stripe	TBD

Note: * These samples are for organics, and are supplied with Teflon lids

17.2.2 FIELD AND TRANSPORT BLANKS

In addition to the bottles required for sampling, one field blank and one transport blank are required for sampling every 6 months per analyte per day of sampling (i.e. one blank for metals, one for sulfate, etc.). Field and transport blanks are required as part of the QA/QC of the sampling programme (see Section 20). A field blank is used to estimate contamination of a sample during the collection procedure, and transport blank is used to estimate the contamination introduced during transport of the sample bottles to and from the field.

To obtain both a field and transport blank, the following procedure should be followed:

24. In the site laboratory, divide a water sample of appropriate quality into two parts.

25. Retain portion A at the site laboratory and transport portion B to the sampling site.
26. Divide portion B into two parts:
    a. portion B1 is used as a field blank, and
    b. portion B2 is used as a transport blank.
27. Process portion B1 using the same procedures used for sampling (e.g. pour it into the sample bottles using same sampling pump or scoops used for collection of the actual samples)
28. Return portions B1 and B2 to the laboratory using the same preservation and transport methods as the monitoring samples.
29. Portions A, B1 (field blank), and B2 (transport blank) can be analysed and results compared.

17.2.3 REPLICATE SAMPLES

Replication is the collection and analysis of more than one sample from the same location at the same time. This provides the experimental sampling error and thus a measure of the sampling precision. One replicate sample should be collected every 6 months per analyte, per sampling period.

17.2.4 BOTTLE WASHING

In the event that pre-preserved bottles cannot be obtained from the analysing laboratory the following guidelines may be followed.

All sample bottles must be washed prior to use. Unless otherwise prescribed, it is sufficient to wash both plastic and glass bottles using a standard detergent, according to the following procedure:

30. Wash container and cap with detergent and tap water.
31. Rinse thoroughly with tap water.
32. Rinse twice with DI water.
33. Drain thoroughly and replace cap.

For bottles requiring a solvent wash, use the following procedure:

34. Wash container and cap with detergent and tap water.
35. Rinse thoroughly with tap water.
36. Rinse twice with DI water and dry.
37. Rinse with acetone of an appropriate quality and drain
38. Rinse with a suitable solvent of an appropriate quality, dry and immediately replace cap.

NOTE: The solvent should be compatible with the analytes of interest and the analytical method to be used.

WARNING: Organic solvents may be hazardous. Provide suitable handling facilities and handle with care.

For bottles requiring acid-washing, use the following procedure:

39. Wash container and cap with detergent and tap water.
40. Rinse thoroughly with tap water.
41. Rinse with 10 % nitric acid.
42. Drain and fill with 10 % nitric acid.
43. Cap and store for at least a week.

44. Empty, rinse with DI water and immediately replace cap.

17.3 FIELD SHEETS

Field sheets should be used to record any details relevant to the subsequent analysis and interpretation of the results. This should include all the information necessary to assist in data interpretation and repeatability of sampling efforts, and should include:

- Location (and name) of monitoring bore or piezometer, with coordinates
- Details of bore, eg depth, screened interval, casing condition
- Date and time of sample collection
- Sampler name (or initials)
- Standing water levels
- Volume of water purged from bore or duration and rate of pumping prior to sampling
- Any relevant descriptive information (e.g. water level)
- Sample appearance at the time of collection (e.g. colour, clarity, odour)
- Field parameters measured, or results of any on site analysis (e.g. alkalinity).
- Sample treatment post collection (e.g. filtration, acidification)

An example of a field sheet is provided in Attachment 2.

17.4 HEALTH AND SAFETY CONSIDERATIONS

A risk assessment should be conducted prior to each sampling event to identify hazards and implement appropriate controls to reduce risks to safety and the environment. General guidance on safety matters is provided in the site Health and Safety Plan.

The following safety aspects should be considered when conducting any groundwater monitoring activities:

- The surface area around wells and boreholes should always be regarded with some caution since there may be a risk of surface collapse, especially around old wells.
- Suitable protective clothing must always be worn when undertaking sampling operations, and under no circumstances should any routine sampling activity continue if safety checks indicate that potentially unsafe conditions exist.
- When dealing with groundwater installations that are potentially contaminated, it is important to carefully consider and define the nature of the necessary safety checks.

A generic Job Safety Analysis (JSA) form is provided in Attachment 4.

18 FIELD MEASUREMENTS

In order for field measurements to be representative of the aquifer, samples withdrawn from the bore must reflect the spatial and temporal variation present in the aquifer. Standing water within a bore is often not representative of the water in the aquifer because it is exposed to atmospheric conditions and can undergo changes to its physical and chemical characteristics over time. Boreholes should therefore be purged before sampling by pumping 'to waste' a volume of water equivalent to at least 4 to 6 times the internal volume of the borehole (AS/NZS 5667.11-1998).

It is important that as many parameters as practicable are determined in the field, or as soon as possible after the sample has been collected. This is particularly important for physical parameters such as pH, electrical conductivity, dissolved oxygen and Eh (Redox). To accurately determine these parameters a continuous measurement technique, such as a flow through cell system, which minimises contact between the sample and the atmosphere, should be employed. The use of such a flow through cell system will also assist in the determination of stable chemistry prior to sample collection.

