

Technical review of mine closure plan and mine closure implementation at Minerales Entres Mares San Martin mine, Honduras

A report prepared for Caritas (Honduras) / CAFOD International by

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1. Terms of Reference

The authors of this report were requested by Caritas (Honduras) / CAFOD International to provide a review of the mine closure plan and its implementation for the Minerales Entres Mares San Martin mine, Honduras. By agreement of both the authors and Caritas (Honduras) / CAFOD International, the review is strictly limited to technical aspects of the closure plan and its implementation. Therefore the review does not address the socio-economic aspects of closure, many elements of which are outside the expertise of these authors e.g. potential health impacts of emissions from mine sites.

2. Introduction and background

In April 2008 Professor Paul Younger of Newcastle University, UK, was requested to discuss closure of the San Martin mine with Caritas (Honduras), due to concerns that had been raised about whether the San Martin mine closure plan and its implementation was being conducted effectively and in accordance with international best practice. Professor Younger therefore reviewed the most up-to-date version of the closure plan at that time (the plan was dated 10 July 2007), and prepared a review of the closure plan (dated 21 April 2008). Professor Younger subsequently visited the San Martin site, though his visit was limited to observations from outside the main operational parts of the mine. Professor Younger's report following that visit is dated 16 December 2008. In both reports Professor Younger raised particular concerns about the level of detail within the mine closure plan, especially with respect to corroborating evidence for a number of key assertions made in the closure plan, and engineering design details for rehabilitation of the mine site. During his site visit Professor Younger also observed acid mine drainage at the point at which the overflow channel from the Tajo Palo Alto enters the Quebrada Casitas.

In light of Professor Younger's conclusions Caritas (Honduras) / CAFOD International invited two of Prof Younger's colleagues, Dr Jaime Amezaga and Dr Adam Jarvis, to conduct a more detailed review of the mine closure plan and its implementation. Their visit to Honduras took place between 2nd and 8th June 2009, and included a visit to the San Martin mine site itself (with mine staff) and detailed discussions with environmental and mining authorities in Honduras. This report details the findings of that visit.

The report is structured as follows. A general overview of the mine site is provided first (Section 3). This is followed by a review of the 3 areas that make up the whole mine site (simply delineated by these authors for ease of reporting):

- 1) The Tajo Palo Alto (Section 4)

- 2) The Tajo Rosa (Section 5)
- 3) The heap leach pad and processing facilities (Section 6)

Within each section there are 3 subsections:

- 1) Observations during site visit
- 2) Comments regarding mine closure planning and implementation
- 3) Recommendations

Overall conclusions and recommendations are provided in Section 7 of the report.

As noted in the Terms of Reference, the purpose of the report is to provide an objective technical assessment of the mine closure plan and its implementation. Whilst the terms of reference necessitate that the authors offer considered expert *opinion* on aspects of the mine closure plan, every effort is made here to avoid *speculative* comments.

Mine staff requested that the photographs were not taken by the authors during the site visit to San Martin mine. That request was of course honoured, and is why no photographs appear in this report.

3. General site layout and operational overview

The active mining area occupies an area of approximately 300 hectares, and in general terms slopes downwards from north to south. At the north east of the site is the Tajo Rosa, which was the first of two open pit voids to be excavated. Operations here have ceased, and rehabilitation of the void has been completed to the satisfaction of the mine company. The main watercourse bounding this eastern side of the mine site is the Agua Tibia, which is partly fed by a confined area (at least in surface expression) of thermal springs immediately to the south of the Tajo Rosa. Approximately 2 km to the west, and slightly south of the Tajo Rosa is the Tajo Palo Alto. This was the second open pit area, at which operations have ceased more recently. Rehabilitation of this void is ongoing. The main watercourse down the western perimeter of the mine site is the Quebrada Casitas.

Some waste rock has been used to backfill the open voids. The remaining waste rock from both open pits has been deposited slightly to the north east of the Tajo Palo Alto, and is in the final stages of rehabilitation.

Crushed ore from both open voids was deposited on an extensive leach heap located centrally between, and to the south, of the two open voids. The heap was leached with a sodium cyanide solution, and the leachate collected in the Piscina de Solución Rica, which lies approximately 500 m to the south of the leach heap. The gold was recovered from this solution principally using an activated carbon process. The dilute CN solution was held in the Piscina de Solución Pobre, adjacent to the Piscina de Solución Rica, from where it was reused as a leaching solution. This process for the recovery of gold from the ore is common practice internationally.

