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Re-evaluation of Recommendation 1: Standard of Practice 4.4, International Cyanide Management Code

Report to:
Granny Smith Gold Mine
January 2014 V2

REPORT

GOLD SUSTAINABILITY RATING
Annual carbon assessments and offsetting all Greenhouse Gas emissions
24th August 2011
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Executive summary

Granny Smith (GS) was certified under the International Cyanide Management Code (Code) in April 2011 and received certification with discharge concentrations of weak acid dissociable (WAD) cyanide above the Code guideline of 50 mg/L. Certification was subject to recommendations and operating parameters developed and provided in a scientific and peer-reviewed report (referred to as the Causational Report [1]). To maintain certification, GS must continue to comply with the recommendations and operating parameters of the Causational Report, which cannot be changed without an accompanied scientific study that is reviewed by peers. The purpose of this report is to provide scientific rational for the amendment of Recommendation 1 of the Causational Report.

Recommendation 1 of the Causational Report requires GS to maintain WAD cyanide concentrations below 83.3 mg/L at the spigot discharge (71.7 mg/L WAD cyanide, 80th percentile). In addition to this, the tailings storage facility (TSF) is to be maintained as hypersaline with 'a minimum of 50 000 mg/L total dissolved solids (TDS) at the spigot discharge and within the TSF (supernatant) as this exceeds the maximum known salinity that wildlife has been observed to be capable of drinking' [1] (p.75). This limit is to be applied 'when the tailings system discharges above 50 mg/L WAD cyanide concentration' [1] (p.75). Recommendation 1 as currently written requires the TDS of the supernatant to be greater than 50 000 mg/L when WAD cyanide concentrations at the discharge are above 50 mg/L, independent of cyanide concentrations of the supernatant. The hypersalinity requirement of the supernatant was originally designed as a protection against wildlife interaction in the tailings plume (the mixing zone of the flowing tailings stream on contact with the supernatant). This requirement was developed for GS based on the site permanently discharging concentrations greater than 50 mg/L WAD cyanide at the spigot. It was written in the absence of long-term wildlife interaction data (less than six months) for the site, however more than three years of wildlife data is now available since this initial study was conducted.

This report provides argument to amend GS's operational parameters associated with Recommendation 1. Specifically, to remove the requirement for maintaining supernatant salinity concentrations above 50 000 mg/L TDS when WAD cyanide discharge concentrations are above 50 mg/L and hypersaline at the spigot. It is proposed that Recommendation 1 be amended to the parameters provided in Table 1.

Table 1. Amended Recommendation 1 operating parameters for GS

	Maximum WAD cyanide (mg/L)	WAD cyanide 80th percentile (mg/L)	TDS (mg/L)
Spigot	83.3	71.7	> 50 000
Supernatant	40	n/a	n/a

No other change to any other recommendation is recommended, although two conditions are included with the amendment of Recommendation 1. In proposing changes to Recommendation 1, consideration is given to the plume, the mixing zone where the flowing tailings stream enters the supernatant. A risk to wildlife can exist in the plume zone and this risk may be episodic. To ensure that there is no increase or detectible risk to wildlife from the proposed amendment to Recommendation 1, the plume would need to be maintained as hypersaline (greater than 50 000 mg/L TDS) while WAD cyanide concentrations are greater than or equal to 50 mg/L. This approach does not take into account cyanide loss through volatilisation of free cyanide in the TDZ. As demonstrated in previous studies some volatilisation occurs, hence an additional safety factor is built into this plume risk management model.

It is considered that when the plume and supernatant mix, the rate of dilution of the salinity will be proportionally the same as for WAD cyanide as long as the differential between the spigot discharge and the supernatant in WAD cyanide and salinity is similar. To ensure that no risk to wildlife exists in the small area of the plume during times when hypersaline tailings containing WAD cyanide concentration above 50 mg/L are discharged and the supernatant is not hypersaline (> 50 000 mg/L TDS), two conditions are proposed for inclusion into the amended Recommendation 1. The conditions are:

- when discharge concentrations of WAD cyanide at the spigot are greater than 50 mg/L while the supernatant is below 50 000 mg/L TDS, the tailings salinity is to be at least 1000 times greater than the WAD cyanide concentration. For example when the WAD cyanide discharge concentration is 60 mg/L the tailings salinity is to be at least 60 000 mg/L or greater; and
- when discharge concentrations of WAD cyanide greater than 50 mg/L occurs while the supernatant is below 50 000 mg/L TDS, the supernatant chemistry is to be such that the salinity is equal to or greater than 1000 times the WAD cyanide concentration. For example when the WAD cyanide concentration of the supernatant is 60 mg/L the salinity is to be at least 60 000 mg/L TDS. This will be easiest to achieve if these parameters are maintained at all times to allow flexible use of hypersalinity as a protective mechanism.

These two conditions to Recommendation 1 will ensure that the plume remains hypersaline while the WAD cyanide concentration is greater than 50 mg/L as the rate of dilution by the supernatant will either be the same or greater for WAD cyanide than it will be for salinity.

The amendment with two conditions to Recommendation 1 have been proposed for endorsement by peer reviewers.

Peer reviewers, after critique of a draft of this report, have stated that additional recommendations be included that primarily relate to management and procedural matters to ensure the operation can adhere to the proposed amendment to Recommendation 1. These recommendations are binding for Code compliance and are provided in the final section of this report.

Contents

Appendices

Introduction
Background

The primary objectives of the International Cyanide Management Code (Code) are to protect human health and reduce environmental impacts associated with the use of cyanide in the gold mining industry. As it applies to gold mining operations, the Code is comprised of two major elements: the code principles, which broadly state commitments that signatories make to manage cyanide in a responsible manner; and standards of practice. The standards of practice follow each principle and identify the performance goals and objectives that must be met to comply with the Code principle. Signatories to the Code must commit to and demonstrate that they adhere to the Code principles and meet the standards of practice.

Code Standard of Practice 4.4 specifically requires operations to implement measures to protect birds, other wildlife and livestock from adverse effects of cyanide process solutions. Specific reference in Standard of Practice 4.4 is made to protecting wildlife from any open water where weak-acid dissociable (WAD) cyanide exceeds 50 mg/L [2], as this is the concentration widely viewed as being protective of most wildlife and livestock. There are however provisions within the Code for mining operations to operate outside this limit, provided they are able to demonstrate that a higher concentration is not lethal to wildlife (as outlined on pages 32 and 33 of the International Cyanide Management Institute (ICMI) auditor's guidance document [3]) and therefore wildlife and livestock are protected from the cyanide-bearing solutions.

In 2006, Granny Smith Gold Mine (GS) and other Australian and African gold mining operations took part in a study, under the auspices of the then Australian Centre for Mine Environmental Research (ACMER), to investigate wildlife cyanide toxicosis risks associated with gold mine waste solutions. The ACMER P58 study identified that the Code guideline to 'limit the concentration of weak acid dissociable (WAD) cyanide in open impoundments to a maximum of 50 mg/L as being protective of most wildlife and livestock' [4] is valid at the point of discharge to tailings systems. The work also found that this guideline was not applicable to hypersaline tailings systems.

Subsequent to this study, GS (along with three other mining operations) participated in a study to further investigate the effects of hypersalinity as a protective mechanism for wildlife from an otherwise toxic solution. The study was conducted under the auspices of the Minerals and Energy Research Institute of Western Australia (MERIWA) as project 398 (referred to here as the M398 study) [5]. The study accepted that hypersalinity acted as a protective mechanism and led to compliance with Code Standard of Practice 4.4 for two operations.

At the time of the M398 study, the GS tailings system was determined to be a saline system rather than hypersaline and therefore required further work to be conducted. To address this, GS installed a hypersaline wash circuit to produce a hypersaline tailings stream and a study (referred to as the Causational Report [1]) commenced and built on the findings of the M398 study. The study developed and rigorously tested hypotheses describing the apparent, general trend of lower wildlife mortality rates from cyanide toxicosis at higher salinity levels. One hypothesis has been accepted by peers under the review process as follows:

Hypothesis 7A: Hypersalinity (> 50 000 mg/L total dissolved solids (TDS)) provides a natural barrier for wildlife exposure to weak acid dissociable (WAD) cyanide contained in tailings solutions because at this salinity the solutions are outside the physiologically safe drinking range of wildlife and wildlife seeks to avoid ingestion while foraging.

Site-specific recommendations for GS were provided in the Causational Report to address maintenance of the protective measures in place at the time of the causational study, specifically maintenance of a hypersaline tailings system (> 50 000 mg/L TDS within tailings). The recommended operating parameters were determined using site-specific data and developed as an adaptive management strategy.

GS was found to be compliant with all Code principles and standards of practice, including the site-specific recommendations and operating parameters derived from the causational study, and attained Code certification on 11 April 2011. To maintain certification, GS must continue to comply with the recommendations and operating parameters of the Causational Report. These recommendations cannot be changed without an accompanied scientific study, reviewed by peers. The purpose of this report is to provide scientific rational for the amendment of Recommendation 1 of the Causational Report. The current operating parameters for WAD cyanide and salinity are given in Table 26 of the Causational Report and provided below in Table 2.

Table 2. Recommended target operating parameters for GS (Table 26 of the Causational Report)

	Maximum WAD cyanide (mg/L)	WAD cyanide 80th percentile (mg/L)	TDS (mg/L)
Spigot	83.3	71.7	> 50 000
Supernatant	40	n/a	> 50 000

Justification for recommendation amendment

Recommendation 1 was developed on the basis that the tailings storage facility (TSF) would be operated permanently as a hypersaline system. Since Code compliance was achieved, GS has implemented changes to mill processes and tailings discharge procedures. This, coupled with increased operational knowledge and increased site-specific datasets, has resulted in improved cyanide optimisation in the mill and reduced cyanide concentrations at the discharge to below 50 mg/L on 97% of days. Hypersaline solutions have not been required or added to the discharge on these days when WAD cyanide was below concentrations of 50 mg/L. Consequently, the supernatant (and discharge) is not maintained above 50 000 mg/L TDS on days when WAD cyanide concentrations are less than 50 mg/L. By adding hypersaline water to the TSF discharge on an as-needed basis rather than on an ongoing basis, GS has also reduced other environmental concerns associated with the increased volume of water held in the TSF cells.