18.1 MEASURING STATIC WATER LEVEL

The depth to groundwater should be measured relative to an established reference point on the well casing and should be documented in the field records. This reference point is usually identified by the well installer using a permanent marker for PVC wells, or by notching the top of casing with a chisel for stainless steel wells. By convention, this marking is usually placed on the north side of the top of casing. If no mark is apparent, the person performing the measurements should take the water level reading from the north side of the top of casing and note this procedure on the recording sheet.

To properly measure the groundwater level in a monitoring bore:

- Decontaminate the measuring instrument (e.g. dipper tape) before lowering it into the well
- Remove the well cap and allow several minutes for the pressure in the well to equalise (this is a good time to set up the bore purging and sampling equipment)
- Lower the tape into the well until it indicates contact with the water surface.
- Move the tape up and down slowly several times in and out of the water to ensure the measurement is made at the precise top of the water surface
- Record the depth to water by reading the tape at the point where it meets the top of the bore casing (record to the nearest millimetre)

Static water level readings are possible in production bores only if the pumping equipment has been switched off for a sufficient length of time to allow full recovery of the groundwater table (this can take several days). An access tube is generally also required to allow clear passage of the water level probe past the pumping equipment.

18.2 BORE PURGING

If required, bore purging is completed by lowering a pump into the borehole to extract a volume of water sufficient to determine representative ground water chemistry. To properly purge a bore:

- Measure the depth to water in the well
- Calculate the total depth of water in the well (h) by:

$$h = [\text{total well depth}] - [\text{depth to water}]$$

- Calculate the well volume (in litres) by:

$$V = (D \div 2)^2 * h * 0.00314$$

Where V = well volume (L), D = well diameter (cm), and h = depth of the water column (m)

- Install pump in the well, ideally so that it abstracts water from near the top of the water column.
- Place pump outlet in a flow-through vessel.
- Purge 4 well volumes, using a low flow rate (ideally matched to the recharge rate so minimal drawdown occurs).
- Measure Temperature, pH, and electrical conductivity (EC) in the flow-through vessel as stabilisation indicators.
- If the values are stable for 3 consecutive readings (Temp ± 0.2°C, pH ± 10 %, EC ± 10 %), then measurements can be recorded, as per Section 18.3.
- If readings do not stabilise after 6 well volumes, then measurements can be recorded, as per Section 18.3.

Notes:

A variable pump rate can be employed to match extraction rates with borehole recharge rates and expedite the collection process. It is not recommended to use an air lift pump as the introduction of dissolved oxygen to the ground water will alter the sample.

Some bores will have a very slow recovery rate and may purge dry during sampling. If this occurs, make a note on the field sheet, and then allow it to recover overnight and come back and sample it directly the next day. Samples obtained in this manner are often highly turbid due to disturbance of sediment in the bore column, and the results from these samples should be interpreted with this in mind.

18.3 MEASURING FIELD PARAMETERS

Once the bore has been purged and the indicator readings have stabilised, field measurements can be recorded by placing the instruments directly in the flow-through vessel. The following should be recorded for each monitoring bore:

- pH
- Electrical conductivity (EC)
- Temperature
- Oxidation-reduction potential (ORP)

There is no need to stir the water with the instruments, as the water is already moving across the sensors as it flows through the vessel. However, instruments should be hand held, or otherwise installed in the vessel so that the sensing instruments are not in contact with the sides or bottom of the container. All readings should be stable (± 10 %) prior to recording.

If the meter is not compatible with the flow-through vessel, the outlet hose can be removed from the flow-through vessel to fill an appropriate container for immediate analysis.

18.4 MEASUREMENTS FROM PRODUCTION WELLS

There is no need to purge an operational production well prior to sampling because it is essentially being continuously purged under normal operating conditions. Field measurements may be made in a similar manner described in Section 18.3 by attaching a hose to the closest water spigot to the bore, and by setting up a flow-through vessel from this hose.

All readings should be stable (± 10 %) prior to recording.

19 COLLECTING SAMPLES FOR LABORATORY ANALYSIS

19.1 BORE PURGING

Bore purging should have already been completed according to the method described in Section 18.2. Collection of samples for laboratory analysis can proceed after the field parameters have been deemed stable.

19.2 SAMPLE COLLECTION

19.2.1 MONITORING BORES AND PIEZOMETERS

To collect a sample, use the overflow from the flow-through vessel, or the pump outlet hose, to fill the required sample bottles. If the bottles were not prepared with preservative in the laboratory, use the following method:

- Ensure that labelling on the bottle to be filled is correct and that the sample number matches the number on the paperwork.
- Perform any necessary filtration and/or preservation procedures, and fill the sample bottles. Note: ALS sample bottles contain preservatives and therefore should not be rinsed.
- Fill sample bottle with bore water.

If the sample bottles already contain preservatives (i.e. acid solutions), then the bottles should not be rinsed in the field, and can be filled directly from the overflow of the flow-through vessel or the pump outlet. All containers should be filled completely, to exclude air from the sample.

