

**Peer Review of the Report:
Influences of hypersaline tailings on wildlife
cyanide toxicosis: Granny Smith Gold Mine**

**by
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Final Review

Introduction

Barrick Granny Smith (BGS) gold mine's Frances Mills has requested that a team of peer reviewers conduct a review of the following report:

Smith, G.B., Donato, G.B. and Madden-Hallett, D. (2010) Influences of hypersaline tailings on wildlife cyanide toxicosis, Granny Smith Gold Mine. Final report, November 2010. Donato Environmental Services, Darwin.

The purpose of this review is to evaluate the information provided in the report relating to the approach BGS is proposing to take in order to fulfill the requirements of the International Cyanide Management Code in relation to issues pertaining to wildlife management, as described in Standard of Practice 4.4 of the Code. This requires mines to 'Implement measures to protect birds, other wildlife and livestock from adverse effects of cyanide process solutions'. Monitoring has shown that discharges at the spigot entry point of the company's tailings storage facility (TSF) sometimes exceed 50mg/L WAD CN. Therefore protective mechanisms need to be in place. The Peer Review Panel (PRP) has been asked to determine whether the study confirms that protective mechanism(s) exist, under specified operating systems and parameters.

The PRP consists of:

- Dr. Owen Nichols, EMRC, Lead Peer Reviewer;
- Mr. Ray Biehl, Independent Metallurgical Operations Pty. Ltd.
- Mr. Jamie Coad, Jamie Coad & Co; and
- Dr. Stuart Halse, Bennelongia Pty. Ltd.

This draft report presents the PRP's findings pertaining to the Smith et al (2010) report.

Work Required by Peer Reviewers:

The reviewers were initially requested to conduct their reviews independently and summarise their conclusions in individual reports. The Lead Reviewer Dr. Owen Nichols then consolidated the findings into this single report ensuring that it addressed the requirements of the definition of peer review. Members of the PRP then reviewed the consolidated report and when all were in agreement, it was submitted to Barrick Granny Smith.

The International Cyanide Management Institute (ICMI) notes that 'For purposes of compliance with (Standard of Practice 4.4), peer review is an independent, documented evaluation of scientific research for competence and validity. The review checks the assumptions, calculations, extrapolations, alternate interpretations, methodology, and conclusions of the research to ensure that the science is sound and the conclusions are well-founded'.

Background:

Details of the BGS tailings storage facility (TSF) are provided in the MERIWA 2008 study (Adams et al 2008, referred to M398) and in the Smith et al (2010) report. Up to 7 May 2010, the BGS system was saline with TDS values generally ranging from 14,000 to 20,000 mg/L TDS. The MERIWA study recorded no wildlife deaths and evaluated a number of hypotheses which attempted to explain this. As BGS is now a hypersaline tailings system, it was decided to retest the nine hypotheses (see Table 1). In M398 it was concluded that two of these hypotheses satisfactorily explained the lack of recorded wildlife deaths on hypersaline TSF's:

Hypothesis 7: Hypersaline process waters (nominally > 50 000 TDS) provide a natural barrier for wildlife exposure to contained WAD cyanide; and

Hypothesis 8: WAD cyanide in hypersaline waters is lost at rates sufficient to have a substantial beneficial impact on the area of wildlife inhabitation to contained WAD cyanide (levels and profiles to be determined on a site-specific basis).

The M398 study concluded that as the BGS tailings disposal system was only saline, a theoretical risk to wildlife remained. Given this, it was concluded that the system would not meet the requirements under Standard of Practice 4.4 of the Code. By contrast, the other two mines studied in M398 (Kanowna Belle and St. Ives), both of which discharge at higher WAD CN concentrations, did receive certification. This is because they are hypersaline systems and it was demonstrated that effective protective mechanisms exist at both.

On 7 May 2010, BGS implemented a hypersaline tailings discharge system by introducing groundwater of TDS >50,000mg/L into the solution prior to discharge. The intention of this was to create a system which, in terms of wildlife protection, functioned similarly to those of Kanowna Belle and St. Ives.

In the period since then, wildlife and cyanide monitoring has continued. Although this has been quite detailed, it is still the case that the BGS system has only operated under hypersaline conditions for a relatively short period largely during the season of winter. For this reason, it was necessary that the Donato Environmental Services (DES) report be based on:

- The findings of ACMER Project P58
- The findings of MERIWA Project M398
- Ongoing wildlife and cyanide monitoring conducted between the completion of M398 and the system becoming hypersaline; and
- Any chemistry and wildlife monitoring data and other observations collected since the system became hypersaline on 7 May 2010.

