Toms Gully Underground Project EIS Supplement

Appendix F – Update Site Specific Trigger Values

Review of Site-Specific Trigger Values for Toms Gully Mine, NT

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Executive Summary

Primary Gold Limited is planning to reopen the Toms Gully mine which has been in care and maintenance since November 2010. The site is characterised by acid mine drainage produced through pyrite and chalcopyrite in the pit walls, waste rock and tailings. In addition, there are a number of water storages from previous operations that contain poor quality water, including two evaporation ponds and the larger water storage in the open pit. It is proposed to discharge treated water into Mount Bundey Creek during either the wet season (when there is sufficient dilution capacity) or the dry season and/or provide water to a third party for potential agricultural and horticultural uses, both of which will require water treatment prior to discharge to meet agreed beneficial uses and water quality guidelines.

Primary Gold requested that CSIRO assess the suitability of the site-specific trigger values (SSTVs) derived by GHD in 2015 and, if required, re-derive trigger values for physical and chemical indicators appropriate to the proposed range of beneficial uses of on-site water. The aim was to assist Primary Gold with their water management strategy, particularly to help maintain a neutral water balance and appropriately dispose of any legacy wastewaters.

For physico-chemical parameters, SSTVs for wet season use only were recalculated using the most recent wet season water quality monitoring data from 2015-2017. The revised SSTVs were similar to previous values, with marginally lower 50^{th} and 80^{th} percentile values for conductivity, and higher values (less conservative) for TSS, turbidity, dissolved iron and dissolved aluminium. No SSTVs could be derived for the dry season due to lack of flow, and hence a lack of monitoring data. If discharges are likely to occur in the dry season, then currently only wet season or default ANZECC/ARMCANZ (2000) Guideline Values (GVs) for physico-chemical parameters can be used.

For sulfate, for which no GV exists, chronic ecotoxicity data from the study by Elphick et al. (2011) in soft waters was used to re-derive an 80% species protection value for sulfate of 316 mg/L. This value was higher than the more conservative 95% species protection value of 129 mg/L from Elphick et al. (2011) that was used by GHD (2015).

For toxicants such as metals, default ANZECC/ARMCANZ (2000) GVs should be used. If an 80% species protection level is chosen at the discharge point, then there should be commitment for continuous improvement such that 90 or 95% species protection is achieved at the end of the 1-2 km mixing zone.

If an appropriate treatment before discharge will likely mean that 90 or 95% species protection values could be achieved in Mount Bundey Creek then discharges in both the wet and dry seasons can occur, without the need for a mixing zone, and assuming no additional contamination from seepage or groundwater infiltration. Minimal impacts could be confirmed using direct toxicity assessment with relevant tropical species and this would help to ensure that there is no chronic toxicity of the discharge beyond the compliance point.

For other beneficial uses, such as stock watering or irrigation, lower levels of treatment may be satisfactory, as defined in ANZECC/ARMCANZ (2000) as these GVs are less stringent than for aquatic ecosystem protection. Monitoring of sulfate and other ions in soils, as proposed by Primary Gold, will be required to ensure that there is no build-up of these ions in soils over the longer term.

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1 Introduction

Primary Gold Limited is planning to reopen the Toms Gully mine which has been in care and maintenance since November 2010. The Toms Gully Underground project will utilise the existing Toms Gully mine footprint, dewatering the existing pit to gain access to historic underground workings. The site is characterised by acid mine drainage produced through pyrite and chalcopyrite in the pit walls, waste rock and tailings. In addition, there are a number of water storages from previous operations that contain poor quality water, including two evaporation ponds and the larger water storage in the open pit. Release of untreated water would require dilutions of up to 250:1 to meet aquatic ecosystem water quality objectives for cobalt and zinc, based on the pit water quality in 2012 (EIS, 2015). Therefore, it was proposed to discharge **treated** water into Mount Bundey Creek during either the wet season (when there is sufficient dilution capacity) or the dry season, both of which will require water treatment prior to discharge to meet agreed beneficial uses and water quality guidelines.

The only discharges into Mount Bundey Creek since November 2010 have been:

1. passive discharges via surface water runoff in the wet season, and groundwater
2. licenced discharges from SWTG12 (concrete weir at wetland oxbow overflow point) from 1/2/13 to 31/8/14.