There are two additional man-made lagoons in this area of the mine site; the Piscina de Control de Tormentas (Storm pond) and the Piscina de Tratamiento de Agua (Treatment pond). The former is reported to have collected surface drainage, via a series of drainage ditches across the site, during rainfall events, whilst the latter is the final repository for water

prior to discharge to the environment. Water from the treatment pond was discharged (reportedly following quality testing by the authorities) to the Pila de los Patos. This was originally a natural depression, which was subsequently widened and deepened to receive discharge water from the mine. In deepening this pond it was made permeable, and therefore water infiltrates to the subsurface. The main watercourse to the south of the mine site is the Quebrada el Guajiniquil, and this is the most obvious potential recipient of any groundwater discharges arising from the Pilas de los Patos.

4. Tajo Palo Alto

4.1. Observations during site visit

Rehabilitation of the Tajo Palo Alto is ongoing, and engineering works here are at the least advanced stage of the three main areas of the mine. The pit had an extent of 80 ha, and was worked to a depth of 150 m (637 m a.o.l.). The current draft of the mine closure plan explains that rehabilitation has comprised backfilling with a combination of waste rock and clay layers, followed by top soil. The current (and final) ground surface level is 696 m a.o.l, which is the height of the decant from the SW corner of the pit. Thus, in principle water will drain freely from the new surface of the pit void to the decant, and thence to the Quebrada Casitas, albeit there may be some infiltration to the water table which is at approximately 675 m a.o.l.

At the time of the site visit, on 4 June 2009, engineering works were ongoing on the eastern face of the main pit wall. It is reported that these works have the aim of encapsulating sulphidic minerals present in this area. Subsequent works will entail further encapsulation with concrete according to the mine staff. In addition, fine material from the benches will be cleared, to limit the potential for this material to be washed into the base of the pit and out over the decant point in the SW corner of the pit void.

A series of surface drainage channels have been excavated above the main pit wall (immediately to the north of the void). Specifically these are the Canal 822, Canal Palo Alto, and Canal 4B (from the plan entitled *Drenaje Superficial Mina San Martin*). On this same plan there is a drainage channel indicated at the western end of the void, running around a section of the perimeter of the base of the pit (Canal 703-696).

There are plans to install a passive treatment system in the base of the pit to intercept any residual polluted waters draining into the pit void. The intention is that this will be a vertical flow wetland system, which is being designed by Lorax Environmental, Canada. The authors of this report have not seen the details of the planned system. As an interim measure a horizontal flow system has been installed along the outlet channel from the pit void (in the SW corner of the site). The system comprises limestone-filled gabions aligned perpendicular to flow at intervals down the length of the channel, and a locally-sourced organic material backfilled between these gabions to a depth of approximately 500 mm. The overall dimensions of this system are approximately 6 m wide by 100 m long (estimate only, by these authors). Effluent from this system drains down a steep ravine to the Quebrada Casitas. Limestone clasts have been placed in the channel at various points along its length. Immediately below the confluence with the Quebrada Casitas a dam has been constructed by the mine, using stone filled gabions, to act as a sediment trap.

During the visit to the site by these authors no water was flowing down the ravine from the open pit, and the Quebrada Casitas was under low flow conditions. However, there was clear

evidence of deposits of hydrous ferric oxide (solid deposits of iron arising from the oxidative dissolution of pyrite) in standing pools of water. In some pools these deposits were in the region of 10 mm thick, and illustrate water with elevated concentrations of iron has flown down the ravine in the past. There was also evidence of iron staining on stones along the banks of the Quebrada Casitas.

4.2. Comments regarding mine closure planning and implementation at Tajo Palo Alto

It is understood that the mine considered the option of allowing the open void at Tajo Palo Alto to flood, creating a pit lake, but that this option was discounted in favour of backfilling with solid material. Both options have been successfully adopted internationally, and since these authors have not seen the documentation outlining the reason for this decision, no further commentary is made here.