In a review of the interim Donato and Smith (2010) draft report, the PRP identified a number of gaps that needed addressing in ongoing wildlife and cyanide monitoring. The following sections review the findings of the final report (Smith et al 2010) in relation to

requirements identified for certification under the Code, and with regards to addressing gaps identified in the review of the interim report.

General Comments:

General approach to assessing implications for wildlife:

Monitoring conducted since the previous M398 study and described in Smith et al (2010) has shown that under specific circumstances mortalities have occurred in the BGS system when it is saline. Although the system is now hypersaline, this finding has important implications for a number of the hypotheses considered in the previous study and re-evaluated in the current one. For example, it proves that if susceptible species are present, mortalities do occur and at least some of these mortalities will be recorded (although it is very likely that others are missed). Even though the possibility that some birds might fly off and die elsewhere cannot be discounted, it appears that some deaths occur on the TSF and are detected. Other considerations pertaining to the hypotheses investigated are discussed in Table 1.

Much of the work described in Smith et al (2010) focused on Hypothesis 7: '*Hypersaline process waters solutions (nominally > 50,000 TDS) provide a natural barrier for wildlife exposure to contained WAD cyanide.*' This is appropriate given that similar protective mechanisms have been shown to operate at three Code certified mines, viz. Sunrise Dam, Kanowna Belle and St. Ives with no or minimal wildlife deaths recorded at any of them. Although comparisons between sites are relevant, some consideration needs to be given to the fact that data provided in Smith et al (2010) show that salinity at BGS is likely to be generally lower than that at Sunrise Dam (>90,000 mg/L) and Kanowna Belle (c. 200,000 mg/L) but similar to that recorded at St. Ives (50,000-60,000 mg/L). It is noted that some species can drink water up to 47,000 mg/L and may utilise habitats in TSFs where solutions are around 50,000 mg/L differently from those where TDS is much higher.

Although there has been little time during which the BGS system has operated under hypersaline conditions, a good indication of wildlife utilization and associated risk has been obtained from a combination of monitoring under hypersaline conditions, together with the considerable amount of monitoring under saline conditions, and findings from other comparable sites. As well as assessing wildlife utilization at BGS when the tailings solution is >50,000 mg/L TDS, it is important that the well-being of fauna be determined at times when WAD CN levels at spigot discharge exceed 50 mg/L. Both these appear to have been done, and are discussed below in the following subsections.

Wildlife monitoring and risk assessment:

As with previous studies designed to assess compliance with Section 4.4 of the Code, the report focuses on a specific set of wildlife potentially 'at risk' by the BGS TSF, notably terrestrial vertebrates and in particular (in this instance) birds and mammals. This focus should be mentioned in the report because it relates to the accepted WAD cyanide toxicity threshold of 50 mg/L, whereas the US EPA's ambient water quality criterion recognizes that 5 µg/L cyanide has chronic effects on aquatic fauna.

The report describes a considerable data set collated between 2006 and August 2010, that includes on-site monitoring as well as that conducted by DES, including intensive bird surveys, bird call detection, and the use of infrared cameras and anabat bat detectors. Operating TSF cells were monitored in detail together with surveys of adjacent water bodies. In combination these give a very good indication of what species utilize the TSFs, and for what purposes.

Bird numbers recorded by in-house monitoring were only around one-quarter of those recorded by DES staff. It is therefore possible that some potentially at-risk species, such as Red-necked Stints, were present at times in numbers greater than those suggested by the in-house surveys. However, it should be noted that the two surveys were conducted over different time periods with DES using telescopes and BGS staff using binoculars. The purposes were also different, with DES surveys aimed at detecting all or most birds present (including any mortalities) and describing their activities in detail, while the in-house surveys were aimed at detecting mortalities and general details of habitat utilization by the species observed using the described methods and survey times.

Overall, the data indicated that by far the highest numbers of individuals interacting with the TSF were Red-capped Plovers and Welcome Swallows, with relatively large numbers foraging, sometimes in habitats where WAD CN exceeded 50mg/L, i.e. parts of the Tailings Deposition Zone (TDZ). Other species, including Red-necked Stints as noted above, utilise the TSF from time to time but generally in low numbers.