Primary Gold lodged a draft Environmental Impact Statement document (EIS) as required by the Northern Territory Environmental Protection Authority (NT EPA). Since the EIS, Primary Gold has been investigating a number of water treatment options including liming and Virtual Curtain technology to improve water quality prior to discharge. Rather than storing poor quality water in an evaporation dam on site, it was hoped to discharge the water offsite either by a stream discharge (into the ephemeral Mount Bundey Creek) or by supplying the water to local pastoralists to either flood irrigate pastures or to water a mango plantation. The purpose of disposing of water is to maintain a neutral water balance and reduce water management resourcing and the requirement for engineered water-holding structures.

The current compliance site is SWTG2, slightly upstream of the Arnhem Highway Crossing, although this may move slightly further upstream in future, to be further away from road runoff. For a short section downstream from the Arnhem Highway Crossing (approximately 3 km), the beneficial use of the water is for stock drinking. However, for all other parts of Mount Bundey Creek, upstream and downstream, including at the SWTG2 compliance point, the beneficial uses of Mount Bundey Creek are environmental, riparian and cultural, and this applies to all tributaries of the Mary River. Given that water quality guideline values (GVs) for aquatic ecosystem protection are more stringent than for other beneficial uses, these are the values that should apply to Toms Gully.

In previous waste discharge licences for Toms Gully, there had been agreement that the 80% species protection GV be applied as Mount Bundey Creek is considered to be a highly disturbed environment. For future discharges, this level of species protection has not yet been agreed to by the NT EPA, as the regulator is now requesting comparison of these GVs with those for higher levels of protection, i.e. 90% and 95% (See Table 1). As a general rule, continual improvement from such a highly disturbed state is recommended in the existing water quality management framework (ANZECC/ARMCANZ, 2000).

Table 1. ANZECC/ARMCANZ (2000) default guideline values for aquatic ecosystem protection

Toxicant	Guideline value for different % species protection, µg/L		
	95%	**90%**	**80%**
Al (pH>6.5)	55	80	150
As	13	42	140
Cd[a]	0.2	0.4	0.8
Cr	1	6	40
Cu	1.4	1.8	2.5
Fe (total)[b]	700	950	1400
Pb[a]	3.4	5.6	9.4
Mn	1900	2500	3600
Ni[a]	11	13	17
Zn	8	15	31
Total ammonia (pH 8)	900	1430	2300

[a]Low hardness value
[b] New guideline under review

Primary Gold requested that CSIRO assess the suitability of the site-specific trigger values derived by GHD in 2015 and, if required, re-derive trigger values for physical and chemical indicators appropriate to the proposed range of beneficial uses of on-site water. The aim was to assist Primary Gold with their water management strategy, particularly to help maintain a neutral water balance and appropriately dispose of any legacy wastewaters.

2 Review of Site-Specific Guideline Values (Trigger Values) Derived by GHD

The assessment of the acceptability of discharges associated with the Toms Gully project area has relied primarily on the development of site-specific trigger values (SSTVs) (now referred to as GVs (Warne et al., 2015)). The ANZECC/ARMCANZ (2000) water quality guidelines discusses the use of site-specific trigger values noting*: 'If background concentrations cannot be measured at a site, measurement at an equivalent high-quality reference site that is deemed to closely match the geology, natural water quality etc., of the site(s) of interest is suggested. If the background concentration has been clearly established and it exceeds the trigger value, the 80th percentile of the background concentration can be accepted as the site-specific trigger value for ensuing steps." Noting also that: 'Users may apply direct toxicity assessment to background or reference waters using locally adapted species, to confirm that there is no toxicity.'*

Another relevant statement from ANZECC/ARMCANZ (2000) is that: *'Toxicant concentrations may vary seasonally. Because of this and the need to be confident about the best estimate of background concentrations, it is recommended that background data be gathered on a monthly basis for at least two years. This applies to both physical-chemical stressors as well as toxicants. Until this minimum data requirement has been established, comparison of the test site median should be made with reference to the default ANZECC/ARMCANZ (2000) guidelines. For those months, seasons or flow periods that constitute logical time intervals or events to consider and derive background data, the 80th percentile of background data (from a minimum of 10 observations) should be compared with the default guideline value.'*

The derivation of SSTVs undertaken by GHD did not specifically follow all the above recommendations in ANZECC/ARMCANZ (2000) (see below). In selecting a relevant GV, a choice was made between the SSTV values and the 80% species protection default GVs from ANZECC/ARMCANZ (2000). The choice of 80% species protection (usually for highly disturbed systems) is yet to be agreed by the regulator, as at the edge of a mixing zone normally the 95% protection or at worst the 90% protection value would be expected to be used. However, there are precedents for selection of the 80% species protection level. We are aware that there is at least one other mine in the NT where the regulator has agreed to 80% species protection, with the aim to gradually improve towards higher levels of species protection.