19.2.2 OPERATIONAL PRODUCTION BORES

To collect a sample, use the spigot or flow-through vessel described in Section 18.4 to fill the required sample bottles as per the method described in Section 19.2.1. The spigot and any attached tubing should be purged for a minimum of 60 seconds (but probably much longer, given the parameter stabilisation steps described in Section 18.4) prior to sampling.

19.3 FIELD FILTRATION

There are two main methods employed in the field filtration of water samples: pressure systems employing syringe, or gravitational pressure and vacuum filtration systems.

The standard procedure for syringe filtration is as follows:

- Draw an aliquot of the sample into the syringe from the flow-through vessel taking care to maintain an air gap between the base of the plunger and the sample to minimise contact and potential contamination.
- Dispense aliquot to waste to rinse syringe. Repeat.
- Draw an aliquot of the sample into the syringe taking care to maintain an air gap between the base of the plunger and the sample to minimise contact and potential contamination.
- Affix appropriate filter unit to syringe (between 0.4 and 0.5 μm) and dispense into laboratory sample container.
- Add any preservative to be used, re-seal laboratory sample container, and invert to mix thoroughly.

When using vacuum filtration, the pressure difference across the filter material is supplied via the application of a vacuum between the collected sample and the laboratory sample container. The standard procedure for vacuum filtration is as follows:

- Thoroughly clean filtration unit employing a method appropriate for the analyte of interest. For example, a filtration unit that is to be used for the collection of samples for metals analysis should be rinsed using a solution of 10% Hydrochloric acid followed by water of appropriate quality.
- Agitate sample bottle to thoroughly mix sample.
- Rinse the filter unit with the water to be sampled.
- Assemble filter unit taking care to not touch filter unit components that will be in contact with the sample or introduce small tears to the filter membrane.
- Apply vacuum
- Collect sample and distribute to laboratory sample bottles.
- Add any preservative to be used, re-seal laboratory sample container, and invert to mix thoroughly.

19.4 STORAGE AND TRANSPORT

Samples should be stored according to the preservation procedures summarised from AS/NZS 5667.1:1998 (or **Error! Reference source not found.**). Generally, samples are stored on ice (or ice-bricks) in an esky for transport to the laboratory. However, depending on holding times and how long it will take you to get your samples to the lab, you may need to freeze some of them (note that some samples should never be frozen). The appropriate method and period of storage is dependent on the analyte of interest and must be adhered to so that representative results from analysis are obtained.

While sample preservation will limit degradation, dispatch to the laboratory should occur as soon as practicable.

The specific procedure for transporting samples is outlined as follows:

- Take the esky and wrap it in the bubble wrap provided, ensuring that all the sample details are complete. Double check to ensure you have ticked the right boxes on the Red / Green and two of the Purple bottles.
- Take the sample back to the camp, and place the esky in the fridge or in the cold room. Hopefully you will have found some form of ice brick for transport.
- Fill in the Chain of Custody Form (see Attachment 3). As well as being the Sample Submission Form, this is a way of tracking who has been responsible for the sample. The person travelling with the sample should typically sign on in the initial position.
- If you are using the small foam esky use some tape to hold the lid on strongly, and make sure the Fragile sticker is in an obvious position.
- Remember to remove the sample from the fridge and take it with you to the sample drop off point of flight, along with the Chain of Custody form.

20 DATA INTERPRETATION AND REPORTING

20.1 OBLIGATIONS

The obligation of an operator of a mining site in the Northern Territory is stipulated in the Mining Management Act Part 3, Division 1 s 16 (2) as:

> *...ensuring that the environmental impact of mining activities is limited to what is necessary for the establishment, operation and closure of the site. Further, the operator must establish, implement and maintain an appropriate environment protection management system and ensure by regular assessment of that system that it operates effectively. This can be adequately demonstrated by the regular submission of a report detailing the analysis and interpretation of monitoring data, and comparison with background or pre operation data*.

20.2 INTERPRETATION OF RESULTS

Water quality data should be analysed and interpreted on an ongoing basis to identify potential impacts and/or assess the status of existing known impacts. Groundwater quality data are to be reviewed monthly, as they are obtained from the field or laboratory. These should be compared with all previous data to assess trends.

The monitoring program has been designed according to the *Australian Guidelines for Water Quality Monitoring and Reporting* (ARMCANZ, 2000) as a “Before-After, Control-Impact” (BACI) program (Figure 3 and Figure 4), with priority applied to early detection, and assessment of biodiversity or ecosystem level response. In order to determine if site activities are affecting the groundwater quality, the pre-disturbance, or “background”, groundwater quality must first be known. It is anticipated that the first 6-12 months’ worth of data collected from the “monitoring” and “analogue” bores will initially be used to set background levels, and this will be analysed and updated according to the *Australian Guidelines for Water Quality Monitoring and Reporting* (ARMCANZ, 2000) to develop a 24 month running average as further data is collected in subsequent sampling events. During site operation, the “analogue” bores will be used to track natural fluctuations in the background levels in both the bedrock and palaeochannel aquifer systems (i.e. a BACI analysis).

Once enough background data has been collected, trigger levels will be set according to appropriate statistical procedures, as outlined in ARMCANZ (2000). To allow for a high level of certainty that a trigger level has been exceeded, a value greater than the trigger level must be detected for three consecutive readings prior to initiating a response (e.g. arsenic detected at an elevated level in monitoring bore M05 for three consecutive months).