Risk prediction is discussed on P.61 using the standard quantitative risk analysis approach, as well as knowledge of species behaviour and CN levels in particular areas of the TSF. All calculated risks were low except for Red-capped Plovers, Welcome Swallows and Ducks, which were moderate (although this is probably an overestimate of risk for ducks, as their interaction was calculated on supernatant, which has almost always been below 50mg/L). Based on the available data, it is reasonable to conclude from this that detailed analysis of these species use patterns, and the effectiveness of protective mechanisms, is focusing on the correct groups and species. Regular use by migratory waders is unlikely. However, whilst data suggest the probability may be low, the greatest consequences resulting from large-scale mortality could potentially result if a flock of migrating species such as Red-necked Stints descended on the TSF in October-November or March. Such species will have a comparatively high salt tolerance and so it is very important that systems are in place to ensure TDS remains above 50,000 mg/L. The PRP therefore recommends that Red-necked Stint be taken into account in planned seasonal monitoring, and factored into risk management procedures, due to the species' habitat utilization, feeding habits and presence in potentially higher numbers.

Aquatic invertebrates

Limited sampling of aquatic macroinvertebrates was undertaken. All 12 individuals, belonging to three families of bugs and beetles, were dead on collection. This is not unexpected because cyanide is toxic to all aquatic life at much lower concentrations than occur in the supernatant. The results confirm that the only food source available on the

TSF is invertebrates that land on the surface. By contrast, a relatively rich aquatic fauna was detected in the adjacent trench, although at times trench water may also have sufficient cyanide to be toxic to aquatic macroinvertebrates.

CN monitoring:

The report describes uncertainty regarding the accuracy of WAD CN values recorded by ALS v. in-house assessment. It notes the variability between the two and also between external laboratories. Analyses conducted prior to January 2010 show consistently higher values for in-house samples and given that other laboratories produced similar values to the ALS readings, it is likely that the in-house results overestimated the true value for that period. The report clarifies on P19 that the on-site data set was not used to determine operating parameters. Subsequent implementation of additional QA/QC measures to in-house analyses seem to have reduced this difference during the time the system has been hypersaline, however considerable variability between and within labs still exists. It is imperative that the QA/QC of WAD CN determination on-site is continually improved and that the correlation between the offsite lab and on-site lab is continually reviewed to ensure that the operating parameters remain valid.

Detailed monitoring of CN shows that discharge concentrations are often well above 50mg/L and comparable to values recorded at Kanowna Belle (which is hypersaline) and Mt Todd (fresh). It is clear from the detailed measurement of CN in particular habitats that at times, WAD CN levels are likely to exceed 50mg/L at the spigot pool as well as in the tailings stream and in adjacent wet tailings. Therefore, understanding species utilization patterns of these habitats and the effectiveness of any protective mechanisms is very important, and the study has recognized this by focusing on these aspects (i.e. synchronized studies) since the TSF system became hypersaline, as well as considering data and associated risk while it was saline.

Wildlife Deaths:

The Smith et al (2010) study demonstrates that, as expected, wildlife deaths occurred while the system was saline, with four Red-capped Plover deaths recorded by DES consultants on 1st May 2010. It is not clear whether the deaths had occurred when in-house monitoring was conducted earlier the same morning. Unfortunately, no WAD cyanide concentrations in spigot discharge or supernatant were recorded at the exact time the four Red-capped Plovers were found dead. Some explanation is given regarding the circumstances relating to the deaths, in terms of plant operations and likely cyanide concentrations. Obtaining data to clarify the relevant cyanide levels in such circumstances requires that BGS staff collect a sample from the discharge at the time of discovery of any mortalities, and also collect the lab data for that day – procedures that, in future, must be adopted should any wildlife mortalities occur.

Another two Red-capped Plover chicks were recorded in the trench at the edge of the TSF in August 2007. Both were technically outside the TSF and in the surrounding trench where WAD cyanide levels were very low. The site is located at least 60m from where elevated WAD CN levels might occur, and separated by a steep, rock-lined TSF wall. The likelihood of death by cyanosis would therefore appear low, but perhaps cannot

be totally discounted given that birds may take 30 minutes or more to die after cyanide ingestion, and because no other cause of death was evident.

Overall, the small number of Red-capped Plover deaths and lack of recorded deaths for any other species strongly suggest that total wildlife mortalities are neither frequent, nor high. However, it is very likely that more deaths occurred than were recorded. Quality assurance monitoring using balloons on the TSF showed that in M398, all balloons placed in supernatant were sighted by both consultants and in-house staff (Table 14). In the present study, almost all balloons were recorded by consultants. Most of these balloons would have been relatively close to the edge of the TSF. However, many of the balloons placed in a flowing tailings stream appear to have been missed by in-house monitoring. While follow-up confirmation that 'missed' balloons were still present does not appear to have been carried out (in some instances balloons may have burst), the fact that most balloons were sighted by consultants suggests balloons usually remained intact. Therefore, it can be concluded from this and other information that the effectiveness of in-house monitoring in detecting bird deaths will depend on where they occur. Possibly most deaths occurring on supernatant, beaches or the tailings surface relatively close to the observation point (<50m) will be recorded but deaths >100m from the observation point, and in flowing tailings stream, are likely to be missed. Other information provided suggests that few deaths will occur in locations where the recording rate is low, due to the low WAD CN concentrations in the supernatant (further from the shore), and the unsuitability of the tailings stream for feeding or drinking by waders and other species.