2.1 Physico-chemical stressors

Toms Gully site is situated at approximately 40 m AHD so would be classed as a tropical lowland river ecosystem for determining default GVs for physico-chemical stressors. The climate is highly seasonal with a distinct wet season from December to April each year. Mount Bundey Creek is an ephemeral creek with limited flow and isolated pools during the dry season.

Site-specific trigger values for physico-chemical parameters (pH, DO, EC, turbidity, and TSS) were derived by GHD (April 2015). They obtained monitoring data (93 samples) for one upstream reference site (SWTG1A) collected between April, 2003 and February, 2015. It is more usual to derive SSTVs from a number of reference sites (not just one). However, Primary Gold has confirmed that no other reference sites were accessible or appropriate.

Background concentrations were derived by GHD for the Mount Bundey Creek reference site, SWTG1A, *'based on samples collected annually from 2003 to 2008 followed by intermittent sampling from 2010 to*

2015'. More frequent wet season data were collected from the 2010/11 wet season and onwards over 4 wet seasons. In the GHD report, plots are shown of sampling frequency for SWTG1A and the compliance point SWTG2, but different axis labels were used so the actual dates of sampling were not easily estimated. The actual raw data were not provided in the GHD report, with only a summary table of the minimum, median, maximum, 20th and 80th percentiles, together with plots of some data in Section 6. From these plots, it appears that both wet and dry season data were used to derive the SSTVs. Because the site is subject to wet and dry season flows, it is not appropriate to use data from both seasons in deriving SSTVs. It would be more relevant to derive separate SSTVs for each season, assuming sufficient dry season data are available.

Ideally SSTVs should be derived from the most recent data. Including data from 2003 to 2008 is not advisable unless trends in the data can be observed using control charting to show that values were not significantly changing. Ideally, a minimum requirement of 10 wet season data points should be used from the most recent monitoring data over several years.

GHD compared the 80th percentile of the monitoring data from the reference site to the ANZECC/ARMCANZ GVs for tropical lowland systems, and then usually took the least conservative of the two values as the SSTV.

- pH: The GV for pH was appropriate, with a SSTV of 5.8-8.0.
- Electrical conductivity: ANZECC/ARMCANZ recommends the lower values from the range 20-250 µS/cm for ephemeral rivers in NT, but recognises that values can be higher during the wet season first flush. GHD quoted this range as the SSTV, but we are unsure of whether the upper or lower limit will be used for compliance and whether this differs between seasons. The 80th percentile of the monitoring data was much lower, 57 µS/cm, and hence would be a more conservative value.
- Total suspended solids (TSS): There is no ANZECC/ARMCANZ GV for TSS (only a value for turbidity), so the 80th percentile of the combined monitoring data from both the wet and dry seasons was used (32 mg/L).
- Turbidity: GHD selected the upper ANZECC/ARMCANZ value of 15 NTU as the GV because there were too few data from the monitoring program to derive a SSTV. It is unclear if this would be applied to the wet season only.

2.2 Nutrients

No SSTVs were derived due to limited historical monitoring data, so default ANZECC/ARMCANZ GVs for tropical lowlands would apply. It is not known how agricultural land use in the area may contribute to nutrient levels in Mount Bundey Creek.

2.3 Toxicants

For toxicants, including metals, it is usual to apply the ANZECC/ARMCANZ (2000) GVs as these are based on a toxicological response of freshwater biota, rather than a statistical distribution of the background chemical monitoring data from a reference site. In this way, ecosystem protection is related to the chemical concentrations that would have no chronic toxicity to freshwater biota. Note that GVs for some toxicants are currently being revised and these new guidelines should be released in 2018. However, for the purposes of this report, we have used the current 2000 toxicant GVs (Table 1), except for iron, for which a new GV based on total iron, is under peer review.