The salinity of the supernatant, due to its volume, does not respond (increase) immediately in response to hypersaline tailings being discharged to the TSF. Recommendation 1, as currently written, requires the TDS of the supernatant to be greater than 50 000 mg/L when WAD cyanide concentrations at the discharge are above 50 mg/L. The tailings solutions and supernatant, without the addition of hypersaline solutions, are typically between 20 000 and 40 000 mg/L TDS. To raise the supernatant to above 50 000 mg/L TDS, typically four days (at least) of hypsersaline discharge is required. This time varies and is dependent on volumes of the supernatant, discharge volumes, salinity of the supernatant and salinity of the tailings discharge. To ensure the supernatant is hypersaline, on-demand hypersaline water would have to be added to the TSF at all times, which would result in an excessive amount of water being placed on the TSF. This would increase the size of the supernatant substantially and creates additional hydrological management issues. This position is contrary to the intent of the Code where cyanide minimisation is encouraged.

Consequently, a conflict arises between part of Recommendation 1 (as currently written), best practice cyanide management in the mill and water minimisation on the TSF. It is not the intent of the recommendation to require the addition of hypersaline water to the TSF while tailings discharge concentrations are below 50 mg/L WAD cyanide and no protective mechanism (hypersalinity) is required. The recommendation, as currently written, limits the ability of GS to use hypersalinity as a protective mechanism on an intermittent basis and does not promote cyanide minimisation as the primary mechanism to maintain Code compliance.

The proposed amendment (with two conditions) to Recommendation 1 (Table 3) are to provide the operation with greater flexibility in managing tailings discharge and meeting the intent of the Code. No other amendments are proposed for the remaining operating parameters or other site-specific recommendations.

Table 3. Proposed recommended target operating parameters for GS

	Maximum WAD cyanide (mg/L)	WAD cyanide, 80^{th} percentile (mg/L)	TDS (mg/L)
Spigot	83.3	71.7	> 50 000
Supernatant	40	n/a	n/a

In proposing amendments to this recommendation, consideration is given to the plume. A risk to wildlife may exist in the plume zone, and this risk may be episodic. To ensure there is no increase or detectable risk to wildlife from the proposed recommendation change, the plume needs to be maintained at concentrations of TDS greater than 50 000 mg/L while concentrations of WAD cyanide are greater than or equal to 50 mg/L.

The plume was not well understood at the time of the previous studies in terms of chemistry or wildlife interactions due to the limited dataset available. The initial M398 and Causational Report did not specify parameters for the plume due to a lack of data and difficulties in monitoring any parameters in the plume. A salinity parameter of 50 000 mg/L in the supernatant addressed this lack of knowledge by providing a protective mechanism. This was the same as for the tailings between the spigot and the plume, what is now referred to as the tailings discharge zone (TDZ). From a compliance perspective, this was not considered problematic for a site discharging hypersaline tailings at all times. Given the now intermittent use of hypersalinity and consequent lack of hypersalinity in the supernatant, a renewed focus on the risk associated with the plume is warranted. It is essential that, if the plume is above WAD cyanide concentrations of 50 mg/L, the salinity of the plume is maintained above 50 000 mg/L TDS.

The recommendations derived in the Causational Report were written in the absence of long-term wildlife interaction data (less than six months) for the site, however more than three years of concurrent wildlife and chemistry data is now available since the initial study.

Granny Smith process and tailings storage facilities

The GS open-pit gold mine is located 950 km northeast of Perth and 23 km south of Laverton. The processing plant has an annual throughput capacity of approximately 3 million tonnes per annum (mtpa) with tailings discharged to a three-celled paddock tailings facility. Processing consists of a two-stage fresh ore crushing circuit including closed-circuit screening and a single-stage oxide ore crushing circuit. This is followed by a semi-autogenous grinding mill in closed circuit with a cone crusher, ball mill, an agitation leaching and carbon-in-pulp circuit, tailings retreatment plant, a gold recovery plant with elution, carbon reactivation and a tailings thickener. Tailings thickener overflow is recycled back to the circuit to increase water re-use, while hypersaline water is added (when necessary) to the thickener underflow prior to discharge to the TSF.

Tailings are peripherally discharged with a supernatant pool forming in the centre of each paddock cell. The cells are operated on a rotational basis for varying lengths of time. TSF cells 1 and 2 were originally commissioned at the commencement of mining and are approximately 40 m above the surrounding landscape. Cell 3 was subsequently commissioned, approximately five to six years ago and has lower walls than cells 1 and 2. Each of the tailings cells provides similar structural features, considered habitats for wildlife, and broadly consists of supernatant (open water), beaches, dry tailings and wet tailings.

Methodology

Literature review

A literature review was conducted and includes searches for information from private and public libraries as well as online databases (e.g. Metadex, Chemical Abstracts, Scopus and Web of Science). The aim of the review was to gain further understanding of WAD cyanide toxicology in mine waste solutions. The literature review has been presented previously in the M398 study and has been included as an appendix to the current report for reference (Appendix A).

Data used for analysis

Data provided in this report includes both data collected by GS personnel and by Donato Environmental Services (DES). On-site chemistry and wildlife data used for analysis in this report was based on data collected the day after GS achieved certification (11 April 2011) to 30 June 2013. Where relevant, the dataset utilised for the GS Causational Report (17 April 2006 to 18 August 2010) has been included for comparative analyses. DES data includes all data collected during 11 quarterly site visits of six data-collection days on each visit between 19 January 2011 and 13 August 2013.

Wildlife data collection

Wildlife monitoring at the active TSF cell is conducted on a daily basis by trained GS mill technicians. The methodology used for the on-site monitoring program and DES monitoring is consistent with that outlined in the Causational Report and is given in Appendix B. DES monitored the TSF for a minimum of four hours and up to seven hours a day over 66 days between 19 January 2011 and 13 August 2013.

Tailings chemistry data collection

Chemistry sampling is conducted at the discharge spigot and supernatant on a daily basis and in the mill every four hours. Tailings are analysed on site for cyanides, copper, salinity, pH and metals. Samples are also analysed at an external laboratory for the same parameters on a weekly basis.

Additional chemistry sampling was undertaken during DES's site visits and was targeted at taking concurrent chemistry samples with wildlife observations. Each morning, prior to commencement of wildlife observations at the TSF, two to three spigot samples were taken that encompassed the wildlife observation period. In addition, during each DES site visit, six samples were taken over a ten-hour period on a single day to measure temporal variability in WAD cyanide concentrations at the spigot discharge. All DES samples were pressure-filtered using site facilities. The solution was split into five bottles: three bottles containing sodium hydroxide for cyanide analysis; one bottle containing no preservative for analysis of physical chemistry parameters (pH and salinity); and one bottle acidified for analysis of metals. One cyanide analysis bottle was sent to each of the on-site, ALS and Chemistry Centre of Western Australia (CCWA) laboratories for analyses. Physical chemistry and metals were analysed at the ALS laboratory. Methods of sampling and cyanide preservation were as required by the previously established procedures and based on the Code guidelines.

More involved chemistry sampling was conducted during the M398 and the causational studies. The data from these studies have been used in this report where applicable and methods are described in the relevant reports [5].

Results

Chemistry data

A summary of salinity and WAD cyanide concentrations from daily on-site chemistry monitoring and analyses at the GS laboratory from 12 April 2011 to 30 June 2013 is presented in Figure 1 (cyanide concentrations) and Figure 2 (salinity concentrations). The average concentration of this data for salinity, WAD cyanide, pH and copper is provided in Table 4.

The average WAD cyanide concentration at the spigot was 32.7 ± 11.5 mg/L with the 80th percentile at 41.4 mg/L and a maximum of 75.5 mg/L. In the supernatant the average WAD cyanide concentration was 13.8 ± 7.0 with a maximum of 34.4 mg/L. The supernatant had a higher average salinity (40 048 ± 840 mg/L TDS) than the spigot (36 344 ± 1117 mg/L TDS), which is expected given the very high evaporation rate at the GS TSF and lower salinity of the raw water. Salinity of the supernatant was greater than 50 000 mg/L TDS on 234 sample days (31.5% of samples) during the period (Figure 2).

The average pH for the period 1 April 2011 to 30 June 2013 at the spigot discharge was 9.1 ± 0.5 with a maximum pH of 10.4 and a minimum of 6.8 recorded. The average pH of the supernatant for the same period was 8.0 ± 0.4 with a maximum and minimum pH of 9.6 and 5.5, respectively. Copper concentrations for the period 12 April 2011 to 9 March 2013 at the spigot discharge and supernatant were 10.0 ± 5.6 mg/L (n = 600) and 9.5 ± 4.5 mg/L (n = 609), respectively.

Table 4. Average salinity, WAD cyanide, copper, and pH concentrations at the spigot and supernatant (1 April 2011 to 30 June 2013)

	Spigot	Supernatant
TDS (mg/L)	36 344 ± 1 117 (n = 625)	40 048 ± 840 (n = 636)
WAD cyanide (mg/L)	32.7 ± 11.5 (n = 628)	13.8 ± 7.0 (n = 639)
Copper (mg/L)	10.0 ± 5.6 (n = 600)	9.5 ± 4.5 (n = 609)
pH	9.1 ± 0.5	8.0 ± 0.4

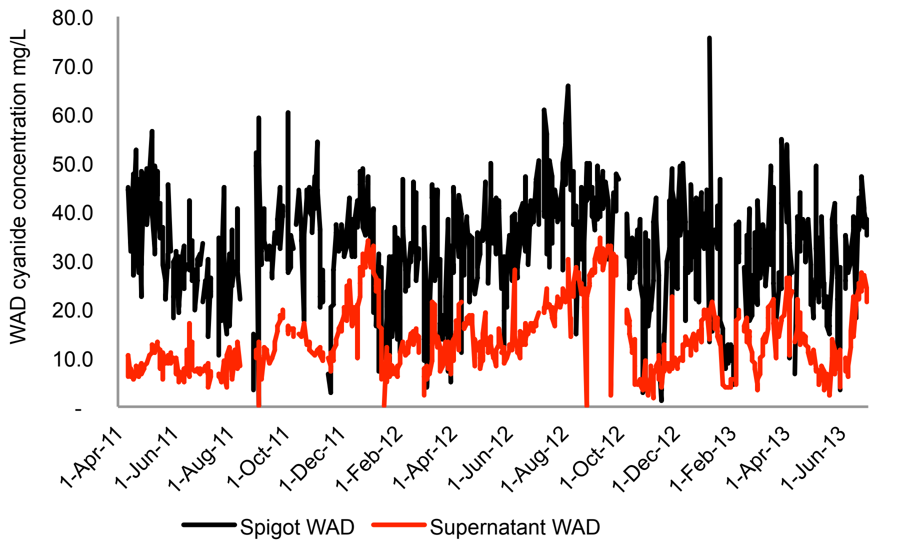

Figure 1. GS WAD cyanide concentrations at the spigot discharge and in the supernatant from on-site analyses conducted from 12 April 2011 to 30 June 2013 (n = 628 and n = 636, respectively)