Re-grading and stabilisation works on the pit walls and slopes around the void are ongoing, and revegetation of the base of the void and some slopes (where feasible) has been undertaken. Given the success of revegetation around other parts of the mine site, in the fullness of time it is anticipated that vegetation will become well established in the Tajo Palo Alto (and already has in some areas). Re-grading and stabilisation works must of course be completed to ensure, as far as practical, safety of the pit void into the future. Again, observations at other parts of the site, and especially Tajo Rosa, suggest this will be achieved.

Of more concern is the potential for generation and discharge of acid mine drainage (AMD) to the Quebrada Casitas in future years. Subsequent to the site visit water quality analyses of DEFOMIN (the mining regulatory authority) have been inspected. Two particular issues have been identified:

- 1) Periodically elevated concentrations of iron in the Quebrada Casitas (at monitoring point M4), as illustrated in Figure 1 and, of more concern
- 2) A clear, and severe, incidence of AMD on 24 September 2008. The relevant data are shown in Table 1.

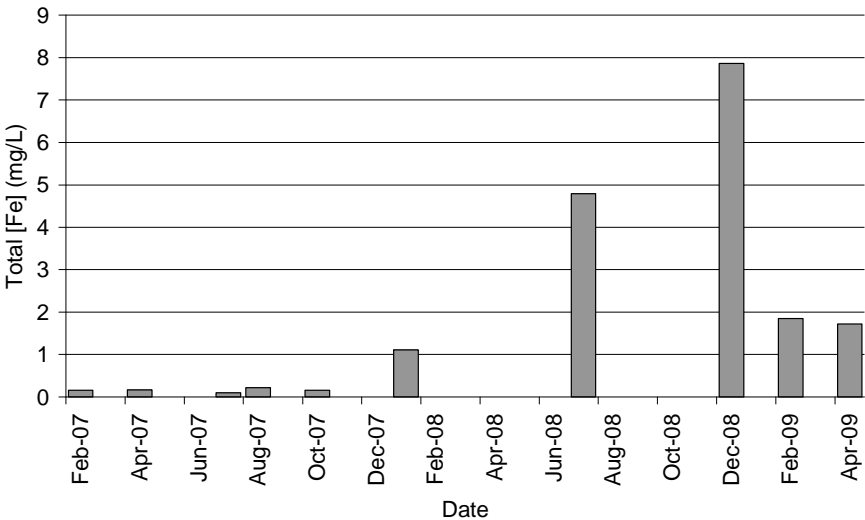


Figure 1. Concentrations of total iron at monitoring point M4 on the Quebrada Casitas. Data collected by DEFOMIN

Table 1. Analytical results showing severe acid mine drainage (AMD) in the Tajo Palo Alto on 24 September 2008 (data collected by DEFOMIN). All concentrations are total metal concentrations in units of mg/L, except pH

	Agua Entrante del Tajo	Salida Tajo Palo Alto
pH	2.58	2.89
Manganese	420.1	221.1
Copper	11.3	5.9
Iron	2565.6	1106.4
Nickel	10.8	5.4
Chromium	0.2	0.1
Lead	< 0.5	< 0.5
Aluminium	1325.7	706.5
Silver	4.1	< 0.1
Cadmium	2.6	2.0

Iron is the contaminant most commonly associated with acid mine drainage, since it arises from the oxidative dissolution of the common mineral pyrite. The occasionally high concentrations of iron in the Quebrada Casitas may be related to AMD from the Tajo Palo Alto. However, this is not absolutely certain from the data available. Additional data would be required to confirm whether any future incidences of elevated iron concentrations were associated with discharges from the Tajo Palo Alto (and recommendations for appropriate sampling and analysis strategies are discussed later in this document).

There is no doubt, however, that the highly elevated concentrations of metals recorded on 24 September 2008 are associated with the Tajo Palo Alto (the names of the monitoring points alone make this clear; Table 1). The concentrations of metals are very high, and pH is very low, which are both typical characteristics of severe AMD.

Using the data viewed by these authors as a guide, DEFOMIN collects samples approximately once every 2 – 3 months. Data for the period February 2007 to April 2009 were inspected by these authors. It is important to point out that the highly elevated metal concentrations in the samples from 24 September 2008 were not observed on any other occasion, or for any other sample point. Neither is it known by these authors what the flow-rate of water leaving the Tajo Palo Alto was on the 24 September 2008.