Detailed data on wildlife utilization at BGS when WAD CN discharge was > 50mg/L and the system hypersaline (Tables 16 and 17) shows that the two most common species were frequently present and feeding without ill-effects. Other data also obtained when WAD CN discharge was >50mg/L, but when the system was saline, similarly shows considerable numbers of Red-capped Plovers and Welcome Swallows present with no recorded deaths (although the results of 1 May 2010 show that such deaths did occur when the system was saline, presumably on relatively infrequent occasions). Further information from Kanowna Belle and St. Ives shows the presence of a range of waterbird species under conditions of hypersalinity and WAD CN >50mg/L, with no recorded deaths.

Secondary evidence supporting the presumed lack of regular, frequent mortalities is provided on P68 where DES note no evidence of carcass scavenging such as regular patrolling by corvids and raptorial birds, and/or the presence of tracks of terrestrial scavengers such as dingo, fox, cat and feral dog.

It is reasonable to conclude from these results that, although some deaths of Red-capped Plover are likely to be missed by in-house monitoring, frequent and/or large numbers of wildlife deaths have not occurred under hypersaline operating conditions and are unlikely to do so.

As with other hypersaline TSFs, monitoring of bat activity showed that this was much lower over the hypersaline tailings dam compared with a control site, as was the extent of

feeding and drinking activity. It is reasonable to conclude that risk to bats from feeding on surface insects and/or drinking, is small. However, the study has a number of limitations, some of which are pointed out. These include:

- Difficulties in identifying some species;
- Little is known about bat CN toxicity thresholds;
- The survey method only enables assessment of relative abundance; and
- As with other wildlife, sampling across seasons has not been uniform.

It is therefore recommended that in the light of these factors, monitoring of bats should continue in conjunction with other wildlife until patterns of use and associated risks for this group are fully understood

Comments on Specific Hypotheses:

The nine hypotheses investigated have been developed from previous studies of hypersaline TSFs. In several cases (e.g. Hypotheses 1 and 6) the wording could have been improved, thereby making interpretation in relation to the data somewhat easier. Nevertheless, the approach used and the overall findings of the study appear to be sound. The PRP believes that the conclusions in Table 1 can be drawn in relation to the information provided in Smith et al (2010) and related studies regarding the hypotheses.

Overall, the PRP concludes from the general comments above that Hypothesis 7: *'Hypersaline process waters solutions (nominally > 50,000 TDS) provide a natural barrier for wildlife exposure to contained WAD cyanide'* is supported by the results presented in the Smith et al (2010) study, based on data obtained at BGS and other comparable sites. The PRP therefore agrees that maintenance of a hypersaline operating system provides a primary protective mechanism for wildlife at the site.

Other data suggest that while factors such as low food availability and habitat structure influence the numbers of bird species present, and probably reduce mortalities, they are not likely to be the primary reasons for low recorded mortalities at BGS during saline conditions, and no recorded cyanide mortalities at BGS when operating hypersaline discharge systems. Likewise, while limitations in the monitoring system mean that the likelihood of some birds dying but not being recorded is high, it is unlikely that monitoring deficiencies are the primary reason for the low numbers of recorded mortalities.

For Hypothesis 3, the PRP feel that further investigation could provide useful information relevant to wildlife risk in relation to the operation of BGS under hypersaline conditions.

Table 1: Comments regarding the specific hypotheses.