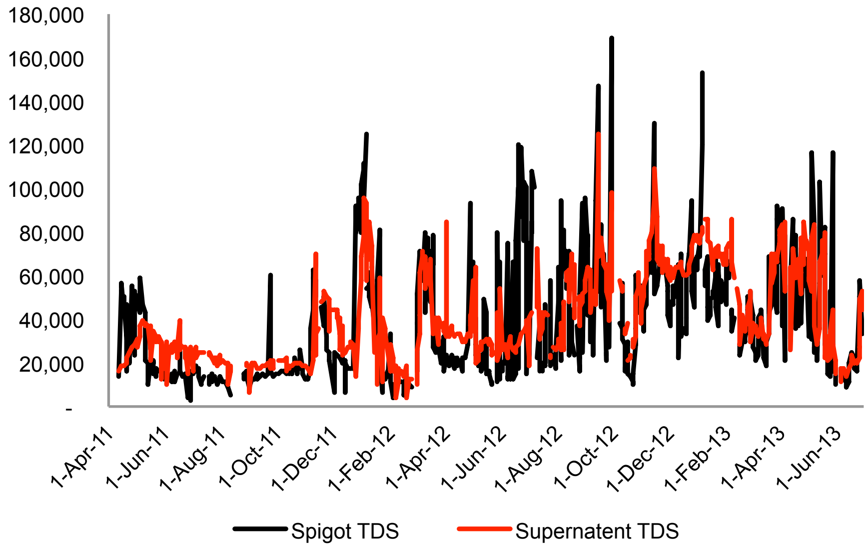

Figure 2. GS salinity concentrations (TDS) at the spigot discharge and in the supernatant from on-site analyses conducted from 12 April 2011 to 30 June 2013 (n = 625 and n = 639, respectively)

Chemistry analyses were conducted off-site at ALS on a weekly basis between 3 January 2011 and 27 August 2013. Off site free cyanide, WAD cyanide and copper data is presented in Figure 3 for the spigot and Figure 4 for the supernatant. As shown, free cyanide (CN^-) is typically between 10 and 20 mg/L and appears not to be as volatile as WAD cyanide at the spigot (Figure 3). Copper was typically less than 10 mg/L at the spigot (Figure 3). In the supernatant, free cyanide is typically less than 10 mg/L and copper is typically less than 10 mg/L but between 10 mg/L and 25 mg/L periodically (Figure 4). WAD cyanide was generally less than 20 mg/L in the supernatant (Figure 4).

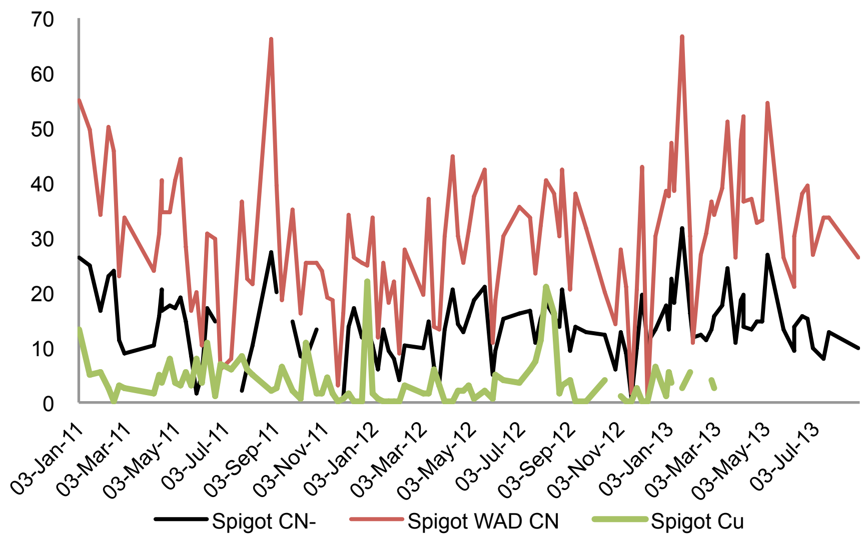

Figure 3. GS WAD cyanide (n = 106), free cyanide (n = 111) and copper concentrations (n = 86) at the spigot as analysed off site at ALS from 3 January 2011 to 27 August 2013

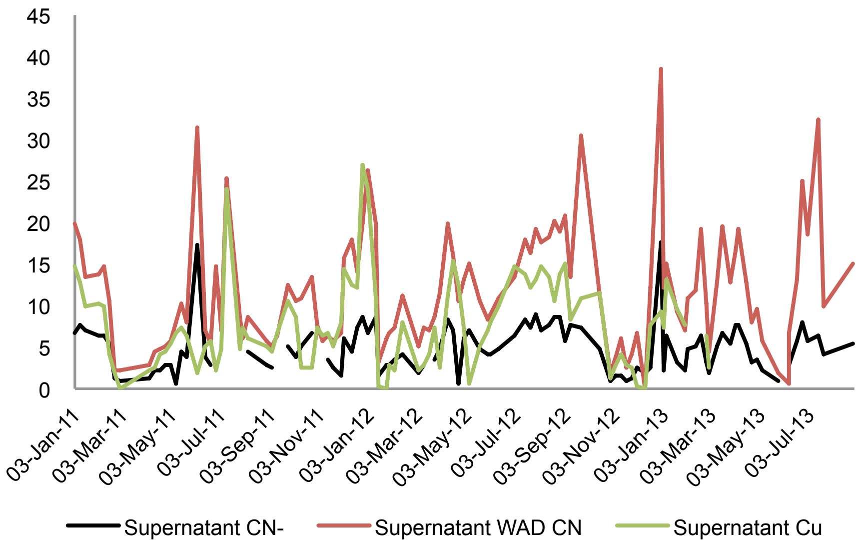

Figure 4. GS WAD cyanide (n = 101), free cyanide (n = 109) and copper concentrations (n = 88) in the supernatant as analysed off site at ALS from 3 January 2011 to 27 August 2013

Relevant data from the M398 and Causational studies including cyanide species deportment

As part of the M398 study samples collected by remote-controlled boat are provided in the tables below (January and May 2008). These samples provide an understanding of the chemistry of the plume (mixing zone of the flowing tailings stream and the supernatant). Additional samples were collected on the same day at the spigot and the supernatant. Comparison of these samples provides a snapshot of the chemistry and plume.

Table 5. Concurrent physical chemistry and cyanide concentrations of the spigot, plume and supernatant (January and May 2008) at GS (single samples)

	Spigot	Plume	Supernatant
January 2008			
pH	8 to 10.1	7.9	8.9
TDS (mg/L)	14 000	20 000	19 000
Total cyanide	140 to 160	130	170
WAD cyanide	35 to 38	20	30
Free cyanide	15 to 17	9	6
May 2008			
pH	9.2	9	8 to 8.6
TDS (mg/L)	16 000	17 000	20 000 to 21 000
Total cyanide		140	82 to 89
WAD cyanide	31	38	23 to 26
Free cyanide		15	15

Chemistry sampling conducted during the causational study in 2010 demonstrated that some loss of WAD cyanide occurs between the spigot and supernatant (Figure 5). Cyanide loss in the TDZ is most likely due to the volatilisation of free cyanide. This is consistent with data collected from other sites during M398 and other studies. Cyanide degradation trials were conducted during the M398 study and a summary of pertinent findings is given:

- Increasing cyanide degradation rates occur in well-mixed solutions exposed to the atmosphere at increasing salinities.
- Ultimately high cyanide losses are achieved in TSF supernatant systems at sufficiently long retention times, regardless of salinity, due to the pH drop arising from atmospheric carbon dioxide absorption (depending on initial pH value).
- Adjustment of pH value of the synthetic solutions to the ~8.5 levels found in the plant solutions proved problematic because cyanide started volatilising immediately and was lost at a very rapid rate. Adjustment to higher levels caused precipitation of metal hydroxides such as Mg, resulting in a non-comparable system.
- Plant solution degradation tests on both spigot and supernatant solutions were carried out for all three sites. The data illustrated the rapid loss of free cyanide in the first hour or two, with residual WAD cyanide stabilising at levels similar to that of the respective supernatant solutions, with copper-bound cyanide showing resistance to further degradation. The hypersaline sites showed faster kinetics, as expected.

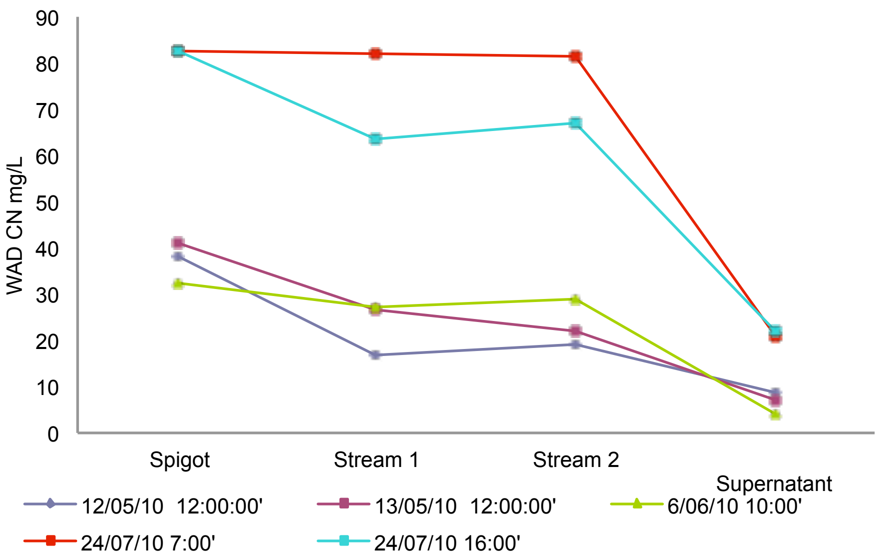

Figure 5. WAD cyanide levels (mg/L) of a lucky spigot plume (spigot-to-supernatant) profile at GS on five occasions (four days) under hypersaline conditions from May to July 2010. Locations for in-stream samples (stream 1 and 2) vary between lucky spigots depending on access.

Cyanide species deportment calculations were conducted as part of the M398 study. Copper was found to be the predominant metal with traces of iron and nickel. The predominant copper-WAD cyanide species was $Cu(CN)_3^{2-}$, with iron predominantly composed of the precipitate $Fe(CN)_6^{4-}$.

The following summarises the deportment investigations of the hypersaline sites:

- in all cases, HCN predominates over CN^-, consistent with the assertion that HCN volatilisation provides the major cyanide loss pathway in these systems;

- the dominant iron cyanide species was $NaFeFe(CN)_6$; and
- the stable $Cu(CN)_3^{2-}$ species accounts for between 30% and 80% of total cyanide in the supernatant.