Ongoing works within the Tajo Palo Alto have the aim of restricting the potential for AMD generation, but with the information available to these authors it is not possible to conclude to what extent these works will be effective. The canal system above the pit has the objective of diverting water around the pit to limit the volume of water entering it, again to limit the potential for AMD generation. Finally, the mine intends to install a passive mine water treatment system in the base of the pit to intercept and treat any AMD that is still generated despite the works noted above.

Notwithstanding the points made in the two paragraphs above, the very high concentrations of metals, and low pH, shown in Table 1 are cause for concern. Clearly incidents of this sort should be prevented from occurring, both now and post-closure.

The use of passive mine water treatment, as proposed by the mine, may not be the best approach to addressing AMD problems in this particular instance. This opinion is based on two observations:

- 1) The very low pH and very high metals concentrations shown in Table 1, and
- 2) The climate of Honduras, which is characterised by extreme differences in seasonal rainfall patterns and, in particular, short duration - high intensity rainfall events

Passive treatment systems are designed for AMD with low to moderate metals concentrations, and consistent and low to moderate design flow rates. The metals concentrations indicated in Table 1, and the climate of Honduras, suggest that neither of these conditions will be met. Even at low flow rates a passive treatment system for the remediation of metals at the concentrations shown in Table 1 would have to be of considerable size, and even then such passive units tend not to function well for the removal of very soluble metals such as manganese. Furthermore, flow-rates to such a system in the base of the Tajo Palo Alto are likely to be anything but consistent. In contrast flows are likely to be sporadically very high in the rainy season, potentially leading to inundation of the system or, even worse, flushing of previously retained contaminants through the system. Conversely, during the dry season a passive unit may dry out entirely, which would not be beneficial to its functioning as a treatment system (note that such evaporative losses are in fact being relied upon for other aspects of the mine site post-closure; see below). It was reported by mine staff during the visit to the site that a contingency for active (i.e. chemical) treatment was in place, though this is not reported in the current draft of the mine closure plan.

In conclusion therefore, whilst some aspects of the rehabilitation of the Tajo Palo Alto appear to be progressing well (e.g. revegetation), it is the opinion of these authors that risks remain in relation to pollution due to AMD post-closure. The event, or course of events, that resulted in the severe water quality problem of 24 September 2008 are not known by these authors, but addressing future problems of AMD at the site will require these circumstances to be understood, such that appropriate measures can be taken to prevent future occurrences. Although the encapsulation of sulphidic materials on the pit walls may go some way to limiting these risks, the very fact that a passive treatment system is being designed suggests that even the mine staff recognise that this will not entirely address these issues. Passive treatment may not be the most appropriate approach to treatment in the opinion of these authors, particularly if the open void, and therefore passive treatment unit, receives short-duration - high intensity inflows of water.

4.3. Recommendations

In many areas the current draft of the mine closure plan for the San Martin mine lacks sufficient detail to give confidence that the mine site will be rehabilitated to an internationally acceptable standard. In fact the lack of detail in the current draft of the mine closure plan belies the considerable efforts that have been made, or are in the process of being made, to successfully rehabilitate the mine site. Therefore it would appear that in many respects it would be in the mine's interests to ensure that the mine closure plan is updated with greater detail on the rehabilitation of the site.

Particular details that it is recommended are added to the mine closure plan, specific to the Tajo Palo Alto, are as follows:

- Details of the volumes of water that enter the pit and the volumes of water that discharge to the Quebrada Casitas. If these are calculated flows the calculations should be shown, and if they are measured flows then the method of measurement should be described
- Details of the sources, pathways and receptors of AMD emanating from the pit. It is clear that AMD is an issue here: visual evidence of hydrous ferric oxides in the channel leaving the Tajo Palo Alto, the analytical results of 24 September 2008, and the very fact that the mine is backfilling various channels with limestone, has already installed a temporary passive treatment unit, and intends to install a permanent unit. Irrespective of whether AMD is a periodic problem or otherwise, the problem should be addressed in the mine closure plan and implemented on the ground. This should include:
 - details of the sources of AMD, the volumes of water involved (measured or calculated), and the range of water quality evident
 - design flow and contaminant loadings (i.e. flow multiplied by concentration), and main design variables (i.e. the principal target contaminants for remediation)
 - details of contingency plans should passive treatment fail to remediate any AMD to acceptable standards
 - details of post-closure water quality monitoring to ensure compliance with relevant standards
 - details of post-closure operational and maintenance activities with respect to the passive treatment system or alternative treatment system. It is worth noting here that passive treatment systems do require maintenance throughout their life, albeit these are not as onerous as for active treatment systems