For most toxicants, GHD have used the ANZECC/ARMCANZ (2000) GVs appropriately, where values exist. Exceptions include:

- Sulfate (for which no ANZECC/ARMCANZ GV exists): GHD used a GV of 129 mg/L based on a chronic ecotoxicity study with temperate organisms in soft water (temperatures ranged from 11 to 25°C) by Elphick et al. (2011). This value is for 95% species protection and is a reasonable conservative approach.
- Ammonia: GHD used a GV of 2.3 mg/L ammonia at pH 8.0 and 20°C for 80% species protection. The median pH of the monitoring data at the reference site was 6.5 (so ammonia toxicity is potentially less) but the 80th percentile of temperature is 31°C (so ammonia is potentially more toxic). Overall, GHD has taken a conservative value (at 31°C and pH 6.5, the GV could be up to 34.5 mg/L), but given that pH changes over a wide range, their approach is conservative and appropriate.
- Aluminium: GHD used the 80th percentile of the monitoring data (260 µg/L) rather than the more conservative and ecotoxicologically-based ANZECC/ARMCANZ (2000) value of 150 µg/L. They justified this by suggesting that there were catchment-specific characteristics that increased aluminium background concentrations, including the impacts of rainfall runoff. This approach is consistent with ANZECC/ARMCANZ (2000) which allows the use of background concentrations as GVs.
- Iron: There was no ANZECC/ARMCANZ GV for iron in freshwaters at the time, so the 80th percentile of reference site monitoring data (430 µg/L) was used. A new guideline for iron of 1400 µg/L for 80% species protection is now available (undergoing peer review) and this is based on toxicity of dissolved and particulate iron to freshwater biota, rather than a statistical distribution of iron monitoring data. However, if iron background concentrations are naturally higher, the 80th percentile of reference site monitoring data is acceptable as a GV.
- Mo, Co and U GVs were classified as low reliability by ANZECC/ARMCANZ (2000).

2.4 Historical water quality at the compliance point

2.4.1 Physico-chemical stressors

For physico-chemical stressors, the median of the monitoring data is compared to the GV (usually derived from the 80th percentile of the reference site monitoring data). A total of 215 samples were collected from the downstream compliance site SWTG2 (approximately 800 m downstream from the project area) from July, 2002 to February, 2015, with the majority collected in the wet season. Table 6-2 in the GHD report compares the median SWTG2 site data over this entire period, with their SSTVs. It is more usual to compare the annual site median with the SSTV, not a site median over 13 years, and in the case of a seasonal difference, to separate data for each season, to be consistent with the ANZECC/ARMCANZ (2000) approach. In addition, only the most recent data should have been used, as operations and discharges have changed since the site went into care and maintenance, and previous data may bear little resemblance to the proposed discharges of treated water outlined in the current EIS.

There were very wide ranges in concentrations of many parameters at SWTG1A, notably pH, hardness and alkalinity, with turbidity, and occasionally EC, elevated above SSTVs. This may have potential impacts on aquatic biota downstream. An aquatic macroinvertebrate, fish and habitat survey in April 2015 (during a lower than usual wet season) showed that the downstream site near SWTG2 had the lowest abundance of macroinvertebrates (Primary Gold, 2015). Water quality monitored at the time showed elevated EC and low pH downstream at the site on the edge of the lease boundary. A more recent survey in May, 2017, at the end of a more typical wet season, showed similar results, with the macroinvertebrate community characterised by pollution-tolerant families. Limited fish data suggested poor fish condition, and low abundance and diversity immediately downstream of the new tailings dam discharge (Primary Gold Ltd, 2017).

2.4.2 Toxicants

For toxicants, action is triggered if the 95th percentile of the monitoring data exceeds the SSTV or default GV. The Guidelines note that this is equivalent to: *'no action is triggered if 95% of the values fall below the guideline value. The more stringent approach is recommended here because, unlike physical and chemical stressors, toxicant default values are based upon actual biological effects data and so by implication, exceedance of the value indicates the potential for ecological harm. Note that because the proportion of values required to be less than the default trigger value is very high (95%), a single observation greater than the trigger value would be legitimate grounds for action in most cases, even early in a sampling program.'*

In the GHD report, median values of the downstream monitoring site SWTG2, were compared to the SSTVs, rather than the 95th percentile. Their summary does include maximum values (from July, 2002 to February, 2015), and, if these were used, exceedances of SSTVs would occur for cyanide, sulfate, and most dissolved metals, including Al, Cd, Co, Cu, Fe, Mn, Mo, Ni, U and Zn. However, it should be noted that since August, 2014, there have been no direct discharges into Mount Bundey Creek and concentrations of metals have substantially decreased. For this reason, drawing conclusions from historical monitoring data is of limited use.