Several algorithms have been developed for plant and TSF cyanide loss by volatilisation, precipitation and other mechanisms. Approaches typically cover both equilibrium and rate terms. The equilibrium term is described by well-known complex stability constant data along with cyanide speciation calculations [6, 7]. The data suggests that HCN volatilisation dominates as a cyanide degradation pathway concurring with literature and data collected as part of the M398 study [5]. As determined by the M398 study, calculations of metallo-cyanides are determined by copper concentrations multiplied by 1.2. Where WAD cyanide and copper were analysed, the free cyanide component was calculated where the solution is pH stabilised (spigot).

Wildlife data

No cyanosis-related wildlife deaths have been recorded by DES or GS staff since Code-compliance was achieved.

On-site data

A total of 6204 wildlife visitations over 786 days (from a possible 822 days) were recorded for the GS TSF from 12 April 2011 to 30 June 2013. Wildlife was most commonly recorded for the beach/wet tailings habitat (58% of all wildlife visitations) and beach/dry tailings habitat (9.6% of all wildlife visitations). Wildlife was recorded at the supernatant on 6.8% of all visitation records (Table 6). The tailings plume is not given a specific habitat category in the on-site monitoring regime.

Guild composition reflects the primary habitats present within the TSF (beaches, supernatant and the airspace above the TSF) with waders the most commonly recorded wildlife guild (76.8% of all observations) (Table 6). The majority (71.6%) of all wildlife visitations were recorded as Red-capped Plover. Swallows and martins were the next most commonly recorded wildlife guild (12.5% of all observations). The majority of direct interactions with the supernatant were associated with Welcome Swallows and Red-capped Plovers (Table 6).

A breakdown of wildlife guilds and interactions with the supernatant for the period 1 January 2012 to 30 June 2013 is provided in Table 7. It should be noted that this is a subset of the GS-collected data as records prior to this did not allow for data analyses of behaviour and habitat. Of the 180 wildlife observations recorded for the supernatant, 25% of all interactions consisted of foraging in the supernatant and 27% consisted of resting in or on the supernatant. The remaining observations (40%) related to wildlife in locomotion, that is, either recorded flying over the supernatant or swimming/wading in the supernatant.

Table 6. Habitat use of wildlife observed using the active cell of the TSF by on-site mill technicians between 1 April 2011 and 30 June 2013

	Aerial	Beach dry tailings	Beach wet tailings	Dam wall	Dry tailings	Wet tailings	Supernatant	Infrastructure	Total
Percentage	6.3%	9.6%	58.0%	6.2%	4.8%	5.3%	6.8%	3.0%	100%
Totals	391	596	3600	386	298	329	420	184	6 204
Ducks and swan (1.2%)									
Grey Teal						2	10		12
Pacific Black Duck			4			3	7		14
Grey Teal Duck							11		11
Australian Shelduck	3		7	2			13		25
Black Swan			2				13		15
Waders (76.8%)									
Red-capped Plover	38	519	3 097	22	271	284	188	22	4 441
Black-fronted Dotterel	7	7	89	10	2		8	1	124
Red-necked Stint	2		19			1			22
Red-necked Avocet			23		4		2		29
Common Greenshank			1				4		5
Common Sandpiper		2	8	4			2	1	17
Plover species		7	13	3					23
Red-kneed Dotterel		9	27		8	4	3	1	52
Black-winged Stilt			2			6	34		42
Wader species						1			1
Banded Stilt						6	1		7
Wood Sandpiper				2					2
Sharp Tailed Sandpiper			1						1
Waterbird (0.1%)									
Hoary Headed Grebe							2		2
Little Pied Cormorant							4		4
White-faced Heron			1						1
Raptors and corvids (1.6%)									
Wedge-tailed Eagle	16	1	2	14	1			5	39
Whistling Kite	7			1			1		9
Nankeen Kestrel	13			17			1	6	37
Crow	6							1	7
Brown Falcon				2				2	4
Black Kite				1				2	3
Swallows and martins (12.5%)									
Fork-tailed Swift	59	3	65	7			16	12	162
Swallow species	35		41			2	3	2	83
Tree Martin		6		19				7	32
Fairly Martin	2			50		2		19	73
Welcome Swallow	133	32	131	10		5	71	46	428
Pigeon (1.1%)									
Pigeon Species								1	1
Crested Pigeon	16			47		2			65
Bush birds (6.5%)									
Magpie Lark	10		1	21				4	36
Richard's Pipit	42	9	65	143	6	11	21	49	346
Willie Wag-tail	2	1	1	6	6			3	19
Mammal (0.1%)									
Kangaroo				5					5
Unidentified (0.1%)									
Unidentified							5		5

Table 7. Habitat use of wildlife observed using the supernatant by on-site mill technicians between 1 January 2012 and 30 June 2013

	Foraging	Resting	Patrolling	Locomotion
Swallows or martins (38.2%)				
Welcome Swallow	2			49
Swallow Species				3
Fork-tailed Swift				16
Waders (25.1%)				
Red-capped Plover	23			
Dotterel sp.	3	5		
Common Sandpiper	2			
Red-necked Avocet	2			
Black-winged Stilt	1	1		1
Common Greenshank	4			
Banded Stilt				1
Ducks (12.5%)				
Grey Teal	1	1	8	
Australian Shelduck	3	8		2
Bush bird (9.8%)				
Richard's Pipit		18		
Swan (4.6%)				
Black Swan		13		
Waterbirds (3.2%)				
Little Pied Cormorant	4			
Hoary Headed Grebe		2		
Raptors and corvids (1.1%)				
Whistling Kite				1
Nankeen Kestrel		1		
Unidentified (2.7%)				
Unidentified		5		
Total	45	54	8	73
Percentages	25%	30%	4%	40%

DES-collected data

Since the completion of the causational study, DES has collected quarterly wildlife observation data in a manner consistent with the causational study. Intensive searching of the TSF for carcasses using a high quality telescope and binoculars by DES failed to detect any cyanide-related wildlife deaths.

A total of wildlife 1505 wildlife was recorded by DES at the active TSF cell over 66 days of observation at a rate of 22.8 +/- 19.4 wildlife visitations per day. A total of 29 species from eight guilds was recorded. Red-capped Plover was the most recorded species with 838 records (55.7%) followed by Welcome Swallow with 377 records (25.0%).

Table 8. Visitations recorded by DES on the active TSF cell over 66 observation days between 19 January 2011 and 13 August 2013

	Total
Average visitations per day (n = 66 days, 1505 records)	22.8 +/- 19.4
Average records per 20-minute survey (n = 339 surveys, 3918 records)	11.6 +/- 14.2
Total	1 505
Ducks	12 (0.8%)
Hoary-headed Grebe	3
Grey Teal	7
Australian Shelduck	2
Endemic waders	878 (58.3%)
Red-necked Avocet	9
Black-winged Stilt	31
Red-capped Plover	838
Migratory waders	12 (0.8%)
Red-necked Stint	12
Raptors and corvids	20 (1.3%)
Wedge-tailed Eagle	7
Black-shouldered Kite	1
Spotted Harrier	1
Nankeen Kestrel	11
Brown Falcon	6
Crow	1
Granivores	70 (4.7%)
Budgerygar	70
Aerial	438 (29.1%)
Welcome Swallow	377
Tree Martin	4
White-backed Swallow	26
Masked Woodswallow	20
Black-faced Woodswallow	11
Passerines/bush birds	66 (4.4%)
Richard's Pipit	43
Willie Wagtail	3
Crimson Chat	4
Orange Chat	4
Ground Cuckoo-shrike	3
Magpie	4
Magpie-lark	1
Pied Butcherbird	4
Terrestrial mammals	2 (0.1%)
Kangaroo	1
Goat	1

Foraging was the most recorded activity during DES surveys and dry tailings beach was the most used habitat (Table 9). This however may be biased by the fact that the most commonly recorded species, Red-capped Plover, was not observable for most of the day and may remain hidden while resting on the TSF cell. If they predominantly rest on the TSF cells, then resting on dry tailings (in cracks) and on walls would be the most common habitat use and behaviour combination. Wildlife use of the supernatant made up 4% of records (268) and use of the wet tailings beach made up 5% of records (369) (Table 9). These habitats are adjacent to, and therefore the most relevant to, the tailings plume hence the use of these two habitats is explored further in Table 10.

Of the total 637 records for these two habitats, 13% (84) of records were of foraging in the supernatant and 50% (319) were of foraging along the wet tailings beach (Table 10). All of the records for foraging along the wet tailings beach were from Red-capped Plovers and 41 of the 84 records of foraging in the supernatant were of Red-capped Plovers (Table 10). The supernatant foraging records are clearly of the plovers foraging in shallow supernatant as they do not forage while swimming and are not large birds hence these records are close to beaches. It is clear that this species does have some exposure to the tailings plume where tailings and supernatant mix. The only other foraging records from these habitats were of swallows flying over and pecking insects from the supernatant and endemic waders (Black-winged Stilt and Red-necked Avocet) attempting to forage in the supernatant while swimming. Ducks were only observed resting in these habitats (Table 10) and although foraging attempts cannot be ruled out in the supernatant, plume or wet tailings beaches it is likely to be rare and short term when it occurs. Other guilds such as swallows may also have limited exposure to the plume.

Oral interactions with the TDZ and supernatant are surveyed in specific interaction surveys and one-minute pecking rate surveys. Pecks were not counted each time interactions were recorded, hence recorded pecks is a subset of what occurred during observations. From these surveys it can be seen that Red-capped Plover and Welcome Swallow have repeated oral exposure to the TDZ (Table 11). This was observed to occur over the extent of the TDZ from close to the spigot to the wet tailings beach. Red-necked Stint also has limited oral exposure to the TDZ (Table 11). Black-winged Stilt, Red-necked Avocet and Welcome Swallow were observed having limited oral exposure to the supernatant (Table 11).