Hypothesis	Comment
<p>Hypothesis 1: <i>Wildlife deaths occurred but the monitoring regime failed to record the presence of any carcasses</i></p>	<p>It is clear from the study that some deaths are likely to be missed; for example, on days when monitoring did not take place, and mortalities that may have occurred a considerable distance from the shoreline on days when in-house monitoring using only binoculars was carried out. From the information provided, it does not seem likely that deaths would occur in the flowing tailings stream, however if this were to occur, results of balloon monitoring suggest that they could well be missed by in-house monitoring. Therefore, in one sense the hypothesis partially supported by DES data due to limitations in the effectiveness of monitoring being likely to lead to an inaccurate estimation of the magnitude of mortality.</p> <p>Nevertheless, the detection of carcasses on 1 May 2010 proves that some deaths <i>are</i> detected, and monitoring limitations do not appear to be sufficiently large to be the primary reason for detecting few deaths. The very low numbers of deaths recorded by DES, and the fact that similar in-house monitoring does record deaths of the same and similar species at other freshwater TSFs mean that if substantial mortalities occurred at BGS, it is likely that some would be recorded (even if others were missed). Overall, it can be concluded that Smith et al (2010) are essentially correct; the lack of recorded deaths is not <i>primarily</i> because species are dying but being missed (although some might be).</p> <p>Conclusion: Partially supported, although this hypothesis is not the primary reason for the lack of recorded deaths.</p>
<p>Hypothesis 2: <i>Wildlife did not die in situ but flew away and died elsewhere</i></p>	<p>Although some of the evidence presented in the literature review suggests that under some circumstances birds can take more than 30 minutes to die, the recording of numerous deaths of the same species at other TSFs with freshwater tailings (e.g. Mt Todd) and a similar range of WAD CN discharge concentrations to BGS suggests that, when conditions are right, many bird deaths occur on the actual sites. Project M398 notes that although the possibility of wildlife leaving the BGS system and dying elsewhere cannot be discounted, were this to occur there is a high likelihood that <i>some</i> deaths would be noted <i>in situ</i> - which has in fact happened. Therefore the possibility of wildlife dying elsewhere does not preclude deaths being recorded, should they occur.</p> <p>Conclusion: Agreed, this hypothesis is not supported at BGS.</p>

<p>Hypothesis 3: <i>Wildlife deaths did not occur during the monitoring period due to seasonal or other environmental influences, resulting in at-risk species not being present during the monitoring period.</i></p>	<p>Over the course of the M398 study, subsequent in-house monitoring, and the 2010 consultant intensive surveys, BGS has been surveyed over a range of seasons. Whilst operating as a saline system (i.e. when risk to wildlife was theoretically greater), all seasons were covered, although proportionally fewer hours were spend conducting surveys in spring than in other seasons. Since the system has become hypersaline, only the late autumn and winter seasons have been covered. On the basis of the findings to date, it is not considered likely that the lack of recorded bird deaths for all but one species is due to them not being present in the area. Some, such as Red-capped Plovers, regularly use the TSF in large numbers with few mortalities. Information obtained from DES confirmed that ‘Red-capped Plovers, Welcome Swallows and wader species were frequently recorded dead on (fresh water) tailings dams in the arid regions of the Northern Territory’. Australian Shelduck, Wood Sandpiper and Black-fronted Dotterel utilize water bodies close to the BGS TSF (including the seepage trench) but were absent from or rarely used the active TSF. M398 presents further data from fresh water bodies adjacent to hypersaline TSFs which clearly shows that at-risk species were in the area at the time of monitoring, but apparently avoiding the TSFs. It is therefore considered unlikely that seasonal factors are primarily responsible for the lack of deaths at BGS and other TSFs in the region. However given the large variability between seasons in inland Australia, it is appropriate that, as recommended in Smith et al (2010), further monitoring be conducted in the season where migratory waders are most likely to be present in the region. Conclusions: Agree - this hypothesis is not supported at BGS, however further monitoring should be carried out as recommended.</p>
<p>Hypothesis 4: <i>Wildlife deaths do not occur due to the physical attributes of the TSF, resulting in no wildlife interaction with the hazard</i></p>	<p>Although the physical attributes of the BGS TSF do reduce the numbers of wildlife interactions (compared to natural wetlands), clearly wildlife do interact with the hazard, as evidenced by the large numbers of Red-capped Plovers present (and several deaths), as well as photographs and monitoring data in M398. More recent monitoring has provided further evidence that at-risk species (Red-capped Plovers and Welcome Swallows) are present in close proximity (i.e. the TDZ) to sites where tailings are being discharged at WAD CN values >50mg/l, with no mortalities observed by consultants. Conclusions: Agree - this hypothesis is not supported at BGS</p>
<p>Hypothesis 5: <i>Wildlife deaths do not occur at any of the sites because at-risk species are not found in the region or on any of the sites.</i></p>	<p>As noted in Smith et al (2010) and the previous studies at BGS, confirmation that many species occur in fresh water bodies adjacent to BGS, BKB and GSI, and in many instances on the TSFs themselves (e.g. Tables 18, 19 and 20), demonstrates that this hypothesis is not the reason for low number of mortalities in the three sites. Other data show that considerable numbers of species known from their behaviour and other studies to be ‘at risk’ are frequently recorded as visiting the BGS TSF, including at times when discharge</p>