In relation to water quality monitoring, it is recommended that additional sampling locations are monitored, and that the analytical suite is expanded. This recommendation applies as much to the activities of the regulatory authorities as the mine operator. Specifically, to properly assess any AMD arising from the Tajo Palo Alto and its impact on the Quebrada Casitas, it is recommended that:

- The discharge from the Tajo Palo Alto is monitored, as is the Quebrada Casitas upstream and downstream of the discharge point from the Tajo Palo Alto. Samples should be collected from all 3 locations on the same sampling trip to allow direct comparison of results.
- The sampling protocol should be expanded to include collection of acid-preserved samples of both total and filtered (0.45 µm pore size) water for subsequent analysis of metals concentrations. This will enable discrimination between metals associated with solids and metals in dissolved phase. Thus, 3 samples should be collected at each point: 1 acid-preserved containing unfiltered water, 1 acid-preserved containing filtered water, and 1 sample not preserved in acid for anion analysis (see point below).
- The analytical suite be expanded to include not only the contaminant metals, but also major anions (sulphate, chloride, and bicarbonate), and major cations (calcium, magnesium, sodium and potassium).
- A flow monitoring device be installed at the outflow from the Tajo Palo Alto.

- A photographic record of the flow conditions and appearance at all 3 sampling points is made on each sampling occasion.

5. Tajo Rosa

5.1. Observations during site visit

The Tajo Rosa was 42 ha in extent, approximately half the size of the Tajo Palo Alto. It was worked to a depth of 717 m a.o.l., but did not extend below the water table, principally due to the close proximity of the thermal springs, immediately to the south of the open pit. It was the first of the two open pits to be exploited, and operations ceased here first. Consequently rehabilitation has already been undertaken and completed to the satisfaction of the mine operator.

The pit was backfilled as far as possible, and has now developed a cover of mixed vegetation. A series of canals (drainage channels) have been installed to transfer runoff from the abandoned pit towards the Quebrada el Guajiniquil and Agua Tibia (Canals R2, R3, R4, R5 and RC1 and RC2). There is nevertheless evidence of some gully erosion in a few confined areas, and slight erosion / collapse of the drainage canals themselves, again in one or two confined areas. There is a small pond in on one part of the site, which is reported to be a former sedimentation pond, but there does not appear to be any surface discharge associated with it.

5.2. Comments regarding mine closure planning and implementation at Tajo Rosa

On the evidence of the site visit the rehabilitation of the Tajo Rosa appears to have been successful. Although there have been some concerns that the vegetation established is not that which was present pre-mining, the authors concur with the mine staff that this was not in likelihood a realistic option.

As noted above, there is some evidence of gully erosion and deterioration of the canal system in a few confined areas. This is not a major cause for concern, but some periodic maintenance of the canal system may be required post-closure, to avoid exacerbation of any minor erosion problems. Walkover surveys by a suitably qualified geotechnical engineer should also be encouraged post-closure, to ensure that the stability of steep slopes in the abandoned pit remains acceptable from a health and safety perspective.

5.3. Recommendations

The only recommendations for the mine closure plan and its implementation with respect to the Tajo Rosa are as follows:

- Periodic walkover surveys to assess the integrity of the canal system on the Tajo Rosa, and the stability of steep slopes, is included in the mine closure plan as an activity, and undertaken post-closure.
- As required, the canal system is maintained to prevent any increased erosion in the vicinity of the site that would otherwise result from the deterioration of the canal system.

6. Heap leach pad and processing facilities

6.1. Observations during site visit

The heap leach pad at the mine site is in the process of being rehabilitated. The first phase of rehabilitation was flushing the heap with water. Simultaneously it is reported that the external slopes of the heap were regarded to a 1:2.5 slope. Both of these aspects of the rehabilitation have been completed, and water quality analyses of the leachate from the pad shows that cyanide concentrations were reduced to levels below detection limits. It is reported that the surface of the leach pad was then compacted to limit its permeability. At the time of the visit a soil cover over the heap was nearing completion. This will be seeded over time to encourage the development of a vegetative cover across the heap. Given evidence from other areas of the mine site there is no reason to think that this will not be achieved successfully. There is some evidence of gully erosion of the soil cover on the slopes of the heap, and photographs of the heap prior to the visit of these authors suggested that this problem has been more severe in the past. However, the installation of a new drainage system on the heap would appear to be improving matters. A series of canals on the top of the heap transfer water to a number of drainage ditches running down its flanks. These drainage ditches will be lined with geomembrane to prevent erosion in the future.