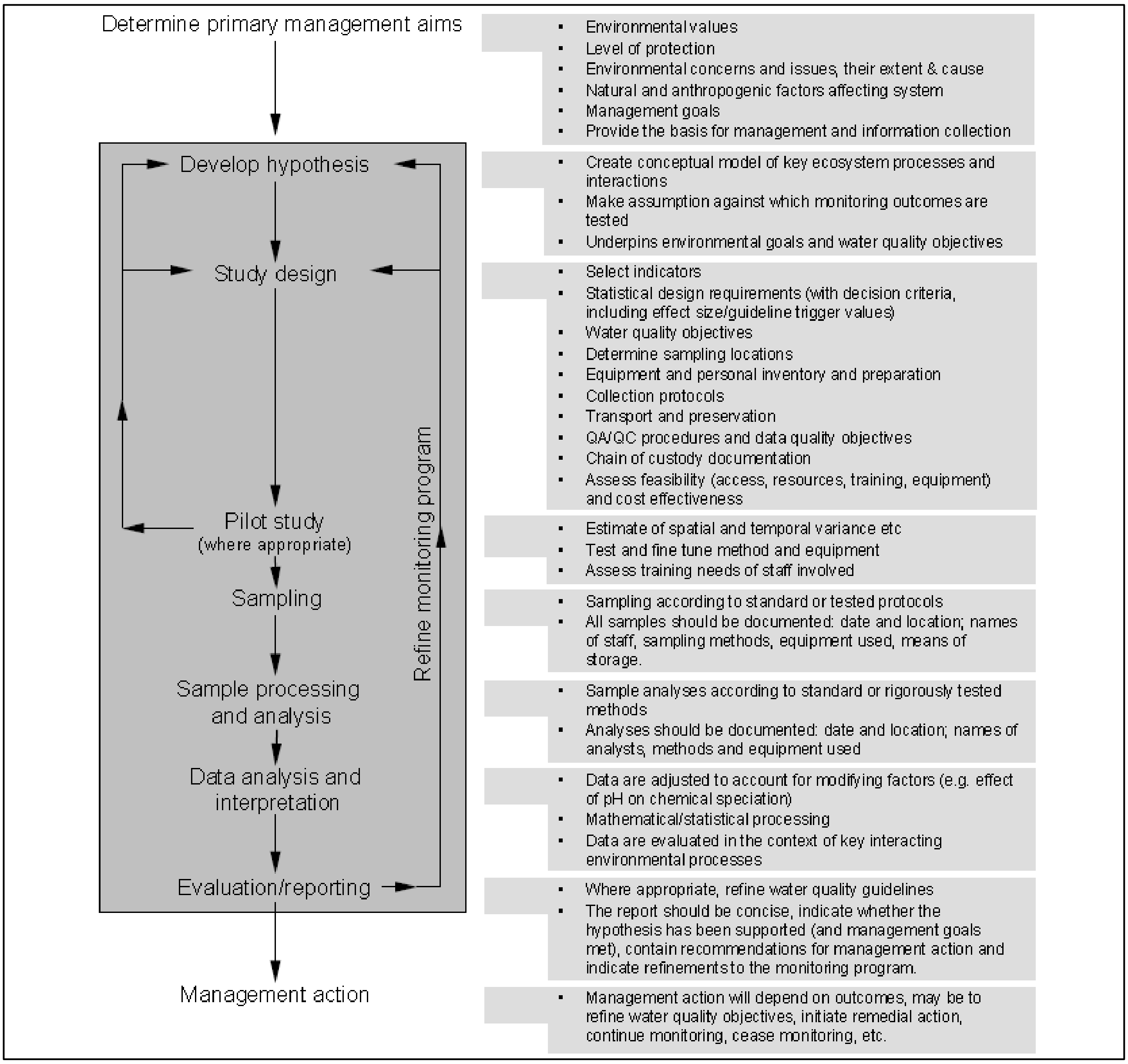


Figure 3. Procedural framework for the monitoring and assessment of water quality (ANZECC & ARMCANZ 2000)