	<p>concentrations are >50mg/l WAD CN. Conclusions: Agree - this hypothesis is not supported at BGS</p>
<p>Hypothesis 6: <i>Wildlife deaths are below detectable levels or non-existent due to a lack of aquatic food within the TSFs resulting in little or no wildlife exposure to the hazard.</i></p>	<p>Whilst both the current study and the M398 study showed that there is a lack of aquatic macroinvertebrates in TSF solutions at BGS, the same is true in fresh water TSFs where there are wildlife deaths. Therefore, absence of aquatic invertebrates is not a <i>primary</i> reason for the lack of wildlife deaths at BGS, BKB or GSI. However, it is likely to be a factor contributing to lower numbers feeding on supernatant, and therefore probably acts as a partial protective mechanism. Small numbers of birds attempt to feed on TSFs due to the presence of some terrestrial macroinvertebrates, and the chance of food being present. Conclusions: Partially supported, although this hypothesis is not the primary reason for the lack of recorded deaths.</p>
<p>Hypothesis 7: <i>Hypersaline process waters solutions (nominally > 50,000 TDS) provide a natural barrier for wildlife exposure to contained WAD cyanide.</i></p>	<p>For reasons discussed earlier, the PRP agrees with the findings of Smith et al (2010) that this hypothesis is supported at BGS, and concludes that maintenance of a hypersaline operating system would provide a primary protective mechanism for wildlife at the site.</p>
<p>Hypothesis 8: <i>WAD cyanide in hypersaline waters is lost at rates sufficient to have a substantial beneficial impact on the area of wildlife inhabitation to contained WAD cyanide (levels and profiles to be determined on a site-specific basis)</i></p>	<p>Whilst this hypothesis was shown to be valid at other sites, this does not appear to be the case at BGS – at least, not to the extent that any CN degradation has a ‘<i>substantial beneficial impact on the area of wildlife inhabitation to contained WAD cyanide</i>’. Measurement of WAD CN concentrations at various points along a tailings stream showed variable rates of decline, or in some cases, no decline. Smith et al (2010) suggest that this is because the tailings solutions at BGS are pH-stabilised (greater than 9.1), which hinders free cyanide volatilisation even at the higher salinities present. It can be concluded from the data presented that higher rates of CN degradation due to higher salinity cannot be relied on as a protective mechanism at BGS. Conclusions: Agree this hypothesis is not supported at BGS</p>
<p>Hypothesis 9: <i>Hypersaline tailings solutions have sufficient buffer capacity to inhibit free cyanide liberation on ingestion</i></p>	<p>Information provided in M398 and the current study suggests that this hypothesis is not supported at BGS.</p>

Code Compliance:

The Smith et al (2010) report concludes that the BGS TSF system can be operated in compliance with Standard of Practice 4.4 of the Code at times when WAD CN discharge is $>50\text{mg/L}$ and salinity is $>50,000\text{mg/L}$ TDS, with no recognized residual risk to wildlife, subject to a number of recommendations being implemented and operating parameters adhered to. These are based on parameters measured at times when wildlife mortalities have not occurred, and other relevant information.

It is the opinion of the Peer Review Panel that this conclusion is likely to be substantially correct subject to clarification and addressing of the matters raised below under the various recommendations. It is suggested that the term 'no recognized residual risk' could be rephrased as 'minimal identified risk to wildlife' (subject to the operating parameters being adhered to). Although not strictly part of this review, the fact that on many occasions spigot discharge is below 50 mg/L WAD CN is important in reducing overall risk of the TSF to wildlife.

Specific details of the Smith et al (2010) recommendations are discussed briefly below.

Recommendation 1: Operating Parameters

The recommended operating values take into account aspects of TSF chemistry and associated risk learnt at this and other operating sites. Thus, for spigot discharge, both an upper limit and an 80th percentile value are given for WAD CN, and a minimum value for salinity. For supernatant, limits are given for maximum WAD CN and minimum salinity. This approach to the development of operating parameters has now been used at a number of Code certified hypersaline sites and to date appears to be successful in terms of maintaining conditions in which no wildlife deaths are recorded. Based on the information presented in the Smith et al (2010) report, it is considered that this is also likely to be the case at BGS, with no reasonable expectation of either large numbers or frequent wildlife mortalities provided the system remains within the designated operating parameters.

It is noted that salinity (one of the critical operating parameters and the primary protective mechanism) values since 7 May 2010 have varied considerably with most in the $50,000\text{-}70,000\text{ mg/L}$ range but quite a few below $50,000$ and some even below $30,000\text{mg/L}$. The reasons for this are probably operational (inc. temporary failure in the pumping system from Goanna pit) and high rainfall. Although determining the causes is not specifically a part of this peer review, it is very important that this be done by BGS and addressed to ensure that values remain above $50,000\text{mg/L}$, and therefore in compliance.