Table 9. Habitat use and behaviour of all wildlife guilds and species combined as recorded by DES on the active TSF cell over 66 observation days between 19 January 2011 and 13 August 2013 (n = 7275 records)

	Supernatant	Beach/wet tailings	Beach/dry tailings	Dry tailings/wet tailings interface	Wet tailings	Dry tailings	Wall	Infrastructure	Aerial over wet tailings	Aerial over supernatant	Aerial over dry tailings	Aerial	Total	Total %
Percentage	4	5	28	14	6	19	1	1	11	2	2	7	100	
Total	268	369	2 036	995	463	1 395	106	68	787	169	141	515	7 312	100
Foraging	84	319	1 654	954	459	621	18		787	169	141	75	5 281	72
Resting	126	48	369	41	4	764	82	68					1 502	21
Locomotion	52		13			10	3					440	518	7
Nesting							3						3	0.04
Bathing	6	2											8	0.11

Table 10. Habitat use and behaviour for wildlife guilds and Red-capped Plover observed using the supernatant and wet tailings as recorded by DES on the active TSF cell over 66 observation days between 19 January 2011 and 13 August 2013 (n = 600 records)

	Supernatant				Beach/wet tailings				
	Foraging	Resting	Locomotion	Bathing	Foraging	Resting	Bathing	Total	Total %
Total %	13	20	8	1	50	8	0	100	
Total	84	126	52	6	319	48	2	637	100.0
Ducks		110				8		118	18.5
Waders (excluding Red-capped Plover)	25	14	4					43	6.8
Red-capped Plover	41	2	48	6	319	39	2	457	71.7
Swallows	18					1		19	3.0

Table 11. Summary of oral interactions with wet tailings and the supernatant observed by DES over 66 days between 19 January 2011 and 13 August 2013

	Interaction surveys	Interaction records	One-minute peck count surveys	Total pecks	Pecking rate per minute
Tailings discharge zone					
Red-capped Plover	445	1 147	242	3 457	15.8 +/- 9.6
Red-necked Stint	6	10	2	97	48.5
Welcome Swallow	79	668	18	124	6.9 +/- 5.3
Supernatant					
Red-necked Avocet	3	8	1	11	11
Black-winged Stilt	2	17	-	-	-
Welcome Swallow	14	18	8	78	9.8 +/- 5.1

Bat monitoring

Bat activity at the TSF remained constant throughout the eight monitoring periods over two years (from April 2011 to February 2013) with activity (as measured by bat calls per hour) ranging from 0.9 (in September and December 2011) to 2.6 (April and June 2011) calls per hour. The number of buzz calls (an indication of feeding/drinking behaviour) at the TSF was also constant for the same monitoring period. Buzz calls ranged from 0.2 (September and December 2011) to 0.6 (April and June 2012) buzz calls per hour (Table 12). Bat monitoring was also conducted at the haul road lakes, an ephemeral series of lakes formed in borrow pits adjacent to the haul road.

In contrast to activity at the TSF, bat activity at the haul road lakes was considerably higher for the same monitoring period with activity ranging from 8.7 to 16.9 calls per hour (October 2012 and February 2013 and April and June 2011, respectively). Bat activity at the haul road lakes has however declined, with results from the latest surveys (October 2012 and February 2013) 50% lower than activity recorded in April and June 2011 (Table 12). Buzz calls at the haul road lakes ranged from 2.3 to 4.8 buzz calls per hour (Table 12).

Table 12. Bat activity at the TSF and the haul road lakes per reporting period from April 2011 through to February 2013

	TSF			Haul road lakes		
	No bat passes/hr	No buzz calls/hr	Pass/buzz ratio	No bat passes/hr	No buzz calls/hr	Pass/buzz ratio
Apr 11 and Jun 11	2.6	0.4	6:1	16.9	2.7	6:1
Sep 11 and Dec 11	0.94	0.2	6:1	16.3	4.8	3.4:1
Apr 12 and Jun 12	2.4	0.6	3.8:1	11.8	2.3	5:1
Oct 12 and Feb 13	1.1	0.2	6.6:1	8.7	2.5	3.5:1

Discussion

The amendment fo Recommendation 1 relate to one parameter only, the removal of the hypersalinity requirement for the supernatant. The supernatant itself, excluding the tailings plume, is known and understood not to present a risk to wildlife under the proposed amendments and is not an issue for Code compliance as WAD cyanide concentrations are below 40 mg/L at all times. The TDZ has previously demonstrated to be safe to wildlife and Code compliant under existing operating parameters. This will remain valid under the proposed recommendation amendment as only the salinity of the supernatant will be affected by the amendment. Consequently the only remaining consideration is the presence or absence of any risk to wildlife from the tailings plume during times when the supernatant is not required to be above 50 000 mg/L TDS (that is, WAD cyanide concentrations in the supernatant are below 50 mg/L).

The area of concern is very small on the GS tailings dam and assessed to be less than 1% of the area of the TSF. All three GS TSF cells are large and consequently the flowing stream length is long, usually between 250 and 400 metres. The tailings are generally flowing in sheet form (rather than channelling) by the time they reach the supernatant due to the long distances and consistent good management of spigots and beach slopes. In addition, specific gravity of the tailings appears (visually) to be relatively high most of the time. This results in the velocity of the tailings being low once it reaches the supernatant. The plume can be observed when present due to the contrast between opaque grey-brown tailings and the typically clearer blue supernatant. This is however dependant on light and wind conditions. An obvious plume is not visible at times and when observable is generally estimated to be no more than 10 to 20 metres from the beach. When conditions are windy, no plume is observable due to the presence of waves and winds stirring up the supernatant causing a colour change that makes detection of the plume difficult. During windy conditions the plume would be expected to mix with the supernatant quickly. Limited chemistry data taken by the remote-controlled boat during the M398 study found that the supernatant was well mixed and this was attributed to windy conditions. The plume area is inaccessible for chemistry monitoring hence no direct chemistry data is available on the plume habitat. Consequently the risk to wildlife in this small area cannot be directly measured. The risk from the plume can only be inferred from direct observations of wildlife behaviour and impact on the TSF (and plume area where available), and relevant TSF chemistry data.

The relevant pathway of exposure to cyanide in the tailings that introduces risk for wildlife is solely through ingestion of tailings solutions. Under hypersaline conditions this is solely through foraging activity where some solution is ingested along with food or during foraging methods. When not hypersaline, it is also theoretically possible that ingestion through drinking may occur as well, although this becomes increasingly unlikely as salinity increases.

Relevant observations

Wildlife interaction is primarily with wet tailings, dry tailings, beaches and aerial habitats and there is limited interaction with the supernatant. The risk to wildlife in these habitats is not affected by the proposed recommendation change. No interaction with the plume has been observed however it cannot be discounted especially considering the plume is not always visible and interaction occurs with adjacent habitats. Considering the extent that the TSF has been observed by experts (at least 300 hours) interaction with the plume is a rare event although may occur episodically.

No wildlife cyanosis deaths have been recorded at GS under the current operating regimes or since Code certification during three years of daily on-site wildlife monitoring and 66 days of observations by experts at the TSF. Carcass detection trials have been conducted on 33 occasions with at least one balloon detected in all trials, demonstrating an ability to detect carcasses should they occur. On one occasion a Little Buttonquail carcass was located on the TSF by DES observers in July 2011. This species is granivorous and does not forage on invertebrates nor forage on habitats present within the TSF. Its location, floating in shallow supernatant along a dry tailings beach, indicates it was attempting to drink from the supernatant. The supernatant was measured at 6.7 mg/L WAD cyanide and 26 600 mg/L TDS and WAD cyanide discharge concentrations were 31.3 mg/L on the day. It is clear that this was not cyanosis as cyanide was well below 50 mg/L in the TSF. The actual cause of death was not established and other scenarios apart from that hypothesised are possible. One kangaroo death also occurred on the TSF due to exhaustion from becoming bogged in the wet tailings. It was observed alive before it died. Background wildlife mortality for the TSF is therefore at least two during the three years since Code compliance was achieved. It is clear that the lack of detected wildlife deaths related to cyanosis at the TSF, including the tailings plume, during the three years has a very strong possibility of accurately depicting the actual mortality rate. It is at least below detectable levels even with an industry best practice wildlife-monitoring regime backed up by many days of intensive wildlife observations by experts.

Tailings plume chemistry

Although changes to mill processes have resulted in decreased cyanide discharge concentrations, other chemistry properties associated with the tailings have not changed from that studied previously by DES in 2007, 2008 and 2010 [1, 5].

Since April 2011 the tailings at spigot discharge had an average pH of 9.1, which is at or close to the pH at which free cyanide is stabilised. The pH is likely to begin to decrease somewhat soon after exiting the spigot due to agitated contact with the air and free cyanide will begin to volatilise. Sampling of the tailings stream conducted in 2010 demonstrated that WAD cyanide is lost between the spigot and the supernatant (Figure 5), which is mainly due to free cyanide volatisation.

On contact with the supernatant, the tailings stream forms a plume and this plume would initially contain WAD cyanide concentrations higher than those of the supernatant. Due to difficulties and safety concerns associated with accessing the supernatant and plume, a remote-controlled boat was used during the M398 study to take samples from the tailings plume (Table 4). This data shows that mixing and dilution of the tailings occurs. When hypersaline tailings containing greater than 50 mg/L WAD cyanide is discharged mixing results in a dilution of WAD cyanide, salinity and a lower pH to concentrations found in the supernatant. The supernatant is typically between 20 000 and 60 000 mg/L TDS and less than 20 mg/L WAD cyanide.

WAD cyanide comparisons of the supernatant and spigot demonstrate that cyanide is lost from the supernatant. The initial source of loss would be volatilisation of free cyanide, which is not stable below pH 9.2. Free cyanide volatilisation will begin to occur as soon as the tailings contacts the supernatant as pH will begin to decrease immediately, although no specific data is available. Volatilisation and cyanide destruction is increased through agitation such as windy conditions and exposure to UV in strong sunlight. Such conditions are normal at GS.

Theoretics of wildlife interaction with the tailings plume

The plume contains tailings diluted to varying degrees by the supernatant. The tailings are abiotic (do not contain life) as they are derived from the mill and the supernatant has previously been demonstrated to be abiotic [1]. Consequently the plume is also abiotic and contains no food (invertebrates) that wildlife may feed on apart from invertebrates that land on the surface of the plume. This is the case for all other habitats within the TSF. The only probable reason for wildlife to interact with the plume is to take observable invertebrates from the surface of the plume or attempt to filter feed in the plume while foraging in the supernatant.

Any invertebrates that may become submerged in the plume are essentially invisible to sight-feeding birds as the plume is opaque. Invertebrates are likely to be present on the surface of the plume to some degree as for other habitats in the TSF although this has not been specifically observed. Invertebrates may increase in the TSF episodically due to short-term ecological factors (such as eruptions of termite alates). Red-capped Plovers and Welcome Swallows have regularly been observed pecking invertebrates from the surface of wet tailings, dry tailings and the supernatant. Red-necked Stints have also been observed foraging in this way on rare occasions and other species may do so rarely. Some tailings or supernatant liquor is likely to adhere to invertebrates as they are pecked.