Surface drainage from the heap leach pad, which should not be contaminated, will be directed to the Pila de los Patos. Any water infiltrating the heap will be collected by the existing drainage system at the base of the leach heap, and transferred to the Piscina de Solución Rica. It is reported that the integrity of the lining of this pond (which has now been emptied) has been thoroughly checked for leaks. At the time of the site visit a new drainage network was being installed at the base of the pond, which is being covered to a depth of approximately 300 mm with granular material. The intention is that any water draining from the base of the leach heap will enter through this pipe network into the pond, the granular material acting as a sorbent for any contaminants. Although the detailed calculations are not included in the current version of the mine closure plan (see below), the system is designed such that evaporative losses will exceed inflows to the pond, and therefore that no active treatment will be required. An overflow system is in place that will allow water to pass from the Piscina de Solución Rica to the Piscina de Solución Pobre and to the Piscina de Control de Tormentas in the event of high inflows. Should water pass from the latter into the Piscina de Tratamiento de Agua then active intervention will be required, although what form this would take is not known to the authors.

6.2. Comments regarding mine closure planning and implementation at the heap leach pad and processing facilities

It appears that any initial problems with gully erosion on the flanks of the leach heap are being addressed. The mine has retained the services of O'Kane Consultants Inc., Canada, to design the rehabilitation of the heap, and the company has a strong reputation in this field. Although the drainage system built into the surface of the heap should in principle work effectively, the effects of intense rainfall events on the soil cover will need to be monitored carefully to ensure that gully erosion does not proceed. The establishment of a good vegetative cover on the heap would appear to be crucial in this respect.

The current version of the mine closure plan does not provide details of the calculations showing that evaporation will exceed inflows to the ponds below the leach heap, and

therefore it is not possible to comment on whether this approach to remediating leachate emanating from the base of the heap will work effectively. Neither is the contingency plan outlined for a scenario in which evaporative loss does not ensure that there is no overflow from this series of ponds. Again, this should be detailed in the closure plan, along with any relevant supporting information.

6.3. Recommendations

As with other sections of the San Martin mine closure plan there is a lack of detail in the plan which makes it difficult to assess thoroughly whether the rehabilitation measures will be effective over the medium to long-term. Again, the absence of detail in the closure plan belies what appears to be good work actually being undertaken on site. It is recommended that closure plan is carefully updated by the mine with further details of the rehabilitation measures being undertaken, or being planned. Specific areas of importance noted during this review, and therefore recommended for inclusion, are:

- Details of the monitoring of the leach pad cover system to ensure that the rehabilitated heap, and especially the integrity of the cover, remains effective in the medium- to long-term
- Details of the calculations that demonstrate that the plan to rely upon evaporative loss from the ponds will in fact be effective
- Details of contingency plans in place should evaporative loss not be sufficient to prevent any overflow of leachate from the series of ponds

7. Conclusions and recommendations

This report provides details of a review of the mine closure plan for the San Martin gold mine, Honduras. The review was conducted over a 1 week period from 2 – 8 June 2009 during a visit to Honduras by the authors, which included a 1 day visit to the mine site itself. It follows an earlier review conducted by Professor Paul Younger of Newcastle University, although his visit did not include a visit to the mine site itself (observations were only possible from the outside perimeter of the site).

By agreement of both the authors and Caritas (Honduras) / CAFOD International, this review was strictly limited to technical aspects of the closure plan and its implementation. Therefore the review does not address the socio-economic aspects of closure, many elements of which are outside the expertise of these authors e.g. potential health impacts of emissions from mine sites.

The core review of the mine site is broken down into 3 sections for ease, representing the 3 main areas of the mine:

- 1) The Tajo Palo Alto (Section 4)
- 2) The Tajo Rosa (Section 5)
- 3) The heap leach pad and processing facilities (Section 6)

In general terms the key problem with the mine closure plan for the mine is its lack of information, particularly with respect to:

- the exact details of the plans for rehabilitation of the site

- evidence to support the proposals made e.g. hydrological / geochemical data, experimental work, geological / hydrogeological plans, and
- details of the post-closure monitoring of the site to ensure that the rehabilitation is effective.