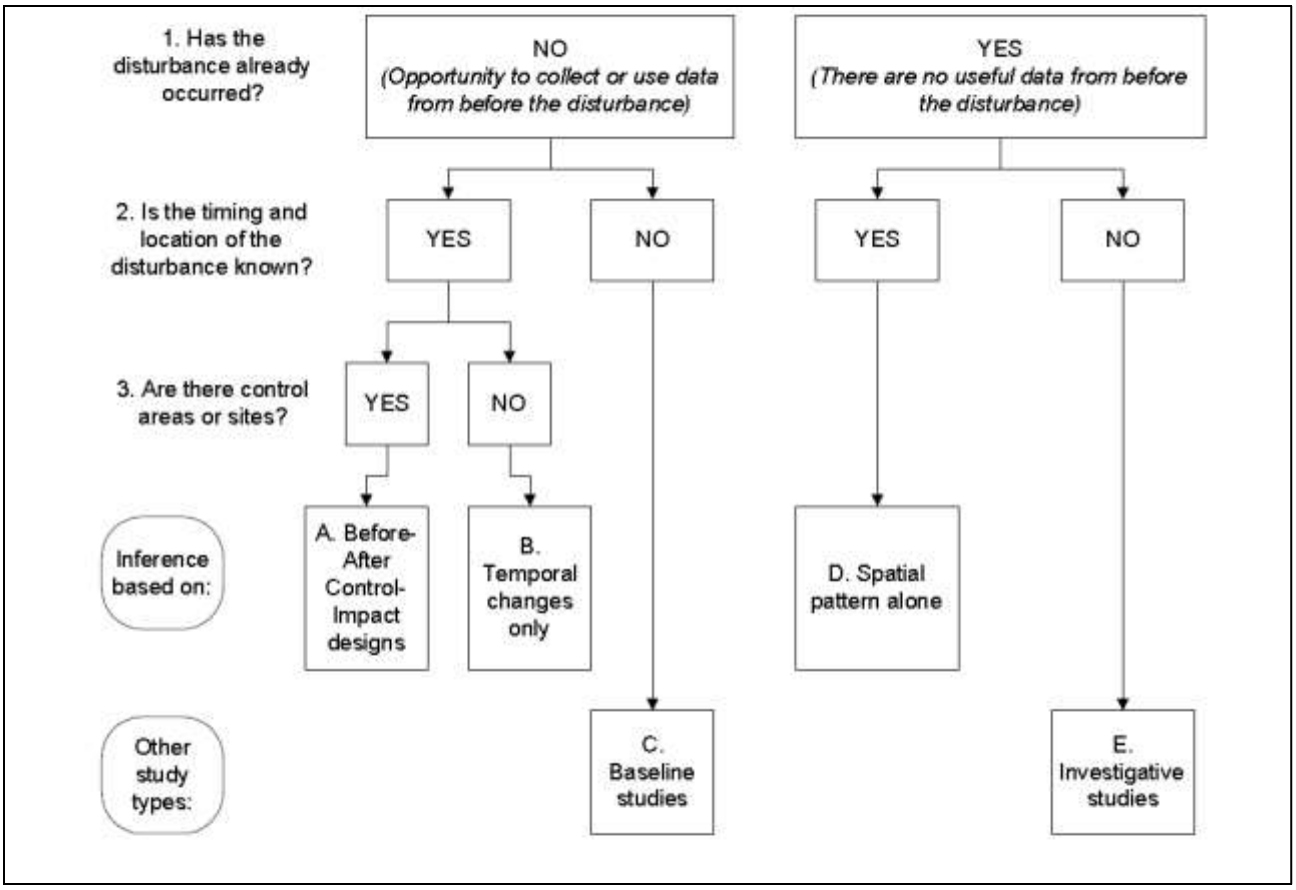


Figure 4. Monitoring program selection (ARMCANZ 2000).

20.3 QUALITY ASSURANCE / QUALITY CONTROL

The collection of field and transport blanks (see Section 17.2.1) enables the identification of any deficiencies in the methodology employed in sample collection or any further training required by the environmental officers collecting the sample. Sample blanks that return greater than anticipated values for analytes may indicate exposure to atmospheric contaminants or introduction of contaminants to the sample by the operator during collection and treatment of the sample.

Replicate samples should return results within a determined acceptable relative percentage difference. This acceptable difference between results can be determined using the detection limits of the analytical procedure employed by the testing laboratory. For example, Replicate samples that return a large relative percentage difference (≥20%) for high concentrations of analytes when compared with the detection limits are potentially indicative of a problem with sampling methodology and warrant further investigation and/or training. The converse is true when samples return a large relative percentage difference for low concentrations of analytes that are close to the detection limits of the analytical procedures employed. In these situations the large relative percentage difference is less indicative of potential methodological problems but does warrant further scrutiny with future sampling efforts. To calculate relative percentage difference:

$$\text{RPD}=\left[(C_1-C_2)\div\frac{(C_1+C_2)}{2}\right]\times 100$$

Where C1 = Concentration of analyte in sample 1 and C2 = Concentration of analyte in sample 2.

20.4 REPORTING

Groundwater monitoring data should be recorded monthly, and reported annually in the *Mining Management Plan* (MMP) in accordance with the *Mining Management Act 2001*. Reporting to regulatory authorities (through the MMP) and stakeholders at the appropriate level of detail is important to demonstrate the effective implementation of an environmental management system on site. The MMP will incorporate an annual water quality report, summarising the water quality data for the previous period, and discussing the implications for the continued management of the site and the potential risks to the environment. This report will include:

- Graphs summarizing water quality data
- Where applicable graphs should indicate:
  - site specific trigger values
  - "total" and "filtered" sample analysis results
- An interpretation and discussion of this data including:
  - identification of any issues (e.g. degrading water quality in a specific site/area);
  - actual and / or potential causes of issues and
  - conclusions drawn from the results.
- Details of any incidents affecting water quality;
- Details of actions taken to address any water quality issues;
- Commitments to specific areas for improvement in the next reporting period
- A list of water quality reporting requirements for wastewater discharge licence purposes if applicable (e.g. bi-monthly reporting due dates, annual report due date etc.).

All the raw data for the previous reporting period is to be presented as appendices to Part B (confidential section) of the MMP.