Recommendation 2 addresses procedures regarding what to do if particular operating parameters are not met.

It is proposed in Recommendation 6 that the operation be reviewed after three to six months and then annually. This is appropriate, particularly given the variation in values

of some parameters such as salinity, as noted above. Recalibration of operating parameters, with peer review, is permitted under the Code and has been carried out at other sites.

Recommendation 2: Write an articulated tailings management plan

This recommendation is appropriate and very important because when completed it will outline the procedures that must be followed to ensure compliance with operating parameters and other key actions and recommendations relating to wildlife management. The point 'investigating the correlation between free cyanide concentration in the mill process with free cyanide concentrations at spigot discharge' could be a separate recommendation instead of in the Tailings Management Plan. A deadline for the preparation and implementation of this plan needs to be set.

Recommendation 3: Assessment of risk to wildlife on a continual basis

Although the conclusions are based partly on long-term monitoring under saline conditions, and experience at other hypersaline facilities, nevertheless given the limited time the BGS system has been operating under hypersaline conditions, some additional risk assessment is appropriate as part of ongoing adaptive management and confirmation of the initial findings. The report suggests that this includes monitoring during the migratory wader passage-migration seasons (usually September, October and March) and extreme water deprivation conditions (usually January and February); these are referred to as targeted seasonal condition surveys and are appropriate to address the limited post-hypersaline dataset. Peer review is recommended, and appropriate.

The report also recommends quarterly expert surveys to address possible inaccuracies of in-house surveys. This is also appropriate, as in-house monitoring is likely to miss smaller wildlife, and mortalities, at distances of more than (say) 100m from the observation point. The recommended approach should be tried and, if there appears to be a likely problem with in-house monitoring, another approach should be considered such as training in-house staff to a higher level, and providing them with a telescope rather than the current binoculars. Any follow up balloon surveys should include assessment of balloon presence *after* the surveys are conducted, to get some idea of how many balloons really were missed, and how many might have just burst.

Recommendation 4: Continuation of structured on-site monitoring regimes

The proposed monitoring program (Tables 27 and 28) consisting of:

- Daily monitoring of WAD CN at the spigot and supernatant;
 - Daily monitoring of Free CN at the spigot;
 - Daily salinity and pH monitoring at the spigot and supernatant;
 - Weekly monitoring of copper at the spigot and supernatant;
 - Weekly duplicate tailings samples from the spigot discharge point analysed for WAD CN, Free CN, Cu, salinity and pH;
 - Daily wildlife monitoring by trained staff;
 - Wildlife monitoring data management; and
 - Environmental and technical staff wildlife monitoring training
- are all appropriate and should be implemented.

The suggestion in Recommendation 3 above relating to the effectiveness of in-house monitoring should be implemented if there is any indication (e.g. from the external monitoring) that important wildlife information, including mortalities, are being missed to a greater extent than expected from the current study.

Also, a recommended procedure for investigating and addressing the causes of any mortalities, should they occur, is needed. This is partly addressed in Recommendations 2 and 4, but as well as determining the specific causes of mortality, it should include full consideration of available wildlife, chemistry, weather and other data at the time by suitable qualified independent experts, and a determination of whether changes to any operating procedures or parameters are needed.

Recommendation 5: Ongoing assessment of laboratory practices to ensure continual improvement in accuracy of analysis

This recommendation is appropriate. It is imperative that the QA/QC of WAD CN determination onsite is continually improved and that the correlation between the offsite lab and on-site lab is continually reviewed to ensure that the operating parameters remain valid.

Recommendation 6: Ongoing assessment of adherence to these conditions

This recommendation is appropriate, particularly given the limited data set under hypersaline conditions and the large variation in salinity levels.

Recommendation 7: Minimise infrastructure in the vicinity of cyanide-bearing habitats

This recommendation is appropriate.

Recommendation 8: Vegetation suppression and removal in and near cyanide-bearing water bodies

This recommendation is appropriate. The presence of vegetation in the seepage trench appears to attract invertebrates and birds into the vicinity of the TSF; consideration should be given to removal of vegetation and creating a sub-surface flow system inaccessible to wildlife. The report should quantify the distance of clearing required so as to achieve protection while minimizing damage to the environment through vegetation loss.