3 Derivation of Revised SSTVs for SWTG1A

3.1 Wet-season SSTVs

The SSTVs derived by GHD used combined wet and dry season historical monitoring data over 2003-2015, far longer than the two years of monitoring data recommended by ANZECC/ARMCANZ (2000). SSTVs for wet and dry seasons should be derived separately. From the more recent dataset provided by Primary Gold, SSTVs for pH, electrical conductivity (EC), total suspended solids (TSS), turbidity, sulfate, aluminium and iron were derived for reference site SWTG1a, for the wet season only and only for the period 2015 to 2017.

The revised SSTVs are shown in Table 2. The revised SSTVs were similar to previous values, with marginally lower 50th and 80th percentile values for conductivity, and higher values for TSS, turbidity, dissolved iron and dissolved aluminium. The revised SSTV for sulfate was 1.5 mg/L, similar to the previous value of 2 mg/L. In keeping with ANZECC/ARMCANZ (2000), the revised 80th percentile values should be used as SSTVs for the wet season only.

Table 2. Recalculated 50th and 80th percentile values using only wet season data for 2015-2017

	Revised 50th percentile	Revised 80th percentile	Old 50th percentile[a]	Old 80th percentile[a]
pH	6.7	6.9	6.5	7.0
EC, µS/cm	28	41	42	57
TSS, mg/L	40	54	17	32
Turbidity, NTU	51	87	22	60
Sulfate, mg/L	1.0	1.5	1	2
Al (total), µg/L	520	1680	-	-
Al (dissolved), µg/L	174	295	-	260
Fe (total), µg/L	1200	2700	-	-
Fe (dissolved), µg/L	256	492	-	430

[a] Old values derived by GHD based on combined wet and dry season data for 2003-2015

Recommended revised SSTVs for Toms Gully Mine are shown in Table 3. SSTVs for all physico-chemical parameters, as well as total iron and dissolved aluminium, were based on the 80th percentile of wet season monitoring data from the reference site SWTG1A, to take into account natural backgrounds. For all other toxicants, the default guidelines from ANZECC/ARMCANZ (2000) were used as these are based on actual ecotoxicological effects.

Sulfate: The exception was sulfate, for which no ANZECC/ARMCANZ guideline exists. Sulfate toxicity is known to decrease with increasing hardness and Dunlop et al. (2016) derived a site-specific GV of 936 mg SO_4/L for 80% species protection for hard waters (550 mg/L as $CaCO_3$). However, as Bundey Creek at site SWTG1A has a median hardness of 9 mg $CaCO_3$/L (i.e. very soft), this GV is not applicable. Instead, the 95% species protection GV for soft waters from Elphick et al. (2011) of 129 mg/L was recommended in the GHD report. A more recent study by Maeys and Nordin (2013) used the data from Elphick together with data from additional species, and derived a similar value for 95% species protection for soft waters (0-30 mg

$CaCO_3$/L) of 128 mg SO_4/L. Neither study derived a sulfate GV for lower levels of species protection. Using the 8 chronic data points (EC10s) from Elphick et al. (2011) at their lowest hardness values (15-40 mg $CaCO_3$/L), we re-derived a sulfate GV for 80% species protection of 316 mg/L, and 210 mg/L for 90% species protection. Although Bundey Creek has a lower hardness, these values are recommended, if 95% species protection is not required.