21 REFERENCES

ANZECC and ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand. Canberra, ACT.

ARMCANZ, A. a. (2000) Australian Guidelines for Water Quality Monitoring and Reporting. In National Water Quality Management Strategy. October. Canberra, ACT. Minerals Council of Australia (1997). Minesite Water Management Handbook. Minerals Council of Australia.Earth Systems (2013): Preliminary groundwater resources assessment for the Old Pirate Gold Project, Tanami Desert, Northern Territory. Prepared for ABM Resources NL by Earth Systems.

Minerals Council of Australia (1997). Minesite Water Management Handbook. Minerals Council of Australia.

Northern Territory Department of Mines and Energy (2009): Methodology for the sampling of ground waters. Advisory Note #: AA7-024.

Standards Australia 1998a, AS/NZS 5667.1:1998: Water quality – sampling. Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples. Standards Australia, New South Wales.

Standards Australia 1998b, AS/NZS 5667.11:1998: Water quality – Sampling. Part 11: Guidance on sampling of groundwaters. Standards Australia, New South Wales.

22 ATTACHMENTS

Attachment 1: Field sampling equipment list

ALS Sampling Pack

- ☐ Foam Esky
- ☐ Security Labels
- ☐ 1 x 500mL plastic (*none*) (green)
- ☐ 1 x 125mL plastic (*Sulfuric acid*) (purple)
- ☐ 1 **x 40mL Amber vials** (*Sulfuric acid*) (purple)
- ☐ 1 x **40mL** Amber vials (*Sulfuric acid*) (purple)
- ☐ 1 x **60mL** plastic (*none*) **(**red and green stripe)
- ☐ 2 x **40mL** Amber vials (*Sulfuric Acid)* (purple)
- ☐ 1 x **100mL** Amber glass (*none*) for primary analysis (orange)
- ☐ Syringes
- ☐ Filters

Field Gear

- ☐ Calibrated probe for measurement of *in situ* parameters (whatever you need or have available to you, e.g. Minisonde, Hydrolab, Quanta or WTW instruments), probe cover, protection cap, surveyor.
- ☐ Field filtering gear (e.g. hand pump, filter tower, filter papers and tweezers) if required.
- ☐ Laboratory deionised (DI) water for field blanks (and quality control samples) if required.
- ☐ Deionised water in a spray bottle for cleaning filter tower (and spare deionised water for refills).
- ☐ Sampling pump and tubing
- ☐ Flow-through container
- ☐ Groundwater level probe
- ☐ Tap water for filling the probe protection cap and drinking water – in separate bottles.
- ☐ Bucket for measurement probes/surveyor.
- ☐ A copy of the sampling and analysis plan (SAP).
- ☐ A copy of the safety plan (includes emergency numbers and routes to nearest hospitals).
- ☐ Chain of custody (COC) forms.
- ☐ Field observation forms (FOF).
- ☐ Plastic lunch bag for COC/FOF to go into in eskies.
- ☐ Courier (or laboratory) information (where do you drop the samples off? e.g. road or air freight couriers; the office address; information to attach to esky with samples to ensure that they are couriered correctly and arrive at the laboratory).
- ☐ Eskies with ice bricks – make sure you have enough!
- ☐ Extendable grab pole sampler.
- ☐ Masking tape (always useful).
- ☐ Nitrile gloves, gumboots, waders, coveralls, safety glasses, sunscreen, hat, and any other personal protective equipment (PPE)
- ☐ Map of sites.
- ☐ A GPS, if sampling at a new site.
- ☐ Permanent marker and pens.
- ☐ Extra labels.
- ☐ Extra sample containers.
- ☐ Spare bucket to carry bottles to and from vehicle

Attachment 2: Field sampling sheet

Groundwater Field sampling sheet | **ABM Twin Bonanza Mine Sample**

Sampler/s:		Station ID:	
		Date:	
Name of monitoring bore / piezometer:		Time:	
		Water depth:	
Location of monitoring bore / piezometer: (Coordinates)		Weather:	
Surface Water Sample ID:		Sample depth (below surface m)	
		Sample Time:	
Number of Sampling Attempts:		Depth of bore:	
		Screeened interval:	
Problems during collection:		Casing condition:	

QC SAMPLE DATA

QA/QC Sample IDs:

NONE | DUP ______________ | BLANK ______________

GROUNDWATER DATA & CONDITIONS

Standing water levels:

Volume of water purged from bore/ duration and rate of pumping prior to sampling:

Description of water from bore:

pH	EC	EH	TEMP	DO	Turbidity	Salinity	Comments

Water colour:

Clarity:

Turbidity:

Odour:

Sample Analytical Parameters:		Bottleware/ Preservation:	Label Colour of bottle:
INORGANICS			
Alkalinity, EC, pH, Cations, Chloride, Sulphate, Fluoride, TDS, Acidity		1 x 500mL plastic (*none*)	Green
Total Phosphorus		1 x 125mL plastic (*Sulfuric acid*)	Purple
DOC (Field Filtered)		1 x 40mL Amber vials (*Sulfuric acid*)	Purple*
TOC		1 x 40mL Amber vials (*Sulfuric acid*)	Purple*
METALS			
Dissolved Heavy Metals (Field Filtered)		1 x 60mL plastic (*none*) AIRFREIGHT OPTION	Red & Green Stripe
ORGANICS			
TPH(C_6-C_9)		2 x 40mL Amber vials (*Sulfuric Acid)*	Purple*
TPH (C_{10}-C_{36})		1 x 100mL Amber glass (*none*) for primary analysis.	Orange *