Conclusions:

The Peer Review Panel has concluded from this review of the Smith et al (2010) report that overall, the conclusions of the authors are correct; i.e. provided the recommendations and operating parameters stipulated are implemented and adhered to, the BGS TSF can be operated in compliance with the ICMC Standard of Practice 4.4 with no significant risk to wildlife.

The relatively short time the system has been operating under hypersaline conditions necessitates that the recommendations be given high priority and their implementation made a condition of certification under the Code. This will provide a better understanding of specific site conditions and required management actions in relation to seasonal factors, for example. Whilst information obtained under hypersaline conditions at BGS is limited, together with the large amount of data obtained under saline conditions, as well as that from other Code certified sites operating under hypersaline conditions, these indicate that it is possible to operate the BGS system with an acceptably low risk to wildlife.

References:

Adams, M.D., D.B. Donato, R.S. Schulz, and G.B. Smith (2008) Influences of Hypersaline Tailings on Wildlife Cyanide Toxicosis; MERIWA Project M398 (II) 'Cyanide Ecotoxicity at Hypersaline Gold Operations' Draft Final Report Volume 2 - Definitive Investigation. 2008, MERIWA: Perth.

Donato, D.B. and Smith, G.B. (2010) Influences of hypersaline tailings on wildlife cyanide toxicosis: Granny Smith Gold Mine. Interim report. Donato Environmental Services, Darwin.

Appendix 1: Suggested Corrections

- P2 - insert the word cyanide in the last line of para 2 between the words WAD and concentration.
- P5 subnote 1 check the wording of the sentence
- P5 Table 1 WAD CN value of 402!
- P8 para 5 – Crescent Ore
- P9 last para – use capital P for each Pit
- P12 last para BGS has “purchased” not “commissioned” an automated WAD cyanide analyser and salinity analyser
- P15 line3 of the Table caption should read ”one” not “ once”
- P19 para 2 line 8 readings not reading; Table 6 insert (mg/L) after analysis
- P21 insert units in Table 7
- P22 insert units in Tables 8 and 9
- P26 Figures 12 and 13 show a difference between the rate of degradation of WAD CN in the plume – seems to be greater in summer. No explanation is suggested. Could this be related to temperature or wind? (or both?)
- P27 para2 line 1 should read “does” not ”hold” up
- P27 correlation between the two labs is close ($R^2 = 0.54$); is this statistically significant?
- P28, Figure 16. The scale on the y-axis appears to be wrong. Is it proportion rather than per cent?
- P28 last para should be Figure 16
- P29 para 6 line 2 Crescent Ore

- P37 para2 line 5 On-site staff were
- P37 Table 14 has dates in US format
- P39 when talking about each of the Pits in dot points 6 and 7 use a capital “P” not lower case “p”
- P43 last line, should this read Appendix 3?
- P51 para 2 line 2 insert space after (Table 19). and Over
- P56 ‘The lack of recorded migratory waders at the TSF reflects low numbers in the region’. Does it really – what evidence is there for low numbers in the region? Is it possible that there might be very high numbers at times, e.g. Lake Carey? (however note that the last sentence in the paragraph acknowledges that an influx could occur under certain conditions).
- P61 para 2 line 2 para 2 use “have” been instead of “has”
- P62 Para 5 ‘The behaviour of at-risk species is not determined by seasonal factors at the TSF’ I thought foraging patterns of Welcome Swallows and ?RCP did vary seasonally? Probably doesn’t greatly affect the conclusions
- P65 para4 line 4 use Winditch Pit instead of pit
- P69 Hypothesis 7 ‘No wildlife species can drink hypersaline tailings solutions of 50 000 mg/L TDS because of osmotic regulatory (water balance) requirements ‘ perhaps better to say ‘no wildlife species likely to be present at BGS...’
- P72 note: Demonstration of no wildlife deaths. Agreed that deaths at a large distance from the shore would be hard to detect, however the problem may be somewhat reduced given that its a peripheral discharge system, and the data indicate that the highest risk habitat is generally close to the shore (plume, spigot pools) whereas supernatant further out is generally well below the toxic threshold, so presumably wildlife there are at a lower risk.
- P72 note: ‘To the author’s knowledge, almost all freshwater peripheral-discharge paddock tailings systems that discharge WAD cyanide concentration above 50 mg/L experience a considerable number of wildlife deaths ‘. It may be worth adding ‘...including, when present, Red-capped Plovers and Welcome Swallows, which are common on the BGS TSF but have suffered no recorded mortalities since the system became hypersaline’ (as indicated to be the case in discussions).
- P75 second last dot point use the word updated not update
- P76 Recommendation 4: Total WAD free cyanide is not correct
- P80 line 5 should read than those of SDGM not that