While it cannot be discounted that filter-feeding ducks of the genus *Anas* forage in the plume under certain (unidentified) circumstances, this is considered a rare or unlikely event. It has not been observed at Granny Smith. The lack of food within the plume precludes successful foraging and subsequent ingestion hence such foraging behaviour is likely to be short as the ducks soon discover food is lacking. The filter-feeding process for these ducks does not allow for accidental swallowing of water due to bill and throat morphology [8, 9].

Interaction with the plume may be influenced by short-term episodic ecological events such as the mass emergence of termite alates. During such events an abundance of food may be available over the entire TSF and an increase of wildlife activity is possible. Wildlife use of habitats typically not used is also possible. Such events have not been observed at GS but have been observed at other mine sites including in the southern goldfields of Western Australia. Risk profiles change during such events due to the increase of wildlife activity and therefore potential exposure to tailings solutions.

Wildlife risk from the tailings plume

The area of the plume is small (less than 1% of the TSF area). No impact on wildlife has been detected from the plume or other habitats in the TSF during the last three years.

While no impact on wildlife has been detected from the plume, a risk to wildlife can exist in the plume zone (habitat) where the flowing tailings streams and deltas mix with the supernatant, and this may be episodic. In order to ensure that there is no increase or detectible risk to wildlife from the proposed recommendation amendment (and associated two conditions) the plume would need to be maintained at greater than 50 000 mg/L TDS while WAD cyanide is greater than or equal to 50 mg/L.

The mixing of the tailings with the supernatant is active due to tailings flow and other factors such as wind and does not rely on osmotic forces. Previous work conducted in M398 found that the supernatant is well mixed, supporting this assertion. Therefore it is considered that the dilution for the cyanide and salinity will occur at proportionally similar rates as long as the differentials in WAD cyanide and salinity between the spigot discharge and the supernatant are similar. This is considered to be the case despite potentially differing molarities of salinity and WAD cyanide in the tailings and supernatant solutions. For example, if the supernatant contains 50 mg/L WAD cyanide and 50 000 mg/L TDS and the tailings stream contains 60 mg/L WAD cyanide and 60 000 mg/L, the proportional rate of dilution for salinity would be similar as for WAD cyanide. In this example the point in the plume at which salinity is below the threshold of 50 000 mg/L will also be the point that the WAD cyanide is below the threshold of 50 mg/L. It follows that when the differential (concentration in the flowing tailings stream compared to the supernatant) is greater for cyanide than for salinity, the point in the plume where cyanide is diluted below 50 mg/L will occur before the salinity is diluted below 50 000 mg/L TDS. This theoretical model is simplified to a degree as mixing will not always occur evenly however any residual risk is likely to be so small that it is assessed unlikely to be measurable beyond background rates.

No measurable increase in risk to wildlife is deemed to occur in the plume provided that salinity is at least 1000 times the WAD cyanide concentration in both the discharge tailings (as a surrogate for the flowing tailings stream) and the supernatant. The salinity and WAD cyanide concentration of the supernatant has been maintained at greater than 1000 times the WAD cyanide concentration on the majority of days since 12 April 2011 (Figure 6). It is therefore considered possible to maintain. The main requirement is then to ensure that when discharging concentrations above 50 mg/L WAD cyanide, the tailings salinity at discharge is equal to or greater than 1000 times the WAD cyanide discharge concentration. Given the access to real time WAD cyanide and salinity data at the tailings thickener via the citect system, this should be achievable.

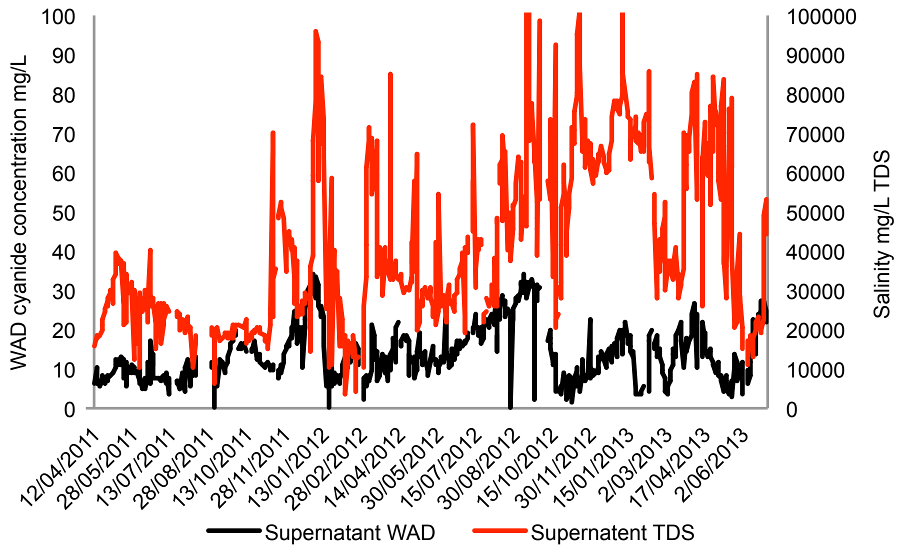

Figure 6. GS WAD cyanide and TDS concentrations in the supernatant from on-site analysis conducted from 12 April 2011 to 30 June 2013 (n = 743 and n = 741, respectively)

It is also possible that tailings will sink below the surface at times under certain conditions (little wind and slower tailings flow rate) due to its higher specific gravity. Regardless of this, the rate of dilution is expected to be roughly similar given that the differentials are maintained.

This approach does not take into account cyanide loss through volatilisation of free cyanide in the TDZ. As demonstrated in previous studies [5] some volatilisation occurs, hence an additional safety factor is built into this plume risk management model. In addition the WAD cyanide of the supernatant is usually less than 1000 times that of the supernatant salinity, which contributes another safety factor under the above dilution model. A safety factor is warranted given that mixing between tailings entering the supernatant will be imperfect with some possible hotspots where higher cyanides are temporarily present. A safety buffer will ensure that dilution effectively maintains the hypersaline protective mechanisms while cyanide remains undiluted at above concentrations of 50 mg/L.

Proposed amendment to Recommendation 1

This report provides argument to amend GS's operational parameters associated with Recommendation 1. Specifically, to remove the requirement for maintaining the supernatant salinity concentrations greater than 50 000 mg/L TDS when WAD cyanide discharge concentrations are above 50 mg/L and hypersaline at the spigot. It is proposed that Recommendation 1 be amended to the parameters provided in Table 13. No change to any other recommendation is recommended.

Table 13. Amended Recommendation 1 operating parameters for GS

	Maximum WAD cyanide (mg/L)	WAD cyanide 80th percentile (mg/L)	TDS (mg/L)
Spigot	83.3	71.7	> 50 000
Supernatant	40	n/a	n/a

To ensure that no risk to wildlife exists in the small area of the plume at times when hypersaline tailings are discharged with concentrations above 50 mg/L

WAD cyanide and the supernatant is not hypersaline, two conditions to Recommendation 1 are provided. The conditions are:

- when discharge concentrations of WAD cyanide at the spigot are greater than 50 mg/L while the supernatant is below 50 000 mg/L TDS, the tailings salinity is to be at least 1000 times greater than the WAD cyanide concentration. For example when the WAD cyanide discharge concentration is 60 mg/L the tailings salinity is to be at least 60 000 mg/L or greater; and
- when discharge concentrations of WAD cyanide greater than 50 mg/L occurs while the supernatant is below 50 000 mg/L TDS, the supernatant chemistry is to be such that the salinity is equal to or greater than 1000 times the WAD cyanide concentration. For example when the WAD cyanide concentration of the supernatant is 60 mg/L the salinity is to be at least 60 000 mg/L TDS. This will be easiest to achieve if these parameters are maintained at all times to allow flexible use of hypersalinity as a protective mechanism.

These two conditions will ensure that the plume remains hypersaline when the WAD cyanide concentration is greater than 50 mg/L as the rate of dilution by the supernatant will be either the same or greater for WAD cyanide than it will be for salinity.

The amendment to Recommendation 1 has been proposed for endorsement by peer reviewers.

Additional recommendations

Peer reviewers' comment on a draft version of this report provided additional recommendations. These were instigated by the peer reviewers to ensure that the operation is capable of effectively implementing the revised Recommendation 1. The peer reviewers recommend that:

- the procedure (Code TSF Deficiency Procedure: Chemistry Operating Parameters) be updated to reflect the new requirements as indicated in this report (amended Recommendation 1) with greater emphasis on ensuring the time to react to WAD cyanide concentrations above 50 mg/L is minimised;
- role accountabilities are included in the procedure to ensure all personnel (Mill Manager, Process Superintendent, metallurgists, operators and laboratory technicians) understand the importance of their respective roles in relation to meeting the Code requirements;
- an operating procedure is developed to ensure the TDS is monitored continuously on Citect in conjunction with WAD cyanide concentration with trigger points to ensure operators are alert to out-of-compliant conditions; and
- the estimated volume of the supernatant is recorded.

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Appendices:

A: Literature review

B: Wildlife monitoring methodologies

APPENDICES

DES
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GOLD SUSTAINABILITY RATING
Annual carbon assessments and offsetting all Greenhouse Gas emissions
24th August 2011
Pangolin Associates

Appendix A: Literature review

Overview

Limited published work exists that documents wildlife deaths from cyanosis on cyanide-bearing solutions and effluents [6, 7, 10-12] contained within gold mine tailings storage facilities (TSFs). In the Northern Territory, 972 wildlife deaths were recorded from four mining operations in a single calendar year [7] and in the USA, between 1986 and 1991, 9512 carcasses comprising over 100 species were reported for the State of Nevada. At Northparkes Mine in New South Wales, Australia, 2700 bird deaths were recorded over a four-month period [13]. As documented in the literature, deaths of birds, cattle, goats, frogs, lizards and marsupials may be widespread [14].

TSFs are environmental control structures, which are standard practice in the global minerals industry [14-18]. Their primary purpose is to provide safe and permanent storage of mining residues [17], with the size and shape of a tailings impoundment determined by the requirement to retain the solid fraction of the tailings [14, 19, 20]. The amount of cyanide-bearing solutions maintained by tailings impoundments is highly variable and dependent on site-specific characteristics. Wildlife, particularly birds, can gain access to cyanide solutions [14] in tailings dams unless deterred or controlled. Death to birds, cattle, goats, frogs, lizards and marsupials may be widespread [14].

Although rigorous methodologies are currently being implemented under the auspices of the Code [21], on an industry-wide basis observations of wildlife on TSFs has been *ad hoc* [22] and opportunistic. Consequently, minimal ecological information on TSFs can be gathered from existing data sources. Despite the limited amount of ecological information available, consensus suggests [14, 17] that cyanide will generally not kill wildlife at a concentration less than 50 mg/L weak-acid dissociable (WAD) cyanide.