Table 3. Final recommended trigger values for discharges into Bundey Creek

Parameter	Trigger Value[a]	Trigger Value (90% species protection)	Final Proposed Trigger Values for the Discharge Point or Compliance Site SWTG2 after dilution
pH	6.9	-	5.8-8.0
EC, µS/cm	41	-	41
TSS, mg/L	54	-	54
Turbidity, NTU	87	-	87
Sulfate, mg/L	316[b]	210[b]	210
Al (pH>6.5), µg/L	295[c]	-	295[c]
As, µg/L	140	42	42
Cd, µg/L	0.8	0.4	0.4
Cr, µg/L	40	6	6
Cu, µg/L	2.5	1.8	1.8
Fe, µg/L	2700[d]	950[e]	2700[d]
Pb, µg/L	9.4	5.6	5.6
Mn, µg/L	3600	2500	2500
Ni, µg/L	17	13	13
Zn, µg/L	31	15	15
Total ammonia (pH 8), mg/L	2.3	1.4	1.4

[a] based on 80th percentile of reference site monitoring data for pH, EC, TSS and turbidity; based on 80% species protection for toxicants
[b] data for soft waters re-derived from Elphick et al. (2011) chronic toxicity study
[c] based on dissolved Al from background data
[d] based on total Fe from background data
[e] new ANZECC/ARMCANZ GV for total Fe (under review)

3.2 Dry season SSTVs

Given that Mount Bundey Creek only flows strongly for 3-4 weeks/year, Primary Gold proposes to also discharge treated water to Mount Bundey Creek in the dry season. Examination of the dry season data for SWTG1A showed that there were data for only 3 samples from 2015 to 2017, which did not meet the minimum sample requirements for derivation of SSTVs. Therefore no SSTVs could be calculated for physicochemical parameters specifically for the dry season. If discharges are to occur in the dry season, then wet season SSTVs, together with toxicant TVs (ANZECC/ARMCANZ, 2000), could be used.

4 Future Compliance with Guideline Values for Stock Drinking Water and Irrigation

Previous monitoring at SWTG12 (wetland oxbow onsite near Mount Bundey Creek – the onsite discharge point) showed that discharge water had low pH, elevated EC, and elevated Co, Cu and Zn concentrations. Therefore, fortnightly monitoring at 13 surface water sites, including Coulter Creek upstream and downstream, for a large range of parameters, is proposed in the Water Management Plan.

The EIS proposed that pit water be treated to meet stock water GVs, to ensure that discharges to Mount Bundey Creek meet the aquatic ecosystem 80% species protection GVs at the compliance site downstream. This means that the section of Mount Bundey Creek that flows through the mining lease would be used as a mixing zone. In this mixing zone for several km (NT EPA says 7 km), the GV for 80% of species aquatic ecosystem protection would not be met. Our understanding is that previous water discharges (2005-2007) had required dilutions of 100:1 for untreated water discharge (from the evaporation pond) into the creek during high flow, but there were no agreed GVs for aquatic ecosystem protection at the time.

Although the EIS states that the compliance point for surface water discharge for the proposed project will be DP1 on Mount Bundey Creek **at the lease boundary**, Primary Gold has suggested that the compliance point will now be a few hundred metres further upstream than SWTG2 to avoid the influence of the road on water quality. A mixing zone of 1-2 km from the point of discharge was proposed.

Table 4 summarises the ANZECC/ARMCANZ (2000) guidelines for stock drinking water. Site water currently stored in pit and evaporation ponds would require treatment before discharge at DP1 to meet stock water GVs for sulfate and a range of metals including Al, Cd, Co, Cu, Ni and Zn. With appropriate treatment technologies, discharge from these storages could meet SSTVs for 80% protection (or better). Meeting sulfate SSTVs would be the biggest challenge, but should be possible using a combination of treatments. If only treated water was discharged, then there would be no need for a mixing zone in Mount Bundey Creek, assuming no seepage or groundwater infiltration of contaminated water. The treated discharge should comply with SSTVs (Table 3) and no dilution would be required. This would mean that discharges could occur in the dry season if necessary.

Lake Bazzamundi is an artificial wetland that was previously used to store mine water and bore water that was compliant with ANZECC/ARMCANZ stock water GVs. No water has been actively pumped into the lake since cessation of underground dewatering in 2010. The lake passively overflows from the south into Coulter Creek. The second proposed compliance site will be DP2 on Coulter Creek at the lease boundary, but there will be no surface water release at this location.

Groundwater, which is assumed to flow from Lake Bazzamundi to the northwest, is fresh and slightly acidic. Water from bores near the underground workings is expected to be of suitable quality for direct release into Lake Bazzamundi, providing the pastoralist with additional water in the dry season. Most bores have groundwater is bicarbonate dominated, but several bores along the edge of the sulfide and oxide waste dumps that is sulfate-dominated, probably due to acid leachate contamination. The Water Management Plan outlines the proposed groundwater concentrations with water quality monitoring upstream, within the site, and downstream on a quarterly basis. Water quality will be assessed against ANZECC/ARMCANZ (2000) stock water GVs and if met, should enable stock watering as a beneficial use.