Sample treatment post collection:
Filtration / acidification

Comments / Observations:

Attachment 3: Chain of Custody form

CHAIN OF CUSTODY

*ALS Laboratory: **please tick →***

☐ **Sydney**: 277 Woodpark Rd, Smithfield NSW 2176
Ph: 02 8784 8555 E:samples.sydney@alsenviro.com

☐ **Newcastle:** 5 Rosegum Rd, Warabrook NSW 2304
Ph:02 4968 9433 E:samples.newcastle@alsenviro.com

☐ **Brisbane**: 32 Shand St, Stafford QLD 4053
Ph:07 3243 7222 E:samples.brisbane@alsenviro.com

☐ **Townsville:** 14-15 Desma Ct, Bohle QLD 4818
Ph:07 4796 0600 E: townsville.environmental@alsenviro.com

☐ **Melbourne**: 2-4 Westall Rd, Springvale VIC 3171
Ph:03 8549 9600 E: samples.melbourne@alsenviro.com

☐ **Adelaide:** 2-1 Burma Rd, Pooraka SA 5095
Ph: 08 8359 0890 E:adelaide@alsenviro.com

☐ **Perth**: 10 Hod Way, Malaga WA 6090
Ph: 08 9209 7655 E: samples.perth@alsenviro.com

☐ **Launceston:** 27 Wellington St, Launceston TAS 7250
Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:

OFFICE:

PROJECT: **PROJECT NO.:**

ORDER NUMBER: **PURCHASE ORDER NO.:**

PROJECT MANAGER: **CONTACT PH:**

SAMPLER: **SAMPLER MOBILE:**

COC Emailed to ALS? (YES / NO) **EDD FORMAT (or default):**

Email Reports to (will default to PM if no other addresses are listed):

Email Invoice to (will default to PM if no other addresses are listed):

TURNAROUND REQUIREMENTS :
(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)

☐ Standard TAT **(List due date):**

☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.:

COUNTRY OF ORIGIN:

COC SEQUENCE NUMBER (Circle)

COC: 1 2 3 4 5 6 7

OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact?	Yes	No	N/A
Free ice / frozen ice bricks present upon receipt?	Yes	No	N/A
Random Sample Temperature on Receipt:	°C		
Other comment:			

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
DATE/TIME:	DATE/TIME:	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where **Metals** are required, specify **Total** (unfiltered bottle required) or **Dissolved** (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES									Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
				TOTAL										

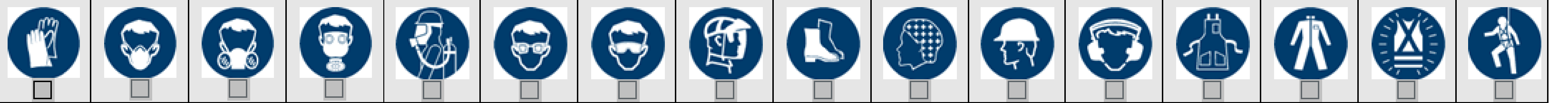
Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Gl
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

Attachment 4: Field sampling health and safety forms

JOB SAFETY ANALYSIS

JSA Number :		**Supervisor:**	**Date of issue:**		**Time of issue:**	
JSA Team	**Scribe:**					
	Facilitator:					
Description of Work/Task:			**Work Location:**			
Qualifications & Training Requirements:			**Tools, Equipment & Substances Required:**			
Isolation Requirements: *(Please List)*						

PERSONAL PROTECTIVE EQUIPMENT - Place a cross in the box of the PPE required to do the task



WORK PERMITS REQUIRED - Place a cross in the box of the required permit

Confined Space Entry		Work Box		HV Electrical Permit		Excavation / Penetration		Floor Roof Wall Opening		O/Side Vessel – Platform		Other	
Live Electrical Work		Non Standard Lift		ATWP Permit		Hot Work		Work at Height		Power Vicinity / Corridor Access		Other	

JOB SPECIFIC RESOURCES – Place a cross in the box of resources required

Barricading		Sentry & Sentry Board		Fire Blankets		Phones		Other					
Drinking Water		Running Water		Voltage Reducer		Extinguishers		Other					
Warning Signs		Fire Watch		Radio		First Aid Kit							

Step No	**Job Step** (Break the job into logical stages)	**Existing & Potential Hazards** (associated with this step)	**Initial Risk**	**Control Measures** (implemented to reduce the level of risk to acceptable levels)	**Residual Risk**	**Controls in place prior to commencement of task**

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JOB SAFETY ANALYSIS

						Whom responsible	Initial

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Step No	**Job Step** (Break the job into logical stages)	**Existing & Potential Hazards** (associated with this step)	**Initial Risk**	**Control Measures** (implemented to reduce the level of risk to acceptable levels)	**Residual Risk**	**Controls in place prior to commencement of task**	
						Whom responsible	Initial