Cyanide toxicity

Cyanide is the most significant contaminant in gold mining that influences wildlife mortality [6]. A casual link with the presence of cyanide, its metal complexes and cyanide degradation products is inferred in mortality events and is supported by observational data [6]. A death was observed within 32 minutes amongst waterfowl exposed to 62 mg/L WAD cyanide [6]. Birds are thought to be particularly susceptible to cyanide in tailings dams but it is not known if this sensitivity is physiologically-related [13] or related to bird access to TSFs, making them relatively more vulnerable than other biota [22].

Limited published work that documents wildlife deaths from cyanosis on gold mining cyanide-bearing solutions and effluent exists [6, 7, 10-12]. Consensus suggests [14, 17] that cyanide will generally not kill wildlife at a concentration of less than 50 mg/L WAD cyanide, although this is regarded as an interim benchmark [14]. Since wildlife dosage (ingestion) in the field is not known, and would vary with environmental conditions, the concentration of the hazard cannot be determined.

The 50 mg/L guideline used by the Code is derived from a survey of mine operators conducted by Henny 1994 [6]. The survey concluded that wildlife deaths of ducks at 69 mg/L (although the concentration was determined some days later) was the lowest concentration that deaths occurred and therefore 50 mg/L would be an appropriate toxicity concentration. This figure

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was concurred by toxicological extrapolation of laboratory work [23] and is deemed appropriate for wildlife protection [17, 24]. Donato (1999) [7] merely stated that those operations that consistently discharge below 50 mg/L WAD cyanide concentration recorded zero wildlife deaths, as documented over a two-year period from two mining operations [7, 22]. The Code guideline is simplistically viewed as a toxicity threshold, while elsewhere [5, 7] it has been argued that it is a management limit on discharge into tailings systems [7, 25-27].

Few companies not signatories to the Code adequately monitor their tailings systems for cyanides and wildlife deaths. As such, limited information can be drawn from these operations. Only Code-certified operations that discharge above or at concentrations approaching 50 mg/L WAD cyanide monitor cyanides and wildlife on a daily basis in a systematic manner. These operations include Granny Smith, Barrick Kanowna Belle, Anglo Ashanti Sunrise Dam and Gold Fields St Ives gold mine. These operations are all hypersaline operations and discharge above 50 mg/L WAD cyanide.

The Barrick Cowal Gold Mine in New South Wales and the Newmont Boddington operation in Western Australia are the only Code-compliant operations that monitor its tailings system by trained staff on a daily basis with WAD cyanide concentrations below 50 mg/L. At Cowal Gold Mine discharge is maintained below 20 mg/L (90th percentile) and below 30 mg/L WAD cyanide (100th percentile). The supernatant typically has WAD cyanide concentrations of 10 mg/L [28]. No wildlife deaths attributed to cyanosis have been documented after seven years of observations. There is no literature available that suggests that wildlife is at risk where WAD cyanide concentrations in open water bodies are below 50 mg/L.

The state of knowledge on toxicity to wildlife of WAD cyanide in a tailings environment is imperfect. All knowledge has been obtained from observational studies and from limited laboratory experiments on laboratory-bred and domestic animals. In lieu of further knowledge, the 50 mg/L WAD cyanide concentration is deemed an appropriate guideline for mine waste water.

Cyanide degradation and gas-phase equilibria

Natural degradation of cyanide in tailings environments is widely reported [13, 17, 19, 20, 29-35], and is caused by a lack of cyanide stabilisers and the volatisation of free cyanide on discharge into the tailings system. Natural degradation occurs in all tailings dam systems, although the rate is variable. Wildlife deaths can occur when the rate and extent of natural cyanide degradation is insufficient to render the tailings dam habitat benign.

Henry's Law constant for HCN volatilisation is the ratio of the concentration of $HCN_{(g)}$ in equilibrium with HCN(aq), defined as follows:

> *At a constant temperature, the amount of a given gas dissolved in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid.*

Heath et. al. [36] give data for the effect of ionic strength on the HCN Henry's Law constant and hence, volatilisation.

APPENDIX A

In a simplistic manner, three cyanide forms are common in gold mining process waste solutions:

- free cyanide;
- WAD cyanides; and
- total cyanides.

Free cyanide is not persistent in the tailings environment [11, 20] and will degrade through physical, chemical and biological processes into other less toxic chemicals [14]. Natural degradation, primarily by volatilisation of cyanide in TSFs, is the most common method of removing cyanide from the gold mining waste [13, 17, 19, 20, 29-35]. Once the pH of a tailings dam drops below 8 [19] or 9.2 [34], the majority of cyanide is liberated via the gaseous state into the atmosphere. The rate of volatilisation and the subsequent destruction of the gaseous state constitutes no hazard [35].

Unlike free cyanide, WAD forms of cyanide, such as the copper complex, are resilient within the tailings dam environment [10, 12, 17, 34] and as such, the release of cyanide ions from these complexes vary depending on environmental conditions. Ingestion [6, 7, 20] and absorption [37, 38] by wildlife also liberates the cyanide ions following dissociation of the cyanide complexes in the animal's gut. The main complexes constituting WAD cyanide in mining tailings waste are $Cu(CN)_{3(s)}$, $Zn(CN)_{4(s)}$, $Ni(CN)_{4(s)}$ and $Fe(CN)_{6(s)}$ [19, 20], and all readily dissociate following ingestion by wildlife. Copper and zinc cyanide complexes are insoluble in water [39], but soluble in ammonia [40], which is present in tailings dams [39]. The solubility of cyanide and its complexes contribute to its bioavailability to biota.

Regulatory distinction between free, WAD and total cyanide is justified for monitoring purposes [39].

Wildlife use of tailings storage facilities

An understanding of wildlife ecology (and interaction) on active mine TSFs is required to understand the risks to wildlife associated with mine waste constituents. On an industry-wide basis, observations on TSFs have been *ad hoc* [22] and opportunistic although some more rigorous methodologies are being implemented under the auspices of the Code [21]. Consequently minimal ecological information can be gathered from existing data sources, although various wildlife visit TSFs to rest and forage for food [17], while some fauna may drink from such facilities [11]. A list of bird species that interact with TSFs in northern Australia exists [7]. Birds are the most documented fauna group to use tailings systems [6, 7, 11, 17], although bats and terrestrial fauna have been recorded elsewhere [41-43].

In New Zealand and Australia, waders, waterbirds [7, 12, 13, 22, 44, 45], ducks, pratincoles, terns, raptors [7, 22], and in the USA, waterfowl, shorebirds, perching birds and gulls [6] are all documented at TSFs, although systematic monitoring studies are few [7]. Ambulatory wildlife can be denied access by fencing TSFs or with in-pit tailings physical features, thus wildlife interactions can be limited to mostly birds [6, 7, 17] and bats [43].

Wildlife species composition on tailings dams can be predicted by habitat provisions [7] although it may be reasoned that natural wetlands provide a better habitat for waterbirds than artificial wetlands [46]. It has been stated that there is no reason to believe that birds are able to distinguish between TSFs and any similar area of water formed from precipitation [38], although it is argued that animals generally avoid tailings dams if natural water is available [17].

Vertebrate wildlife utilise TSF habitats primarily for the following reasons:

- provision of drinking resources;
- provision of food resources;
- resemblance to natural habitats, and
- structural features provide roosting habitats [47].

There is also some literature quantifying or describing availability of food resources such as macroinvertebrates associated with TSFs [5, 48, 49]. Availability of food is likely to influence visitation rates and diversity of wildlife and hence, levels of interaction with TSF solutions. The presence, abundance and diversity of food for at-risk species within TSFs strongly influences the level of wildlife interaction with these facilities [47]. Aquatic habitats within tailings facilities have been found to be devoid of aquatic biota including fish, invertebrates and plants and therefore food for waterbirds and waders. Food provisions within TSFs are generally limited to aerial insects flying overhead and those that land on or become embedded in the surface of supernatant, ponding, wet tailings and mud. They provide a regular food source for some birds and bats. Pan trap sampling has illustrated that moths, wasps, flies, beetles and bugs are present [1, 5, 47, 49]. Birds and bats feed on flying macroinvertebrates by taking them in flight and birds have been observed picking invertebrates from the supernatant and wet tailings.

A number of habitats within TSFs, particularly supernatant and tailings beaches, resemble natural habitats and attract some avian species despite a complete lack of food. A lack of food resources (aquatic macroinvertebrates) in these TSF habitats does not therefore deter them from using these habitats until they have ascertained that no food is present. Field observations suggest that these species ascertain quickly that there are no aquatic plants or animals present within the TSF as they cease attempting to feed after a few attempts [1, 48, 50].

Some species use the TSFs as a place of rest or refuge [51]. Waterfowl, waders, swallows, corvids and even raptors have all been observed roosting within TSFs with little or no attempt to forage.

Exposure pathways

Assessment of wildlife exposure and behaviour is required to understand the influences of cyanosis risks on tailings systems. There are three ways that wildlife is exposed to cyanide in the tailings environment:

- epidermal absorption (absorption of aqueous cyanide through the skin);
- inhalation of cyanide gas; and
- ingestion (drinking of the supernatant and foraging in supernatant or on wet tailings) [51].

Inhalation of cyanide gas

Cyanide gas on tailings systems results from the liberation of hydrocyanic acid (HCN) from free cyanide as it volatilises from the surface of tailings dams [13, 17, 19, 20, 29-35], although atmospheric concentrations immediately above tailings solutions are not considered toxic [35]. Cyanide gas levels will vary from the spigot to the decant pond. Routine monitoring at one site has shown cyanide gas concentrations at below threshold limit value (TLV) trigger levels (< 10 ppm) and is considered benign to wildlife [52]. Cyanide gas concentrations are often measured and found to be safe within TSFs in the gold industry. This exposure pathway is not considered a sufficient pathway of exposure to cause cyanosis in wildlife.

Ingestion (drinking)

Drinking is a primary avenue of exposure and a major cause of cyanosis in wildlife within the gold industry [6, 7]. The propensity of wildlife to drink from tailings facilities is influenced by many factors such as climate, availability of cover for wildlife, fencing, water chemistry and salinity.

Ingestion (foraging)

Foraging amongst the supernatant and wet tailings is an exposure pathway to cyanide [7] by inadvertent ingestion of supernatant or wet tailings. Cyanide-bearing solutions are toxic to aquatic wildlife and contain no plant or animal life [53]. However, an exposure pathway still exists for species that take invertebrates from the surface of cyanide-bearing habitats such as supernatant, wet tailings and solution pools, as well as those species that attempt to forage for food within cyanide-bearing solutions. Wildlife limits the intake of saline water [54] through physiological or behavioural adaptations [54, 55].