Table 4. ANZECC/ARMCANZ (2000) guideline values for stock drinking water and irrigation

Analyte	Stock Drinking Water GV (ANZECC/ARMCANZ, 2000)	Irrigation GV (Short-term ANZECC/ARMCANZ 2000)
Sulfate, mg/L	1000	-
EC, µS/cm	~ 3000	-
Al, µg/L	5000	20000
As, µg/L	500	2000
Cd, µg/L	10	50
Co, µg/L	1000	100
Cr, µg/L	1000	1000
Cu, µg/L	1000	5000
Fe, µg/L	-	-
Pb, µg/L	100	5000
Mn, µg/L	-	10000
Ni, µg/L	1000	2000
U, µg/L	200	100
Zn, µg/L	20000	5000

Another possible beneficial water use is for irrigation of mango crops. The ANZECC/ARMCANZ (2000) GVs for short-term irrigation (up to 20 years) are shown in Table 4. There are no GVs for sulfate, chloride or sodium specifically for mango cultivation. Generally the irrigation GVs are less stringent than the stock watering GVs for metals, except for Co, Cr and U. There were very few monitoring data for water quality in Lake Bazzamundi. Site CCO2 (a reference site on Coulter Creek below Lake Bazzamundi) had elevated EC in the April, 2015 and May, 2017 aquatic biota surveys, but all downstream sites had no GV exceedances. There were no exceedances of dissolved metals compared to stock GVs at this site or downstream.

Given the lack of GVs, Primary Gold proposed to regularly survey soils to ensure that there is no long-term build-up of sulfate or other ions in soils over time.

5 Recommendations

For physico-chemical parameters, SSTVs for wet season use only were recalculated using the most recent wet season water quality monitoring data from 2015-2017 (Table 3). No SSTVs could be derived for the dry season due to lack of flow, and hence a lack of monitoring data. If discharges are likely to occur in the dry season, then wet season SSTVs for physico-chemical parameters would have to be used.

For sulfate, for which no GV exists, chronic ecotoxicity data from the study by Elphick et al. (2011) in soft waters was used to re-derive an 80% species protection value for sulfate of 316 mg/L. This value was higher than the more conservative 95% species protection value of 129 mg/L from Elphick et al. (2011) used by GHD (2015).

For toxicants such as metals, default ANZECC/ARMCANZ (2000) GVs should be used. If an 80% species protection level is chosen, then there should be commitment for continual improvement such that 90 or 95% species protection is achieved at the end of the 1-2 km mixing zone.

Liming, Virtual Curtain technology or some equivalent water treatment before discharge, will be required before discharges will meet the SSTVs for physico-chemical parameters and toxicants. Sulfate, aluminium and EC remain elevated after Virtual Curtain treatment (G. Douglas, pers. comm), but could be removed with additional post-treatment, e.g. reverse osmosis. Appropriate treatment before discharge will likely mean that 90 or 95% species protection GVs could be achieved in Mount Bundey Creek with discharges in both the wet and dry seasons, without the need for a mixing zone, and assuming no additional contamination from seepage or groundwater infiltration.

While Primary Gold proposed to undertake water and sediment quality monitoring, as well as biological monitoring downstream, direct toxicity assessment (DTA) of discharges using tropical freshwater species relevant to these soft waters should also be undertaken. This will ensure that there is no chronic toxicity of the discharge beyond the compliance point and will provide a further line of evidence in the weight of evidence approach now recommended in the revised guidelines. This knowledge gap has been identified in the Water Management Plan. DTA of the treated water discharge (with upstream water as the diluent) would provide a “safe” dilution and would be undertaken prior to each wet season, with results used by NT EPA for discharge approval. However, the WMP does not currently include DTA in its monitoring plan.

For other beneficial uses such as stock watering or irrigation, lower levels of treatment may be satisfactory, as GVs are less stringent than for aquatic ecosystem protection. Monitoring of sulfate and other ions in soils as proposed by Primary Gold, will be required to ensure that there is no build-up of these ions in soils over the longer term.

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