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JOB SAFETY ANALYSIS

Sign Off By Persons Conducting the Work:					
Name	***Signature***	***Position***	***Signature***	***Name***	***Position***
Authorised By:					
Name	***Signature***	***Position***	***Signature***	***Name***	***Position***

Situations to consider

Work Environment	**Human Factors**	**Skills required**	**Can anyone be:**
Illumination / Lighting	Pace, stamina	Truck operator	Crushed, sheered or cut
Noise	Complexity	Machine operator	Injured by ejected objects or substances under pressure – compressed air or hydraulic fluid
Temperature / Humidity	Familiarity, Job knowledge, Repetition	Boiler maker / Mechanic	Electrocuted
Vibration	Concentration, Alertness	Dogman	Slip or trip or fall
Dust	Resources available to do the job	Crane driver	Fall from heights - unprotected edges, brittle surfaces, fall from ladder
Space available	Manual handling	Forklift operator	Strain from pulling, pushing, lifting
Tools, Equipment	Time	Engineer	Exposure to a substance - inhalation, ingestion, skin or eye exposure
Facilities to be used	Existing Work Instructions	Electrician	Exposed to excessive noise, heat or cold
	Supervision	Observer/Spotter	Risk of fire, explosion or major spill

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Risk Calculator – use this methodology for both initial and residual risk

Step 1 – Consider the consequences
What are the consequences of this incident occurring? Consider what could reasonably have happened as well as what actually happened. Look at the descriptions and choose the most suitable Consequence

Step 2 – Consider the likelihood
What is the likelihood of the consequences identified in step 1 happening? Consider this without new or interim controls in place. Look at the description and choose the most suitable Likelihood.

Step 3 – Calculate the risk
1. Take Step 1 rating and select the correct column
2. Take Step 2 rating and select the correct line.
3. Circle the risk score where the two ratings cross on the matrix:

Hierarchy of control

Elimination	Eliminate the risk altogether. *eg. stop the activity altogether.*
Substitution	Substitute a hazardous item with a safer alternative. *eg. use water based chemicals rather than solvent based chemicals*
Isolation / Engineering	Isolate the hazard from workers and/or install equipment to counteract the hazard. *eg.Install machine guarding, mechanical lifting aids, exhaust ventilation.*
Administrative	Procedures and work practices to control the hazard. *eg. Training / Procedures / Job rotation for repetitive tasks.*
PPE	Specialised clothing to protect workers from the hazard. *eg. ear plugs / safety glasses / gloves / high-visibility clothing.*

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JOB SAFETY ANALYSIS

Risk Matrix

LIKELIHOOD	CONSEQUENCE	Insignificant	Minor	Moderate	Major	Catastrophic
	Almost Certain	11	16	20	23	25
	Likely	7	12	17	21	24
	Possible	4	9	13	18	22
	Unlikely	2	5	10	14	19
	Rare	1	3	6	8	15

SEVERITY RANKING	RESPONSE
Extreme	Immediately stop the job
High	Immediate risk controls required, including instruction and training to exposed persons
Medium	Risk controls required as soon as possible
Low	Maintain Risk Awareness – introduce additional controls if practicable

CONSEQUENCE	PRIMARY INCIDENT TYPE			
	INJURY, ILLNESS, DISEASE	SYSTEM OR PROCESS FAILURE	ENVIRONMENTAL EFFECTS	PROPERTY DAMAGE
INSIGNIFICANT	Low-level short-term subjective inconvenience or symptoms. No measurable physical effects. No medical treatment.	Immediate corrective action. No loss of production. No damage to equipment	No lasting detrimental impacts. Little impact on environment. Minor repairable damage. Minor infringement of cultural values.	> $1,000
MINOR	Nature and severity of the injury determines the classification, not who delivers the treatment Any one-time treatment & any follow-up visit for observation	Minor damage to equipment and/or facility. No loss of production.	Short-term impact with no lasting detrimental effects. Minor permanent disturbance or damage to significant structures or sites.	> $10,000
MODERATE	Any work injury/illness incurred which results in a modified or alternate work program being established. No lost time.	Serious service deficit. Moderate damage to equipment and/or facility. Loss of production < one day	Significant general impact or damage. Significant impact on environment. Moderate permanent damage to significant structures or sites.	> $100,000
MAJOR	Any incident where the employee is affected to such an extent that they are required to take time off from work.	Potential loss of business. Major system failure. Loss of production < one week	Widespread impact. Destruction with long-term effects to environment, endangered species, flora and fauna. Significant damage to structures, sites or items of cultural significance.	> $1,000,000
CATASTROPHIC	Fatality and/or severe irreversible disability or impairment(>%30)	Loss or major client due to service deficit. Urgent corrective or remedial action. Loss of production >one week.	Extensive long-term detrimental impacts on the environment, community, public health. Total destruction of highly valued structures, sites or items of cultural significance or sacred value.	>$10,000,000

Rating/Level	Measure – What is the likelihood of the hazard resulting in an incident?
Almost Certain	The event will occur more than once per year
Likely	The event will occur once every 3 years
Possible	The event will occur once every 10 years
Unlikely	The event does occur somewhere from time to time.
Rare	Have heard of the event occurring elsewhere