Birds that feed in watery or muddy environments forage either by sight (visual inspection), filter feeding using the bill to sift through water or mud for prey or by feeling for prey using the bill. Species that hunt by visual inspection will only interact with the habitats if food is available. The presence of a range of live and dead insects within TSFs has been demonstrated [51].

The lack of food within the tailings system does not preclude some species from attempting to feed within the TSF [51]. Some inadvertent ingestion of solution while attempting to feed may occur but it is likely that amounts ingested will be very small compared to direct drinking of the supernatant [5].

Influences of hypersalinity on exposure pathways (ingestion – foraging)

Salinity strongly influences ingestion rates as salt can cause dehydration and even toxicity at high concentrations [56-62]. Many bird species utilise hypersaline environments in Australia [63]. Species and guilds with salt glands are physiologically adapted to eliminate salt once ingested. However, hypersaline environments can place such great stress on an animal's water balance that many species have either physical or behavioural adaptations to limit salt intake in the first place [54, 64]. Such physical adaptations include structures that remove excess water such as a thick tongue and bill lamellae that remove saltwater from prey before ingestion [64]. Alternatively behavioural adaptations include removing excess water through shaking prey before swallowing [54]. It is likely that as birds forage within hypersaline waters, amounts ingested will be very small as animals seek to avoid dehydration caused by hypersaline water.

Exposure pathways on the Granny Smith tailings storage facility

The GS TSF is typical of other tailings systems, having no aquatic macroinvertebrates in the supernatant. Food resources are limited to dead terrestrial macroinvertebrates entrained in the tailings and floating on the supernatant. Wildlife does forage at the TSF and the inadvertent ingestion of cyanide during foraging is recognised as the primary exposure pathway of cyanides at GS [1].

Appendix B: Wildlife monitoring methodologies

Wildlife monitoring is conducted at the active tailings storage facility (TSF) cell for a period of approximately 20 minutes each day, commencing within three hours of sunrise. This timeframe was chosen to maximise biodiversity detection and detection of carcasses should they be present (prior to removal by scavenging species or entombed into the tailings surface). Additional surveys of the groundwater interception trench (seepage trench) surrounding the TSF are also conducted on a regular basis (although not necessarily daily) and are conducted by driving slowly along the trench looking for wildlife and stopping at regular intervals to check for wildlife and carcasses. Surveys of the trench take approximately 15 minutes.

Monitoring is conducted using 8x magnification binoculars from various vantage points around the TSF. As part of training, observers are instructed to concentrate observations on the discharge zone (beaches), wet tailings and supernatant. All wildlife is identified to species level where possible, otherwise grouped according to guilds. For each observation conducted, the following data is recorded:

- observer's name;
- date of survey and start and finish times;
- wildlife species (or guild) and the number of individuals present (alive and dead);
- habitats used by each species or guild; and
- behaviour of each individual.

The habitat and behaviour categories used for all observation methods are defined in Table 1. All data is collated and entered into a spreadsheet with wildlife recorded at the species or guild taxa where possible (typical of industry standards). Where carcasses are observed during routine maintenance inspections of the tailings system (including outside of the routine wildlife monitoring program), mill technicians notify environment staff and the data is recorded.

Table 1. Behaviour and habitat data categories used for intensive diurnal wildlife monitoring

Data category	Definition
Foraging	Searching for food, irrelevant of observation of food source consumed or success of feeding action
Resting	Not engaged in any activity or engaged in comfort activities such as preening
Locomotion	Moving from one location to another
Nesting	Used for Red-capped Plovers observed sitting on a nest within the TSF
Drinking	Only for observations where wildlife was actually observed drinking
Bathing	Wildlife engaged in active bathing behaviour in tailings solutions
Patrolling	Hunting/searching behaviour
Supernatant	Open water
Flowing stream	Stream of tailings flowing in a channel from the spigot to the supernatant
Beach/dry tailings	The interface between supernatant and adjacent dry tailings
Beach/wet tailings	The interface between supernatant and adjacent wet tailings
Dry tailings/wet tailings interface	The interface between dry tailings and adjacent wet tailings
Dry tailings	Dry consolidated tailings
Wet tailings	Wet unconsolidated tailings
Infrastructure	Any infrastructure present in the survey area such as pipes, decant towers, causeways, etc.
Aerial	Only for wildlife flying over the water bodies
Aerial over supernatant	Used for flying birds foraging or patrolling very low over the supernatant (< 1 m) with an obvious interest or interaction with the supernatant
Aerial over wet tailings	Used for flying birds foraging or patrolling very low over wet tailings (< 1 m) with an obvious interest or interaction with the wet tailings
Aerial over dry tailings	Used for flying birds foraging or patrolling very low over dry tailings (< 1 m) with an obvious interest or interaction with the dry tailings

In addition to the routine wildlife monitoring program conducted by Granny Smith (GS) staff, Donato Environmental Services (DES) undertook daily, intensive wildlife observations at the TSF during quarterly site visits. Observations were conducted from:

- 24 to 29 June 2011;
- 14 to 19 September 2011;
- 5 to 10 December 2011;
- 2 to 8 April 2012;
- 11 to 17 June 2012;
- 12 to 17 October 2012; and
- 5 to 10 February 2013.

APPENDIX B

All observations by DES were conducted using 8x magnification binoculars and a 20 to 60x magnification telescope. The telescope was moved to a variety of locations within the TSF and was generally used within two hours of sunrise to minimise the effects of heat shimmer and wind. Only active TSF cells (those containing bio-available cyanide) were monitored on a daily basis. Specific monitoring for carcasses was carried out each day using a telescope or binoculars and involved careful inspection of the tailings discharge zone (TDZ), beaches, decant finger and areas where carcasses may collect or be blown.

Intensive diurnal vertebrate observations within the TSF consisted of four data collection methodologies:

- determining daily TSF visitation totals for each species;
- 20-minute intensive surveys;
- habitat and behaviour surveys (using the categories provided in Table 1); and
- interaction surveys over a one-minute period (conducted of specific wildlife using cyanide-bearing habitats, including documentation of foraging rates of individuals).

Daily totals

All wildlife visitations to the TSF for a given day were recorded. A visitation is defined as an individual that visits the TSF within a given 24-hour period. Repeated visits to the TSF by an individual on the same day (where known) are treated as a single visitation. Attempts were made to avoid double counting the same individual.

20-minute intensive surveys

During observation sessions, all wildlife present, entering or leaving the tailings system during a 20-minute period is recorded. Care is taken to avoid double counting. For each observation, the following information is recorded:

- time;
- species;
- number of individuals; and
- any relevant comments.

Habitat and behaviour surveys

A snapshot observation of the habitat and behaviour of all wildlife present within an active TSF cell was periodically conducted. The number of wildlife engaged in a behaviour and the habitat it was using was recorded. This provides an understanding of habitat preferences and behaviour in these habitats.

Interaction surveys over a one-minute period

Wildlife interactions with cyanide-bearing habitats were the focus of intensive observations, with wildlife closely observed when they were identified to be using such habitats. When wildlife was interacting orally (drinking or foraging) with cyanide-bearing habitats, data over a one-minute period was recorded for individual, randomly selected animals. Data recorded included time, habitat use, any visible signs of distress or effect and the

APPENDIX B

number and manner of discrete oral interactions (pecks, head ducks, probes, etc.). Relevant notes including proximity to active spigots were also recorded. Where flocks of birds were interacting with cyanide-bearing habitats, the number of birds and type of interaction was recorded.

In addition to the monitoring conducted at the TSF, a number of alternative on-site water bodies of varying salinity concentrations were also monitored by DES. These were: Goanna pit (hypersaline), Winditch pit (brackish), the haul road lakes (fresh), Lake Carey (dry or hypersaline), the dewatering trench surrounding the TSF (hypersaline), the sewage ponds (fresh), the waterhole adjacent to the new transfer pond and TSF1 (fresh) and the wetlands next to the Harold Child waste dump (when water (fresh) was present). At these sites, most of the surveys conducted were 20-minute intensive surveys however other observation methods were also used opportunistically to capture observations of interest.

Nocturnal bat monitoring methodology

Insectivorous bats were monitored by DES at the active TSF cell and the haul road lakes in April, June, September and December 2011 and April, June and October 2012 and February 2013. Monitoring was undertaken using Anabat™ echolocation devices with the Anabat™ devices set to record for four continuous hours from sunset during each of DES's site visits. The Anabat™ devices were set to face over the supernatant at the TSF and over the water body at the haul road lakes. The division ratio (divides bat call frequency for identification purposes) was set to 16, while sensitivity was set to 6.5. The echolocation devices record onto compact flashcards and Analook W software is used to view calls for identification. Bats emit different calls for different activities such as communication, location (or cruising), socialising and feeding or drinking. When bats are hunting for food (and not just flying past) they emit calls more frequently, which are referred to as a feeding buzz or a buzz call. The ratio of these buzz calls to cruise calls (bat passes) provides a relative measure of bat activity and behaviour. Cruising calls indicate the presence of bats at a site and feeding buzzes indicate hunting for food or drinking where water is present. One bat pass is defined as a continuous sequence of at least two echolocation calls from a passing bat. A minimum gap of five seconds between passes was applied to ensure each call sequence was a separate pass.

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TO: **Frances Mills, Environmental and Community Relations Superintendent**
Granny Smith Gold Mine

FROM: **Owen Nichols**

DATE: **12 March 2014**

RE: Peer Review Panel Findings

Dear Frances,

I am writing in relation to matters raised in the final consolidated report of the Peer Review Team, provided to you on 9 January 2014. These matters have since been addressed in the following report:

Donato, D. B., Gursansky, W., Smith, G.B. and Overdevest, N. D., 2013. Re-evaluation of Recommendation 1: Standard of Practice 4.4, International Cyanide Management Code, Report to Granny Smith Gold Mine v2. Donato Environmental Services, Darwin.

As noted in the conclusions to the Peer Review Team report, the PRT agrees with the conclusions of the Donato et. al. (2013) report, and supports the recommended changes to the operating parameters. However, we believe that a number of issues should be considered and a number of recommendations must be actioned by the operators to ensure that either tailings are discharged with WAD cyanide <50 mg/L, or if not, the protective mechanism of hypersalinity is in place and the risk to wildlife is minimised. These are outlined in our report.

If all of these recommendations are addressed, the PRT believes that the changes to Recommendation 1 can be implemented without resulting in a measurable increase in risk to wildlife.

I can confirm that the corrections and changes to the Donato et al (2013) report requested in our PRT consolidated report have been made.

Thank you for the opportunity to review this study. Please contact me if you have any further questions.

Kind regards,

O G Nichols

Dr. Owen Nichols

Lead Peer Reviewer