The mine closure plan in fact fails to provide details of much of the good rehabilitation work that is actually being undertaken at the site.

Specific to particular areas of the site, rehabilitation works are least advanced at the **Tajo Palo Alto**, where engineering works are ongoing. Whilst some aspects of the rehabilitation of the Tajo Palo Alto appear to be progressing well (e.g. revegetation), it is the opinion of these authors that risks remain in relation to pollution at the Tajo Palo Alto due to AMD post-closure. The event, or course of events, that resulted in the severe water quality problem of 24 September 2008 are not known by these authors, but addressing future problems of AMD at the site will require these circumstances to be understood (if they are not already), such that appropriate measures can be taken to prevent future occurrences. Although the encapsulation of sulphidic materials on the pit walls may go some way to limiting these risks, the very fact that a passive treatment system is being designed suggests that even the mine staff recognise that this will not entirely address these issues. Passive treatment may not be the most appropriate approach to treatment in the opinion of these authors, particularly if the open void, and therefore passive treatment unit, receives short-duration, high intensity inflows of water, and / or if the quality of water is similar to that of 24 September 2008.

Particular details that it is recommended are added to the mine closure plan, specific to the Tajo Palo Alto, are as follows:

- Details of the volumes of water that enter the pit and the volumes of water that discharge to the Quebrada Casitas. If these are calculated flows the calculations should be shown, and if they are measured flows then the method of measurement should be described
- Details of the sources, pathways and receptors of AMD emanating from the pit. It is clear that AMD is an issue here: visual evidence of hydrous ferric oxides in the channel leaving the Tajo Palo Alto, the analytical results of 24 September 2008, and the very fact that the mine is backfilling various channels with limestone, has already installed a temporary passive treatment unit, and intends to install a permanent unit. Irrespective of whether AMD is a periodic problem or otherwise, the problem should be addressed in the mine closure plan and implemented on the ground.

Further details of the second of these recommendations are provided in Section 4.3 of this report, as are recommendations for additional sampling and analysis in and around the Tajo Palo Alto, which will be essential to both (a) understand the source and fate of any AMD and (b) ensure that measures taken to prevent AMD are effective.

Rehabilitation of the **Tajo Rosa** has been completed to the mine's satisfaction, and observations during the site visit suggest that this has been largely effective. The only recommendations for the mine closure plan and its implementation with respect to the Tajo Rosa are as follows:

- Periodic walkover surveys to assess the integrity of the canal system on the Tajo Rosa, and the stability of steep slopes, should be included in the mine closure plan as an activity, and undertaken post-closure.
- As required, the canal system should be maintained to prevent any increased erosion in the vicinity of the site that would otherwise result from the deterioration of the canal system. Details should be included in the closure plan and implemented on the ground.

As with other sections of the San Martin mine closure plan there is a lack of detail in the plan regarding rehabilitation of the **heap leach pad and processing facilities**, which makes it difficult to assess thoroughly whether the measures proposed will be effective over the medium to long-term. Again, the absence of detail in the closure plan belies what appears to be good work actually being undertaken on site. It is recommended that the closure plan is carefully updated by the mine with further details of the rehabilitation measures being undertaken, or being planned. Specific areas of importance noted during this review, and therefore recommended for inclusion, are:

- Details of the monitoring of the leach pad cover system to ensure that the rehabilitated heap, and especially the integrity of the cover, remains effective in the medium- to long-term
- Details of the calculations that demonstrate that the plan to rely upon evaporative loss from the ponds will in fact be effective
- Details of contingency plans in place should evaporative loss not be sufficient to prevent any overflow of leachate from the series of ponds

As with all areas of the mine site, how the success or otherwise of rehabilitation measures will be monitored beyond completion of engineering works should be explicit in the mine plan and, of course, implemented on the ground after closure.

Notwithstanding the positive advances that are being made with rehabilitation of the San Martin mine site, the possibility that rehabilitation is ineffective should be considered as part of the closure plan. Thus, as noted at various points through this report, contingency plans for failure of the various parts of the rehabilitation works must be included within the closure plan. This should include measures proposed to address the potentially damaging effects of extreme weather conditions and seismic events.